DOCUMENT RESUME

ED 454 813 IR 020 792

TITLE	Learning Societies in the New Millennium: Creativity, Caring & Commitments. International Conference on Computers in Education/International Conference on Computer Assisted Instruction (Taipei, Taiwan, November 21-24, 2000).
INSTITUTION	Association for the Advancement of Computing in Education. Asia-Pacific Chapter.
PUB DATE	2000-11-00
NOTE	3343p.; For individual papers, see IR 020 793-821.
PUB TYPE	Collected Works - Proceedings (021)
EDRS PRICE	MF31/PC134 Plus Postage.
DESCRIPTORS	Computer Mediated Communication; *Computer Uses in Education; *Educational Technology; Elementary Secondary Education; Instructional Design; Postsecondary Education; World Wide Web
IDENTIFIERS	Learning Environments; *Learning Society; Web Based Instruction

ABSTRACT

This conference addressed pedagogical, social, and technological issues related to computers in education. The conference theme, "Learning Societies in the New Millennium: Creativity, Caring & Commitments," focused on creative learning, caring for diverse cultures and global issues, and committing oneself to a new way of learning/instruction via computer-mediated communication technologies. This proceedings contains full and short papers in the following topical areas: artificial intelligence in education; cognition and conceptual change; collaborative learning; computer-assisted language learning; creative learning; educational agent; evaluation of learning and systems; globalization vs. localization; humanities and learning technology; instructional design; intelligent tutoring system; interactive learning environments; knowledge construction and navigation; lifelong learning; methodologies; multimedia and hypermedia in education; networked social learning; policies, ethics, standards, and legal issues; special education; student modeling; system design and development; teaching and learning processes; telecommunication in education; virtual lab/classroom/school; virtual reality in education; and World Wide Web-based learning. (MES)

Reproductions supplied by EDRS are the best that can be made
from the original document.

ED 454 813

"Learning Societies in the New Millennium: Creativity, Caring & Commitments" International Conference on Computers in Education/International Conference on Computer Assisted Instruction (Taipei, Taiwan, November 21-24, 2000).

PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY

G.H. Marks

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

1

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

- This document has been reproduced as received from the person or organization originating it.
- Minor changes have been made to improve reproduction quality.

- Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

IR020792

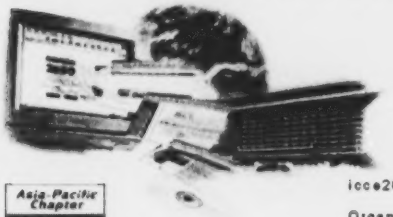
BEST COPY AVAILABLE

ICCE / ICCAI 2000

International Conference on Computers in Education
International Conference on Computer Assisted Instruction 2000

Learning Societies in the New Millennium : Creativity, Caring & Commitments

November 21-24, 2000 The Grand Hotel, Taipei, Taiwan



Asia-Pacific Chapter AACE

icce2000@tcfst.org.tw

Organized by : Asia-Pacific Chapter of AACE
Hosted by : National Tsing Hua University
Co-Sponsored by : Ministry of Education
National Science Council

BEST COPY AVAILABLE

ICCE/ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS

Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings

HOME

Proceedings

Preface

Content

- ►Keynote Papers
- ►Invited Papers
- ►Full & Short Papers (by topics)
- ►Posters
- ►Author Index
- ►Title Index

▲HOME

ICCE/ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsor
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▶Full & Short Papers (by topics)

Artifical Intelligence in Education
Cognition and Conceptual Change
Collaborative Learning
Computer-Assisted Language Learning
Creative Learning
Educational Agent
Evaluation of Learning and Systems
Globalization vs. Localization
Humanities and Learning Technology
Instructional Design
Intelligent Tutoring System
Interactive Learning Environments
Knowledge Construction and Navigation
Lifelong Learning
Methodologies
Multimedia and Hypermedia in Education
Networked Social Learning
Others
Policies, Ethics, Standards, and Legal Issues
Special Education
Student Modeling
System Design and Development
Teaching and Learning Processes
Telecommunication in Education
Virtual Lab/Classroom/School
Virtual Reality in Education
Web-Based Learning

▲HOME

Proceedings

Content

▸Full & Short Papers (Artifical Intelligence in Education)

A Computational Model for Learner's Motivation States in Individualized Tutoring Systems
A Fuzzy-based Assessment for Perl Tutoring System
A Genetic Approach to Parallel Tests Construction
A Learning Environment for Problem Posing in Simple Arithmetical Word Problems
A Method of Creating Counterexamples by Using Error-Based Simulation
A Study of Networked Constructive CAI System Using Multiplication-Concept of
Adaptive Programming Language Tutoring System on the Web
An Agent-Based Intelligent Tutoring System
An Educational System that can Visualize Behavior of Programs on the Domain World
An Environment for Learning by Design : In the Case of Learning of Search Algorithms
Applicability of an Educational System Assisting Teachers of Novice Programming to Actual Education
Case-Based Evaluating Assistant of Novice Programs
Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW
Development and Evaluation of a Mental Model Forming Support ITS-the Qualitative Diagnosis Simulator for the SCS Operation Activity-
Development of Intelligent Learning Support System with Large Knowledge Base
Educational Agents and the Social Construction of Knowledge: Some Issues and Implications
Facilitating examples understanding through explicit questioning
Generating interactive explanations by using both images and texts for Micro World
Intelligent Interactive Learning Environment: Design Issues
Internet Video on Demand System of Classroom Teaching Cases
Is a Learning Theory Harmonious with Others?-To form Effective collaborative Learning Groups with Ontological Engineering-
Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education
Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language
Multimedia Intelligent Tutoring System for Context-Free Grammar
Natural language-like knowledge representation for multimedia educational systems

Strange Creatures in Virtual Inhabited 3D Worlds
The Application of Uncertainty Reasoning for an Intelligent Tutoring System
The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS
The Design of CAI with Thinking Activity to Progress Constructive Teaching - An Example of Division-concept in Mathematics of Elementary School
The Estimation of Music Genres Using Neural Network and its Educational Use
The externalization support system of self-explanation for learning problem-solving process
Traversing the Case Graphs. A Computer Model for Developing Case-based Learning Systems
Use of abstraction levels in the design of intelligent tutoring systems
Using Decision Networks for Adaptive Tutoring

▲ HOME

ICCE/ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitment

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▶Keynote Papers

Using Technologies to Model Student Problem Spaces
Millennium eLearning: The Next Killer Application-Implications for Educators and Information Professionals
Social and Technological Innovations for a Knowledge Society
Computer-Based Strategies for Articulatev Reflection (and Reflective Articulation)

▲HOME

ICCE/ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS

Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings

HOME

Proceedings

Preface

These are the Proceedings of the International Conference on Computers in Education/International Conference on Computer-Assisted Instruction (ICCE/ICCAI 2000), held in Taipei, Taiwan, November 21-24, 2000. The first ICCE conference was also held in Taiwan in 1989. We are pleased that ICCE returns to Taiwan as a much bigger event spanning a wide range of topics related to computers in education in this millennium year 2000. Building on very successful ICCE Conferences in Taiwan during 1989-1993, in Singapore in 1995, Kuching, Malaysia in 1997, Beijing, China in 1998 and Chiba, Japan in 1999, this conference promises to also be a great success. The conference also subsumes the International Conference on Computer Assisted Instruction (ICCAI) for the first time. In 2001, ICCE will be held in Korea.

The ICCE conferences are organized under the auspices of the Asia-Pacific Chapter of the Association for the Advancement of Computers in Education (APC/AACE). The society's aims are to promote educational uses of technology in the service of enhanced learning, to bring together researchers, practitioners and policy-makers to improve communication and understanding, and to foster standards of excellence in educational research and practice involving technology. The focus is across the Asia-Pacific region, but participants are welcomed from the whole world.

This conference focuses on pedagogical, social and technological issues and many papers in these Proceedings make important contributions to these central issues. The conference theme, "Learning Societies in the New Millennium: Creativity, Caring & Commitments", indicates a focus on creative learning, caring for diverse cultures and global issues, and committing oneself to a new way of learning/instruction via computer-mediated communication technologies. In an effort to continue seeking the best possible ways to exploit technologies for enhancing learning, many papers in these proceedings contribute further insights on areas that will challenge global citizens in the new century. Questions we ponder include: What sort of learning society will be formed in the new millennium through our collective efforts toward creativity, caring and commitment on the Internet? Through this new learning society, will we be able to educate learners as well as educators of the next generation to be creative and caring and to make a commitment to creating a new kind of learning environment?

We are delighted to report that ICCE/ICCAI 2000 attracted more than 360 submissions, from nearly 30 countries. All submissions were reviewed by an international panel of 3 expert referees. A total of 154 papers were accepted for presentation as full papers, and for publication in full in these Proceedings. Further submissions of high standard were selected for presentation and publication as short papers and as posters.

The invited speakers program is a highlight of the ICCE/ICCAI Conferences. This year we have 13 invited speakers with 4 of them giving special keynote presentations. Papers from the invited speakers are also included in these

Proceedings. We believe that the high standard of papers included here, and the wide variety of issues they address, confirm the creativity, caring and commitment of workers in the global field of education and technology, and especially in the Asia-Pacific region.

Many people contributed to making ICCE/ICCAI 2000 a success and we are grateful to them all. The International Organizing Committee and the International Program Committee played important intellectual and practical roles. Here we are pleased to acknowledge especially the invaluable assistance of the international referees, who are named on another page.

As the program chairs of ICCE2000 we are proud to present these Proceedings for use by all participants both during the Conference and later as an archival record of an informative and stimulating event.
As the program chairs of ICCE/ICCAI 2000 we are proud to present these Proceedings for use by all participants both during the Conference and later as an archival record of an informative and stimulating event.

Jim Greer, University of Saskatchewan, Canada
Shelley Shwu-Ching Young, National Tsing Hua University, Taiwan
Herman Maurer, University of Graz, Austria
Yam San Chee, National University of Singapore, Singapore

Chairs of ICCE/ICCAI 2000 Program Committee
November 2000
▲HOME

Using Technologies to Model Student Problem Spaces

David Jonassen
School of Information Science and Learning Technologies
University of Missouri
221J Townsend Hall
Columbia, Missouri 65211 USA
Tel: +1-573-882-2832
Jonassen@missouri.edu

Problem solving is generally regarded as the most important cognitive activity in everyday and professional contexts. Research on the application of multiple representations in learning makes it clear that the key to problem solving is rich, integrated, multiple representations of the problem space. Computer-based cognitive tools can be used as formalisms to help learners to represent the problem space of problems they are learning to solve. In this presentation, examples of semantic network, expert system, and systems modeling representations of problems will be contrasted. A research agenda for examining the efficacy of these tools will be presented along with some preliminary prescriptions for problem-specific problem representation tools.

Keywords: **problem solving, multiple representations, problem space, cognitive tools**

1 Introduction

I assume that the primary intellectual purpose of all education should be to teach students to solve problems. If educational institutions agreed, they would have to increase their emphases on learning to solve problems. Why should they? 1) Problem solving is at the heart of practice in professional and everyday settings. Professionals are paid to solve problems, not to complete exams, write prescriptive papers, or complete canned laboratory exercises. 2) Requiring learners to only memorize information for tests is not important, relevant, or transferable to everyday and professional practice. 3) Additionally, memorization for examinations models immature, absolutist epistemic beliefs (beliefs about what knowledge is and how we come to know it), thereby restraining learners' intellectual development. Modeling and reinforcing memorization is intellectually stultifying and restricts mental and brain development [1]. Finally, most contemporary learning environments (constructivist learning environments, problem-based learning, goal-based scenarios, anchored instruction, etc.) and learning theories (situated learning, social cognition, everyday cognition, case-based reasoning, etc.) support different forms of problem solving, even though they have not articulated the nature of the problem-solving processes being supported. Problem solving is at the heart of contemporary research and theory. Although problem solving is tacitly accepted as an essential life skill, too few instructional efforts support learning how to solve problems.

An exception to the absence of problem solving in curricula occurs regularly in science and math courses at public schools and universities. Instructors pose problems in these disciplines all of the time. However, there are at least two limitations of these problem-solving activities. 1) The problems that are solved are almost exclusively well-structured problems that have convergent solutions and known, teachable solution paths. 2) These problems are too often taught as procedures, so they are learned as procedural processes bereft of the conceptual understanding necessary to transfer those procedures to new problems or to similar problems in different contexts or reason beyond the procedures. As a result, students rely on formulaic approaches that do not support transfer of existing skills, let alone the ability to solve complex and ill-structured problems that are regularly faced by practitioners. When students are learning to solve problems, there are a number of reasons for poor problem-solving performance among students:

1) When solving problems, students are typically taught to represent problems in a single way (too often memorization). Representing what learners know in only a single way engages only a single set of cognitive representation skills that use only a single formalism for representing their knowledge. Therefore, students' understanding of what they are studying is necessarily constrained. Understanding for problem solving requires multiple integrated representations of what we know. Mayer and Greeno [2] found that students who were taught to solve probability problems by calculating a formula versus learning about the conceptual meaning of the variables represented and solved the problems very differently. The way that a problem is represented determines how the problem is solved. Students in a physics class at Harvard who were competently solving physics problems that were represented mathematically failed a test of conceptual understanding of the problems and their underlying principles [3]. Students could apply equation-based problem-solving procedures without understanding the physics concepts they were representing mathematically, so they were unable to transfer their skills because of their limited conceptual understanding. The over-emphasis on teaching procedural, quantitative models necessarily limits students' understanding of the problem. They represent the problem mentally as a series of solution steps. More emphasis on learning to qualitatively represent problems is needed. Ploetzner, Fehse, Kneser, and Spada [4] showed that when solving physics problems, qualitative problem representations are necessary prerequisites to learning quantitative representations. When students try to understand a problem in only one way, they do not understand the underlying systems they are working in. Multiple models are needed to represent performance at the skill-, rule-, and knowledge-based levels[5]. In order to solve problems, Rasmussen argues that we need to understand the system in which the problem is embedded at different levels of abstraction, including the physical form, physical functions, generalized functions, abstract functions, and functional purpose. Although these abstraction types are likely to vary with the nature of the problem, the conclusion is clear. Successful problem solving requires different kinds of knowledge represented in different ways. I believe that at least three knowledge types are important: conceptual or systemic knowledge, procedural knowledge, and strategic knowledge. Extensive research is needed to identify the knowledge bases required for different kinds of problem solving.

2) The most commonly encountered problems, especially in schools and universities, are well-structured problems. Typically found at the end of textbook chapters, these well-structured problems require the application of a finite number of concepts, rules, and principles being studied to a constrained problem situation [6]. Ill-structured problems are the kinds of problems that are encountered in everyday practice, so they are typically emergent dilemmas. Because they are not constrained by the content domains being studied in classrooms, their solutions are not predictable or convergent. They may also require the integration of several content domains.

Jonassen [7] has articulated a typology of problems, including logical problems, algorithmic problems, story problems, rule-using problems, decision making, troubleshooting, diagnosis-solution problems, strategic performance, case analysis problems, design problems, and dilemmas. Within each category, problems vary with regard to abstractness and complexity. The specific learning outcome for each of these problem types as well as the criteria for judging the success of problem solutions varies. Well-structured problems focus on correct, efficient solutions, while the ill-structured problems focus more on decision articulation and argumentation. There are many types of problems, most of which are not well understood. However, it is reasonable to assume that different problems engage and require different intellectual skills, which makes it even less likely that any single form of problem representations will work with al problems.

2 Constructing the Problem Space

I believe that the most important cognitive activity in problem solving is constructing the problem space, that is, representing the problem. Why? 1) Research confirms that the quality and modality of problem spaces best distinguishes experts from novices [8]. Novices focus too much on surface features of the problem in their representations, while experts represent problems in terms of their principles and abstractions of processes. This enables them to recognize problem types more efficiently than novices. 2) Different problems require different kinds of problem spaces (emphasizing different components or modalities [7]. 3) Multiple representations scaffold understanding and solution development, but they place a burden on working memory. Based on cognitive load theory, integrating multiple representations places high demands on working memory [9]. While representing problems in multiple ways provides richer representations in memory, learners need to learn how to integrate these representations.

The conclusion from this research is clear: if we want students to become better problem solvers, we must explicitly teach or scaffold problem space construction.

2.1 Using Technologies for Modeling Problem Spaces

Modern technologies afford learners numerous methods for representing what learners know. When learners use technologies to represent what they know, the technologies function as cognitive tools or Mindtools [10]. Cognitive tools are any technologies that amplify the learners' thinking by enabling learners to represent what they know using different representational formalisms. As knowledge representation formalisms, cognitive tools are premised on the idea that humans learn more from constructing and justifying their own models of systems than from studying someone else's. Using cognitive tools to represent their own understanding necessarily engages learners in a variety of critical, creative, and complex thinking, such as evaluating, analyzing, connecting, elaborating, synthesizing, imagining, designing, problem solving, and decision making [7,10]. When using computers as cognitive tools, learners are teaching the computer, just as artificial intelligence researchers do when they build intelligent systems. However cognitive tools represent AI in reverse: rather than having the computer simulate human intelligence, we require the human to simulate the computer's unique intelligence and come to use it as part of their cognitive apparatus [11]. When learners internalize the tool, they begin to think in terms of it, thereby amplifying their cognitive skills.

In this presentation, I will demonstrate three technology-based knowledge representation tools (semantic networking, expert systems, and systems modeling) for modeling different kinds of problems that students are learning to solve. Semantic networking tools enable students to model conceptual knowledge. Expert systems enable students to model their procedural knowledge. Systems modeling tools enable students to model their dynamic and strategic knowledge. Externalizing learners' problem spaces using these technology tools will enable learners to articulate and collaborate on the construction of richer, multi-faceted problem spaces that are necessary for solving more complex and ill-structured problems.

2.1.1 Semantic Networks for Modeling Conceptual Knowledge

Semantic networks, also known as concept maps, are spatial representations of concepts and their interrelationships that are intended to represent the knowledge structures that humans store in their minds [12]. These knowledge structures are also known as cognitive structures, conceptual knowledge, structural knowledge, and systemic knowledge. Semantic networks are graphs consisting of nodes representing concepts and labeled lines representing relationships among them. Most semantic networking programs also provide the capability of adding text and graphical representations to each node.

Semantic networking is the process of constructing those maps — of identifying important concepts, arranging those concepts spatially, identifying relationships between those concepts, and labeling the nature of the semantic relationship between those concept. These maps are used by learners to represent what they are learning as multidimensional networks of concepts. Meaningful learning requires that learners connect new ideas to knowledge that they have already constructed. Semantic networks help in organizing learners' knowledge by integrating information into a progressively more complex conceptual framework. That is, they scaffold semantic organization processes in learners. When learners construct concept maps for representing their understanding in a domain, they reconceptualize the content domain by constantly using new propositions to elaborate and refine the concepts that they already know. More importantly, concept maps help in increasing the total quantity of formal content knowledge because it facilitates learners to use the skill of searching for patterns and relationship. That is important because well-organized and integrated domain knowledge is essential for problem solving.

Semantic networking tools assist learners in representing the underlying conceptual knowledge in a problem space. In order to use a semantic networking program to support problem solving, learners must identify the factors and variables, and concepts in a problem and use a semantic networking program to construct a conceptual representations of the problem. Examples of these will be demonstrated in the presentation.

2.1.2 Expert Systems for Representing Procedural Knowledge

Expert systems are artificial intelligence programs designed to simulate expert reasoning in order to facilitate decision making for all sorts of problems. Like a human expert, an expert system (computer program) is approached by an individual (novice) with a problem. The system queries the individual about the current status of the problem, searches its knowledge base (which contains previously stored expert

knowledge) for pertinent facts and rules, processes the information, arrives at a decision, and reports the solution to the user.

Building expert systems is a knowledge modeling process that enables experts and knowledge engineers to construct conceptual models [13]). This process focuses primarily on the explication of procedural knowledge that an expert (or at least a knowledgeable person) possesses. The expert system is the primary formalism for depicting procedural knowledge. But, expert systems do not necessarily have to be built be experts and knowledge engineers. In fact, using expert system shell programs, novices can easily learn to build expert systems to reflect their own procedural knowledge as it grows. Building expert systems requires learners to synthesize knowledge by making explicit their own reasoning, thereby improving retention, transfer, and problem-solving ability. Lippert [14] found that the analysis of subject matter that is required to develop expert systems is so deep and so incisive that learners develop a greater domain comprehension which is essential for problem solving. Building expert system rule bases engages learners in analytical reasoning, elaboration strategies such as synthesis, and metacognitive strategies. Having students construct small knowledge bases is a valuable method for supporting problem solving because of their emphasis on causal reasoning.

Expert systems assist learners in representing the underlying procedural knowledge in a problem space. In order to use an expert system program to support problem solving, learners must identify the decision factors and values of those factors that will predict a solution to the problem encode those values in a set of IF-THEN rules that represent the decision-making. Examples of these will be demonstrated in the presentation.

2.1.3 System Models for Representing Strategic Knowledge

Building models of real-world systems (representations that are abstracted from the details of a situation but grounded in the particulars of phenomena) is the basis of strategic scientific thinking. Building models and simulations requires diverse mental activities such as planning, data collecting, collaborating and accessing information, data visualizing, modeling, and reporting [15]. A systems model is a conceptual, conjectural representation of the dynamic relations among factors in a system, resulting in a simulation that imitates the conditions and actions of it. These dynamic simulation models represent the changing nature of system phenomena. Systems modeling tools use a simple set of building block icons (stocks, flows, converters, and connectors) to construct a map of any dynamic process. These tools enable learners to run and test the model that they have created and observe the output in graphs, tables, or animations. Constructing systems models supports the construction of strategic understanding of a problem system.

Systems modeling assists learners in representing the dynamic relationships among factors in any problem space. In order to use a systems modeling tools to support problem solving, learners must identify the all of the dynamic factors and values of those factors that will predict a solution to the problem and encode those values in stocks and flows that represent the way that the system works. Systems modeling is perhaps the most intellectually engaging activity that students can ever perform. Examples of these will be demonstrated in the presentation.

3 Research Questions

The effects of using cognitive technologies to support the problem representation process are not known. Extensive research is needed, and the topic justifies that effort. We must help to develop a new generation of problem solvers. That research will be guided by research questions such as these:

- Are there classes of problems that share similar problem representations structurally and conceptually?
- If so, will those classes of problems be represented equally well by the different tools?
- How domain-specific are those problems? That is, how similar or different are cognitive requirements among classes of problems in different domains (e.g. science, political science, economics, mathematics)?
- Can those cognitive requirements be scaffolded through the use of cognitive learning technologies? That is, can students improve their conceptual/procedural/strategic understanding of domain knowledge as well as problem solving abilities through modeling their understanding of problem within classes?
- Will learners be able to integrate these multiple representations into a coherent understanding of the problem?

- How can we design problem-specific environments that scaffold the development and integration of multiple problem representations in support of problem solving?

References

[1] Healy, J. (1996). *Endangered minds*. New York: Simon Shuster.,

[2] Mayer, R.E., & Greeno, J.G. (1972). Structural differences between learning outcomes produced by different instructional methods. *Journal of Educational Psychology, 63*, 165-173.

[3] Mazur, E. (1997). *Peer instruction*. Upper Saddle River, NJ: Prentice-Hall.

[4] Ploetzner, R., Fehse, E., Kneser, C., & Spada, H. (1999). Learning to relate qualitative and quantitative problem representations in a model-based setting for collaborative problem solving. *Journal of the Learning Sciences, 8*(2), 177-214.

[5] Rasmussen. J. (1983). Skills, rule, and knowledge: Signals, signs, and symbols, and other distinctions in human performance models. *IEEE Transactions on Systems, Man and Cybernetics. SMC-13* (3), 257-266.

[6] Jonassen, D.H. (1997). Instructional design model for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology: Research and Development 45* (1), 65-95.

[7] Jonassen, D.H. (in press). Toward a meta-theory of problem solving. *Educational Technology: Research and Development*.

[8] Ericson, K.A., & Smith, J. (1991). Prospects of the limits of the empirical study of expertise: An introduction. In K.A. Ericson & J. Smith (Eds.), *Toward a general theory of expertise: Prospects and limits* (pp. 1-38)., New York: Cambridge University Press.

[9]Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*(3), 185-233.

[10] Jonassen, D.H. (2000). Computers as Mindtools in schools: Engaging critical thinking. Columbus, OH: Merrill/Prentice-Hall.

[11] Salomon, G. (1988). AI in reverse: Computer tools that turn cognitive. *Journal of Educational Computing Research, 4*(2), 123-139.

[12] Jonassen, D. H., Beissner, K., & Yacci, M. A. (1993). *Structural knowledge: Techniques for representing, conveying, and acquiring structural knowledge*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[13] Adams-Webber, J. (1995). Constructivist psychology and knowledge elicitation. *Journal of Constructivist Psychology, 8* (3), 237-249.

[14] Lippert, R. (1987). Teaching problem solving in mathematics and science with expert systems. *School Science and Mathematics, 87*, 407-413.

[15] Spitulnik, J., Studer, S, Finkel., Gustafson, E., Laczko, J., & Soloway, E. (1995). The RiverMUD design rationale: Scaffolding for scientific inquiry through modeling, discourse, and decision making in community based issues. In T. Koschman (Ed.), *Proceedings of Computer Support for Collaborative Learning*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Millennium eLearning: The Next Killer Application

Implications for Educators and Information Professionals

Ching-chih Chen
Graduate School of Library and Information Science
Simmons College
Boston, MA 02115, USA

The rapid technological change in the last decade and the fast proliferation in the use of the Internet and World Wide Web have indeed transformed the way we live, work, communicate and learn. With the shifting market and social conditions, our education systems are challenged with providing increased quality educational opportunities to more people who have not been reachable by traditional educational means. To answer this challenge, technology-based distance education has been introduced. On the other hands, with the introduction of the Next Generation Internet, together with powerful web-based systems and authoring tools, many, including commercial entities, have considered eLearning the next killer application. The playing field of higher education has become more and more crowded and muddy. While potentials for this development are obvious, so are many problems and issues. This speaker intends to describe the millennium eLearning development, particularly in the US, and discuss some of the complex problems and issues facing us. Implications for educators and information professionals will be explored in the hope to stimulate more creative use of technology among these professionals in meeting the needs of the learning societies in this new Millennium.

I am delighted to take part at this exciting conference as we gathered together from all over the world to share our views on the creativity, caring, and commitments of the learning societies in this new millennium. We face great challenges at a time with unparallel opportunities and potentials. Never before in our history, there is a more pervasive change-agent on our campuses than information technology, which has transformed the way we learn.

As was introduced earlier, since February 1997, I have been privileged to serve as a member of President Clinton' s Presidential Information Technology Advisory Committee (PITAC). I would like to share with you some of the Committee' s deliberations. In the PITAC Report to President Clinton in February 1999, entitled *Information Technology Research: Investing in Our Future*, the Committee identified 10 vital areas that information technology will transfer. These include:

- Transforming the way we communicate,
- Transforming we deal with information,
- Transforming the way we learn,
- Transforming the practice of health care,
- Transforming the nature of commerce,
- Transforming the nature of work,
- Transforming how we design and build things,
- Transforming how we conduct research,
- Transforming our understanding of the environment, and
- Transforming government.

As to the transformation of the way we learn, a vision of learning transformed by information technology was articulated:

> *"Any individual can participate in on-line education programs regardless of geographic location, age, physical limitation, or personal schedule. Everyone can access repositories of educational materials,*

easily recalling past lessons, updating skills, or selecting from among different teaching methods in order to discover the most effective ways of learning. Educational programs can be customized to each individual's needs, so that the information revolution reaches everyone and personal digital libraries provide a mechanism for managing ones accumulated knowledge resources. Learning involves all our senses, to help focus each student's attention and better communicate educational material." (p.13)

This vision will drive progress in the 21st century. Yet, to realize this vision, there are many technical challenges and benefit. As stated in the same report:

"In addition to research to meet the scalability and reliability requirements for information infrastructure, improvements are needed in the software technologies to enable development of educational materials quickly and easily and to support their modification and maintenance. We know too little about the best ways to use computing and communications technology for effective teaching and learning, in particular, how to effectively use multimedia capabilities to create a richer, and more appealing learning experience. We need to better understand what aspects of learning can be effectively facilitated by technology and which aspects require traditional classroom interactions with the accompanying social and interactive contexts. We also need to determine the best ways to teach our citizens the powers and limitations of the new technologies and how to use these technologies effectively in their personal and professional lives." (p. 14)

The Report calls for the strengthening of use of information technology in education. Realizing that there are challenges and issues, a PITAC/Learning Panel was created to address these challenges, and draft more substantive recommendations, which are forthcoming at the later part of this year. However, some of the findings that will be used to support the Panel's recommendations were reported at the PITAC Public Meeting of September 20, 2000. They include:

- Information Technology, used within classroom settings with well-educated and motivated teachers, has the potential for providing many of the benefits of one-on-one tutoring.
- Information Technology that has been successfully applied in industrial and military training contexts has been effective and reduced costs.
- Current Web-based technologies are beginning to be applied in a grass-roots way in many educational and training contexts, but teacher training, absence of adequate educational performance metrics, the expense of developing materials, and lack of standard, application-level infrastructures are key barriers to more rapid diffusion of existing beneficial technologies and materials.
- The role of the teacher is changing and will continue to change.
- The most exciting and potentially beneficial E&T applications of IT require research that has yet to be done.
- The breadth and scale of the required research effort and the necessity for technology diffusion imply that partnerships of governments, industry, universities, and schools are essential.
- As a basis for future progress, current levels of computer access are inadequate. Computers and high-speed Internet connections are needed in every classroom, preferably for every student, and accessible from outside the school, preferably from every home or at least in readily accessible community centers that can provide access and appropriate training.

I am delighted to see that some of the similar issues and challenges are being addressed at this very meeting as well. While discussions and debates are ongoing everywhere on these learning related issues and challenges in the world, we are witnessing an explosive phenomenon with eLearning activities surging ahead in a speed unmatched in any other activities before. This development should have great implications for educators and deserve our close attention. This is why I have taken this opportunity to discuss the millennium eLearning, the next killer application.

1 INFORMATION TECHNOLOGY, INTERNET, NEW ECONOMY, AND EDUCATION

"The next big killer application for the Internet is going to be education."

John Chambers, CEO, Cisco Systems

While we, educators, are addressing the challenges facing us in this new information technology era, one thing is certain – with the dramatic technological development, and the wide spread use of Internet and World Wide Web in the most recent years, the new economy has moved at apace never seen before. According to Michael T. Moe, Director of the Global Growth Stock Research of Merrill Lynch, "the new economy is a knowledge economy based on brainpower, ideas and entrepreneurism. **Technology is the driver of the new economy, and human capital is its fuel.** The knowledge economy is people-centric. Or economy has evolved from manufacturing-intensive to labor-extensive. Fundamental to success in the new economy is how companies obtain, train and retain knowledge workers. The knowledge enterprise industry is over $2.2 trillion. We expect the online component to grow from $9.4 billion to 53.3 billion by 2003, a 54% CAGR" (Moe and Blodget, 2000). The evolutionary phases of e-Business shown in Figure 1 shows the predicted dramatic growth of e-Knowledge industry.

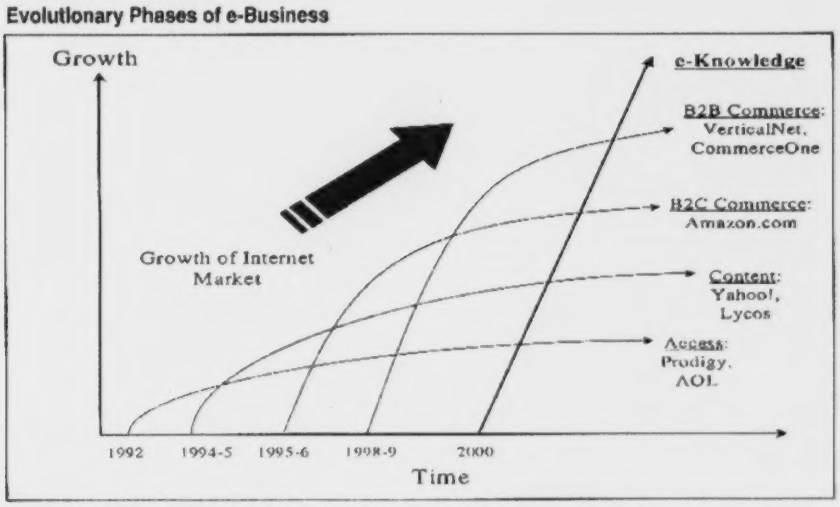


Figure 1. Evolutionary Phases of e-Business showing the sharp growth of e-Knowledge

In concert with the vision articulated in the PITAC report, Moe and Blodget state, "ubiquitous PCs and high-speed bandwidth will facilitate access to knowledge anytime, anywhere. The Internet democratizes knowledge, increasing access to it, lowering its cost and ultimately improving its quality. We believe combining the "richness" of an offline experience and "reach" that only the Internet provides creates a network effect that allows scale knowledge enterprises to be born. Moreover, we see significant potential advantages that offline operators can achieve by leveraging their experience and brand online."

Some Useful Statistics and Statements

From its modest beginning in the '60s and '70s, the Internet has quickly become the largest global communications network. The number of web sites via the Internet has increased from a mere 130 in 1993 to well over 17 million in 2000, according to the latest figure cited in the September 25, 2000 issue of *Infoworld* (Coopee, 2000). The Internet traffic is expected to top 15 million terabytes per month by 2003. This explosive growth can be translated from business point of view to huge potential for profits. Therefore, it is no surprise that to see the potentials for learning as described by Moe and Blodget in the following:

- Domestic online corporate learning is expect to grow from $1.1 billion in 1999 to $11.4 billion in 2003 (a 79% CAGR);
- At the end of 1999, more than 196 million people were using the Internet worldwide. The number of global Internet users is expected to more than triple to 638 million by 2004, a 27% CAGR;

BEST COPY AVAILABLE

- The e-knowledge market will reach $53.3 billion by 2003 from $9.4 billion in 1999, growing at a CAGR of 54%;
- These technology-intensive industries are growing 3-6 times as fast as economy-wide job growth;
- Colleges and universities are the most wired community on the Web, with over 90% of college students accessing the Internet, 52% of them daily. Students spend nearly 19 hours per week on the Internet, 84% of the time pursuing academic activities. College students currently spend $105 billion annually, with $1.5 billion of that online;
- Currently there are 84 million students enrolled in higher education worldwide. Global demand for higher education is forecasted to reach 160 million by 2025 – if online learning captures even half of this growth, there would be 40 million students for online education...The online higher education market will grow to $7 billion by 2003 in the US alone.
- The number of K-12 schools connected to the Internet has climbed from 35% in 1994 to 96% today... Today is the Generation "i" with 53 million schoolchildren, three million teachers and 23 million families, the K-12 marketplace encompasses a huge number of potential users. The Internet is the world's greatest library..that gives the same access to knowledge everywhere...

2 THE HIGHER EDUCATION

In discussing the impact of information technology on education, we should really cover all levels of education from K-12 to the highest level of research in our academic institutions. Yet, time does not permit me to do so here. I shall concentrate some of the following discussions on the higher education.

Again, Figure 2, taken from Moe and Blodget, provides an excellent overview of the enormous higher education market both in the US and the world, with 15-million students and 1-million faculty in the US, and 84-million students and 2.8-million faculty abroad, not mentioning the large number of alumni and other population who will need continuing education activities.

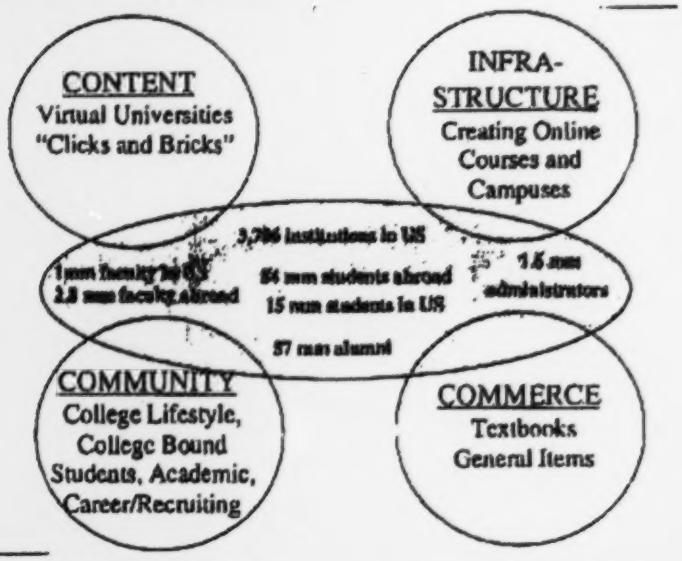


Figure 2. The higher education market (Source: Merrill Lynch Global Growth Group)

This speaks for the potentials for eLearning from each of the four components – Infrastructure, Content, Community, and Commerce.

Infrastructure

With the ever-increasing speed and high-bandwidth global network, and the coming of the Next Generation

BEST COPY AVAILABLE

Internet, it is fair to say that the truly revolutionary impact of the Internet is just beginning to be felt. As technology reshapes the world, more than ever; institutions of higher learning has begun to take advantage of the technological advances that can provide more efficient ways of teaching and learning for their students, and can offer them exciting new opportunities as well.

Wireless Technology

In addition, wireless technology will begin to be utilized in big ways. Wireless business has grown so fast, and it is expected that it will grow from 1.2 billion in 2000 to about 4.6 billion in 2004. Currently, students at the School of Public Health of the Johns Hopkins University, for example, can literally access anything from their laptop via wireless network. In Pennsylvania, Widener University with the help of 3Com is making its library resources available to students totally via wireless network. Many other universities, like Cornell University and Carnegie Mellon University are also heading toward this direction. Commercially, online learning activities also test wireless waters in big ways, as reported in Informationweek.com*(July 24, 2000). For example, MindSurf, invested by $60 millions from Sylvan and Aether, will deliver pilot programs to schools nationwide beginning this school year. The goal of these programs is to encourage students and faculty to collaborate in real time using wireless devices, even when learning takes place outside the classroom, such as in a museum.*

Distance Learning and Virtual Universities

The technology and infrastructure are also in place to provide multimedia-intensive contents to people in rural, and isolated areas. For example, overcoming distance in rural education in East Texas that is full of isolated towns hundreds of miles apart, fibre-optics system is installed to provide distance-learning capabilities for students, teachers, and community members there. Thus, in the new economy, "distance" has been eliminated. In addition to "distance", learning opportunities are also wide open now for those working people who cannot afford to have the conventional higher education, or those who are homebound. So, the Internet has truly "democratize" education, increasing universal access to learning on-demand opportunities, and reducing its cost. As a result, "distance learning" becomes hot buzzword, and also great moneymaking enterprise.

"According to the US National Center for Educational Statistics, the number of institutions offering distance learning course has risen rapidly, from 33% of all colleges in 1995 to 58% of two-year and 62% of four-year public colleges today, with another 28% of two-year and 23% of four-year public colleges planning to start offering courses within the next three years. When translating these percentages to real students, according to estimates from International Data Corporation, 710,000 college students were enrolled in distance learning courses in 1998; the number is expected to soar to 2.2 million by 2002" (Computer-based learning, January 7, 2000). Thus, there is an explosive increase of distance learning courses offered via the Internet by all types of academic institutions. In addition, there is a proliferation of a different breed of universities, such as the Western Governors University (WGU), which claims to be "the university that comes to you" (www.wgu.edu). WGU is a degree-granting, competency-based, online, distance-education institution. 19 states and governors as well as 20 leading corporations and foundations support WGU. Its online catalog has nearly 1,000 distance delivered courses from 50 different education providers including colleges and universities, corporate providers, and independent learning resources. It established agreements with Bellevue University, Empire State College, Jones International University, Masters Institute, and Thomas Edison State College. Every W GU student is assigned a mentor – a WGU faculty member who is an expert in the student's field of study. The mentor provides one-on-one advising to help student determine what they need to learn, and where to go to get it.

From another angle, online learning has found an enormously promising corporate market. We have seen that big monies are investing in this activity. It ranges from much smaller venture like the International Center for Distance Learning, Inc. in Boston (www.ICDLcourses.com) that offers degree and certificate programs, as well as business training and others; to big venture capital enterprises, like UNext.com. UNext.com, reaching over 100,000 learners now, is hoping to grow quickly to over 1 million learners. It is partner with top-ranked universities such as Stanford University, Columbia University, University of Chicago, Carnegie Mellon and the London School of Economics to create an elite online academic institution, Cardean University, specifically designed to serve the needs of Fortune 500 companies, as well as individuals abroad. The company's investment in the creation of each course is very substantial, in the order of over $1 million per course. This is clearly something that cannot be matched by academic institutions. Yet, numerous "born on the web" universities are also tapping into the corporate market. For

example, some of the prominent ones include:

> The National Technologic University consists of 50 of the top engineering schools in the US including the Massachusetts Institute of Technology and University of California, Berkeley. It is to provide the best of the best courses through both the Internet and/or satellite; and
>
> The Calibre Learning Network consisting The Wharton School, Georgetown University, University of Southern California Marshall School of Business, Teachers College of Columbia University, and Johns Hopkins University School of Medicine, is to provide best quality distance courses for their corporate clients.

So, these alliances have moved the academic content beyond the institutions' classrooms into the business world.

On the global scene, similar explosive activities can be felt. For sometime we are aware of the partnership between MIT and the two major universities in Singapore – National University of Singapore and Nangyang Technological University.

In February 2000, the British government announced a distance-learning project for higher education that officials said was designed to give U.K. higher education the capacity to compete globally with the major virtual and corporate universities in the United States and elsewhere, as reported in the March 3, 2000 issue of *The Chronicle of Higher Education*, p. A41. "The venture, whose working title is e-University, will be jointly established, owned, and operated by a consortium of higher-education institutions working with the private sector and overseas partners...A prime impetus behind the e-University project is an effort to expand Britain's share of the overseas higher-education market, as well as to fulfill the government's goal of providing lifelong learning by increasing professional-development and vocational courses."

In that same issue of *The Chronicle of Higher Education*, it was reported "The World Bank's Global Distance Learning Network is scheduled to begin operating this summer, with courses initially delivered to 10 nations. The network will use the Internet, videoconferencing, and satellite links to connect "learning centers" at participating institutions." Under an agreement, the National University for Distance Education (UNED), in Madrid, will provide courses for delivery in Latin American countries, including Bolivia and the Dominican Republic. The UNED (http://www.uned.es) is among the first in developed countries to agree to provide content for the project. "This is a landmark step forward in enabling developed and developing countries to become partners in sharing and using knowledge and learning as an effective development tool," said the bank's president, James D. Wolfensohn.

Content Development and Online Courses

While online courses and campuses are springing up everywhere – both offered by traditional higher education institutions and commercially, one key concern and highly debatable question got to be related to the "**quality**" of these courses. There will continue to be the most challenging considerations for all of us for a long time to come. In addition, there are instructional design and development issues for web courses and web-enabled courses. These include:

- Types and levels of web courses,
- Strategies for student interaction and learning
- Selecting web templates, and
- Course management

Tools

Currently, many tools are available for course development, online course delivery, and teaching and learning with Web and distance learning technologies. Let me just name a few in the following:

Blackboard [www.blackboard.com] – Claimed to have been used by over 1000 institutions in every state of the US and in more than 60 countries.

eCompanion [www.eCollege.com] – Designed for faculty who teach in a classroom, but want to put the power of the Internet to full use. It has all the features of eToolKit, plus it allows you to make lectures available, conduct online practice tests, guide students to Internet resources, share documents and continue

class discussion outside the classroom.

eCourse 4.0 [www.eCollege.com] – an easy to use set of tools for managing and delivering online courses over the Internet. It includes course management, outlining assignments, delivering lectures, testing, grading and interacting with students.

e-education [www.jonesknowledge.com] -- online software from JonesKnowledge.com for both administration and faculty.

WebCT [www.webct.com] – Used by a number of universities in development their web-based courses. For example, Marshall University, an institution of 16,000 students, has 400+ courses and 6000+ students enrolled in classes that use WebCT for delivery of instructional material.

Education professionals can gain valuable knowledge about using Web-based or Web-supported teaching and for supporting distributed learning and/or distance learning programs since there are sufficient reporting in both literature and conferences. We are having some reporting at this meeting as well on this topic.

3 IMPLICATIONS FOR EDUCATORS

It is clear that in this millennium, as the personal computers and laptops become more and more affordable, and access to the Internet becomes common place, the computer-based learning delivery systems will predominate on the new distance learning frontier. As stated by Andy DiPaolo, Director of the Stanford Center for Professional Development, there is "a seismic shift from the campus-concentric to student-concentric" learning in a culture that has been moved from place-based to information-based. He also stated "In the industrial age, we went to school. In the communication age, the school comes to us" (Computer-based learning, January 7, 2000).

In this environment, the educators need to realize that there are many parties fighting for the "learning" turf. With many high-capital commercial .coms as key players, this has not been an easy time for many traditional educational institutions, particularly when the enrollment of some of these institutions are shrinking. News media reports frequently teachers' and educators' attempts to block the accreditation of online colleges, particularly those proposed by a commercial venture, such as the recent case with Harcourt Higher Education and the accreditation of its online college by the Massachusetts Board of Higher Education (Soule, September 3, 2000). Main reasons for objection tend to center around the doubt on these the online colleges' ability to provide quality education and to meet the same educational standards. Yet, supporters for virtual universities argue that they can indeed meet high standards. In fact, in a recent survey from Michigan State University on the educational success rate of exam performance of 200 undergraduates taking a macroeconomics introductory class, students taking online courses were found to score higher on exams than their classroom-bound counterparts.

Thus, attempting to block the online learning offerings at this time will likely be a futile exercise. Like it or not, we need to realize that distance learning technologies – primarily the Internet – have changed the way education will be consumed in the future. Like a tidal wave, online learning offerings will be introduced in different formats from different public and private, educational and commercial entities in great speed and quantity, and are not stoppable.

Instead, we educators should make more effort to explore computational media, to determine what technological base can best serve education, and to find the most flexible systems to create web-based courses so to empower our teachers and students (Disessa, 2000).

4 IMPLICATIONS FOR INFORMATION PROFESSIONALS

Finally, I would like to close my talk on the implications of eLearning for information professionals. On September 20, 2000, on my trip back from Washington DC, I notice an interesting statistical chart on digital book sales on the first page of the *USA Today* of that day, as show in Figure 3.

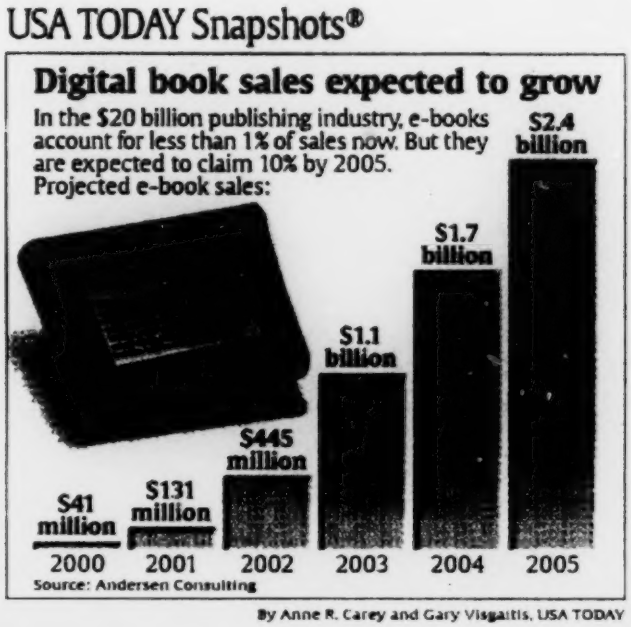


Figure 3. Digital Book Sales over from 2000 to 2005 (from USA Today, September 20, 2000, p.1.)

As online distance learning offers the possibility of overcoming both pedagogical and physical limits of traditional education, we need to realize that quality online education needs to be supported with needed information resources which must be "digital." Although many people consider the Web as a huge "digital library," yet, the quality of information retrievable from the Web is often questionable. I believe that everyone will agree that no quality education – online or traditionally class-bound – can be achieved without the support of information resources available from information rich places like libraries. Yet, most libraries in academic and other institutions are current not digital. While digital libraries are beginning to be created, most of our students and faculty in academic institutions are still obtaining their needed information resources from the hard-copy books, journals, and reports. While some small-scale digital libraries are available, they are mostly limited distributed systems that often cannot be interoperable, and have limited interactive and retrieval capabilities. We face many challenges in this area.

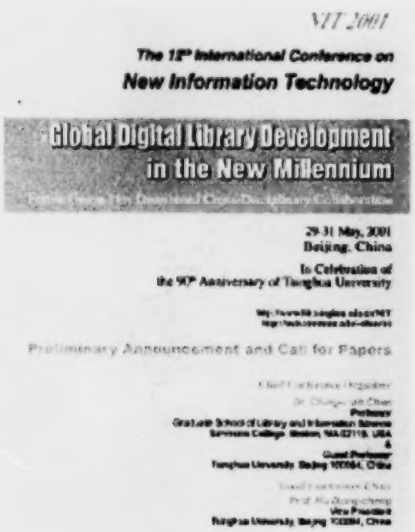


Figure 3 shows that currently in the $20 billion publishing industry, e-books account for lesst than 1% of the sales now. But they are expected to claim 10% by 2005. This is certainly a positive and needed development, in line with the demand resulted from the growth of eLearning.

Nevertheless, we need to remember that a great majority of our hard-copy information resources currently available from our academic libraries are not available digitally. Efforts need to be made to find ways to link the eLearning to the use of these resources.

In the last decade, I have advocated the need to develop global digital libraries so that quality information resources cannot only be shared globally, and can also be available to us at our fingertips. Currently, my own effort in leading a major International Digital Library Project, called Chinese Memory Net, supported by the US National Science Foundation, is a collaborative

BEST COPY AVAILABLE

R&D project working with researchers in interdisciplinary fields in China, Taiwan and the USA on various problems and issues related to the global digital library development. A major international conference, *NIT 2001*, will be held in Beijing. As shown in the graphics, it is organized by me to address some of the essential problems and issues related to global digital libraries. More information on this can be found at http://web.simmons.edu/~chen/nit.

5 CONCLUSION

Chancellor Robert Berdahl of the University of California, Berkeley has stated, "distance-learning promises to transform the manner in which education -- or, perhaps more accurately, teaching materials – are delivered around the world."

As the world economy is shifting its emphases from manufacturing to service jobs, and human capital is replacing physical capital as primary productive asset to human capital (Moe & Blodget), we can understand why education has emerged to become the second of the four top sectors in the US domestic economy – Health, 14.1% of GDP; Education, 9.5%; Social Security, 5.0%; and Defense, 4.0%. The significance of the education sector is likely to be found in many other developed countries in the world.

eLearning has transformed to be a killer application in this new millennium, and we must prepare ourselves to capitalize this technology environment, and to capture the opportunity to advance both the quality of our educational content delivery and to provide wider access for our citizens and students to better educational opportunities. It is an understatement to say that we are living in a very interesting time. Let's prepare ourselves well to be a proactive mover of this tidal wave.

REFERENCES

[1] "Computer-Based Learning Prepares to Go the Distance," *The Chronicle of Higher Education*, January 7, 2000, p. A50.

[2] Coopee, Todd, "The Internet today," *Infoworld*, September 25, 2000. p. 52.

[3] DiSessa, Andrea A. *Changing Minds: Computers, Learning, and Literacy*. Cambridge, MA: MIT Press, 2000.

[4] *Information Technology Research: Investing in Our Future: President's Information Technology Advisory Committee Report to the President*. Arlington, VA: National Coordination Office of Computing, Information, and Communications, February 1999.

[5] Moe, Michael T. and Henry Blodget. *The Knowledge Web: People Power – Fuel for the New Economy*. New York: Merrill Lynch & Co., May 23, 2000.

[6] "Online learning tests wireless waters: New company explores elearning via wireless devices for students and business," *Informationweek.com*, July 24, 2000, p. 145.

[7] Soule, C. A., "Bringing an online college to the Bay State," *Mass High Tech*, August 28-September 3, 2000. p. 2.

Social and Technological Innovations for a Knowledge Society

Marlene Scardamalia
Ontario Institute for Studies in Education
of the University of Toronto
252 Bloor Street West, Toronto, Ontario, M5S 1V6, Canada
mscardamalia@oise.utoronto.ca

Knowledge building--the creation of knowledge as a social product--is something that scientists, scholars and employees of highly innovative companies do for a living. We have demonstrated that these same activities can be integral to schooling, grades one to post graduate, and extensible to a variety of health care and workplace settings. The central purpose of CSILE (Computer Supported Intentional Learning Environments), and now second-generation Knowledge Forum®--and the Knowledge Society Network that it enables-- is to democratize knowledge. The most radical possibilities arise from restructuring the flow of information within and between organizations so as to allow participants to work continuously at the edges of their competence and to marshal high levels of "collective cognitive responsibility" and "collective intelligence." The ubiquity of such human capabilities, rather than ubiquitous computing, information access, and content delivery, will define a knowledge society.

Keywords: **innovation dynamic, knowledge creation, knowledge society**

1 Introduction

Twenty-first century knowledge work and technological innovation are inextricably related, as suggested by the global economy, the ever increasing demands for knowledge management resulting from the digitization of the world's knowledge resources, and the increasingly familiar *e-* prefix to signal electronic conversion of myriad forms of communication and commerce. Information-age societies will be founded on new knowledge media and on the redefinition of social and cultural practices afforded by them. While there is general agreement that the much heralded 'knowledge society' will have profound effects on our health, educational, cultural, and financial institutions, there is little analysis of the inner workings of such a society: Do we actually know how to promote the skills and the processes that would make a knowledge society work? Is it even legitimate to speak of a knowledge society if the majority of citizens do not belong to it?

The transformation from an industrial society with a manufacturing economy, to that of a knowledge society with a knowledge economy, represents a transformation comparable in significance to major transformations from prehistoric and historic times. Since the beginning of civilization technology and social innovations have been intertwined. These transformations are occurring at an ever quickening pace, and each involves technology breakthroughs and new social forms that are in reciprocal relation to one another. A very rough chronology, as presented by Keating & Mustard (1993) [1], is presented in Table 1.

Date	Technology Innovation	Social Innovation	Overall Result
40,000 B.C.	advanced stone technology	intertribal communication	recognizable civilizations with characteristic crafts and symbolic art
10,000 B.C.	the agricultural revolution	massing of populations in fertile regions	state structures and cumulative knowledge growth

1700 A.D.	machine technology	complex organizations of labor and capital	global trade and communication; specialization of knowledge production
2000 A.D.	advanced information technology	knowledge-based societies and economies	???

Table 1: Major transformations attributable to an innovation dynamic involving technological and social innovations

There is nothing new in the dynamic that binds technological and social innovation together. What is new is the purposefulness with which this dynamic is harnessed to specific achievements. In earlier times, major transformations occurred without plan. The industrialization of Europe and North America during the 19th century came about through the cumulative effect of countless individual initiatives with no overall plan. But in the 20th century we saw many nations embarking on plans for deliberate industrialization. Now we see nations the world over, developing policies to ensure a place for themselves in the global knowledge economy. The result of the 2000 A.D transformation is, of course, yet to be determined, and it may be different in different societies. According to one scenario, technological advances will democratize knowledge. According to another scenario, there will be a widening split between educationally advantaged and disadvantaged groups, leading to the rapid decline of nations and groups that are unable to keep up with the increasing demand for knowledge and skills.

2 Capturing the knowledge-creation dynamic

An innovation dynamic favorable to the creation of a knowledge society is enabled by social and technological systems working in reciprocal relation, each biasing knowledge work toward increasingly high-level processes. Democratization of knowledge additionally requires systems that *enable rather than presume advanced knowledge processes*. We refer to the social and technological systems that enable advanced knowledge processes as knowledge building systems because they engage all community members in the core knowledge creation dynamic: ideas and achievements are continually contributed to the community, and their usefulness is magnified through availability and continual refinement in a community context.

The last row of Table 1 is reproduced as Table 2, reframed to indicate knowledge building innovations hypothesized to lead to the democratization of knowledge--an optimistic version of the 2000 A.D. transformation.

Date	**Technology Innovation**	**Social Innovation**	**Overall Result**
2000 A.D.	Knowledge Building Technology	Collaborative knowledge-building communities, embedded in a Knowledge Society Network	The democratization of knowledge

Table 2: The knowledge building innovation dynamic

2.1 Core facets of knowledge creation

The knowledge-building innovation dynamic is elaborated in Table 3. It begins with a brief account of four facets of knowledge creation, which take into account frequently cited characteristics of twenty-first century knowledge work, including teamwork and knowledge sharing [2] [3] [4].

In this paper terms are used that signify the ways in which these aspects of knowledge work must be extended beyond their common meaning if the result is to be knowledge creation. Thus, for example, we use the term community knowledge. Teamwork is involved, but the production of community knowledge additionally requires that all members add value to shared ideas; otherwise, teamwork settles into joint productions that do not extend the team's knowledge. Team members enjoy information access, but access does not lead to knowledge creation. The four facets of knowledge creation presented in Table 3 are:

2.1.1 Community Knowledge

Expert knowledge-based societies are believed to gain advantage through collective contributions--what we might think of as knowledge-in-the-aggregate as opposed to the talents or contributions to knowledge of individual outliers. A growing literature suggests that the pursuit of excellence in a knowledge society will depend increasingly on what have been termed "21st Century skills" and the teamwork they imply. "In the knowledge society it is not the individual who performs. The individual is a cost center rather than a performance center. It is the organization that performs." [5]. There will be a premium on abilities over and above those that marked genius in previous centuries. Emphasis on individual excellence may even prove counter-productive to societal excellence.

2.1.2 Rise Above

It is easier to deal with the concrete, immediate, and simple than to cope with complexity, diversity, and messiness. Yet these later qualities typify most innovative environments and work at the cutting edge of a discipline. In knowledge building communities rise-above is built into the social fabric of the organization and into the technologies that support it. Its members establish shared goals that stretch their collective abilities. They move to increasingly high levels for resolving conflicts and for solving problems, thus they learn to accommodate emergent goals rather than working with goals that are fixed from the beginning. They learn to do the exceptional routinely.

2.1.3 Improvable Ideas

The history of scientific achievements teaches a lesson: ideas are improvable. Aristotle's physics was superseded by Newton's; Newtonian physics gave way to Einstein's relativity theory; relativity was further advanced by Planck's quantum theory. We still think of Aristotle, Newton, and Einstein as geniuses, but people who hold physical beliefs similar to Aristotle's are considered to hold misconceptions while contemporary physicists pursue theories that continue to advance improved versions of last year's theories. Creating knowledge new to the world, improving on existing knowledge, and grasping and applying what others say are all similarly intensive knowledge processes. Those who are able to continually build more complete knowledge are engaged in the same processes through which expert knowledge is achieved in the first place.

2.1.4 Symmetric knowledge advancement

This is a variant of what is popularly known as creating win-win situations, applied to knowledge work. Knowledge building is served when one group's knowledge serves as foundation for work elsewhere. Many institutions represent the antithesis of a model of 'symmetric knowledge advance.' Activities typically are organized so that participants do the same thing and do not learn from one another. For example, in educational contexts the teacher's knowledge does not advance appreciably in the course of instruction; outputs have no value outside the organization, except in rare cases where reports have value to others; and organizations--especially schools--form a distinct and separate community, minimally affected by knowledge advances in other sectors of society. The situations we wish to explore, in contrast, maximize knowledge resources through creating more synergistic relations both within and between communities engaged in knowledge work.

Nonaka and Takeuchi [6] present five phases of a knowledge-creation process: (a) sharing tacit knowledge, (b) creating concepts, (c) justifying concepts, (d) building an archetype, (e) and cross-leveling knowledge. The goal in listing facets of knowledge creation, as presented above, is not to identify steps in a linear process, nor an exhaustive classification, but rather to illustrate the correspondences between essential processes and technological and social supports that enable them. A row-by-row review of Table 3 highlights these correspondences, and planfulness in aligning them with technological and social innovations fine-tuned to their production. The implication is not that there is a one-to-one correspondence between these processes and these innovations. Rather, there is productive redundancy, with many routes, and no set pathways to the complex of socio-cognitive processes supported by knowledge building technologies.

Core Facets of Knowledge Creation	Technology Innovation: Knowledge Forum® *Bolded items refer to processes specifically supported by Knowledge Forum software*	Socio-Cognitive Innovation: Collaborative Knowledge Building Knowledge Society Network
Community Knowledge Contribute to collective knowledge advancement and shared goals; contribute ideas to communal design spaces; serve as a valuable team member; cultivate openness in knowledge work	Individuals and teams **contribute** ideas in the form of **notes** and **views** to **collaborative** and **public design spaces**; ideas are shared and refined as collaborators **read, build-on, reference, search, summarize,** add **keywords, collect** and **annotate** knowledge artifacts contributed by participants. Openness in knowledge work is supported through **links** to views of different team members and to the production of higher-order **conceptual frameworks**	Knowledge jointly constructed; priority given to the production of ideas of value to others, not simply to demonstrations of personal achievement
Rise Above Move to increasingly higher levels to resolve conflicts and to solve problems; transcend expectations; accommodate complexity, diversity, and messiness; translate ideas into action and new contexts; engage in progressive problem solving and self assessment	**Rise-above notes** and **views-of-views** support increasingly high-level formulations of problems and ideas, as well as **coherence** and **synthesis** of ideas; the rise-above-it principle is reflected in **publication-and-review, in a multimedia journal,** in individual and group **portfolios** and in **multiple representations** of ideas, viewed from **different perspectives;** customizable **scaffolds** for high-level knowledge processes support **theory refinement**, evaluation of **evidence** and **counterarguments, constructive criticism, experimentation,** and a host of high-level knowledge processes.	Community members view conflicts and problems from high-levels; they engage in theory refinement and explanatory coherence: Do our ideas fit together? Where are the gaps in understanding? What new information has been found that we must take into account? What is missing from our current conceptualization?
Improvable Ideas Cultivate promising and improvable ideas; sustain inquiry at the edges of understanding; move beyond current best practices; work with emergent goals; approach problems as opportunities	Idea improvement is supported through **peer review**, **coauthored** notes and views, **links** to **views** of different team members, higher-order **conceptual frameworks**, **reorganization** and **revision**, and integration of **new information; process models** and **knowledge-building discourse** are supported through **animation** and **video notes** **Analytic tools** work in the background and record processes automatically--**research** and **reflection** become integral to the workings of the organization; participants serve as ethnograpers of knowledge building.	Communities living at the edge of their collective understanding, sustained by a culture that prizes reflection, critical analysis, emergent goal states, and high-level integrations that do justice to the ideas of all contributors

Symmetric knowledge advancement Progressive refinement of ideas within and between communities; work at the cutting edge of inquiry; situate and refine ideas in the context of broadly distributed communities	Interleaved **local-and wide-area networks** support the work of **local and globally configured communities**; **replication**, **merger** of workspaces, and a system of **virtual visitations**, support **knowledge building discourse** within and across communities; online-offline **synchronization**, wireless capabilities, and **Palm KF** will soon provide **anytime, anywhere access**	Distributed and opportunistic workgroups treat diversity as strength and enable integration of work across disciplines and communities

Table 3: The knowledge-building innovation dynamic: core facets of knowledge creation, knowledge building technology, and knowledge building social structures

2.2 Knowledge building technology

Column two of Table 3 indicates technology supports to enable the core facets of knowledge creation listed in Column 1. The technology that provides these supports is Knowledge Forum, a second-generation CSILE (Computer-Supported Intentional Learning Environment) product [7] Knowledge Forum is designed to make the underlying, hidden aspects of knowledge creation transparent to its users. There is not space to elaborate here, but we have found that the facets of knowledge creation listed above are in evidence with Grade One students using Knowledge Forum. This finding is suggestive of the goal underlying its design--to provide 'a way in' for everyone, and thus to take the essential first step in democratizing knowledge. These same processes are supported by the same technology and the same social structures in health care, graduate school, business, cultural organizations, and other workplace environments. Thus we have demonstrated that these activities are integral to schooling, grades one to post graduate, and extensible to a variety of health care and workplace settings. This opens the way for a knowledge society.

2.3 Knowledge building social structures

Column 3, Table 3 indicates the social innovations that correspond to Knowledge Forum's technological innovations and, in turn, to the core facets of knowledge creation it is designed to support.

2.3.1 Knowledge building communities.

Knowledge-building communities [8] are not simply collections of people who individually pursue knowledge, even though their individual interests may be diverse. They are a community in the sense that they share their knowledge, support one another in knowledge construction, and thus develop a kind of collective expertise that is distinguishable from that of the individual members. Participants may be co-located or distantly located. The defining characteristic is their commitment to the collective goal of improvable ideas--the essence of knowledge creation. Advancement of knowledge is pursued strategically and with deliberate investment of resources. Participants aim to redefine problems at deeper or more inclusive levels as they proceed rather than to eliminate problems. The result is continual advancement of the community's knowledge and capabilities, similar to the process of expertise in cutting-edge research and development teams [9] [10]. Although knowledge creation depends on chancy processes of discovery and invention, we take it for granted that some communities will make advances with greater regularity than others. That is what we expect of knowledge building communities, as they represent a social organization that invests its resources in the advancement of the group's knowledge, so that the group as a whole is striving for advancement beyond present limits of competence.

Participants within a knowledge building community, supported by Knowledge Forum, share an electronic design space in which important aspects of their intellectual work are recorded in digital form and entered into Knowledge Forum's communal workspaces. Processes of reflection, review, and publication encourage each community to create high-level syntheses of their work. Analytic tools work in the background of these design spaces and record processes automatically so that research becomes integral to the day-to-day workings of the organization, encouraging the community to reflect on their processes and to continually improve them. The design spaces support multimedia--video, animation, audio, graphing--and cross-application inter-operability is on the design agenda. Knowledge building discourse is the dynamic that brings various knowledge operations into the service of knowledge advancement.

2.3.2 The Knowledge Society Network.

Experts seldom exist in isolation. Nor do expert communities. Often they are linked together by associations or informal networks, but even when that is not the case they are connected through a tradition in which expertise evolves over generations. Globally networked knowledge building communities enable the Knowledge Society [11]-- a network of networks, providing a natural extensions of the progressive refinement of problems, knowledge sharing, and group interactions that define work within a community. Knowledge Forum supports this process through integration of knowledge work within and across communities. Select portions of the design spaces of local communities can be opened to cross-community searches. Features such as replication and merger of design spaces allow communities to replicate portions of one design space into another and to create new cross-community discourses. Thus, for example, elementary school biology communities might work with high school biology communities, and they in turn with pre-med students. However, there is no predetermined alignment, and communities may find their cutting edge in unanticipated places. The work of these communities is enriched by virtual visitations, and also made increasingly demanding by the commitment to openness in knowledge building that these visitations entail. Participants agree to allow their design space to serve as an object of inquiry, giving new meaning to work at the cutting edge. By making use of talents within and between communities, knowledge building communities have access to enhanced knowledge resources, and continual effort does not have to be exerted to make the system function, as knowledge building is built into the dynamics by which participants communicate and pursue organizational goals.

3 Conclusion

Knowledge creation must operate at all levels of an organization and across a wide range of organizations if we are to democratize knowledge. In order for this to happen, both technological and social innovations are required that go beyond what is presently regarded as the state of the art. Inquiry into the social and technological innovations required for a knowledge society is in its infancy. The goal of this paper is to contribute to an understanding of the issues and possibilities of a special form of a knowledge society--one that enables rather than presumes advanced knowledge processes; one that is committed to giving away its understanding of these processes.

References

[1] Keating, D.P., & Mustard, J.F., "Social economic factors and human development". In D. Ross (Ed.), Family security in insecure times (Vol. 1, pp. 87-105), Ottawa, ON: National Forum on Family Security, (1993).

[2] "21st Century Skills for 21st Century Jobs: A Report of the U.S. Department of Commerce, U.S. Department of Education, U.S. Department of Labor, National Institute for Literacy, and the Small Business Administration". Presented at the National Summit On 21st Century Skills for 21st Century Jobs. Washington, D.C., (1999).

[3] SCANS Commission, "What Work Requires of Schools: A SCANS Report for America 2000", The Secretary's Commission on Achieving Necessary Skills, Washington, DC: U.S. Department of Labor, (1991).

[4] Amidon, D. M., "Innovation Strategy for the Knowledge Economy: The Ken Awakening", Boston, MA: Butterworth-Heinemann, (1997).

[5] Drucker, P. F., "The age of social transformation", Atlantic Monthly, November, pp. 53-80, (1994).

[6] Nonaka, I., & Takeuchi, H., "The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation", New York, NY: Oxford University Press, (1995).

[7] Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E., "Computer supported

[8] Scardamalia, M., & Bereiter, C., "Schools as knowledge building organizations". In D. Keating & C. Hertzman (Eds.), Today's children, tomorrow's society: The developmental health and wealth of nations (pp. 274-289). New York: Guilford, (1999).

[9] Bereiter, C., & Scardamalia, M., "Surpassing ourselves: An inquiry into the nature and implications of

[10] Choo, C.W. "The knowing organization: How organizations use information to construct meaning, create knowledge and make decisions". New York: Oxford University Press, (1998).

[11] Scardamalia, M., & Bereiter, C., "Engaging Students in a Knowledge Society". In Jossey-Bass Reader on Technology and Learning, pp. 312-319, San Francisco, CA: Jossey-Bass Publishers, (2000).

Computer-Based Strategies for Articulate Reflection (and Reflective Articulation)

John Self, Erol Karakirik, Ah-Lian Kor, Patricia Tedesco and Vania Dimitrova
Computer Based Learning Unit, University of Leeds, Leeds LS2 9JT, England
{jas,erol,lian,patricia,vania}@cbl.leeds.ac.uk

In 1993, the last time ICCE was in Taiwan, theories of situated cognition were promising to change the field of educational computing. What has happened since? It seems that many of the superficial interpretations of situated cognition (that thinking is a physical skill, that knowledge cannot be separated from activity, that learning takes place through participation and not in an individual mind) have been sufficiently refined that they may be considered to accord with current emphases on collaborative learning environments. However, the precept that "'situated' means coordination without deliberation", which, superficially (and, of course, situationists would attempt to clarify that it is much deeper than this), seems to reduce cognition to unreflective practice does not appear to correspond to current system designs. There is now an increased emphasis on learning systems providing an environment not just for practice but also for articulation and reflection. The reasons for this will be discussed and some strategies for promoting articulate reflection will be illustrated with reference to five systems: EUCLID (for geometry problem-solving), BSL (for understanding floating and sinking), STURM (for supporting essay planning), MArCo (for group planning) and STyLE (for learning terminology).

Keywords: system design, reflection, articulation

1 Introduction

The aim of this paper is to consider trends in the development of advanced computer-based learning (CBL) systems in the last decade and, in particular, to focus on strategies for supporting articulate reflection by students. In 1993, the last time this conference was held in Taiwan, there was a heated debate underway concerning the implications of situationism or situated cognition, a specific form of constructivism, for the design of CBL systems. Proponents of this philosophy of cognition considered that a revolution in the way we conceptualise CBL system design was needed.

We do not hear so much about this debate nowadays (for example, at the recent AIED and ITS conferences there was barely a mention of situated cognition). What has happened? Has the theory been abandoned? Has it been entirely accepted, so that there is nothing left to debate? Have some of the tenets been quietly absorbed and some put aside?

The tenets of situationism always seemed rather elusive in the sense that the simplistic slogans which were sometimes put forward to summarise the revolutionary nature of the theory were inevitably accompanied by detailed discussions indicating that the slogans never quite captured the essence of the theory. What appears to have happened over the last decade is that the tenets have been refined so that they no longer seem so revolutionary - and indeed current system designers unaware of the previous heated debate might well wonder what all the fuss was about. For the simple fact is that researchers and designers are situated too. What they do is determined also by their community of practice and environment, and, obviously, over the last decade there have been major changes towards networked learning and lifelong learning, with which situationism is more in tune than the traditional symbol-processing forms of cognitive science, more appropriate for individualised, adaptive systems.

However, there is one current trend in CBL systems, the focus on supporting articulate reflection, which it is difficult to relate to the principles of situationism. Of course, situationists had much to say about articulation and reflection (along with everything else) but most of it appeared to be rather confused. As we will see, this is basically because situationism is a theory of knowledge and performance and not directly one of learning.

In this paper, we will briefly discuss the nature of situationism and consider trends in the design of CBL systems. After considering articulation and reflection in more detail, we will then present various strategies for supporting articulate reflection, illustrated by specific CBL systems, leading to conclusions about CBL system design.

2 The tenets of situationism

Situationism is one of many variants of constructivism. The defining characteristic of constructivism - the principle that learners construct knowledge and do not somehow passively receive or absorb it - is hardly arguable. The corollaries which are emphasised begin to be more questionable:

- that an essential part of what is learned is the context in which learning takes place (both the physical and social environment);
- that knowledge is constructed by learners through actively interacting in situations in which they experience a domain;
- that previously constructed knowledge influences the way learners interpret new experiences and affects their thinking and learning;
- that construction of knowledge occurs over time from the learners' attempts to connect new and previously developed experiences.

Situationism departs from other forms of constructivism in its view of what it is that is constructed. Non-situationists need not necessarily deny that knowledge construction leads to symbolic representations or cognitive structures held in the brain (as conventional cognitive science might be considered to hold). Situationists do not agree that the 'construct' is an entity in this sense.

The following appear to be the main tenets of situationism (although it is risky to present such a brief list because situationists will always say that matters are really much more complicated than this):

- Knowledge is an analytic abstraction, like energy, and not a substance or thing that can be inventoried [3]. It does not reside "in the heads of tutors, getting there through experience, abstracted but not necessarily accessible in an articulatable form", as asserted in [16]. Knowledge may be represented symbolically, for theoretical purposes, but such symbolic representations are not themselves knowledge, no more than a map is the territory mapped.
- The activities of a person and an environment are parts of a mutually-constructed whole. A person does not act *in* or *on* an environment (or vice versa) but *with* an environment. Therefore, one cannot describe either separately but only in terms of their contributions to an activity. The mind is then a functional property of this interaction between a person and an environment, not an entity that exists in the head. Perception and acting are mutually shaping, or "'situated' means coordination without deliberation" [1], a phrase subsequently elaborated to mean much more than it appears to say.
- Language is the "instrument of social cooperation and mutual participation" [7], rather than a means of describing some separately given reality. Therefore, language is the means to enable learners to participate in a jointly constructed social activity rather than to transfer reality from one head to another.
- Learning is "a process that takes place in a participation framework, not in an individual mind .. learning is, at it were, distributed among co-participants, not a one-person act [11]. This proposition seems less counterintuitive once it is clarified that 'social' does not mean 'in the presence of other people': "an action is situated because it is constrained by a person's understanding of his or her 'place' in a social process" [3]. So an individual reading a book may be situated and engaged in a social process.
- In general, situationism begins with practice and works towards theory (rather than vice versa, as attributed to the symbol-processing paradigm). There is, therefore, an emphasis on learning from apprenticeship, rather than from teaching or formal schooling. This denial of the role of theoretical abstractions, necessarily situation-independent, does, of course, create difficulties with the notion of 'transfer'. One could deny that transfer ever happens [6] or attempt to provide a situationist account of the apparently contradictory notion of transfer ([10], a lengthy but ultimately unconvincing article).

It was striking that the studies that led to the theory of situated cognition were mainly studies of performance (grocery shopping, Liberian tailoring, reasoning about land rights in the Tiobriand Islands) and not of learning (e.g. of how a Liberian tailor becomes competent). It was rather assumed that the only or the best way to acquire the situated knowledge that people appear to have was for them to be immersed in the 'community of practice' - as if, after observing expert skiers on the mountainside one concluded that a novice skier should learn within that community, when in fact the opposite happens, with novice skiers being excluded until they are capable of joining. It was also implicit that because knowledge was observed to be situated this was therefore a desirable state of affairs - that it should be the aim of education to help learners acquire such situated knowledge.

In response to the question "So, what should we as system designers do differently, according to situation cognition?" a list [2] was provided (where I have omitted the "rather than .." clause which ended each item, in order to focus on the nature of the proposal, not its purported contrast with alternatives):

- participate with users in multidisciplinary design teams
- adopt a global view of the context in which a computer system will be used
- be committed to provide cost-effective solutions to real problems
- facilitate conversations between people
- realise that transparency and ease of use is a relation between an artefact and a community of practice
- relate schema models and computer systems to the everyday practice by which they are given meaning and modified
- view the group as a psychological unit.

As we look at the list today we may conclude that it is not so controversial. Situationism has been sound in its broad proposal - that we would do better to concentrate on restructuring the social-cognitive settings within which students learn than to try to manipulate the internal information-processing of students. However, there is one aspect which is missing, or at most muddled, within situationism and that is the role of activities specifically to aid learning (not performance), such as articulate reflection.

3 Reflection and articulation

By *reflection* we mean more than 'deep thinking', as in the everyday sense. We mean the consideration of one's own thought processes, problem-solving strategies, knowledge and skills. In short, thinking about one's own thinking. In general terms, this reflection needs to be both motivated (so that the learner feels there is some potential gain in pausing during the problem-solving process) and supported by some kind of externalisation of the learner's thought processes (so that there is something upon which the reflection may focus).

Reflection is therefore an interruption to action. With competent problem solvers, where there is no intention to seek improvement in any related activity, there may well be no reflection. If situated cognition implies action "without deliberation" then this appears to leave no place for reflection, although it has always been a key component of cognitive apprenticeship [4]. Reflection was considered to be the fourth and last stage of the cognitive apprenticeship process. However, it was considered appropriate only in domains for which the target process is external and thus readily available for observation and comment and also bears a relatively transparent relationship to concrete products.

Articulation is the process of verbalising, for the benefit of oneself or others, the thought processes and problem-solving activities that are occurring or have occurred. Articulation is important for three reasons. First, at the philosophical level, the link between language and thought, the later sometimes being considered to be a kind of 'internal language', may mean that the act of making verbally explicit may in itself help develop the thought processes being described. Secondly, articulation may bring into the open current (mis)understandings so that they may be inspected, discussed and edited by oneself or others. Thirdly, being able to provide an articulate explanation is itself a worthwhile educational objective. Situationist researchers may be in awe of remarkable, but inarticulate, problem-solving processes but generally we prefer a solution which is accompanied by some explanation of how it has been derived.

For computer-based learning systems, we need to support *both* reflection and articulation together, neither alone being of much help to the system or the learner. The system needs to provoke reflection but it needs to receive some information about that reflection if it is to provide support.

4 Strategies for promoting articulate reflection

In this section, five strategies intended to promote articulate reflection are described, illustrated by projects underway at Leeds.

4.1 Present novel problems which require articulation for their solution

If one presents a traditional geometry problem (such as Figure 1, on the left) to an expert, a solution is obtained almost instantaneously, with the expert often being unable afterwards to say precisely how the solution was obtained. Asking the problem-solver to describe the process during problem-solving only interferes with the process. Such problems, characteristically, have the fortunate properties of being complete and non-redundant,

that is, every thing that needs to be known is in the figure and there is nothing in the figure which is not needed in the solution. Problem solvers therefore soon realise that any step is likely to be a useful one.

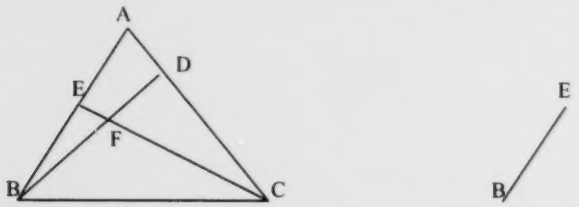
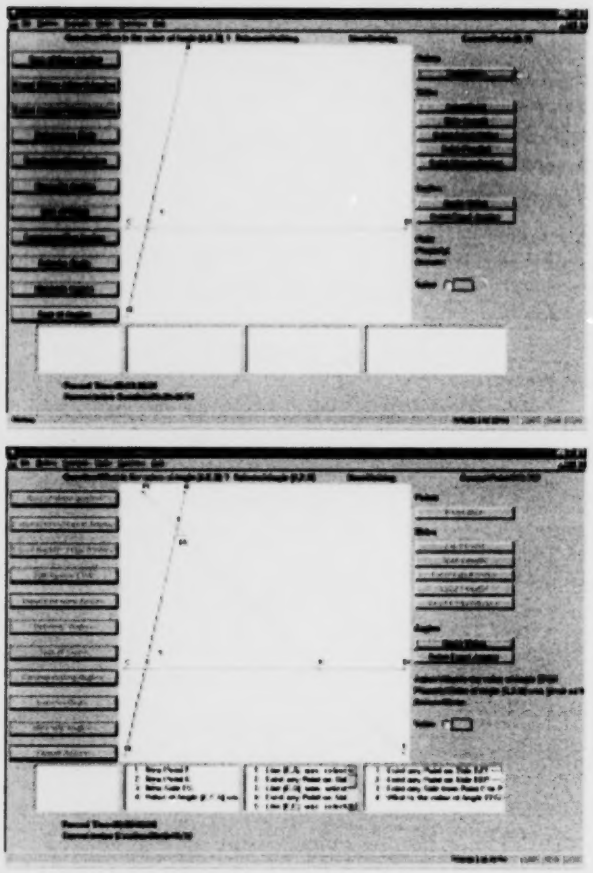


Figure 1. (a) A 'traditional' problem: Given BCF=FCD, CBF=EAD, BF=5, what is the length BE?
(b) An 'incomplete' problem: What is the length BE?



If, however, we present an 'incomplete' problem (Figure 1, on the right), then solvers have to think carefully before asking for information which they hope will be useful. For example, for this problem, we might ask:

"Is there a line parallel to BE?"

"Is there another line through point B?"

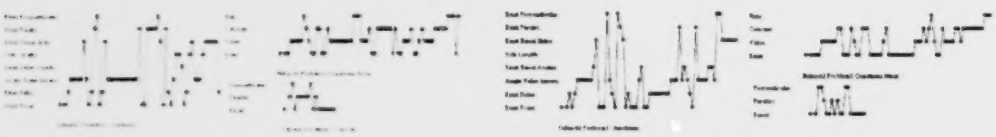
Even experts (at traditional problems) have difficulty in devising an effective series of questions for such problems. Generally, however, those with a better understanding of geometry realise that more 'conceptual' questions (such as those to do with parallel and perpendicular lines) are more useful than specific questions, because they are related to the inferences (opposite angles, exterior angle, etc.) which need to be made.

The EUCLID system (Figure 2) has been implemented to enable solvers to solve such problems and enable them to develop an understanding of geometry concepts. Users use the right menu to ask questions of various forms and the left menu to apply inference rules, thereby making explicit their problem solving process. The system records the questions asked and this provides a focus for reflection.

Figure 2. The EUCLID system, showing the starting problem (above) and midway through a solution (below).

The questions may be considered to be of four kinds: existence, value, conceptual, rule application. Users' strategies may then be plotted, showing differences between novice (focussing on specific questions) and expert (asking more conceptual questions) problem solvers [12].

Figure 3. A trace of two subjects' solution of the problem shown in Figure 2.



BEST COPY AVAILABLE

4.2 Provide an appropriate language, especially where the proper language is too formal

Most people can venture an answer to a problem such as that shown in Figure 4, but find it hard to give a justification for their solution. They simply do not have the technical or everyday words to express their justification. Here are two typical explanations:

"The shape of the bottom of the boat is slanting and the gradual change of the slope… helps it float. In the block….no gradual change of slope….so it sinks."

"Something to do with the shape. Don't know why….saw on TV where the speed of motion depends on shape."

It does not help to provide a list of technical definitions (buoyant force, etc.).

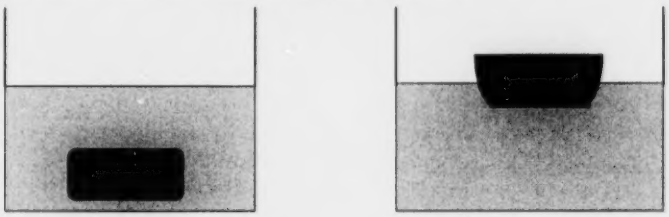
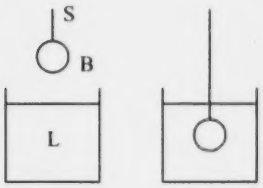


Figure 4. A floating problem: *A lump of plasticine sinks when it is placed in water. When the same lump of plasticine is shaped into a boat, it floats as shown on the right. Explain this phenomenon.*

Instead, we might try to provide an intuitive, informal language which may provide a bridge to the technical language. For example, consider the situation (Figure 5) in which a body B hangs from a string S above or in a liquid L (in a infinite container). B, S and L are the only things we need to talk about. What can we say if we make B heavier (but the same volume)? S has to hold it up a bit more. What if L is denser? What if B is a cylinder not a sphere? ... fairly soon, one starts using B, S and L for the forces associated with them (without, of course, necessarily using the word 'force'). Once one has this 'language', more complicated questions can be tackled: When a body is lowered into a liquid do B, S and L change in the same way if B is a sphere and a cylinder? How do B, S and L change if the body floats when it is lowered?



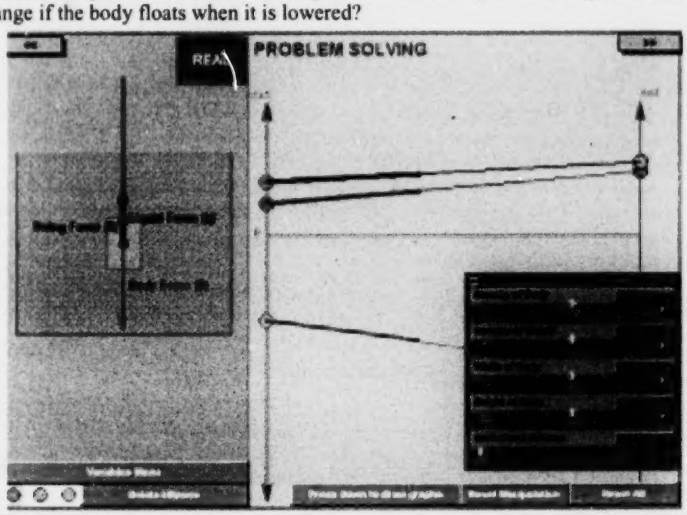


Figure 5. The BSL situation and the BSL environment for experimentation and problem solving.

The BSL system (Figure 5) was designed to help students articulate and reflect upon their thinking about buoyancy and floating concepts. The evidence is that students are enabled to provide more articulate explanations, and, through experimenting with the simulation, can test out hypotheses and develop conceptual understanding [13]. For example, here is an extract of an explanation given while using BSL:

S: "Increase depth of submergence….as you increase….body force will remain constant, I guess….your liquid force, I guess is going to increase because….due to the height….you are going deeper…"

E: "What height is that?"

BEST COPY AVAILABLE

S: "The deeper....as you go deeper into the water, there is water pressure pushing it up. But I am not very sure about the string force...as you go deeper, the string force is getting less because of the upward force of the liquid....so....the thing is getting less....I think it's getting constant....I guess."

4.3 Monitor the student's activities and help him to articulate his problem-solving strategies

Imagine that you are a music undergraduate and you have been given the following essay assignment: "In what ways was Schumann a more romantic composer than Beethoven?" Imagine also that your tutor has kindly provided a list of potentially useful web addresses (music dictionaries, biographies, examples, etc.). How would you proceed?

The planning stage of writing involves goal setting, content generation and argument building. The potential argument structure of an essay should not emerge after all information has been gathered but should guide the information-gathering process. Therefore providing advice on appropriate research strategies should help students begin to build an argument structure from the material which they are reading. We have identified a number of strategies potentially useful for tackling essays of the form "Compare A and B with respect to X", such as:

- identify the characteristics of X (so that you may compare A and B with respect to each characteristic)
- see if the characteristics of X change over time (so that you may see when A and B best fit X)
- search for discussions of whether A (or B) has a specific characteristic of X or not
- consider whether there is an exclusive-or relationship between X and some Y (so that, if so, you might consider A (or B) with respect to Y

The STURM (Studying, Teaching and Understanding Research Methodologies) system has a catalogue of such general purpose information-gathering strategies. The idea is that as a student browses the web resources the system maintains a simple model of the information of which they are aware and then when a student asks "What should I do next?" it is able to provide advice, by determining which of its strategies are applicable at that time. For example, if the student has accessed a resource which suggests that a characteristic of romanticism is that it is more descriptive or programmatic than abstract a number of steps might be proposed, including an instantiated form of the third one above: "See if Schumann's music is descriptive". Of course, it is conceivably useful to present an abstract form of the advice, as being potentially helpful for all essays of this type. As the student carries out this browsing, what he discovers begins to form the structure of the essay. For example, finding out (from the second piece of advice above) that the notion of romanticism changed considerably from the Beethoven to Schumann eras provides one basis for organising the essay.

4.4 Require students to develop problem-solving strategies in a group and help to resolve conflicts

There has been much discussion of the idea that cognitive conflict triggers reflection. However, it is clear that such conflict does not always trigger reflection and, if it does, it is often quite shallow. Partly, this is because the notion of conflict is itself quite shallow, amounting to the holding of a proposition and its negation. The resolution therefore involves only the consideration of which proposition(s) need to be discarded. 'Strategy conflicts', however, are more subtle. If a strategy is a partially ordered sequence of steps to achieve some goal, then two strategies may conflict in various ways, for example, some of the steps may be out of order, different ones may be in parallel, etc. It is not always clear whether the differences are significant. If there is a significant conflict, its resolution involves more than just deleting one or more components. In short, the resolution of strategic conflicts is likely to provide a basis for deeper articulate reflection than ordinary cognitive conflict.

The MArCo system (Figure 6) is designed to support two or more students in group problem solving and then to resolve potential conflicts. Conflicts happen through dialogue and are inevitable in group problem solving, and, indeed, are beneficial to it. To provide support, the system needs first to model individual activities and to detect conflicts. We distinguish between a 'difference of views' (where agents have different views but have not yet communicated them to each other); a 'disagreement' (where the agents inform each other about their different views but a discussion does not then follow); and a 'conflict' (where the agents try to convince one another about their own points of view). Conflicts may be of various kinds [17]:

- non-task related or social conflicts
- belief conflicts, i.e. conflicts about facts and rules within the domain
- contextual conflicts, related to defining what exactly is the problem being solved
- reflector conflicts, related to how goals are selected

- intention conflicts, concerning the steps to be taken to solve a problem
- goal-definition conflicts, relating to defining the goal
- goal-achievement conflicts, concerned with disagreements about whether the goal has been achieved.

For example, a belief-conflict is defined as:

Bel_Conflict(x,y,s) = def[Bel(x,s) and Bel(x,Bel(y,~s)) and Intend(x, Bel(y,s))]

According to this definition, x has a conflict with y if x intends that y should change his belief to conform to x's, but not necessarily vice versa. We can also define a mutual belief conflict:

Mutual_Bel_Conflict(x,y,s) = def[Bel_Conflict(x,y,s) and Bel_Conflict(y,x,~s)]

The distinction is important because, in the first case, x may be mistaken about y's beliefs and the conflict situation may cause confusion, whereas the second situation has more potential for articulate reflection. Similarly, we define a collaboration and a mutual collaboration as:

Collab(x,y,p) = def[Bel(x,p) and Bel(x,Bel(y,p)) and Intend(x,strategy(x,p)) and Expects(x,Intend(y,strategy(y,p)))]

Mutual_Collab(x,y,p) = def[Collab(x,y,p) and Collab(y,x,p)]

In a mutual collaboration, the strategy(x,p) and strategy(y,p) are interleaved or merged to contribute to a problem solution; in a mutual cooperation, the strategies are concatenated (i.e. they are independent and both contribute directly to the solution).

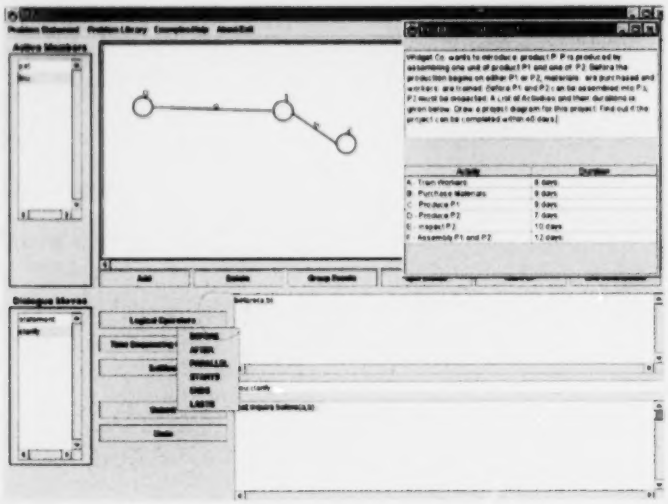


Figure 6. The MArCo system

The MArCo interface provides:

- a graph window, where members of the group build a common graphical solution
- a constraints window, where members may discuss the constraints and goals of the problem
- an active members window, showing who is involved in the discussion
- a dialogue region, where members contribute by selecting dialogue moves and selecting the content (from the graph window or the constraints window)
- a dialogue record, maintaining a history of the interaction.

On detecting a conflict, MArCo may (1) simply inform the group that a conflict has been detected, leaving the group to decide how to proceed; (2) after detecting a conflict, ask a member who has expressed a view different to the group model to elaborate on his apparent change of mind; (3) suggest actions that may lead to more refined solutions, by, for example, building up solutions involving more members of the group.

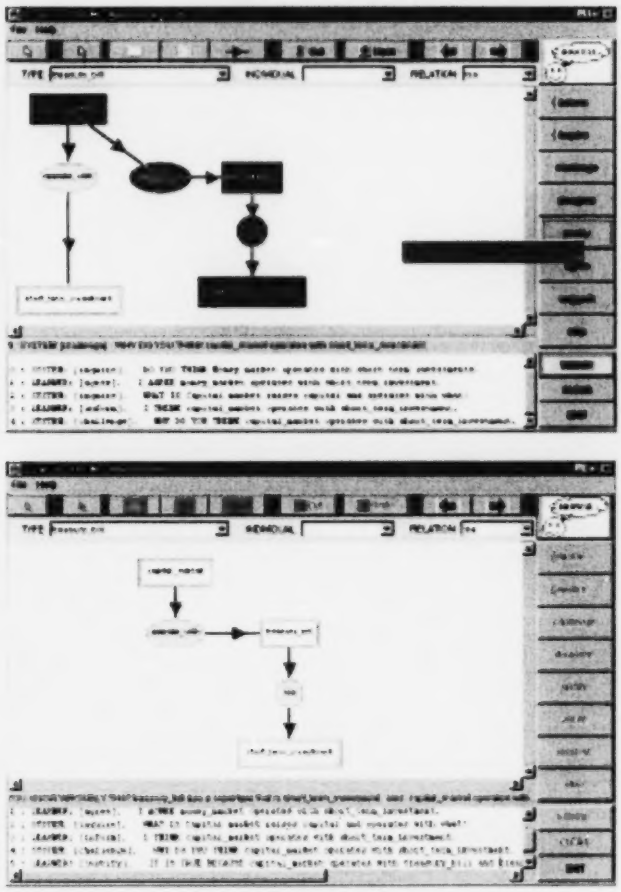
4.5 Present the student with a representation of his own understanding, which he may discuss and edit

Presenting the learner with an externalisation of their thoughts, e.g. System: "You seem to think that money markets operate with short-term investments", will not by itself provoke much articulate reflection. The system needs to be able to sustain a focussed interaction probing the justifications for such beliefs.

BEST COPY AVAILABLE

STyLE-OLM (Figure 7) is an environment for interactive diagnosis where a learner and a computer system are involved in an ongoing dialogue about the content of the learner model [8]. It supports the elaboration of the definitional structure of a terminology domain. It provides a communication medium based on a graphical representation of conceptual graphs that allows externalisation of the learner's conceptualisation of the domain and thus articulation of his domain structural model. An interactive model based on dialogue games maintains the communication between the learner and the computer.

Involving students in situations where they can inspect and discuss their models is a reflective activity which leads students to think about their domain knowledge as well as to articulate, validate, and challenge the robustness of their domain competence. STyLE-OLM provides a variety of reflective situations. It encourages the student to make statements about his beliefs and allows him to go back to his previous claims about these beliefs and (possibly) to change his claims. Throughout the interaction, the scope of the articulated beliefs is extending and he is provided a manner to explore various aspects and alternatives for expanding his beliefs. Additionally, the system leads the learner to search for and render grounds that support his beliefs.



STyLE-OLM provides two modes: DISCUSS, where a learner can discuss aspects of his domain knowledge and influence the content of the learner model (figure 7 above), and BROWSE, where a learner can inspect the current state of his learner model (below).

The graphical tools on the top allow the student to manipulate the graph that will present the proposition of his communicative act. He adds illocutionary force by selecting a dialogue move from the right area of the screen. Both the student and the system contribute to the discussion in the same way - by selecting a graph component and a dialogue move. The bottom text window shows a generated transcript of the dialogue. The learner can browse this textual form of the dialogue history or a graphical one. As the dialogue proceeds, the system makes plausible inferences about what further the learner believes on the basis of what is explicitly asserted, and from this a dialogue strategy is determined. The dialogue is guided by general explanations of misconceptions, for example, that an entity may be believed to be a member of a class if it has some features of that class. The example shown presents a situation of a session with STyLE-OLM in a Finance domain.

Figure 7. The STyLE-OLM system

STyLE-OLM is called by STyLE (a learning environment for Finance terminology) to solve problems with the diagnosis faced by the components that analyse a student's performance. In this example, initially, the learner model contains information that the learner knows some aspects of the terms MONEY_MARKET and CAPITAL_MARKET but often mixes these terms. STyLE-OLM initiates a dialogue to explore the learner's knowledge about these terms and to find possible reasons for his beliefs. This is an extract from this interaction (note that is a generated transcript - all communication is actually done graphically, using the graph and menus):

```
STyLE-OLM(inquire) DO YOU THINK MONEY_MARKET operates with SHORT_TERM_INVESTMENTS.
Learner(agree) I AGREE MONEY_MARKET operates with SHORT_TERM_INVESTMENTS.
```


BEST COPY AVAILABLE

STyLE-OLM[inquire] WHAT IS CAPITAL_MARKET raises CAPITAL and operates with WHAT?
Learner[inform] I THINK CAPITAL_MARKET operates with SHORT_TERM_INVESTMENT.
STyLE-OLM[challenge] WHY DO YOU THINK CAPITAL_MARKET operates with SHORT_TERM_INVESTMENTS?
Learner[justify] IT IS TRUE BECAUSE CAPITAL_MARKET operates with TREASURY_BILL and TREASURY_BILL is a SHORT_TERM_INVESTMENT.

The screen shot in Figure 7 depicts the environment at the moment when the learner constructs and submits his justification. STyLE-OLM may continue the dialogue:

STyLE-OLM[challenge] WHY DO YOU THINK CAPITAL_MARKET operates with TREASURY_BILLS and TREASURY_BILL is a SHORT_TERM_INVESTMENT?

At this time the student may challenge the robustness of his domain beliefs. He switches to a browse mode where he looks through the current state of the learner model. The lower screen shot in figure 7 presents this stage. The learner realises that his claim that CAPITAL_MARKET operates with TREASURY_BILL and TREASURY_BILL is a SHORT_TERM_INVESTMENT is wrong. He can now ask the system to help him to explore the domain knowledge about these terms. The learner may switch back to a discuss mode where he asks questions:

Learner[inquire] IS IT TRUE TREASURY_BILL is a SHORT_TERM_INVESTMENT?
STyLE-OLM[inform] I KNOW TREASURY_BILL is a SHORT_TERM_INVESTMENT.

The learner now realises that this domain belief is correct and asks for the other part of his wrong belief:
Learner[inquire] IS IT TRUE CAPITAL_MARKET operates with TREASURY_BILLS?
STyLE-OLM[inform] I DO NOT KNOW CAPITAL_MARKET operates with TREASURY_BILLS.

The learner has now clarified the wrong part of his beliefs. Now, he could possibly withdraw his claim that CAPITAL_MARKET operates with SHORT_TERM_INVESTMENTS, ask what CAPITAL_MARKET does operate with, or explore his knowledge about SHORT_TERM_INVESTMENTS by making claims about other examples of short term investments.

5 Related work

There are, of course, other strategies for promoting articulate reflection not illustrated by the Leeds systems, for example:

- Use a 'reflective follow-up' in which, after a problem has been completed, the student is stepped through his solution steps in comparison with the steps that the system itself (as an expert problem solver) would have taken [14].
- Use a simulated peer (which has access to an expert domain model) to prompt a student to explain the reasoning behind his actions [9].
- Require students to complete self-explanations, that is, to provide explanations to cover gaps in worked examples [5].
- Provide an interface for students to express their theories of how to do inquiry [18].

Finally, to indicate that articulate reflection is not always beneficial, consider the following problem: "Two glasses, two inches and four inches wide, are both filled up to one inch from the top. Which glass has to be tilted the most before the liquid pours out?". When people close their eyes and imagine the glasses being tilted they always answer correctly - but when twelve pairs considered the problem and engaged in some discussion about it, none of them answered the problem correctly [15]. Evidently, there are times when articulate reflection in a group does not lead to productive outcomes!

6 Conclusions

Ideas about the design of computer-based learning environments have evolved over the last decade. We no longer have such heated debates about the implications of apparently contradictory philosophies. The tenets of what appeared to be the most revolutionary philosophy (situationism) have largely been absorbed, although there is, of course, much work to do to develop practical applied systems. However, this has probably occurred not as a result of any philosophical conversion but as a result of changes in the technological and social context, in particular, the growing emphasis on networked, lifelong learning. Somewhat paradoxically, however, situationism's genuflection to efficient and effective problem-solving performance, without apparent reflection or traditional teaching, led to a neglect of aspects which are crucial for learning, if not performance. In particular, the role of articulate reflection was never clearly integrated into the theory of situationism, because its ideas

about learning were inferred from its theory of performance. Computer-based learning systems designers, however, have proceeded to develop a number of strategies for supporting articulate reflection, as illustrated in this paper, indicating that they continue to be more influenced by their own communities of practice and social and technological contexts than by theoretical philosophies (as situationism would predict).

References

[1] Clancey, W.J. (1992). 'Situated' means coordinating without deliberation, McDonnell Foundation Conference, Santa Fe, New Mexico.

[2] Clancey, W.J. (1993). Guidon-Manage revisited: a socio-technical systems approach, *Journal of Artificial Intelligence in Education*, 4, 5-34.

[3] Clancey, W.J. (1995). A tutorial on situated learning, in Chan, T.W and Self, J.A. (eds.), *Emerging Computer Technologies in Education*, Charlottesville: AACE.

[4] Collins, A., Brown, J.S. and Newman, S.E. (1989). Cognitive apprenticeship: teaching the craft of reading, writing and mathematics, in L.B. Resnick (eds.), *Cognition and Instruction: Issues and Agendas*, Hillsdale, NJ: Erlbaum.

[5] Conati, C. and VanLehn, K. (1999). Teaching meta-cognitive skills: implementation and evaluation of a tutoring system to guide self-explanation while learning from examples, in S.P. Lajoie and M. Vivet (eds.), *Artificial Intelligence in Education*, Amsterdam: IOS Press.

[6] Detterman, D.K. and Sternberg, R.J., eds. (1993). *Transfer on Trial: Intelligence, Cognition, and Instruction*, Norwood, NJ: Ablex.

[7] Dewey, J. (1958). *Experience and Nature*, New York: MacMillan.

[8] Dimitrova, V., Self, J. and Brna, P. (1999). The interactive maintenance of open learner models, in S.P. Lajoie and M. Vivet (eds.), *Artificial Intelligence in Education*, Amsterdam: IOS Press.

[9] Goodman, B., Soller, A., Linton, F. and Gaimari, R. (1998). Encouraging student reflection and articulation using a learning companion, *International Journal of Artificial Intelligence in Education*, 9, 237-255.

[10] Greeno, J.G., Smith, D.R. and More, J.L. (1993). Transfer of situated learning, in Detterman, D.K. and Sternberg, R.J., (eds.). *Transfer on Trial: Intelligence, Cognition, and Instruction*, Norwood, NJ: Ablex.

[11] Hanks, W.F. (1991). Preface to Lave, J. and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press.

[12] Karakirik, E. (2000). The usage of conceptual knowledge during geometry problem solving, PhD thesis (in preparation), University of Leeds.

[13] Kor, A.L. (2000). A computer-based learning environment for the exploration of buoyancy, , PhD thesis (in preparation), University of Leeds.

[14] Lesgold, A., Katz, S., Greenberg, L., Hughes, E. and Eggan, G. (1992). Extensions of intelligent tutoring paradigms to support collaborative learning, in S. Dijkstra, H. Krammer and J. van Merrienboer (eds.), *Instructional Models in Computer-Based Learning Environments*, Berlin: Springer.

[15] Schwartz, D.L. (1999). The productive agency that drives collaborative learning, in P. Dillenbourg (ed.), *Collaborative Learning: Cognitive and Computational Approaches*, Amsterdam: Pergamon.

[16] Sleeman, D. and Brown, J.S., eds. (1982). *Intelligent Tutoring Systems*, Orlando: Academic Press.

[17] Tedesco, P.A. and Self, J.A. (2000). MArCO: using conflict mediation strategies to support group planning interactions, in G. Gauthier, C. Frasson and K. VanLehn (eds.), *Intelligent Tutoring Systems*, Berlin: Springer.

[18] White, B.Y., Shimoda, T.A. and Frederiksen, J.R. (1999). Enabling students to construct theories of collaborative inquiry and reflective learning: computer support for metacognitive development, *International Journal of Artificial Intelligence in Education*, 10, 151-182.

Proceedings

Content

Invited Papers

Matching the Infoverse: About Knowledge Networks, Knowledge Workers, and Knowledge Robots
Learning on the Internet: Taking the ecology metaphor further
What can we Learn from the Systems we Build ? From Providing Support to Students to Providing Support to Teachers
The role of emotional agents in Intelligent Tutoring Systems
Web Portfolios: Tools for Monitoring and Assessing Learning Process
Can And Should Teaching Systems Mimic Human Teachers?
Human activity in learning societies
Towards Intelligent Media-Oriented Distance Learning and Education Environments
Research on Internet Addiction: A Review and Further Work

▲ HOME

BEST COPY AVAILABLE

Matching the Infoverse: About Knowledge Networks, Knowledge Workers, and Knowledge Robots

Joachim Hasebrook
Head of Unit Concept/Program Development, Bank Academy & University of Banking, and
CEO Knowbotic Systems Inc. Ltd.

Humans are not able to cope with the exponential growth of information and the increasing speed of information and business processes fostered by information and communication technologies. Technical support not only for information storage and retrieval but also for information selection, process planning, and decision support is needed. Moreover, the use of a (desktop) computer is restricted in many ways. In this paper, it is predicted that smart and mobile computing units embedded in a variety of things, such as TV sets and cars, will bring computing power close to their users. It is also predicted that users will get closer to computing power by using natural language and by using their social skills in computer mediated communication. A holistic architecture of knowledge robots (knowbots) is described based on multi-agent platforms and distributed computational intelligence. Knowbots consist of a self-learning artificial brain, speech recognition and synthesis, direct access to other software agents and computer programs, and direct connections to networks of human users. It is pointed out that a newly defined partnership between men and machine is a possible way to keep control of the exploding 'infoverse'.

Reasoning and simulation mechanisms of currently unthinkable complexity will take over the control of process planning and information exchange. Fourth generation robots with the capability of performing more than 30 million instructions per seconds (MIPS) will be the heart of a company's knowledge base. This is the vision propagated by Hans Moravec, Principal Research Scientist at the Robotics Institute and Director of the Mobile Robot Laboratory of Carnegie Mellon University, Pittsburgh (USA).

The global economy gets accustomed to the idea of the 'new economy' where the knowledge workers' creativity and skills are the companies' most important capital and competitive advantage. If only parts of Moravec's vision come true, however, it will certainly mean that the relevance of human expertise and experience will diminish. Current developments seem to support this point of view: A supplier of computer storage systems reports that especially banks are consuming more storage space within six months than has been used during the last twenty years; the increasing speed of product innovation and life cycles depreciate technological knowledge and skills within one to three years.

The 'infoverse' stored in the worldwide Internet starts to exceed the amount of information that has been stored in more than 60,000 years of human culture before: It has been estimated that in the years 1972 to 1980 more information has been collected than in the 2000 years before. Fifty years after the publication of the first Gutenberg bible about two million books had been published; today, more than 3000 books are published per day, more than one million per year. Some authors, therefore, are discussing the advent of the 'age of knowledge'. Others, however, argue that the Internet is not more than a gigantic heap of information garbage.

Recent studies show that we are not able to remember more than one to two percent of all the information we perceive in the mass media, such as radio, TV, or newspapers. A single search engine covers not more than about twenty to thirty percent of the World Wide Web pages, meta-search services using more than one search engine comprise about fifty to sixty percent of the WWW pages. Even the best text searching and indexing techniques do not come up with more than 25 percent of relevant links or search results, that is, an optimal search process accesses a quarter of a half of the information in the Internet - and one or two percent of this information can be remembered. Thus, we have to state that we have lost control over all the information gathered in technical systems.

Exponential growth of information, information access at light speed and the increasing speed of business processes and the decreasing value of human knowledge force to re-focus the development of information and communication technologies (ICT). Information accessibility is no longer the main concern, but navigation, orientation and selection of relevant information. As computers and robots provide us with incredible capabilities to process increasing amounts of data within decreasing periods of

time, it seems clear that we can only master the self-made 'information overload' if we manage to enhance our skills by developing a real computer-man dialogue and partnership.

The key topics of this new level of CMC (computer-man communication) is a mobile, ubiquitous and selective information access enabled by smart software agents based on multi-agent platforms using distributed computational intelligence. We are now at a turning point in our cultural development where sustainable progresses can only be made if we are able to delegate information retrieval, process planning and decision support to technical systems. We have to decide whether we want to become garbage collectors within heaps of information - or the human masters of smart agent systems which we do not fully understand.

If it works, it's not AI

Up to now, the progresses of the so-called Artificial Intelligence (AI) have been disappointing. A recent study about the commercial success of AI startup companies comes to the conclusion: 'If it works, it's not AI'. This assumption has been reflected in the revenues of AI corporations during the last decades (cf. figure 1). The strong position of AI is to develop machines that are intelligent in a human way. The weak position of AI is to implement programs that can be viewed as 'partly intelligent' because they are able to perform actions that used to be dedicated to human workers. This mode of AI is now referred to as 'Computational Intelligence' (CI). Patricia Churchland pointed out that we are at a stage where the strong AI position tries to mimic human intelligence in the same way the first pioneers of flight tried to mimic the birds' way of flying. As no modern airplane or helicopter is flapping its wings, it is clear that solutions enabling flight are not relying on flapping wings but on a proper lift. So, what might be a way to lift the weak position of AI to a higher level?

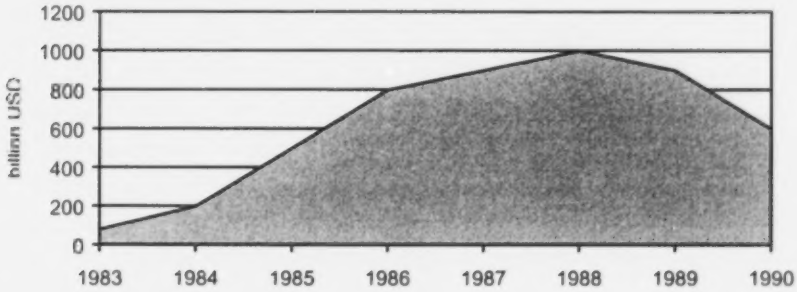


Figure 1: Approximate AI revenues (Philipps, MIT, 1999).

In 1998, the non-profit association 'Institute of New Media' and Bank Academy, a non-profit educational institution of the German bank associations, formed a joint venture to implement and test new ways of autonomous software agents which could help learners and knowledge workers in information intensive industries, such as banking and finance. At the beginning of the year 2000, Knowbotic Systems Inc. Ltd. was founded by the Institute and the Bank Academy. The purpose of this company is to develop and to examine knowledge robots or 'knowbots' which help to fully exploit the knowledge capital of a company by facilitating information selection, planning and decision making. The mission of Knowbotic Systems relies on two basic assumptions: (1) As long as key concepts, such as 'learning' and 'intelligence', are not fully understood and clearly defined, computers won't be intelligent learners. Therefore, a formal learning theory has to be deduced from recent theories and empirical studies in order to set up a virtual testing environment for knowbots which helps to measure their adaptability and to extend their learning capabilities. (2) The critical lift of CI will not come if a system is intelligent in itself, but it comes from the human capability to communicate with such a system in a intelligent and social way. Thus, knowbots have to mimic intelligent communication behavior in order to transfer the results of machine learning and machine reasoning to human users (cf. figure 2).

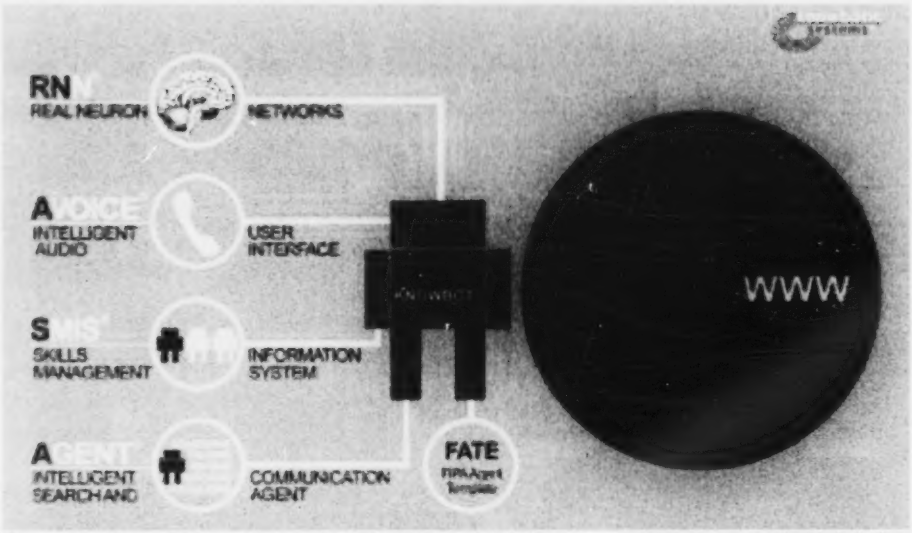


Figure 2: Knowledge robots (knowbots) are bridging the gap between technical information and data collections (right) by using artificial brains (RNN), ears and voice (AVOICE) and connecting information (AGENT) and people (SMIS) based on the multi-agent platform FATE.

The artificial brain

Most programs which mimic intelligent behavior are based on logical oriented knowledge-based techniques which proved to be too inflexible to represent even primitive forms of learning. Moreover, they elicit a number of paradox behavior when applied to support human learning. In classical AI different forms of logical based representational schemes are used and in connectionism researchers adhere to different types of artificial neural networks (ANN). ANNs have achieved some success in non-linear forecasting, pattern matching and in artificial life paradigms. But ANNs still lack many of the vital features of biological neural networks (BNN), such as the ability of real neurons to allow self-modification with regard to short term and long term learning. The simulation of BNNs developed by neurobiologists does not seem to be promising either because recent attempts have shown that exact simulations of neuron brain cells consume a vast amount of computer resources. For instance, 18 hours of computing time on five connected Sun Sparc workstations is needed to simulate one second of the activity of a single neuron.

Knowbotic Systems combines the behavioral perspective with the physiological perspective, both embedded in concepts of learning and sign based communications (or Semiotics). We call these self learning and sign-using systems 'knowbots'. The physiological structure is the main cause for observable behavior. Thus, we have to find a model of the human brain neuron which should be empirically more sound than the classical ANNs and should also be still practically feasible on 'ordinary' PCs. Knowbotic Systems' RealNeurons® almost perfectly simulate human brain cells with respect to the height of the potentials, the timing of the processes and the concentrations of chemical substances involved. Moreover, our neural networks can model the local and global influence of hormones and psycho-pharmaceutics on brain cells. We are modeling only those properties of biological cells which are most likely underlying learning of new behavior patterns.

Only a few BNNs underlying learning, however, have been identified yet. As a first test case we have chosen a classical conditioning circuit and several candidates that might be responsible for operant conditioning. In first experiments we implemented the network which represents the eye blink reflex of a rabbit. The network matches the neuropsychological data almost perfectly (cf. figure 3): The connection of the unconditioned stimulus (US = air flow) and the conditioned stimulus (CS = sound) is learned in a few trials, if the CS is given slightly before the US. Several runs presenting the CS without the US extinguish the connection. It is re-established very quickly, if the CS and the US are displayed together

BEST COPY AVAILABLE

again. This means, that not only the neuro-biological structure of brain cells can be simulated on a PC, but also basic learning behavior which perfectly matches empirical data.

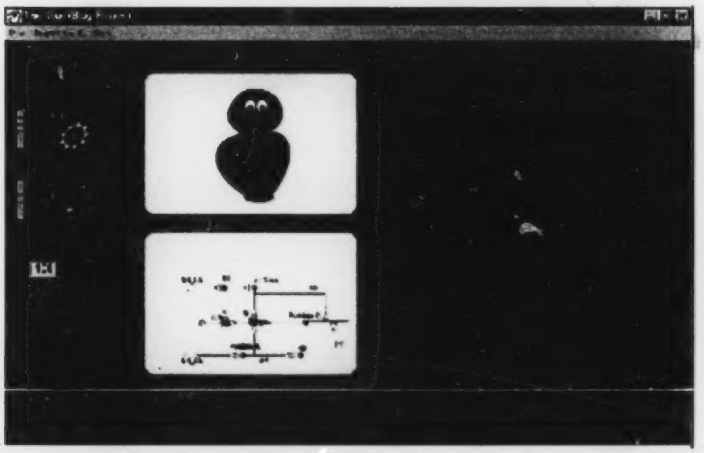


Figure 3: Test environment for (classical and operant) conditioning experiments with Knowbots based on artificial biological neural networks implemented with Java.

The artificial body

The artificial brain cannot communicate to humans and environments without a body. Robotics' research has shown that intelligent or adaptive behavior is based on a close interaction with the outside world. Moreover, the measure of learning or intelligence clearly depends on observable behavior corresponding to well defined learning tasks and environments. Knowbotic Systems, therefore, concentrates its technical developments on interface technologies which facilitate the access to knowbots by human users. The most important way to communication is speech. Knowbots are equipped with the speech recognition and synthesis system *AVOICE*. The speaker independent speech recognition is able to identify about fifty words in five different languages at a time. As the word recognition can be adapted according to the actual context, this small amount of words is sufficient to implement small navigational or command systems. The speech recognition unit may also be trained to understand a specific user and it is then capable to handle dictionaries of several hundreds or thousands of words. The speech synthesis can read any text, such as HTML pages, tables or documents. The user can choose between several 'speakers' with different pronunciation or intonation. In summary, AVOICE equips knowbots with a - still limited - human ear and voice. Knowbots, therefore, connect their users directly to all the information stored in the Internet, regardless whether they hook onto the Internet via a computer, a telephone, or a mobile phone.

Knowbots can also move around in the Internet, access data bases and organize their user dialogues. This is done by *AGENT*, an intelligent search agent and dialogue manager. The search agent is able to act as a search robot and a crawler in the World Wide Web. It can also get access to data bases or transform graphical information into text information. Thus, AGENT provides knowbots with a variety of ways to 'perceive' the virtual infoverse of the Internet.

The artificial environment

Up to now, there is much more talking about the irreplaceable value of the human capital and knowledge than taking actions to maintain and support the development of this capital. Most technical systems concerning the human capital of a company focus on the administration of personnel and training, such as SAP Human Resource modules, Peoplesoft or SABA - just to mention a view of them. An US-American study lists about 300 systems for training administration and delivery. But finding matches of needs and

BEST COPY AVAILABLE

demands in the infoverse certainly means more than matching keywords to indices or user profiles to software agents. The knowledge economy is not so much about information, it is about people. Knowbotic System is, therefore, engaged in a jointly initiative of several partners to implement a Skills Management Information System called 'SMIS'.

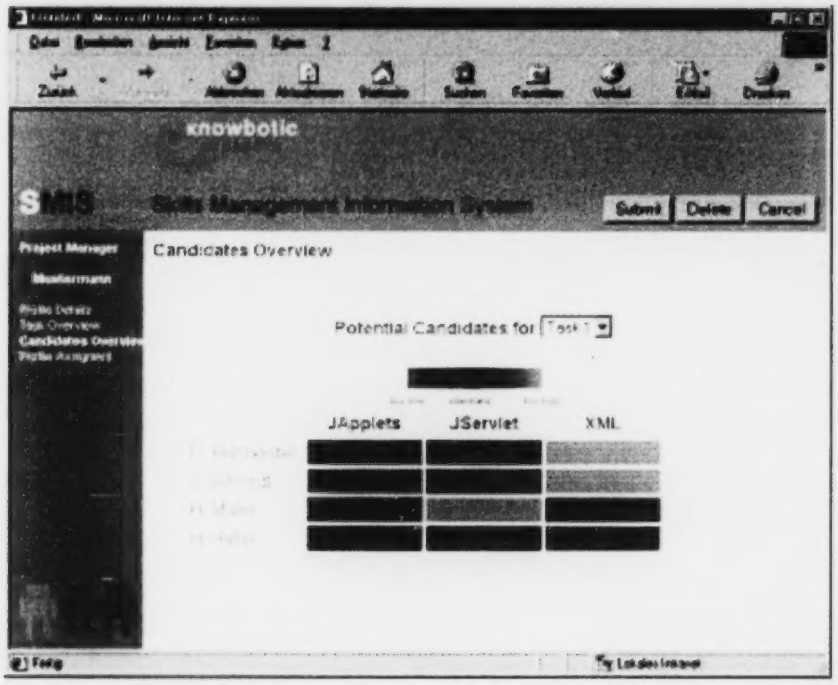


Figure 4: Screen shot from the Skills Management Information System 'SMIS' - the candidates overview lists possible candidates for a project tasks in acolored table indicating skills below or above the standard.

Human users, the users of information systems, visitors and creators of the infoverse, are the main 'component' of a knowbot's environment. Additionally, other knowbots or standardized software agents may also enrich the knowbot environment. For this purpose, Knowbotic Systems has developed one of three worldwide available multi-agent platforms based on the FIPA standard (FIPA = Foundation of Intelligent Physical Agents). The platform *FATE* (FIPA Agent Template) comprises templates or suits which allow programmers to convert nearly any computer program into a software agent, that is, the knowbot technology provides easy-to-use ways to introduce a large variety of programs into the virtual learning environment. FATE also allows to run several platforms on different Web sites. This enables knowbots and other agents to communicate, move or replicate themselves all over the World Wide Web.

The (artificial) future

We envision future developments in networked computing and distributed computational intelligence where the users are no longer forced to adapt to the computer. The computers will adapt to the human capabilities to perceive and process data. The communication between and with computers will adapt to the human way of communication, namely natural language. And computers will be accessible at any time from any point with any device, such as handhelds, laptops, or mobile phones. Computer networks will also become people networks, taking into account specific deficits and potentials of computers and humans.

Knowbots are one of the few holistic visions of a man-machine dialogue in its actual sense, dedicated to support humans where they need help to access and select information - and to learn from

BEST COPY AVAILABLE

them. But knowbots are not the only development in this field. A new level of smart agents and self-learning machines will develop in the near future. Figure 5 summarizes some major developments which are expected in the near future. Among them are software agents, mobile computing, and speech control. But, most of the forecasts of technological growth and development turned out to be too conservative.

2004	2005	2006	2007	2008	2009	2010
Ubiquitous online learning in universities	Online learning in schools (K12) Interactive communities in the WWW Increasing use of eCommerce	Software agents to search and select information Interactive TV for big audiences	Increasing use of speech recognition and synthesis Central remote control station for 'intelligent buildings'	Increasing use of electronic cash Broadband access to information	Mobile computing and eCommerce	Self-learning software agents 3D virtual reality

Figure 5: Some major developments in interactive media in the next ten years according to a recent study of the Fraunhofer Gesellschaft (Institut für Systemtechnik & Innovationsforschung).

Up to now, many individuals and companies are fascinated by the potentials and the exponential growth of the Internet. We do not think that future generations will be too enthusiastic about slow networks, unstructured information heaps and poorly equipped online shopping malls. Smart computers will be part of our every-day life, will be part of houses, cars, TV sets, refrigerators, bags, and suits. As a matter of fact, many ordinary machines are based on so-called embedded systems, that is, a small specialized computer. So, the things start to become computational things - and they will be smart things in the future. Knowbots and other smart agent technologies will support work, leisure and even cultural or social entertainment. Computers in the form of smart things will make computational intelligence as ordinary as cars or TV sets. But if the computers get nearer to their users, at the same pace the humans will get nearer to the computers: Not individual human beings nor software agent platforms will be the masters of the infoverse, but partnerships of robots, knowbots, and humans.

References

Doeben-Henisch, G. (1998b). Semiotic machines - an Introduction. In E. W. B. Luettich, J. E. Mueller & A. van Zoest (Eds.), Signs & space, Raum & Zeichen. An international conference on the semiotics of space and culture (pp. 313-327). Tübingen: Gunter Narr.

Goddard, N. & Hood, N. (1997) Parallel GENESIS for large scale modeling. In J. M. Bower (Ed.), Computational Neuroscience '96. New York: Plenum.

Harasim, L. M., Hiltz, S. R., Teles, L. & Turoff, M. (Ed.)(1995). Learning Networks : A Field Guide to Teaching and Learning Online. Boston: MIT Press.

Hasebrook, J. (1995a). Lernen mit Multimedia (Learning with multimedia). German Journal of Educational Psychology, 9(2), 95-103.

Hasebrook, J., & Nathusius, W. (1997). An expert advisor for vocational guidance. Journal of Artificial Intelligence in Education. 8(1), 21-41.

Maass, W. (1997). Networks of Spiking Neurons: The Third Generation of Neural Network Models. Graz: Institute for Theoretical Computer Science, TU Graz.

Moravec, H. (1998). When will computer hardware match the human brain? Journal of Transhumanism (1).

Sheperd, G. M. (Ed)(1998). The synaptic organization of the brain. Oxford, New York: Oxford University Press.

Sproull, L. & Kiesler, S. (1991). Connections: New ways of working in the networked organization. Cambridge, MA: MIT Press.

Learning on the Internet: Taking the ecology metaphor further[1]

Chee-Kit Looi
Institute of Systems Science
National University of Singapore
31 Science Park Road
Singapore 117611

The Internet is a powerful phenomenon that is radically transforming many of our economy, politics, culture, education, business and social processes, and almost everything else. In order to make sense of such a phenomenon, researchers have applied the ecology metaphor to information production and consumption on the Internet. In the education and training arena, some authors and researchers have also applied the ecology metaphor to viewing learning on the Internet (Brown, 1999). The Internet is seen as a powerful medium for creating and supporting a learning ecology. In this paper, we explore the notion of a learning ecology on the Internet by looking at the dimensions of diverse participation, information production and consumption, representations and experiences. We hope such a discussion would be useful in framing some of the educational technology problems and solutions on the Internet as well as deriving implications for designing tools and learning activity structures for online learning.

1 Introduction

Metaphors serve as a kind of mirror that brings out illuminating aspects of the phenomenon we are trying to understand. Lakoff and Johnson (1980) say that metaphors are pervasive because they reflect how we think, and, when we change the metaphor, we change the way we think about things. Stefik (1997) writes that the policies that shape the design and use of the Internet are often influenced by the metaphors that we ascribe to it. The most common metaphor of the Internet is the information superhighway. The metaphor for the digital library on the Internet is a publishing and community memory; the metaphor for the electronic marketplace is a place for buying and selling goods and services; and the metaphor for the digital worlds is a gateway to experience (Stefik, 1997).

In this paper, we examine the phenomenon of learning on the Internet in terms of a digital ecology. What does such a learning ecology metaphor buy us? How does it help us to recast or reframe some of the classical problems of education and distance learning in quite new terms (Brown, 1999)? We would expect a learning ecology metaphor to allow us to see things from a systemic perspective, and understand the components of the system and how they interplay with each other to enable and to support the processes of learning.

We posit that an ecological perspective is consistent with the perspective of distributed cognition. By viewing cognition as fundamentally distributed rather than residing "in the head", in a classroom situation, the tools, the rules, values and actors in a classroom form a highly complex, interacting system (Hewitt & Scardamalia, 1997). Knowledge is distributed among different people and mediated by tools and artifacts in the environment. An ecological perspective emphasizes the relationships and dynamics between the various participants in the classroom or in any learning situation.

[1] This paper is a revised copy of the paper that appeared in Educational Technology, May-June 2000.

2 Ecology of Diverse Participation

The Internet has properties that make for an open ecology. It is diverse, dynamic, self-organizing, self-regulating, inter-dependent, and removes boundaries. Brown (1999) states: "An ecology is basically an open, adaptive system comprising elements that are dynamic and interdependent. One of the things that makes an ecology so powerful and adaptable to new contexts is its diversity." Maes (1999) describes a digital ecology as a collection of people and machines that perform activities in a distributed way. It is adaptive in that none of the components is critical: even if some people and machine are removed, the system will still perform.

The Internet as a digital ecology provides new solution paths to problems. Brown (1999) describes it as small efforts by many people and machines to solve problems, rather than large efforts by the few. In his aggregate analyses of participation in discussion forums and newsgroups, Guzdial (1997) observes that few students contribute many notes to the conversations, and many students contribute few notes to the conversation.

Diversity of participation provides efficient, adaptive and robust way of doing things. Within the walls of a classroom, the student is limited in his interactions with the other participants, the teacher and other students. When the students are connected online through the WWW, she has access to diverse sources of information and expertise. The learning tasks for the students become one of knowing how to look for relevant information and knowledge, how to evaluate, assimilate, synthesize and apply them, and how to work with others to achieve their goals. When we view learning from a systemic perspective, we consider all the diverse participants – students, teachers, parents, the principal, education officers, colleges, universities, libraries, organizations, etc.

In recent years, many researchers and practitioners have viewed learning as a process in which learners construct knowledge and negotiate meanings together. Learning is seen from the perspective of participating in a "knowledge-building community" (Scardamalia & Bereiter, 1994), a "community of practice" (Lave & Wenger, 1991), or "community of learners" (Brown, 1992). In such communities, learning is an "intermental process" (Vygotsky, 1978; Edwards & Mercer, 1989; Morrison & Collins, 1995) that takes place in the context of real-time discourse. Knowledge internalization occurs when this interpersonal process at the social level is transformed into an intrapersonal process at the individual level. The Internet provides the technology infrastructure for enabling many interpersonal and social processes that were not possible or even imagined before.

Online communities are the herds that have a current standing common area of interest. Myriads of communities thrive on the WWW. There are collections of communities with overlapping interest, and cross-pollinating each other (Brown, 1999). Communities evolve and self-organize on the WWW. Designers of educational technologies need to think of the mechanisms to help such cross-pollination and to help sustain and grow good communities for learning.

In biological evolution, there is a major pattern of speciation. In speciation, the original species splits into more than one descendant species, each adapted to a different niche. Niche is a term in ecology which means the place occupied by a species in its ecosystem, or the potential place or role within a given ecosystem into which a species may or may not have evolved. The notion of niches maps to the communities of interest on the Internet. If the community is too narrowly defined, it may risk extinction as its niche disappears. The larger, the more varied (resulting in diversity of contributions), and more flexible a population, the greater its ability to spread to new niches. Here is the notion of communities of interest splitting and specializing into different niches.

The survival of population is defined as the continuation of its genetic code. The analogy for a learning community is for its knowledge base, tools, approaches, practices, and values to continue in some form. Online communities are a means to help preserve and continue the interests, knowledge and culture of a group bound by common interests.

Different parts of the ecology coevolve, changing together according to the relationships in the system (Nardi & O'Day, 1999). As people participate in the ongoing development of their ecologies on the Internet, they drive some of the technological and social aspects in the evolution of the Internet. The participants of a learning ecology are responsible for deciding how to use the tools and technologies available on the Internet, and in doing so, establish the identity and place of the technologies on the Internet. Designers of tools on the

Internet are responsible for providing useful and clear functionality, but they do not complete the job (Nardi & O'Day, 1999). It is left to the users of these tools to integrate them into their own context of use that make sense for them. Learning ecologies provide the context of use of tools as well as content available on the Internet.

3 Ecology of Information Production, Access and Consumption

Aggregate behaviour within an information space such as the WWW is seen an "information ecology" (Card, Robertson & York, 1996). The participants in such an information ecology are the producers, gatherers, and consumers of information. We study the rules of behavior and the relationships between variables in the information ecology to learn how to maximize the ecology, for example, by gathering more information at lower cost (Guzdial, 1997). Ecological models of the WWW are being developed, for example, that describe when pages are created or deleted, and when they are accessed (Pitkow & Pirolli, 1997). When information is accessed or consumed by participants for the purpose of learning or knowledge advancement or performing or acting upon, the information ecology becomes a learning ecology.

Ecological theory focuses on populations, not individuals, and on the dynamics of the relationship between populations and environment. A ecological system has variables {x,y,z,...}, relationships {a(x+z), ...} and dynamics such as attractors and manifolds. If we look at the Internet as an ecology, then in terms of variables, we understand that anyone can become an author, and contribute content to the WWW. This may take the form of sending emails, creating and uploading web pages, contributing to discussion groups or chat forums, participating in communities of interest, and others. Relationships comprise the links, relevance evaluation, aggregation, and search, which relate the contents created by authors. Authors of content can create the linkages from their content to other content, for example, web pages can be linked to other web pages, and messages may contain URLs. Such web content may be rated with relevance ratings, and catalogues of web content can be created such as Yahoo.com. Once the web content is on the WWW, search engines will be able to index such content and include them in future searches.

The dynamics comprises content design and delivery mechanisms. Good content or designs are copied instantaneously, or at the upper end - at the speed of light. The Internet as a medium makes this possible. Contrast this with the print medium where information transfer is several orders of magnitude slower. Once content is posted or uploaded to the WWW, the gatherers and consumers of the content can access them immediately. And of course, on the Internet, digital content feeds many unlike in physical ecological systems. The exponential growth of the WWW is expedited by the increasing availability of delivery mechanisms, which make it easy for anyone to be a producer of content. Delivery mechanisms includes free hosting services for websites, email accounts, personal organizers, groups, etc.

One attempt to maximizing the ecology is the effort to develop software application frameworks and approaches to enable true interoperability of learning systems on the Internet. The perspective is not to see learning systems functioning as an independent island among an ever increasing base of online learning content and service providers, partners, suppliers and competitors (Singh, 2000). There is a need to move from creating and delivering large training courses toward creating learning content objects that can be reused, searched and modified independent of their delivery mechanism. A growing consensus is growing around an object-based approach to constructing content for online delivery. The concept is based on chunking content into reusable components and developing methods to create instructional sequences. Such "componentization" of the content provides several benefits: from the development perspective, reusability decreases the time and cost of content development; from the delivery perspective, a higher level of individualization is possible by "late binding" or personalization of curriculum with individual needs and interest (Singh, 2000). Technologies like XML (Extended Markup Language), a standard format for Internet data information exchange, make possible the meta-data tagging of content objects. If a planned or de facto standard indeed arises for reusable educational objects, products and services will grow to harness such opportunities. This will stimulate substantial growth in the use of the Internet for delivering learning.

From another perspective, if we view learning as knowledge advancement, learning is a form of intellectual foraging. Learners forage for "food" on the Internet. This metaphorical food suggests good information, data and knowledge, which can promote learning. Some consume good knowledge and produce better knowledge. Others consume bad knowledge and suffer ... Can we extend the analogy further? How do foragers learn

what are good and bad food? How do foragers pass this knowledge on to other members of their clan? Herein lie opportunities for designing and using technologies and tools to provide such mechanisms to support this process and improve the ecological balance. For example, while paper publishing is a one-way medium, the web is different. A consumer of web content can invariably tell the author of the contents what he thought.

Ecological systems exhibit the herd principle: when searching for sustenance, follow the track of others. Recent work has looked into the capture of the interaction history and the notion that the work done by past users can be important to helping current users solve problems such as navigation in a complex information space. For example, map and trail mechanisms are created on top of hypertext systems or WWW by designers for guidance or pedagogical purposes. They include: Scripted Documents, which are top-down created artifacts to assist in navigation (Zellweger, 1989); WebWatcher, a tour-guide agent for the Web (Joachims, Freitag & Mitchell, 1997), and Walden's Paths, a K-12 educational application of scripted paths (Furuta et al, 1997).

Metadocuments are higher-level structures that link information related by topic or interest. Tools based on this concept include IBM's Aqui (http://www.aqui.ibm.org), Web rings (http://www.webring.org), and Footprints (Wexelblat & Maes, 1999). Recent developments have now enabled any user, not just the designer, to script and create these map and trail mechanisms (see, for example, Third Voice at http://www.thirdvoice.com).

A personification of a natural law is "Nature abhors a vacuum." Would it be the same on the Internet? Any published content on the Web would like to draw a ready audience but it is not always the case unless the content is linked from existing web resources, and there are easy and effective ways of accessing the content. A discussion forum or a chat tool open to the public can draw some form of participation but the organizer of such forums would like to draw productive participation instead of nominal or frivolous participation. "Build it and they will come" is a philosophy that will not work for attracting traffic to your contents or portal or learning community unless there are strategies in attracting traffic and bringing them back again (Hagel & Armstrong, 1997).

4 Ecology of Representations

An ecology has diversity through its participants. This provides resilience and feedback on the contributions made by any participant. We now discuss the notion of diversity now just from participants but by the representational forms of knowledge. Many representational forms can be used for learning on the Internet thus creating a kind of ecology of representations.

Looking at the Internet as a learning ecology in terms of representations, the variables are the representations freely available to all users. Relationships comprise the various design patterns for content creation. The dynamics involves leveraging on the combinations of representations to deliver the messages.

The Internet, as a new medium for learning, is the first medium that respects multiple forms of intelligence: textual, visual, abstract, musical, social and kinesthetic (Brown, 1999). There is now a plethora of media now available on the Internet: streamed video, images, and text that provide multiple ways of expressing ourselves. There are effective ways in which these different media augment each other. A representational learning ecology, populated by many different representational kinds including visual and verbal ones, respects multiple forms of intelligence. For example, there is a place for text verbal representation, as witness the success of many text-based MUDs and MOOs in supporting communities of learning.

The medium plays an important role in terms of the affordances for visual and verbal representation. An audio stream provides for a linear exposition, while a text stream allows for more introspective reading where you can go back to previous portions of the text. Video by itself is a visual medium, but it does not provide for active engagement and interactivity. The development of Internet technologies has shifted heavy use of verbal representations on the Internet (initially with text, and later graphics and voice) to more visual representations (videos, etc). Visual and verbal representations augment each other. We can use verbal text tools to annotate not just web pages, but visual streamed media. In this way, visual tools provide the richness of context, while textual tools allow the formulation of discourse, which focuses on particular aspects of the

context. Conversely, visual tools are often used to animate or depict what the participant wants to communicate (as researchers, we would grab the nearest napkin to illustrate our ideas quickly). Augmenting representations through annotations add more context to the main representation or message.

One of the effective ways of fostering learning is by fostering conversation. A learning conversation is more likely to revolve round a co-production of an insight around a joint activity (Brown, 1998). On the Internet, we can use or design tools to support these joint activities. Conversation is not just language, but also multimodal and multimedia in form. Visual tools for representation expand the range of representations beyond *linear* speech & writing, and support the creation of knowledge *in situ*. On the Web as a learning platform, verbal tools leverage on our capacity for conversation while visual tools provide a focus for conversation.

A diversity of different representation forms is now possible in the new learning ecology. The coupling of different representations in innovative ways allows the creation, capture and sharing of knowledge that supports effective learning, and respects multiple ways of knowing and multiple intelligences. We can now present multiple perspectives of a phenomenon, and we can build and provide rich representations of situations, simulations and phenomenon.

Consequently, we propose the law of foraging for optimal representations: the forager is attracted to the representation that provides the highest information yield at the lowest access cost. The advent and pervasiveness of portable devices make possible information access at any time. With the right bandwidth and at the right cost, you can have rich representations such as video and other complex media. With lower bandwidths and at lower cost, you can get a digest or summary or surrogate version of richer representations. Herein lie opportunities for adapting presentations to suit the bandwidth, the display device, the cost and the type of consumer. Content sites are offering their own products, such as quick updates beamed to small handheld computers and cell phone screens and subscriptions to longer versions of articles and other features.

5 Ecology of Experiences

A more recent model of the Internet is Pine and Gilmore's notion that we have moved beyond a service economy to an "experience" economy (Pine & Gilmore 1999). In the business sector, all business must orchestrate memorable events for their customers. Pine and Gilmore explain the difference between service and experience: "When a person buys a service, he purchases a set of intangible activities carried out on his behalf. But when he buys an experience, he pays to spend time enjoying a series of memorable events that a company stages – as in theatrical play – to engage him in a personal way". Pine and Gilmore argues that for any compelling experience, there should be elements of entertainment, educational, esthetic and escapist, the design of which would invite participants to enter and to return again and again. As McLellan (1999) observes, Pine and Gilmore's model of the experience economy provides an excellent starting place for educational institutions to plan how to capitalize upon their valuable experience assets in cyberspace.

We look at a learning ecology in terms of the providers of education experiences, the space and the props, and the consumers of the experiences. If we think about providing educational experiences on the Internet, we need to think about the design of the entertainment, educational, esthetic and escapist elements (McLellan, 1999). McLellan notes that organizations like PlanetAll (http://www.planetall.com) seek to capitalize on the lasting experience value of higher education in cyberspace by helping alumni network with each other and shared continued experiences such as travel and enrichment opportunities.

Digital stories is another compelling metaphor for the experience economy (Atchley, 1999). It involves the gathering, creation, sharing and acting out stories. The learning ecology involves the provision of tools for authors to create the space, props and stories, and the provision of the space for participants to actively participate and immerse into the digital stories.

6 Conclusion

The ecology metaphor helps us understand the phenomenal growth of the web as well as its dynamics. Applying the ecology metaphor to learning on the Internet is a complex endeavour. It is more than an

information ecology as the chain does not stop when the user accesses and receives relevant information. We also need to consider whether learning occurs, what and how is being learned, and how information and knowledge are processed, used, applied and internalized in the user.

In this article, we articulate the dimensions of diverse participation, information production and consumption, representations and experiences that pertain to a learning ecology on the Internet. An ecology perspective to studying Internet learning enables analysis at a high level of abstraction by studying aggregate relationships and behaviours. Such an understanding can suggest successful learning designs, and to inform designs of technologies and tools for online learning.

As the WWW expands, and Internet technologies and services develop and proliferate, new theories of information and learning ecologies can be expected to develop. As we further understand the learning ecologies of the Internet, we can better design and use these facilities in order to facilitate learning, and to help design activities and tools that foster learning communities as learning ecologies.

References

[1] Atchley, D. (1999). Digital storytelling. Presentation at the Consumer Electronics Show, Las Vegas, as quoted by McLellan (1999).

[2] Beer, M. (1999, Dec. 12), Content makes comeback on Web, *San Francisco Examiner*.

[3] Brown, A.L. (1992), Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings, *Journal of the Learning Sciences*, 2(2), pp. 141-178.

[4] Brown, J S.B. (1998), Leveraging the Web For Creating Learning Ecologies, keynote talk at International Conference on Computers in Education, Beijing, China, http://www.apc.src.ncu.edu.tw/apc/ppt.html.

[5] Brown, J.S.B. (1999), Learning, Working & Playing in the Digital Edge, Address to the AAHE 1999 Conference on Higher Education.

[6] Card, S. K., Robertson, G. G., & York, W. (1996). The WebBook and the Web Forager: An information workspace for the World-Wide Web. In M. J. Tauber (Ed.), *CHI96 Conference Proceedings* (pp. 111-117). Vancouver, BC: ACM.

[7] Conklin, J., Ellis, C., Offermann, L., Poltrock, S., Selvin, A. and Grudin, J. (1998), Towards an Ecological Theory of Sustainable Knowledge Networks, http://www.gdss.com/ecology.html.

[8] Davis, J. R., & Huttenlocher, D. P. (1995). Shared Annotation for Cooperative Learning. In J. L. Schnase & E. L. Cunnius (Eds.), *CSCL '95 Proceedings* (pp. 84-88). Bloomington, IN: Lawrence Erlbaum and Associates.

[9] Edwards, D. & Mercer, N. (1994), Reconstructing Context: The Conventionalization of Classroom Knowledge, *Discourse Processes*, 12, 91-104.

[10] Furuta, et al. (1997), Hyptertext Paths and the WWW: Experiences with Walden's Paths, Proceedings of the 8th ACM Conference. New York ACM Press.

[11] Guzdial, M. (1997), Information Ecology of Collaborations in Educational Settings: Influence of Tool, http://guzdial.cc.gatech.edu/papers/infoecol.

[12] Hagel, J. & Armstrong, A.G. (1997), *Net Gain: Expanding Markets through Virtual Communities*. Cambridge, MA: Harvard Business School Press.

[13] Hewitt, J. & Scardamalia, M. (1997), Design Principles for the Support of Distributed Processes, http://csile.oise.utoronto.ca/abstracts/distributed.

[14] Joachims, F. & Mitchell (1997), WebWatcher: A Tour Guide for the WWW, *Proceedings of IJCAI 97*.

[15] Lakoff, G. & Johnson, M. (1980), *Metaphors We Live By*, Chicago: University of Chicago Press.

[16] Lave, J. & Wenger, E. (1991), *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press.

[17] Maes, P. (1999), Very Personal Computers, in Peter J. Denning (ed), *Talking back to the machine: Computers and Human Inspiration*, Copernicus, New York: Springer-Verlag.

[18] McLellan, H. (1999), Online Education as Interactive Experience: Some Guiding Models. *Educational Technology*, September-October 1999, pp. 36-42.

[19] Morrison, D. & Collins, A. (1995), Epistemic Fluency and Constructivist Learning Environments, *Educational Technology*, 35(5), 39-45, reprinted in B.G. Wilson (ed) Constructivist learning environments. Englewood Cliffs NJ: Educational Technology Publications.

[20] Nardi, B.A. & O'Day, V.L. (1999), *Information Ecologies, Using Technology with Heart*, MIT Press.

[21] Pine, A.J. & Gilmore, J.H. (1999), *The experience economy: Work is theatre and every business is a stage*. Cambridge, MA: Harvard Business School Press.

[22] Pitkow, J., & Pirolli, P. (1997), Life, Death, and Lawfulness on the Electronic Frontier. In S. Pemberton (Ed.), *CHI97 Conference Proceedings* (pp. 383-390). Atlanta, GA: ACM.

[23] Scardamalia, M. & Bereiter, C. (1994), Higher Levels of Agency for Children in Knowledge-Building: A Challenge for the Design of New Knowledge Media, *Journal of the Learning Sciences*, 3(3), 265-284.

[24] Singh, H. (2000), Achieving Interoperability in e-Learning, ASTD Learning Circuits, March 2000, http://www.learningcircuits.com/mar200/singh.html.

[25] Stefik, M. (1997), *Internet Dreams – Archetypes, Myths and Metaphors*, Cambridge, MA: MIT Press.

[26] Vygotsky, L.S. (1978), *Mind in Society: the development of higher psychological processes*, Harvard University Press, London.

[27] Wexelblat, A. & Maes, P. (1999), Footprints: History-Rich Tools for Information Foraging, CMI '99 Conference Proceedings, New York: ACM Press.

[28] Zellweger, P. (1989), Scripted Documents: A Hypermedia Path Mechanism, Proceedings of the 2nd ACM Conference on Hypertext, New York: ACM Press.

What can we Learn from the Systems we Build? From Providing Support to Students to Providing Support to Teachers

Pierre Tchounikine* and Daniel Luzzati
LIUM
**Université du Mans - Avenue Olivier Messiaen*
72085 Le Mans Cedex 9
FRANCE
Email: Pierre.Tchounikine@univ-lemans.fr

Computer scientists involved in the field of learning systems must study the implications within individual and social behaviors of theoretical and technical advances. In particular, integrating learning systems within real classes supposes their acceptation by the social context, i.e. not only the students, but also the "human" teachers. We will present two research projects of the LIUM lab. that correspond to very different approaches of constructing learning systems and we will study what the teachers' role is within these types of systems. We will investigate how these systems are viewed by human teachers and discuss what lessons can be learned from these projects in order to facilitate the acceptation of new technologies within the social context. We will underline that while working on how to construct apprenticeship situations, a large part of our research work focuses in fact on instrumentalizing human teachers' (new) activities and providing these teachers with some support, and we will highlight how this point finds some echo within the current debates that the up-coming revolution introduced by Internet causes in traditional educational structures.

Foreword

Certain occasions give the opportunity of looking back and attempting to understand what we have done and what we are doing in order to decide where we should go. The LIUM lab (Laboratoire d' Informatique de l' Université du Mans – computer science lab of the Mans University), well known French laboratory with a fifteen years experience in developing state-of-the-art learning systems, has a sad occasion to analyze its activities: the tragic disappearance of Martial Vivet, founder and scientific leader of the lab. This paper has been written in this context and is dedicated to Martial. However, the point-of-view is that of the authors.

1 Introduction

Martial Vivet and LIUM' s credo is that computer research and educational research can and must progress together by focusing on apprenticeship with technical features. Artificial Intelligence and new technologies modify student-teachers relations. Research must be student-centered and not technology-centered and computer scientists involved in the field must study the implications within individual and social behaviors of theoretical and technical advances.

As a direct consequence, constructing Intelligent Tutoring Systems seen as a paradigm whose ultimate objective is to replace human teachers by intelligent software agents is not our objective. As other labs, we were confronted with the intrinsic difficulties of constructing such systems, i.e. dealing with curricula, pedagogic knowledge, students' models, etc. However, working "in the field" and experimenting our prototypes with real students and real teachers gave the major reason: integrating such systems within real classes supposes their acceptation by the social context, i.e. not only the students, but also the "human"

teachers. Therefore, most of the lab work focuses on using technology as a support to construct apprenticeship situations that the teachers can deal with rather than attempting to replace these teachers by autonomous systems.

Examining the current projects of the lab puts the following point into evidence: a large part of our research work focuses on instrumentalizing human teachers activities and providing them with some support. The apprenticeship situations we create require the teachers to play new roles, to tackle new activities. Expliciting what role should be played by human teachers in order to take the best from the interaction situations we create and specifying what software agents can be built in order to support these teachers are of the core problems we address.

What interested us when putting this point into evidence is how it matches the current debates that the up-coming revolution introduced by Internet causes in traditional educational structures, in our case in the French educational social micro-world. Internet impacts the system in different ways one of which is the potential globalization of the educational offer it introduces. This conducts teachers to reconsider their role, from a positive point of view ("how to use Internet as a powerful vector") or from a less positive and more existentialist point of view ("how to survive Internet impact").

We present here below two research projects of the lab that correspond to very different approaches of constructing learning systems: Croisière, a pre-commercialized Web based distance learning system that teaches French as a foreign language, and RoboTeach, a commercialized environment for micro-robotic activities. We discuss what the teacher role within these types of systems is, how they are viewed by human teachers and what lessons can be learned from these projects that can help us to facilitate the acceptation of new technologies within the social context. Note that our reflection is based on how the LIUM research activities are connected to the French social context. However, we believe that some of the ideas presented here can be useful from a more general point of view.

2 Croisière[1]

Croisière is the result of a collaboration between the LIUM and the CNED (Centre National d' Enseignement à Distance), the French national operator for distance teaching, as one of its very first full-size (2200 multimedia pages, approximately 120 hours of activity) Web-based self-instruction course. The system aims at teaching "French for foreigners", the pedagogical objective being to enable students to develop communicative skills rather than grammatical competence.

Fig 1. A Croisière module

[1] The Croisière project is managed by Philippe Teutsch (LIUM).

BEST COPY AVAILABLE

Croisière is specified as a (Web-based) environment that proposes a set of activities and human tutoring. The teaching strategy has been developed by didacticians that have explicited the different types of competencies to be addressed (conversation, listening, exchange, writing and lecture). For every competence a set of activities has been constructed and structured. Fig. 1 presents an example of an exchange module. First, the student is presented with a support-text, its translation and its recording. The second part of the module is a questionnaire that the student must complete according to his understanding of the support-text. Depending on the activities students deliver different productions such as questionnaire answers, text selections or open sentences. Part of these productions (e.g. predefined questionnaires) are managed automatically by the system and part of them (e.g. open sentences) are sent to a human tutor.

Constructing a system such as Croisière is standard state-of-the-art. From a technical point of view, current Web-page generators allow an easy integration of text, image and sound materials. In order to facilitate the construction of new courses the modules are generated using predefined frames and a data-base that contains the different materials. The overall conception of the system is based on a very classical approach of a virtual class: students are provided with educational material and a set of activities to tackle on their own. Every student is (virtually) connected with a tutor he can contact or, from another point of view, a tutor manages a set of individual students. Tutor-student communication is made available through standard E-Mail. Communication between students is not taken into account by the system (we are not in a collaborative paradigm). The most important feature of Croisière environment is in fact its very careful and proven didactic approach.

Within a system such as Croisière, the tutor's role is first of all to correct some of the students' productions. Learning French definitely requires students to produce open sentences, and an understanding (and correction) of such (often erroneous) productions is not in the scope of automatic natural-language understanding current state-of-the-art. The second aspect of the tutor's role is to follow the student progress within the set of activities and provide a first-line support. The tutor-role thus remains indispensable. However, what can be noticed is that such activities are pedagogically poor and do no not valorize the tutor, they correspond to what we can call general guidance and cross-information support.

3 RoboTeach[2]

RoboTeach is an open learning environment developed as the result of several years of research and experimentation within the micro-robotics paradigm, which has proved to be a paradigm that allows creating interesting apprenticeship situations. A micro-robot is typically an articulated arm built from different components (e.g. motors, translation axis or electric contactors) and directed from a computer through a dedicated interface. Students work in groups of two or three. They are asked to perform tasks such as directing pre-assembled micro-robots, assembling a micro-robot from plans or specifying and constructing a new robot from a technical directive book. In fact, the micro-robotic activity is a playground to address different-register competencies: dexterity and precision; problem solving; understanding of technical figures; French expression (explicitation, verbalisation); group work, collaboration and cooperation, social interactions ; space and time organization. In addition to its use for teaching technology, RoboTeach can thus be viewed as a support environment for a teacher who wants to use micro-robots as a paradigm for project pedagogy.

RoboTeach framework proposes a course environment (electronic course books that provide the necessary technical notions), an interface for the students to describe the robot they are working on and a programming environment to define and run the robot control programs. These interfaces have been carefully studied with a multidisciplinary team (pedagogues, teachers) and experimented "in the field" in order to avoid unnecessary difficulties (e.g. syntactical aspects of the robot programming). The environment can be used in different ways by teachers according to their objectives and to their will to invest themselves. When using ready-to-use sequences of activities (e.g. "study these electronic books, construct this robot, define a program that makes the robot put objects from place-1 to place-2"), the teachers' role is to introduce the activity and provide technical assistance.

However, the environment also enables the teachers to create new sequences of activities, modify electronic books or create large-scale projects such as designing new robots.

---

[2] The RoboTeach project is managed by Pascal Leroux (LIUM).

Analyzing how RoboTeach is used in classrooms allows the identification of how the teacher intervenes and what problems he has to deal with when supporting a set of groups. From a general point of view, teachers are often overloaded by different groups seeking urgent (although often unnecessary) help. From a technical point of view, teachers manipulate the robot, test the programs or analyze students' previous actions in order to identify the problem. From a pedagogic point of view, analyzing the group work is of course a matter for pedagogic interactions (and the difficulty of managing different parallel groups a good argument to ask students to be autonomous).

RoboTeach is currently being re-designed in order to support collaborative work through Internet. From a pedagogic point of view, the idea is to define large scale projects (design of a complete robot and its control programs from a requirement list) tackled by a team composed of different groups distributed over different distant classes. The objective is the classical "learning to cooperate and cooperate to learn". Students get involved in different activities such as general analysis (processed by the team), decomposition of the robot into different modules (processed by the team; each group gets in charge of a module), planning the activity (processed by the team; an agenda is defined in order to synchronize the different groups' activities), robotic activities (processed asynchronously by the groups: use of RoboTeach to perform the group-task, group-documentation and team-documentation). The different activities are instrumentalized by specific tools: agenda editor, shared-document editor, asynchronous communication tools (dedicated E_Mail and Forums), synchronous meeting tool (cf. Fig. 2).

Distance, of course, causes new tutoring problems. As an example we will point out the team-management and the group-management aspects. Group management (i.e., dealing with students located in one class) is an activity that already existed in the standard RoboTeach. From the point of view of managing the process, the tutor's role is slightly different from the "local project" context as the tutor has to deal with the overall team organization. From the point of view of managing technical problems, things are very different according to whether the group is managed by a local human tutor or by a distance tutor via Internet (which is currently a project under work). Team management (i.e., dealing with the different groups) is a new distance activity. The general objective of the team manager is to facilitate the collaboration between the different groups. This can be tackled through both the synchronous and the asynchronous groups and team activities. For instance, Fig2 highlights how the team manager (Sébastien) intervenes in the synchronous meeting in order to approve the proposition of one of the groups.

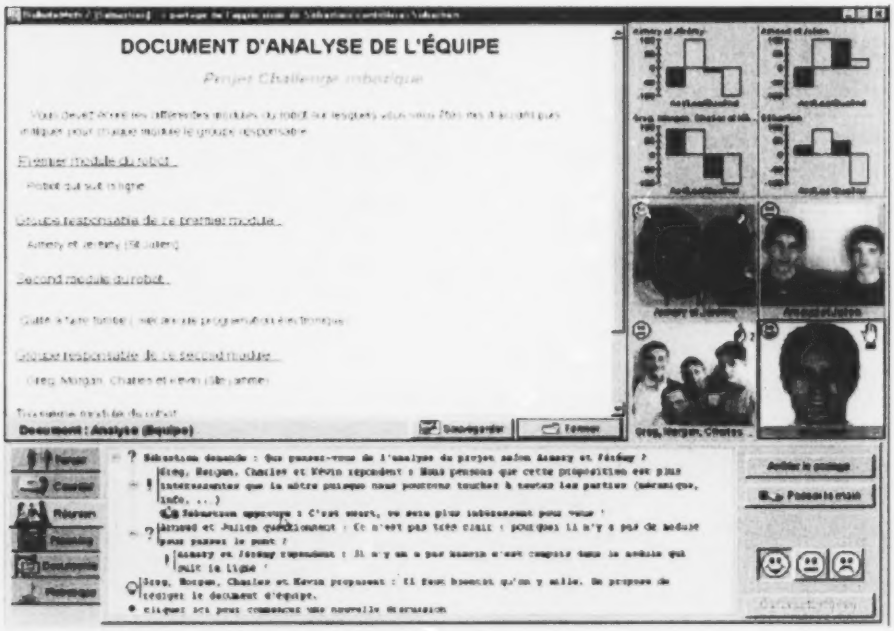


Fig 2. A synchronous meeting with RoboTeach

BEST COPY AVAILABLE

4 Matching research activities with human teachers' will

While Artificial Intelligence seemed to be a promising technology that will change the face of education, its impact is in fact minimal. Unexpected difficulties (mainly caused by a bad understanding of the problems to be tackled) is part of the reason. Another part is how AI has been viewed by real "in-the-field" human teachers: complicated, useless and psychologically difficult to admit ("you want to replace me by a computer ?"; "thirty years of experience modeled by a simple graph ?"). Internet is seen very differently and, principally, as a positive technology that vehicles notions such as freedom, communication, access to knowledge everywhere by anybody, etc. In any case, teachers are convinced that, positive or not, they will have to deal with Internet.

However, when it is the time for a large-scale introduction of Internet-based systems, more negative points of view reappear. As an example, what is discussed and how it is discussed in the context of the introduction of new technologies for open and distance learning within the French University system reveals how Internet impacts the system. Specialists involved in the domain explain what can be done, how Internet permits distance learning, new pedagogic situations (..) and being competitive on the educational market. If many teachers adhere with enthusiasm to such an evolution, many others focus exclusively on the last argument ("being competitive on the educational market ") and what it implies: the good old world (students need competencies to have some work, University provides competencies, therefore, students come to University) is a lost world. This "ideal" vision resisted the fact that other (for instance private) institutions provided some competence as long as this alternative offer remained limited. But Internet gives some consistency to the *cliché* of the very rich very competent international University based anywhere in the world that provides worldwide students with an excellent teaching system and renders all the other Universities obsolete. Moreover, diplomas are no longer the national Universities' prerogatives as (for instance) the European construction already permits diploma cross-reconnaissance (as an example, the UK Open University currently award diplomas to students residing in France). In other words, education is an industry and many teachers suddenly realize that they are in a competitive world, that it is here and now, that it concerns their competence and their job.

5 Socially viable systems

As what we are discussing here can be considered as far away from pedagogic problems, we will recall our credo: computer scientists involved in the field must study the implications within individual and social behaviors of theoretical and technical advances. As said before, AI was supposed to render human teachers obsolete and useless, but nothing happened. From this point of view, Internet appears as socially much more dangerous.

The impact of Internet on educational societies is of course very contextual. In the French and European context, how Internet is seen as a potential danger cannot be disconnected from the current movement against the generic notion of "globalization" as it appeared for instance in Seattle when all sorts of organizations protested against the World Trade Organization's trade policies. Many people worldwide and especially in Europe and France promote alternative models of society. Within this general context, a parallel is made between farmers fighting against genetically modified products or use of hormones and teachers fighting against an international Internet-based educational offer, i.e. education viewed and promoted as a product independent from the cultural specificities, human-human relations, etc. Note that such points of view also find some echo within the educational-systems users.

In such a context, it is not surprising that many teachers (and students) do not feel very comfortable with approaches such as Croisière. The explicit argumentation is concerned with the intrinsic educational value of such systems. The implicit idea is bound to the fact that a very little set of tutors can manage a very large number of students. On the contrary, a system such as RoboTeach is seen very differently as it makes the most of the intrinsic and un-automatizable capacities of human tutors. In other words: some systems appear as more "socially viable" than others. Note that not only the intrinsic nature of the system (standalone teaching system vs learning environment) participates in the way the system is socially viewed, the considered domain also has some influence: people are more prone to accept automated systems dedicated to robotics than to a culturally connoted domain as a foreign language.

We will not discuss the effectiveness of such points of view (although it would be an interesting discussion), what is important is that we have to deal with such a context.

6 Supporting teachers: an educational and social requirement

Introducing new technologies in classrooms requires making computers accessible and enabling the teachers to take the best of them. Forgetting this latter aspect conducted to the failure of many programs. Therefore, institutions attempt to make teachers aware of what can be done with computers. Such an objective is addressed for instance by national programs such as the US Department of Education International Society for Technology in Education "NETS for Teachers" project, that is devoted to "preparing tomorrow's teachers to use technology" on the basis of a national consensus on what teachers should know about and be able to do with technology[3].

On the other hand, we must of course attempt to build systems on the basis of socially situated analyzes of how teachers really use computers. For instance in France a recent study pointed out that "education is less concerned by ready-to-use software than by software that can be customized by their users according to their own conception of what they must teach and how they must teach it"[4]. From this point of view, a system such as RoboTeach appears as perfectly adapted.

However, we have to deal with the fact that RoboTeach-like systems are time -consuming, money-consuming and teacher-consuming projects and that less adapted systems and systems that allow very little latitude to the tutors (e.g. Croisière) already exist and will proliferate. We must thus consider all the different types of systems and not only the ones that correspond to our will.

As we do not work on Intelligent Tutoring Systems but on learning environments that teachers/tutors can deal with, what we point out is the difference between stock and service. Stock, i.e. providing high quality educational material, is no more the prerogative of human teachers. Internet allows anybody (if economically solvent) to be presented with high-quality materials produced by national or private business institutions. Service, i.e. providing a positive context, interacting with students, exploiting situations to provide a constructivist education (etc.) remains human teachers' prerogatives and they are issue of teachers' creativity.

Systems such as RoboTeach expect tutors to play a pedagogically rich role. They are viewed positively because they are based on the intrinsic and un-automatizable capacities of human tutors. However, this can become a weakness if using such systems requires "specialized" tutors. We believe that we have to work to make these systems economically viable. For this purpose, we have to design and construct support systems that will help "basic" teachers to make the best of such systems.

Systems such as Croisière theoretically only require a very simple tutoring, The quality of the educational material and the didactic structure they are provided with are supposed to be sufficient to enable the students to manage by themselves. However, we believe that we must study how we can build systems dedicated to the tutor that present him with a synthetic view of the students' actions and behavior. First, because this will valorize the tutor role and facilitate the social acceptation of such systems. Second, because it will help tutors to manage their basic tutoring tasks. Third, because we believe that human tutors' natural inclination is to invest themselves, to invent new unexpected ideas, new educational services or new roles as soon as they are put in a valorized situation. Tutors provided with synthetic information will go further than a simple "cross-information" tutoring. This is particularly important for domains such as learning French as the tutoring activity has to take into account the social and cultural specificities of the students.

In other words, we believe that integrating in educational systems functionalities that are explicitly dedicated to supporting the human teachers who have to deal with them participates both to the "social" acceptation of the technology and to its best use (the "social" aspect being a prerequisite to its best use). This must be achieved both for "well-fitted" systems and with others, with the objective to make teachers aware of the difference between stock and service.

---

[3] http://cnets.iste.org/index3.html

[4] http://www.industrie.gouv.fr/observat/innov/rntl/groupeb2.htm

7 Problems to be addressed

In a system such as RoboTeach, the fact that the tutor role is pedagogically rich renders the support functionalities a sine-qua-non condition. The general problem is that of the tutor's overload, that requires automatizing part of the support currently provided by human tutors in order to allow them to focus on their core role. For instance in the distance learning RoboTeach version we have two types of tutors, the group tutor (in the distance group tutor configuration) and the team tutor. Of course, what comes first in mind is the technical point of view, i.e., how to manage distance group tutoring. A distance group tutor cannot manipulate the robot and the environment must thus provide the information he needs (in our current work we address the problem with a multi-agent spying architecture). However, the technical aspect is only part of the problem. For instance, within RoboTeach a teacher is no longer a "stock" of technical micro-robot technology but a team or a group manager. This is not what he has been trained for and he must be helped while achieving this task. Moreover, using RoboTeach in a distance context requires the teacher to manage new inputs (what the spying agents can grasp) and to interact through new media. For instance, one of the roles of the team manager (Sébastien in Fig. 2) is to help the different groups to take the best of their synchronous discussion. For this purpose, the tutor has to highlight his position towards the different groups' discussion (approval of an idea, etc.). This is instrumentalized within the environment by the fact that the forum is structured according to a typology of language acts that are supposed to facilitate the students' collaboration. Human tutors should be supported to achieve such a complex activity. For instance, the tutor should be presented with a pedagogically dedicated view of the group actions, robot state and first line software agents actions. If we cannot neglect the technical problems, what is crucial is in fact the identification of what the information that is needed by the teacher is, how it should be synthesized and presented to the teachers and how these teachers can intervene.

In a system such as Croisière students are supposed to manage on their own. They learn by doing individual actions (in this case, reading texts, listening to audio, looking at videos, etc.) and being aware of their activity (in this case, evaluating themselves by answering questions and producing texts). As real students do not necessarily deal with sufficient auto-organization abilities, the tutor's role is mainly to provide them with some organizational and cross-information support. Automatizing such a support (e.g. building a software companion that explains how to use the system, orientates towards additional educational material, presents other students' answers or provides some guidance through the different activities) appears as technically tractable. The core difficulty is to identify what data is meaningful for the human tutor in order to facilitate additional pertinent interventions, i.e. provide a synthetic view of the student course and actions.

In both cases the problem is to dissociate what can/must be taken in charge by first line automated agents and what can/must be delegated to the tutor, i.e. to construct models that mix automated and human tutoring. While constructing these models we have to take into account both "social aspects" and "technical aspects" (what can be grasped from student-action spying, how the tutor's actions can be mediatized). Of course, things are easier to take into account when inventing systems proposing pedagogically rich roles than when attempting to permit humans to add additional services to systems designed without this objective. This is why we have to accentuate our work towards designing support systems for such contexts.

References

[1] Leroux P., Vivet M. (2000). Micro-robots Based Learning Environments for Continued Education in SMEs. The Journal of Interactive Learning Research, Special Issue on Media Technology for the further Evolution of Learning Paradigms (under press).

[2] Vivet M., Beacco J.-C., Teutsch Ph., Gueye O., Di Giura M., Tauzer-Sabatelli F. (1999). Croisières: Le Français pour débutant sur Internet. Deuxièmes Entretiens Internationaux du CNED, Poitiers Futuroscope (under press).

The role of emotional agents in Intelligent Tutoring Systems

Claude Frasson

Many attempts have been made in Artificial Intelligence for reproducing human behavior or reasoning, adding believability and humanism. Recent works have shown the importance of emotions for including a human-like perception. Emotions are particularly important in Intelligent Tutoring Systems that try to reproduce the behavior of good teachers. They also can be integrated into social learning systems to reproduce reactions between learners or between learners and teachers. Emotions play an important role in the learning process and new strategies have to take into account this human factor for improving knowledge acquisition. Intelligent agents can help in this process, adding emotional behavior to believability of their actions. This talk discuss some main orientations and results in emotional agents that can strengthen the social interaction in a learning environment. We show in particular how to represent and quantify an emotional status, as well as a means to guess the learner's emotional state.

Web Portfolios: Tools for Monitoring and Assessing Learning Process

Gwo-Dong Chen

Portfolio is a purposeful collection of student work that exhibits the student's effort, progress, and achievement. By adopting portfolio assessment in a web learning system, web portfolio not only contains learning activity log recorded by web server in web log but also portfolio submitted by students that represent their learning process, learning result, and learning evidence. Thus, web portfolios provide enough information for teachers to (1) make decision for applying learning strategies, (2) be aware of student performance, and (3) model student learning performance by analyzing student portfolios. However, the web portfolio is too big and unorganized for a teacher to handle in achieving the above-mentioned tasks. Thus, tools are built for providing information to assist teachers in performing the tasks.

Keywords: portfolio, assessment, student model

Can And Should Teaching Systems Mimic Human Teachers?

Benedict du Boulay

In the 1980s Ohlsson offered a critique of ITSs and ILEs in terms of the limited range and adaptability of their teaching actions as compared to the wealth of tactics and strategies employed by human expert teachers. The purpose of this paper is to examine how far that critique still holds true. One of the promises of ITSs and ILEs is that they will teach and assist the learning process in an intelligent manner. Historically this has tended to mean concentrating on the interface, on the representation of the domain and on the representation of the student's knowledge. Systems have attempted to provide students with reifications of the domain and of the learning process as well as optimally sequencing and adjusting activities, problems and feedback to best help them learn that domain. Of course, we now have embodied (and disembodied) teaching agents, computer-based peers, and a much greater interest in collaborative activities and tools to support that collaboration. Nevertheless the issue of the teaching competence of ITSs and ILEs is still important, as well as the more specific question as to whether systems can and should mimic human teachers. Are we in any better position in modelling teaching than we were in the 80s? Are Ohlsson's criticisms still as valid today as they were then? This talk will review progress on understanding human expert teaching and in developing systems that embody those human teaching tactics, referring in passing to work carried out at Sussex: for example, on responding effectively to the student's motivational state, on contingent and Vygotskian inspired teaching strategies and on the plausibility problem. This latter is concerned with whether tactics that are effectively applied by human teachers can be as effective when embodied in computer tutors.

Human activity in learning societies

Robert Lewis
Professor of Knowledge Technology,
Information Systems and Services, University of Lancaster,
Lancaster LA1 4YW. United Kingdom.
Email: r.lewis@lancaster.ac.uk

This paper suggests a framework for thinking about the themes of the Conference — learning societies, creativity, caring and commitments. The focus is on human activity but this has to be placed in the context of what is meant by a learning society and what might be the motivations and intentions for change in such societies. An interpretation of Activity Theory is used to identify insightful foci for the complexity of issues — *pedagogical, social, technological* — that influence human activity. An analysis of the context of working together, either collaboratively or cooperatively, makes a clear and important distinction between the two. This becomes important as human activity in undertaking tasks passes through various stages over time, and the focus of the immediate task changes. Information and communication technology may promote and support change but how can these tools be managed and their value exploited for the benefit of all members of society?

Keywords: **Activity theory; Collaboration; Cooperation; Human activity; Learning communities**

1 Introduction

It is first necessary to establish what we mean by the term 'learning societies' and for this it is helpful to draw on the notions of *learning organisations* developed in the management literature and extensively reviewed by Easterby-Smith and colleagues (1999).

However, caution is required as learning organisations may be *intentionally* created in order to capitalise on knowledge within an organisation and hence to improve its competitivity. For this reason, there is an explicit intention, an explicit goal, and, whilst this has social implications, it is the latter that may be predominant, yet implicit, in a learning society.

Quite often organisations are propelled into action by a failure or a threat that has arisen. Is this the case in society at large? Why are we concerned at this moment? Perhaps one clue arises from the foci of creativity, caring and commitment that suggest that there is a lack of these features in the way that society is developing. To many in society, child labour, the excessive emission of greenhouse gases, oil pollution of the seas and international trading in weapons are a few of the many ills of present society.

As mentioned earlier, learning organisations are being created in companies, often from the top, but with the explicit *intention* of bringing about change. Learning societies will be created only when social *intentions* are made explicit and are accepted. As educationalists, it appears to us that to enhance learning might change social attitudes and bring such regrettable actions to an end. Perhaps information technologies have a role to play but this can be the case only when explicit intentions are established.

In order to help us think about the complex dimensions that make up society, we need a framework that temporarily isolates the various parameters of human activity and this will now be explored.

2 Human activity

Activity is rarely carried out individually. Groups or teams work together to achieve a goal and the skills of individual members are brought together for this purpose. In the area of cognitive development, the classical notions of Vygotsky are helpful.

One may consider that the knowledge of an individual has a central core which is 'owned' by the individual, who is able to use that knowledge in the autonomous performance of tasks. Surrounding that core is a region (the zone of proximal development — zoped) in which the individual has some knowledge, but needs help in performing tasks which depend upon that knowledge. It is important to stress that Fig. 1, which is an attempt to represent this perspective, should not be viewed as a physical model. Core knowledge is not just that which is internalised but represents the 'system' (other people and artefacts) in which people function as asserted by the distributed cognition approach.

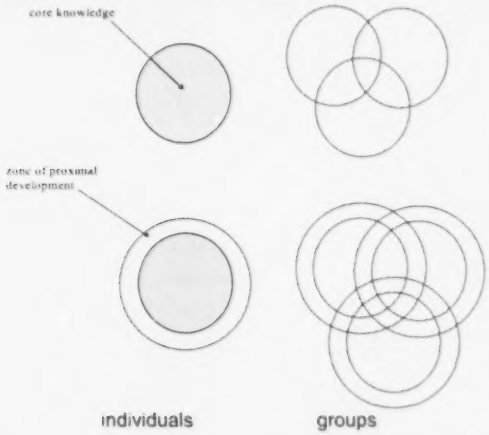


Fig. 1. Core knowledge and zones of proximal development (from Lewis, 1995)

As suggested by Fig. 1, when a community of humans is considered, some parts of each person's core knowledge overlap those of others and, most importantly, one person's 'zoped' overlaps with the core knowledge of others. From this model one might conclude that the collective core knowledge is, not surprisingly, greater than that of an individual but also that each person can support cognitive development in the group by providing 'scaffolding' for others in domains where their knowledge is not yet available for autonomous use. Recent research (reported by Schwartz, 1995) supports this view through the analysis of the performance of pairs of learners. It is suggested that (in certain circumstances) the performance of dyads is much better than would be expected from the simple addition of each individual's performance.

This collective potential can be realised only if each member of the community is aware of the knowledge of others and can capitalise on that by offering and receiving help from the others. To be effective, the group working together must appreciate that the knowledge of the group does not reside in individuals but is distributed amongst them — the term 'distributed cognition' is sometimes applied to this situation though the term is broader and includes artefacts. Schwartz (*op cit*) suggests that the creation of abstract representations (rules or visualisations) is a key to collective problem solving; for example, students who drew sketches to represent the problem they were attempting to solve together were more successful than those who did not do so. The act of drawing the rough sketches formed a common representation of the problem, which is how they created a mechanism for the 'construction of shared representation'.

This viewpoint argues strongly for the design of learning environments in which learners, by making their knowledge explicit and visible to others, can become engaged in undertaking a common task and solving a common problem.

However, there is more than one way of 'working/learning' together and the distinctions are very important. Two terms often used are *collaboration* and *cooperation* and there is a significant difference between the two. There are many definitions of these terms, for example:

> "Collaboration is the process of shared creation: two or more individuals with complementary skills interacting to create a shared understanding that none had previously possessed or could have come to on their own." (Schrage, 1991)

The nature of cooperation has also been expressed in the following way:

> ". . . the term 'cooperative' is the general and neutral designation of multiple persons working together to produce a product or service. It does not imply specific forms of interaction or organisation such as

comradely feelings, equality of status, formation of a distinct group identity, etc." (Bannon & Schmidt, 1991)

Some clarity emerges if the notions of Activity Theory are invoked. A key dimension in this theory is the concept of 'intention of action'.

Cooperation depends upon a supportive community of actors who agree to help one another in activities aimed at attaining the *goals of each person* involved. *Collaboration*, on the other hand, depends upon the establishment of a common meaning and language in the task which leads to the community setting *a common goal*.

This last point is emphasised by Littlejohn and Häkkinen (1999) who acknowledge various definitions in the research literature but note that: "*. . . there is a consensus amongst researchers that collaboration involves the joint construction of meaning through interaction with others and can be characterised by a joint commitment to a shared goal.*"

One way to illustrate the distinction is to take the example of a team of people wishing to write a book (Fig. 2). They may decide, having established the scope of the chapters, to allocate the responsibility for each chapter to one member of the team. In the way the term is used here, that means they will *cooperate* in the production. On the other hand, they may decide that everyone will contribute to all the chapters — that is, they will *collaborate* in the production.

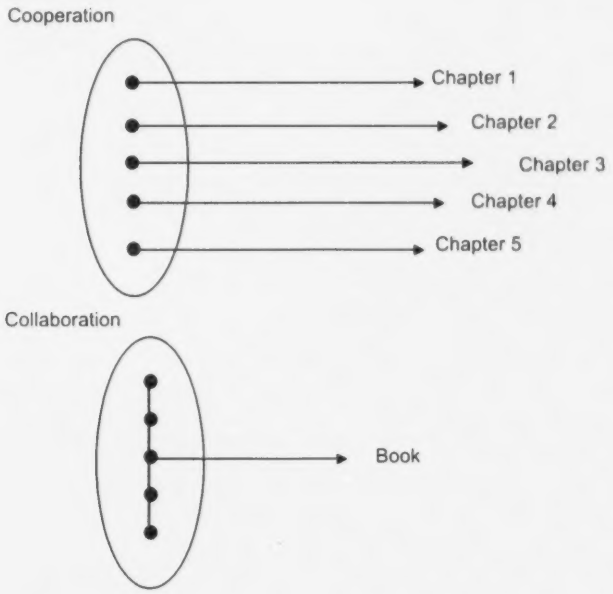


Fig. 2. Cooperation or collaboration in writing a book.

To what extent might learners establish common intentions with others (so that they might collaborate) and to what extent might learners accept that their peers have different intentions (and yet still see benefits in cooperating)?

Before beginning to answer that question, it must be stressed that the case for 'learning together' may be more an 'act-of-faith' than a well-proven and tested mechanism. The situation is well summarised in the following conclusions to a paper which reported on problem solving and peer interaction:

> "Nobody should suppose on the basis of (existing) studies that truly collaborative work is going to provide a panacea for education. Indeed, rather exacting conditions may need to be met before it proves possible at all. However, it seems likely that a better understanding of the mechanisms at work in such

interactions may make it possible to improve significantly upon this aspect of educational practice and the potential benefits are considerable." (Light & Glachen, 1985)

3 Stages of activity

Linard (1995) described Leontiev's (1978) and Von Cranach's (1982) three hierarchical levels of human processes, each of which are related to a type of object. These levels may be interpreted as follows.

- The *intentional level* is oriented toward motives: needs, desires, or values. It is the level of global orientation that gives meaning to human processes.
- The *functional level* is oriented to specific, conscious goals in the context of motives. It is the level of focused organisational, planning and problem-solving processes in order to achieve a final goal or intermediate goals.
- The *operational level* is oriented to the practical conditions of actions which are a prerequisite to the conscious, purposeful actions at the functional level.

The intentional level provides context for the functional level, which in turn serves as a focus for the operational level. The framework is flexible, however, in that the level of a particular activity depends on the task; for example, developing an internal communication and management structure may be quite routine for one research group, but a challenging activity for another.

An important characteristic of the framework is its dynamic nature, in that human processes may move from one level to another as a result of 'frustrations' relative to their objects. 'Frustrations' or contradictions may be the result of external factors changing. For example — continuing the illustration above — if a problem is met in the practical routine of organising the community's communication (operational level), strategies for adapting the communication structure may be needed. Therefore a new goal is formulated, and the focus of human action moves up the hierarchy to the functional level. Once the new routine is agreed on, the action may take on an operational character again.

Contradictions may also result from the interconnectedness of webs of activities in real-life situations (Kuutti, 1991): each community member participates in multiple activity frameworks, including multiple communities, and developments in one activity framework may influence and lead to contradictions in others. The shifts in the focus level of human activity could, for example, follow the changes indicated in Fig. 3.

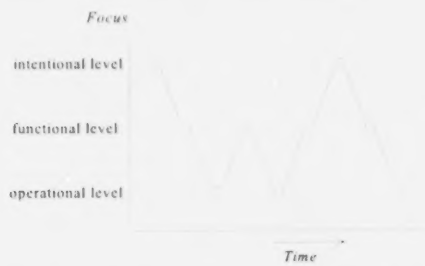


Fig. 3. Over time, the focus of human activity is at different levels.

Contradictions or 'frustrations' are thus a source for development on all three levels (Kuutti, 1991). In addition, this development provides human activity with *intentionality and history* which serve as a context for understanding human processes (Kaptelinin, 1996). Hence, Activity Theory provides a rich and dynamic perspective on human activity including team work in distributed working and learning communities.

4 Activity theory

Activity Theory (AT) has its origins in the Russian tradition of socio-historical approaches some 70 years ago and can be characterised by a combination of (a) objective, (b) ecological, and (c) socio-cultural perspectives on human activity (Kaptelinin, *op cit*, p. 107). The basics and the applications of AT are very well described in a recent book (Nardi, 1996) and only certain elements will be outlined here. Kuutti (1996, p. 28), inspired by Engeström (1987), represents the structure of an activity in the diagrams below. Figure 4 includes an individual's actions to achieve an object where the action is *mediated* by artefacts (tools) and Fig. 5 extends

that to a community context with the addition of rules and divisions of labour.

Fig. 4. Mediated relationship at the individual level (after Kuutti, 1996)

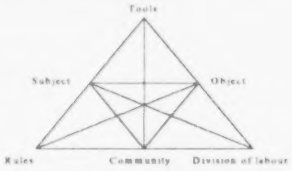


Fig. 5 Basic structure of an activity (after Kuutti, 1996)

A narrative for Fig. 5 could be: an individual (subject) is helped by tools to achieve an objective (object) and may accept rules to work in a community which contributes to the object through a division of labour. From such an activity there is an outcome.

Another notion contained in AT is that of hierarchical levels:

activity — action — operation

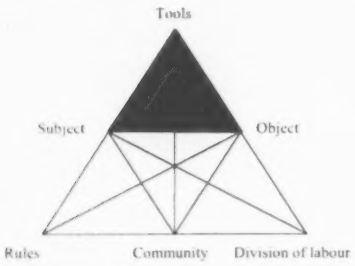
An activity (global) may be achieved through a variety of actions, and the same action may be used as a contribution to different activities. Similarly, operations may contribute to a variety of actions. Kuutti (1996, p. 33) uses a simple example of these levels when the activity (motive) may be 'building a house' in which 'fixing the roofing' and 'transporting bricks by truck' are at the action level; and 'hammering' and 'changing gears when driving' are at the operation level.

5 The framework in action

Activity Theory points to critical features of effective working communities and it is constructive to consider ways in which they can be applied to create frameworks for distributed communities. The nodes of Fig. 5 form a possible structure for analysis (see also Lewis, 1997 and 1998).

Attempts to consider all the relationships influencing human learning activities are likely to fail due to the multitude of interdependent parameters but it may be that the complexity can be constrained if various triads of nodes taken from Fig. 5 are examined one at a time. Some of the triads include 'community' and these may help to focus on creativity, caring and commitments. Papers from the ICCE99 proceedings will be used to illustrate how the triads may help such focusing.

5.1 Subject-tools-object



When analysing the papers in ICCE99, it is clear that most of the reported research is concerned with developing tools which allow a 'subject' to achieve a learning 'object'. The panel at that conference discussed verbal and visual tools (Okamoto, 1999).

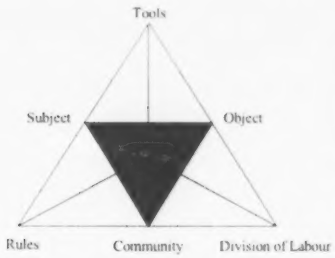
> "The goal of this panel is to debate on human activity, communication skills, methods of (self-) expression and logical thinking ability, in the context of the new growing Internet society." (p. 80)

Major sections of the conference were devoted to topics such as agents, intelligent support, web resources and interactive learning environments all of which are in effect simply tools to support a subject to attain a (learning) object. The creation of such tools may also require tools such as authoring systems for the creation of materials for learning and it can be argued that the training of teachers can also be viewed as the development of (human) tools which are used by students in the process of their learning.

However, the main theme of this paper is on society which comprises a variety of communities and it is the triads that include 'community' which will be explored. It is worth remembering though that the 'subject'

may be an individual or a group (a community) and that communities are often members of other larger communities; also, that an individual will surely be a member of different communities. When considering both these structures, it is necessary to rethink the nature of the most appropriate tools to be used.

5.2 Community-subject-object



This triad focuses on how 'subjects' reconcile personal goals so that these lead to actions to support a community. Can a common goal become established? An activity emerges or is set up with a number of intentions. In a community this requires the establishment of a 'common language' amongst all members who come to be *committed* to a shared, explicit motive (object). In other words, the actions cannot be set along predetermined lines; there must be space for interpretation, negotiation and the establishment of both individual and group ownership of the motive. Watabe and Yuze (1999) draw certain conclusions relating to *creativity* from their experiment with students working on projects as individuals or in small groups.

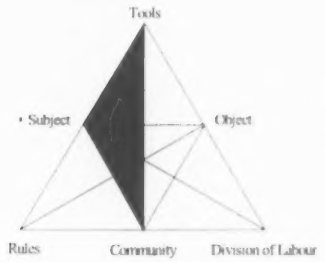
"a) In collaborative learning, the subjects could hit upon such new ideas as they would never reach if they thought by themselves. This enabled them to see a problem from another point of view. On the other hand, in individual learning, a subject tended to stick to his/her idea, which made it difficult to change his/her standpoint.

b) In collaborative learning, the idea was deepened as they discussed it. For example, when a subject was reading an article about a case and was wondering why that had happened, the others thought from various angles and tried to find out answers. The subject accepted the explanation they offered and then a new problem was proposed. Through these successive events, the discussion was deepened and spread. On the other hand, in individual learning, subjects did not hear others' opinions and therefore they seem to reach their conclusion before thinking deeply." (p. 176)

Ang and colleagues have identified the establishment and maintenance of common goals as a critical feature of collaboration:

> "In order to collaborate with other members of the learning community, members must be able to agree on some shared goals for the community. The goals will help the members to stay focused and also assess whether they are achieving what they set out to do. Members must be able to negotiate meanings and not just accept what was said. Otherwise it becomes an information exchange without construction. (Ang, *et al.*, 1999, p. 604)

5.3 Community-subject-tools



This triad is concerned with how tools are selected in order that they support, equally, all members of a community. It draws attention to the personal skills of members, some of which are social as they relate to capitalising upon available help from peers and tutors (seen in this context as 'tools'), and to skills in the use of the technological tools available. If community activity is to have full participation, communication tools should be selected which are accessible to and easily usable by all members.

Returning to intentional learning communities: it is clear that tutors play a key role, not only in being instrumental in making appropriate channels freely available but in monitoring how they are being used and in taking corrective action to sustain fragile learning communities. Ogata and colleagues (Ogata *et al.*, 1999, p. 277) experimented with an agent which made links between groups of students working on collective tasks. They reported that "*a matchmaker agent took the burden of the work instead of the teacher.*" Nakamuru and colleagues (Nakamuru *et al.*, 1999, p. 685) also experimented with individual

and group agents; they included a difference model to assess the variations of opinion between members of a group.

This triad of nodes also extends to include the design of groupware — software designed for group communication, shared workspaces, the collective editing of documents, etc. The focus in this triad is on the *subject(s)* rather than on the object. The constraint of ubiquity referred to above is critical.

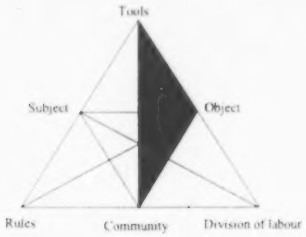
Watabe and Yuze (*op cit*) also comment about the limitations of the synchronous communication system used in their experiment:

> "In collaborative learning, even when a subject finished reading part of the screen, he/she had to wait until the others would finish with it because they shared the lesson material window. It was also necessary for a subject to get the assent by partners to go to the following subject (topic) during discussion." (p. 175)

Svensson and Östlund (1999) report on the value of the bulletin board system that they made available in a department:

> "The communication that took place on the SQ-board bare the mark of a novel cybergenre. The content of the e-Quality genre has two different strands. On the one hand it is focused on a rich discussion about intended quality issues, (i.e. services and education) and on the other hand there are clear traces of the community building process." (p. 696)

5.4 Community-object-tools



This triad draws attention to how tools (for example, hypermedia materials) may be designed and used so that they support the achievement of the *object* of the community. How well do they support the achievement of the community goals? The interpretation of tools in Activity Theory needs to be made explicit.

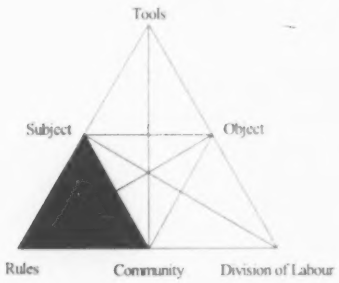
"An activity contains various artefacts (e.g. instruments, signs, procedures, machines, methods, laws, forms of work, organisation). An essential feature of these artefacts is that they have a mediating role." (Kuutti, 1996, p. 26)

Buiu and Aguirre (1999) are concerned with this triad as they consider the requirements for an intelligent user-interface (IUI):

> "The purpose of the research reported in this paper is to study advanced issues in this area of IUIs with learning capabilities. The main problem concerned is that of designing and technically realizing interfaces that make human-computer interaction easier and more effective and make complex co-operational relationships easier to grasp. The application domain we have chosen is collaborative problem solving." (p. 301)

This triad also draws attention to the fact that the definition of the object by a community will be influenced by the availability of specific tools. AT is concerned with the whole environment and so this formulation should include human artefacts: those people who are not a part of the community of learners (for example, tutors, gurus) but who may provide considerable 'mediation' in the tasks being performed.

5.5 Community-subject-rules



This triad centres on the protocols of interaction. How do 'subjects' establish rules for their interaction? The simplest example of this in the context of groups using communication technology is the meaning of 'no reaction' when a proposal is made (by email or in a conference) to take a certain decision. At a face-to-face meeting, the interpretation is usually accepted as agreement; in an electronic interaction, some ambiguity remains unless the reaction is explicitly defined in the interaction protocol. How the protocols are established relates to the role of individuals in the community and their expectations of others and of themselves.

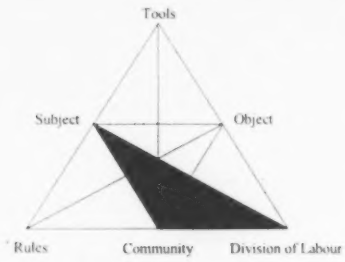
Svensson and Ostlund (*op cit*) clearly have this issue at the heart of the experimentation that they report. Despite the valued overall outcome of community building, it is not clear how well the protocols of interaction were established or shared in any explicit way.

> "The Community-aspect that is represented in all thread categories points to a set of tacit and shared norms, stating what can and cannot be done on the board. These norms surface when being tested, challenged or violated, often resulting in corrective remarks." (p. 695)

Nowhere in a learning context is the agreement about rules as critical as in the assessment of learners' knowledge. Bhattacharya and colleagues (Bhattacharya, *et al.*, 1999) have experimented with a system for collaborative evaluation during problem-solving activities. It is clear that the 'rules' for assessment must be negotiated with the learners as there is self and peer rating as well as teacher rating.

> "These three ways of rating have been adopted to assess a board range of skills, including effort, self-directed learning, group cooperation and communication skills. Use of ratings from peers and teachers is based upon the belief that co-workers are in a good position to evaluate each other. Use of self rating is congruent with problem-based learning's emphasis on judging the state of one's own knowledge as an essential element of the learning process." (p. 181)

5.6 Community-subject-division of labour



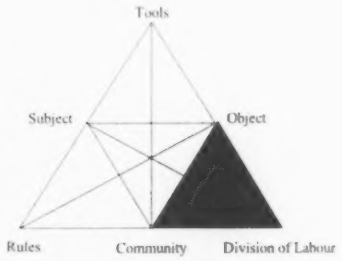
This triad focuses on how a division of labour is established and maintained in order to be effective. It is when thinking about this issue that the question of intentions arises and highlights the question of whether the group is to work through cooperation or collaboration. During cooperation, the object of each member of the community might be different but achievement of the common goal is attained through a certain division of labour with other members of the community. During collaboration, a different division of labour is necessary to ensure that the capitalisation of individual skills reinforces the clear ownership of the global, shared task.

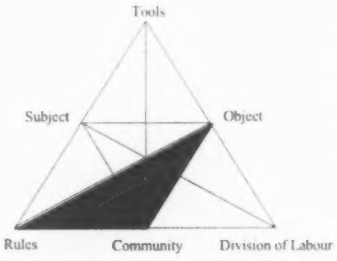
Ang and colleagues (*op cit*) consider this area in their conceptual framework:

> "Cooperative work is accomplished by the division of labour among participants. Members have different talents and skills. For example, some members may be better at web page design, while others may be better in content knowledge. The tasks can be divided such that there are multiple ways for members with different skills to participate." (p. 604)

It is important to be aware that the nature of the activity will change over time (Fig. 3) and so both the rules/protocols and division of labour will need to alter. This dynamic nature of activity is a topic that Engeström (*op cit*) has examined in very interesting ways.

5.7 Community-object-division of labour/rules





The left-hand triad focuses on the object of the community, making the members of the community secondary to the achievement of the common object. It is in strong contrast to the previous triad in which

members' wishes and satisfaction were paramount. However, only in an authoritarian regime could (in theory) an individual's motivation be ignored. Again, the distinction between working and learning on shared tasks may be important.

The concern of the right-hand triad is how rules (protocols) support the community to meet their common goal. Again, the 'subjects' take a secondary role; it is rules which allow the attainment of the object which are paramount. However, rules can be established which are seen by the members of a community to be supportive in the achievement of common goals and individuals may accept certain rules unwillingly but for the common good.

These last three triads demand a full consideration of the organisation of the group. Both the rules and the division of labour form the management structure of the community and, again, this will need to change as the nature of the task varies. For example, in setting up a community to undertake an activity, it will be necessary to begin with a very democratic structure so that each person 'owns' the task in hand. At a later stage, it will probably be most efficient to allocate specific responsibilities to one of the group, maybe establishing a protocol in which each member takes it in turn to lead the group for a period of time. Two possible structures may be illustrated by the communication pathways shown in Fig. 6.

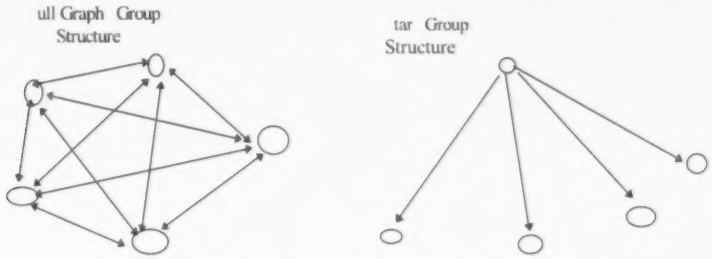


Fig. 6. Communication in two possible group structures

This theme emphasises a major distinction between working and learning communities. In the former, a member may take on a minor role which matches his/her competence or availability to devote time to the activity. In a learning community the task must be capable of subdivision such that every member can contribute (in time and impact) equally. This is very difficult to achieve especially when some members may have greater commitment to the task and be able to offer more than others and yet all are to be assessed on the same basis. This also raises the issue of how the assessment is to be undertaken when it may not be transparent who contributed what to the common task.

6 Conclusions

No single theory or framework can be expected to cover the highly complex domain of human activity in complex, changing societies. However, the examples given in this brief paper do illustrate that some of the complexity can be unravelled by the use of this interpretation of Activity Theory.

Of the set of concerns which this Conference is exploring, I'm afraid it is that of *caring* that I have failed to weave into this 'story'. There were just a few papers at ICCE99 that touched upon disadvantaged learners, learner satisfaction and environmental issues, but perhaps during ICCE2000 this situation will be remedied. The theme clearly falls within the 'community-subject-object' triad which also includes creativity and commitment. Perhaps caring as such cannot be isolated from creativity and commitment to other members of society. I look forward to hearing more on this topic during ICCE2000.

References

[1] Ang, D.B.S., Chan, H.C. & Lim, J.L.H. (1999) Learning Communities in Cyberspace: A Porposed Concentual Framework. In *Advanced Research in Computers and Communications in Education Vol. 1* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 600-607. IOS Press, Amsterdam.

[2] Bannon, L.J. & Schmidt, K. (1991) CSCW: Four characters in search of a context. In *Studies in Computer Supported Cooperative Work* (eds. J.M. Bowers & S.D. Benford) pp. 3-16. North Holland, Amsterdam.

[3] Bhattacharya, M., Tanagisawa, M. & Akahori, K. (1999) Internet Based Collaborative Evaluation of Learning in a PBL Environment. In *Advanced Research in Computers and Communications in Education Vol. 2* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 181-184. IOS Press, Amsterdam.

[4] Buiu, C. & Aguirre, G. (1999) Learning Interface for Collaborative Problem Solving. In *Advanced Research in Computers and Communications in Education Vol. 1* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 301-303. IOS Press, Amsterdam.

[5] Easterby-Smith, M., Burgoyne, J. & Araujo, L. (eds.) (1999) *Organizational Learning and the Learning Organization*. Sage Publications, London.

[6] Engeström, Y. (1987) Learning by expanding. Orieta-konsultit, Helsinki.

[7] Kaptelinin, V. (1996) Activity theory: Implications for human computer interaction. In Context and consciousness: Activity theory and human computer interaction (ed. B.A. Nardi) pp. 103-112. MIT Press, Cambridge, MA.

[8] Kuutti, K. (1991) Activity theory and its applications to information systems research and development. In *Information systems research: Contemporary approaches and emergent traditions* (eds. H.-E. Nissen, H.K. Klein & R. Hirschheim) pp. 529-549. North-Holland, Amsterdam.

[9] Kuutti, K. (1996) Activity Theory as a Potential Framework for Human-Computer Interaction Research. In Context and consciousness: Activity theory and human computer interaction (ed. B.A. Nardi) pp. 17-44. MIT Press, Cambridge, MA.

[10] Leontiev, A.N. (1978) Activity, consciousness, personality. Prentice Hall, Englewood Cliffs, NJ.

[11] Lewis, R. (1995) Editorial: Professional learning. *Journal of Computer Assisted Learning*, **11**, 4, 193-195.

[12] Lewis, R. (1997) An Activity Theory framework to explore distributed communities. Journal of Computer Assisted Learning, 13, 4, 210-218.

[13] Lewis, R. (1998) Apprendre conjointement; une analyse, quelques expériences et un cadre de travail. *Hypermédias et Apprentssages 4*. 11-28. INRP et EPI, Paris.

[14] Light, P. & Glachan, M. (1985) Facilitation of Individual Problem Solving through Peer Interaction. *Educational Psychology*, **5**, 3&4, 217-225.

[15] Linard, M. (1995) New debates on learning support. *Journal of Computer Assisted Learning*, **11**, 4, 239-253.

[16] Littleton, K & Häkkinen, P. (1999) Learning Together: Understanding the Processes of Computer-Based Collaborative Learning. In *Collaborative learning, cognitive and computational approaches* (ed. P. Dillenbourg). Elsevier Science, London.

[17] Nakamuru, M., Hanamoto, K., Tsutsumi, Y., Fukuda, M. & Otsuki, S. (1999) Models and Negotiations for Group Learning Support. In *Advanced Research in Computers and Communications in Education Vol. 1* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 677-684. IOS Press, Amsterdam.

[18] Nardi, B.A. (1996) Studying context: A comparison of activity theory, situated action models, and distributed cognition. In Context and consciousness: Activity theory and human computer interaction (ed. B.A. Nardi) pp. 69-102. MIT Press, Cambridge, MA.

[19] Ogata, H., Sueda, T., Furugori, N. & Yano, Y. (1999) Augmenting Collaboration beyond Classrooms through Online Social Networks. In *Advanced Research in Computers and Communications in Education Vol. 1* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 277-284. IOS Press, Amsterdam.

[20] Okamoto, T. (1999) Visual Tools versus Verbal Tools - Towards Creating a New Learning Ecology. In *Advanced Research in Computers and Communications in Education Vol. 1* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 79-84. IOS Press, Amsterdam.

[21] Schrage, S. (1991) *Shared minds: The new technologies of collaboration*. Prentice Hall, NY.

[22] Schwartz, D.L. (1995) The emergence of abstract representations in dyad problem solving. *The Journal of the Learning Sciences*, **4**, 3, 321-354.

[23] Svensson, L. & Östlund, C. (1999) e-Quality: A Cybergenre for Quality Discussion. In *Advanced Research in Computers and Communications in Education Vol. 2* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 689-696. IOS Press, Amsterdam.

[24] Von Cranach, M. (1982) The psychological study of goal-directed action: Basic issues. In *The analysis of action: Recent theoretical and empirical advances* (eds. M. von Cranach & R. Harre) pp. 35-73. Cambridge University Press, Cambridge.

[25] Watabe, K. & Yuze, H. (1999) Evaluation of Learning through Discussion in Synchronous Collaborative Distance Learning. In *Advanced Research in Computers and Communications in Education Vol. 2* (eds. G. Cumming, T. Okamoto & L. Gomez) pp. 173-176. IOS Press, Amsterdam.

Towards Intelligent Media-Oriented istance Learning and Education Environments

Toshio Okamoto, Alexandra Cristea and Mizue Kayama
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5620; Fax: +81-424-89-6070
E-mail: {okamoto, alex}@ai.is.uec.ac.jp

The recent astonishing progresses in information technology, computer and information communication hardware and the spread of the Internet have opened a variety of new ways for many fields. Although slower than the business field to catch up with these new developments, the educational field has gradually migrated towards the World Wide Web, mostly under the slogan of free, accessable education, to and from anyplace, at anytime. This development triggered, among other effects, also the important shifting of the weight from the teaching paradigm to the learning paradigm. However, slow network speed hindered the first learning environments from being more than simple, electronic text-books. The latest trends in research are trying to go one step further, making use of increased bandwiths, and integrate various media to enhance learning. Moreover, for obtaining learner-oriented, customized learning environments, ITS and AI-ED techniques are adapted and developed for the Web. These advances promis revolutionary changes in the whole educational system of the new millenium. This paper presents these trends and progresses on one hand, but on the other hand, also addresses the dangers and pitfalls that such an avalanche of changes can bring, and stresses the responsibility we have, to make sure the real goal is never left out of sight: *enhancing and improving learning*. Finally, we show how we tackle this challenge at the Laboratory of Artificial Intelligence, University of Electro-Communications, Japan, where we have built the framework and prototype of an intelligent media-oriented integrated distance education environment.

Keywords: **Learning Ecology, Learning Environments, Distance Education, Multi-media enhanced learning, ITS**

1 ntroduction: the new trends

When in 1995 Schneider [37] was trying to define the levels of WWW use in Education, he suggested the *web as an information tool*, for distribution of learning material, and only as difficult to implement, the *web as a collaboration tool* and the *web for interactive educational applications*.

Four-five years is a long time for the net. Nowadays, opinions have changed. "If the Internet is the next industrial revolution, then net based learning may be the next educational revolution" [40]. "Colleges and Universities have embraced distance learning, doubling the number of courses offered and enrolment in them" in the US [5]. Other countries, like the initially refractory Germany, follow the distance education and wired teaching and learning path [24].

However, not all researchers and educators look favourably upon these changes in the education field. In 1996, Self predicted "a reaction against this apparent dehumanisation of the learning process" [38]. In 1997, Oppenheimer [32] criticized strongly computer in education that, in his opinion, failed to provide what they promised. Moreover, they break down, decrease creativity, teachers are difficult to train, etc. While some of the problems that were brought to light are addressed in current systems, many new problems he hasn't even

mentioned appeared. A recent survey of a distance education course showed that distance learning could lead to isolation, anxiety and frustration [16].

Adaptability and collaboration are possible answers to such problems [6], as we will discuss also later on. Moreover, it is equally important to train the teachers first, to be able to use the new technologies [30]. Although the current trend is towards more automatization, and less human interference, the human teacher will still be an important factor in education for many years to come. However, "teachers will increasingly develop new roles as technology-society mediators" [38]. A teacher's role is changing from text based teaching, to facilitating, advising, consulting, and his/her role becomes more that of a designer of the learning environment. Moreover, under the "life-long-learning" paradigm [12], learners are no longer pupils enrolled in the full-time educational system, but part-time, or one-course-only students. Learners' age limits disappear, and the backgrounds can be various (company workers, other employees beside full-time students).

Another important step towards increased learning effect and user-friendliness is the multi-media technology, and, more recently, Video on Demand (VOD). A recent survey showed that "video access would soon constitute a large percentage of WWW bytes transferred on the Internet" [3]. However, many of the new products just give in to the glitter of media, without paying attention to the educational goals. As Shneiderman [39] points out, the educator – and we may add here, also the educational software developer and courseware author - has to have "a pedagogic or curricular destination in mind" and to know that "technology is just a vehicle for getting there".

The current paper presents the three trends in education: distance learning environments (section 2), ITS systems (section 3), and Media-Oriented learning (section 4) first separately, then we discuss the benefits of their integration, pointing also to the possible pitfalls, and giving a short systematic solution about how to avoid them (section 5). Finally (section 6), we describe our own efforts at the University of Electro-Communications towards integrated, intelligent, media-oriented, distance-learning environments and the resulting system, called RAPSODY-EXT. In the end we draw some conclusions and list some yet open questions of the field.

2 Distance Learning and Education

Although the hindrances and problems in building distance-learning environments were and are still various, distance education is here to stay. "Exploring educational frontiers on the Web frightens some professors and maybe some students, but it can also generate unusual levels of motivation and pride in creating something new", says Shneiderman [39]. Many universities offer course modules, whole courses, or even degrees on-line. Moreover, many companies offer all sorts of education-oriented material and educational software via the WWW.

Generally speaking, educational courseware can be designed from scratch, in an **application-oriented** way, or built via **general purpose authoring** tools. Here, one of the new roles of teachers as courseware authors becomes clear. The final product can be built by the teachers/ course designers from scratch, or built with the help of a **commercial** product or **freeware** product.

Moreover, teachers nowadays have to be able to opt to build their own, **off-the-shelf Web course** [20] or to choose among the many **on-line course delivery tools**, like WebCT, Blackboard, eCollege.com, etc. If choosing among the latter, teachers have to decide for the best balance between developmental features, instructor tools, instructional features, student tools, technical support, administrator tools, administrative features, software costs and hardware requirements [23].

Many universities have decided to build their own authoring tools for their faculty staff ([41], [8]).
Basically, although these tools make authoring of web courses easier, one on their main problems is that they "always provide the same look and feel", whereas the off-the-shelf component software can "mimic the style of the typical classroom", according to Kaplan [20]. Moreover, integrated packages actually need more time spent in teacher training, and they don't allow enough creativity for expert users.

We, however, don't see the imitation of the typical classroom as a positive feature. We predict that this imitation tendency will disappear in time - although it may come in handy as being familiar to both teachers and students at the present development state of the distance education environments, and may help in the

transition process towards Web-based education. As many researchers noted [40], it makes no sense in trying to only create a copy of the classical education process – which might just lead to bad results, due to the fact that it would only be an incomplete copy - but it is a better approach to try to make use of the advantages which the new environment brings.

- The main advantages of distance learning over the web are, as is well known, the **from – and to any place, at any time** attributes. Often, the **free education** aspect also appears, although much of the offered educational software today is not free, and many educational institutions offer (distance) learning programs at a price.
- Plain, text-based course materials are not enough anymore. The very recent increases in bandwidth made more expression ways possible, images on the Internet are commonplace, sound tracks and videos are used with growing frequency, other **(multi-) media** types evolved (animation, etc.).
- Based on learner modelling [33], also presented in the next section, **adapting teaching strategies** and, generally speaking, **(intelligent) user adaptation** in ITS [44] are being developed. More recently, the field of adaptive hypermedia [10] emerged, at the crossroads of hypertext (hypermedia) and user modelling. *Adaptive presentation of the educational material* can mean one or more of the following: providing prerequisite, additional or comparative explanations, conditional inclusion of fragments, stretch-text, providing explanation variants, reordering information, etc. *Adaptive navigation support* can mean one or more of the following: direct guidance, sorting of links, links annotation [7], link hiding, link disabling, link removal, map adaptation, etc.
- Another main advantage of the Network is that it favours **collaborative work**, which in turn favours learning [11].
- Moreover, distance education finds a justification in the **life-long learning** concept. The recent technological changes are influencing our society, and each member of this society must acquire new knowledge all the time. The age of encyclopaedia brains, and one-time-learnt, good-for-ever educations lies now in the past. Education has to be provided for all sorts of busy people that only sporadically have time to learn, coming from many different backgrounds, with different knowledge levels and various cognitive styles.

In the following sections, we will look at ITS and user modelling and at Media-oriented education, as an answer to the rigidity of the present Web courses and courseware.

3 ITS: learner models, domain models; ITS on the Web

"Traditional ITS presents very little flexibility regarding the pedagogical strategy they use". Moreover, "ITS are usually developed following a fixed strategy that would basically apply to all learners" [2]. Also, "numerous ILE (Interactive Learning Environments) offer a variety of functionalities without taking into consideration their relevancy to the learning process" [27]. Obviously, the only reason of using ITS and/ or adaptive/ interactive methods and (intelligent) strategies should be an educational goal, e.g., faster and/or deeper understanding of the learning material, due to a more appropriate teaching method, etc. A possible user adaptation method is to switch among pedagogical strategies, also called **cooperative strategy contexts** [2].

Pedagogical strategies	Explanation
Tutor-tutee	Traditional: computer is teacher, user is student
Learning companion	A computer-simulated learner, to accompany the user [14]
Learning by disturbing	Learning with a simulated troublemaker. [13]
Learning by teaching	Human student teaches the simulated companion. [21]
Learning with a co-teacher	Both simulated teacher and co-teacher

Within these strategy contexts, direct strategies exists, such as: *Learning by examples, learning by story-telling, learning by doing, learning by games, learning by analogy, discovery learning, learning by induction/ deduction*, etc.

To switch between strategies, a **learner model** is necessary [29]. In 1996 already, Greer [15] was pointing towards the importance of taking into account the student's values; moreover, he mentioned that offering adapted activities, producing appropriate feedback, favouring communication between students and offering assistance are crucial. For the correct choice, though, the "student's values, learning style metacognition and

preferences regarding feedback" have to be appropriately inferred [27]. Ultimately, the student model has to be mapped on the **knowledge domain model**. The latter represents the model of the course contents knowledge, and is (naturally) domain dependent.

The latest student models contain a layered evaluation of the learner, starting with the classical **knowledge and cognitive model level**, wrapped by the **learning profile**, or curricula. The last wrapping layer to be added is the **believability and emotional layer**, which, if correctly interpreted, is supposed to point to the best learner-tailored pedagogical strategy [1].

The way the system acquires knowledge about the learner varies:

- The most straightforward way is via, e.g., **single/ multiple-choice questionnaires**, where the learner inputs his/her preferences, his/her opinion(s) about his/her knowledge level, learning profile, emotional profile, etc. The exact preferences of the user can be checked in an equally straightforward way via selections during the learning (e.g., pushing of button "utterance" or "question", after some text input, etc. [18]). To the same category belongs also the setting of the environment parameters, such as background color, favourite text size, color scheme, frame layout, etc.
- Another method, which can be used separately, or together with the previous, is to **test the learner**, in order to establish his/her profile. These tests can vary from knowledge tests to IQ tests or even personality tests.
- The last and most difficult of these methods is to **trace the learner's steps during learning**, and interpret the user's choices and results into a learner model [9, 22]. This learner model can then be used to select the learning strategy, etc.

The questioning and testing methods of more or less explicit ly gathering information on the learner have the advantage that the information is correct (providing the user knows him-/herself, which is not necessarily always the case). The user-model building is transparent to the learner, who can directly influence it.

As the psychological foundation of user modelling is not yet clearly defined, due to the complexity of the real human mental profile, it is therefore preferable to allow the user to exercise direct influence on the modelling, and to correct eventual misinterpretations. However, this explicit information gathering, although easier on the automatic interpretation side, is leading to a high user overhead. Beside of learning how to use the educational software, and the normal load of learning, the user has to waist a lot of time to tell the system what s/he is and what s/he wants and needs. Frequent user prompting, especially when having nothing to do with the current user focus, can lead to tiredness and even make the student give up. It is also questionable if we can call such systems "intelligent".

On the other hand, however, the implicit tracing of the user method has the advantage that it lets the user concentrate on the subject at hand and doesn't prompt him/her with numerous questions. Their problem is that, without explicit user feedback, the conclusions reached by the system might be wrong, leading to sub-optimal or even inadequate adaptation.

Therefore, it is a fine balance between these three main modelling methods that can lead to optimal strategies. As the current psychological and pedagogical research cannot give us the solution to this balance problem, it is quite possible that practical studies of educational software implementations will provide the answer, and lead not only to the progress of educational software research, but also work as a feedback into the psychology and pedagogy field. We predict that optimal solutions will imply a combination of these methods, with fine tuning between the fuzzy set of goals of *user-friendliness*, a *low user overhead* and, last but not least, *learning enhancement*.

The advantages of introducing advanced ITS user-adaptation methods in Web-based systems, as opposed to stand-alone environments, are as follows.

- Due to client-server architecture, huge servers can store material and model users from tiny client machines, making it possible to add facilities that wouldn't have had **space** on the stand-alone machines.
- Moreover, the **great number of (actual/ potential) users** on the Internet makes user modelling and interpretation of average behaviour, classifications, etc., more meaningful. New directions of user modelling include *nation – and region – oriented classification and adaptation*.
- Last but not least, the whole Internet is loaded with (potentially) useful educational material, and a modern ITS system can make use of **more than just the local data and facilities**.

4 Media-Oriented Learning and Education

Media can be used in Educational Software:

- for building **Virtual Environments** (wherein the whole learning process takes place),
- for enhancing the **user-friendly** aspect of the Educational Software, or, finally,
- for storage and presentation of **media-oriented learning material**, as opposed to text-based learning material.

Nowadays, educational software can present any kind of combination of these features. The most important aspect is, however, the correct balance, towards an improvement of the learning function.

A multitude of stand-alone media-oriented software, multimedia educational software, etc., has been developed in the past years. Recently, however, these technologies started moving towards the net. As the old saying goes, "a picture is worth a thousand words", and photographs, images, clip art on the Internet are commonplace, Shockwave, Flash technology is being used newly for more effects, audio and video have a growing role and are remodelling the "look" of the Internet in general, and the educational Internet in particular. VOD technology emerged, supported by the rapidly increasing bandwidth in WWW transfers [28, 35]. "VOD allows users to browse, query linked text and video databases, author video modules and play back the selected video over the network. This technology is likely to greatly enhance the availability of multimedia information to teachers and adds substantial value to the educational process" [17]. Moreover, systems are being developed which are able to play Multimedia on Demand (MOD) [34], i.e., not only audio and video, but also the numerous other kinds of media that exist today.

Naturally, all these developments have been reflected in the new on-line courses and courseware. Our eyes and years, in conjunction with our brain, form a formidable system that transforms sense data into information, i.e., data with meaning [36]. This is extremely beneficial especially in the education domain. Psychological studies of human attention span, distraction tendency, etc., have shown that variation in presentation is recommended in teaching. Every beginning teacher knows (or should know) that the greatest enemy of knowledge transfer between teacher and student is boredom. However, multimedia as "l'art pour l'art" is dangerous. Riley [36] argues that "'analogue' methods of teaching and learning should not be abandoned and superseded by 'digital' methods unless there are clear cost *and* pedagogical advantages to be had".

Of course, costs are maybe much easier to estimate than pedagogical advantages, which very often can be computed only experimentally, i.e., after using the proposed innovations, and such a drastic remark as the previous one may stop any kind of progress. However, where estimation or evaluation can be done, it should, and course designers and courseware implementers should not only give in to the impact of novelty.

5 Combining ITS, Media and Distance Learning

In this paper, we are predicting that the education of the new millennium will be marked by the combined intelligent, media-oriented, distance-learning phenomenon. Although research in these areas has been done more or less independently, for the emerging distance education to become effective, an inspired merge of these directions is necessary.

Following are the advantages over classroom teaching. The classical classroom teaching method is *limited in time*. (Guided) learning is possible in a *synchronous* mode only. The distance-learning paradigm is the one that can solve these problems. Moreover, a teacher has to speak so most of his/ her students understand him/ her, so s/he will always *address the average pupil*. Addressing each student separately is, of course, tailored to that respective student's needs, but this time period is very often an *idle period for the other students*. Therefore, adaptive, customized teaching environments can become superior to the standard classroom method from all these points of view. Media, on the other hand, can enhance the human aspect of the course contents, working on the believability level and smoothing the transfer from face-to-face teaching and learning to learning in front of the computer. Moreover, media presentations can come as extra clarifications, or even belong to the main contents, etc.

However, in order to enhance the learning effect in building a learning environment, one has to tackle the following questions:

- **Should it be a distance learning system?** I.e., who are the target learners, how far are they from the site? Does their spread justify the distance-learning paradigm? Do we expect an extension of our audience in time, more students from different locations? Etc. This kind of analysis should also clarify the type of distance system needed and the technical aspects of the distance system implementation.
- **Should it be an intelligent, adaptive system?** I.e., are the students very different? Do their backgrounds vary very much? Do the students belong to different age groups? Are they full-time and part-time students? Are there company workers among them? Is the subject of the course of such a nature, that different parts of the contents might be relevant to different people? Do all students have to study the whole material, or should there be alternatives, according to their needs? At what granularity should the course be presented, depending on both the predicted student attention span and smallest unit containing useful information [9]? Etc. These kinds of questions, again, don't only point to the show if an adaptive system is needed or not, but also show what kind of adaptation is necessary.
- **Should there be various media?** I.e., does text suffice for the presentation, or can we expect a better student reaction from different media? Will the media enhance the student motivation, his/ her comprehension of the contents, other learning related matters? What kind of media is appropriate, and for which part of the system (contents presentation, testing, virtual environment building, etc.)?

In the following, we will show how we proceed towards an intelligent media-oriented distance learning and education environment at the University of Electro-Communications (UEC), under the concept of life-long learning, in-service training, career development, information sharing and collaboration. The project is supported by MITI (Ministry of International Trade and Industry) and is part of a larger project called ALIC.

6 An Example: The RAPSODY-EXT project at the UEC

As we have shown as resulting from the current trends in education, nowadays it is extremely important for almost every member of the society to acquire computer communication literacy [26]. The importance of fostering and expanding teachers' practical abilities and comprehensive teaching skills, as well as company workers' IT knowledge, in the sense of life-long learning and career development, with the help of the new technologies (computers, Internet, multimedia) is stressed by many studies [42].

We have built a free and flexible self-training environment, called "RAPSODY" (Remote and AdaPtive educational System, Offering a DYnamic communicative environment). Moreover, we have extended the current framework of an individual learning support environment to an individual and collaborative learning support environment, that we called "RAPSODY-EXT". We will present a short outline of each system in this section.

Until now, when a teacher or company worker wanted to take an ITE (Information Technology Education) class, s/he had to leave the office or school. Now it is possible to learn about various subjects via virtual Internet schools. Figure 1 shows the 3-D concept of our RAPSODY framework environment [31]. Figure 2 shows how the material on RAPSODY is built by teachers or specialists, via our cell editing and authoring environment, and how the beneficiaries of this material can be various learners, accessing the system remotely from their working place or from their homes.

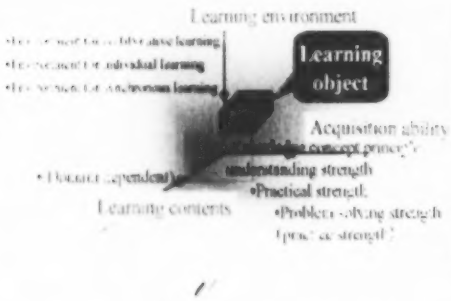


Fig.1 RAPSODY conceptual image

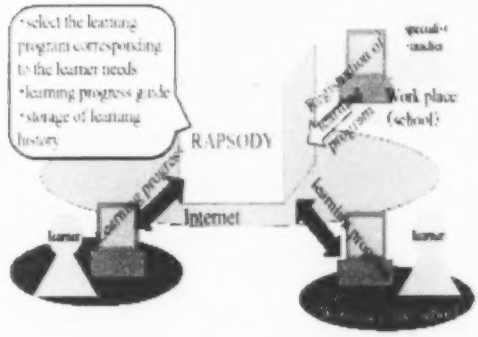


Fig.2 RAPSODY Usage Image

BEST COPY AVAILABLE

6.1 Distance Educational Model: RAPSODY

Our Distance Educational Model, RAPSODY, is built on 3 dimensions: *learning environment, learning contents* and *acquisition ability* (fig. 1). By selecting an item on each dimension, the current learning cell is determined and a cell guide script mechanism triggers the education / training process. For an instance of the RAPSODY concept (a teacher training system) and mo re details, please see our paper [31]. The prototype of our system was built, and some preliminary tests of the functioning system were performed [30]. The hybrid nature of the learning process in RAPSODY, embracing teacher training models, workplace education models and domain oriented learning models is shown in figure 3.

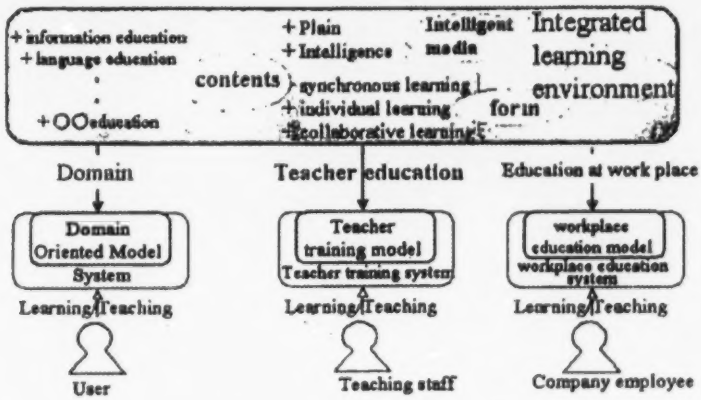


Fig.3 RAPSODY Integrated Distance Learning Model

At the present stage, the RAPSODY system has united the following systems resulting from the research at the Laboratory of Artificial Intelligence and Knowledge Computing:

- a Case Based Reasoning System for Information Technology Education [19], that facilitates the usage and sharing of examples cases of actual ITE practices, via a browsing and search module based on case similarity computation;
- a Collaborative Learning Environment based on three Companion Agents, a novice, an expert, and a facilitator [21], applied successfully on maths and physics teaching;
- a Hypermedia Navigation system [22] based on SOM (Self Organizing Maps) pre-processing and clustering features of the Hyperspace representation, followed by user modelling based on the user history and on a NN (Neural Network) teaching strategy generator, applied on Unix and Hypermedia course contents, and finally,
- a VOD-based distance teacher training system, with basic and adaptive feature search [28], allowing teachers to get familiarized with the new developments in ITE.

In a following step, the system will also integrate:

- a Qualitative Diagnosis Simulator for the SCS (Space Collaboration System) Operation Activity, supporting Mental Model Forming [29].
- an agent based, adaptive hypermedia distance CALL system for English teaching [9] and
- a discovery learning based CAD (computer aided design) system for learning basics and more about Neural Networks [4].

Moreover, the system allows access to a multitude of individual and collaborative learning tools, like a tele-conferencing environment, supporting environments for problem solving, such as Stella, CASE, distance teaching environments, such as Tele-Teaching, and so on.

6.2 Learning with RAPSODY

The main functions of the learning mechanism in RAPSODY are: identifying the **learning object** that corresponds to the learner's needs, serving as a **learning guide** with the help of a guide-script, and storing

BEST COPY AVAILABLE

the **learner's history**. The learning object is built of *learning goal(s), learning contents, learning steps* and *learning contents understanding verification method*. The selection of the learning object (L.O.) and the user feedback is shown in figure 4. The learner expresses his/ her learning needs via an input interface with various options, in this way determining a cell in the previously shown 3-D model. Based on the guide script and on expert knowledge, the appropriate learning contents is selected – if the respective cell is already pre-defined in the RAPSODY system. Moreover, based on the learner model inferred from the learning history, the appropriate learning environment is fixed. The package of learning environment and contents is then returned to the learner, who can then start the learning process.

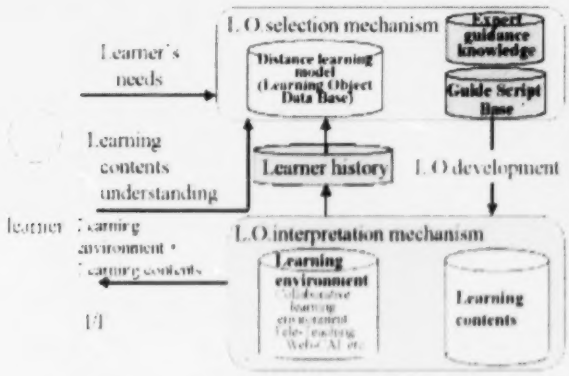


Fig.4 The dataflow in RAPSODY

Fig.5 Learning environment presentation

An example of using real-time, synchronous distance lectures from within the RAPSODY system is shown in figure 5. Moreover, chat windows for collaboration and other explanatory messages can also be seen (e.g., the lower left corner shows the information about the presenter, the university which is transmitting and the theme of the course). The figure also shows that the user can opt for VOD (asynchronous learning option).

6.3 RAPSODY-EXT: Collaborative Learning Environment Extension

The main collaborative learning extensions of RAPSODY-EXT over the previous RAPSODY system include:

- basic equipment of Synchronous /Asynchronous collaborative learning
- Synchronous /Asynchronous collaborative learning materials development facilities
- Synchronous /Asynchronous collaborative learning support function supplement

The extension of RAPSODY-EXT over RAPSODY can be seen in figure 6. The most important are the collaboration learning support tools, that have to do goal oriented work path planning, to select the tool(s) offering the common working environment, to function as a work history registration/ administration tool, and finally, to do manage results. In this way, RAPSODY-EXT becomes a remote and adaptive educational environment and, at the same time, a dynamic communicative system for collaborative learning and WWW synchronous and asynchronous collaborative learning support. Therefore, additionally to the previously enumerated characteristics of the RAPSODY system, the RAPSODY-EXT extended system also features:

- Synchronous or asynchronous collaborative learning group - or individual portfolio construction
- Collaborative activity logging in the collaborative memory
- Portfolio and collaborative memory knowledge management
- Offer of various directory information

We base many of our management function implementations on one of the strongest tools in collaborative environments, **agent technology**, which we have not gone into details about in the current paper. Beside of performing low-level management functions and communication functions, agents can build user models, infer interpretations, simulate students or teachers in the collaborative environment, therefore implying different levels of intelligent processing [11].

BEST COPY AVAILABLE

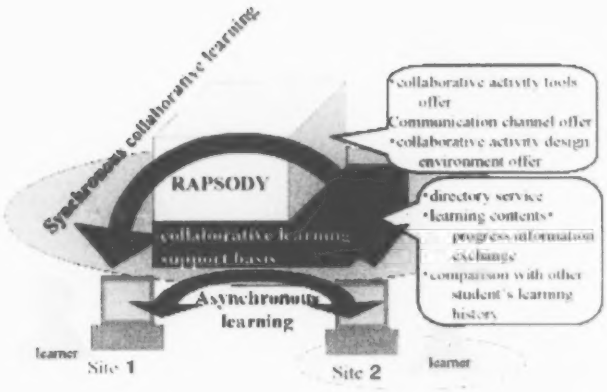


Fig.6 Collaborative Learning environment

6.3.1 Group and individual portfolio construction

In short, portfolio construction takes place as follows. Depending on the collaborative learning style (synchronous/ asynchronous), an individual/ group portfolio is created as a collection of log data about important collaborative activities. Concretely, the following mechanisms are offered: *communication message management* and *knowledge management*. The communication management function is a software acting at a higher level than the learner computer terminal and the collaborative learning management server. Depending on the learner's terminal, the learner data for communication is collected from public and shared applications, is grouped according to the communication message type (data development time stamp, learner ID, message attribute, shared application operation data, etc.) and sent to the collaborative learning management server. On the server, the communication message received from the learner computer terminal is handed over to the knowledge management mechanism. This mechanism does a structure analysis of the message received from the communication message management mechanism, and arranges and integrates the new data with the already accumulated data available in the collaboration learning management database.

6.3.2 Knowledge Management of Collaborative Learning Data

The main goals of the knowledge management in RAPSODY-EXT are to *link the information* stored in the Collaborative memory, such as the worker/learner group history and the portfolio contents to *useful knowledge* for each learner, to *reflect each learning stage*, i.e., to be able to exteriorise not expressed acquired knowledge. In knowledge management, we distinguish between the following two main categories:

Text information management, as in, for instance, *concept information extraction*: extracted concept dictionary, "on the fly" dictionary; *data mining process*: computational (frequency, mutual frequency), conceptual (topic/viewpoint, etc.); *information visualization*: task dependent (word processor, task viewer, etc.), task independent (SOM, state diagram, etc.).
Non-textual information management, as in the *mining process* via information gain machine learning methods: ID3 (C4.5), decision trees; *information visualization*: NN usage: SOM, Symbolic "map" generation.

6.3.3 Directory information

The directory information in RAPSODY-EXT has the role to offer information that accelerates group problem solving, as for example: Problem solving tools, Problem solving FAQ, Group work history, Mutual Group matters (information interchange, exchange), etc.

6.4. Resuming RAPSODY-EXT

We have presented in an extremely concentrated form some of the concepts and ideas of RAPSODY-EXT. RAPSODY-EXT is an individual/ collaborative learning support environment extension of our previous RAPSODY system [31], and stands for the networked virtual learning environment based on a three

BEST COPY AVAILABLE

dimensional representation. The aim of our system is to support teachers' self-learning, provided as in-service training, and company employees' or other learners' studies, under the umbrella of life-long learning. We have realized the foundation of the integrated distance education project and proposed a Self-Development oriented distance-learning model. This system is superior to a simple rule-based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. Our system is therefore a good example of how to integrate various media and intelligent adaptation techniques with distance learning, in a hybrid, goal oriented manner. As shown, RAPSODY already encompasses other distance education projects in our laboratory and is constantly growing. Further on, we need to extend our databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" can be brought to life. With this system, we can implement various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalised knowledge-acquisition and knowledge-sharing via communication processes, and support learning methods such as "Learning by asking", "Learning by showing"," Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining". Expected learning effects are meta-cognition and distributed cognition, reflective thinking, self-monitoring, and so on. As a result, we trust that a new learning ecology scheme will emerge from our environment.

7 Conclusion

As Fischer [12] noted, the new millenniumwill be marked by the changing of mindsets : the teacher evolving from "sage on the stage" to "guide on the side", the student switching from a dependent, passive role, to a self-directed, discovery-oriented role and by life-long learning. We have to be prepared for these changes, and intelligent, media-oriented distance learning environments are the answer we foresee.

Moreover, we have pointed out that in building such systems, the focus should always be on the learning enhancement and educational goals. Although we have made some suggestions about how to balance the usage of new technologies in view of the learning goals, and how to estimate the effect of introducing them with respect to these goals, one of the main problems with educational systems still remains the difficulty involved in evaluating them. Furthermore, there is no absolute way in which two educational systems can be compared. This field has no benchmarks or standards yet, as some researchers correctly remarked [25]. Although we view setting standards for an emerging field as potentially dangerous, as it can inhibit creativity, we can see a possible benchmarking solution in **simulated students**. Some researchers already have started using such evaluation methods. Although when built by the educational system designers themselves, by following the predicted user model, simulated students might incur tainted results, simulated learners can be useful. *A suggestion would be the design of a pool of students representing the different cognitive styles that can be used by the international research community for system tests.* This might be the answer to the evaluation problem.

As more and more human-like responses and functions are integrated into the remote learning environments, we are faced with a number of questions:

- *How much of the learning can be done solely via remote computer environments, and is there a percentage that will always need human interaction with the human teacher?*
- *How human-like, on the other hand, should these environments be?* Some new research directions go towards integrating emotions, etc. What human features should we mimic in building automatic intelligent teachers, and are there maybe features that should be better left aside?
- *Should we work towards standardization in remote, Media oriented ITS, or should we encourage diversity, as the field is still new, and with a great growth potential?*
- *How will distance learning affect the future generations and humankind in general?* Will there be more isolation? Are distance collaborative environments the answer to that? Will there be internationalisation, as the current trend seems to be? Will this internationalisation in the long run threaten the individual cultures of the different countries, regions, etc.?
- *How much are <u>we</u> modelling the future world of the new millennium, and how much is this world modelling <u>us</u>?* And, finally, and more important:
- *Are these changes actually going to improve life?*

We tried to reply to some of these questions in the current article, making some predictions and showing our opinions.

Our position is that we have to start by teaching our main teaching force, the teachers, and making them first adjust to the new challenges of the coming millennium. A trained teaching force is the one that will model

and mark the coming generations. In Japan, the whole education system is going through a revolution and is being gradually adapted to the modern IT world.

At the same time, workers everywhere should be given the opportunity to keep in touch with the new developments and have the chance to improve their career paths via various remote learning systems.

It is difficult to break with old customs on one hand, and dangerous to through away old methodologies, just because they are old, on the other. There is a delicate balance here to maintain, and education, especially, is too important to be merely fashion oriented. We have to choose carefully what to keep from the old ways, and what to change, and we have to educate the future generations to keep an open mind. In this way, we can trust they will be able to make the right choices and build on the basis we are laying out for them.

References

[1] Abou-Jaoude, S., and Frasson, C., Integrating a Believable Layer into Traditional ITS,AI-ED99,Le Mans, France (1999)

[2] Abou-Jaoude, S., and Frasson, C., An Agent for Selecting a Learning Strategy, NTICF 98, Rouen, France (1998)

[3] Acharya, S., Smith, B., and Parnes, P., Characterizing User Access To Videos On the World Wide Web, Multimedia Computing and Networking, MMCN (2000)

[4] Belkada, S., Okamoto, T., Cristea, A., Supporting Discovery Learning in Building Neural Network Models, ITS 2000, Montreal, Canada, 5th International Conference on Intelligent Tutoring Systems (2000)

[5] Blair, J., Colleges, Education Week on the Web, http: //www.edweek.org/ew/ , Jan. 19 (2000)

[6] Brna, P., Collaboration in a Virtual World: Support for Conceptual Learning?, HTI-ET 97, http: //www.cbl.leeds.ac.uk/~paul/papers/hci-et97paper/hci-et.html (1997)

[7] Brusilovsky, P., Methods and techniques of adaptive hypermedia, User Modelling and User-Adaptated Interaction, No. 6, pp. 87-129 (1996)

[8] Collis, B.: Design, Development and Implementation of a WWW-Based Course-Support System. ICCE99, IOS Press, pp.11-18 (1999)

[9] Cristea, A., Okamoto, T., and Cristea, P., MyEnglishTeacher - An Evolutionary, Web-based, multi-Agent Environment for Academic English Teaching", Congress of Evolutionary Computation CEC 2000, San Diego, USA (2000)

[10] De Bra, P., Brusilovsky, P., and Houben, G.-J., Adaptive Hypermedia: From Systems to Framework, ACM Computing Surveys (1999)

[11] Dillenbourg, P., Collaborative Learning, Cognitive and Computational Approaches, Advances in Learning and Instruction Series, Pergamon (1999)

[12] Fischer, G., Lifelong Learning: Changing Mindsets, ICCE 99, IOS (Ohmsha) Press, pp. 21-30 (1999)

[13] Frasson, C., and Aimeur, E., A Comparison of Three Learning Strategies in Intelligent Tutoring Systems, Journal of Educational Computing Research, Vol 14 No 4, p. 371-383 (1996)

[14] Gilmore, D, and Self, J. The application of machine learning to intelligent tutoring systems Teaching, Intl. Conference on the Learning Sciences, AACE (1988)

[15] Greer, J., Student modelling, Student Modelling workshop at the User Modelling Conference, Hawaii (1996)

[16] Hara, N., and Kling, R., Students' Distress with a Web-based Distance Education Course, Information, Communication & Society, also: http: //www.slis.indiana.edu/CSI/wp00-01.html

[17] Hui, S., Video-On-Demand in Education, http: //www.cityu.edu.hk/~cc-ncom/net14/vod2.htm

[18] Inaba, A., and Okamoto, T., Negotiation Process Model for intelligent discussion coordinating system on CSCL environment, AIED 97, pp. 175-182 (1997)

[19] Inoue, H., and Okamoto, T., Case Base Reasoning System for Information Technology Education, ICCE 99, IOS (Ohmsha) Press, pp. 1083-1086 (1999)

[20] Kaplan, H., Building your Own Web Course: The Case for Off-the-Shelf Component Software, CAUSE/EFFECT journal, Vol. 21, No. 4, http: //www.educause.edu/ir/library/html/cem9849.html (1998)

[21] Kasai, T., and Okamoto, T., The Support for Collaborative Learning with Companion Agents, ICCE 99, IOS (Ohmsha) Press, pp. 760-767 (1999)

[22] Kayama, M., Okamoto, T., and Cristea, A., Exploratory Activity Support based on a Semantic Feature Map, Adaptive Hypermedia Conference (AH 2000), Trento, Italy (2000)

[23] Marshall University's Center for Instructional Technology, Comparison of Online Course Delivery Software Products, http//multimedia.marshall.edu/cit/webct/compare/comparison.html

[24] Meissner, G., Closing in on Distance Learning, German institutions start to embrace wired teaching, Educom Review, http//www.educause.edu/ir/library/html/erm9914.html, Jan./ Feb. (1999)

[25] Mizoguchi, R., Ontology Awareness for Intelligent Instructional Systems, ICCE 99, IOS (Ohmsha) Press, pp. 45-52.

[26] Nishinosono, H.: A Teacher Education System for Information Education Teachers at High School Level in the Information Society. Proc. of the conference JET, pp.523-524 (1998)

[27] Nkambou, R., IsaBelle, C., and Frasson, C, Supporting some pedagogical issues in a Web-based distance learning environment, NTICF'98, Conference internationale sur les nouvelles technologies de la communication et de la formation, Rouen, November (1998)

[28] Okamoto, T., Matsui, T., Inoue, H., and Cristea, A., A Distance-Education Self-Learning Support System based on a VOD Server, IWALT 2000, Palmerston North, New Zealand (2000)

[29] Okamoto, T., Cristea, A., Matsui, T., and Miwata, T., Development and Evaluation of a Mental Model Forming Support ITS - the Qualitative Diagnosis Simulator for the SCS Operation Activity -, OZCHI 2000, Sydney, Australia (2000)

[30] Okamoto, T., Seki, K., and Cristea, A., RAPSODY: A Self/Collaborative-Learning Internet and Multimedia Distance Support Model for Teacher Training, IMSA 2000, Las Vegas, USA (2000)

[31] Okamoto, T., A Distance Ecological Model to Support Self/Collaborative-Learning via Internet, ICCE 2000 (2000)

[32] Oppenheimer, T., The Computer Disillusion, The Atlantic Monthly, http://www.theatlantic.com/issues/97jul/computer.htm

[33] Paiva, A., Communicating with Learner Modelling Agents, ITS 96 Workshop on Architectures and Methods for Designing Cost-Effective and Reusable ITSs, Montreal, June (1996)

[34] Parnes, P., Mattsson, M., Synnes, K., and Schefstroem, D., mMOD: the multicast Media-on-Demand system, WebNet 97, http://www.cdt.luth.se/publications/1997.html (1997)

[35] Peltoniemi, J., Video-on-Demand Overview, http://www.cs.tut.fi/tlt/stuff/vod/VoDOverview/vod1.html (1995)

[36] Riley, F., Understanding IT: Developing Multimedia Courseware, http://www.keele.ac.uk/depts/cs/Stephen_Bostock/docs/mmauthor.htm

[37] Schneider, D., and Block, K., The World-Wide Web in Education, ANDREA, Vol. 2, No. 5, June 12 (1995)

[38] Self, J., The Development of the Computer Based Learning Unit: A Discussion Document, http://cblslca.leeds.ac.uk/~jas/discussion.html (1996)

[39] Shneiderman, B., Educational Journeys on the Web frontier, Teaching your students where to go and how to get there, Educom Review, http://www.educause.edu/ir/library/html/erm9861.html

[40] Synnes, K., Parnes, P. , Widen, J., Schefstroem, D., Net-based Learning for the Next Millennium, SCI/ISAS99, Florida, USA. (1999)

[41] Teletop, http://teletop.edte.utwente.nl/

[42] UNESCO Report: World Declaration on Higher Education for the 21 Century Vision and Action, Paris (1998)

[43] Salvador, L. G.: Continuing Education Through Distance Training. ICCE99, pp. 512-515, IOS Press (1999)

[44] Woods, P. J., and Warren. J., Adapting Teaching Strategies in Intelligent Tutoring Systems, ITS 96 Workshop on Architectures and Methods for Designing Cost-Effective and Reusable ITSs, Montreal, June (1996)

Research on Internet Addiction: A Review and Further Work

Chien Chou

The purpose of this article is to review studies on Internet addiction since 1996, including empirical studies conducted in Taiwan. The first part discusses definitions, terms used, and assessment criteria. The second part reviews published research findings on Internet addiction focusing on these issues: (1) Internet usage and time, (2) problems related to Internet addiction, (3) gender difference in Internet addiction, (4) Internet addiction and social-psychological factors, and (5) Internet addiction and attitudes toward computers. Also covered is a discussion on future research directions.

Keywords: Internet addiction, Internet dependence, Internet abuse, Internet pathological use

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▸ Full & Short Papers (by topics)

Artifical Intelligence in Education
Cognition and Conceptual Change
Collaborative Learning
Computer-Assisted Language Learning
Creative Learning
Educational Agent
Evaluation of Learning and Systems
Globalization vs. Localization
Humanities and Learning Technology
Instructional Design
Intelligent Tutoring System
Interactive Learning Environments
Knowledge Construction and Navigation
Lifelong Learning
Methodologies
Multimedia and Hypermedia in Education
Networked Social Learning
Others
Policies, Ethics, Standards, and Legal Issues
Special Education
Student Modeling
System Design and Development
Teaching and Learning Processes
Telecommunication in Education
Virtual Lab/Classroom/School
Virtual Reality in Education
Web-Based Learning

▲ HOME

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitment

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▸Full & Short Papers (Artifical Intelligence in Education)

A Computational Model for Learner's Motivation States in Individualized Tutoring Systems
A Fuzzy-based Assessment for Perl Tutoring System
A Genetic Approach to Parallel Tests Construction
A Learning Environment for Problem Posing in Simple Arithmetical Word Problems
A Method of Creating Counterexamples by Using Error-Based Simulation
A Study of Networked Constructive CAI System Using Multiplication-Concept of
Adaptive Programming Language Tutoring System on the Web
An Agent-Based Intelligent Tutoring System
An Educational System that can Visualize Behavior of Programs on the Domain World
An Environment for Learning by Design : In the Case of Learning of Search Algorithms
Applicability of an Educational System Assisting Teachers of Novice Programming to Actual Education
Case-Based Evaluating Assistant of Novice Programs
Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW
Development and Evaluation of a Mental Model Forming Support ITS-the Qualitative Diagnosis Simulator for the SCS Operation Activity-
Development of Intelligent Learning Support System with Large Knowledge Base
Educational Agents and the Social Construction of Knowledge: Some Issues and Implications
Facilitating examples understanding through explicit questioning
Generating interactive explanations by using both images and texts for Micro World
Intelligent Interactive Learning Environment: Design Issues
Internet Video on Demand System of Classroom Teaching Cases
Is a Learning Theory Harmonious with Others?-To form Effective collaborative Learning Groups with Ontological Engineering-
Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education
Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language
Multimedia Intelligent Tutoring System for Context-Free Grammar
Natural language-like knowledge representation for multimedia educational systems

Strange Creatures in Virtual Inhabited 3D Worlds
The Application of Uncertainty Reasoning for an Intelligent Tutoring System
The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS
The Design of CAI with Thinking Activity to Progress Constructive Teaching - An Example of Division-concept in Mathematics of Elementary School
The Estimation of Music Genres Using Neural Network and its Educational Use
The externalization support system of self-explanation for learning problem-solving process
Traversing the Case Graphs. A Computer Model for Developing Case-based Learning Systems
Use of abstraction levels in the design of intelligent tutoring systems
Using Decision Networks for Adaptive Tutoring

▲ HOME

A Computational Model for Learner's Motivation States in Individualized Tutoring System

Behrouz H. Far* and Anete H. Hashimoto**
** Faculty of Engineering, Saitama University*
*** Technical Development Department, IDO Corporation*
Shimo-okubo, Urawa 338-8570, Saitama, JAPAN
Tel: + - - - Fax: + - - -
E-mail: far@acm.org

A goal of the research is to develop an intelligent tutoring system (ITS) that adapts the delivery of instruction according to the learner's needs by taking into account learner's motivation states. Long-term and short-term parameters involved in the learning process are identified. We have found that learner's motivation has strong influence on the learning achievement. A computational model to represent learner's motivational states, using Bayesian network, is proposed. This model is further used to plan the individualized tutoring actions. This probabilistic model is the key to represent both learner 's knowledge and motivational states.

Keywords: **ITS, Student Modeling, Motivation, Bayesian Network**

1 Introduction

When designing an ITS system, usually, the first consideration is the teaching side, that is, deciding what to teach, what teaching strategies to apply, and what sequence of instruction to follow to facilitate learning. Although all these tasks are of unquestionable importance, to whom to teach, that is, the learning side should not be ignored. Teaching involves knowing what the learner wants or needs to study and planning the teaching material that leads to the desired learning outcome. However, since learners come with different background knowledge and needs, planning the individualized tutoring is not a trivial task.

Both background knowledge and motivational states of the learner have strong influence on the learning outcomes. Educational psychologists have revealed that human's motivational states are the driving forces for learning. In other words, no matter how attractive the lecture is, the learner will not benefit from it if he/she does not have the willing to engage in the learning process. But since bandwidth between the teacher and learner in a conventional classroom environment is relatively unlimited, human teachers may have a chance to bring the unmotivated learner back to the class. In the virtual classroom, the virtual tutor must be equipped with a mechanism to increase learner's knowledge via diagnosis of learner's motivational states and plan the tutoring while keeping learner motivated. We will see that, although motivation cannot be transferred from person to person, there are some principles explaining the increase (or decrease) of motivation.

A goal of this research is to develop a framework of an intelligent tutoring system (ITS) that adjusts instructions to the individual learner's needs by taking into account the motivational states of the learner [1]. A key task is increasing the bandwidth between learner and the ITS system. In order to increase the bandwidth, one must find out the hidden relationship in the learner's behavior and observed learning outcomes. Usually, learning outcome is associated to the learner's knowledge level, only. In this research, we first observe what actions contribute to increase learner's motivation to engage in the tutoring and then to plan a course of actions.

2 The Nature of Human Learning

What makes the learning process easy for one and hard for others? Looking for the answer is the primary concern of educational psychologists. In this section, we look further into the parameters influencing the human learning process.

2.1 Human learning parameters

In educational psychology individual's learning aptitude difference is explained in terms of several external and internal causes [2-5]. The external sources are usually associated to causes beyond the learner's control like the type of media or the learning environment that affect the quality of learning outcome. On the other hand, internal sources are associated with the learner's own parameters like abilities and motivations. In this work, we focus on the internal causes.

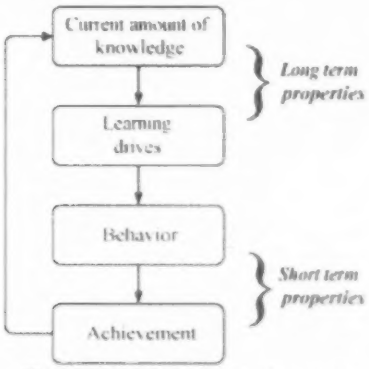


Figure 1 Human learning parameters

Figure 1, shows the set of parameters that influence the learning process. Each block in the model represents the set of parameters that describe the learning process, and the arrows indicate the direction of the influence. The first two parameters depict the learner's intrinsic characteristics. It comprises the learner's current amount of knowledge and aspects describing the learner's unconscious learning drives, like the motivation to learn. The learner's characteristics, in turn, are relevant to his/her behavior. It comprises the conscious learning drives used to measure how much effort his is putting to learn the new material. As the result of the learner's behavior, his/her achievement can be measured by the learning outcomes. The achieved learning outcome, in turn, is fed back to the current amount of knowledge. In Section 3 we specify parameters compris ing each block.

Among the subject's characteristics, one parameter that receives special attention in educational psychology is the motivation that drives learning. Motivation can be classified in two types: extrinsic and intrinsic [4]. Extrinsic motivators comprise external driving forces like studying to pass an exam or to receive a reward. The intrinsic motivators, on the other hand, are internal forces inherent to the individual like the interest in the subject matter or the desire to be successful. The ideal is that both motivators influence learners, but the reality is different. Usually extrinsic motivators, like grades and prizes, become the objective in the classroom. Unfortunately, extrinsic motivators tend to have a short-term effect and affect the learning activity [5,4]. The intrinsic motivators are the parameters that generate learning results in long-term perspectives. The favor to intrinsic motivators can be observed in a study conducted in [6]. The explanation found is consistent with what is known about the relationship between extrinsic motivations (such as grades) and intrinsic motivation (such as challenging tasks): extrinsic motivators tend to inhibit intrinsic motivators. That is, if learners were given the choice, they would rather choose easier exams in order to get high grades than selecting more challenging tasks.

Based on this argument, the proposed tutoring system emphasizes learner's intrinsic characteristics like abilities, progress, and confidence. It does not mean that extrinsic motivators are useless (test grades are not excluded in our system). Rather, the ideal is to balance both kinds of motivating drives. In the next subsection, the theories and principles that support our idea are explained.

2.2 The motivational and learning principles

We think that learning occurs only if the learner is motivated to learn. This desire to learn, whether intrinsic or extrinsic, is the driving force of how much effort the learner is willing to put in order to learn (see Figure 1). These efforts will be measured taking into account the learner's observable behaviors such as the time spent to read a lesson or the frequency of visiting the same lesson to study. Herewith, we define the intrinsic characteristics that later will serve as the backbone of the student model.

1. ***Motivation:*** Motivational state is the force that drives the learner to engage in an activity because of a feeling of need or desire. Though motivation cannot be transferred, it may increase (or decrease)

depending on the situation that the learner is faced. One of the situations in which changes in motivational states may be observed is when the learner is presented tasks that fall in a range of challenge such that success is perceived but not certain [7]. Besides the perceived probability of success, others works [2,3] suggest also that the value of obtaining goal and acknowledge of progress are factors affecting motivation.

2. ***Learning:*** Learning is the ultimately desired change in behavior and knowledge to be achieved by the learner. Because of different background, motivational states and goals, learning results in different acquisition rate and outcomes. With regard to the factors influencing learning, readiness to understand the instruction is an essential requirement. Prerequisite knowledge is suggested as a measure of readiness. Anxiety and uncertainty of achieving goal have negative influences on learning.
3. ***Interest and progress:*** The acquisition of an ability or skill is a potential activator of interest since people tend to repeat things in which they are successful [4]. That is, when learners obtain evidence of their learning progress, not only interest tends to increase but also performance will be superior to what it would have been without such acknowledgment. Progress, may be thought of as the sum of learning achievements.
4. ***Retention:*** Retention is a measure of how well learners remember already acquired facts. The longer the time delay, the lower the retention factor. While time delay decreases retention, rehearsal strengths the ability to recall old information.
5. ***Ability degree:*** The learner's ability degree is a measure of preparedness to learn academic material [3]. We define it as directly dependent on readiness, expertise level, and complexity of the topic. Expertise level, in turn, is measured by the amount of knowledge the learner has accumulated.
6. ***Attention:*** By attention we mean a measure of how the learner is directing his/her mind to the given task. We define it as the result of the positive influence of motivation and ability degree and the negative influence of distraction due to complexity of topic.
7. ***Effort:*** The effort tells us how the learner is behaving in order to achieve learning goals. Since it is not possible to observe it directly, we measure it by the frequency of dedicating to the study (frequency of use), the time delay between studies, the amount of time engaged in reading (time for reading), whether the learner performs the tasks (practice), and whether non-mastered topics are rehearsed (rehearsal).

It is obvious that intrinsic motivators are difficult to measure. Choosing challenging tasks neither brings immediate results nor it is easily measured. Marks and points, on the other hand, are concrete measures, easily interpreted and cause immediate satisfaction. The first task is to use intrinsic motivators in the student model such that they bring immediate and measurable results. The model presented in the next section covers this.

3 Student Modeling Task

In this section, we present the student model, using Bayesian network, based on the parameters mentioned in Section 2. The student model is divided in two parts: the motivational model and the knowledge model. The motivational model is generic, domain independent and applies to all learners. The knowledge model, on the other hand, is domain specific. The subject matter chosen for knowledge model is the concepts of the C programming language.

3.1 Modeling learner's motivational states

Tutoring based on the learner's motivation requires a mechanism to diagnose motivational states. Here, we take an approach that complements the limitation of existing proposals, such as [8]. However, it may introduce a new burden in creating motivational diagnosis. It is due to the modeling process and the task of estimating the probabilities for all variables in the network. On the other hand, the advantage is that it eliminates the learner's burden because the diagnosis is running in background mode while the learner is using the system.

Building a student model based on Bayesian network requires two distinct tasks: the qualitative part that concerns the modeling of relevant variables involved in the domain, and the quantitative part that deals with the probabilities. As we are interested in representing the student motivational model, the qualitative modeling is concerned with the problems of identifying what information about the learner will be modeled and how that information will be modeled. In the quantitative modeling, we are concerned with the problem of specifying how the probabilities will be computed.

3.1.1 Qualitative analysis: encoding of dependence

The difficult part in the qualitative analysis is to find out how the variables influence each other. Our starting point was the learning parameters described in Figure 1: knowledge states, learning drives, learner's behavior, and learning achievements. These rough sets were further expanded based on the learning and motivational principles explained in Section 2. The refinement is done top-down: start from the first parameter down to the last one. The result is depicted in a network of Figure 2. The nodes in the network are divided into two types: directly observable nodes denoted by dashed-lines, and unobservable ones represented by solid-lines. The graph encodes the causal dependency among the motivational aspects relevant in the process. The common positioning of the variables is from cause to effect. An arrow from A to B is read as "A influences (or affects) B". For example, readiness is a factor that influences (or affects) motivation; ability influences attention.

Figure 2 Student's motivational states model

3.1.2 Quantitative analysis: expressing in numbers

The nodes probabilities may come from two different sources: probabilities set by experts and probabilities coming from repetitive calibration. It is worth mentioning that obtaining exact numbers is not really crucial since we are interested in the changes between the parameters rather than the values. In many cases, the advantages of Bayesian networks outweigh the load of eliciting the numbers. For example, locally encoding of information is an important aspect. Deleting or adding new information does not require the whole network be revised.

Initially, the probabilities in the student motivational model are rough estimations. The principles behind learning and motivation were translated to sentences like:

There is a high probability that motivated learners (motivation) works harder (effort)

or

There is a low probability that the learner is persistent (persistence) if the task completion ratio is low (task completion ratio).

We repeated this example for all variables in the network. Next, the qualitative terms like high and low are expressed in numbers. Finally, using a Bayesian network editor that we have built, those values are tested

BEST COPY AVAILABLE

with repetitive calibration.

3.2 Modeling learner's knowledge states

Now, the qualitative and quantitative analyses for the student knowledge model are discussed.

3.2.1 Qualitative modeling: semantic of the network

The network depicted in Figure 3 represents the Bayesian network for the student knowledge models. Again there are two kinds of nodes: knowledge units and test nodes. Knowledge units represent relevant concepts comprising the domain to be taught. Test nodes represent problems that serve to verify the understanding level of each knowledge unit.

In order to build the Bayesian network of Figure 3 we start by eliciting the knowledge units comprising the domain, represented by a solid node, and ranking them according to the difficulty/complexity of the unit. For example, if a unit does not require mastery of other units, then it is a candidate to be in the easiest level. Another unit that requires just mastery of the easiest level unit is the candidate to be the second easiest level, and so on.

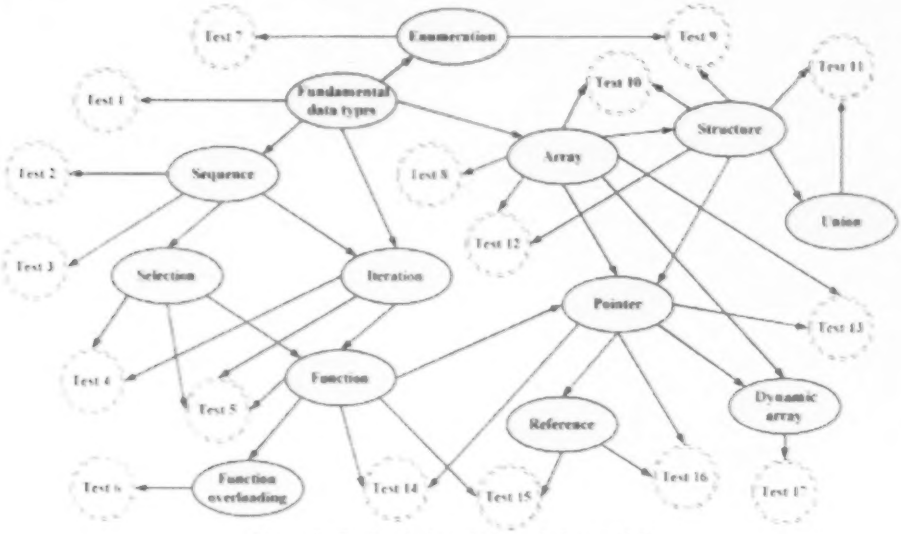


Figure 3 Student's domain knowledge model

Besides this classification, we have to find out how to represent those knowledge units in the network. Usually, Bayesian network is modeled based on cause-effect relationship. Since this is not easily perceived in our case, we extracted the factors that describe the units such as description, usage, and limitation. This analysis helps us to understand the hidden relationship between apparently unrelated units. We observed that some units fulfill the limitation of other units: for example, array and structure. In other cases, units present similarity in usage: for example, pointers and references. A link is added between those units in order to depict the fact that knowing one unit makes the probability of understanding the related unit more likely. Depending on the relevance of the knowledge unit within the domain, we can add more test nodes to the unit. In this example, since "Function", "Array", and "Pointer" play an important role within the domain of programming language, we can elaborate several test nodes covering those concepts.

The line of reasoning is as follows: if the learner solves correctly a problem associated to a knowledge unit, then the probability of knowing that unit increases. A link is added between knowledge unit and test node if it is required to know the unit in order to solve the problem. We add a link between knowledge units if exists a relevance relationship between them. Of course there is a tradeoff between compactness and preciseness. For example, learning about the "Fundamental data types" is essential for all remaining knowledge units, which we would have to add a link between that node and all other units. But, considering the precedence condition of the concepts, we were able to limit the links only to the directly relevant knowledge, such as

BEST COPY AVAILABLE

"Sequence expressions" and "Enumeration".

3.2.2 Quantitative modeling: dealing with probabilities

For each variable in the network, there is a conditional probability table (CPT) with respect to its parent nodes. For example, for the node "Test14", we have a CPT associating the "Test14" node to its parent nodes "Pointer" and "Function" knowledge units. That is, in order to answer the test correctly, the learner must understand both pointer and function. If the learner answers it correctly, it is inferred that he understands both units. If, however, the test was answered incorrectly, then, in the absence of other evidences, the associated units are considered not mastered yet. Suppose that we have already collected evidences that the learner knows about functions. In this case, rather than inferring both units as not mastered, it is more likely that only pointers have not been mastered yet. After including all the evidences and propagating the probabilities through the adjacent nodes, the network reaches an equilibrium state and we obtain the probability of the learner being in mastered level in each knowledge unit.

3.3 How the model works

Since learning occurs only if the learner has the desire or motivation to learn, the task we are concerned with is to keep the learner motivated to complete the tutoring. Consequently, the problems are: how to assess learner's motivational states and how to proceed tutoring in order to keep (or increase) motivation.

Let's consider the following situations: a novice learner who spends a long time without accessing the tutorial comes back to continue the lessons. Because of the long time delay between lessons, it is likely that he/she forgot something about the past lessons and needs a review. But, at the same time, the novice learner would probably become more motivated if he/she made some progress. In another case, an intermediate learner is apparently loosing motivation because of repetitive unsuccessful response to exercises.

In each case, the system can infer different treatments for each learner needs and set appropriate courses of actions. Therefore, the model will be used to perform the following tasks:

1. ***Monitoring:*** observe the learner in a sequence of interactions to adjust prior beliefs about learner's knowledge and learning drives.
2. ***Inference:*** because only a limited number of events are observable, infer what these directly observable actions tell about the other parameters.
3. ***Prediction:*** predict learner's knowledge and motivational states in the next interaction given the information currently available.

To depict the evolution of the tutoring, we represent the learning cycle as a dynamic process, as shown in Figure 4. At each interaction, the learning achievement increases (or decreases) the amount of knowledge the learner possesses in the next interaction, which indirectly increases the motivational states. Including temporal characteristic is important because if episodic interactions were considered, the learner's motivation, for example, would be inferred based on the current situation without taking into account past failure or success in outcome.

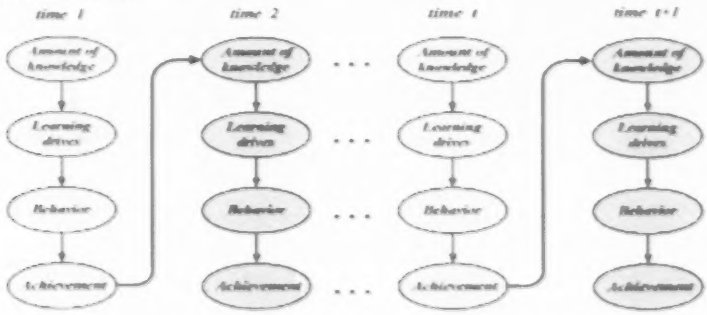


Figure 4 The dynamic process of tutoring

Dynamic Bayesian network [9] provides a mechanism to foresee the probability of interest in the next state

BEST COPY AVAILABLE

with regard to the current beliefs. That mechanism is called probabilistic projection and can be performed by a three step updating cycle called *roll-up*, *estimation*, and *prediction* phases, as suggested in the dynamic model of Figure 4. Keeping at the most two time slices are sufficient to perform the inferential cycle. Figure 5 depicts the steps for updating a dynamic Bayesian network and below, a brief description of each step.

1. ***Prediction:*** suppose the network in Figure 5(a). Assuming that all the values have been calculated in time slice *t-1*, i.e., $Bel(X_{t-1})$, this probability should be incorporated in the next time slice by estimating $\hat{Bel}(X_t)$. In this step, the predicted probability distribution expected given the evidences known at time slice *t-1* is calculated.

$$\hat{Bel}(X_t) = \sum_{X_{t-1}} P(X_t \mid X_{t-1}, E_{t-1}) Bel(X_{t-1})$$

Where E_{t-1} is all the evidence at time slice *t-1*; *P* is the probability and "^" denotes an estimation.

2. ***Roll-up:*** the roll-up is the process of removing the network on time slice *t-1* and assigning a prior probability table for the state variables at time *t*, which is the $\hat{Bel}(X_t)$ (Figure5(b)).

3. ***Estimation:*** now, using the standard probabilistic network updating, the probability distribution over the current time slice *t+1* is found and the steps for the next cycle can be repeated (Figure 5(c)).

$$Bel(X_t) = \alpha P(E_t \mid X_t) \hat{Bel}(X_t)$$

Where α is normalization constant.

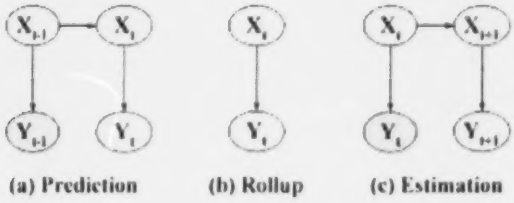


Figure 5 The updating cycle

4 Planning Actions

Through educators frequently rely on experience and common sense to prepare a curriculum plan, there are some theories helping educators to organize the lessons and offer learners an easier way to assimilate new concepts. Following we describe the theories about the sequence of instruction and motivation strategies that we adopt in our project.

1. ***Theories about sequence of instruction:*** helps the instructor to select the next instruction when there are conflicting candidates.
   - *Simple-to-complex theory:* given two concepts A and B, if A is simpler than B, then choose A as the next candidate.
   - *Laws of organization:* if A and B are similar concepts and the learner knows A, then the probability of understanding B becomes higher.

2. ***Motivational Strategies:*** dictates the teaching strategies to apply given the learner's motivational states and experience. Following, some examples of strategies:
   - Whenever a less motivated or confident learner does a task well, present similar tasks that are likely to be successful in order to increase his/her confidence and motivation.
   - If the learner presents high persistence or motivation, let him/her try again the task rather than promptly presenting the correct answer.
   - Show the learner his/her motivational and knowledge states in order to stimulate self-monitoring.

The way of actually planning actions and delivering instructions will be treated in the authors' another paper.

5 Discussions

In order to model motivational states, we need a formalism that simultaneously offers mechanisms to: (a) model the causality explaining the principles involved in the learning process, (b) reason under the uncertainties inherent to the effects of the process, and (c) represent the temporal changes observed due to learning. The framework we proposed in this paper can cover all these factors. It is suitable for handling problems that can be modeled according to certain relevance conditions. In our case, the learning principles are the conditions that enable us to model the learning parameters. Although it is impossible to identify and to model all the parameters involved in learning, but Bayesian network's reasoning mechanism is capable of dealing with incomplete as well as limited amount of data. Moreover, the ability to reason about the problem without necessarily observing all the variables involved constitutes another advantage.

With respect to the computational advantages of Bayesian networks, the structure of the network allows the locally encoding of information rather than globally. That is, once the network is consistently built, each node interacts only with the directly connected nodes [9]. The gain with this property is that addition or deletion of nodes can be done locally without revising the whole network. Additionally, the computation can be performed with regard to the adjacent parameters only.

6 Conclusions

We proposed a framework for an intelligent tutoring system that adapts instruction based on the learners' needs by taking into account learner's motivation states. Our main claim is that learner's needs do not refer only to knowledge needs, but also to motivational needs. The bottleneck, however, is the limited bandwidth between human and machine. The first thought is, then, to direct the research in the latest technology in human-machine interface, like natural language understanding or eyes movement reading methods in order to increase the narrow communication channel. But is it really only the technological bottleneck that hinders the communication between human and machine? If so, then why human teachers have troubles with their pupils? This was the question that arose during the development of this work.

The bandwidth problem limits the communication channel, but providing the system all available information does not guarantee perfect communication. We realized that the cognitive and educational aspects come first. What is behind the human learning process? Why some students learn faster than the others? These questions, then, became the priorities in our work. After eliciting the parameters involved in learning, we faced with the problem of how to make best use of the limited source of information the system was capable of computing. The computational formalism that fulfilled our needs was Bayesian network. This probabilistic method not only reasons under limited source of information but also infers about yet unobserved variables. In this way, we could virtually increase the communication channel.

Planning based on motivational strategies is still in an immature stage and a subject of our forthcoming paper. For clarity, the student motivational model possesses a large number of parameters, which can be omitted according to the intended use. Since the model is modularized and domain-independent, it is also possible to reuse it to teach different domain application. The set of rules to execute motivational strategies we have defined is simply an adaptation of the motivational principles. Improvements are still needed in this direction.

References

[1] Hashimoto, A.H., Hajji, H., and Far, B.H., "A Probabilistic Approach for Student Modeling Task," 13th Annual Conference of Japanese Society for Artificial Intelligence, JSAI' 99, pp. 68-69, (1999).

[2] Eftekhar, N., Strong, D.R., and Hawaleshka, O., "Towards Dynamic Modeling of a Teaching-Learning System: The Unified Theory," International Journal of Engineering Education, vol. 12, no. 6, (1997). Also available at: http://www.ijee.dit.ie/articles/999981/article.htm (accessed on August 7, 2000).

[3] McIlrath, D.A., and Huitt, W.G., "The Teaching-Learning Process: A Discussion of Models," http://www.valdosta.edu/~whuitt/psy702/files/modeltch.html (accessed on August 7, 2000).

[4] Spencer, R., Ludington, J. and Graham, S., "Motivation and Learning: A Teacher's Guide to Building Excitement for Learning and Igniting the Drive for Quality," Peak Learning Systems, (1999). Also partially available at: http://www.peaklearn.com/chap1.html (accessed on August 7, 2000).

[5] Lumsden, L.S., "Student Motivation to Learn," ERIC Digest 92, (1994).
[6] Litchfield, B.C., and Newman, E.J., "Differences In Student And Teacher Perceptions Of Motivating Factors In The Classroom Environment," National FORUM of Applied Educational Research, vol. 12E, no. 3, (1999). Also available at: http://www.nationalforum.com/16LITCHF.htm (accessed on August 7, 2000).
[7] Knight, J., "Educational Foundation," http://ag.arizona.edu/aed/aed695a/educatio.htm (accessed on August 7, 2000).
[8] de Vicent, A., and Pain, H., "Towards Motivating Instructional Systems," In G. Cumming, T. Okamoto, and L. Gomes, editors, Proceeding of the International Conference on Computers in Education (ICCE'99), vol. 1, pp. 744-751, IOS Press, (1999).
[9] Stuart, R., and Norvig, P., "Artificial Intelligence: A Modern Approach," Prentice Hall, (1995).
[10] Hirashima, T., "Student Modeling and Adaptive Interaction," Journal of Japanese Society for Artificial Intelligence, Special Issue on Student Modeling and Adaptive Interaction, vol. 14, no. 1, (1999).

A Fuzzy-Based Assessment for Perl Tutoring System[1]

Tang Ya*, Keith C.C. Chan*, Albert Wu and Pinata Winoto*****
**Department of Computing*
Hong Kong Polytechnic University, Hong Kong
Email:{ csytang, cskcchan } @comp.polyu.edu.hk
***Faculty of Education*
Chinese University of Hong Kong, Hong Kong
Email: albertwu@cuhk.edu.hk
****School of Business and Management*
Hong Kong University of Science and Technology, Hong Kong
Email: pwinoto@ust.hk

In this paper, we present a fuzzy-based assessment for Perl Tutoring system. The Perl Tutor is implemented in a multi-domain framework so that it can teach target domain knowledge by giving supporting knowledge to reinforce the learning. In order to assess supporting knowledge, an assessment is performed *before* the tutoring begins. Its main purpose is to test student's previous declarative knowledge of computer programming. At the end of it, a directed tutoring graph will be generated to optimize the tutoring process.

Keywords: **fuzzy rule, assessment, student modeling, multi-domain tutoring**

1 Introduction

There exist many works on optimized assessment process concerned with the efficiency of testing and its completeness. *Granularity, prerequisite relationships, Bayesian propagation* and *neighborhood of knowledge states* are some of the successful attempts employed to increase the efficiency of testing [2,5,6,13,17]. Yet, even though they could increase the efficiency significantly, they still have too many burdens given the large knowledge spaces. Fortunately, not all the student models need to be precise to be useful [10]. To ease the burden to student modeling, a fuzzy approach has been used and has so far worked quite well [3,10,11].

The purpose of this paper is to present the fuzzy approach in the assessment of student's knowledge in the Perl Tutoring System [16], which teach programming language (Perl) by reinforcement from other supporting languages (C++ and/or Java). For the effectiveness of reinforcement, the system should quickly evaluate the student's knowledge of supporting languages. But the assessment needs not to be in high precision. Other works related to student modeling almost put their emphasis on the adaptive assessment *during* tutoring [14,15,17]. Yet due to the nature of our Perl tutor, we apply an assessment module *before* tutoring begins and it consists of two parts: questionnaire and testing. During the questionnaire part, students are asked to self-assess their knowledge by filling out a form provided by the system. In order to evaluate their statements, a testing part is given based on those statements. At the end of the assessment, the tutor will have a general picture of students' prior knowledge of supporting languages: with which part they are familiar etc. Since the goal of the assessment is only to get a rough knowledge states for supporting purpose, it should not take too long to complete. Thus, a coarse granularity with imprecise mastery level is appropriate.

In the next part of this paper, we briefly discuss the Perl tutoring system followed by the fuzzy logic. Then we will describe the questionnaire part and the testing part and end with discussion.

[1] The work related to this paper is funded under the Hong Kong Polytechnic University research grant No. PolyU5072/98E.

2 Overview of the Perl Tutoring System

Figure 1 illustrates the directed tutoring graph in the system [16]. The three pieces of knowledge items presented to students are: data type, logical operators and control structures. In the figure,

- Each vertex represents a sub-domain;
- Each pair of the sub-domain may be connected with a unidirectional or bi-directional arc.
- Each arc represents the relationship between two sub-domains.

Moreover, each sub-domain may consist of several vertices, which are the sub-sub-knowledge items of their parent domain. For example, under ' data type' , we also have ' integer' , ' float' , ' boolean' etc.

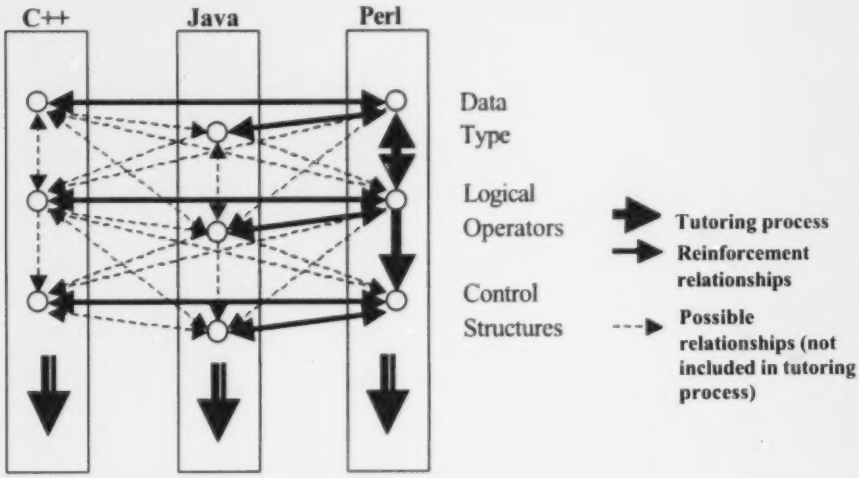


Figure 1 A Digraph of the Perl Tutoring System

C++ [1] and Java share many similarities with Perl, although they, of course, have their own features. See Table 1 for a comparison.

CDR terms (General)			Knowledge piece in PERL	Knowledge piece in C++	Knowledge piece in Java
Operators	Numeric operators		+,-,*,/, %, **	+,-,*,/, %,	+,-,*,/, %,
	Relational operators		<,<=,>,>=,<=>**(for numeric)** lt,le,gt,ge,cmp**(for string)**	<,<=,>,>=	<,<=,>,>=
	Equality operators		=,!=**(for numeric)** eq,ne**(for string)**	==,!=	==,!=
	Logical operators(binary)		&&,||	&&,||	&&,||
	Logical operators(unary)		!,	!,-	!,-
	Bit manipulation operators		&, |, ^, ~	&, |, ^, ~	&, |, ^, ~
	Bit shift operators		<<, >>	<<, >>	<<, >>, >>>
	Auto-increment & auto-decrement operators		++,--	++,--	++,--
	Speical operators	Conditional operators	?:	?:	?:
		Other operators	•,x(string operators) , >,**(dereference/reference operator**	Sizeof ,	Instanceof
	Multiple operators			+=, -=, *=, /=, %=, &=, |=, <<=, >>=, ++=, --=	+=, -=, *=, /=, %=, &=, |=, <<=, >>=, >>>=, ++=, --=
Control structures			If,if/else, unless/else, While, do/while, for, continue, goto Notes:labled loops can be used within for, while, or do	If, if/else, while, do/while, for, continue, goto, switch, break	if, if/else, while, do/while, for, continue, break, switch Notes:labled loops can be used within for, while, or do
		Special structures	**Foreach** **Redo**	Exit	

Table 1 Similarities and differences in C++, Java and Perl

CDR represents 'cross-domain reference' which serves as a dictionary for the domains. It is composed of basic terms used across the computer language regardless of which language is being referred. If the student has learned computer language before, he will develop a clear picture of the terms or concepts used, which serves as a guide for the learning of Perl. Besides, he will also integrate his former learning into his current. Through this knowledge transfers, the time spent on learning Perl will be greatly reduced [8].

Before tutoring begins, a weight is assigned to every direction of arc that represents the easiness of the acquisition of one sub-domain (target) after acquiring another (source). Since different students have different knowledge levels, the weight assigned to the same arc may not be the same. Thus, the weight across domain is jointly determined by the student model and the characteristics of knowledge (for detailed explanation, refer to [16]), i.e.,

$$w_{ij} = f(\mathbf{d}_{ij}, \mathbf{m}_{ij})$$

Where, w_{ij} is the weight of arc from i to j.

$f: R^n \times R^m \rightarrow R_+$ is a non-decreasing function.

$\mathbf{d}_{ij}$ is an n-dimensional vector representing the similarity of i and j. $\mathbf{m}_{ij}$ is an m-dimensional vector representing the student model, i.e., the student's knowledge level of i.
The dimension of $\mathbf{d}_{ij}$ and $\mathbf{m}_{ij}$ depends on the number of attributes considered. Moreover, the value of $\mathbf{d}_{ij}$ is predetermined and the value of $\mathbf{m}_{ij}$ is determined based on the student model. Thus, the system would carry an assessment module to test the knowledge of a student towards a specific supporting domain knowledge *before* tutoring begins. In this paper, we focus on the determination of $\mathbf{m}_{ij}$.

3 The Assessment Model—A Fuzzy Approach

Since the main purpose of the model is to test student's overall abilities, it is not necessary for us to gain a very accurate picture of it (although it helps). And somehow we also cannot gain a clear picture of student history. Thus, we choose a fuzzy approach in analyzing the student's performance, and we believe that the imprecise assessment of the student's prior knowledge level is adequate.

3.1 The 'neighborhood of knowledge states'

The *knowledge state* has been defined as the subset of knowledge items from a large item pool that can be mastered by students [4]. Remember that knowledge items in different domains are identified by their names, which in turn are determined by a cross-domain vocabulary. Besides, each item is characterized by its relationship with other items. The neighborhood of a knowledge state was defined by Falmagne and Doignon [7] as all other states within a distance of at most one. It has been utilized for adaptive assessment by Dowling *et. al.* [6]. In our system, we will not measure the exact distance within knowledge items, but we adopt it from another perspective. We define the neighbors of a knowledge item as the possible knowledge items which could be mastered in association with it. Let us have a look at an example.

Example 1.

1. '<','<=' represent 'less than' and 'less than or equal to' respectively, and they are relational operators.
2. '>','>=' represent 'greater than' and 'greater than or equal to' respectively.
3. '==','!=' represent 'equal to' and 'not equal to' respectively, and they are equality operators.
4. '<','<=' can be used for both numeric and strings.
5. '>','>=' can be used for both numeric and strings.
6. '==','!=' can be used for both numeric and strings.
7. Numeric is data type.
8. Strings are data type.
9. The relational and equality operators can be used for all data types, numbers, expressions or their combinations.

Let $M_S(X)$ denotes the student is sure to have mastered X. And $M_l(Y)$ denotes the student is likely to have mastered Y. Where X,Y are sets of knowledge items. Then,

$M_S(X) \square M_l(Y)$ can be interpreted as "if the student is sure to have mastered X, then he/she is likely to have mastered Y."

Then we will have:
1. $M_S(1) \square M_l\{2,4,7,8\}$
2. $M_S\{3\} \square M_l\{6,7,8\}$
3. $M_S\{4,5,6\} \square M_S\{7,8\}$
4. $M_S\{9\} \square M_S\{1,2,3,4,5,6,7,8\}$

For example, if the student knows well how to make comparisons for numeric and strings, then we assume

that he/she is sure to have mastered: what is numeric, what is a string and the usage of the operators. Although we cannot determine that whether he masters other data types or not (that is, he is likely to have mastered other data types such as float etc), we can assess student's knowledge state without having to extensively test his abilities of each knowledge item he/she may have learned. Therefore, test items in our model may test knowledge items in a wider ranger than similar work by Collins *et. al.* [2].

3.2 Fuzzy Logic

To express precisely the notion "sure", "likely" or "unlikely", we adopt fuzzy set methods and therefore using fuzzy rule for the inferences. For example, we define

Answer = {True, False}. And A1, A2 $\subset$ Answer, thus

$$Ai = \mu_{Ai}(T)/True + \mu_{Ai}(F)/False$$

Confidence = {unlikely, likely, sure}. And B1, B2 $\subset$ Confidence, thus

$$Bi = \mu_{Bi}(u)/unlikely + \mu_{Bi}(l)/likely + \mu_{Bi}(s)/sure$$

Assume we have two rules: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2

Then, by Mamdani's direct methods:

$$B' = A' \circ R$$

Where, $R = R1 \cup R2$

$$Ri = \begin{pmatrix} \mu_{Ri}(T,u) & \mu_{Ri}(T,l) & \mu_{Ri}(T,s) \\ \mu_{Ri}(F,u) & \mu_{Ri}(F,l) & \mu_{Ri}(F,s) \end{pmatrix} \quad \text{and} \quad \mu_{Ri}(x,y) = \mu_{Ai}(x) \wedge \mu_{Bi}(y)$$

Note here that all operators used, such as: +, /, $\subset$, $\wedge$, $\cup$, and o, are defined in fuzzy domain.[2]

To illustrate it, let us assume that A1 is "doing well in bit shift operator", A2 is "doing bad in bit shift operator", B1 is "understand bit manipulation if doing well in bit shift operator", and B2 is "understand bit manipulation if doing bad in bit shift operator". Then, we can assign values such as:

A1 = 1.0/T A2 = 1.0/F

B1 = 0.5/l + 0.5/s B2 = 1.0/u + 0.1/l

And satisfied: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2. Thus,

$$R1 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B1}(u) & \mu_{B1}(l) & \mu_{B1}(s) \\ 0 & 0.5 & 0.5 \end{array} \\ \begin{array}{c} \mu_{A1}(T)\ 1.0 \\ \mu_{A1}(F)\ 0 \end{array} & \begin{bmatrix} 0 & 0.5 & 0.5 \\ 0 & 0 & 0 \end{bmatrix} \end{array}$$

$$R2 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B2}(u) & \mu_{B2}(l) & \mu_{B2}(s) \\ 1.0 & 0.1 & 0 \end{array} \\ \begin{array}{c} \mu_{A2}(T)\ 0 \\ \mu_{A2}(F)\ 1.0 \end{array} & \begin{bmatrix} 0 & 0 & 0 \\ 1.0 & 0.1 & 0 \end{bmatrix} \end{array}$$

[2] Many books [18,19,20] in fuzzy set theory provide good explanations on these operators. We are not going to explain it further in this paper due to limited space.

With two rules, the fuzzy relation Ri is made from the implication Ai → Bi (in this case, i=1,2). The compiled fuzzy relation R is given as Mamdani's method:

$$R = R1 \cup R2, \text{ computed as:}$$

$$R = \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix}$$

Now, assume after a series of testing, a student performance show A' = 0.9/T + 0.2/F in doing bit shift operator. Then, we can calculate his performance in bit manipulation as:

$$B' = A' \circ R$$

$$= \begin{array}{cc} & \begin{array}{ccc} T & F & \end{array} \\ & [0.9 \quad 0.2] \end{array} \circ \begin{array}{cc} & \begin{array}{ccc} u & l & s \end{array} \\ \begin{array}{c} u \\ l \end{array} & \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix} \end{array}$$

$$= [(0.9 \wedge 0) \vee (0.2 \wedge 1.0),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0.1),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0)]$$

$$= [0.2 \quad 0.5 \quad 0.5]$$

$$B' = A' \circ R = 0.2/u + 0.5/l + 0.5/s$$

Which shows 0.5 likely to understand, 0.5 surely to understand and only 0.2 unlikely to understand bit manipulation.

4 Questionnaire and Testing

The questionnaire part consists of a series of knowledge items to be checked by students. The knowledge items are grouped into several groups based on the their similarities and difficulties. Then, students are asked to fill the form about their mastery level in each group. Five grades are provided for each answer, i.e., very familiar, familiar, moderately familiar, not familiar, and never heard. After students provided their answers, the system retrieves a series of testing questions based on the difficulty (upper limit) of students' answers, especially for the items marked 'moderately familiar'. But it does not mean that the presumably mastered items are not tested at all. Even the items marked 'very familiar' will be tested, but with a very low probability. Testing could be in the forms of short program lists or short questions, which are made as short, clear, and simple as possible. The reason is to avoid noise or errors which do not come from student knowledge iteself. In order to avoid ambiguity in judging knowledge level when the question is not answered well, every question only consists few higher level concepts to be handled.

Moreover, an average of membership value is used if the same item occurs in several questions. (We can use Bayesian update but with higher cost, i.e., to set all the conditional probability among every question).
For example, if from question 1, 2 and 3, a student performance on 'bit manipulation' shows

0.8/T + 0.2/F, 0.9/T + 0.3/F, and 1.0/T + 0.1/F respectively,

then the overall performance is, simply, the average, i.e., 0.9/T + 0.2/F.

If the question needed does not exist in the database, then a similar question is retrieved. The measure of similarity is based on the maximum number of high level concept appeared.

Prerequisite relationship

In addition to the neighborhood relationships, prerequisite relationships are also applied. The prerequisite relationship provides not only test item ordering criteria in a "strong" sense, but also in a "weak" sense. In ordinary prerequisite criteria P(A, B) denotes "A is prerequisite of B". In our extended criteria, we introduce A' as:

If A' is closely related to A and $M_S(A') \supseteq M_S(A)$

then we have $P'(A', B)$, that is, A' is weakly prerequisite of B.

So, if students have mastered item A', we have: they are sure to have mastered B without testing whether they have mastered item A or not. By doing this, we can largely tighten the testing items and thus save more time.

5 Discussion

To know student's learning history and his knowledge level, we cannot ask them too detailed questions in order to gain a more full picture of their knowledge state (although it helps) since it will make student modeling itself a kind of a complex system. But we need them to aid in the assessment, so how much trust should we have in the student's own assessment? This is the question we need answer before we proceed. In our system, we will not generate the tutoring graph solely based on their answers. Our solution is to test by giving them several pre-stored test items: if they can write out the outcome correctly, we assume that he has mastered the knowledge pieces and rules needed for this program.

Thus, the assessment will proceed. Test items need not to be like traditional testing questions in classrooms. They can be mini-programs or short questions provided that they can be used as a guide to assess students' mastery level of declarative knowledge.

Furthermore, we also should consider the nature of the language. For example, If the student has studied both Prolog and Java before, considering the respective relationship of them with Perl, we will still use Java as supporting knowledge because it is closer to Perl. This factor is called Knowledge Relation (K-R), and it will be assigned to d_{ij}.

At the end of the self-assessment section, a directed tutoring graph is generated. And student will be tutored based on it.

Currently, we are constructing the fuzzy rules which are applied for the assessment module, followed by the implementation and evaluation of it.

References

1. Capper, D.M. "Introducing C++ for Scientists, Engineers and Mathematicians", U.K., Springer-Verlag, (1994).
2. Collins, J.A., Greer, J.E. & Huang, S.X. "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the 3d International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
3. Derry, S.J. & Hawkes, L.W. "Toward fuzzy diagnostic assessment of metacognitive knowledge and growth", Proceedings of the Annual Meeting of the American Educational Research Association, San Francisco, CA, (1992).
4. Doignon, J.-P. & Falmagne, J.-C. "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, Vol 23, pp.175-196, (1985).
5. Dowling, C.E. & Kaluscha, R. "Prerequisite relationships for the adaptive assessment of knowledge", Artificial Intelligence in Education, pp. 43-50, AACE: Charlottesville, VA, (1995)
6. Dowling, C.E., Hockemeyer,C., Ludwig, A.H. "Adpative assessment and training using the neighbourhood of knowledge state", Proceedings of the 3d International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
7. Falmagne,J.-C. & Doignon,J.-P. "A Markovian procedure for assessing the state of a system", Journal of Mathematical Psychology, Vol. 32, pp. 232-258, (1988).
8. Harvey, L. & Anderson, J.R.. "Transfer of declarative knowledge in complex information processing domains", http://act.psy.cmu.edu/ACT/papers/Harvey_Anderson95.html, (accessed on August 1, 2000).
9. Juliano,B.A. & Bandler,W. "Tracing Chains-of-Thought", Heidelbert: Physica-Verlag, (1996).
10. Katz, S., Lesgold, A., Eggan, G., & Gordin, M. "Approaches to student modeling in the Sherlock tutors", Proceedings of the Third International Workshop on User Modeling, Germany, pp. 205-230, (1992).

11. Lesgold, M., Eggan, G., Katz, S. & Rao, G. "Possibilities for assessment using computer-based apprenticeship environments", Cognitive Approaches to Automated, Hillsdale, Lawrence Erlbaum Associates, (1991).
12. Matsubara, Y., Nagamachi, M. "Motivation system and human model for intelligent tutoring", Proceedings of the 3rd International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada. LNCS 1086, (1996).
13. McCalla, G. I., Greer, J. E. "Granularity-based reasoning and belief revision in student models", Student Modelling: The Key to Individualized Knowledge-Based Instruction, pp. 39-62. Springer-Verlag, Berlin, (1994).
14. Nguyen-Xuan, A., Joly, F., Nicaud, J.F., Gelis, J.M. "Automatic diagnosis of the student' s knowledge state in the learning of algebraic problem solving", Proceedings of the Conference on Artificial Intelligence in Education, Japan, (1993).
15. Sime, J.-A. "Modeling a learner' s multiple models with Bayesian belief networks", Proceedings of the Conference on Artificial Intelligence in Education, Edinburgh, Scotland, pp. 426-432, (1993).
16. Tang, Tiffany Ya. & Wu, Albert. "The implementation of a multi-agent intelligent tutoring system for the learning of computer programming", To appear in the 16th IFIP World Computer Congress—International Conference on Educational Uses of Communication and Information Technologies (ICEUT 2000) Beijing, China, (2000).
17. Villano, M. "Probabilistic student models: Bayesian belief networks and knowledge space theory", Proceedings of the 2nd International Conference on Intelligent Tutoring Systems (ITS' 92), Montreal, Canada, pp. 491-498, (1992).
18. Zadeh, L.A "Fuzzy sets", Information and Control, Vol. 8, pp. 338-353, (1972).
19. Zadeh, L.A. "A fuzzy-set-theoretic interpretation of linguistic hedges", Journal of Cybernetics, Vol. 2, pp. 4-34, (1973).
20. Zhu, Q. & Lee, E.S. "Fuzzy and Evidence Reasoning", Physica-Verlag, Germany, (1995).

A Genetic Approach to Parallel Test Construction

Koun-Tem Sun
Institute of Computer Science and Information Education
National Tainan Teachers College
Tainan 700, Taiwan
e-mail: ktsun@ipx.ntntc.edu.tw

The genetic algorithms have been widely applied to scientific and engineering problems in which a huge of computation is required for finding optimal solutions. In educational measurement, the parallel test forms' construction is a very important and difficult task. Since this problem is a combinatorial optimization problem that is required a large of time to select items for constructing tests with approximation a test information function. The genetic algorithm can code this parallel test construction problem as binary strings and solves them by using the genetic operations: reproduction, crossover, and mutation. Experimental results show that the genetic algorithm obtained very well results that are much better than those obtained by other methods. The average improvement ratio exceeds 98.26%. We successfully extend the applications of genetic algorithm to the educational measurement and this technique will be very useful to the test designers.

Keywords: **genetic algorithm, parallel tests, test information function, combinatorial optimization.**

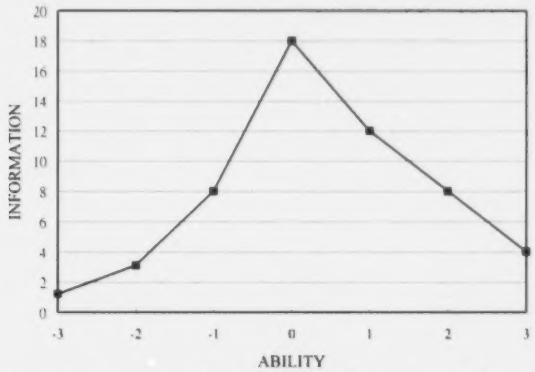
1 Introduction

Since John Holland introduced the Genetic Algorithm (GA) in 1975 [10], many applications, especially the optimization problems and the search problems, have been studied and solved by this technique [2, 5, 7, 8, 21]. However, many problems in education, such as the parallel tests' construction, are also very difficult to solve and urgently find a more effective method to generate better results. The design of parallel test forms can be performed by the *Item response theory* (IRT) [9, 11, 12, 13, 20, 22]. *Item response theory* has served as the basis for test design for a variety of measurement purposes [1, 3, 6, 18]. However, the test construction problem (or item selection problem) can be formulated as a zero-one combinatorial optimization problem [14] and therefore processing time increases exponentially with the number of items in the item bank. For this reasons, many mathematical programming methods and heuristic methods have been developed to facilitate test design. These methods commonly involve the construction of parallel test forms, in which the test information function varies as little as possible between forms. The test information function can be computed by calculating the sum of the item information function $I_i(\theta)$ for the items included on the test [4]:

$$I(\theta) = \sum_{i=1}^{m} I_i(\theta), \tag{1}$$

where m is the number of items on the test. For example, if a test for screening out the middle ability students is required to be constructed (see Figure 1), then items with greater information at the middle ability levels would be selected from the item pool. Table 1 shows the three parameters and item information of items in the item pool. For constructing parallel tests, a test is dedicated as the target test and another test is designed to approximate the test information function of the target test. The less the deviation there is between the target test information function and the constructed test information function, the more satisfactory the test is. Therefore, a test designer selects items which allow the information function of the constructed test to most closely approach the target test information function. Since the item selection problem is a combinatory optimization problem, the number of combinations increases exponentially with the number of items in the item bank. For this reason, the designers must use the weak methods (heuristic

algorithms), which are capable only of finding "good" solutions but not "optimal" solutions. For example, linear programming (LP) techniques are the most commonly used for the test construction. In linear programming techniques, items are selected in order to optimize objectives within the given constraints.



Good solutions can be produced by a variety of heuristic methods, such as the branch-and-bound method, the revised simplex method which use the relaxed 0-1 linear programming model, the

Figure 1. The curve of test information for screening out middle ability students.

Table 1. Three parameters and item information of items (the first 20 items of the item pool)

Item	Item Parameters			Ability Level						
	a	b	c	-3	-2	-1	0	1	2	3
1	0.763	-3.000	0.270	0.242	0.193	0.078	0.024	0.007	0.002	0.001
2	0.435	-0.546	0.200	0.024	0.052	0.083	0.093	0.075	0.049	0.027
3	0.803	0.537	0.310	0.000	0.003	0.035	0.171	0.250	0.130	0.041
4	1.187	0.080	0.350	0.000	0.002	0.059	0.466	0.293	0.052	0.007
5	0.844	-1.176	0.180	0.031	0.191	0.364	0.215	0.068	0.017	0.004
6	0.730	0.169	0.290	0.001	0.012	0.075	0.199	0.192	0.090	0.030
7	0.732	1.127	0.370	0.000	0.001	0.010	0.062	0.169	0.164	0.076
8	0.625	-1.650	0.260	0.062	0.147	0.164	0.101	0.044	0.017	0.006
9	1.428	2.831	0.370	0.000	0.000	0.000	0.000	0.001	0.102	0.715
10	0.541	0.063	0.280	0.006	0.024	0.069	0.117	0.114	0.072	0.035
11	0.983	-1.587	0.310	0.035	0.265	0.342	0.116	0.025	0.005	0.001
12	0.661	-1.707	0.250	0.070	0.171	0.182	0.102	0.041	0.014	0.005
13	0.538	-1.368	0.230	0.048	0.105	0.134	0.105	0.058	0.027	0.011
14	1.183	-0.378	0.290	0.000	0.012	0.247	0.549	0.156	0.024	0.003
15	0.400	-0.363	0.350	0.012	0.027	0.047	0.058	0.054	0.039	0.024
16	0.558	0.220	0.270	0.004	0.020	0.064	0.122	0.127	0.082	0.040
17	0.960	0.378	0.280	0.000	0.003	0.045	0.287	0.340	0.116	0.026
18	0.814	1.828	0.300	0.000	0.000	0.002	0.019	0.126	0.267	0.174
19	0.891	-0.490	0.310	0.002	0.033	0.205	0.301	0.132	0.035	0.008
20	1.083	-1.295	0.240	0.016	0.231	0.526	0.195	0.036	0.006	0.001

weighted deviation model, the neural network technique, and the greedy approach. Test construction problems commonly involve a list of objective functions with various purposes, but the test information function is the common objective of all test design problems. Therefore, in this paper, we will only consider how to select items in order to meet the requirements of the test information function. The difficulty of this problem, however, is not reduced by eliminating consideration of the content attributes. The test construction problem can be coded as binary strings, and then solved by the genetic operations: reproduction, crossover, and mutation. In order to evaluate the performance of this method, two hundred test information functions

for parallel test forms of two types (one-peak and two-peak functions) were randomly generated. Experiments show that the GA technique generates much better results than those obtained by other methods with improvement ratios exceeding 98.26% (i.e., the errors of test information functions obtained by our method are better than others one order of magnitude). The GA method produces tests in which the test information functions very closely approach the target test information functions. It should be very useful to test designers for constructing parallel tests.

2 Test Construction by the Genetic Algorithm

The GA technique for the test construction problem is to code the state of the items as binary strings (i.e., chromosome strings), and then apply the genetic operations: reproduction, crossover, and mutation, to generation a set of new chromosome strings for next generation. The evolution of chromosome strings will proceed until the number of generations reaches the presetting value. Then, the most "fit" chromosome string is the result for the problem. So, a simple GA works as follows:

1. Randomly generate a population with $\boldsymbol{P}$ n-bit chromosome (candidate solutions to a problem).
2. Calculate the fitness (error), $f(x)$, of each chromosome x in the population.
3. Repeat the following steps until k offspring have been generated:

Cross over a pair of chromosomes with probability p_c (crossover probability) at a randomly chosen point to form two offspring (as shown in Figure 2).

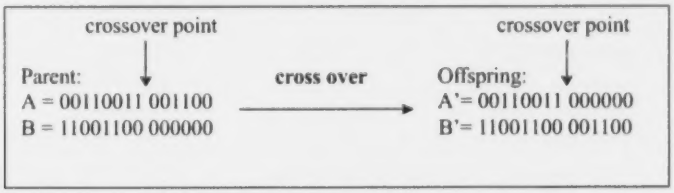


Figure 2. An illustration of 1-point crossover operation for a pair of chromosomes with 14-bit binary strings, and a crossover point is randomly selected between the 8th and the 9th bit positions.

(1) Mutate the state of gene in the chromosome with probability p_m (mutation probability), and place the resulting chromosomes in the new population (as shown in Figure 3).

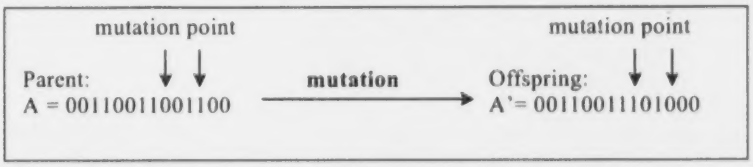


Figure 3. An illustration of mutation operation for a chromosome with the 14-bit binary string, and two mutation points are randomly selected at the 9th and the 12th bit positions.

(2) Select a number of chromosomes with the probability p_r from the current population, the probability of selection being an increasing function of fitness. The selected chromosomes are reproduced for the new population.

4. Replace the current population with the new population.
5. If the number of generations reaches the presetting value or obtain the required solution, then stop. Else go to step 2.

Each iteration of this process is called a generation, and the entire set of generations is called a run. For the test construction problem, the chromosome string and the fitness function are designed as follows. We use a binary string (i.e., chromosome), $\boldsymbol{X}$, to represent the state of all items in the item bank. Each element, x_i, i=1 ~ n, in $\boldsymbol{X}$ is used to represent the state of item i which is included in (x_i=1) or excluded from (x_i=0) the item bank. Then, the fitness function for evaluating the score of a chromosome is defined as Equation (2).

$$E_l = \sum_{j=1}^{t} (d_j - O_j)^2 \cdot \qquad (2)$$

The less the value of the fitness function, the less the error of the solution. Based on the fitness function, the chromosome strings in new population can be generated by genetic operations and then find better solutions. This evolution process will continue until reaches the presetting generation number or the required quality of result. For all generations, the best chromosome string with the least fitness function will be the final solution which closely approximates the target test information function. The detailed operations of the proposed approach are described as follows.

The Genetic Algorithm for Item Selection

In the proposed genetic algorithm, each chromosome string, X, contains n-bit, where n is the number of items in the item bank, in which m bits are "1" and else are "0" for constructing a test with m bits. The state of bit x_i in the chromosome represents the corresponding item i that is included in (x_i=1) the test or excluded from (x_i=0) the test. Then, for each chromosome, we can compute the error between the test information function of constructed test and the test information function of target test. This squared error (see Equation (2)) is then defined as the fitness function for evolution process. By applying the genetic operations: crossover, mutation, and reproduction, the population in the new generation can be obtained such that the better chromosome strings (less error) may be generated.

The detailed operations for this approach are stated as follows.

1. Set the initial population of chromosome strings and parameters of evolution process.
   An initial population of P chromosome strings is randomly generated, with each containing n binary bits in which m bits are "1" and else are "0". The crossover, mutation and reproduction probabilities are set to p_c, p_m and p_r respectively. The maximum number of generations is set to *gener_no*, and the initial generation number, t, (the iteration index) is set to zero.
2. Compute the values of fitness functions for all chromosome strings in population.

$$fitness(X^k) = \sum_{j=1}^{s} (d_j - O_j^k)^2, \tag{3}$$

   where O_j^k is the value of test information function at ability level j for chromosome k. It can be computed as:

$$O_j^k(t) = \sum_{i=1}^{n} w_{ij} x_i^k(t), \ \forall j = 1 \sim s. \tag{4}$$

   where w_{ij} is the item information function for the item i at the ability level j, and x_i^k is the state of item i in the chromosome k.

3. For each chromosome k in the population, complete the following genetic operations for generating P offspring.
   3.1. Two-point crossover is used in our method. The offspring for each pair of parent is generated with the probability p_c, and then a period of chromosome string in the offspring is the same as one parent and else is the same as another parent (as shown in Figure 4).

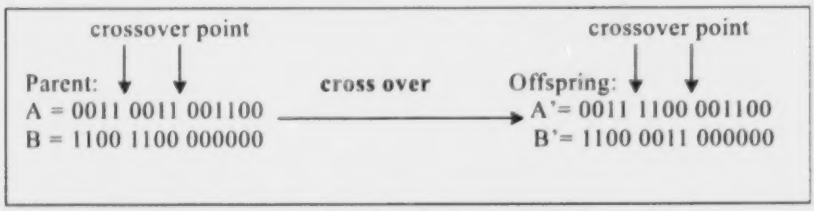


Figure 4. An illustration of the two-point crossover operation and 4 bits in the middle of chromosome strings are exchanged in offspring.

   3.2. For all chromosome strings, a mutation probability p_m is used to selected some chromosomes for changing the state of gene randomly.
   3.3. Find some chromosome strings with the probability p_r from the population, and then become the offspring for the new population.
   3.4. If the best chromosome in offspring is satisfied the requirement of test designer, or the generation number is reached the maximum, then the evolution process is stopped. Else, the generation number is increased by one, and goes to step 2.

4. Stop.

At the end of computation, the best chromosome string is the solution of the item selection problem and

the genes with state $x_i = 1$, for all i, are the items selected for inclusion on the final version of the test.

In the proposed GA approach, all chromosome strings are selected by the genetic operations such that the new chromosome strings in the new population are generated. In this way, the offspring may be better than the parent, and obtain the better solution for the item selection problem. Experimental results show that our method is much better than other methods, as will be discussed in the next section.

3 Performance Evaluation

Several methods have recently been proposed for more efficient construction of parallel test forms; we will use four of them to compare the performance with our method. Those are the greedy approach [16], the neural network method [15], the Swanson and Stocking method [17], and the Wang and Ackerman method [19]. We used a real item bank with 320 items based on the three-parameter model of IRT to compare the performance of genetic algorithm with that of other methods. The amount of information on the target test varied within the ranges shown in Table 2 (for a one-peak shape test information curve) and Table 3 (for a two-peak shape test information curve). Following the limitations of the information quantities defined in these two tables, one hundred target test information functions were randomly generated for each of the two shapes. The parameters for evolution are defined as following: $\boldsymbol{P} = 150$, $n = 320$, $m = 40$, $p_c = 100\%$, $p_m = 0.4\%$, $p_r = 13.3\%$, and $gener_no = 2000$. Figures 5 and 6 show the evolution process for one-peak and two-peak test information functions, respectively. The test information functions constructed by different methods are shown in Figures 7 and 8. The average sum of the squared error between the information functions of the target tests and that of the constructed tests is shown in Table 4. We see that the proposed genetic approach greatly reduces error, with average improvement ratios greater than 98.26%. We see that the proposed item selection method can be applied to generate excellent results. It should prove be very useful to test designers who are constructing parallel test forms or desired tests for a variety of assessment purposes.

Table 2. The ranges of test information used to randomly generate 100 target test information functions (one-peak shape).

	Index of Ability Level				
	1	2	3	4	5
Ability Level	-2.0	-1.0	0.0	1.0	2.0
Test Information	4 ~ 5	6 ~ 8	18 ~ 21	6 ~ 8	4 ~ 5

Table 3. The ranges of test information used to randomly generate 100 target test information functions (two-peak shape).

	Index of Ability Level				
	1	2	3	4	5
Ability Level	-2.0	-1.0	0.0	1.0	2.0
Test Information	5 ~ 6	11 ~ 13	7 ~ 9	11 ~ 13	5 ~ 6

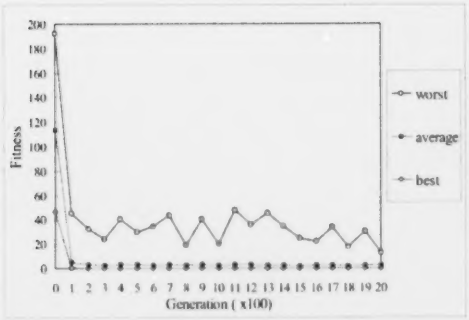


Figure 5. The worst, the average, and the best cases in the evolution for solving the item selection problem selection with one-peak shape test information function by using the genetic algorithm.

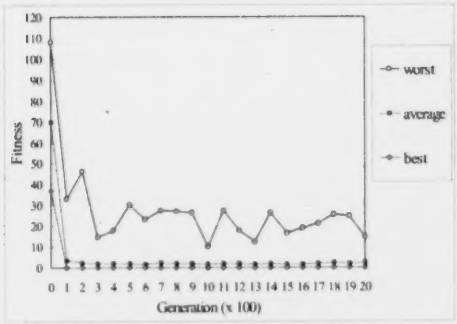


Figure 6. The worst, the average, and the best cases in the evolution for solving the item problem with two-peak shape test information function by using the genetic algorithm.

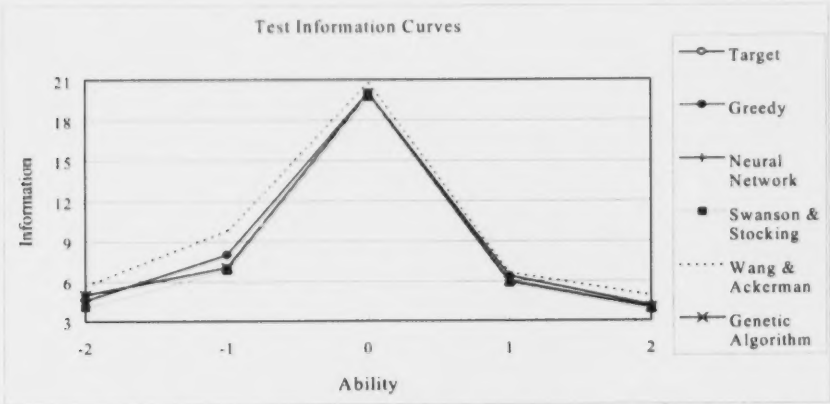


Figure 7. Test information curves (one-peak shape) for a target test, a test produced by the greedy approach, the neural network approach, Swanson & Stocking method, Wang & Ackerman method, and the genetic algorithm.

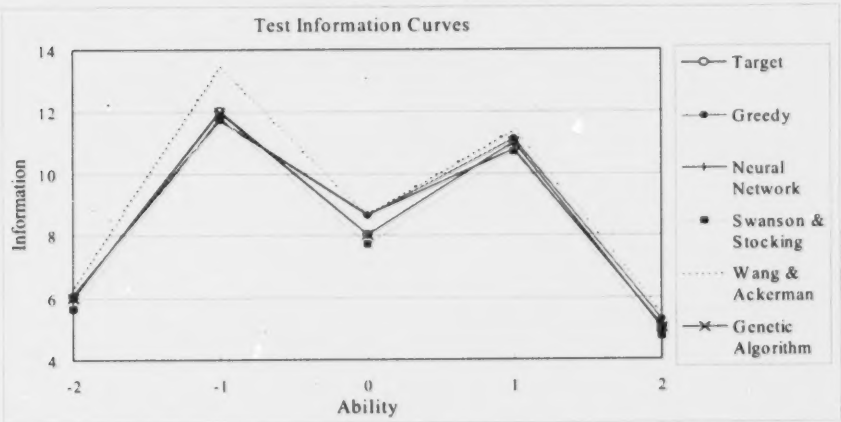


Figure 8. Test information curves (two-peak shape) for a target test, a test produced by the greedy approach, the neural network approach, Swanson & Stocking method, Wang & Ackerman method, and the genetic algorithm.

4 Conclusions

In this paper, a novel method, based on the genetic algorithm, is proposed to construct a desired test from an item bank. The proposed method can effectively construct parallel test forms or a test whose test information function closely approximates that of a target test. A real item pool was used to evaluate the performance of our method. The experimental results show that the proposed approach is able to obtain very well results that are much better than other methods. The average improvement ratio exceeds more than 98.26%. We successfully extend the applications of genetic algorithm to educational measurement and this technique will be very useful to the test designers..

Acknowledgments

This research was supported by the National Science Council of Taiwan, ROC, under the grant NSC 89-2520-S-024-001-.

Table 4. The average sum of squared error between the information function of the target test and the information function of the constructed test. The improvement ratios of the average error are also shown.

Methods / Conditions	Genetic Algorithm	Greedy Approach	Neural Network	Swanson & Stocking	Wang & Ackerman
Table 3	1.3925E-2	0.7251	0.6945	0.9715	12.8340
Table 4	5.6887E-3	0.6986	0.7416	0.2755	2.9536
Average Errors	9.8069E-3	0.7119	0.7181	0.6245	7.8938
Improvement Ratio* (%)	---	98.2664	98.6343	98.3976	99.8758

*Improvement Ratio (%) = $(error_X - error_G) / error_X \times 100$

$error_G$: the errors generated by the genetic algorithm.

$error_X$: the errors generated by one of the following methods: the greedy method, the neural network, the Swanson & Stocking method, or the Wang & Ackerman method.

References

[1] Ackerman, T., "An alternative methodology for creating parallel test forms using the IRT information function," The Annual Meeting of the National Council for Measurement in Education, San Francisco, (1989).

[2] Altenberg, L., "The evolution of evolvability in genetic programming," In K. E. Kinnear, Jr., ed., Advances in Genetic Programming, MIT Press, (1994).

[3] Baker, F. B., Cohen, A. S., & Barmish, B. R., "Item characteristics of tests constructed by linear programming," Applied Psychological Measurement, Vol. 12, pp. 189-199, (1988).

[4] Birnbaum, A., "Some latent trait models and their use in inferring an examinee's ability," In F. M. Lord & M. R. Novick, Statistical theories of mental test scores (pp. 395-479). Reading, MA: Addison-Wesley, (1968).

[5] Bramlette, M. F., "Initialization, mutation and selection methods in genetic algorithms for function optimization," In R. K. Belewand L. B. Booker, eds., Proceedings of the Fourth International Conference on Genetic Algorithm, Morgan Kaufmann, (1991).

[6] De Gruijter, D. N. M., "Test construction by means of linear programming," Applied Psychological Measurement, Vol. 14, pp. 175-181, (1990).

[7] Davis, L., ed. Handbook of Genetic Algorithms, Van Nostrand Reinhold, (1991).

[8] Goldberg, D. E., Genetic Algorithms in Search, Optimization, and Machine Learning, Addison-Wesley, Reading, Mass, (1989).

[9] Hambleton, R. K., & Swaminathan, H., Item Response Theory-- Principles and Applications.

Netherlands: Kluwer Academic Publishers Group, (1985).
[10] Holland, J. H., Adaptation in Natural and Artificial Systems, University of Michigan Press, Ann Arbor, Mich, (1975).
[11] Lord, F. M., "A theory of test scores," Psychometric Monograph, 7, (1952).
[12] Lord, F. M., & Novick, M. R., Statistical theories of mental test scores, Reading, MA: Addison-Wesley, (1968).
[13] Lord, F. M., Applications of item response theory to practical testing problems, Hillsdale, NJ: Erlbaum, (1980).
[14] Papadimitriou, C. H., & Steiglitz, K., Combinatorial Optimization: Algorithms and Complexity, Prentice-Hall, Inc., NJ: Englewood Cliffs, (1982).
[15] Sun, K. T. & Chen, S. F., "A study of applying the artificial intelligent technique to select test items," Psychological Testing, Vol. 46, No. 1, pp. 75-88, (1999).
[16] Sun, K. T., "A greedy approach to test construction problems," Submitted to *The Proceedings of the National Science Council (Part D): Mathematics, Science, and Technology Education,* (2000).
[17] Swanson, L., & Stocking, M. L., "A model and heuristic for solving very large item selection problems," Applied Psychological Measurement, Vol. 17, No. 2, pp. 151-166, (1993).
[18] Theunissen, T. J. J. M., "Binary programming and test design," Psychometrika, Vol. 50, pp. 411-420, (1985).
[19] Wang, C. S., & Ackerman, T., "Two item selection algorithms for creating weakly parallel test forms using the IRT information functions," Psychological Testing, Vol. 44, No. 2, pp. 123-140, (1997).
[20] Weiss, D. J., "Improving measurement quality and efficiency with adaptive testing," Applied Psychological Measurement, Vol. 6, pp. 379-396, (1982).
[21] Wright, A. H., "Genetic algorithms for real parameter optimization," In G. Rawlins, ed., Foundations of Genetic Algorithms, Morgan Kaufmann, (1991).
[22] Wright, B. D., & Stone, M. H., Best test design, Chicago: MESA, (1979).

A Learning Environment for Problem Posing in Simple Arithmetical Word Problems

Akira Nakano, Naoki Murakami, Tsukasa Hirashima and Akira Takeuchi
Kyushu Institute of Technology Department of Artificial Intelligence
680-4 Kawazu, Iizuka 820-8502, Japan
E-mail : nakano@minnie.ai.kyutech.ac.jp

Several researchers indicate that to pose arithmetical word problems is an important way to learn arithmetic. However, the problem posing practice actually is not popular. In this paper, we describe an Intelligent Learning Environment which realizes the problem posing practice. In the problem posing practice, the learners pose problems by using the tools provided by the ILE. The ILE has a facility to diagnose the problems posed by the learners. By using the result of the diagnosis, the ILE indicates whether the problems are correct or not, helps the learner to correct the wrong problems, and provides the next step of problem posing. We used the ILE in three different situations for evaluation. The subjects were elementary school teachers and elementary school students. We also report the results of the evaluation. In the ILE, the interface was implemented in Java, and the diagnosis module was implemented in Prolog. So it can be used on World Wide Web. The current environment deals with simple arithmetical word problems.

Keywords: **intelligent learning environment, problem posing, intelligent tutoring system, interactive education, World Wide Web**

1 Introduction

The main purpose of the practice to solve arithmetical word problems is to make learners recognize the relations between concepts and numerical relations, and master to use the relations. Although the problem solving practice is the most popular way, it is not the only way. Several researchers indicate that to pose arithmetical word problems is also effective. However, the problem posing practice actually is not popular.

The main reason is that the problem posing practice is strongly required teachers to deal with each learner individually in comparison with the practice of problem solving. We aim to realize computer-based learning environments for the problem posing practice [1]. For the problem solving practice, many ILEs are developed so far [2-6]. However, there are few ILEs for the problem posing practice until now.

This paper describes an Intelligent Learning Environment for the problem posing practice for simple arithmetical word problems that can be solved by the addition of one time or the subtraction of one time. The main characteristic of the ILE is the function to diagnose the posed problems. By using the results, the ILE indicates errors in the posed problems and suggests that the next step of problem posing.

Interface of the ILE was implemented in Java, and the diagnosis module was implemented in Prolog. Therefore, if only users have a computer connected to Internet with a popular internet browser, they can use the ILE through WWW: E-mail: nakano@minnie.ai.kyutech.ac.jp http://www.minnie.ai.kyutech.ac.jp/~nakano/problem-posing.shtml (currently Japanese only).

In this paper, the first, the necessity of problem posing and an Intelligent Learning Environment for it are described. Then, interface and diagnosis module of the ILE are explained. The results of preliminary evaluation of the ILE are also reported.

2 Background

2.1 The necessity of an ILE for problem posing

Several researches about problem posing of arithmetical word problems suggested that problem posing was important to learn arithmetic, for example, analysis and investigation about the task of problem posing [7,8], investigation about effect of the problem posing practice [9], investigation in the problem posing practice at arithmetic class [10,11]. Besides, the Curriculum and Evaluation Standards for School Mathematics (in USA, 1989), and Professional Standards for Teaching Mathematics (in USA, 1991) also indicated that it was important for learners to experience to pose problems.

However, the practice actually is not popular in arithmetic class in comparison with problem solving practice. In the practice of problem solving, every problem has an answer and one or a few solution methods. Therefore, the teachers can easily judge the results of problem solving by learners. Then when the answer is wrong, to tell the correct answer or the solution method is not meaningless.

In contrast with problem solving practice, to prepare every correct problem in the problem posing practice is very difficult. Besides, the correct problem that a learner is trying to pose, after depends on the wrong problem posed by the learner. Therefore, the teachers have to examine each problem whether the problem is correct or not, and where of the problem is wrong.

Based on this consideration, we believe that to realize an ILE for problem posing with problem diagnosis function is the promising way to make learning by problem posing popular.

2.2 The problem posing dealt in the ILE

Silver has noted that the term "problem posing" is generally applied to three quite distinct forms of mathematical cognitive activity [12]. They classified three types of problem posing: (1) presolution posing, in which one generates original problems from a presented stimulus situation, (2) within-solution posing, in which one reformulates a problem as it is being solved, and (3) postsolution posing, in which one modifies the goals or conditions of an already solved problem to generate new problems. The problem posing deal in our ILE is (2) within-solution posing. In the ILE, because, in the ILE, first, a learner decides a calculation formula to solve the problem, and next, he/she is trying to pose problem solved by the calculation.

Currently, the LIE can deal with only Change-Problem[13]. In Change-Problem, the quantity in the initial situation is changed to the quantity in the final situation by the change action. The Change-Problem usually consists of three sentences: the first sentence describes the initial situation, the second sentence describes the change action, and the third sentence describes the final situation. Therefore, we prepare a "problem template" that composed of three single sentence templates. By filling in the blanks of three single sentence templates, the problem is completed.

In the ILE, the template of Chang-Problem is composed of the tree single sentence templates that describe: initial situation, change action, and final situation, respectively. The initial situation has the four information: "owner", "object", "number", and "unit". This means that "owner" has "object" and the number of "object" is "number", then, the unit of the number is "unit". The change action has the five information: "actor", "object", "number", "unit", "action". Several actions, for example, "take" has two more information: "from" and "to". The final situation has the four information: "owner", "object", "number", and "unit".

3 ILE for problem posing

3.1 Configuration of the ILE

The current version of the ILE consists of clients and server shown in Figure 1. A client is an interface of the ILE. The interface provides learners the tools to pose problems and gives them guidance to promote problem posing. Inter face is explained in more details in this section 3.2.

The server has two modules: the one is Problem Diagnosis Module and the other is Advice Generator. First, the ILE receives the posed problem, and diagnoses it in Problem Diagnosis Module. Next, in Advice Generator, the ILE generates advice for each learner by using the result of diagnosis. These are explained in

more details in this section 3.3.

Because the ILE deals with several learners by one server, the ILE manages ID, PW, and Learner Model in Private Information Manager.

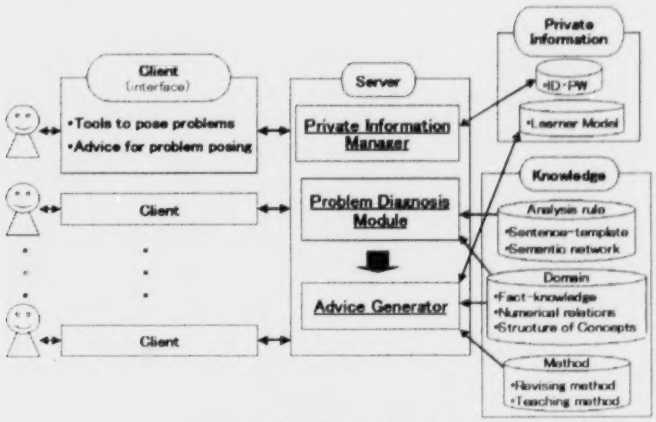


Figure 1: The frame of the ILE

3.2 Interface

Figure 2 shows the interface of the ILE. Current interface deals with only Japanese. In Figure 2, Japanese was translated into English for this paper. The parts of the interface are expressed as follows.

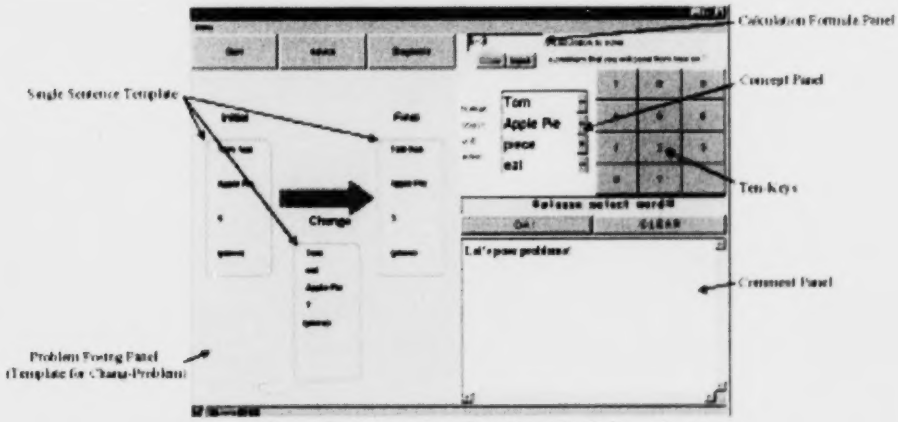


Figure 2: the prototype Interface (English version)

• Calculation Formula Panel

In this panel, a learner gives calculation formula. The learner poses problems which can be solved by this calculation formula.

• Concept Panel

This panel provides concepts to fill in blanks of sentences (three single sentences templates). The concepts that are provided in the Concept Panel are classified in the five categories: "human", "object", "unit", "action", "number".

• Ten-key

BEST COPY AVAILABLE

Numerical values are put into blanks of sentences with Ten-key.

• Problem Posing Panel

In the current version, this panel provides the template of Change-Problem. The ILE asks a learner to fill in blanks of sentences. In the order of the blanks, the ILE gives questions. By answering the questions, the blanks are filled in. Here, the learner has to select concepts from Concept Panel. By using Figure 3, posing a sentence of initial situation in Chang-Problem is explained. The left side of the figure shows questions.

For example, the initial situation in Chang-Problem is composed of four elements: "owner", "object", "number" and "unit". So, the ILE asks the learner "Who has?", "What the person has?", "How many?", "What is unit?". The learner also should decide what number is the answer by selecting the question mark in Ten-key.

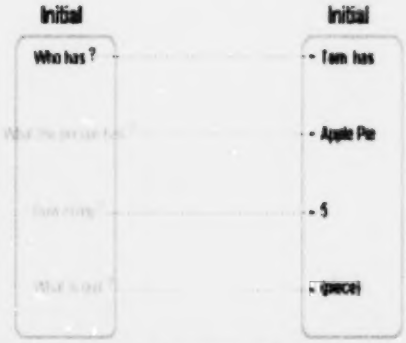


Figure 3: An example of posing sentence by using Single Sentence Template

The right side of the figure shows an example which the learner answered the questions. The result shows "Tom has 5 pieces of Apple Pies".

By answering the all questions, learners pose problems For example, Figure 2 shows the correct problem in Problem Posing Panel: the initial situation is "Tom has 5 pieces of Apple Pies", the change action is "Tom eats the 3 pieces of Apple Pies", and the final situation is "How many pieces of Apple Pies does Tom have?".

• Comment Panel

This panel shows advice and suggestion massages that are generated based on the diagnosis of the posed problems.

3.3 Problem posing in the ILE

A learner poses a problem by the following process.

(1). Giving a calculation formula

First, the learner gives a calculation formula. The calculation formula consists in three elements. That is, two operands and an operator. Because the calculation formula is the way to get the answer of the problem, we call it solution.

The solution can be applied to several numerical relations. For examples, if the learner assigned "5-3" to the solution, the solution can be applied to the following four numerical relations: (a) "5-3=X", (b) "5-X=3", (c) "3+X=5", (d) "X+3=5" (the current version of the ILE only handles natural numbers). Here, numerical relation (a) means the answer is the number in the final situation, numerical relation (b) and (c) mean the answer is the number in the change action, and numerical relation (d) means the answer is the number in the Initial situation.

(2). Selecting concepts from Concept Panel and combining them with the template of Change-Problem

The template has several blanks, and the ILE asks the learner to pose a problem by filling the blanks with the concepts. Then, if the learner selected a concept from the set of wrong concepts, the ILE can give the learner feedback, which suggested that the concept is wrong.

(3). Request to diagnose a problem

When the learner clicks the "diagnosis button", the problem is sent to the server and is diagnosed.

(4). Revising the wrong problem by using the suggestion given in the Comment Panel

When the posed problem is wrong, the learner receives feedback that indicates an error at Comment Panel.

The ILE generates the message by using the result of the diagnosis.

(5). Posing the new problem by using the suggestion

When the learner posed the correct problem, the learner receives feedback which is suggests to pose the new type of problems.

3.4 Problem Diagnosis Module and Advice Generator

Problem Diagnosis Module and Advice Generator are functions of the server in the ILE. Problem Diagnosis Module diagnoses problems sent by the client, and Advice Generator generates messages that are provided for each learner.

The ILE, first, diagnoses a single sentence and then diagnoses the problem composed of three sentences, and compares the solution given by a learner with the problem posed by the learner. In the first step, the module has knowledge about acceptable sentences (initial situation, change action, final situation). We call each sentence "basic relation", and the knowledge "single sentence schema". The single sentence schema checks each basic relation to find the errors in a sentence.

In the second step, the relation among the sentences is diagnosed. The module has the knowledge about acceptable relations among basic relations. We call the knowledge "problem schema". The problem schema checks the numerical relation between the sentences to find the wrong sentence in the problem.

In the third step, the relation between the solution and the problem is diagnosed.

In the following section, the diagnosis process is explained. Then, the feedback made by the diagnosis result is presented.

3.4.1 Diagnosis of the posed problems

Diagnosis of the posed problems is carried out in three steps: the first step is the diagnosis of a single sentence. The second step is the diagnosis of the problem composed of three sentences. The third step is the diagnosis of the relation between the problem and the solution.

(1). Diagnosis of a single sentence

In this diagnosis, two types of errors are detected: (1-a) errors in the relation between object and action, and (1-b) errors in the relation between object and number. Here, Mismatch of blanks (that is, object blank or action blank and so on) and concepts is already checked in the interface.

An example of (1-a) is a sentence that "Tom eats his 2 sheets of postcards." "Tom has 5 cups of apple pies" is an example of (1-b). These errors are detected by checking with sentence schema in that the acceptable relations between object and action or object and number are described.

(2). Diagnosis of problem

In this diagnosis, three types of errors are detected: (2-a) errors in the final situation, (2-b) errors in the change action and (2-c) no relation errors. (2-a) means that the initial situation can be changed by the change action, but cannot be changed to the final situation. (2-b) means that the initial situation can be changed to the final situation, but cannot be changed by the change action. (2-c) means that the initial situation cannot be changed by the change action and to the final situation. These errors are detected by comparing by problem schema in that the acceptable relations among the situations and the change action are described.

An example of (2-a) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats Tom's 3 pieces of apple pies" and "how many pieces of lemon pies does Tom have?" An example of (2-b) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats her 3 pieces of apple pies, and "how many pieces of apple pies does Tom have?"

(3). Diagnosis of the relation between the problem and the solution

The diagnosis module can generate an equation from the problem. In this diagnosis, first, the module solves the equation. Then the calculation to derive the answer is compared with the calculation posed by the learner as the solution. When the two calculations do not correspond, an error in the relation between the problem and the solution is detected.

3.4.2 Feedback for the client

(1). Indication of an error

If the diagnosis module finds an error, the ILE indicates it. Even if the problem includes several errors, the

ILE indicates the error detected first.

(2). Suggestion of the next step of problem posing

The ILE suggests the next step of problem posing when the posed problem is the correct one. In the diagnosis, the module diagnoses not only whether the problem is correct or not, but also what concepts, actions or equations are used in the problem. Based on the results, the ILE can suggest more difficult problem posing by specifying concepts or an equation type to be allowed to use in problem posing.

4 Preliminary evaluations

A prototype of the ILE has been already developed. We used it in three different situation for evaluation, as follows: (1) Use by teachers of the elementary school, (2) Use by students of elementary school in arithmetic classes, (3) Use by students of elementary school outside the class.

In (1), we asked the teachers to evaluate the ILE from the viewpoint of teaching. Then, two of them permitted us to use the ILE in their arithmetic class. So, we had two opportunities to evaluate the ILE in the second situation. In (2), we asked the students of elementary school to pose arithmetical word problems with the ILE in two arithmetic classes. In the trial, although we collected the answers for our questionnaires, we failed to record logs of problem posing. Therefore, we could not get the data about the number of posed problems, and the students behave for feedback from the ILE. In (3), we gathered several students again, and asked them to use the ILE out of class. Here, the students used the ILE for the first time.

In this section, we report these results.

4.1 Use by the teachers of the elementary school

To evaluate a learning environment, the evaluation by teachers is important. We asked five teachers of elementary school to use the ILE. After they posed several problems by using this ILE, we asked them several questions. The questions are as follows: (1) How do you evaluate the effect of problem posing to learn arithmetic? (2) How do you evaluate the way of problem posing used in the ILE? (3) How do you evaluate the interface? (4) How do you evaluate the indications for the errors in posed problems? (5) How do you evaluate the advises to suggest the next step of problem posing? Table 1 shows the results.

Table 1: Evaluation of the teachers

	Good	So-so	Bad
(1)	5	0	0
(2)	3	2	0
(3)	2	3	0
(4)	4	1	0
(5)	5	0	0

Table 1-(1) means that all teachers think to learn arithmetic by using problem posing is effective. Table 1-(2) suggests that the ILE realizes an useful environment for learning by problem posing. Two teachers out of three teachers who answered "Good" to the question (2), gave us opportunities to use the ILE in classes. A few teachers also indicated that the limitation of concepts that were allowed to use in problem posing should be revised. This is one of our future works. In Table 1-(3), three teachers answered "So-so". The result means that the interface is not always easy to use. In Table 1-(4), four teachers answered "Good". The result suggests that the indications for the errors in the posed problem are acceptable. However, several teachers also indicated that the sentences of the indications may be difficult for elementary students. In Table 1-(5), the all teachers answered "Good". This result means that the teachers think the suggestions to make learners progress the next step of problem posing adequately support learning by problem posing.

4.2 Use by the students of elementary school in arithmetic classes

We used the ILE in two classes: the one was composed of 25 students in third grade and the other was composed of 30 students in fifth grade. In each class, 15 minutes were used to explain the use of the ILE, and 20 minutes were used for the problem posing practice with the ILE. In this problem posing practice, students were two people one set, and they operated one personal computer with two. Then two assistants assisted them to operate the ILE in the experiments.

Table 2: Evaluation of the

		Yes	No Answer	No
Third -grad	(1)	22	0	2
	(2)	22	0	2
Fifth-grad	(1)	27	2	1
	(2)	25	4	1

We asked two questions after the problem posing practice: (1) Are you interested in problem posing by using this ILE? (2) Do you want to pose more problems by using this ILE? The result is shown in Table 2.

The results suggested that most students were interested in problem posing with the ILE. But we were not able to get enough data to confirm that the students pose problem well.

4.3 Use by the students of elementary school outside the class

Subjects were one student of fourth-grade, and threes students of sixth-grade in elementary school. In the experiment, we used 15 minutes in the demonstration of this ILE, and 25 minutes in the problem posing practice. The results were as follows. In Table 3, *Diagnosis* indicates the number of time of request to diagnose.

Table 3: Logs of the problem posing

Diagnosis	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
i	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**
ii	**α-C**	**α-C**	**β-W**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**		
iii	**α-C**	**α-C**	**β-C**							
iv	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**	

α: A±B=X, **β**: A±X=C, γ: X±B=C (A,B,C are numerical values. X is a variable)

C: Correct, **W**: Wrong

In Table 3, equations named by Greek (α, β, γ) specify the type of problem posed by subject. "A" is the number in the initial situation, "B" is the number of the change action, and "C" is the number in the final situation. "X" is the number that is derived by the solution. In the α type, the answer is in the final situation. So this type of problem is the easiest one. In the β type, the answer is in the change action. In the γ type, the answer is in the initial situation. In this order, problems become difficult. The ILE can judge not only "C (correct)" or "W (wrong)", but also the type of problem whenever the student requests the diagnosis.

In Table 3, three subjects (i, ii, iv) tried to pose the problems of the all types, and subject-iii tried to pose the two types of the problems. The subject-i posed the wrong problem of the γ type on the 3rd request to diagnose in the practice. And the subject was repeating to revise it in seven times. As a result, the subject posed the correct problem of the γ type in the 10th trial. And the subject-ii posed the wrong problem of the β type on the 3rd request to diagnose in the practice, then the subject posed the correct problem of the β type in the 4th trial. And the subject-iv posed the wrong problem of the γ type on the 3rd request to diagnose, then the subject posed the correct problem of the γ type in the 9th trial, too. But, the subject-ii gave up to correct the wrong problem of the γ type, although s/he was repeating to revise the wrong problem in three times. The results suggest that the feedback is effective to forward the learner to revise the wrong problem.

In the current ILE, if a learner corrected the problem, the ILE suggests the next step of problem posing. The first step is problem of the α type. the second step is problem of the β type. and the third step is problem of the γ type. In Table 3, all subjects follow the suggestion. In the results, when a learner posed a correct problem, the learner can not poses only the same type of problem again, but also other types of problem by using the feedback. This suggests that the feedback is also effective to advance the next step of problem posing.
Conclusions

5 Conclusion

In this paper, we described ILE for problem posing in simple arithmetical word problems. The ILE provides the template to pose Change-Problem in current version. And the ILE can diagnose the problem that learners fill blanks of the template with several concepts, values, and question mark. Besides, the ILE can support

each learners by using the results of diagnosis. We used the ILE in three different situations for evaluation. In the results, we consider that this research provides basis functions to realize the problem posing practice by ILE about simple arithmetical word problems.

In future work, we will refine functions in the ILE. For example, in the ILE, we will deal with not only Change-Problem, but also the other types of problems. And we will develop a function in which teachers can customize concepts provided for their students in their problem posing practice, because teachers hope to use concepts which are popular in their classroom. Then, we will evaluate the ILE again in order to investigate about the effect to learn arithmetic.

References

[1] Nakano・A.・T.Hirashima・A.Takeuchi・"Problem-Making Practice to Master Solution-Methods in Intelligent Learning Environment・" Proc of ICCE'99・pp891-898・1999.

[2] Barr,A., Beard, M., Atkinson, R.C., "The Computer as a Tutorial Laboratory: the Stanford BIP Project". Int.J. Man-Machine Studies, Vol.8, pp.567-596, 1976

[3] MaCalla, G.I. "The Search for Adaptability, Flexibility, and Individualization:Approaches to Curriculum in Intelligent Tutoring ILEs", In Jones, M. and Winne P.H.(Eds.), Adaptive Learning Environment: Foundation and Frontiers, Springer-Verlag, pp.91-122, 1990

[4] Hirashima, T., A.Kashihara, J.Toyoda : "Toward a Learning Environment Allowing Learner-Directed Problem Practice". Proc. of ITS'96 Lecture Notes in Computer Science 1086, pp.466-474,1996

[5] Hirashima, T., A.Kashihara, J.Toyoda : "Providing Problem Explanation for ITS", Proc. of ITS'92 Lecture Notes in Computer Science 608, pp.76-83, 1992

[6] Hirashima, T., T.Kohno, A.Kashihara, J.Toyoda : "Development of Support Facilities for Arithmetical Word Problem Exercises in Intelligent Tutoring ILE". Electronics and Communications in Japan, pp.22-33, 1992

[7] Silver・E.A.・Mamona,J.・"Posing Mathematical Problems:An Exploratory Study・" Journal of Research in Mathematics Education・vol.27・No.3, pp293-309・1996.

[8] Lyn D. English・"Children's Problem Posing Within Formal and Informal Contexts・" Journal of Research in Mathematics Education・vol.29・No.1, pp83-106・1998.

[9] Ellerton, N. F., "Children's made up mathematics problems: A new perspective on talented mathematicians," Educational Studies in Mathematics, 17, pp261-271, 1986.

[10] Silverman, F. L., Winograd, K., Strohauer, D. "Student-generated story problems. Arithmetic Teacher," 39, pp6-12, 19992.

[11] Silver・E.A.・Cai,J.・"An Analysis of Arithmetic Problem Posing by Middle School Students・" Journal of Research in Mathematics Education・vol.27・No.5, pp521-539・1996.

[12] Silver, E.A, "On mathematical problem posing. For the Learning of Mathematics," 14(1), 19-28

[13] Kintsch, W., Greeno, J.G., "Understanding and Solving Word Arithmetic Problems," Psychological Review, vol.92, No.1, pp109-129, 1985.

A Method of Creating Counterexamples by Using Error-Based Simulation

Tomoya Horiguchi* and Tsukasa Hirashima**
**Faculty of Information Engineering, Kobe University of Mercantile Marine*
5-1-1, Fukaeminami, Higashinada, Kobe 658-0022 JAPAN
Phone: +81-78-431-6263, E-mail: horiguti@ti.kshosen.ac.jp
***Department of Artificial Intelligence, Kyushu Institute of Technology*
680-4, Kawatsu, Iizuka, Fukuoka 820-0067 JAPAN
Phone: +81-948-29-7618, E-mail: tsukasa@ai.kyutech.ac.jp

The method of creating counterexample by using educational simulation is proposed. Error-Based Simulation (EBS) is used for this purpose, which simulates a learner's erroneous equation in mechanics problem. A learner's error is visualized as unnatural motion of a physical object. In order for EBS to be effective as counterexample, the followings are essential: (1) A learner can recognize the difference of unnatural motion in EBS from natural one in correct simulation, and (2) EBS must provide a learner sufficient information to understand the cause of error and to reach correct understanding. The former has been studied in the authers' previous works. In this paper, the latter is discussed. To identify a learner's error, misconceptions are classified based on problem-solving model, and are linked to their appearance on a learner's answer (error-identification rules). Then, to indicate the cause of error by EBS, unnatural motions in EBS are classified and linked to the misconceptions which they suggest (error-visualization rules). These functions are realized as rule-base systems. The architecture of EBS management system, which judges a learner's error and generates the suitable EBS using these functions, is proposed.

Keywords: **counterexample, simulation, mechanics, error, student model, motion perception**

1 Introduction

It is well known that cognitive conflict promotes learning process. It often occurs when a learner encounters the fact which is contradictory to her/his idea. Cognitive conflict motivates a learner to reconsider her/his idea, and often causes conceptual change [Gagne 85, Fujii 97].

Counterexample is useful for creating cognitive conflict. It provides a case in which a learner's idea doesn't account for the fact, or her/his procedure doesn't produce the correct solution.

However, one must be careful in using counterexample, because a learner often ignores or refuses it. Even when she/he accepts the counterexample, she/he needs some kinds of help to reach correct understanding. Without any assistance, a learner often comes to an impasse, or makes ad hoc rules which explain the exception only. Therefore, in using counterexample, the followings are essential [Fukuoka & Suzuki 94, Nakajima 97]:

(1) Counterexample must be recognized to be meaningful and acceptable. When the difference is clear and reliable between counterexample and a learner's expectation, she/he easily accepts it and reconsiders her/his idea.

(2) Appropriate assistance must be provided to lead a learner to correct understanding. Counterexample must include sufficient information for this. It will be helpful to explicitly describe the distinguishing attributes of counterexample.

Error-based Simulation (EBS) is an educational simulation which provides a learner counterexample. It simulates an erroneous equation made by a learner in solving mechanics problem. In EBS, a learner's error often appears as unnatural motion of a physical object, which differs from her/his prediction (She/he can usually predict the correct motion).

The authors have developed the method of generating effective EBS mainly from the above viewpoint (1) [Hirashima et al. 98, Horiguchi et al. 99]. The condition on which a learner can recognize the difference between EBS and correct simulation was formulated (Criteria for Error-Visualization: CEV), and the mechanism to estimate the quality of difference was proposed, which considers both clarity and reliability of the difference.

However, though such an EBS motivated a learner by indicating the existence of errors, it was not sufficient to lead her/him to correct understanding. It didn't provide sufficient information for this.

Therefore, this paper proposes the method of managing EBS from the above viewpoint (2). EBS must justly indicate the cause of a learner's error, and suggest how to correct it. The followings are the requirements and approaches for this purpose.

(a) The function which identifies the cause of error behind a learner's erroneous equation or her/his handwriting diagram.
Approach: First, construct a problem-solving model of mechanics. Secondly, based on the model, classify the misconceptions which occur in problem-solving as causes of errors. Thirdly, classify the appearances of the misconceptions on a learner's equation or handwriting diagram. Lastly, appearances and causes of errors are linked together correspondingly. These are called *Error-Identification Rules*.

(b) The function which generates the EBS indicating the identified cause of error by unnatural motion of a physical object.
Approach: First, classify the unnatural motions in EBS. Then, link them to the corresponding causes of errors, considering what kind of unnaturalness suggests what kind of misconception. These are called *Criteria for Cause-of-Error-Visualization*. With these criteria, EBSs are estimated their effectiveness. When there is no EBS which is judged effective, other teaching methods will be considered.

2 Previous works in Error-Based Simulation

Before proceeding to the main topic of this paper, we outline the stream of study in Error-based Simulation, which may be helpful to clarify the present problem and the position of this paper.

***Stage 0* [Hirashima et al. 98 for summary]**

The fundamental idea of EBS is very simple. In mechanics problem, many learners feel difficulty in thinking by equations, so EBS maps their equations from mathematical world to physical world. It embodies a learner's error as unnatural motion of a physical object, which makes it much easier to recognize the error. Here, we assume that unnatural motion in EBS is differ from a learner's prediction, that is:

Precondition-1: A learner can predict the correct motion (in spite of her/his erroneous equation).
This precondition is set through all stages of the research of EBS.

***Stage 1* [Hirashima et al. 98]**

Apparently, the key of this method is how a learner sees the difference between the unnatural motion in EBS and the predicted natural motion. At least, the difference must be noticed by a learner. When the difference of two motions is small, she/he may not notice it, or cannot judge which motion is correct (unfortunately, the ability of human vision is not so sensible). Therefore, we set the following assumption:

Assumption-1: EBS must satisfy CEV-1 and/or CEV-2 below to indicate the existence of error.
Condition for Error-Visualization 1 (CEV-1): There is a qualitative difference between the motion in EBS and the one in correct simulation, that is, the qualitative values of a physical object's velocity are different between them.
Condition for Error-Visualization 2 (CEV-2): There is a qualitative difference between the change of motion in EBS and the correct simulation, that is, the qualitative values of the derivative

of a physical object's velocity are different between them.

Stage 2 **[Horiguchi et al. 99]**

When regarding EBS as counterexample, the viewpoints (1) and (2) in chapter 1 are important. We previously worked out how to estimate the effectiveness of EBS from the viewpoint (1). It is subdivided into two viewpoints: (1-1) how clear the error appears in EBS, and (1-2) how reliable the EBS is as counterexample.

From the viewpoint (1-1), the more CEVs the EBS satisfies, the more effective it is. In general, changing parameters of the mechanical system makes EBS satisfy more CEVs. For example, in Figure 2, the EBS based on erroneous equation m2a = T + μm2g (Figure 2d) satisfies CEV-1. (The qualitative value of relative velocity between two blocks is [+], while it is [0] in normal case.) But, when the mass of m2 increases, the EBS becomes to satisfy CEV-2 besides CEV-1. (The velocity of m2 increases, while it decsreses in normal case.) We categorized the methods of parameter-change and their influence on the clarity of errors.

However, from the viewpoint (1-2), such parameter-change harms the reliability of EBS, because a learner feels it factitious to change parameters too largely. The smaller parameter-change the EBS has (no change is the best), the more reliable it is. This discussion is summarized as follows.

Assumption-2: From the viewpoint of clarity, EBS should satisfy more CEVs.
Assumption-3: From the viewpoint of reliability, EBS should have less parameter-changes.

Stage 3 **[just this paper]**

In estimating the effectiveness of EBS, there is another, and important viewpoint: whether the EBS provides appropriate information for correcting the error, that is, the viewpoint (2) in chapter 1. Stage 0-2 have been mainly concerned with how to make a learner notice the error, while at this stage, our concern is how to make him correct the error.

For example, consider the erroneous equation m2a = T + μm2g (Figure 2d). From the viewpoint of reliability (1-2), the EBS shown in Figure 2c is generated. But it shows the string between two blocks shrinking, which may suggest something is wrong about tension of the string. It is misleading because the real cause of error is the friction of m2. In this case, the EBS in Figure 2e should be generated to indicate the cause of error. (It is generated when taking the viewpoint of reliability (1-2), but by accident.)

Of course, the viewpoints (1-1) and (1-2) are useful to impress on a learner the existence of error. However, in considering the error-correction, to generate EBS from the viewpoint (2) becomes necessary. It is the very topic of this paper.

3 Mechanism for Identifying the Cause of Errors

Now, we'll explain how to realize the functions described in chapter 1. The mechanism for identifying cause of errors is realized as follows:

1. to generate the correct solution by problem-solving model.
2. to specify the erroneous part of a learner's solution by comparing with the correct solution.
3. to identify the cause of error by applying the Error-Identification Rules, which link the appearance of erroneous part to its cause.

Here, a learner's solution means the equation and handwriting diagram made by her/him, from both of which the information about her/his problem-solving process is derived.

3.1 Problem-Solving Model

We deal with the mechanics problems of high school level, which ask a learner to set up equation of motion by using Newton's second law. The problem-solving process is divided into three steps [Robertson 90, Plötzner 94]:

step-1 to predict the motion of physical objects in the mechanical system qualitatively.
step-2 to enumerate the forces acting on each object.
step-3 to compose the enumerated forces and substitute them for the left side of formula F = ma.

Table 1. Force-Enumerating Rules (FERs) (abstract)

force	Rules for enumerating forces		
gravity	R0: r0-c1	Object-1 has mass m > 0	
	→		
	r0-a1	Gravity F to Object-1	Qualitative
	r0-a2	Direction: vertically downward	Qualitative
	r0-a3	Magnitude: F = mg	Quantitative
friction	R3: r3-c1	Object-1 and Object-2 are touching together	∧
	r3-c2	coefficient of friction of touching surface μ > 0	∧
	r3-c3	normal force N acting on touching surface	∧
	r3-c4	Object-1 and Object-2 are moving oppositely along the tangent	
	→		
	r3-a1	friction Ff1 to Object-1	Qualitative
	r3-a2	friction Ff2 to Object-2	Qualitative
	r3-a3	Direction(Ff1): opposite to the velocity of Object-1	Qualitative
	r3-a4	Direction(Ff2): opposite to the velocity of Object-2	Qualitative
	r3-a5	Magnitude: Ff1 = Ff2 = μN	Quantitative

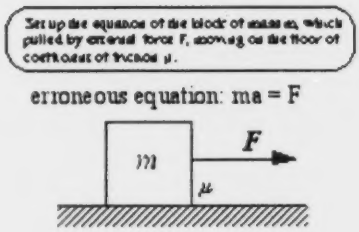


Figure 1. Example Problem-1

In step-1, a learner predicts the motion of objects in the system, and gives each object acceleration vector. Approproate axes are also set up. In step-2, she/he enumerates the forces which aren't given in problem description. Both qualitative knowledge (what kind of force acts in which direction?) and quantitative one (algebraic description of the magnitude of force) are used. In step-3, she/he decomposes/composes the enumerated forces along the axes, and substitute them for the formula F = ma.

In this paper, we don't model the error-occurring process in step-1, because it is presupposed that a learner correctly predicts the qualitative motion of objects in using EBS (Precondition-1 in chpter 2). We also omit the occurrence of error in step-3, which mostly concerns the knowledge of vector calculation.

Therefore, modeling step-2 is our central issue. Takeuchi and Otsuki (1997) considered that a learner constructs a model of causal structure of mechanical system, with which she/he infers the occurrence and propagation of forces. They formulated this process as a set of production rules. We modify them considering their qualitative/quantitative characteristics. A part of our model is shown in Table 1. The rules are called Force-Enumerating Rules (FERs).

3.2 Error-Identification Rules

In our model, a learner's errors are considered as the ones of FERs. The errors of FERs themselves and the ones in their application are included. In fact, these errors appear as the missing/extra/errors of the term of force in equation, or of the arrow of force in handwriting diagram. They are also linked to the strategies for correction.

For example, in Figure 1, the term of friction (-μmg) is missing in the erroneous equation. The cause of this error and its instruction are considered as follows:

1) A learner doesn't know the concept of friction itself, that is, doesn't know the rule R3 (Table 1).
   Instruction: Re-teach the concept/definition of friction.
2) A learner is overlooking the preconditions of R3, that is, overlooking the fact that the block is touching the floor (r3-c1), or the fact the coefficient of friction is nonzero (r3-c2).
   Instruction: Re-show the problem and indicate the corresponding part of the diagram.
3) A learner is missing the force which causes the friction, that is, missing the normal force (r3-c3).
   Instruction: Proceed to the correcting strategy of normal force.
4) A learner doesn't think the block moves along the floor, that is, missing the relative velocity of them (r3-c4).
   Instruction: This is the erorr of prediction of movement. So, out of the range of this paper. But, it may be useful to indicate the force which causes the block's motion.

BEST COPY AVAILABLE

Through such a consideration, the appearances of errors and their causes are classified as shown in Table 2. These are the Error-Identification Rules (EIRs), which are applied to the erroneous part of a learner's answer (specified by comparing with the correct solution), to identify the cause of error.

In Table 2, each error has its strategy for correction. Note that, it is not necessary to use EBS for every case. Of course, when other instruction method is more appropriate, it should be used. However, the aim of this paper is to clarify what kind of errors EBS is effective for, and how to estimate its effectiveness. For this purpose, we need to study the unnaturalness of physical objects' motion in simulation.

4 Criteria for Cause-of-Error Visualization

The identified error must be corrected. In this chapter, we formulate the criteria for judging whether an EBS is effective for the error. It means that EBS rightly indicates the cause of error and suggests the way of correction.

4.1 Motion and Forces

In EBS, it is the motion of physical objects (or their relationships) to be observed. Therefore, we classify the motions and connect them to the mechanical concepts they suggest.

Table 2. Error-Identification Rules (EIRs)

force	appearance	cause of errors	correcting strategy
external force/ gravity	missing	missing knowledge of gravity (R0)	re-teach the concept/definition
	extra error	misunderstanding the problem (r0-c1)	re-show the problem and indicate the corresponding part
tension	missing	missing knowledge of tension (R1) overlooking the string (r1-c1) missing the force which causes tension (r1-c2)	re-teach the concept/definition re-show the problem and indicate the corresponding part proceed to the correcting strategy of that force
	extra	belief that string propagates tension (r1-c2) overlooking that motion loosens string (r1-c2)	re-show the problem and indicate the corresponding part indicate that tension is extra
	error	error of the force which causes tension (r1-c2) error of direction/magnitude (r1-a2/3)	proceed to the correcting strategy of that force indicate that direction/magnitude is erroneous
normal force	missing	missing knowledge of normal force (R2) overlooking the touching/attachment (r2-c1) missing the force which causes normal force (r2-c2)	re-teach the concept/definition re-show the problem and indicate the corresponding part proceed to the correcting strategy of that force
	extra	belief that normal force works (r2-c2) extra of the force which causes normal force (r2-c2)	indicate that normal force is extra proceed to the correcting strategy of that force
	error	error of the force which causes normal force (r2-c2) error of direction/magnitude (r2-a2/3)	proceed to the correcting strategy of that force indicate that direction/magnitude is erroneous
friction	missing	missing knowledge of friction (R3) overlooking the touching together (r3-c1) overlooking that coefficient of friction $\mu > 0$ (r3-c2) missing normal force (r3-c3) belief that normal force doesn't work (r3-c4)	re-teach the concept/definition re-show the problem and indicate the corresponding part re-show the problem and indicate the corresponding part proceed to the correcting strategy of normal force indicate that friction is missing
	extra	missing that coefficient of friction $\mu = 0$ (r3-c2) extra of normal force (r3-c3) belief that normal force works (r3-c4) extra of the force which causes friction (r3-c4)	re-show the problem and indicate the corresponding part proceed to the correcting strategy of normal force indicate that friction is extra proceed to the correcting strategy of that force
	error	error of normal force (r3-c3) error of the force which causes friction (r3-c4) error of direction/magnitude (r3-a3/4/6)	proceed to the correcting strategy of normal force proceed to the correcting strategy of that force indicate that direction/magnitude is erroneous
propagating force	missing	missing knowledge of force propagation (R4/5) overlooking the touching together (r4/5-c1) missing of the force which causes force propagation (r4/5-c2)	re-teach the concept/definition re-show the problem and indicate the corresponding part proceed to the correcting strategy of that force
	extra	belief that force propagates (r4/5-c2) extra of the force which causes force propagation (r4/5-c2)	indicate that propagating force is extra proceed to the correcting strategy of that force
	error	error of the force which causes force propagation (r4/5-c2) error of direction/magnitude (r4/5-a2/3)	proceed to the correcting strategy of that force indicate that direction/magnitude is erroneous
other	extra	unperm	indicate that unperm is extra

BEST COPY AVAILABLE

How does a human perceive and recognize moving objects? Though it is well known that their figurative characteristics (figure, size, texture, etc.) and composition (position, direction, symmetry, etc.) have great influence on the arising images, it is difficult to generalize them because they much depend on the cultural factors. Therefore, we limit our target to the physical world of simulation, in which things are thought in the sense of mechanics.

When observing an object to move, a human feels its motive 'force' working. Of course, this kind of 'force' is of naive impression and doesn't always correspond to the real force. But it appeals to human's intuition so much more. Bliss & Ogborn (1992) classified such naive concepts of force according to the stages of child development. Based on their findings, we consider the relations between the mo tions in EBS and the forces they suggest.

4.2 Motion of a single object

A moving object arises the feeling of force working. (e.g. A falling down ball suggests gravity.) Therefore, the object moving unnaturally in EBS is supposed to suggest the erroneous force acting on it. (e.g. gravity, friction etc.) Unnatural motions of a single object are classified as follows:

(a) Directions of both velocity and acceleration are opposite to the ones of correct motion.
(b) Direction of only velocity is opposite to the one of correct motion.
(c) Direction of only acceleration is opposite to the ones of correct motion.
(d) Directions of both velocity and acceleration are same as the ones of correct motion.

Here, it is assumued that human can distinguish at most the qualitative difference of velosity or acceleration of an object in motion [Hirashima et al. 98, Horiguchi et al. 99].

For example, in case (a), when a learner observes an object moving in the opposite direction to her/his prediction (which is correct), she/he will recognize that the force is missing which acts in the predicted direction, or that the force is extra which acts in the present direction.

Table 3 shows the relations between unnatural motions and the errors they suggest. They are called Criteria for Cause-of-Error Visualization (CCEVs).

4.3 Relative Motion of two objects

Moving plural objects also arises the feeling of force working. We limit to two objects. When observing two objects moving together, the force maintaining their relative motion is felt. (e.g. A moving dolly pulling another one connected by string suggests tension.) Therefore, two objects relatively moving in unnatural manner in EBS are supposed to suggest the erroneous force interacting between them. (e.g. tention, normal force etc.) Unnatural relative motions of two objects are classified as follows:

(e) Two objects are closing with each other, which are connected by string. (String shrinks.)
(f) Two objects are going away from each other, which are connected by string. (String stretchs.)
(g) Two objects are overlapping each other.
(h) Two objects are parting from each other, which are attached together.

For example, in case (g), when a learner observes such unnatural relative motion, she/he will recognize that the normal force is missing or too small which interacts between two objects.

Table 4 shows the relations between unnatural relative motions and their suggesting errors. They are also called Criteria for Cause-of-Error Visualization (CCEVs).

Note that, all of the motions in Table 3 and 4 have at least some kinds of qualitative difference from the correct motions. This is because, however precisely an EBS indicates the error, it isn't effective unless a learner recognizes it as 'unnatural.' The difference is judged with Criteria for Error-Visualization (CEVs) [Hirashima et al. 98, Horiguchi et al. 99].

Table 3. Criteria for Cause-of-Error Visualization (CCEVs) (for single object)

situation		difference	suggesting errors
correct situation		–	–
situation (a)		velocity: opposite acceleration: opposite	missing of the force opposite to moving direction ⊕ extra of the force same as moving direction ⊕ larger of the force same as moving direction ○ smaller of the force opposite to moving direction ○
situation (b)		velocity: opposite acceleration: same	missing of the force same as moving direction △ missing of the force opposite to moving direction ⊕ extra of the force same as moving direction ⊕ extra of the force opposite to moving direction △ larger of the force same as moving direction ○ smaller of the force opposite to moving direction ○
situation (c)		velocity: same acceleration: opposite	missing of the force same as moving direction ⊕ extra of the force opposite to moving direction ⊕ smaller of the force same as moving direction ○ larger of the force opposite to moving direction ○
situation (d)		velocity: same acceleration: same	missing of the force opposite to moving direction △ extra of the force same as moving direction △

note 1. ⊕ : able to suggest the error by itself with great effect
○ : able to suggest the error by itself with small effect
△ : need to be modified some parameter(s) to suggest the error

note 2. The error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction.

Table 4. Criteria for Cause-of-Error Visualization (CCEVs) (for two objects)

situation		interrelation	suggesting errors
correct situation		correct distance	–
situation (e)		closing string shrinks	extra/larger of the tension ⊕ extra/larger of the propagating force ○
situation (f)		going away string stretches	missing/smaller of the tension ⊕ missing/smaller of the propagating force ○
situation (g)		overlapping	missing/smaller of the normal force ⊕ extra/larger of the normal force ○ missing/smaller of the propagating force ○ extra/larger of the propagating force ○
situation (h)		parting from each other	missing/smaller of the normal force ○ extra/larger of the normal force ⊕ missing/smaller of the propagating force ○ extra/larger of the propagating force ○

note 1. ⊕ : able to suggest the error by itself with great effect
○ : able to suggest the error by itself with small effect

note 2. The error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction.

5 Examples

In this chapter, we illustrate the process of identifying the cause of error and generating the EBS which indicates the error. The example problem is shown in Figure 2.

5.1 A Simple Case

First, the solution (correct equation and diagram: Figure 2a) is generated by problem-solver. Then, it is compared with a learner's answer (Figure 2b) to specify the erroneous part. In this case, it is the erroneous

BEST COPY AVAILABLE

value (too large) of tension beside block m2. Secondly, EIRs (in Table 2) are applied to identify the cause of error. It is identified as the error of magnitude of tension. According to Table 2, the correcting strategy of this error is to indicate the fact. Then, CCEVs (in Table 3 and 4) are applied, to find that the motion (g) satisfies this demand.

Based on the erroneous equation of Figure 2b, the EBS shown in Figure 2c can be generated, in which block m2 moves faster than its normal case, consequently the string shrinks. This unnaturalness is equal to the one of motion (g). Therefore, this EBS is judged to satisfy the instructional demand, and shown to the learner.

5.2 A Complicated Case

Consider the erroneous answer of a learner in Figure 2d. In this case, the erroneous part is the erroneous direction of friction acting on block m2. By EIRs, the cause of error is identified as the error of direction of friction, and the correcting strategy is to indicate the fact. Since the error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction (see note 2 of Table 3), the motions (a), (b), (d) satisfy this demand.

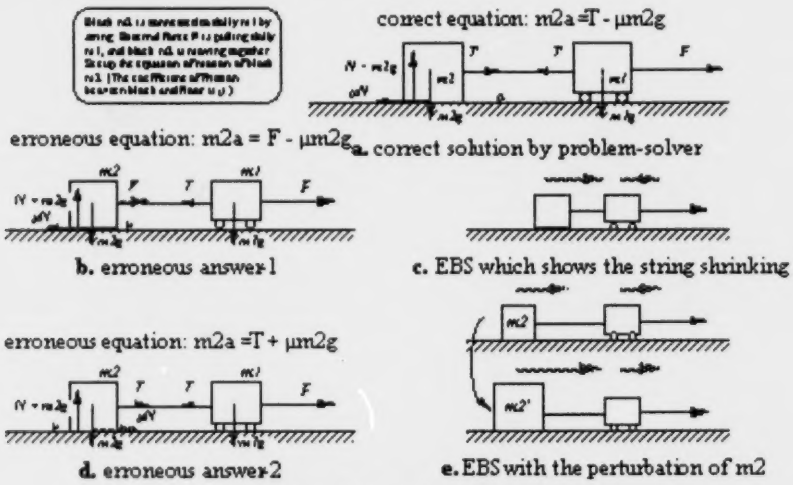


Figure 2. Example Problem-2

Based on the erroneous equation of Figure 2d, however, it is impossible to generate the EBS which contains the motion (a) or (b). In addition, even when the EBS containing the motion (d) is generated (it is possible), it causes the unnatural relative motion (e), which indicates another error. In fact, the EBS, in which block m2 is closing to dolly m1 (the same as Figure 2c), strongly suggests the error of tension. This misleads a learner.

Therefore, in this case, the EBS must be modified to precisely indicate the identified error. Perturbing the mass of block m2 is a promising method. When the mass m2 increases, in EBS, the velocity of the block increases (Figure 2e). This is a strange change of motion. Observing this, a learner may think some physical amount is wrong which concerns the mass m2. She/he may notice the erroneous friction acting on block m2.

As for the EBS of Figure 2e, the difference from the correct simulation is not so much clear and reliable as the EBS of Figure 2c. Instead, it provides precise information for correcting the error, while the EBS of Figure 2c doesn't. In general, plural EBSs can be generated from one erroneous equation. The best should be chosen according to the purpose.

6 Concluding Remarks

In this paper, we proposed a method of creating effective counterexamples by using Error-Based Simulation. The effectiveness of EBS is judged mainly from the viewpoint whether it provides sufficient information to recognize the cause of error and correct it. The mechanism for identifying the cause of error and for

BEST COPY AVAILABLE

generating the EBS which satisfies the instructional demand was also proposed. We are now implementing the mechanism. The experiment to evaluate our method is planned.
Our future works are as follows:

1. *Cooperation with other instructional tools:* Of course, EBS isn't sufficient for all of the error correction in Table 2. It must be studied to use other instructional tools (textbook, normal simulator etc.), and to coordinate them with EBS.
2. *Refinement of the problem-solving model:* Our model for problem-solving is very simple, so the range of the error it covers is limited. We are going to refine the model, especially considering the process in which a learner qualitatively predicts the motion of mechanical system.
3. Consideration of conflict among CCEVs: As is noted in section 5.2, the effects of plural unnatural motions sometimes conflicts each other. One unnatural motion may invalidate the effect of other unnatural motion. Therefore, it is necessary to set some kind of preferences to CCEVs.

References

[1] Gagne, E.D. (1985). The Cognitive Psychology of School Learning, Little Brown and Company.

[2] Fujii, T. (1997). Mathematical Learning and Cognitive Conflict, In Japan Society of Mathematical Education (Ed.), Rethinking Lesson Organization in School Mathematics, Sangyotosho, Tokyo (in Japanese).

[3] Fukuoka, T. & Suzuki, K. (1994). A Case Study on Lower Secondary School Pupils' Conceptual Changes through Demonstration of Counterexamples: The Concept of Dynamics in the Case of Roller Coaster Models, Bulletin of Society of Japan Science Teaching, Vol.35, No.2, pp.21-32 (in Japanese).

[4] Nakajima, N. (1997). The Role of Counterevidence in Rule Revision: The effects of instructing metaknowledge concerning non adhocness of theory, Japanese Jour. of Educational Psychology, 45, pp.263-273 (in Japanese).

[5] Hirashima, T., Horiguchi, T., Kashihara, A. & Toyoda, J. (1998). Error-Visualization by Error-Based Simulation and Its Management, Int. Jour. of Artificial Intelligence in Education, Vol.9, pp.17-31.

[6] Horiguchi, T., Hirashima, T., Kashihara, A. & Toyoda, J. (1999). Error-Visualization by Error-Based Simulation Considering Its Effectiveness: Introducing Two Viewpoints, Proc. of AI-ED99, pp.421-428.

[7] Robertson, W.C. (1990). Detection of Cognitive Structure with Protocol Data: Predicting Performance on Physics Transfer Problems, Cognitive Science, 14, pp.253-280.

[8] Plötzner, R. (1994). The Integrative Use of Qualitative and Quantitative Knowledge in Physics Problem Solving, Frankfurt: Peter Lang Verlag.

[9] Takeuchi, A. & Otsuki, S. (1997). An Intelligent Tutor for Kinetic System Modeling, Proc. of AI-ED97, pp.340-346.

[10] Bliss, J. & Ogborn, J. (1992). Steps Towards the Formalisation of a Psycho-logic of Motion, In A. Tiberghien & H. Mandl (Eds.), Intelligent Learning Environments and Knowledge Acquisition in Physics, Heidelberg: Springer-Verlag.

A Study of Networked Constructive CAI System Using Multiplication-Concept of "Transformation of Unity Quantity" on Elementary School

Pou-Yah Wu*, Shu-Fen Tsai, Yao-Quan Li, Jian-Zhi Lin, Jun-Rong Chen, and Xiang -Ting Huang

Department of Mathematics Education, National Tainan Teachers' College

33, Sec. 2, Su-Lin Street, Tainan, Taiwan 700

**Pou-Yah Wu's email:pywu@ipx.ntntc.edu.tw*

The feature of networked constructive CAI system lies in shaping the computer environment in which students clarify and construct the concept by ways of communication, discussion, and dialectics, utilizing the practical pedagogic content edited by the spirit of new curriculum in Taiwan at 1993. Because we stress the concept of "transformation of unity quantity" as main activity in teaching multiplication, students' comprehension of "unity quantity", "unity number", and "combined numbers" plays an important role in establishing networked constructive CAI system. We consider that the greatest difference between the networked learning environment and that of the general classroom pedagogy is the deficiency of interaction. Thus, analyzing the strategy of students' solving problems to establish the effective tool table of operation and judging the mode of the students' thought by checking the tools which students use will strengthen the interactive relationship of the system and the learners. Then, use the networked technology and the principle of the expert system to set up the CAI of constructive pedagogy, so that the learners can communicate with each other and the system can conduct dynamically which formally construct a wholly co-operative learning environment and will help the learners to form the whole mathematics concepts.

Keywords: **Constructive pedagogy, Elementary School, Multiplication of Mathematics, Networked CAI.**

1 Introdution

The characteristic of implementing new curriculum of mathematics at elementary schools in Taiwan now lies in the addition of spirit of constructivism, aiming at expecting students to construct knowledge positively. Thus, the teachers' role, in the process of pedagogy in new curriculums, changes into "problem poser", whereas students' learning activities in class attain socialized mutual sense, chiefly by communication, construct their own mathematical knowledge by way of mutual dialectics [5,6]. However, it takes pedagogy of construction longer than traditional pedagogy. The atmosphere and skill as to how the teacher directs students to construct knowledge and how the students discuss influence the effect of implementing new curriculum. In the light of the fact the trend of the times facilitates pedagogy of network to become widespread, the future construction of leased network lets us expect the popularity of "learning at home" and "long distance pedagogy". Therefore, the possibility of displaying a really approximate leaning setting of constructing pedagogy in the network environment becomes much higher. The establishment of the network system of pedagogy of construction, owing to the trend of current situation, is becoming imminent.

The aim of this study consists in designing a learning environment of network suitable for "multiplication concept in elementary school" . The greatest difference between the learning environment of network and that of the general classroom is the deficiency of mutual response [22,26]. And the pedagogy of construction hopes the communication and dialectics to bring about reflection, inspiring students to construct mathematics self-concept. Therefore, how to promote the mutual relationships between the system and the user is one of the considered points about constructing system in this study. Furthermore, how to develop the characteristic of pedagogy of

construction in the system and how to make the pedagogic contents of the new curriculum manifested in the system wholly and fluently is the second chief point taken into account. Aimed at the above two points, that we use network technology, letting the real-time communication proceeded between the learners, or between the learning and system make up a wholly cooperative learning environment. Furthermore, making use of the principles of the expert system to deal with the learning strategy of the problem solver, through the concepts manifested by the problem solver, the system will feedback suitably, and will communicate with the students properly, which can make the pedagogic activity proceed dynamically [19,25]. The design of the pedagogic content, expect considering the sprit of the new curriculums, the students' learning state, after the teachers' real pedagogy, is mainly considered about designing pedagogy. Hence, this system is much closer to the real situation of pedagogy them CAI sold in the market. And the activities of problem solving given to the learner by system would be more congenial to the learner's mode of thought.

2 Principles of system constructing

2.1 Base of learning theory

"Knowledge is positively constructed by the learner rather than being inculcated passively from outside," which is the fundamental proposition of constructing pedagogic paradigm. The students, with acquired knowledge, enter another stage as an active subject of recognition, with good theory by themselves, instead of ignorance and irrationality [16]. But pedagogy of construction does not mean the teacher's role is unnecessary. On the contrary, we realize the aim of pedagogy is to make children construct the activity types of solving problems. In the light of this, the teachers' role becomes "problem poser" rather than "problem solver" in the process of pedagogy. By way of the teachers' posing problems, children undertake the activity of solving problems by themselves; or children become "imitators" through the activity of solving problem provided by the teacher [4]. By these processes, students are provided sufficient experience of solving problems, and then construct the correct mathematics conceptions. Besides, what we must also pay attention to is the teacher and the learner grasp the intentions of each other aiming at the proceeding actives of each other, through trial and dialectics, until both of them relieve the pressure aroused by the interchange actives. The relief of pressure is limited by the fact if the problem is solved according to the activity, and is also influenced by the affectionate expression of them both present of them both present [24]. Therefore, in pedagogy of construction, socialized communication is an important feature [3].

2.2 Base of system establishing

This system is a learning environment constructed in the network, adopting three-tier client/server system architecture: that is, adding another service server on the original framework of the two-tier client/server system in this three-tier client/server system architecture, the management of Database Server charges learning data. Web Server is responsible for teaching, whereas the user of Client precedes all kinds of learning activities ivies through browser machine.

3 Pedagogic design of Multiplication using transformation of unity quantity

3.1 Concept of multiplication

Multiplication referred to by Davydov (1991) is the problem of transformation of unity quantity, that is, the transformation from composite unit to that of the single item [20]. And Clark and Kamii (1997) think that if children own the multiplicative thinking, they will simultaneously deal with lower level unit such as unit of one and the higher level unit different from unit of one [18]. Tzyh-Chiang Ning (1994) mentions that the so-called multiplication operation contains at least two kinds of relationship: (1)the coordinating relationship of two levels,(2)the part-whole relationship of two levels. The problem of multiplication is in reality that of the transformation of unity quantity, namely, the problem of transforming quantity from higher level unit to lower level unit [7,8,9].

3.2 Pedagogic design of multiplication using transformation of unity quantity

The recognition of new curriculums toward mathematics concepts specifies the activity types of solving problems of interiorization [17,23,26]. And he origin of mathematics knowledge embodies the activity of solving problems, instead of tangible objects [5]. Thus, the ideas of new curriculum do not emphasize the existence of calculating problems. The generation of all forms of calculation is entirely for the need of the practical contexts; also the measurement serves as the source of multiplication in the practical contexts [20]. Hence, the appearance of new curriculums in pedagogic content lets students have the necessary sense of owing multiplicative thinking rather than multiplication directed by "multiplication table" of old curriculums; whereas "transformation of unity quantity" is the pivotal point in designing teaching material of new curriculums, different from the viewpoints that look upon multiplication as "repeated addition" [21] in the design of multiplication of old curriculums. In other words, students' comprehending "unity quantity", "unity number" and "combined numbers" in the process of solving problems plays an important role in the design of material content of new curriculums. Tzyh-Chiang Ning (1993) [8]mentions that there are three classification of difficulty in the management of initiatory material of multiplication in new curriculums:(1)the students can tackle the problem of transformation of unity quantity (2)the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Therefore, in the design of pedagogy of multiplication, the arrangement of new curriculums lies in the fact the teacher set up a problem of multiplication in the practical contexts, and the students handle and record the problem by themselves after conveying the message of the problem. The students' knowledge is chiefly constructing from the consultation, inquiry and dialectic between the teacher and the peers; via the established learning by the concept of constructive pedagogy, the teacher should, in the process and record of the students' solving problems, help the students clarify the existence of "unity quantity", "unity number", and "combined numbers" in the problems. The students should also attain the unanimous compromise of the format of record; that is, the format of the students should wholly suggest "unity number ", "unity number", and "combined numbers". When the process of pedagogy arrives here, students have at least finished the level of the second difficulty mentioned by Tzyh-Chiang Ning. As to the application of multiplication sign, it is the flowing and economic problem of culture and communication. New curriculums, thus, undertake such a linguistic transformation of "a×b=>a lots of b=>b multiplied by a." and then bring multiplication sign serving as the operator of recording format. If the students can make use of multiplication symbol as the operator in the recording format, we may well say that they attain the level of the third difficulty. While the students reach that level, they are equipped with initiatory concept of multiplication; in other words, arrive at the formation of " multiplication" concept gradually through "experience"," perception" and "realization" [4].

4 Simulation of the process in the constructive pedagogy

Since our CAI system stresses the spirit of the constructive pedagogy, we hope that the whole computer environment would become more compatible with the real environment of pedagogy. What we must emphasize is the teacher himself/herself is the most important natural resource in the environment of pedagogy. All our set CAI would attain is how to let the computer simulate the mode of thought in the teachers' real lecturing, even to let the computer "realize" the mode of the students' thought. With a view to achieving such an effect, we design operation tools for users' use. We can discriminate the stages of students' thought by the users' choosing tools, which will let the computer analyze the students' mathematics competence through the stage of the students' operation, and simultaneously let the computer carry on dialectics, clarification and discussion by simulating the role of the teacher or that of the student. We can achieve a process of socialization on the computer by such a process of the design. And via such a process, the user can "experience"," observe", and "realize" the concept of multiplication, and finish three tasks of the stages: (1) the students can tackle the problem of transformation of unity quantity (2) the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Take Figure 1 as an example, students can move the bone to the bay by the mouse, then the computer system may judge whether does he/she understand the meaning of problem. We hope to make students gain more self-affirmation by manipulating. As show in Figure 2, our system provides the electric board and the tool table. User can simulate the situation in the class to solve the problem and record the format. In additional, system also supports the different operation tools for users. And the system can provide different solving method to help users constructing their operation by judging what kind of tools they choose. The system also can judge users' operation mode by checking their record format, then, the system will master students' learning condition well, and teach dynamically. Besides, the system also provides virtual students to communicate with users as showing in Figure 3. It will increase the users' learning interest. Virtual students that design for guiding user and make the environment of discussion can provide proper help but not answers in

fitting time.

5 Architecture and implementation of system

5.1 Environment of design and tool

This system uses Windows NT server as server. Developing languages include HTML, JavaScript, Active X, ASP (Active Server Page) and so on. ASP is used as the chief method of control, and ASP and ODBC (Open Database Connectivity) are exercised to match. The management of the teaching material's user becomes simplified. As to the edition of the curricular software, Authorware 5 is mainly used for developing tools.

5.2 Process of system

Process of the system we designs just as Figure 4 shows, the general elucidation is as follows,

1. Pedagogic situation of network construction

The system after the analysis of the pretest makes sure the sorts of the user's operation and then to pose problems according to the classification. The system will communicate and clarify the messages of the problems by the tools in tool table. After the sorts of tools by user to discriminate if he/she has grasped the messages of the problems, the system will provide tool table further, letting the user record by the tools. In this stage, along with level of the user's operation, the system will afford problems, via simulating the role of the student or the teacher to carry on the activities of dialects, clarification, and let the user reflect and modify his/her recording format to match the basic requirements of "unity quantity", "unity number" and "combined numbers" suggested in the recording format". Afterwards, adjust the next learning activity according to the learning state of the user until he/she can construct the concept of multiplication on the acquired basis and attain the learning level of the afore-specified third difficulty. Besides, the system can simulate the real learning environment on the network, letting the user's learning environment diverse.

2. 「Student model」 database

Student model consists mainly of three databases:

(1) Student basis database

It chiefly records the students' basis data such as name, age, the experience of using computers and so on.

(2) Database of learning.

It records the unit of teaching materials the student learned, the learning state of each unit and the duration of time, and the positive result of the students' learning.

(3) Database of learning achievement.

It records the students' assessment about answering and the stage of operation.

3. Database about "posing problems of constructive pedagogy"

The content of teaching material about constructive pedagogy include

(1) Phenomenal problem: this sort of problem can facilitate students to "experience" the mathematics concept.

(2) Psychological problem: this sort of problem can facilitate students to "observe" the mathematics concept.

(3) Sociological problem: this sort of problem can make students via discussion; attain the common sense of using recording, which would become the tool of communication.

(4) Anthropologic problem: this sort of problem can make the above – mentioned communicating tools and the correspondent expression in cultural become congenial.

4. Database of " problems"

This database is to store the problems for the pretest and the posttests.

5.3 Function of on-line communication

The system would establish a learning environment more congenial to real teaching situation thus the convenience for the user and for other users on the line to communicate, thereby setting up a network environment for undertake cooperative learning. The system designs a series of functions for on-line communication on the line, illustrated as the followings.

(1) Group of discussion

Group of discussion is an open but not synchronized function on the line. When the user encounters the difficulty in learning, he/she put up his/her questions in the group of discussion, letting other users put forth solutions to these questions.

(2) Room for discussion

As showing in Figure 5, the function of the room for discussion can improve the disadvantages of the personal computer learning CIA's failure to carry on communication, real-time discussion to a large extent, for it is an open and synchronous for communication. Besides calling the virtual teacher or student, the user can enter the room for discussion for help when he/she needs others' help to solve the questions.

(3) On-line Call

On-line call may be inputted simple information to communicate with other on-line users.

5.4 The operating process for the user on the system

When the user enters the system with the browser for the first time, the system will ask he/she to register as showing in Figure 6, thereby acquiring the basic data to establish the Database for "student model", and simultaneously letting the user accept pretest to discriminate the levels of the user's operation, and recording the situation of their answering, and the connection of active modification letting the user join the curricula suitably.

Afterwards, whenever the user enters the system, he/she must key in user name and password to make sure the identification. The system will continue the following activities according to the previous record of the user. The system would record each learning activity the user undertakes one by one, with the view of analyzing the fact if the learning state of the user will attain the expected aim. When the user encounters the line provided by the system: he/she can also check his/her learning state at any moment to grasp the learning progress.

6 Conclusions

The age of computer is that of knowledge explosion indeed. Undoubtedly, "Self-learning" is the best way to enrich self in the age of widespread information. With network becoming so widespread, it is not uncommon for the students of the elementary school to enter the network. It is incumbent on us to let the teaching environment of CAI congenial to the concepts of teaching nowadays. We hope our CAI system will become compatible with the social need now, breaking through the limitation of time and space and overcoming the barriers of learning environment now, giving the learner more space to exert himself/herself. At present, this system has finished the prototype, and plans to precede real teaching experiments and systematic assessment in a few months.

Reference

[1]周筱亭, "數學新課程的趨勢", 研習資訊, Vol. 11, No. 3, pp. 28-50, (1994).

[2]侯志欽, "教學設計的哲學省思—由客觀主義到建構構主義", 國民教育集刊, Vol. 17, pp. 221-229, (1999).

[3]甯自強, "「根本建構主義」—認知研究的另一種架構", 師友月刊, 12 月號, pp. 30-32, (1987).

[4]甯自強, "經驗、察覺、及了解在課程中的意義—由根本建構主義的觀點來看", 論文發表於國立台東師範學院八十一學年度國小理科教育學術研討會, pp. 191-197, (1992).

[5]甯自強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看", 科學教育學刊, Vol. 1 No. 1, pp. 101-108, (1993).

[6]甯自強, "「建構式教學法」之教學觀—由根本建構主義的觀點來看", 國教學報,Vol. 5, pp. 33-41, (1993).

[7]甯自強, "單位量的轉換(一)正整數乘除法運思的啓蒙",教師之友, Vol. 34, No. 1, pp. 27-34, (1993).

[8]甯自強, "新課程對乘法啓蒙教材的處理", 論文發表於國立嘉義師範學院八十二學年度數學教育研討會, 四月二十九日, (1994).

[9]甯自強, "單位量的變換(二)—正整數乘除運思的融合", 教師之友, Vol. 36, No.5, pp. 35-44, (1995).

[10]甯自強, "數學的格式與內容—皮亞傑對維高斯基", 論文發表於台北市立師範學院「皮亞傑及維高斯基的對話」百年校慶學術研討會, 元月二十五、六日, (1996).

[11]甯自強, "劉裕誠的數概念", 1997 海峽兩岸幼兒教育學術研討會論文集, pp. 167-185, (1997).

[12]甯自強, "涂景翰的數概念", 科學教育學刊, Vol. 6, No. 3, pp. 255-269, (1998).

[13]甯自強, "顏淑茹的數概念", 國教育研究學報, Vol. 4, pp. 231-264, (1998).

[14]羅清水, "認知心理學理論對電腦輔助教學設計發展與成效之影響", 研習資訊, Vol. 15, No. 1, pp. 1-15, (1998).

[15]鍾靜, "從疑難問題談乘法文字題教學", 國教月刊, Vol. 36, No. 9,10, pp. 33-35, (1980).

[16]蘇育任, "建構主義式的教育的迷思與省思", 國民教育集刊, Vol. 5, pp. 121-139, (1997).

[17] Bridgaman, P. W.," The way things are", New Your: Viking Compass, pp. 83, (1959).
[18] Clark, F. B. & Kamii, C., " Identification of multiplicative thinking in children in grades 1-5", "Journal of Research in Mathematics Education", Vol. 27, No. 1, pp. 41-51, (1996).
[19] Dalgarno, B., "Constructivist Computer Assisted Learning: Theory and Techniques", http://services.Canberra.edu.au/~barney/articles/ascilite96/paper.htm (accessed on Oct. 21, 1997).
[20] Davydov, V. V., "A psychological analysis of the operation of multiplication", In L. P. Steff (Eds.), Psychological abilities of primary school children in learning mathematics, Soviet Studies in Mathematics Education Series, volume 6, pp. 9-85, (J. Teller trans.) Reston, VA: NCTM. (1991)
[21] Fischbein, E., Deri, M., Nello, M. S., & Marino, M. S., "The role of implicit models in solving verbal problems in multiplication and division", Journal of Research in Mathematics Education", No. 16, pp. 3-17, (1985).
[22] Hiltz, S. R., " Teaching in a Virtual Classroom", http://it.njit.edu/njIT/Department/CCC/VC/Papera/Teaching.html (accessed 1995).
[23] Piaget, J., "The Psychogenesis of knowledge and its epistemological significance", In M. Piatelli-Palmarini (Eds.), Language and learning: The debate between Jean Piaget and Noam Chomsky, Cambridge, MA:Harvard University Press, (1980).
[24] Steff, L. P. & Wood, T. (Eds.), " Transforming Children's Mathematics Education: International Perspectives", Hilsdale, NJ:LEA, (1990).
[25] Squires, D., "Can multimedia support constructivist learning?" http://www.spirit.net.au/ACEC96/papers/squir.htm (accessed on Oct. 21, 1997).
[26] Van Engen, H., "An analysis of meaning in arithmetic I & II", The elementary School Journal, pp. 321-329 & 395-400, (1949).
[27] Webb, G., " A Theoretical Framework for Internet-Based Training at Sydney Institute of Technology", http://ausweb.scu.edu.au/proceedings/webb/paper.html (accessed on July 5-9, 1997).

Figure 1:The clarification of the problem

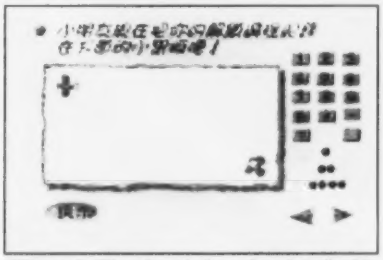


Figure 2: The electric board and tool table

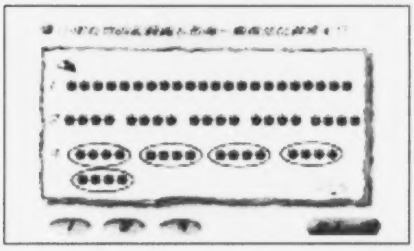


Figure 3:The strategies of virtual students

Figure 5:Room for discussion

BEST COPY AVAILABLE

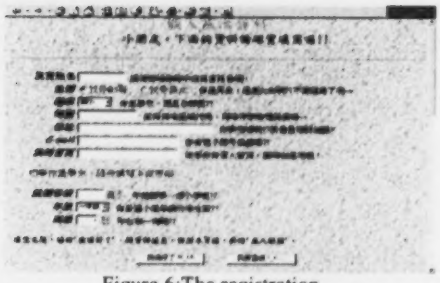


Figure 6:The registration

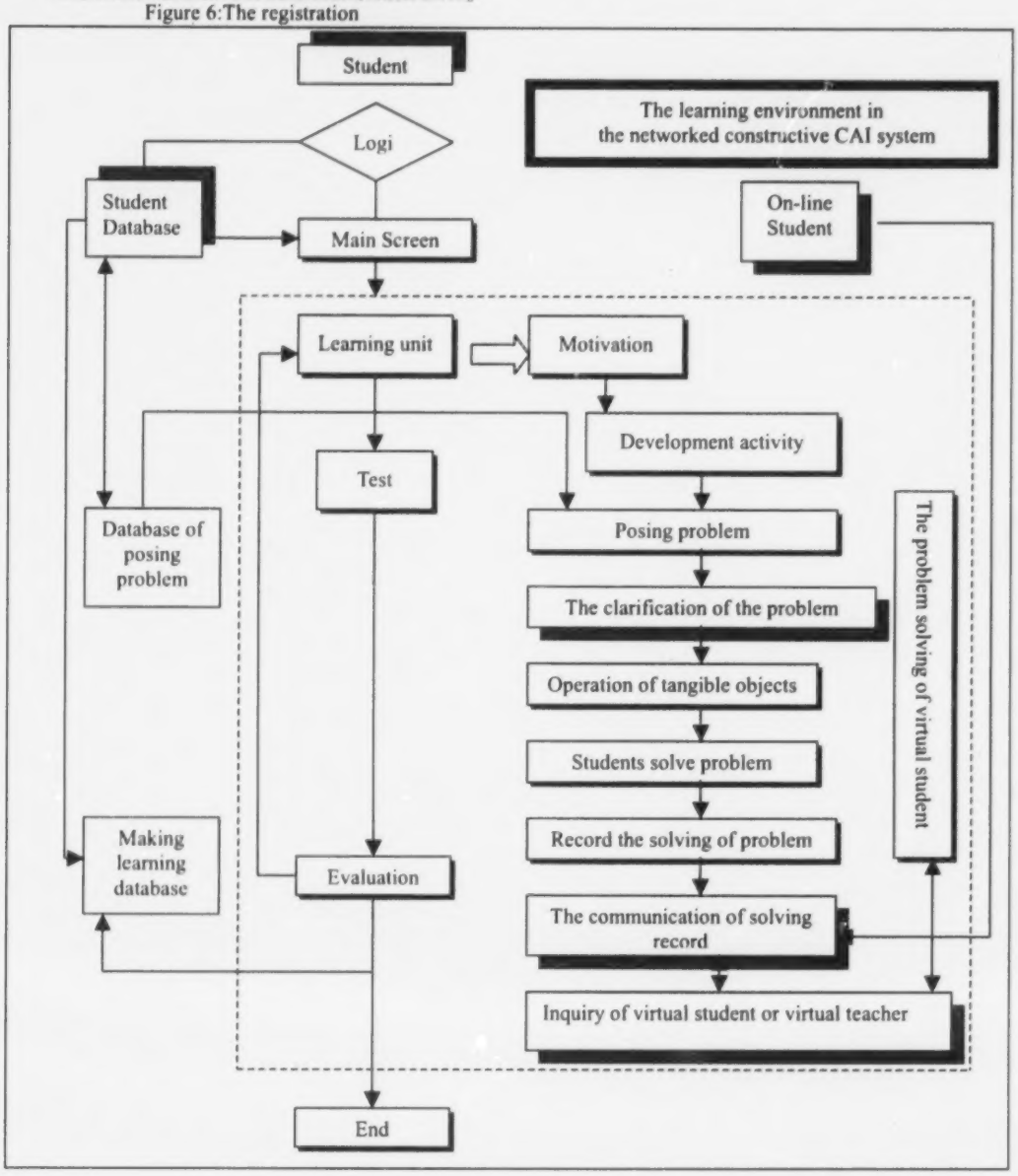


Figure 4: System flowchart

BEST COPY AVAILABLE

Adaptive Programming Language Tutoring System on the Web

Jin-woo Choi and Chong-woo Woo
Department of Computer Science, Kookmin University
861-1 Chongnung-Dong, Sungbuk-ku, Seoul, Korea
Tel: +82-2-910-4795
Fax: +82-2-910-4799
Email: cwwoo@kmu.kookmin.ac.kr

Many of the web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing proven techniques from the stand-alone Intelligent Tutoring System(ITS). Some recent web-based ITS researches show this efforts by employing the techniques selectively, and this needs to be studied further to support more effective web-based instruction. In this paper, we describe the design and the development of a Web based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting previous ITS techniques into the system successfully. Especially our focus is on the three levels of the instructional planning mechanism, which can generate lesson contents dynamically whenever it is requested. This way we do not need to crate all the lesson contents in HTML forms which must reside in the system in advance. In addition, the system has adapted CORBA structure to support the user more consistent and reliable performance. Together, the system behaves more adaptive and interactive, than the existing non-ITS based web systems. The test domain of the system is learning C programming language for the first year computer science student.

Keywords: **Web-based learning system, Intelligent Tutoring System, Instructional planning**

1 Introduction

Many recent web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing techniques from the stand-alone ITS. Brusilovsky[2] states that some ITS techniques can be adapted into a web-based educational system, and divides the techniques into three distinctive parts, such as, automatic creation of curriculum, dynamic problem solving, and intelligent analysis of student model. However, most of the recent web-based ITS research show the efforts by employing the techniques selectively[2][3][4][7], such as adapting student modeling or problem solving capability at some level. Therefore, this needs to be studied further to enhance the overall capabilities of the system at the previous stand-alone ITS level. For instance, automatic generation of curriculum or lesson plan is necessary to provide a flexible instruction for each individual user.

In this paper, we describe the design and development of Web-based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting many techniques from the stand-alone ITS into the web-based systems. First, we designed the knowledge base using the object-oriented method in order to handle flexible management of object inheritance and tutorial strategies. Second, the student modeler can avoid the network traffic by designing the modeler stays in the server-side at the beginning of the session for maintaining necessary administration duties, and creates an individual student model in the client side. And the third important approach is having the instructional planning mechanism, which generates lesson contents dynamically for each individual user. This is important feature for moving towards the web-based system, because most web-based educational systems

creates all the lesson contents in HTML forms in advance, and they must reside in the system physically. And then the user navigates the system for learning, such as in ELM-ART[2] or CALAT[4]. Intelligent navigation strategy might be one of the intelligent way of guiding the user to learn the material, but rather inefficient compare to the dynamic generation of lesson contents. WALTS only generates the necessary lesson contents whenever it is requested by the system, which can be another advantage. In addition, we have approached distributed architecture by employing CORBA(Common Object Request Broker Architecture) structure to support the user more consistent and reliable performance while the user using the system. The initial web-based educational systems are mostly developed by using the CGI(Common Gateway Interface) techniques, which often results in bottleneck problem when many users access the system at the same time. In this sense, our structure might avoid such a problem, and the system could also be easily updated when we need to revise some part of the system. Together, the system behaves more adaptive and interactive, than the existing non-ITS web-based educational systems. The test domain of the system is learning C programming language for the first year computer science student.

The rest of the paper is organized as follows. In section 2 we described a distributed infrastructure of WALTS system. Section 3 presents each components of the system and also some intelligent aspects of the system. We conclude the paper in section 4.

2 Distributed infrastructure

The previous web-based educational systems have been built as either a server-based architecture or a client-based architecture[6]. Each of them has some advantages and disadvantages. The server-side architecture mostly rely on CGI techniques, which has shown some problems of handling complex client/server communication because of its connectionless feature. Also client-side architecture needs to have all the plug-ins installed on client computer before using the system. Therefore the recent web-based applications tend to adapt CORBA or Java based distributed infrastructure. That is free from the connectionless or stateless problem, and also has some advantages of distributed system technology, such as message passing, RPC(Remote Procedure Call), and proprietary communication protocol. The client connects to the server using the HTTP protocol only for the initial connection, and after the downloading the specific mobile code application(for example, client side application, JavaScript, Java Applet, and etc), the client use the proprietary protocol(non-HTTP), so it does not communicates with web server, but communicates with proprietary server(non-Web server).

WALTS employed CORBA to adapt this kind of distributed infrastructure. The system is designed by HTTP server which takes care of user requests and responses, and CORBA-based server which performs the capabilities of the ITS. Also the system could be easily re-organized if we want to modify the structure later on [see figure 1]. In short, one of the major advantages of WALTS is that it can easily avoid the bottle-neck problem of CGI techniques, and also we believe that this style of architecture might be another best solution for building web-based client/server educational system.

3 Basic architecture of the system

The basic architecture of WALTS is designed by typical ITS structure primarily, including expert module, the student modeler module, and the instructional planning module.

3.1 The expert module

The expert module of the system consists of the object-oriented knowledge base, and the problem solver.

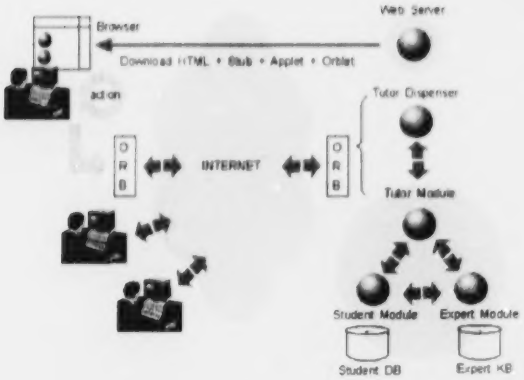


Figure1 The main architecture of the WALTS

Object Oriented-based knowledge base. First, we employed the frame knowledge representation techniques for the main knowledge base. Because the domain knowledge does not require any complex causal relationships, but rather it is consists of simple C language concepts. The object-oriented approach make it easy to modify the data type, can reduce the knowledge base reference by having slot values as member data, and can provide more flexibility for updating or manipulating tutoring strategy [5].

In this system we designed a frame with several meaningful slots, and each frame does not have to have the same number of slots, since the inference engine can get all the necessary informations due to the inheritance feature of the system. The 'type' slot can possess a concept, example, or quiz. The 'source' slot points to its superior frames. The 'Pfame' and 'CFrame' slot is necessary when we need to show the related nodes in linked list structure. The 'reference' slot may contain all the necessary frame names that are related to the current frame. This kind of slot structure is very common in every frame structure, and also important in object-oriented structure, because each frame can have common attributes and can generate an object of having its own attribute. Also, the system allows an abstract class, which plays the backbone of the system, and supports a hierarchical structure, and the definition of the method can be done only in the lower class [figure 2].

```
Frame Variable Declaration Quiz
        [Source] Chapter1-3-1-1
        [Type] Quiz
        [Title] Variable declaration Quiz
        [Template] Data Type | Variable | General Grammar
                1 : Select the correct %type variable declaration
                2 : ...
        [PFrame] Variable Declaration
        [CFrame] Null
```

Figure2 Variable declaration quiz frame

The Problem Solver. WALTS can generate a problem dynamically depending on the current topic. Since the planner knows what is being taught at the moment by generating a lesson unit, the tutor can decides whether it is 'teaching concept' or 'show example' or 'quiz'. At the moment, we have only three styles of lesson unit. If it is a 'teaching concept', the planner sends the lesson unit to the user in HTML form. If it is a 'quiz' type, then planner requests the problem solver to generate a question. The problem solver first creates a problem table by referring to the current lesson unit. The generating and solving a problem occurs at the same time, and the solver stores the correct answer. And then, it presents the generated questions to the user in appropriate HTML form through the HTML generator. This method can provide different styles of questions for different users even though they are accessing the same lesson unit, which can be another advantage of WALTS. Since the column name of the table is object's name, the planner can reply to the user's request, such as hint or help, by referencing this table.

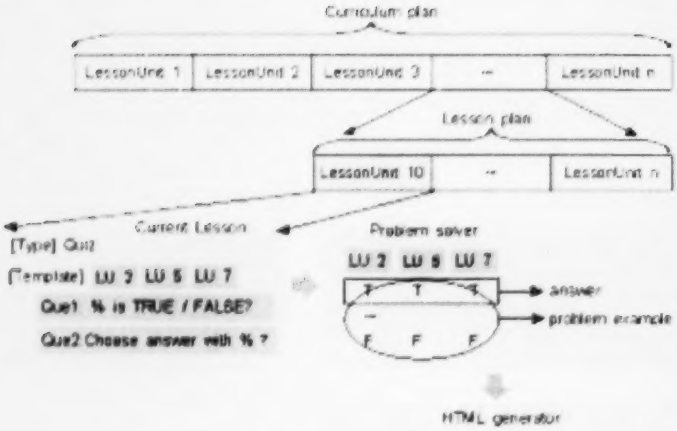


Figure3 Creation of a quiz for 'variable declaration'

The strategy of asking user for answering quiz is multiple choices. So that we need to generate problems along with the appropriate multiple choice answers also. For instance, let us think about a simple quiz about asking user 'a data type'. A typical 'data type' is consists of three parts, for example, 'int x ;'.The 'int' is a data type integer, 'x' is a user-defined variable name, and ';' is needed for ending a sentence in C language. We are trying to generate this simple data type declaration statement sentence as follows. First, the data type 'template' slot consists of three parts as in [Figure 3]. Then we can generate eight different answers as in [Figure 5], since each one part of a statement can be correct or incorrect. And we can select some of them randomly including correct answer; the numbered answers are selected ones in the figure. And also we can obtain designated unit object's content as in [Figure 4]. The generated correct answer is stored in memory, and then later it is compared with the user's answer. For example, if the user selected number 2 as in [figure 5], we can analyze that the user does not know about reserved word. And the planner needs to revise the lesson plan to correct the misconceptions by giving special messages, such as hint or help, and then the planner re-organizes the lesson plan including 'reserved word' lesson unit. The [figure 6] shows a sample session of solving a generated quiz.

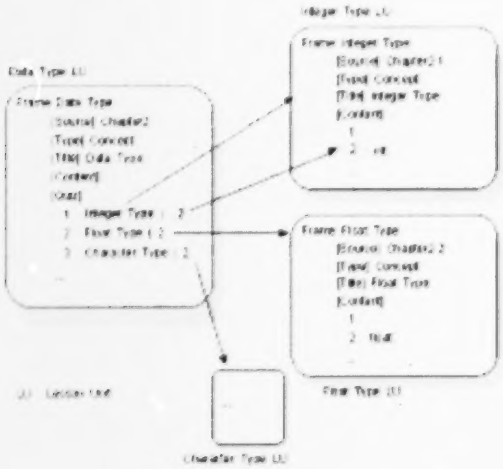


Figure4 Data type unit frame

BEST COPY AVAILABLE

Data Type	Variable	General Grammar	
T	T	T	④
T	T	F	
T	F	T	②
T	F	F	①
F	T	T	
F	T	F	③
F	F	T	
F	F	F	

Figure5 Table for possible answers for data type quiz

3.2 The Instructional Planner

The most web-based educational systems built upon hypertext, which is hard to make hyperlink in every HTML pages, and also needs to have carefully designed navigation strategy[2]. And also all the lesson contents are built as HTML pages in advance, and must reside in the system physically. We believe that generating a lesson plan dynamically, for each individual user, is more efficient than the above approaches. Therefore, we adapted the traditional ITS instructional planning mechanism into the system. The instructional planning of the WALTS can be further divided into 3 steps, a curriculum planning, a lesson planning, and a delivery planning. The curriculum planning of WALTS generates a curriculum in tree structure; the curriculum planner extracts information from the knowledge base and creates a curriculum hierarchically in the order of prerequisites. Then the lesson planning sets up the lesson sequence within a single lesson unit. The role of delivery planning is limited to presenting the selected lesson content to the user.

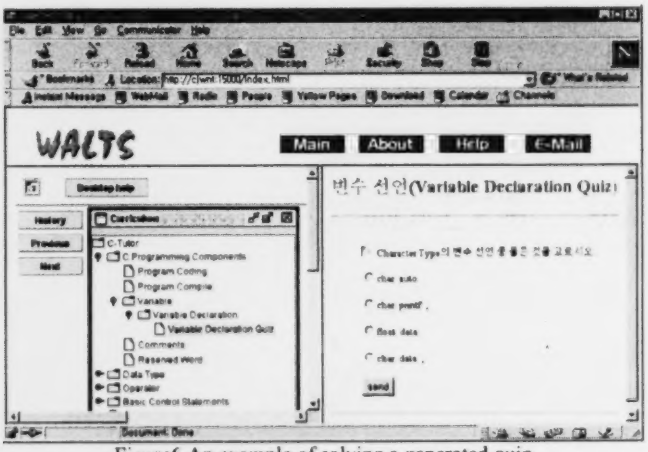


Figure6 An example of solving a generated quiz

Curriculum planning. The purpose of the curriculum planning is to provide a curriculum to the user, in other words, to provide an individualized optimal learning path to the user[1]. The generated curriculum is in the form of a tree structure. It is constructed by creating an initial node by referencing the value of the attributes in the lesson unit slot, and further expands the structure in the order of the way the student must learn, which will be accessed as linked list structure. The lesson unit of the system is organized according to some basic rule, such as the student must learn prerequisite concept first and the move to the next topic. So the curriculum is set up in the form of hierarchical and linear sequence.

Lesson Planning. The lesson planner generates a lesson plan by referencing the curriculum and the student model. The information from the student model shows the results from single lesson unit and based on this record, the planner sets up appropriate lesson plan for the student. When the student selects other learning path on purpose before the current lesson plan is finished, the system must decide what to do next, such as whether to store the current lesson plan and execute the user's request, and then resume the current plan or destroy the current plan and re-plan the whole sequence all over again. In that sense, WALTS uses re-planning strategy when the user wants to quit the current topic, and move to another learning path. Another

case of re-planning occurs when the student made an error on the selected quiz lesson unit. If the student made a mistake on this, the current lesson plan is suspended, and another new lesson plan is created to correct the student's error. After the remediation process is finished, the suspended plan will be resumed.

Delivery Planning. The lesson unit has been generated by lesson planner and needs to be delivered to the user. The possible delivery tactic in this domain could be "present concept, show example, give exercise, and etc". Of course if the system allows mixed-initiative control, the delivery planning needs to be more sophisticated in order to handle all the user request or questions. The delivery planning part of the WALTS is made of simple structure, and will be enhanced further in the next research.

The HTML generator. The very distinctive feature of the system is the HTML generator. This feature can be regarded as the interface part of the system. When the delivery planner decides the immediate unit lesson, the content of the lesson is converted into HTML form by the HTML generator. The HTML generator generates HTML pages according to the HTML2.0 protocol and inserts "next" or "previous" button in order to navigate adaptive learning path. But if the lesson unit contains some applet, the system directly searches the physical location and sends the URL to the student's browser without consulting HTML Generator. The [figure 7] describes the HTML generator sends two different results to two different users, since their learning background is different.

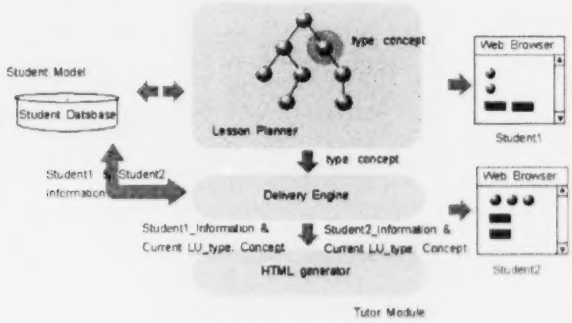


Figure7 The HTML generator

3.3 The student modeler

The strategy for building the student modeler is the simple overlay, which simply reflects user's learning process about current topic. And this should be enhanced by including the buggy information later on. But an important enhancement is that the student modeler of WALTS can avoid the unnecessary network traffic. For instance, if the system maintains the student model in the server-side, then whenever the user accesses the system the server needs to update the user's student model in the server. This may cause another bottleneck problem, and the most CGI-based systems still have this problem. Our approach on the student modeler is as follows. The server-side student modeler creates a table, and keeps all the necessary administrative informations on the server-side, such as initial student's ID, password, e-mail address, the access time[figure 8], which can be used for various administrator purposes. And the information regarding the student's learning process is stored in the student model[figure9], which is created in the client-side machine for each individual user whenever they logged on. The student model has several parameters that reflect the student's learning history, and each parameter has unique meanings. For example, the 'HelpCount', means how many times the user has been helped, and 'HintCount' means how many times the user has requested hints, and they can be updated only when the 'unit lesson' is quiz. The 'ReferenceCount' means the user is weak at the current unit lesson since the specific lesson has been accessed more often than other frames. The 'LessonLevel' stores information about how the level of the current topic, and the 'LessonType' means whether the current unit lesson is concept, example, or quiz, and so on.

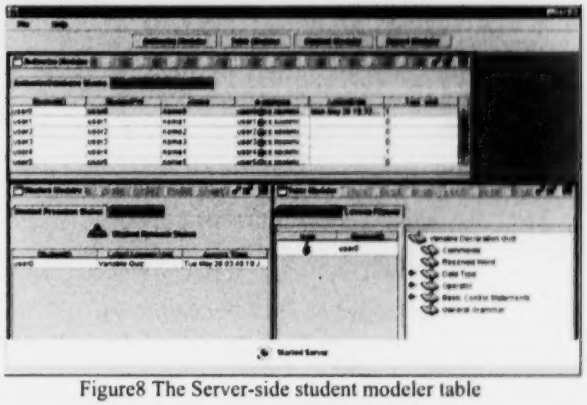
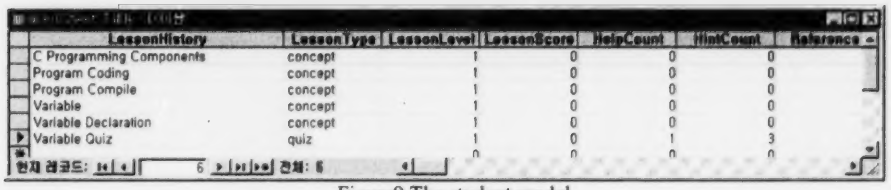


Figure8 The Server-side student modeler table



LessonHistory	LessonType	LessonLevel	LessonScore	HelpCount	HintCount	Reference
C Programming Components	concept	1	0	0	0	
Program Coding	concept	1	0	0	0	
Program Compile	concept	1	0	0	0	
Variable	concept	1	0	0	0	
Variable Declaration	concept	1	0	0	0	
Variable Quiz	quiz	1	0	1	3	
		0	0	0	0	

Figure9 The student model

4 Conclusion

We have designed and implemented a web-based ITS, WALTS, which is a learning C programming language tutor aiming for the first year computer science students. The main goal of this paper is, first, the adaptation of the existing ITS techniques into the web platform. Therefore, we have designed and implemented the system based on the major ITS architecture, and this brings us several advantages over traditional HTML-based educational systems. First, the main knowledge base is created as an object-oriented concept, which can provide more flexibility for manipulating frame objects and tutoring strategy also. Second, we have generated a quiz dynamically by the problem solver and also can solve the problem. Third, we designed a student modeler that can avoid the network traffic in the minimal, by having the modeler in the server-side, and creates an individual student model in the client-side. Fourth, the instructional planner can generate an instructional plan dynamically, and this is another advancement of building web-based ITS, since the current web-based ITS research shows further work on this subject. Additional issue of the paper is that we designed the system as the distributed infrastructure using CORBA as backbone of the system. This structure solves the bottleneck problem of previous CGI dependent systems, and also gives some benefits of better performance and also gives flexibility in the case of further enhancement of the system.

References

[1] P. Brusilovsky. "Adaptive Educational Systems on the World-Wide-Web: A Review of Available Technologies" http://www-aml.cs.umass.edu/~stern/webits/itsworkshop/brusilovsky.html

[2] P. Brusilovsky, E. Schwarz, and G. Weber. "ELM-ART: An Intelligent Tutoring System on the WWW." The Proceedings of ITS'96, pp261-269, Springer, (1996).

[3] J. Kay and R.J. Kummerfeld "An Individualized Course for the C Programming Language." The Proceedings of 2nd International WWW Conference, Chicago, IL, pp17-20, (1994).

[4] K. Nakabayashi, M. Maruyama, Y. Koike, Y. Kato, H. Touhei, and Y. Fukuhara. "Architecture of an Intelligent Tutoring System on the WWW." The Proceedings of AI-ED'97, pp39-46, (1997).

[5] K. Nakabayashi, H. Touhei, S. Hitoshi, and Y. Fukuhara. "An Object-Oriented Architecture for a Web-based CAI System", The Proceedings of EDMEDIA'98, (1998).

BEST COPY AVAILABLE

[6] A. Silva, M. Silva, and J. Delgado. "A Survey of Web information Systems." The Proceedings of WebNet'97, pp520-530, (1997).
[7] M. Stern, B. Woolf, and J. Kurose, "Intelligence on the Web?," The Proceedings of AI-ED'97, pp490-497, (1997).

An Agent-Based Intelligent Tutoring System

C.M. Bruff and M-A. Williams
University of Newcastle,
NSW 2308, Australia
Email: cgcmb@cc.newcastle.edu.au *and* maryanne@eBusiness.newcastle.edu.au

In this paper we describe the architecture of an agent-based intelligent tutoring system. The agent architecture is based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using an agent oriented programming language called JACK [1]. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to embed previously developed Java modules in an agent environment. In essence our intelligent tutoring system builds and maintains a student model in a dynamic learning environment where new, possibly inconsistent or uncertain, information is obtained through interactions with the student, and where the system may not have complete knowledge when deciding on the next instructional step. Our architecture supports the development of highly individualised student models using techniques in belief revision, nonmonotonic reasoning and possibility theory.

Keywords: **Educational Agent, Intelligent Tutoring Systems, Artificial Intelligence in Education, Belief Revision**

1 Introduction

In this paper we describe the architecture of an agent-based intelligent tutoring system. The agent architecture is based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using in an agent-oriented programming language called JACK. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to embed previously developed Java modules in an agent environment. In essence our intelligent tutoring system builds and maintains a student model in a dynamic learning environment where new, possibly inconsistent or uncertain, information is obtained through interactions with the student, and where the system may not have complete knowledge when deciding on the next instructional step. Our architecture supports the development of highly individualised student models using techniques in belief revision, nonmonotonic reasoning and possibility theory. This architecture was described in a previous paper [5].

2 Using Intelligent Agents

Agents vary in capability from procedural wizards to information agents which are used for information filtering and retrieval. Herein the term agent is taken to mean: *an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives,* as suggested by Wooldridge [29]. By autonomous we mean agents have control over both their internal state and their behaviour, in other words they can make choices regarding their actions depending on their internal state and the goal they seek to achieve. Objects in the object-

[1] JACK was developed at Agent-Oriented Software (http://agent-oriented.com)

oriented paradigm do not have this capability. Agents can be both reactive or proactive, in other words, they can react to external events and they can pursue goals. Agents can make run-time decisions that were not foreseen at design time.

It has been consistently argued, for example by Wooldridge [29], that an agent-oriented approach to problem solving and software engineering offers substantial benefits for complex systems. In particular, Jennings [14] has argued that the usual tools identified by Booch [4] of problem decomposition, abstraction and organisation acquire more power if an agent-oriented approach is adopted, because the agent-oriented approach supports distributed processing and at the same time reduces the system's control complexity. Decisions about the next action to be performed are devolved to the agents, and this obviates the need for a global controlling module and as a consequence gives rise to more flexibility and better performance.

3 Implementing Intelligent Agents in JACK

JACK is an agent programming language, which in essence provides agent infrastructure to the Java programming language. Agents are designed in JACK and compiled into standard Java code before being executed. Agent-oriented programming is a highly sophisticated paradigm which is highly suited to intelligent tutoring in a real-time environment.

JACK agents are based on the BDI Framework of Rao and Georgeff [20]. They are autonomous software components that execute plans (intentions) to achieve their goals (desires). The plan chosen at any given time depends on the current set of beliefs. JACK agents can also respond to events as well as striving for goals, in other words they exhibit both proactive (goal-driven) and reactive (event-driven) behaviour. Each agent possesses: (i) a **database** (set of beliefs), (ii) a set of **events** it will respond to, (iii) a set of **goals** that it wishes to achieve, and (iv) a set of **plans** that describe the appropriate responses to events or ways to achieve goals.

A JACK agent remains idle until it is given a goal to pursue, or until it is has to respond to an event. The agents are autonomous and they must determine the appropriate response to goals and events, i.e. the appropriate plan to be executed. A JACK Agent is able to exhibit the following behaviours [JACK Manual]:

- A goal-directed focus. The agent focuses on the objective and not the method chosen to achieve it.
- Real-time context sensitivity. The agent will keep track of which options are applicable at each given moment, and makes decisions about what to try and retry based on the present conditions.
- Real-time validation of approach. The agent will ensure that a chosen course of action is pursued only for as long as certain maintenance conditions continue to be true.
- Concurrency. The agent system is multithreaded. If new goals and events arise, the agent will be able to prioritise.

The JACK Agent Language extends Java in the following ways:

- It defines new base classes, interfaces and methods.
- It provides extensions to the Java syntax to support new agent-oriented classes, definitions and statements.
- It provides semantic extensions (runtime differences) to support the execution model required by an agent-oriented software system.

The JACK Agent Language provides the following five main class-level constructs:

- **Agent**: The agent construct is used to define the behaviour of an intelligent software agent. This includes capabilities an agent has, what type of messages and events it responds to and which plans it will use to achieve its goals.
- **Capability**: The capability construct allows the functional components that make up an agent to be aggregated and reused. A capability can be made up of plans, events, databases and other capabilities.

- **Database**: The database construct provides a generic relational database. It has been designed specifically so that it can be queried using logical members. Logical members are like normal data members, except that they follow the rules of logic programming. Agents can also use regular Java data structures for storing information, but the built-in database can generate events when particular changes occur.
- **Event**: The event construct describes an occurrence that the agent must take an action in response to.
- **Plan**: An agent's plans are analogous to functions. They are the instructions the agent follows to try to achieve its goals and handle its designated events.

4 Agent Communication

Our system is a multi-agent system. Agents need to interact to build and manage the student model. As a consequence our agents require the ability to communicate to one another. JACK provides the infrastructure of the communication but does not specify a particular language or protocols, hence designers can choose the most appropriate for their application. We have chosen KQML as our protocol for exchanging information and knowledge. It is based on speech acts theory as described by Searle [23]. One of the main reasons for our choice is that all the information for understanding the content of the message is included in the communication itself. It is defined by the following protocol structure, as outlined by Huhns and Stephens [13]:

```
(KQML-performative
        :sender        <word>
        :receiver      <word>
        :language      <word>
        :ontology      <word>
        :content       <expression>
        ..)
```

The performatives in our systems are: evaluate, achieve, monitor, revise, extract, tell, and ask. In JACK the agents must know one another's name, and when agents that are communicating are running in separate processes, then the JACK network communications layer needs to be used to allow these processes to communicate. KQML-speaking agents behave as clients and servers, and communication can be synchronous or asynchronous.

5 The Architecture

The ability of an Intelligent Tutoring System to deliver appropriate individualised instruction to a student depends heavily on the type and calibre of the information held about the student in the student model. This in turn depends on the type and level of sophistication of the knowledge representation used in the system and on the effectiveness of the methods used to elicit new information about the student and to incorporate the new information into the student model. Problems arise when new information conflicts with information already in the student model; when the student model contains insufficient information for the tutor to decide on the next instructional step; or when there is uncertainty associated with some of the information about the student - for example, there may be more than one way of interpreting an error made by a student in terms of what the student knows or does not know. There have been many approaches to dealing with these problems.

A number of studies (e.g. Mizoguchi et al [19], Kono et al [17], Giangrandi and Tasso [9]) have applied Truth (or Reason) Maintenance Systems (Doyle [7], DeKleer [6]) to overcome the problem of new information conflicting with old. The TMS identifies the conflicts, which must then be resolved by some domain specific reasoning system. A TMS must maintain not only the beliefs of the student, but also the justifications for them, and therefore use of a TMS is computationally very intensive. Huang and McCalla [12], and Huang [11] have developed a "Logic of Attention", a modification of the TMS which overcomes the problem of efficiency by focusing only on the parts of the student model and instructional planner that are relevant to the current sub-goals. Jones and Poole [15] examined how Reiter's default logic [21] could be

used to build expert diagnostic systems.

One general approach to coping with uncertain or incomplete information is to assume that student models do not need to be completely accurate and absolutely precise to be successful. In granularity-based recognition of students' problem solving strategies the philosophy is that student behaviour can be recognised at some level of detail, even if this is very coarse (McCalla and Greer [18]). In the "fuzzy" student model approach (eg Hawkes et al [10] and Katz et al [16]), which is grounded in fuzzy set theory, a student might have partial membership in the set of students who are expert in a particular skill, and partial membership in the set of students who are less expert in that skill. Alternatively, application of Bayesian belief networks (e.g. Villano [25], Shute [24], and Reye [22]) deals with the problem of uncertain information and also facilitates prediction of student knowledge and performance, but most likely at the cost of extensive knowledge engineering and programming.

Intelligent tutoring systems will, in general, have to provide mechanisms to deal with four interrelated information modeling problems:

- Uncertainty of information,
- Incompleteness of information, ie all relevant information may not be known.
- Fusion of information, where information is merged from different sources, and
- Revision of an existing knowledge base when new information is obtained. This new information may be inconsistent with the knowledge base.

Information that is uncertain or incomplete may need to be revised as it is refined over time. Hence, revision of a knowledge base is closely related to modelling both the uncertainty and the incompleteness of information.

In a previous paper [5] we proposed an architecture in which the problem of conflicting information is resolved using methods recently developed by Williams [26, 27, 28] based on the AGM paradigm for belief revision (Alchourron et al [1]). We used possibility theory (see Dubois and Prade [8]) to take care of uncertain information, nonmonotonic reasoning, in particular Reiter's default logic [21] and the formalism of Antoniou and Williams [2], to deal with missing information, and Theory Extraction for fusion.

Our new proposed system architecture is illustrated in Figure 1 below. It has been modified to take advantage of the agent-based architecture, and consists of the three component agents: the knowledge management agent, the student agent, and the inference agent.

6 The Agents

The **Knowledge Management Agent**: This agent mainly responds to events which take the form of requests from other agents. Agents request information regarding such things as domain knowledge, typical errors and misconceptions, suggestions for the next task to present the student. The domain knowledge is structured to suit the application at hand and managed by an agent. We are currently exploring two applications; one based on a mathematical dictionary for schools, The MathProbe[2], and a second focusing on database design for our own courses at the University of Newcastle. An agent that knows about common student errors and misconceptions has a better chance of diagnosing problems than a system without this knowledge. The quality of this knowledge is often what sets a good teacher apart. In both the domains that we have selected this knowledge is well known and widely accepted. For example, *students who consistently place foreign keys in the wrong database table normally do not understand the concept of cardinality of relationships between entities.*

The notion of knowledge granularity has been widely used in the literature (eg. McCalla and Greer [18]). In our architecture granularity is used in both the domain knowledge and in the set of common errors and misconceptions. Levels of granularity fit naturally into the agent architecture and can be used to help the agent choose an appropriate plan.

The **Student Agent**: Each student is assigned an individual agent instantiation. The main objective of this agent is to manage the evolution of the student model, i.e. a representation of the student's knowledge about

[2] See http://mathresources.com/mathbrow.html

the domain knowledge and the student' s personal goals and preferences. This model is described using the following components:

- The Student' s Goals using JACK Goals
- The Student' s Preferences using the JACK Database,
- Explicit Knowledge about the Student based on their performance so far using the JACK Database.

The student agent is autonomous and responds to input from the student.
The **Inference Agent**: The inference agent manages a team of agents that provide several forms of useful inference mechanisms and sophisticated reasoning operators. It is not necessary for the agents requesting knowledge to know how the Inference Agent generates that knowledge. The Inference agent uses slave agents for deduction[3], abduction and induction. The belief revision agent[4], possibilistic reasoning agent[4], nonmonotonic reasoning agent[4] and theory extraction agent[4] rely exclusively on the slave agents.

The student agent' s goals will typically vary from student session to student session, and can be customised by a third party such as a human tutor. These goals determine the learning strategies and tasks to be used during a given learning session. The learning strategies together with the database describing the current state of the agent and its knowledge about the student' s capabilities will largely control the agent' s behaviour. These strategies are ultimately implemented via an agent that constructs a learning task hierarchy. This learning task hierarchy is constructed at run time. It can be viewed as a sub-hierarchy of the global task hierarchy customised using the current student profile. This sub-hierarchy is designed to provide feedback about the student that can be used to build and manage the student model during a learning session. In addition, it is used to diagnose student problems and subsequently offer remedial action.

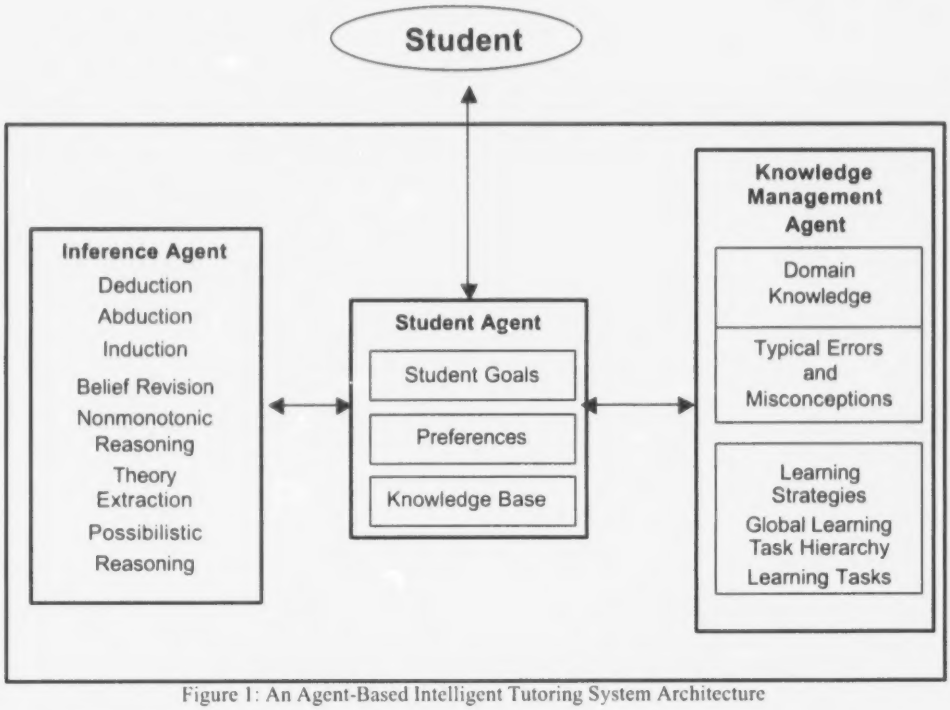


Figure 1: An Agent-Based Intelligent Tutoring System Architecture

[3] See http://ebusiness.newcastle.edu.au/vader
[4] See http://ebusiness.newcastle.edu.au/saten

7 Conclusions

In a previous work we identified several information modeling problems that arise in Intelligent Tutoring Systems: change, incompleteness, information integration, and uncertainty. We described an architecture for an intelligent tutoring system that addressed these problems based on recent developments in knowledge representation and reasoning in the areas of belief revision, possibilistic reasoning, nonmonotonic reasoning and theory extraction.

In this paper we described an agent-based design of the architecture based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using an agent oriented programming language called JACK. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to use previously developed Java modules in an agent environment.

The main advantage of using an agent-based approach is that the control module has been eliminated. Control has successfully been devolved to the agents, i.e. there is no need for a superagent to oversee the communication and interaction. This leads to better performance and a more customised student learning session.

References

[1] Alchourrón, C., Makinson, D. and Gärdenfors, P. (1985), On the Logic of Theory Change: Partial Meet Functions for Contraction and Revision, *Journal of Symbolic Logic* **50**: 510 - 530.

[2] Antoniou, G. and Williams, M-A., Reasoning with Incomplete and Changing Information, *Journal of Information Science*, 99, **1 & 2**: 83 – 99, (1996).

[3] Antoniou, G. and Williams, M-A., Teaching Intelligent Information Management, in the *Proceedings of the First International Conference on Computational Intelligence and Multimedia Applications*, 380 – 384, (1997).

[4] Booch, G., Object-oriented Analysis and Design with Applications, Addison-Wesley, Reading, MA, 1994.

[5] Bruff, C.M. and Williams, M-A, An Intelligent Tutoring System Architecture based on Knowledge Representation and Reasoning, in *Proceedings of the 7th International Conference on Computers in Education*, IOS Press, 736-743, 1999.

[6] De Kleer, J., An Assumption-based TMS, *Artificial Intelligence*, **28**, 127 – 162 (1986)

[7] Doyle, J., A Truth Maintenance System, *Artificial Intelligence*, **12**, 231 – 272 (1979)

[8] Dubois, D. and Prade, H., Epistemic Entrenchment and Possibilistic Logic, *Artificial Intelligence*, **50**, 223–239, (1992).

[9] Giangrandi, P. and Tasso, C., Truth Maintenance Techniques for Modelling Students' Behaviour, *J. Artificial Intelligence in Education*, **6**, 153 – 202, (1995).

[10] Hawkes, L.W., Derry, S.J. and Rudensteiner, E.A., Individualized Tutoring using an Intelligent Fuzzy Temporal Relational Database, *International Journal of Man-Machine Studies*, **33**, 409 – 429, (1990).

[11] Huang, X., Modelling a Student's Inconsistent Beliefs and Attention, *Student Modelling: the Key to Individualized Knowledge-Based Instruction*, eds. J.E. Greer and G.I. McCalla, 267 – 280, (1994).

[12] Huang, X. and McCalla, G., Instructional Planning using Focus of Attention, *2nd International Conference on Intelligent Tutoring Systems* eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 443 – 450, (1992).

[13] Huhns, M.N. and Stephens, L.M., Multiagent systems and societies of agents, in *Multiagent Systems: a Modern Approach to Distributed Artificial Intelligence*, ed. G. Weiss, MIT, 79 – 120 (1999).

[14] Jennings, N.R., On agent-based software engineering, Artificial Intelligence **117**, 277 – 296, (2000).

[15] Jones, M. and Poole, D., An Expert System for Educational Diagnosis based on Default Logic, *Proceedings of the 5th International Workshop on Expert Systems and their Applications*, Vol. **2**, 673 – 683, (1985).

[16] Katz, S., Lesgold, A., Eggan, G. and Gordin, M., Modelling the Student in Sherlock II, *J. Artificial Intelligence in Education*, **3**, p. 495, (1993).

[17] Kono, Y., Ikeda, M., Mizoguchi, R., To Contradict is Human - Student Modelling of Inconsistency, *2nd International Conference on Intelligent Tutoring Systems*, eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 451 – 458, (1992).

[18] McCalla, G.I. and Greer, J.E., Granularity Based Reasoning and Belief Revision in Student Models, *Student Modelling: the Key to Individualized Knowledge-Based Instruction*, eds. J.E. Greer and G.I. McCalla, 39–62, (1994).

[19] Mizoguchi, R., Ikeda, M. and Kakusho, O., An Innovative Framework for Intelligent Tutoring Systems, *Artificial Intelligence Tools in Education*, eds P. Ercoli and R. Lewis, 105 – 120, (1988).

[20] Rao,A. and Georgeff, M., Modeling rational agents within a BDI-architecture, in the Proceedings of the International Conference on Principles of Knowledge Representation and Reasoning, (1991).

[21] Reiter, R., A Logic for Default Reasoning, *Artificial Intelligence*, **13**, 81 – 132, (1980).

[22] Reye, J., A Belief Net Backbone for Student Modelling, *3rd International Conference on Intelligent Tutoring Systems*, Montreal, 596 – 604, (1996).

[23] Searle, J.R., Speech Acts: An essay in the philosophy of language, Cambridge University Press, 1970.

[24] Shute, V., SMART evaluation: Cognitive Diagnosis, Mastery Learning and Remediation, *Proc. Artificial Intelligence in Education*, 123 – 130, (1995).

[25] Villano, M., Probabilistic Student Models: Bayesian Belief Networks and Knowledge Space Theory, *2nd International Conference on Intelligent Tutoring Systems* eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 491 – 498, (1992).

[26] Williams, M-A., Iterated Belief Revision: A Computational Model, in *the Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence*, Morgan Kaufmann Publishers, San Francisco, 1541 – 1550, (1995).

[27] Williams, M-A., Towards a Practical Approach to Belief Revision: Reason-Based Change, Luigia Carlucci Aiello and Stuart C. Shapiro (eds), *Proceedings of the Fifth International Joint Conference on Principles of Knowledge Representation and Reasoning*, Morgan Kaufmann Publishers, 412 – 421, (1996).

[28] Williams, M-A. Anytime Belief Revision, in the *Proceedings of the Fifteenth International Conference on Artificial Intelligence*, Morgan Kaufmann Publishers, San Francisco, 74 - 80, (1997).

[29] Wooldridge, M., Agent-based software engineering, IEEE Proceedings Software Engineering **144 (1)** 26 – 37, (1997).

An Educational System that can Visualize Behavior of Programs on the Domain World

Taketoshi Ando*, Yoshinobu Kawada*(†), Ryoji Itoh*, Tatsuhiro Konishi*, Yukihiro Itoh*

* *Department of Computer Science, Shizuoka University.*
Johoku3-5-1, Hamamatsu, Shizuoka, 432-8011, Japan.
Tel: +81 - 53 - 478 – 1474• • Fax: +81 - 53 - 478 – 1499
E-mail: s5005@cs.inf.shizuoka.ac.jp

In this paper, we discuss extension of our educational system that gives domain-oriented-explanations of programs. A programmer solves problems on a world where elements necessary to describe the problems and the solving processes of them (objects in the problems, relation among the objects, and so on) are represented. We call such a world 'the domain world' of the problem. Our system has a domain world model and simulates a target program on the model, to understand behavior of the program. By analyzing the result of understanding, it generates an explanation. Outputs of our original system are only verbal explanations. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the program. Therefore, we are trying to add a facility of generating explanations by using animations (visual explanations) to the system. Our extended system can generate both visual and verbal explanations (bimodal-explanations) in various abstraction levels. We discuss the method of generating bimodal-explanations from the result of simulation.

Keywords: **Intelligent Tutoring System, Programming Education, Algorithm Animation System, Bimodal-explanation**

1 Introduction

The purpose of our research is to construct an educational system that helps novice programming learners by explaining domain-oriented-functions of programs. We take Pascal as our target programming language.

Programming is generally carried out in the following process.

Step1. A programmer understands a problem that must be solved.
Step2. He considers the solving process of the problem on a world where the problem is present. We call such a world 'the domain world' of the problem. For example, when he considers a solving process of sorting, he imagines a world in which he pays attention to numerical order such as greater and lesser (we call this world the world of greater and lesser).
Step3. He implements the algorithm: selects data structures suitable to represent the domain world and translates the algorithm into a programming language.

Usually, relatively simple problems are set in novice class of programming. So it is rare that learners fail in the step 1. But they tend to confuse because they cannot distinguish between step 2 and 3. So many novice programmers cannot find whether the causes of bugs are hidden in the algorithm or in their implementation. On the basis of this idea, we proposed an educational system explaining programs using vocabularies on a domain world[2][5][6][7]. Difference of our system from existing educational systems of programming [1][8] is that the purpose of our system isn't pointing out bugs in learner's programs, but rather helping learners find bugs by themselves. Our system helps learners in the following way:

- To help learners to understand sample programs given by a teacher by explaining them.
- To help learners to find and fix bugs in their own programs by explaining the faulty behavior of them.

Our previous system outputs sentences using vocabularies on a domain world as the explanation. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the

(†) *Presently with System Integration Group, VICTOKAI, LTD.*

program. If animations of the behavior of programs are shown with the sentences, learners can easily understand their algorithms. Therefore, we realize the ability to generate animations (visual explanations) that show behaviors of the target programs. In this paper, we discuss the way to generate visual explanations for programs in the domain world of greater and lesser.

Existing algorithm animation systems can be classified into two types: The first one is a system such as courseware editors embody particular commands to target programs in order to generate visual explanations, like Zeus[3] and TANGO[9] system. So, this type of systems can generate visual explanations of high quality by using concrete objects on the domain world. For example, a length of bar is used to concrete values of variables on the visual explanation of XTANGO system. The second type of system doesn't need embodying particular command to target programs, like UWPI[4] and tracers. However, this type of systems cannot generate any visual explanation using concrete objects on the domain world. They can only generate visual explanations showing structure of data and changes of contents of variables. Our system can generate a visual explanation using concrete objects on the domain world without embodying any special commands to programs. It generates visual explanations on the basis of the result of "simulation based program understanding[5]". So it can accept buggy programs and generate visual explanations of buggy behaviors of the programs. Moreover, it can also generate verbal explanations on the basis of the result of program understanding.

In the next section, we illustrate an overview of our previous system. In section 3, we point out some functions necessary to generate an effective explanation by using both verbal explanation and visual explanation (a bimodal-explanation). In section 4, we describe the method of constructing the bimodal-explanation system. Then, we show examples of bimodal-explanations by our system.

2 Our Previous Work

2.1 Overview of our previous system

Our previous system is composed of the static analyzer, the simulation based analytical unit and the explanation unit (Figure 1). In this paper, we omit detail of the system (For further details, please see our previous papers[2][5][6][7]). The static analyzer parses target programs and analyzes information necessary for the simulation such as data flow. The simulator simulates target programs, and the observer observes the world model while simulation, and recognizes some important characteristics of data or patterns of structured data. The explanation generator generates verbal explanations of target programs.

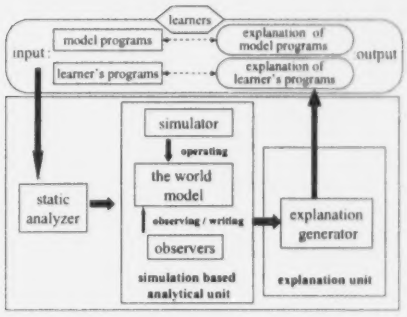


Figure 1: Configuration of our system

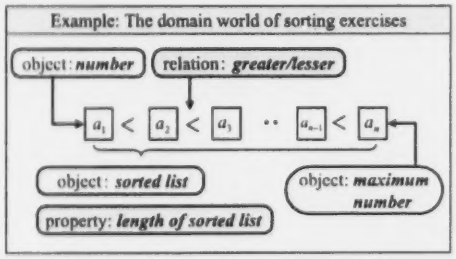


Figure 2: An example of domain world

2.2 Domain world models

We examine programming exercises and classify them into 15 types. We prepare domain world models designed for each type of exercises [2].

A domain world model consists of four types of elements called 'object', 'property', 'relation among objects' and 'change'. For example, Figure 2 shows the domain world model of greater and lesser as an example. In order to recognize specified characteristic or patterns in the domain world, our system has daemon units called "observer" which are burnt when they are observed. In the Figure 2, the object *'maximum number'*, *'sorted list'* and property *'length of sorted list'* are recognized by observers. There are some cases that some observers take outputs of the other observers as their inputs. Then the outputs of observers make hierarchy. When a result of observation is output on the basis of a result of another observer, the former has larger grain-size than the latter and implies the fact corresponding to the latter.

BEST COPY AVAILABLE

2.3 Generation of a verbal explanation

The explanation unit generates verbal explanations of the target program by using results of simulation and outputs of observers. The results of observations have a hierarchical structure, as mentioned above. The system generates a hierarchical verbal explanation by using the hierarchical structure (it also uses syntactical structures of programs). In other words, the system notices the largest grain-sized result of the observation firstly, in order to generate the verbal explanation. Secondly, if learners request the detailed verbal explanations, the system generates the explanation using results of observation having smaller grain size. Figure 3 shows the example of verbal explanations generated by our system. It illustrates the verbal explanation of behavior of a sorting program on the domain world of greater and lesser. The indentation in the figure means that *behavior 1* and *behavior 2* are executed sequentially and that *behavior 2* is equivalent to the sequence of *behavior 2-1, behavior 2-2,* and *behavior 2-3*. Each Behavior is implemented by a single statement or a sequence of statements. When a verbal explanation for a behavior implemented by a sequence of statements is clicked, more detailed verbal explanations showing the way to implement the behavior are displayed.

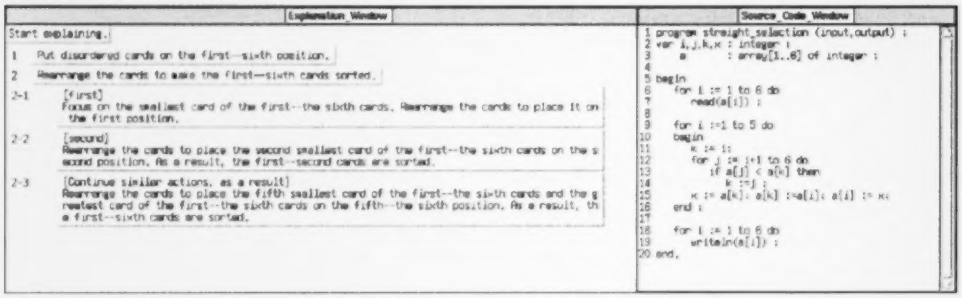


Figure 3: An example of the verbal explanation of a target program

Next, we show procedures for generating the hierarchical verbal explanation like Figure 3. An input is a result of simulation of some statements (For further details, please see our previous paper[7]).

(1). The case that a certain behavior is implemented by a sequence of statements.
The system observes differences of the states of the domain world model before and after execution of the sequence of statements. According to these differences, the explanation unit selects a template and generates verbal explanations for the statement. Now we show an example of a template.

- The case that extension of the sorted list is observed.

The differences are composed of the following three elements.

Object(s) recognized at the state before execution of some statements: a sorted list
Object(s) recognized after execution of the statements : an extended sorted list
Recognized changes of states of objects : an extension of the sorted list

A template for the extension of the length of a sorted list is applied (Please see Figure 3).

Template: "Rearrange the [Type of added object] to place [An added object] on [The position of the insertion] position. As a result, [A sorted list at the after state] [Type of inserted objects] are sorted."

"[]" means a procedure which generates a certain pattern of string.••

[An added object]
: A procedure that generates a noun phrase expressing the new object added to the sorted list.

[A sorted list at the after state]
: A procedure that generates a noun phrase expressing the range of the sorted list at the after states.

(2). The case that a certain behavior is implemented by a single statement.
The explanation unit calls each procedure corresponding to types of the statement. The procedures are defined for each structure of the program like sequential structures, selective structures, iterative structures, an assignment statement, a statement for input, and a statement for output. Same as the case (1), templates are prepared for each structure of the program. For example, we show a template of 'if' statement.

Template: "if [explanations of the conditional clause], [explanations of the 'then' clause]
(otherwise [explanations of the 'else' clause])"

[explanations of the conditional clause]
: The procedure that explains the conditional statement of 'if' statement.

[explanations of the 'then' clause]
: Apply the procedure for generating the verbal explanation to the clause recursively.

[explanations of the 'else' clause]

BEST COPY AVAILABLE

: Apply the procedure for generating the verbal explanation to the clause recursively.

Thus, the system can generate hierarchical verbal explanations. When a verbal explanation generated by the procedure (1) is shown and a learner requests more detailed explanation, the system tries to apply the procedure (1) recursively to make such an explanation. If it cannot generate any explanation, it applies the procedure (2).

3 Functions necessary to generate an effective bimodal-explanation

In order to construct a system generating effective visual explanations, we have to consider what visual explanation is effective for learners to understand an algorithm or behavior of a target program. By designing mock up visual explanations repeatedly, we find that the effective visual explanation has following three facilities.

(1) The facility to generate visual explanations with various grain-sizes.
When learners learn programming by using a system explaining behaviors of programs, they need various grain-sized explanations. For example, when a learner wants to grasp algorithm roughly, a large grain-sized explanation would be effective. On the other hand, when he wants to understand a precise method of implementation, smaller grain-sized explanations are effective. Moreover, when he wants to diagnose his own program at a glance, he needs the largest grain-sized explanation. When he wants to find buggy codes, he needs smaller ones. In order to generate such various grain-sized visual explanations, the system should be able to :

- regard a sequence of statements as a blackbox and generate a visual explanation showing its function.
- generate a visual explanation showing a function of each statement sequentially.

(2) The facility to explain a function of a program by using both animations and verbal texts.
If a system shows only visual explanations, learners sometimes cannot understand behavior of target programs clearly, because such learners cannot understand what phenomena are essential. Thus, it is necessary for our system to have the facility to generate verbal explanations showing a major phenomenon of each step of visual explanations. Thus our system should have a facility of generating combination of verbal explanations and visual ones (bimodal-explanations).

(3) The facility to generate explanations on the total effect of a sequence of statements.
Generally, a task is achieved by a sequence of statements, and each sub-task is achieved by each sub-sequence of the statements. When the system shows a sequence of explanations each of which has a certain grain-size corresponding to a sub-task, a learner sometimes cannot find the fact that the task has been achieved. In order to prevent learners from such misunderstanding, the system should show them a verbal explanation remarking the fact.

4 Methods to realize the functions to generate bimodal-explanations

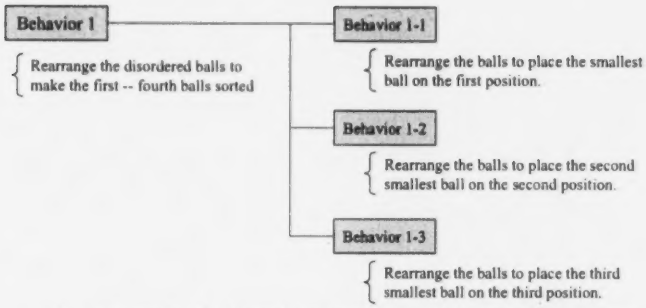
4.1 Basic ideas

(1) The method of generating visual explanations on various grain-size.
As we describe in section 2, our system can generate hierarchical verbal explanations. In other words, it can understand behavior of a target program on various grain-size. And the system holds the result of understanding as hierarchical data. Therefore we can realize a system generating visual explanations on various grain-size, by developing a method to generate a visual explanation from a result of understanding.

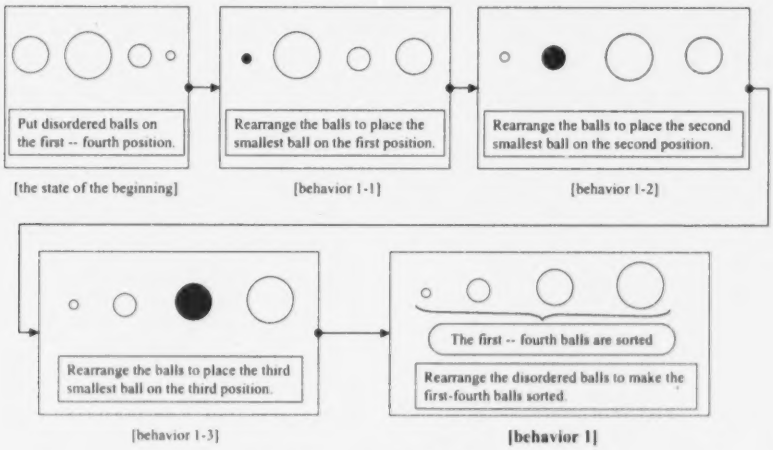
(2) The method of generating combination of verbal explanations and visual explanations.
Our program understanding mechanism can recognize the major phenomena in the domain world. And we have already developed a method to generate verbal explanations from the result of program understanding. Thus, if the system can generate a visual explanation from the result of it by the method (1), it becomes to be able to generate both visual explanations and verbal explanations remarking major phenomena from common data.

(3) The method of generating explanations on the total effect of a sequence of statements.
By generating an explanation remarking that a task is achieved just after explanations of sub-tasks are finished, the system can generate explanations on the total effect of the task. The explanations of the task and the sub-task can also be generated by the method (1) and (2). For example in Figure 4, just after the explanation corresponding to the behavior 1-3 is finished, the system generates the explanation corresponding to the behavior 1 as the explanation of the total effect. As a result, the explanation shown in Figure 4 is generated.

In consequence, if we can realize the method (1), the method (2) and (3) can also be realized. Therefore we discuss the detail of the method (1) in the next section.



(a): An example of a hierarchical structure of behaviors of a program



(b): Generated explanations

Figure 4: An example of a bimodal-explanation of a total effect

4.2 Generating visual explanations

The system visualizes behavior of the target program in various grain-size. The generated animations are shown with verbal explanations. The detail of our method to generate verbal explanation is seen in [6], so we omit it in this paper.

At first, the system starts explaining with the largest grain-size, then shows more detailed explanation on an action of which detail a learner wants to see.

The methods to draw a step of animation are classified into the following two types:

1) The method of visualization for a function implemented by a single statement.

2) The method of visualization for a function implemented by a sequence of statements.

The detailed process of 1) and 2) is discussed in 4.2.1 and 4.2.2 respectively.

4.2.1 How to generate a visual explanation of a function implemented by a single statement

In order to generate a visual explanation on a statement, we prepare specific procedures for each type of a statement. The statements of inputting, assignment, selection, and iteration have their individual procedures.

Procedures for inputting statement should be classified into several types in order to generate effective explanations. For example, the basic function of inputting statement "read (A);" must be "a datum is input to the variable A". However, showing only the basic function is not always a good explanation. If a meaningful datum has been stored in the variable "A" before inputting, the system should also explain that the datum is deleted by the inputting. Therefore, the procedures for inputting statement are classified according to some conditions on the role of the statement in the target program and the domain world: for example, the condition whether the datum stored in the destination variable of inputting has been referred before the input sentence or not (if it has been referred, it must be meaningful).

BEST COPY AVAILABLE

Similarly, procedures for assignment statement should also be classified. For example, the basic function of the statement "A:=B;" is "the datum in the variable B is copied and the copy is written on the variable A". But, if the datum in B will never be referred after the assignment, the explanation " the datum in B is moved to A" must be better because it represents the role of the statements more directly. We show an example of a condition to classify procedures for assignment statement and a procedure corresponding to the condition, by using the statements illustrated in Figure 5.

The condition and procedure for assignment statement meaning the copying process of objects in a sorting program is as follows.

Condition: [the datum in B represents an object in the world of greater and lesser]
and [B is referred during *2] and [A is also referred during *1]

Procedure: Seen in Table 1. And the visual explanation generated by the procedure is seen in Figure 6.
Table 1 also shows the templates for generating verbal explanations in this condition.

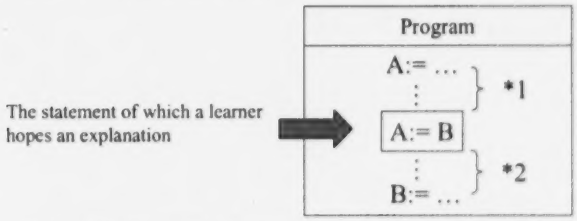


Figure 5: An example of an assignment statement in a program

The system doesn't generate visual explanations corresponding to statements of selection and iteration. For example on "if-then-else" statement, it generates visual explanations corresponding to 'then' block or 'else' block, while it generates verbal explanations whether the condition part of the statement is true or false. By the verbal explanation, a learner can understand why the 'then' block or the 'else' block is executed. Templates used to generate such verbal explanations are not the ones mentioned in 2.3 because of the following reason:

- In general, verbal explanations can be abstract. For example, we can explain a sorting process of N pieces of balls.
- Visual explanations must be concrete. For example, the system has to decide how many balls exist in the domain world in order to draw sorting process.
- Therefore, verbal explanations corresponding to visual explanations have to be generated by templates designed for bimodal-explanation.

Table 1: Examples of procedures and templates for generating explanations of an assignment statement

order	Procedures for generating visual explanations.	Templates of verbal explanations
1	Show a ball having an assigned value with a black color.	Focus on [a ball holding an assigned value].
2	Show a copy of the ball having the assigned value.	Prepare a copy of this ball.
3	Show a ball assigned the value with a gray color.	Remove a ball on [an assigned position].
4	Draw an arrow from the copy of the ball having the assigned value toward the ball assigned the value.	Move the copy of this ball to [an assigned position].
5	Show the copy of the ball having the assigned value at an assigned place.	Move this ball to [an assigned position].
6	Show a state of end.	

As mentioned above, "[]" in template means a procedure by which a certain pattern of string is generated. The bimodal-explanation corresponding to a single statement is composed of 3 ~ 5 scenes.

4.2.2 How to generate an explanation of a function implemented by a sequence of statements

In order to generate such a visual explanation, the system needs to display the states before/after the function has been applied. In order to decide designs of both states, the system generates a sequence of visual explanations on the statements by which the function is implemented. The generated explanations are only stored in a database without being displayed to a learner. The system picks up the initial state and the final state from the database and displays them one after another.

In addition, the system also needs to explain an effect of the sequence of statements directly. In order to generate an explanation of a total effect of statements, the system should generate a verbal explanation remarking the total effect and a step of animation showing the effect directly. The system can generate the verbal explanation by applying templates to the result of simulation. In order to generate a step of animation, we

prepare procedures for visualizing a concept recognized as a result of the simulation. For example, brace and the words attached to it in Figure.4 (b) are drawn by such procedures. The number of such procedures is nearly equal to the number of template for the result of simulation (illustrated in 2.3.(1)).

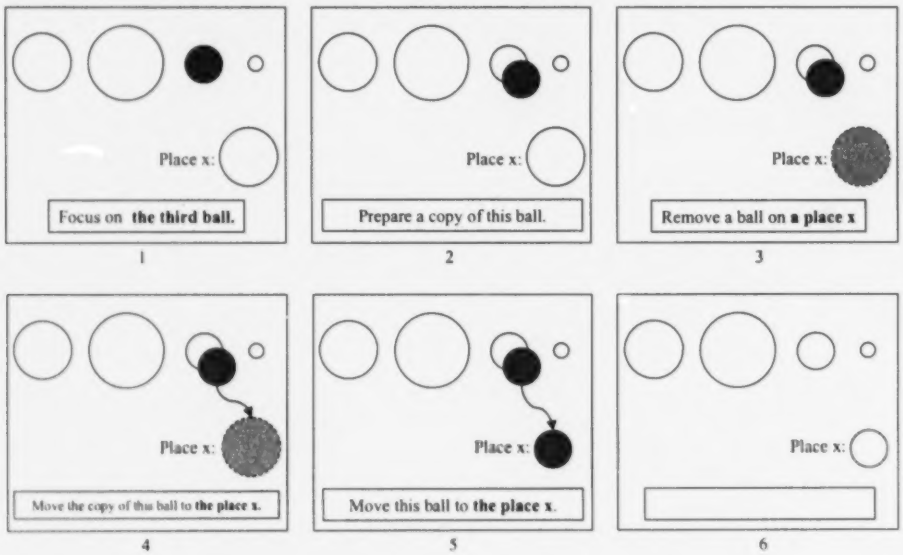


Figure 6: The visual explanation corresponding to each statement

5 Implementation

The system is developed on Unix workstations. The unit of generating bimodal-explanation is implemented by Tcl/Tk. Now we have finished implementation of procedures generating bimodal-explanations of statements of input, assignment, selection and iteration. Figure 7 shows an example of bimodal-explanations generated by our system. The target program is sorting by straight insertion. The system explains the process of sorting five balls according to their sizes. Figure7-1 shows the state just after that the smallest ball (in this figure, it is the 4th ball from the left end) has been found, the ball has been copied to the 'place x', and it has been removed. After that, the following processes are explained one after another.

- The copy of the first ball is moved to the fourth position (Figure7-2, 7-3).
- The ball on the 'place x' is focused (Figure7-4).
- The ball on the first place is removed (Figure7-5).
- The ball on the 'place x' is moved to the first position (Figure7-6, 7-7).

By these explanations, learners can imagine the process that the smallest ball is moved to the first place. The explanation after Figure7-8 continues in a similar way. The system also shows the process that the second - fifth smallest ball is moved to the second - fifth place respectively. Thus, the whole process of the sorting is illustrated. The original messages generated by our system are Japanese, but we add corresponding English messages to this figure.

6 Conclusion

In this paper, we proposed a method of generating a bimodal-explanation. Our system accepts the result of simulation and generates bimodal-explanations. Our current system can deal with only on the domain world of greater and lesser. Constructing procedures for the remaining types of a statement and applying this system to other domain worlds will be our future work.

Acknowledgments

This research was supported in part by Grant-in-Aid for Scientific Research (c)(11680216) from Japan Society for the Promotion of Science.

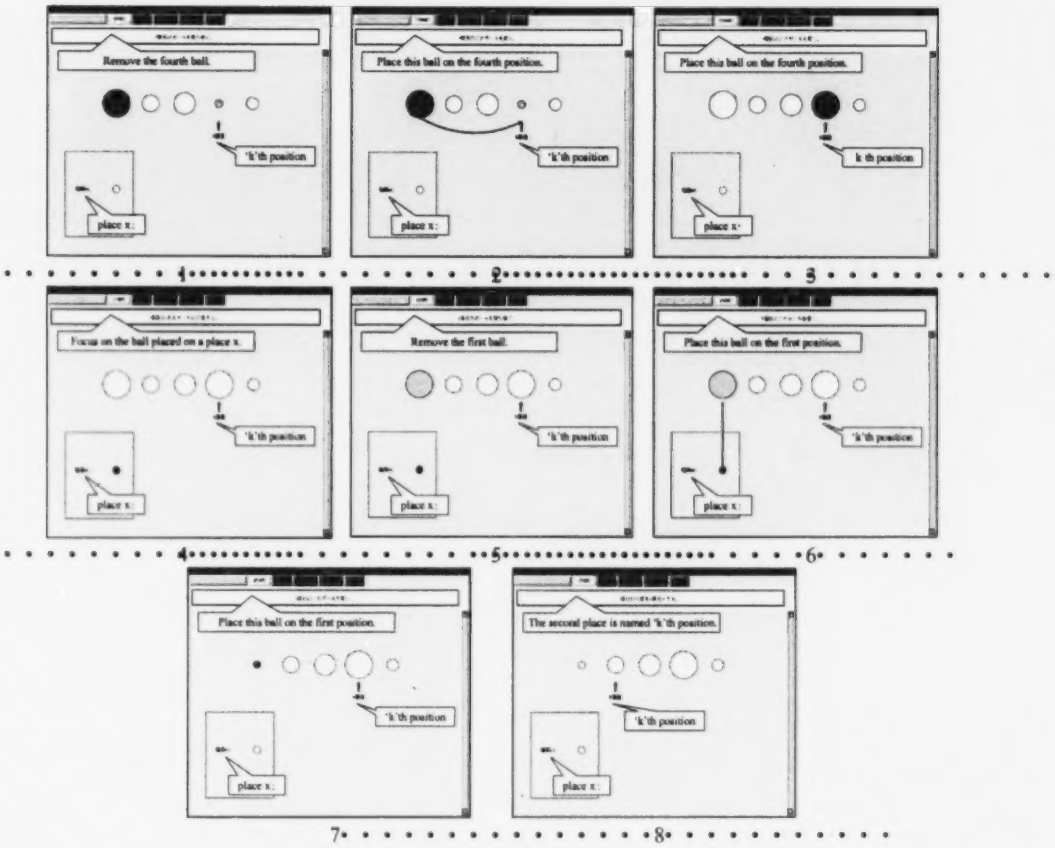


Figure 7: Outputs of our bimodal-explanation system

References

[1] Adam, A., Laurent, J.P.: "LAURA, A system to debug student programs", Artificial Intelligence, Vol.15, pp.75-122, (1980)

[2] Ando, T., Itoh, R., Konishi, T., Itoh, Y.: "Extension of the Educational System that Generates Domain-Oriented-Explanations of Programs – On Methods for Designing Domain World Models and for Simulation", Proc. of ICCE'99, Chiba, Japan, Vol.1, pp.856-860, (1999)

[3] Brown, M. H.: "Zeus: A system for algorithm animation and multi-view editing (research report No.75)", DEC systems research center, (1992).

[4] Henry, R. R., Whaley, K. M., Forstall, B.: "The university of Washington Illustrating Compiler ", Proc. of The ACM SIGPLAN'90 conference on programming language design and implementation, pp.223-233, (1990).

[5] Itoh, R., Nishizawa, M., Konishi, T., Itoh, Y.: "On analysis of novice PASCAL programs based on simulation to extract Information for education", Proc. of ICCE'97, Kuching, Sarawak, Malaysia, pp.485-492, (1997)

[6] Itoh, R., Nishizawa, M., Konishi, T., Itoh, Y.: "A programming learning system which makes Domain-Oriented-Explanations", Proc. of ICCE'98, Beijing, China, Vol.1, pp.432-440, (1998)

[7] Itoh, R., Konishi, T., Itoh, Y.: "On Constructing a programming Education System that makes domain-oriented-explanations", Journal of JSAI, Vol.15 No.2, pp.362-375, (2000), in Japanese.

[8] Johnson, W.L., Soloway, E.: "PROUST:knowledge-based program understanding", IEEE Software, vol.11, no.3, pp. 267-275, (1985)

[9] Stasko, J. T.: "Tango: A framework and system for algorithm animation", IEEE computer, Vol.23, No.9, pp27-39, (1990).

BEST COPY AVAILABLE

An Environment for Learning by Design
- In the Case of Learning of Search Algorithm -

Tsukasa HIRASHIMA, Hidenori IKEMATSU, Mayt Kalayar, Akira TAKEUCHI
Kyushu Institute of Technology, Department of Artificial Intelligence
680-4, Kawazu, Iizuka, 820-8502, JAPAN
TEL: +81-948-29-7618, FAX: +81-948-29-7601
tsukasa@ai.kyutech.ac.jp

This paper described a learning environment for search algorithms. In the learning environment, learners can build search algorithms by combining several parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. In the diagnosis, errors in the algorithms are detected. By using the results of this diagnosis, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms. We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising.

Keywords: **Learning by design, Error diagnosis, Search algorithm**

1 Introduction

An effective way to learn procedural knowledge in depth is to make learners apply it to various cases. However, although the learners may master how to use the procedure through the experience, it is not enough to answer the question "what the procedure is". Several investigations [1-4] suggested that "learning by design" is a promising way to promote the learner's understanding about "what that is". For example, in order to understand a machine in depth, assembling it from its smaller parts is the best way. In the case of the understanding of procedure, to build up the procedure by trial and error is useful in order to understand it.

This paper reports about a learning environment for learning by design, targeting basic search algorithms taught in an introduction to artificial intelligence lecture, that is, depth-first search, breadth-first search and three heuristics searches (best-first, minimum consuming cost, and A algorithm). In the lecture, usually, the procedure of each search algorithm is taught and learners carry out the searches following the procedures by hand. Some of them understand the meaning of the algorithms through the practice, but some of them only memorize the procedures. Our environment provides several parts of the search algorithm as icons. Learners can assemble them by direct manipulation in the environment. The environment interprets the assembled parts as a search algorithm and diagnoses it, for example, as to whether it falls into the loop or not. Then, the environment gives feedback for the algorithm to revise it or to try to build the next one. The tree structures that are generated as the results of the searches following the algorithms are also presented to the learners. These feedbacks are necessary to realize learning by design effectively.

In this paper, first, the model of the search algorithm that is the basis of the design of this environment is described. Then, the configuration and functions of the learning environment are explained. The preliminary evaluation of the environment is also reported.

2 Interactive Learning Environment of Search Algorithms

Figure 1 shows the configuration of the ILE. It is composed of the interface and reasoning module. In the interface, learners design and build search algorithms, and receive feedback from the system. In the

reasoning module, the algorithms are diagnosed and feedback messages for them are generated. The interface is implemented in Java as a client and the reasoning module is implemented in Prolog as a server. Therefore, the ILE can be used on the Internet.

In this section, first, the model of search algorithms used in the ILE is described. The modeling is indispensable for designing the interface for algorithm building and in order to diagnose algorithms. Then, the interface where learners can build the search algorithms by direct manipulation is presented. The diagnosis of the algorithms and the feedback generated based on the results of the diagnosis are also explained.

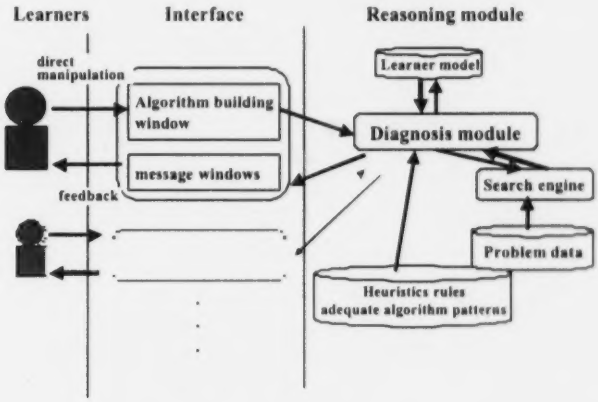


Figure 1. Configuration of the ILE

2.1 A Model of Search Algorithm

Search algorithms taught in the introductory lecture of artificial intelligence share the same procedure as follows. Here, both "Open" and "Closed" are lists composed of search nodes.

1) The start node is put into Open.
2) If "Open == []" then "the end of the search is in failure".
3) Pick up one node at the head of Open (the node is called *n*)
4) If "*n* == goal" then "the end of the search is in successful".
5) Generate child nodes from *n*.
6) Put the child nodes into Open.
7) Put *n* into Closed.
8) Return to Step-2.

The differences between the search algorithms are characterized by the operation of Step 6. For example, depth-first search is characterized as the algorithm in which the child nodes are put into the head of Open in Step 6. Breadth-first search is characterized as the algorithm in which the child nodes are put into the tail of Open in Step 6. In heuristics searches, the way to sort Open is an essential characteristic. In addition, for every algorithm, the method of selection of child nodes to put into Open is also an element that characterizes the search algorithms.

In our system, search algorithms are characterized by the combination of the following three list operations used in Step 6: "selection," "connection" and "sort." There are two types of selection operations: the first is "to select nodes that are not included in a list," and the other is "to select nodes that are not included in a list or are lower in cost than the same node in the list." Connection also has two types. The first is "to put nodes into the head of a list" and the other is "to put nodes into the tail of a list." The referred list is usually Open. We prepared three types of sorts: "to sort in the order of the consumed cost (minimum consumed cost search)," "to sort in the order of predicted cost (best-first search) " and "to sort in the order of the total of the consumed and predicted cost (A algorithm)."

BEST COPY AVAILABLE

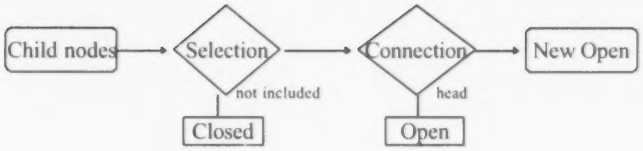


Figure 2. An example of the model of Search Algorithm

Figure 2 shows an example of a search algorithm built by the operations. The lozenge is the operation, and the rectangle is the list. The parameter that indicates "referred cost" or "head or tail" to specify the operator is presented at the bottom right of the lozenge. Therefore, Figure 2 means that "the child nodes that are not included in Closed are put into the head of Open." This is a kind of depth-first search that prunes using Closed.

Every part described above is necessary to build the search algorithms taught in the introductory lecture to artificial intelligence. In order to make learners understand search algorithms more deeply, our ILE provides an environment where learners can build search algorithms freely, and can receive feedback for the algorithms. In the following section, the ILE designed based on the model of search algorithms is described.

2.2 Building Search Algorithms

The interface for building search algorithms is shown in Figure 3 (currently, the interface is written in Japanese. Explanations in Figure 3 are translated to English for this paper. Japanese version is shown in [5]). Learners

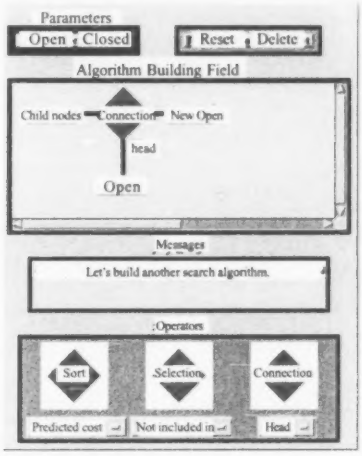


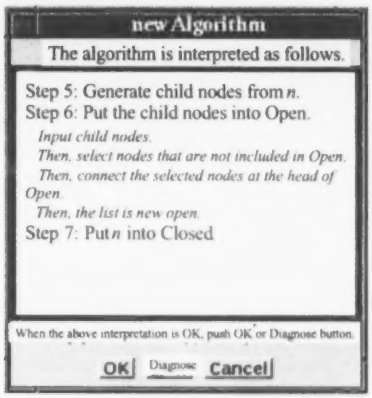
Figure 3. The Algorithm Building Field.

build search algorithms in the "building field" by assembling parts provided in the interface. At the bottom of the Interface, three operators are provided in the lozenges. The parameters specifying the operators are selected from the menu under the lozenges. The reference lists of the operators are selected from the box at the upper left. All manipulation in the interface can be done with a mouse. The algorithm in the building field is a depth-first search without having pruned.

Learners can confirm the algorithm built by themselves in two ways: a written explanation and a trace of the

BEST COPY AVAILABLE

search tree. The explanation is generated by interpreting the operations in order of sequence in the building field. Figure 4 is the explanation of the algorithm shown in Figure 3. A search tree is generated by showing the trace results in a search space. The search spaces are provided as mazes in the environment. Figure 5 is an example of search tree that is the results of the search for the maze shown in the right in the figure.



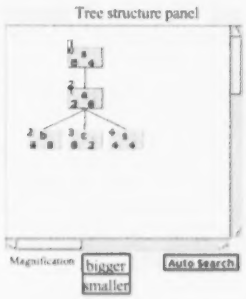


Figure 4. An Example of Explanation an Algorithm. Figure 5. An example of search tree.

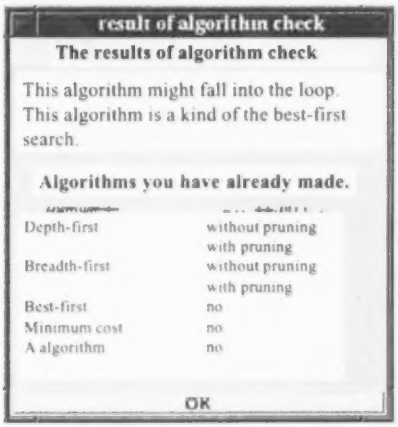


Figure 6. An Example of the Results of Problem Diagnosis.

Learners can also ask the system to diagnose the algorithms built in the building field. The reasoning module has both the adequate combinations of operations and heuristics rules to criticize the algorithms that are not adequate. By using the adequate combinations, the adequate algorithms can be detected. By using the heuristics rules, the errors in the inadequate algorithms are detected. If no errors are detected by the heuristics rules, the reasoning modules can not judge the type of the errors. The heuristics rules are prepared from the following three points of view: the kind of algorithm, redundancies in the algorithm and the covering of the search space. An example of messages generated from the results of the diagnosis is shown in Figure 6. In the following section, the diagnosis of the search algorithms is described.

2.3 Diagnosis of Search Algorithms

In the reasoning module, the algorithms are diagnosed using heuristics rules. The heuristics rules of each viewpoint are shown in this section.

BEST COPY AVAILABLE

2.3.1 Type of Algorithm

The algorithms built by the learners are categorized by the following heuristics rules.

* When, after child nodes are put into the head of Open, either any nodes are not put into the head of Open or Open is not sorted, the algorithm is categorized as depth-first search.
* When, after child nodes are put into the tail of Open, either any nodes are not put into the tail of Open or Open is not sorted, the algorithm is categorized as breadth-first search.
* When, after child nodes are put into Open, Open is finally sorted in the order of consumed cost, the algorithm is categorized as minimum consumed cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of predicted cost, the algorithm is categorized as predicted cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of the total of consumed cost and predicted cost, the algorithm is categorized as A algorithm.

When the algorithm has no characteristics checked by the above rules, the kind of algorithm cannot be specified.

2.3.2 Redundancy of Algorithm

When the algorithms include the following operators, the diagnosis module judges that the operators are redundant in the algorithms.

* The same operators are used continuously.
* When several operators of sort are used, only the operator of sort used at the end has meaning.
* After using the connecting operator with a list as the parameter, the execution of the selection operation with the same list as the parameter results in deleting the added nodes.

2.3.3 Covering of the Search Space

Several search algorithms that can be built by learners can not find goals that exist in a search space. The reasoning module diagnoses whether or not the algorithm can cover the search space, by using the following heuristics rules.

* When several child nodes which might imply goals are not put into Open, the algorithm might fail to reach the goal included in the search space.
* When the algorithm that isn't categorized as breadth-first, minimum consuming cost or A algorithm doesn't include the selection operator with Closed as the parameter, the algorithm falls into the loop.

2.4 Feedback based on the Diagnosis

Based on the results of the above diagnosis with heuristics rules, the messages to criticize the algorithm are provided in the interface. Figure 7 shows an example of the messages. When the type of an algorithm is judged, the type is indicated. When the algorithm includes the redundant operators, the operators and the explanation of the redundancies depending on each heuristics rule are provided. When the algorithm might not cover the search space because several child nodes fail to be input into Open, the explanation prepared for the heuristics rule is shown. When the algorithm might fall into the loop, the possibility of falling into the loop is indicated.

When the algorithm includes a pruning operation, the fact is also indicated. In the interface shown in Figure 7, to motivate learners to build the next algorithms, the algorithms the learner has made correctly and hasn't made yet are shown.

3 Preliminary Evaluation

For a preliminary evaluation of the learning environment, we gathered thirty college students and asked them to use the learning environment. Those who were in the second grade or in the third grade have already taken the lecture of artificial intelligence. Their participation was voluntary. Before the experiment, we explained how to operate the environment for ten minutes. Then, we asked them to build search algorithms in the learning environment for an hour.

In the experiment, we recorded the following data: (1) the number of algorithms built by the learners, (2) the number of adequate algorithms, (3) the number of inadequate algorithms that could be diagnosed with heuristics rules, (4) the number of inadequate algorithms that couldn't be diagnosed, and (5) the number of types of the adequate algorithms the learner made. The results are shown in Table 1. After the experiment, we asked four questions: (a) Are you interested in the system? (b) Is the system easy for you to use? (c) Would you like to use the system more? (d) Do you understand the search algorithms better than before? The results are shown in Table 2.

Table 1. The results of the students algorithm building.

Student number	(1)The total number of algorithms	(2)Adequate algorithms	(3)Inadequate algorithms (be diagnosed)	(4)Inadequate algorithms (not be diagnosed)	(5)the type of the algorithms
No.1	26	11	15	0	5
No.2	24	10	6	8	5
No.3	16	10	6	0	5
No.4	38	17	13	8	5
No.5	44	13	20	11	5
No.6	48	10	26	12	5
No.7	21	8	8	5	3
No.8	26	15	9	2	5
No.9	23	14	4	5	5
No.10	16	5	6	5	1
No.11	43	24	11	8	5
No.12	20	8	12	0	5
No.13	16	9	7	0	5
	361	154	143	64	

Table 2 . The Results of Questions.

	Yes	Maybe yes	No	No answer
Qusetion-a	10	3	0	0
Question-b	1	7	5	0
Question-c	7	5	0	1
Question-d	3	3	4	3

In Table 1, the total number of algorithms the learners made was 361, that is, 27.8 per student. The total number of adequate algorithms was 154, that is, 43 % of the algorithms. The total number of inadequate algorithms was 207 (57%). The number of diagnosed errors by heuristics rules was 143. This means that the system could detect the errors in 69 % of the inadequate algorithms. Among thirteen students, eleven students made every type of algorithm.

In Table 2, the results of Question-a and –c suggest that most of the students had interest in the learning environment. The result of Question-b indicates that the interface is not easy for the students to use. For Question-d, four students answered "no", and three students didn't judge, that is, more than half the students didn't think they gained a deeper understanding by using the learning environment.

Students made many algorithms in the experiment and they answered that the learning environment was interesting. In addition most of them could make every type of algorithm. These results suggest that the learning environment is promising. The answers for Question-b mean we should improve the interface. In Question-d, Six students thought they got deeper understanding by using the environment, but seven students didn't think so. When we gathered students, we told them that we would ask them to use a learning environment for search algorithms. Therefore, most of the students participating in the experiment might have confidence about their understanding of search algorithms. This is one reason for the result for Question-4.

As for the results, the experiment suggests that the learning environment is promising to be used in the real world, but the effect couldn' t be confirmed clearly.

4 Conclusions

This paper described a learning environment for learning by design in the case of search algorithms. In the learning environment, learners can build search algorithms by combining parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. The heuristics rules detect errors in the algorithms. By using the results of this diagnoses, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms.

We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising to be used in the real world and that is promising, but the effect couldn' t be confirmed clearly. In the next step, we will use the learning environment in class and evaluate it in a real learning context.

References

(1) S.Papert: Mindstorms, Basic Books, Inc(1980).

(2) G.Fisher, K.Nakakoji: Empowering Designers with Integrated Design Environments, Proc. of the First International Conference on Artificial Intelligence in Design, pp105-117(1991).

(3) A.Repenning: Programming Substrates to Create Interactive Learning Environments, Interactive Learning Environments, Vol.4, No.1, pp.45-74(1994).

(4) E.Soloway, M.Guzdial, K.Hay: Learner-Centered Design: The Challenge for HCI In The 21st Century Interactions,Vol.1, No.2, pp.36-48(1994).

(5) H.Ikematsu, Myat, T.Hirashima, A.Takeuchi: Interactive Learning Environment for Search Algorithm, Proc. of Research Meeting of Kyushu Division of Information Processing Society of Japan, 3A-5, pp.101-108(2000)(in Japanese).

Applicability of an Educational System Assisting Teachers of Novice Programming to Actual Education

Hiroyuki Suzuki*, Tatsuhiro Konishi and Yukihiro Itoh****
* *Graduate School of Science and Engineering, Shizuoka University*
** *Faculty of Information, Shizuoka University*
Johoku 3-5-1, Hamamatsu, Shizuoka, Japan 432-8011
Tel: +81-53-478-1474 Fax: +81-53-478-1499
E-mail: {h-suzuki, konishi, itoh}@cs.inf.shizuoka.ac.jp

In this paper, we propose a technique for reducing processing time during program evaluation, and examine processing time of evaluating programs of which sizes are relatively large in novice programming courses. We proposed a method of constructing an automated evaluation system assisting teachers teaching novice programming. Our system evaluates learners' programs by comparing them with a standard algorithm representing teacher's intentions. By using our system, teachers can easily pick up learners' defective programs. We constructed a prototype system, and examined whether the system can evaluate programs actually submitted by learners. We confirmed that it could evaluate the programs validly. However we found that we should improve the processing time after evaluating various programs. In order to reduce processing time, we extend the matching algorithm using two ways. As a result, processing time is improved without spoiling the accuracy of matching. After that, we design a model course of novice programming based on actual courses in our university. And we examine the relation among program size, arbitrariness of teacher's intention and processing time. Then we confirm that the processing speed of our system is fast enough to be used in actual education environment.

Keywords: **educational system assisting teachers, automated evaluation system, program diagnosis, experimental evaluation**.

1. Introduction

By using program diagnosis technique, many programming education systems have been developed[1][2]. Most of them are designed to help learners, not the teachers. We think it is necessary to help teachers in order to give learners better advice. It needs much effort for teachers to evaluate many programs. So we constructed a prototype system assisting teachers teaching novice programming[4]. We have designed a model course on the basis of actual novice programming education course. Then, we have examined whether the system can evaluate programs written by learners. We confirmed that it could evaluate the programs validly[5]. However we found that we should improve the processing time after evaluating various programs. In this paper, we propose a technique for reducing the processing time (section 3), and examine processing time of evaluating programs of which sizes are relatively large in novice programming courses, then confirm that the processing speed of our system is fast enough to be used in actual education environment (section 4).

2. Our previous work

Generally, teachers teaching novice programming arrange goals for their exercises, and set exercises related to the goals. We call these goals "*teacher's intentions*". They evaluate whether each program submitted by a learner achieves the goals or not, and advise the learners according to the result of the evaluation. However, it needs much effort for them to evaluate many programs with various bugs. So we support them by developing an automated evaluation system classifying programs which perfectly satisfy *their intentions*, which partially satisfy *their intentions* or do extra work, and which don't satisfy *their intentions*. Therefore they only have to check the

unsatisfied programs carefully.

We found that most of *teacher's intentions* can be represented with standard algorithms to solve exercises. So we use the standard algorithms for inputting *teacher's intentions*. We designed an algorithm representation based on PAD expression. We call the representation "Extended PAD". By using the Extended PAD, teachers are allowed to use the following structures in order to represent arbitrariness included in *their intentions*.

Non-ordering structure: It represents arbitrariness on the order among tasks,
Alternative structure: It represents arbitrariness on method to achieve a goal.

The Extended PAD consists of two types of elements: elements which correspond to a Pascal operation or control structure, and which correspond to a sequence of Pascal operations. We call the previous elements "primitive operations", and the other "macro operations".

We developed a method matching learners' programs with a standard algorithm. According to this method, the system tries to check correspondence of every combination of statements in a learner's program with the statements in a standard algorithm. If it judges that a statement in a learner's program matches with a statement in a standard algorithm, it makes a hypothesis on a correspondence of these statements and correspondences of variables referred by the statements. Then it continues matching the other statements on the basis of the hypothesis. As the matching process succeeds, the hypothesis grows up. Generally, possible correspondence of variables is not unique. So the other hypotheses containing the other correspondences of variables are set up at the same time. According to the result of matching, it outputs its judgement, "perfect match", "partial match" or "no match" based on the most plausible hypothesis. "Partial match" means that a learner's program doesn't match with a standard algorithm perfectly, but both the ratio of matched statements to the whole in the learner's program and the ratio of matched statements to the whole in the standard algorithm are higher than each threshold we defined.

3. Improvement of processing time

In order to reduce processing time, we should re-consider a method of matching programs. The system outputs the result of judgement on the basis of the most plausible hypothesis. The others are rejected. So if the system has an ability to find useless hypotheses on the way during matching process and avoid checking the correspondence of statements on the basis of the useless hypotheses, processing time must decrease.

So we extend the matching method as follows:

1) When the system intends to make new hypothesis containing correspondence of a new combination of statements in a learner's program and a standard algorithm, it calculates the ratio of matched statements to the whole under the assumption that all of the following statements will be matched perfectly. If the ratio cannot reach the threshold, the system doesn't make the hypothesis and omits the process of matching the following statements based on the hypothesis.

2) After the system has matched whole statements on the basis of a certain hypothesis, it tries to match statements on the basis of another hypothesis. In such a case, when the system finds that the ratio of matched statements to the whole cannot reach the ratio of previous trial, under the similar assumption to 1), it stops matching the following statements.

As a result, processing time is improved without spoiling the accuracy of matching. We confirm that evaluation of programs is not changed by the extension. Table 1 shows improvement of processing time necessary to judge the programs. Exercise (1), (2) and (3) are illustrated in Table 2. The computer system used for both experiments before and after the extension is an Engineering Workstation JU2/2300 (CPU: Ultra SPARC-II (300MHz) * 2, SPECint95: 12.3, SPECfp95: 20.2, Operating System: SunOS5.6, Made by: Japan Computer Corp.).

Table 1: Improvement of processing time.

	Number of programs	Average time of processing [sec/program]	
		Before extension	After extension
Exercise(1)	42	184.98	1.57
Exercise(2)	56	1.43	0.13
Exercise(3)	49	109.06	1.10

4. Applicability of our system to actual education environment

In order to discuss applicability of our system to actual scene in education, we design a model novice programming course based on actual courses in our university[5]. The exercises in the course are seen in Table 2. We use programs submitted by learners in the actual courses of our university.

We write each standard algorithm of exercise within the following restriction: the number of steps of

Extended PAD must be less than twice the number of steps of a standard program for corresponding exercise. The reason is that teachers don't prefer writing more detailed standard algorithms because of their costs.

The computer system used for this experiment is also the Engineering Workstation JU2/2300.

Table 2: The exercises in the model course.

Exercise(1)	There are several birds and tortoises. Find the number of them when the following conditions are given: (1) Sum of the heads of birds and tortoises. (2) Sum of the legs of birds and tortoises.
Exercise(2)	A character datum that is an uppercase character will be input by user. Convert it to lowercase.
Exercise(3)	A hexadecimal number will be input by user as two digits of character datum "0-9" or "A-F". Convert it to a decimal number.
Exercise(4)	Solve an equation "ax^3+bx^2+cx+d=0" by using the Newton method.
Exercise(5)	Sort integer data in an array by using the straight selection sort algorithm.
Exercise(6)	Solve simultaneous equations by using the Gaussian elimination.

4.1 Result of experiment

In order to evaluate processing time, we must consider the following factors: program size of standard algorithms and one of learners' programs, arbitrariness of *teacher's intentions*, judgement of learners' programs. Therefore we examine the relation among these factors and processing time. Table 3 shows:

- Program size of a standard algorithm and arbitrariness of *teacher's intention*.
- The number of learners' programs and average of their program size.
- Judgement of learners' programs, and the average processing time.

We measure the program size by the number of statements, blocks and variables, and the arbitrariness by the number of alternative structures and non-ordering structures including a standard algorithm. The judgement means the number of learners' programs that are judged "perfect match", "partial match" and "no match" by our system.

As program size increases, the number of combination of statements in a learner's program with the statements in a standard algorithm also increases. At the worst case, the number of the combination increases proportionally to factorial of number of the statements. However Table 3 shows gentler increasing. From the result, we think our extended matching method works well. Exercise (4) needs rather long processing time. We think that the number of statement per block is larger than the other exercises, and most of statements in the block have dependencies, i.e. a variable assigned some value by an assignment statement is often referred in the following statements in the same block. In such a case, the system must compound formulas and the process of compound needs rather long time. However, we check how often such an exercise appears in actual textbook[3] for novice programming and find that only one exercise.

Table 3: Relation among program size, arbitrariness of standard algorithm and processing time.

	Standard algorithm					Learners' programs				Judgement of Learners' programs			Processing time	
	Number of:					Average of:				Number of:			[sec/program]	
	State-ments	Blocks	Vari-ables	Alter-native	Non-ordering	Pro-grams	State-ments	Blocks	Vari-ables	Perfect match	Partial match	No match		
(1)	5	1	4	0	0	42	9.2	9.1	1.4	0	4	38	0.96	
(2)	4	1	2	0	0	56	9.3	2.1	3.1	3	17	36	0.30	
(3)	11	5	4	0	0	49	19.7	7.7	5.9	0	0	49	1.50	
(4)	9	4	5	0	0	14	9.9	2.0	6.6	7	1	6	6.23	
(5)	10	4	5	0	0	14	9.8	4.0	5.1	1	10	3	0.30	(*,#)
	10	4	5	1	0	14	9.8	4.0	5.1	1	10	3	0.31	(*)
	10	4	5	2	0	14	9.8	4.0	5.1	1	10	3	0.43	(*)
	10	4	5	3	0	14	9.8	4.0	5.1	1	10	3	0.44	(*)
	10	4	5	0	1	14	9.8	4.0	5.1	1	10	3	0.35	(#)
	10	4	5	0	2	14	9.8	4.0	5.1	2	9	3	0.52	(#)
(6)	28	12	11	0	0	24	27.3	11.8	11.0	1	11	12	9.87	(*)
	28	12	11	11	0	24	27.3	11.8	11.0	1	11	12	31.00	(*)

We evaluate our system on another standpoint. As arbitrariness of *teacher's intention* increases, possible combinations of statements in a learner's program with the statements in a standard algorithm also increase. We prepare some standard algorithms for the exercise (5) and (6), and process actual programs of learners. The result is seen in the lines with (*) and (#) in Table 3.

We prepare a standard algorithm including three alternative structures representing two methods to achieve a goal. At the worst case, the number of combination of statements in a learner's program with the statements in the standard algorithm increases 8 (=2^3) times. However Table 3 shows 1.5 times increasing. We also measure processing time by using a standard algorithm of exercise (6) including 11 alternative structures representing two methods. Although it seems that processing time increases 2048 (=2^11) times, Table 3 shows only 3 times increasing. Similarly, on exercise (5), we prepare a sample of Extended PAD including 2 non-ordering structures

representing arbitrariness on the order between two tasks. In this case, it seems that processing time increases 4 (=(2!)^2) times. However Table 3 shows 1.8 times increasing. We think that the reason why the processing time isn't so increased is that our extended matching method works well. When our system evaluates using standard algorithms that include alternative structures or non-ordering structures, useless hypotheses are rejected at earlier stage of matching process.

In the next section, considering the result shown in Table 3, we discuss applicability of our matching method to actual education.

4.2 Estimation of processing time for actual exercises in novice programming

We survey model programs in a textbook[3], and write standard algorithms considering alternative coding methods or alternative order of statements. Then we investigate the program size, numbers of alternative structures and numbers of non-ordering structures. The result is seen in Table 4.

We can regard that our matching algorithm processes even programs belonging to the most complicated class in actual education within practical processing time. The reasons are as follows:

- The number of statement in programs of high level is less than the exercise (6) on average. And the largest number of statement is equivalent to the exercise (6).
- The number of alternative structure is almost 4 for programs of middle or high level.
- The number of non-ordering structure is less than 2.
- Therefore we think that our system can evaluate the most complicated program in the textbook with processing time similar to exercise (6) (31.00s/program).
- In fact, if a teacher takes care of 100 students in a class, the time necessary to evaluate their programs by our system is only 50 minutes or so. We think this is practical enough.

Table 4: Program size of exercises in a standard textbook of novice programming.

Exercise		Number of programs	Number of statements	Alternative structures		Non-ordering structures
				Iteration	Others	
Basic level	(the four rules of arithmetic, etc.)	19	8.5	1.1	0.2	1.2
Middle level	(sorting, etc.)	34	17.9	4.0	0.5	1.1
High level	(searching trees, etc.)	14	20.9	3.5	0.3	1.1

5. Conclusions

In this paper, we extend our matching algorithm to improve the processing time. Through the examinations and the discussion about processing time, we confirm that our system can evaluate actual programs in novice programming in practical time. Now, we are constructing a graphical user interface for describing standard algorithm. We will evaluate usability of our system after constructing it.

Acknowledgements

This research was supported in part by Grant-in-Aid for Scientific Research (c)(11680216) from Japan Society for the Promotion of Science.

References

[1] Anne Adam & Jean-Pierre Laurent, "LAURA, A System to Debug Student Programs", Artificial Intelligence, Vol.15, pp.75-122, (1980).

[2] Haruki Ueno, "Integrated Intelligent Programming Environment for Learning Programming", IEICE Transactions on Information and Systems, Vol.E77-D, No.1, pp.68-79, (1994).

[3] Nobuo Yoneda, Teruo Hikita & Takafumi Sakurai, "Pascal Programming"(in Japanese), SAIENSU-SHA Co.,Ltd., (1991).

[4] Tatsuhiro Konishi, Akihiro Suyama & Yukihiro Itoh, "Evaluation of Novice Programs Based on Teacher's Intention", Proceedings of ICCE'95, Singapore, Dec. 5-8, pp.557-566, (1995).

[5] Yukihiro Itoh, Tatsuhiro Konishi & Hiroyuki Suzuki, "On Experimental Evaluation of an Educational System that Supports Teachers of Novice Programming", Proceedings of ICCE'98, Beijing, China, Oct. 14-17, Vol.2, pp.234-238, (1998).

Case-Based Evaluating Assistant of Novice Programs

Hiroyoshi Watanabe, Masayuki Arai and Shigeo Takei
School of Science and Engineering, Teikyo University
Toyosatodai Utsunomiya-shi Tochigi, 320-8551 Japan
E-mail: {hiro,arai,takei}@ics.teikyo-u.ac.jp

This paper presents a method of implementing an evaluating assistant system that supports teachers' evaluation work of students' programs using case-based reasoning. The target evaluation tasks are to judge whether a student's program satisfies the requirements of the given problem and to give advice for the student's program. The case-based evaluating assistant system compares a program submitted by a student with evaluation cases in the case-base. If some case matches the program, the system applies the judgment and advice on the case to the program. We implemented a case-based evaluating assistant system for novice programs written in an assembly language based on the proposed method. The implemented system was utilized for actual classes and the results showed that the system reduced the teachers' evaluation work drastically.

Keywords: **program evaluation, programming classes, supporting teachers, case-based reasoning.**

1 Introduction

This paper describes a method of supporting teachers' evaluation work of students' programs. In programming education, programming exercise courses play an important role, because writing programs is indispensable to learning programming. In programming exercise classes, however, the teacher's loads of evaluation tend to be very heavy because the teacher has to read so many programs and reports. We aim to implement a computer system as an evaluating assistant that supports the teachers' evaluation work.

There are two approaches to the evaluation of students' programs. The first one is to diagnose programs and give advice by knowledge-based program recognition [1]-[3]. Most of the systems based on the approach require a huge amount of knowledge on bugs, and it would be difficult to constitute the systems practically. The second approach is to support teachers' evaluation work [4]. This approach may not necessarily aim at automating the evaluation work. It aims at implementing practical systems by limiting computers' evaluation work. We took the second approach.

We consider the program evaluation work as collaboration between teachers and computer systems and propose an evaluating assistant model of programs. We also propose a framework of the case-based evaluating assistant system.

2 Target Task and Evaluating Assistant

2.1 Task of Program Evaluation

The target evaluation tasks of a student's program are the following two tasks: (1) the first task is judging whether a student's program satisfies requirements of the given problem. When teachers set problems, they have educational intentions about what students should learn, namely concepts, algorithms, instructions and so on. Teachers read students' programs to see whether the educational intentions are achieved. Therefore, teachers accept a student's program when the program satisfies requirements of the given problem. The first task is defined on the assumption that students have to submit their programs over and over until their

programs are accepted. (2) The second task is giving written advice. Teachers give advice to students whether they accept a program or not: teachers give advice about the reasons why the program is rejected, and advice about bettering the program even if the program is accepted.

2.2 Evaluating Assistant of Programs

Figure 1 illustrates an evaluating assistant in the electronic submission environment of programs. The evaluating assistant pre-evaluates submitted programs and a teacher can refer to the results when he or she evaluates the programs. If the teacher trusts the evaluating assistant, the results from the assistant can be sent to students directly. Such an evaluating assistant is expected to save a teacher a lot of time and energy.

The output of the evaluating assistant consists of evaluation results, their reasons and the degree of confidence. The evaluation results include the judgment of acceptability (accept or reject) and written advice. The degree of confidence is one of surely, probably or unknown. When the degree of confidence is unknown, evaluation results and their reasons are not given.

The evaluation results of the assistant are required to be always correct when the degree of confidence is surely. If so, the results of the assistant with surely confidence can be sent to students directly, in other words, teachers can trust the evaluating assistant.

The evaluating assistant should have the capability to learn. The final results of the teacher's evaluation are available for the learning. If the assistant is capable of learning, almost the same programs as ones which the assistant has evaluated incorrectly, are expected to be evaluated correctly in the future.

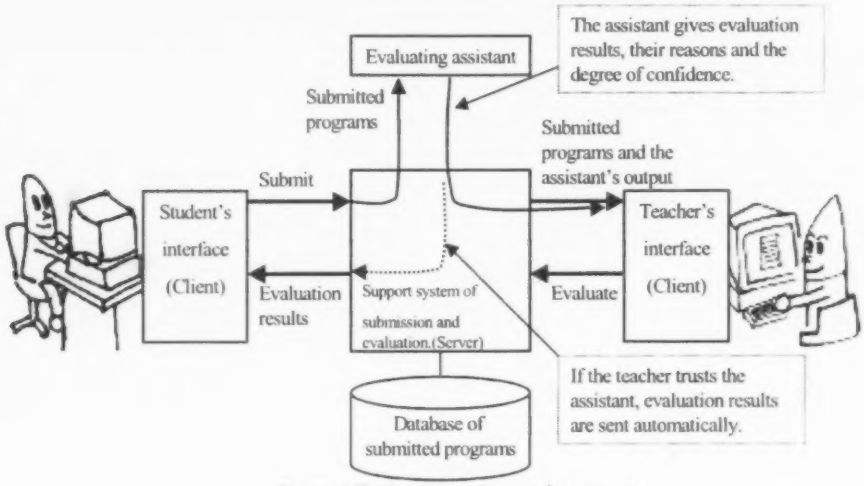


Figure 1 Evaluating assistant of programs

3 Case-based Evaluating Assistant

The case-based reasoning approach is one of the best approaches to implement an evaluating assistant described in Section 2.2. Case-based reasoning systems make use of stored past cases directly in solving newly presented problems [5]. The case-based evaluation of programs is defined as "if some evaluation case of a program whose implementation is the same as the newly given program, then the evaluation results on the case are applied to the given program".

3.1 Representation of Cases

A case for the case-based evaluating assistant consists of retrieval information, problem description, solution description and maintenance information.

(1) The retrieval information includes problem identification that the program is written for and features of the program. The features of the program depend on target programming languages. For example, numbers of if-statements, while-statements and other statements are available in the case of language C.
(2) The problem description in the domain of a program evaluation task is a program list itself. A program list should be represented as a normalized form [2], or a generalized form [6], because there are many variations of program lists for the same implementation.
(3) The solution description includes the judgment of acceptability and written advice.
(4) The maintenance information includes a teacher's name and the date of adding or updating the case.

3.2 Processes of Case-based Program Evaluation

The processes of case-based program evaluation are the following:
(1) Problem analysis: The retrieval information is extracted from a student's program list.
(2) Case retrieval: Cases are retrieved using information generated by analyzing a given program. Cases that have no possibility of matching the given program should be pruned here.
(3) Evaluating and selecting cases: Evaluating cases is the process of matching a given program against cases. The purpose of the process is to investigate whether the given program has the same implementation as the cases, or not. All candidates of cases are evaluated and the best match case is selected. The method of matching programs depends on the target programming languages.
(4) Applying and adapting cases: If there is a case that matches the given program, the judgment of acceptability on the case is applied to the given program. In addition, advice sentences on the case are available for the given program, although the sentences should be adapted for the given program. If no case matches the given program, the judgment and advice is not generated.

3.3 Case-base Maintenance

The maintenance of the case-base is performed using teacher's final evaluation results. One of the most important maintenance tasks is adding new cases when the evaluation results of the assistant are different from the teacher's. New cases are also added when the confidence of the evaluating assistant is not *surely*. More advanced maintenance, e.g., generalizing, specializing and forgetting cases [7], may be needed in order to refine the case-base.

4 The Evaluating Assistant System for Assembly Language Programs

Based on the proposed idea, we implemented a case-based evaluating assistant system for novice programs written in an assembly language [6]. The target assembly language is CASL which is adopted in examinations for information-technology engineers certified by the Japanese ministry of international trade and industry.

4.1 Implementations Depending on The Target Language

In this section, implementations depending on the target language CASL are described.
(1) Evaluating the program's action: Before the case-based program evaluation, the assistant system tests the action of a submitted program using prepared sample data. Only programs executed correctly are evaluated by case-based reasoning [6].
(2) Case representation: Although cases are represented in the form described in Section 3.1, no features except for a program ID are used for the retrieval information. A program list in a case is represented in CASL itself, or its generalized form that we defined [6].
(3) Case retrieval: The implemented system retrieves all cases whose problem ID is the same as a given program. That is to say, the system does not prune candidate cases.
(4) Case evaluation (program matching): The program matching process aims at making consistent correspondences of instructions, labels and registers between a case and a student's program [6]. If the following condition1 is met, the case matches the given program.

- **Condition 1**: All instructions of the case correspond to instructions of the given program, and all instructions that correspond to nothing do not affect to the program's action.
  Especially, if the following condition is satisfied, it is called a "perfect match":
- **Condition 2**: Instructions of the case and the given program correspond one-to-one and the differences of the order of corresponding instructions are trivial.

If the best match case meets condition2, *surely* is assigned as the degree of confidence. If the best match case meets condition1 but not condition2, *probably* is assigned. In the other cases, that is, when no case meets the condition 1, *unknown* is assigned.

4.2 Experimental Results

The implemented assistant system was utilized for actual classes of the CPU and assembly language course at our university in 1999. Seventy-three sophomore students in the department of computer science took this course. Problems presented in classes of the course are the following: (P1) select bigger of the two given integers, (P2) sum the given N integers, (P3) select the maximum of the given N integers, (P4) rotate N bits to the right and (P5) check the correspondence of "(" and ")".

Table 1summarizes results of using the assistant system. The following are found from Table 1:

- The values of (f) show that the implemented case-based assistant system achieves sufficiently high accuracy of judgments. Furthermore, the accuracy of the case-based assistant system satisfies the requirements described in Section 2.2, because it is a hundred percent in cases of *surely* confidence.
- The values of (g) show that the ratios of available advice without modifying are not as high as the accuracy of judgments, although it is fairly high.
- Because teachers do not need to evaluate the acceptability when the case-based assistant system outputs evaluation results with surely confidence, it is estimated that the system reduces the teachers' evaluation work by percentages shown as (h). In other words, by using the assistant system, the evaluation work of teachers is reduced by 60 to 90 percent depending on problems.

These results demonstrate that the case-based assistant system is very effectual in reducing teachers' evaluation work. Still, there is room for improvement in the capability to generate written advice.

Table 1 Evaluation data of the assistant system based on practical use in classes

	P1	P2	P3	P4	P5
(a)Cases saved in the case-base	15	10	29	34	38
(b)Submitted programs	119	119	140	156	157
(c)Programs rejected by checking their action	44	39	44	54	79
(d)Programs evaluated by the assistant system with *surely* confidence	62	72	72	67	46
(e)Programs evaluated by the assistant system with *probably* confidence	8	3	5	5	0
(f)Judgment accuracy of the assistant system (%)	100 (100)	100 (100)	97.4 (100)	100 (100)	100 (100)
(g)Ratio of available advice generated by the assistant system without modifying (%)	92.9 (100)	69.3 (72.2)	88.3 (90.3)	66.7 (64.2)	91.3 (91.3)
(h) $((d)/((b)-(c)))\times 100$ (%)	92.7	90.0	75.0	65.7	59.0

( ) : values for programs evaluated by the assistant system with *surely* confidence only.

5 Conclusions

We have proposed a concept of a program evaluation assistant and a method of implementing the assistant by case-based reasoning. Based on the method, we implemented a system for a simple assembly language CASL and used it in actual classes; the results demonstrated that the system reduced teachers' evaluation work drastically. We plan to improve the modification functions of advice sentences (written advice) and the method of the case-base maintenance. This research was supported in part by the Japanese Ministry of Education Grant No.11680400 and No.12780293.

References

[1] Adam,A. and Laurent,J.P., "LAURA, A System to Debug Student Programs, Artificial Intelligence", vol.15, pp.75-122 (1980).

[2] Johnson,W.L., "Understanding and Debugging Novice Programs", Artificial Intelligence, vol.41, pp.51-97 (1990).

[3] Ueno,H., "Concepts and Methodologies for Knowledge-Based Program Understanding — The ALPUS's Approach", IEICE Trans. Inf. & Syst., vol.E78-D, no.2, pp.1108-1117 (1995).
[4] Konishi,T., Suyama,A. and Itoh,Y., "Evaluation of Novice Programs Based on Teacher's Intention", Proc. of ICCE95, pp.557-566 (1995).
[5] Kolodner,J. ," Case-Based Reasoning", Morgan Kaufmann Publishers,Inc. (1993).
[6] Watanabe,H., Arai,M. and Takei,S. , "Automated Evaluation of Novice Programs Written in Assembly Language, Proc. of ICCE99, vol.2, pp. 165 - 168 (1999).
[7] Watanabe,H., Okuda,K. and Yamazaki,K., "Methods for Adapting Case-bases to Environments", IEICE Trans. Inf. & Syst., vol.E82-D, no.10, pp.1393 - 1400, (1999).

Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW

Jie Chi Yang* and Kanji Akahori**
**National Central University,*
38, Wu-Chuan Li, Chung-Li, Tao-Yuan, Taiwan 320
E-mail: yang@src.ncu.edu.tw
***Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan
E-mail: akahori@cradle.titech.ac.jp

This paper describes the development and evaluation of a Computer Assisted Language Learning (CALL) system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, cohesive expressions are used as cue words. The rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts is developed using Natural Language Processing (NLP) techniques. The main functions of the system are: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study. Furthermore, two evaluation experiments are conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the two experiments, respectively. The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning.

Keywords: **Computer Assisted Language Learning, Natural Language Processing, evaluation, technical Japanese texts**

1 Introduction

The aim of this research was to construct a Japanese learning environment for foreign students on the Internet. For students in science and technology universities, there is little time for enrolling in a regular Japanese language course, which involves spending a lot of time on experiments, studies and research, etc. The Internet environment is provided in almost all laboratories and can become an excellent virtual learning environment if there is a Japanese learning system which can be accessed on the Internet anytime and anywhere. The Internet has stimulated many new approaches to language instruction and learning, and it provides a great opportunity to learn one of the most important skills, writing. This is especially true for students in the science and engineering fields who need to write technical texts.

However, almost all CALL systems are concerned with learning how to improve one's reading and listening skills. Few systems are concerned with writing because of the difficulty of implementing an analysis of sentences typed by students who need to learn to phrase their own sentences freely without following any predefined rules. More and more researchers, therefore, use Natural Language Processing (NLP) techniques to analyze learners' typed sentence [9][16]. Recently, NLP techniques designed for use with CALL have attracted special attention (see, for example, [21][22], etc.), as this is expected to help improve writing skills.

Yang and Akahori [28][29] developed a Japanese writing CALL system using NLP techniques which can be used for learning and producing the Japanese passive voice on the WWW. Comparison of two Web-based CALL systems showed that the method of 'free input' and 'feedback corresponding to learners' typed sentence' is better than the method of 'multiple choice' and 'feedback that only displays the correct answer' [31]. Furthermore, an evaluation of the learning histories of the subjects who have actually used the system through the Internet shows that the system obtained a high degree of accuracy and instructional effectiveness [29]. These results demonstrate the effectiveness of the CALL system for writing using NLP techniques on the Internet.

Having sufficient vocabulary and grammatical knowledge is important when learning a foreign language. However, although vocabulary and grammatical rules are provided for correct sentence building in a foreign language, this knowledge alone is not enough. Being able to form correct sentences is by no means enough when it comes to expressing complex thoughts. The major problem for most foreigners learning Japanese is, apart from the writing system, the building of sentences: that is, knowing the corresponding words, the postfixes signaling the word's function (*de*, *ni*, etc.) and the position of the words (verbs final form). It is of paramount importance to learn how to structure one's thoughts: i.e., how to make an outline, how to signal the relative importance of a piece of information, and how it relates to the whole. Therefore, in order to write or to comprehend a structured sentence, it is necessary to learn how to associate sentences, in addition to having a good command of vocabulary and grammar. The connection between sentences can be described as conjunction of adjacent sentences, which is an important criterion for writing a good text as per research in *cohesion* or *discourse structure* [1][3][13][17][26]. Unfortunately, discourse structure is not amenable to single-sentence grammatical analysis, because there are no 'discourse grammars' [11].

Many methods concerning the analysis of discourse structure have been proposed in previous related works. Mann and Thompson's [18][19] rhetorical structure theory (RST) is an influential theory of text structure that is being extended to serve as a theoretical basis for computational text planning. RST postulates that a set of about 25 relations suffices to represent the relations that hold within normal English texts. Most relations have a cue word or phrase which informs the listener how to relate the adjacent clauses. RST can be applied to a computational model. There have been attempts at text generation using RST for the implementation of a prototype of the theory [10][20]. Cue words are also widely used in the identification of rhetorical relations among portions of a text [8][15][24]. Hobbs claims that coherence in conversations and in texts can be partially characterized by a set of coherence relations, which are classified into four categories. Hovy [10] collected and taxonomized the discourse segment relations; this set of relations contains three taxonomies of approximately 120 relations. Hirschberg and Litman [7] also summarize the proposed meanings of items classed as cue words in six computational and linguistic treatments.

In most of these earlier works, emphasis was put on the knowledge that is necessary for recognizing discourse structure. The problem of inference based on that knowledge was also emphasized. However, this does not mean that knowledge can be constructed easily from information available on computers. Constructing common knowledge to implement a practical system is often beyond the capabilities of current NLP techniques. Kurohashi and Nagao [14] proposed an automatic method for detecting discourse structure by checking surface information in text sentences. The information included 'clue expressions', 'occurrence of identical/synonymous words/phrases', and 'similarity between two sentences'. Their result indicates that, in the case of technical Japanese texts, considerable portions of discourse structure can be identified by incorporating the three types of surface information.

Since there are few practical CALL systems that use discourse analysis, the purpose of this study is to develop such a system for helping learners to write technical Japanese texts on the WWW. Section 2 describes the implementation of the system using NLP techniques. The authors took a similar approach to Kurohashi and Nagao [14], namely using surface information in texts. The rules for analyzing technical Japanese texts are based on micro-level (cohesive expressions) and macro-level (headlines) information. Section 3 describes the study that evaluates the effectiveness of the system in two experiments.

2 Implementation of the system

2.1 Method

The combination of cohesive expressions and headlines are employed in the implementation of the system. To examine discourse structure of technical Japanese texts, the classification of basic expressions by Yamazaki et al. [27] is adopted in this study. The reason for this is that their classification covers most of the

elements of technical Japanese texts. Based on their findings, the authors have classified cohesive expressions into 15 categories as follows: *comparison, contrast, analogy, cause and reason, basis, composition and enumeration, presentation, definition, classification, hypothesis and conditions, change of state, process of change, change with prerequisites, means and methods, selection*. The total number of expressions is 82. All of the expressions are converted into regular expressions to make the rules. In all, 654 distinctions in the regular expressions were extracted from the 15 categories of cohesive expressions. These formed 654 original rules, which are used in the process of analysis.

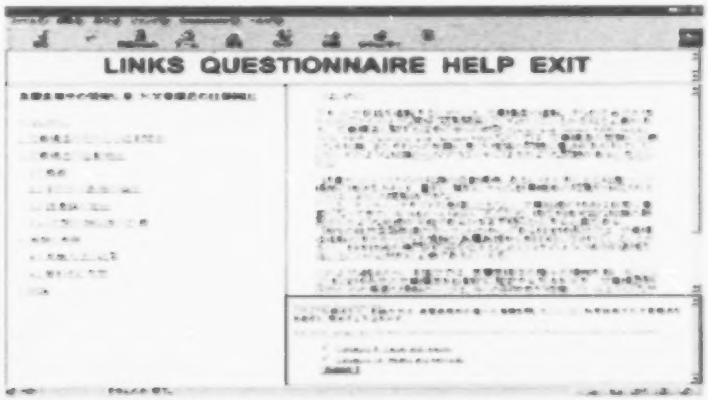
There are two patterns of rules: one is for 'simple pattern matching' and the other is for 'discourse analysis'. The former, called rule set A, is written as a regular expression form and the latter, called rule set B, is written as a regular expression combined with the result of morpheme analysis and syntax analysis. The rule in rule set B is written in a more restrictive form to improve the accuracy of discourse structure analysis. For example, if a sentence is applied to rule set A, it is then analyzed by the morpheme analysis and syntax analysis and the result will be matched to rule set B.

There are many text books on good writing, which nearly all contain a lot of material concerning the different kinds of categories or conceptual bricks at the discourse level out of which texts are built (see, for example, [4][5][6][12][25][26]. However, it is difficult to detect the text structure by just using their framework because it is too extensive and the varieties of different formats used by people for building technical texts too numerous. Instead of predefined framework, headline is used as macro-level information in this study. There are several reasons why the authors decided to use 'headline' instead. First, a well-chosen headline allows the reader to infer the text structure. Second, different formats of texts can be analyzed independently of the texts' style by using the headline. Third, it is easier to understand when the headline is displayed rather than a tree structure because the headline is a part of the original text.

2.2 The discourse structure analysis module

The discourse analysis module of the system contains 'simple pattern matching', 'morpheme analyzer', 'syntax analyzer', and 'discourse analyzer' components. First, the headlines are extracted and the Japanese texts are divided into sentences using several heuristic rules. Then all the sentences in all texts are matched with all the rules in the 'simple pattern matching' component. The 'rules for pattern matching' is used during the process of pattern matching. Because of the exclusive character of almost all of the rules, they are written in order of frequency to reduce the running time on the computer. The frequency of rules is made from the 'rules corpus'. The present system analyzes Japanese text sentences with the morpheme analyzer and syntax analyzer to check the dependency of sentences in the case grammar. Therefore, each cue word in the rules is not only matched against the word itself, but also against the 'parts-of-speech' of the cue word. Only sentences that match the rules written in restrictive form are needed for morpheme analysis and syntax analysis. This takes into consideration the problem of computer running time. The 'rules for discourse analysis' is matched again in restrictive form after the process of syntax analysis. The additional information (parts-of-speech, tense, etc.) is checked to identify the cohesive expressions, especially in the case where one sentence is matched with two or more rules.

Figure 1. One screen shot of discourse structure analysis



The learning page shows a list of technical Japanese texts. Learners can choose any one text by clicking the hyperlink on the list. When learners choose one of the texts from the list, headlines of the selected text are

BEST COPY AVAILABLE

analyzed and displayed first to help learners grasp the whole text structure. Secondly, learners can click on the headline of any part of the text that they want to read. Then the original sentences corresponding to the headline are displayed with the extracted cohesive expressions. The cue words in the cohesive expressions are displayed in color to enable learners to focus on it more easily. Learners can click on any cue words to further find out the cohesive expressions corresponding to the sentences. They can also refer to examples that correspond to the cohesive expressions from the 'examples corpus'. Figure 1 shows one screen shot of the system (text source: [14]). As shown in this figure, the headlines of the Japanese text are analyzed and displayed on the left side of the browser. The headlines show the structure of the text. On the right side, the original sentences corresponding to the selected headline are displayed on the upper part with the cohesive expressions extracted and a link made. When the cue word '*kotoniyori*' (in the first line of the third paragraph) is clicked, the matched cohesive expressions are displayed on the bottom right side of the browser.

2.3 System evaluation of the discourse structure analysis module

A system evaluation is conducted to evaluate the performance of the discourse structure analysis module on 24 technical Japanese texts. The system evaluation is designed for text analysis in two stages (pattern matching in Stage 1 and discourse analysis in Stage 2). The analysis consists of 3 items on both stages: *headline extraction*, *cohesive expression extraction* and *frequency of the rules*. The accuracy ratio of the headline extraction in Stage 1 is 95.22% on average. After a heuristic rule is added, the result of the headline extraction using the revised rules in Stage 2 gained an exceedingly high accuracy rate of 99.17%. The accuracy of the cohesive expression extraction in Stage 1 is 70.23% on average. On the other hand, the accuracy in Stage 2 improved to 92.70% on average. This result shows that using the rules combined with morpheme analysis and syntax analysis gained a higher degree of accuracy than only using the rules of simple pattern matching. After the cohesive expression extraction, the frequency of rules is calculated. The result of 'frequency of the rules' is saved to the 'rules corpus'. The order of frequency is taken as the order of the rules to reduce the running time on the computer.

2.4 The system for supporting technical Japanese texts writing

A CALL system is developed to help learners in the writing of technical Japanese texts. The system is implemented in terms of headlines and cohesive expressions, which is based on the method of the discourse structure analysis module. For headlines supporting, a connection between headline and texts corresponding to the headline is made automatically. Learners can click on any headline to immediately link to the content of texts corresponded to it. For cohesive expressions supporting, examples with the selected cohesive expressions are automatically extracted from the corpus of technical Japanese texts. Learners can refer to these examples to help them improve their writing skills.

The flow of the system is as follows:

(1) Learners register themselves to use the system. An ID number is given after registration. The ID number is used to identify the learner because a log of all learning histories is registered during the operation of the system.
(2) The page for headlines input is appeared. Learners can free input their headlines here. When learners completed their construction of headlines, each headline is automatically linked and displayed on the left side of the browser. The left side of Figure 2 shows an example of linked headlines.
(3) When learners choose one of the headlines, a text box is appeared on the top right side of the browser. Learners can compose their texts corresponded to the clicked headline in the text box. The top right side of Figure 2 shows an example of texts input.
(4) When learners click on the 'basic expressions' button on the bottom right side of the browser, the categories of cohesive expressions is appeared on a new page. Each category is classified further into sub-categories. When learners choose one of the sub-categories from the list, examples are automatically extracted from the corpus of technical Japanese texts and the result is displayed on the bottom of the browser. Figure 3 shows that examples are displayed corresponded to the selected sub-category of cohesive expressions.

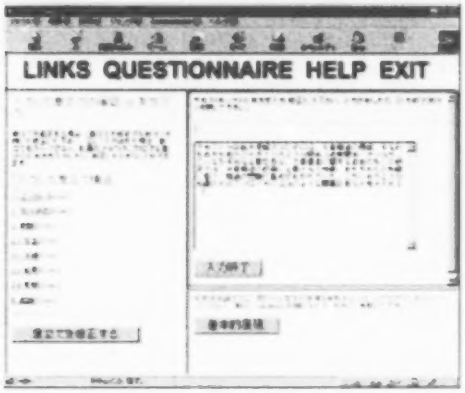


Figure 2. One screen shot of the linked headline and texts input

Figure 3. One screen shot of examples extracted from corpus

3 The study

Two evaluation experiments were conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the experiment 1 and the experiment 2, respectively. Thirty-three subjects participated in the experiment 1; the other seven subjects participated in the experiment 2. The subjects almost use the WWW and computer everyday.

3.1 Experiment 1

The purpose of the experiment 1 was to examine the functions of the system in terms of subjects' intuitive impression. Therefore, the experiment was designed to make a comparison between the system with the popular and well-known word processor: the MS-Word. During the experiment, the subjects were asked to look at the operation of the system and the MS-Word using video for duration of 10 minutes. The subjects were informed that they would be asked to fill in the questionnaire concerning the comparison of the two systems. The questionnaire consisted of 3 categories: *items of technical sentences writing*, *items of general sentences writing*, and *items of system operation*. The subjects were asked to rate 24 items on a 5-point scale. The subjects were also asked to make comments on the system.

Figure 4 shows the rating of the system and the MS-Word for each item with the 3 categories in experiment 1 and 2. The result of the experiment 1 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing. For those items of general sentences writing and system operation, the result shows that the MS-Word obtained a higher rating than the system or there was no significant difference on the two systems. However, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning').

Comments on the system are summarized as follows: Almost all of the subjects answered that it is necessary to involve the functions to access other objects, such as figures, tables and numerical expressions, etc. Since the system is emphasized on the discourse analysis of technical Japanese texts using NLP techniques, the target of the system is limited to 'texts'. However, figures, tables and numerical expressions are important components of technical texts. Therefore, development of such visual tools for supporting these objects is expected.

3.2 Experiment 2

The result of the experiment 1 suggests that the system is preferred to the MS-Word on technical texts writing. However, actual usage of the system is not evaluated. Therefore, in order to examine the effectiveness of the system in terms of actual usage of the system by foreign students, experiment 2 was conducted. During the experiment, the subjects were asked to compose a technical Japanese text using the system. The subjects were asked to write sentences concerning their specialization instead of a given task because a variety of subjects' different fields. After the composition is completed, the subjects were asked to fill in the questionnaire concerning the comparison of the system and the MS-Word. The questionnaire is identical to experiment 1, which is divided into 3 categories. Finally, the subjects were interviewed based on

BEST COPY AVAILABLE

their response to the questionnaires.

From Figure 4, the result of the experiment 2 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing, which is consistent with the result of experiment 1. For those items of general sentences writing and system operation, the result shows that the subjects preferred the system, or the MS-Word or there was no significant difference on the two systems. Comparing this result to experiment 1, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning'), which is consistent with the result of experiment 1. On the other hand, some items obtained different result between the two experiments. These items can be divided into 3 types: First, items 7 ('I want to recommend it to my friends') and 24 ('I want to use it more') are rated from 'no significant difference' to 'a higher rating to the system'. Second, item 2 ('It is friendly') is rated from 'a higher rating to the MS-Word' to 'no significant difference'. Third, item 11 ('It is easy to see') is rated from 'no significant difference' to 'a higher rating to the MS-Word'.

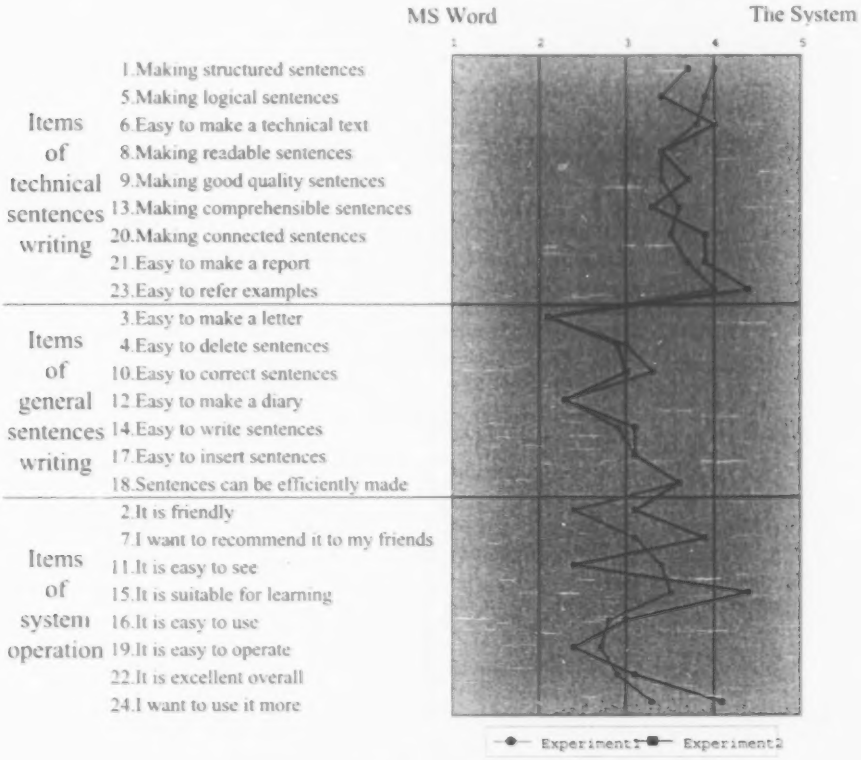


Figure 4. The rating for each item in Experiment 1 and 2

The subjects were asked to give reasons for their responses to the questionnaire items during the interview. The result of the interview concerning the functions of the system is divided into 4 types and summarized as follows: First, for automatically analyzing and displaying headlines, almost all of the subjects answered that it is very useful because they can click on any headline to immediately read the content of texts corresponded to it. The subjects also answered that headlines can be treated as an important role to help them to grasp the whole structure of the texts. Second, for automatically analyzing and displaying cohesive expressions, almost all of the subjects answered that it is very useful because they can find it is easier to convey their thoughts using explicit cohesive expressions. The subjects also answered that it is easy to find their errors because cohesive expressions in the texts are highlighted. Third, for referring to examples from corpus, almost all of the subjects answered that it is very efficient to writing because they can save a lot of time for finding examples from other references. The subjects also answered that they can imitate and learn more examples from the output of corpus. They can learn very much from the process of referring to examples in different texts, especially if there are many different usages in an expression. Fourth, for

Japanese language learning, almost all of the subjects answered that the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts. The subjects also answered that they can learn not only new cohesive expressions but also correct usages of cohesive expressions even they already know one of them.

Other comments on the system are summarized as follows: Almost all of the subjects answered that it is desired to improve the system to support the functions of electronic dictionary, thesaurus, grammar checking, etc. Therefore, construction of a good electronic dictionary for technical texts writing is considered as an important issue. Moreover, some subjects answered that it is better to extract examples form corpus according to learners' specialization than only random accessing to the corpus. From this result, constructing a corpus should not only consider the number of texts but also the balance of texts in each field.

4 Conclusion

In this paper, the authors describe the development and evaluation of a CALL system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, the rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts has been developed using NLP techniques. The system has the following functions: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study.

The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning. Based on the functions of the system, these results can be explained as follows: First, headlines can be treated as an important role to help learners to grasp the whole structure of the texts. Second, cohesive expressions often explicitly appear in the surface expressions of technical Japanese texts. Thus, it seems important and necessary to use these explicit cohesive expressions to structure one's thoughts in technical Japanese texts. Foreign learners especially may find it is easier to convey their thoughts using explicit cohesive expressions because these can be treated as an indicator of a discourse. Third, the corpus consists of the actual usage in technical Japanese texts from different fields. Instead of predefined examples, examples are automatically extracted from the corpus. Therefore, learners can learn very much from the process of referring to examples in different texts if there are many different usages in an expression. They can also save a lot of time for finding examples from other references.

In conclusion, the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts.

Acknowledgements

The authors would like to thank Dr. Kikuko Nishina (Professor in the International Student Center, Tokyo Institute of Technology) for her kind help during the analysis of technical Japanese texts. The authors would also like to thank Ms. Cheong Meng-Mei (Tokyo Institute of Technology) for her suggestions and comments on an earlier version of this paper. This study is funded by the Scientific Research Grant from the Ministry of Education of Japan (Subject No. B(2)10558019, Period: from 1 Apr 1998 to 31 Mar 2001).

References

[1]Chan, S.W.K. and T'sou, B.K. (1998). Analyzing Discourse Structure using Lexical Cohesion: A Connectionist Tool. In *Proceedings of the 1998 IEEE International Joint Conference on Neural Networks*, V1: 657-662.

[2]Hajicova, E. (1996). The information Structure of the Sentence and the Coherence of Discourse. In Hovy, E.H. and Scott, D.R. (Eds.), *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, 97-107. Berlin: Springer – Verlag.

[3]Halliday, M.A.K. and Hasan, R. (1976). *Cohesion in English*. London and New York: Longman.

[4]Hamada, M., Hirao, T. and Yui, K. (1997). *Paper Workbook for University/Foreign Student*. Tokyo: Kuroshio. [In Japanese.]

[5]Hayes, J.R. and Flower, L.S. (1980). Identifying the Organization of Writing Processes. In Gregg, L. and Steinberg, E. (Eds.), *Cognitive Processes in Writing: An Interdisciplinary Approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[6]Hayes, J.R. (1989). Writing as Problem Solving. In Hayes, J.R (Eds.), *The Complete Problem Solver*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[7]Hirschberg, J. and Litman, D. (1993). Empirical Studies on the Disambiguation of Cue Phrases. *Computational Linguistics*, 19(3), 501-530.

[8]Hobbs, J.R. (1979). Coherence and Coreference. *Cognitive Science*, 3: 67-90.

[9]Holland, V.M. and Kaplan, J.D. (1995). Natural Language Processing Techniques in Computer Assisted Language Learning: Status and Instructional Issues. *Instructional Science*, 23: 351-380.

[10]Hovy, E.H. (1993). Automated discourse generation using discourse structure relations. *Artificial Intelligence*, 63: 341-385.

[11]Hovy, E.H. and Scott, D.R. (Eds.) (1996). *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, Berlin: Springer – Verlag.

[12]Kinoshita, K. (1981). *The Techniques of Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[13]Kuno, S. (1978). *The Grammar of Discourse*. Tokyo: Daisyukan. [In Japanese.]

[14]Kurohashi, S. and Nagao, M. (1994). Automatic Detection of Discourse Structure by Checking Surface Information in Sentences. *Journal of Natural Language Processing*. 1(1): 3-20. [In Japanese.]

[15]Litman, D.J. (1994). Classifying Cue Phrases in Text and Speech Using Machine Learning. In *Proceedings of the Twelfth National Conference on Artificial Intelligence*, V1: 806-813.

[16]Loritz, D. (1992). Generalized Transition Network Parsing for Language Study: The GPARS System for English, Russian, Japanese and Chinese. *CALICO Journal*. 10(1): 5-22.

[17]Mann, W.C. (1984). Discourse Structures for Text Generation. In *Proceedings of the 10th COLING*. 367-375.

[18]Mann, W.C. and Thompson, S.A. (1987). Rhetorical Structure Theory: Description and Construction of Text Structures. In Kempen, G. (Eds.), *Natural Language Generation: New Results in Artificial Intelligence, Psychology and Linguistics*, 85-95. Dordrecht: Martinus Nijhoff Publishers.

[19]Mann, W.C. and Thompson, S.A. (1988). Rhetorical Structure Theory: Toward a Functional Theory of Text Organization, *Text*, 8(3): 243-281.

[20]Moore, J.D. and Paris, C. (1994). Planning Text for Advisory Dialogues: Capturing Intentional and Rhetorical Information. *Computational Linguistics*, 19(4), 651-694.

[21]Nagata, N. (1996). Computer vs. Workbook Instruction in Second Language Acquisition, *CALICO Journal*. 14(1): 53-75.

[22]Nerbonne, J., Dokter, D. and Smit, P. (1998). Morphological Processing and Computer-Assisted Language Learning, *CALL Journal*, 11(5): 543-559.

[23]Nishina, K. (1997). The Fundamental Research for the Development of Learning System of Technical Japanese. *Doctoral Dissertation*. Tokyo Institute of Technology, Tokyo. [In Japanese.]

[24]Reichman, R. (1985). *Getting Computers to Talk Like You and Me: Discourse Context, Focus, and Semantics*. The MIT press, Bradford Books.

[25]Shimizu, I. (1959). *The Manner of Japanese Writing*. Tokyo: Iwamani. [In Japanese.]

[26]Sugihara, K. (1994). *The Manner of English Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[27]Yamazaki, N., Tomita, Y., Hirabayashi, Y. and Hatano, Y. (199[illegible]). *Handbook of Technical Japanese*. Tokyo: Soutakusha. [In Japanese.]

[28]Yang, J.C. and Akahori, K. (1997). Development of Computer Assisted Language Learning System for Japanese Writing Using Natural Language Processing Techniques: A Study on Passive Voice, In *Proceedings of the 8th World Conference on Artificial Intelligence in Education (AI-ED97)*. 263-270.

[29]Yang, J.C. and Akahori, K. (1998a). Error Analysis in Japanese Writing and Its Implementation in a Computer Assisted Language Learning System on the World Wide Web. *CALICO Journal*, 15(1-3): 47-66.

[30]Yang, J.C. and Akahori, K. (1998b). A Discourse Structure Analysis of Technical Japanese Text. In *Proceedings of the Sixth International Conference on Computers in Education (ICCE98)*. Beijing, China. 643-650.

[31]Yang, J.C. and Akahori, K. (1999). An Evaluation of Japanese CALL Systems on the WWW Comparing a Freely Input Approach with Multiple Selection. *CALL Journal*, 12(1): 59-79.

[32]Yang, J.C. and Akahori, K. (2000). A Discourse Structure Analysis of Technical Japanese Texts and Its Implementation on the WWW. *CALL Journal*, 13(2): 119-14[illegible].

Development and Evaluation of a Mental Model Forming Support ITS

- the Qualitative Diagnosis Simulator for the SCS Operation Activity-

Toru Miwata, Tatsunori Matsui, Toshio Okamoto and Alexandra Cristea
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621
Fax: +81-424-89-6070
E-mail:matsui-t@ai.is.uec.ac.jp

In this study, we built an educational qualitative diagnosis simulator, which models SCS (Space Collaboration System: system the remote conferences and education via satellite communications) conferences. A student engages in the conference, by operating a control panel and proceeds by making the necessary selections according to the agenda of the virtual conference, and its intention and purpose, which can change at any time. The purpose of this study is supporting the student to form a correct mental model in this environment. Therefore, we incorporate an abstract model of possible computations as a logical circuit attached to the SCS system. Using this model, the system has two functions: to diagnose the student's conceptual understanding mistakes about the SCS system and to explain to him/her the cause of these mistakes. With these functions, we expect to be able to support the student in forming a correct mental model and in understanding the SCS essentials.

Keywords: **Mental Model, Space Collaboration System, Remote Conference**

1 Introduction

Recently, with the increased awareness of the necessity of individual, subjective learning, a change occurred in the building of computer based educational systems. The existing learning supporting systems are based on automatically generating the learning method, according to the relation between the state defining parameters and the subject's (learner's) behavior. However, in recent years, the trend to construct systems, that positively encourage the student to work, and allow him/her to change the current state parameters by him-/herself, offer system behavior simulation, moreover, verification and correction of the student inputs, emerged. In this type of subjective/ individual learning environment, it is necessary to add a causality explanation function of the target environment. This is important due to the fact that, by letting the student/ learner adjust and change the system parameters, and then showing him/her the system behavior simulation, as derived from the current configuration and structure, fundamental system comprehension can be supported and achieved [2..11]. We have, therefore, used the above mentioned specifications and background information, to implement an educational qualitative diagnosis simulator, for supporting fundamental system comprehension and understanding. For this purpose, we have based our mental model design on the object oriented approach. The mental model is a representation of the individual comprehension about the structure and functions of the objects involved in the simulated system model. Moreover, depending on the simulation of the object functions within the learner's mental model, it becomes possible to predict the problem solving act results. Therefore, important learning can occur and, at the same time, causality explanation within the virtual learning environment can be offered. We based the mental model used in our system on the qualitative modeling. The qualitative model is a fundamental model representation based on the causality relations that generate the target system's behavior. The causality relations are reflected in the relations between the system's structure, behavior and functions. Here we consider the following definitions. The **structure** reflects how the elements of the target organization are combined. The **behavior** shows how the system characteristics, expressed by the object structure, change in time. The **function** expresses how the goal, related to the object behavior, is achieved. By modeling the

causality relations between the system' s structure, behavior and functions, and designing a qualitative model, the causality relation simulation becomes possible. In our system, we have constructed a qualitative diagnosis simulator for conferences via SCS. SCS, standing for Space Collaboration System, is a remote conferences and distance education system via satellite communications. The learner/ student follows the progress of the conference, by operating a control panel, and making the necessary selections, according to the agenda of the virtual conference, and its intentions and purpose, which can change in time. In this environment, we integrate a computable model abstraction of the remote conference via communication satellites, as a logic circuit. Moreover, based on this abstraction, we add a causality explanation function, and a diagnosis system of the student' s/ learner' s operation mistakes, which generate the appropriate guidance information for the student. In this way, we support the fundamental comprehension of the SCS system.

2 Qualitative reasoning

Qualitative reasoning is one of the most vigorous areas in artificial intelligence. Over the past years, a body of methods have been developed for building and simulating qualitative models of physical systems (bathtubs, tea kettles, automobiles, the physiology of the body, chemical processing plants, control systems, electrical circuits, and the like) where knowledge of that system is incomplete. Qualitative models are more able than traditional models to express states of incomplete knowledge about continuous mechanisms. Qualitative simulation guarantees to find all possible behaviors consistent with the knowledge in the model. This expressive power and coverage are important in problem-solving for diagnosis, design, monitoring, and explanation. Qualititative simulation draws on a wide range of mathematical methods to keep a complete set of predictions tractable, including the use of partial quantitative information. Compositional modeling and component-connection methods for building qualitative models are also discussed in detail [1].

3 SCS

Figure 1 displays the SCS based remote conference concept. SCS was established as a satellite communication network between universities, to enable real-time remote video conferences. Each participant' s station (called VSAT station) is enabled with a satellite communication control panel, an image and sound transceiver control panel, multiple video-cameras, monitors, and so on.

3.1 SCS constrains and limitations

The SCS conference can take place as an inter-station, bi-directional communication between two stations, or as a multiple VSAT stations communication, where only one station has the role of the moderator, and has authority upon transmission control. In the latter case, all the other station, with the exception of the moderator station, are called client stations, and can participate as such in the conference. The moderator station is decided in advance, before the actual conference, by the conference organizer, according to the requested time-schedules and conference contents. The line control is usually under the sole authority of the moderator station. However, a client station can send a request for line usage for transmission to the moderator. This operation is enabled by the proposal request button existent on each VSAT station panel. By pushing this button, a proposal request notification is sent to the control panel on the moderator station. Moreover, during the conference, it is possible for two different stations to send image and sound, namely, the carrier, at the same time, so there can be up to two distinct proposing stations. The respective client stations are depicted in the lower part of figure 1.

The communication satellite has two reception parts, and a converting switch that allows the selection of the received carrier. Depending on the existing constrains and conditions, a decision mechanism is involved, before actually sending the carrier selection from the satellite. After verifying the current constrains and conditions, the carrier is sent from the satellite. This carrier is sent without exception to all client stations. In figure 1, the sending of the carrier to all the client stations is depicted. The station carriers depicted in figure 1 as a black solid arrows show the connection between the individual stations and the transmission part of the satellite. The figure shows also that the satellite receives only two carriers at a time. However as all stations are connected with the satellite, as depicted by the solid black arrows, all stations are prepared to send a carrier.

The satellite reception part is built of a receptor, and a converting switch. In this way, by means of the

restrictions set by the converting switch receptor, the satellite can receive, all in all, only two carriers. Moreover, these have to be from two distinct stations only. Also, in the case of multiple carrier reception, the moderator station operator can decide, according to his/ her free will, to commute to the receiving of one carrier only, disregarding the choices and modes of the client stations. These constrains, limitations and specifications, and the fact that the client stations can all in all send only two carriers, are depicted in the figure as dotted thick arrows. The two carriers that can be sent are named [send 1] and [send 2]. Their contents is re-sent from the satellite. The restriction that the two carriers, [send 1] and [send 2], should not come from the same station is enforced before this re-transmission. Only when al the above restrictions are fulfilled, can the received carriers be broadcasted from the satellite to all stations. At the reception of the broadcast signals, each client station can separate the two carriers, [send 1] and [send 2]. The station sending the carrier is also receiving the broadcast, without exception. Therefore, the sound and image received by the transmitting stations are:

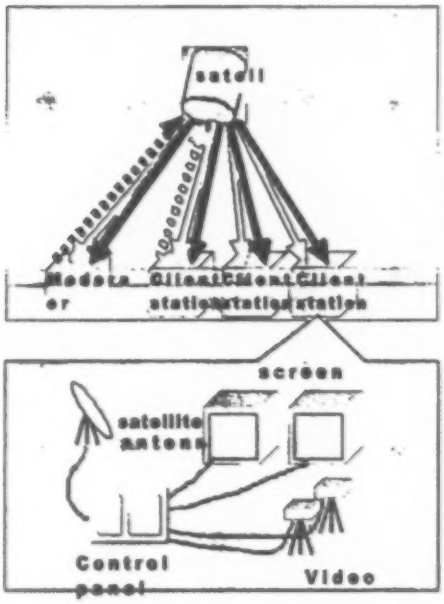


Fig. 1 Conference with SCS

(1) image+sound from the other transmitting station (if existent);
(2)the image and sound sent to the satellite by the station itself.

Moreover, as it is impossible to send the image and sound carrier to a specific station directly, by sending them to the satellite, they are broadcasted automatically to all stations. Bi-directional communication is also possible, but is actually a quasi-bi-directional communication, as the broadcast carrier of the two communicating stations is sent, at the same time, as a broadcast signal to all client stations.

3.2 SCS system frequent user errors

In table 1, the error types for different user skill levels of SCS conference practice, as gathered by surveying 4 domain specialists with over 2 years of SCS system operation experience, is shown. They were asked to give us first a list of frequently appearing user errors during the SCS usage and managing. This list is displayed in table 1 in the column headed by the label "Error/ misconception". Next, they were asked to evaluate the frequency of apparition of these errors for beginner, medium and advanced user. In table 1 their replies were represented as follows: [• •] means high, [• •] means medium, and [• •] means low frequency of errors. The table presents therefore the specialists' primary classification of errors according to the operation skills. To this classification, we have added a new error classification, based on the previously explained SCS system constrains and limitations. We have managed to group all errors enumerated by the specialists into four big classes of errors and misconceptions: A, B, C and D. The definitions of these classes are given below.

Table 1 Error types

Error/ misconception	beginner	medium	advanced	Error classification
Disregarding the function of the satellite• • believing direct/ dedicated transfer between fellow stations is possible.	• •	• •	• •	A,B,C, D
Believing that the sending of two carriers from the same station is possible.	• •	• •	• •	A
Believing that receiving two carriers from the same station is possible.	• •	• •	• •	A
Not understanding that, by switching the carrier to a different station, the current proposing	• •	• •	• •	B

BEST COPY AVAILABLE

station carrier will disappear.				
Believing that all stations can send a carrier at the same time.	. .	. .	. .	C
Not understanding the concept and necessity of the carrier request proposal.	. .	. .	. .	C
Assigning carriers to three or more stations.	. .	. .	. .	C
Not understanding why the image and sound signal sent by ones own station is received again.	. .	. .	. .	D
Believing that bi-directional communication is possible only with a specific station.	. .	. .	. .	D
Assigning the carrier to each	. .	. .	. .	D

station consecutively.				
Believing that only one broadcast is possible.	. .	. .	. .	D
Not making the distinction between the moderator station and the other client stations.	. .	. .	. .	static state
Believing that the client station is in charge of the transmission control.	. .	. .	. .	static state
Not making the distinction between the two wave forms (signals), [send 1] and [send2].	. .	. .	. .	static state
Believing that the [send 1] wave form is the signal coming from the moderator station.	. .	. .	. .	static state

Class A: Misconception/ incomplete information about the sending of two different waves/ signals with the help of the judgement/ decision mechanism.
Class B: Misconception about the sending of one carrier to one station with the help of the converting switch.
Class C: Misconception/ incomplete information about the receiving of two carriers.
Class D: Misconception/ incomplete information about broadcasting to all stations.

4 The SCS qualitative model

Figure 2 shows the qualitative model of the SCS conference abstraction, in the form of a logic circuit. This qualitative model can express the structure, behavior and functions of the SCS system. In this figure, we displayed four client stations and one communication satellite. As can be seen, the satellite has two receptors, and one judgment/ decision mechanism, as a converting XOR switch between the two receptors. The two client stations sending carriers at one time can therefore have a pseudo- bi-directional communication. The structure, behavior and functions, so, the objects of the original SCS system are expressed, in this way, as a qualitative model.

The characteristics of this model make it possible to simulate the dynamic changes occurring during a distance conference, allowing to decide and evaluate the proper parameter settings for each station, moreover, to simulate the system behavior in the case of mistaken parameter settings. By using the XOR function, it is ensured that each reception part of the communication satellite can receive only one carrier from only one station. This station has sent a prior transmission proposal to the moderator station, which was accepted.

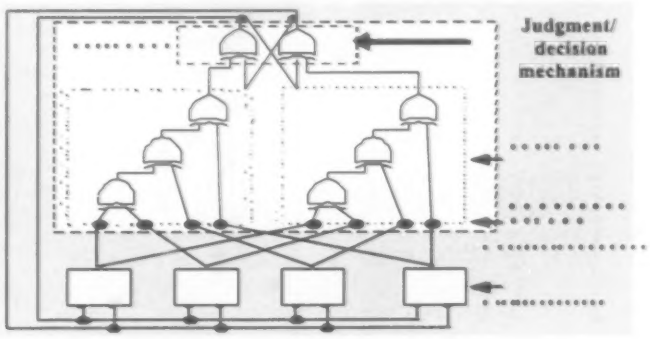


Fig 2 The qualitative model of the • • • system

BEST COPY AVAILABLE

Next, it is necessary to make sure that the two accepted carriers come from two distinct stations. This restriction is enforced by the judgment/ decision mechanism. The judgment/ decision mechanism eliminates via an extra XOR function the possibility that the two carriers were sent by the same station. If the two carriers, 1 and 2, are validated by the judgment/ decision mechanism, the communication satellite broadcasts one or both to all VSAT stations. Therefore, all VSAT stations will receive the two carriers 1 and 2 and will not be able to receive any other carriers from other stations, or any wrong transmissions. Moreover, by using this model it is possible to infer the error source, as shown previously, based on the SCS system structure. The previous A, B, C, D classification can be thought of as: (A) sending of two distinct waves by using the judgment/ decision mechanism, (B) sending of maximum one carrier per station by means of the converting switch, (C) using of two carriers by means of the satellite reception mechanism, (D) existence of broadcast type of transmission only. In this way, the virtual model enables the learner to derive the cause and source of the operation error, as related to the SCS system structure. Furthermore, we have presented here a model based on only 4 client stations, that is implemented via the XOR module, but as in the case of more than 4 client stations, we can increase the number of the reception part XOR modules, adapting them to the number of stations, we can express, cope with and model therefore the converting switch for any arbitrary, greater than 2 number of client stations.

5 Learning Environment

5.1 System outline and overview

Figure• •Learning environment

Figure 3 shows the overview of the system. The learner/ student is performing the conference steps by taking over the role of the moderator station operator. The goal is to cope with the dynamically changing agenda of the conference, proposed by the system. The agenda presents a description of a dynamic conference state, where bi-directional communication is required. The student can take decisions about the SCS system state and change parameter by operating the control panel. The previously described qualitative model evaluates these settings and parameters.

Next, disregarding if the parameter setup and assignment is appropriate or not, the result of the new user choices is reflected on the control panel of the interface, changing the current representation. The control panel displays also the transmission requests coming from other stations. The student has to choose the appropriate response to these requests. The student has to be able to judge the appropriateness of his/her own operations and actions, by interpreting the information presented on the control panel. By repeating the above steps, the student can learn the constrains and usage of the SCS system. Moreover, to prevent deadlock situations, where the student is unable to judge his/her own errors, due to misunderstandings regarding the SCS system constrains, an explanatory function was added. This is implemented via an explanation button, which can be pressed by the student in need. The student guidance follows as has been previously shown, conform with the SCS qualitative model. In this way, the student can achieve not just a quick, superficial understanding, but also a deep, structure related knowledge about the SCS system. For example, explanation are given such as: "There are only two

BEST COPY AVAILABLE

satellite receptors.", "There is an exclusive OR switch on each receptor, so each receptor can receive from one only station at a time.", "The judgment/ decision mechanism does not allow 2 carriers from the same station.", and so on. By leading the student to understand the connection between the parameter setup and the way the SCS system is actually built, as well as the real system components and the relations between them, via messages and state representations on the control panel, the student can be expected to perform the parameter setting by him/herself successfully in the future.

5.2 System flow

Figure 4 shows the system flow. The rapidly changing conference goal and intention of the agenda is described in chronological order. The contents of this description are on one hand, the conference state change requirements that have to be performed by the student, put into words that can be easily understood by him/her, and on the other hand, the description of the current SCS system state. In figure 4, this is expressed as [word] utterances, at the different moments in time (t0, ..,tn).

$$word : state(t0) \sim word : state(tn)$$

For example, [word] can be a prompting message about the conference state change, with the value of "Please reply to the question from university A!", and so on. As shown in figure 4, the operation panel managing module receives from the agenda, or from the other client stations the current parameter for each given conference state, and then reflects the resulting state on the panel. For example, the button of the station, which is currently in charge of a carrier, turns red. Also, in the case of requests from other stations, the button of the station sending the carrier request signal turns also red.

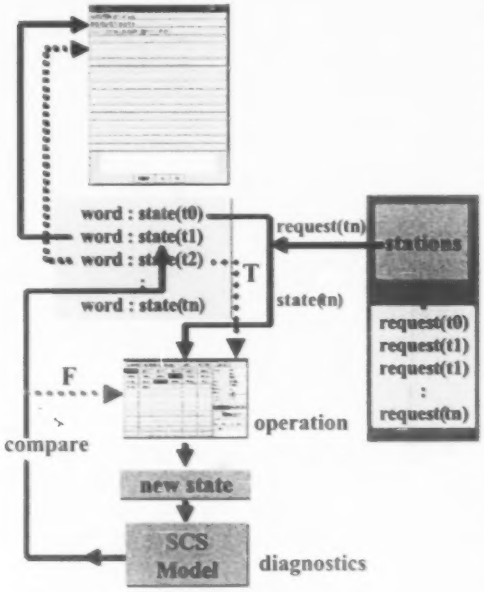


Figure 4 System flow

The student infers the present conference state from the state of the panel. Moreover, from here the student can notice if it is necessary to change the state of the conference, according to the agenda requirements. Next, to change the conference state, the student has to operate the control panel. By doing this, the parameters determining the conference are changed, and a new conference state emerges. This new state is evaluated with the SCS qualitative model. When evaluating with the SCS model, the result is compared with the next agenda. It is, in principle, possible to perform such comparisons on the SCS system without the computable module, and to judge if the operation is appropriate or not, but, in that case, the student cannot achieve a deep understanding of the SCS conference, that is, s/he cannot identify the SCS behavior as derived from structural constrains. In order for the learner to achieve a deep understanding, it is necessary to perform the parameter evaluation with the help of the SCS computable model. After the parameter evaluation, if the settings are judged as appropriate, the system moves to the next agenda. In figure 4, this is the case of "T" (True). In this case, the setup parameters decided by the student are handed over to the administrating module, which, in turn, reflects these changes on the operation panel. On the other hand, if, after the parameter evaluation, the settings are judged as not being appropriate, the system does not move to the next agenda. This case is shown in figure 4 as the "F" (False) case. In such a case, the wrongly set parameters are displayed on the operation panel. In this way, the deficient, real SCS state can be represented.

For example, in the case when three or more stations ask for the carrier at the same time, and the carrier is passed over to them, the moderator station's carrier disappears. The student notices that the respective state is not appropriate, and corrects the setup parameters. Moreover, in the case that s/he doesn't notice the errors, s/he cannot continue with the next agenda. When entering a deadlock situation, the SCS qualitative model can, at the student's request, explain to the student what kind of error s/he has done. In this way, by explaining not the protocol and process steps, but the SCS system behavior, as a result of the structural constrains, our system supports the formation of the SCS learner mental model. For instance, let us consider a case where the present transmission rights belong to universities B and C, and a proposal request is received from university A. This

request is represented on the panel by the button representing university A turning red, together with a simultaneous indication message appearing in the agenda window, stating "Please answer the question from university A". If the student decides to assign a carrier to university A, without previously modifying the state of one or both stations B and C, which have the current transmission rights, the result is that the system will have 3 or more simultaneous carriers at the same time. In this case, the system represents the buttons of universities A, B, C on the panel with red color, and lets the student therefore know that the parameter setup is not appropriate.

At the same time, the agenda window will also display a message for the student. The content of this message is something like: "There are only two receptors on the satellite.", so is an explanation of the behavior, as resulting from the structural constrains.

6 Agenda

Table 2 Agenda example

agenda(t0)	The conference starts.
agenda(t1)	The moderator station is the University of Electro-Communications.
agenda(t2)	Please allocate carrier • •to Yamagata University• •
agenda(t3)	Please start sending from the lecturer camera• •
request(t4)	Carrier request• •Tsukuba University• •
agenda(t4)	Please reply to the question from Tsukuba University• •
agenda(t5)	The conference has ended• •

The SCS conference is based on a general agenda. Our system offers SCS based remote conference simulation environment and, moreover, stores typical SCS agenda models, in order to dynamically produce conferences that require conference state changes.

In this way, the student becomes the operator of the moderator station, and has to take decisions compatible to the agenda, engaging therefore in the simulated steps of the SCS conference. In table 2 we show an example of a model agenda for our system. In this table, agenda(tn) represents the agenda at moment (tn) in time, and request(tn) represents the carrier request at moment (tn) in time. In the real SCS conference, the time moment concept exists, but, in our system, we have the supplementary restriction that, only after accomplishing the current agenda, it is possible to go on with the new one. As shown above, the agenda is organized as a time series, and the student receives indications and instructions from the agenda window. The changes occurring in the conference state in the respective agenda example above correspond to a respective intention and goal. Disregarding if these intentions and goals come from the original operator's decisions, or if they were prepared by the system from the beginning, the beginner student doesn't have to loose his/her way during the SCS conference proceedings, and can give the panel operation his/her undivided attention. In other words, the indications and instructions coming from the agenda window can be thought of as an experienced operator teaching the beginner student during the SCS conference proceedings. After receiving the indications and instructions from the agenda window, the student can decide on the next conference state that seems appropriate, given the present conference state and the indications received, and operates the control panel to perform the respective change. The new state that results as a consequence of the student's operations is checked by the system, to decode if it is appropriate or not, conform with the indications and instructions of the agenda. One agenda is recorded in the system as one word and 6 state descriptors. The words are the ones that appear in the agenda window. The six possible state descriptors are shown below.

• • *station name (list of all client stations)*
• • *carrier request (list of all client stations)*
• • *carrier 1 (list of all client stations)*
• • *carrier 2 (list of all client stations)*
• • *reception 1 (list of all client stations)*
• • *reception 2 (list of all client stations)*

The state descriptor called "station name" contains a list of all client station names. Next, the carrier request, carrier 1, carrier 2, reception 1 and reception 2 state descriptors contain respective lists of [on] and [off] states corresponding to each station. In figure 3, we show the correspondence between [1] and [0] and [on] and [off].
The reason of describing all client stations carrier and reception states with [off/on] descriptors is to be able to represent also the incomplete understanding of the learner/ student, as well as his/her mistaken parameter setups and assignments.

7 Testing, experiments and evaluation

BEST COPY AVAILABLE

Table 3 comparison of situation before and after learning takes

Error	Pre Test	Post Test	Error classification
Disregarding the function of the satellite and believing direct/ dedicated transfer between fellow stations is possible.	N/A	N/A	A,B,C,D
Believing that sending of 2 carriers from one station is possible.	3 persons	1 person	A
Believing that receiving two carriers from the same station is possible.	3 persons	1 person	A
Not understanding that, by switching the carrier to a different station, the current proposing station carrier will disappear.	5 persons	1 person	B
Believing that all stations can send a carrier at the same time.	3 persons	3 persons	C
Not understanding the concept and necessity of the carrier request proposal.	5 persons	1 person	C
Assigning carriers to more than three stations.	5 persons	1 person	C
Not understanding why the image and sound signal sent by ones own station is received again.	5 persons	3 persons	D
Believing that bi-directional communication is possible only with a specific station.	5 persons	1 person	D
Assigning the carrier to each station consecutively.	5 persons	1 person	D
Believing that only one broadcast is possible.	5 persons	5 persons	D

We have performed an evaluation experiment of our system over a small sample. 5 beginner students with no SCS system experience were selected as the object of our SCS conference experiment. We have first explained them the control panel representations, meanings and operation mode, as well as the agenda window functionality, and the SCS system setup as a bi-directional communication system. They were able to consult the SCS user manual. Next, we have done a pre-test with the system without the diagnosis mechanism, and followed and checked the operations and mistakes of the beginner operator. Then, we have performed the same experiment, this time, with the help of the diagnosis mechanism. In the last step, we have compared the understanding level before and after learning. The result is displayed in table 3. A system screen display during the experiment is shown in figure 3. This figure displays a student deadlock situation, where the student has asked for an explanation about the deadlock, and the system has next checked the SCS system structure related error cause, and finally displayed it on the screen for the student to see. In the case presented in figure 3, the student hasn't realized the fact that there are only two receptors on the satellite, and has mistakenly allocated carriers to 3 stations. The explanation of his/her error is displayed on the control panel. The state of 3 stations having the carrier is represented on the panel as the respective stations' buttons turning all red (left corner of fig. 3, darkened buttons). However, if the student doesn't grasp the meaning of the representation and the cause and source of his/her errors, and asks therefore the system for help, the system will display the following message: "There are only two receptors on the satellite". With this explanation, the student understands that, as there are only 2 receptors on the satellite, s/he cannot allocate carriers to 3 stations, and will operate the panel correctly in his/her next steps.

According to our system's result shown in table 3, the students can understand the SCS system: constrains and limitations, the fact that the signal has to be sent from different stations, the fact that there are only two carriers, and the concept of the XOR receptors of the satellite. However, the broadcasting mechanism was not completely understood. This is probably due to the fact that, in the current simulation system, there is no visual display of the broadcasting mechanism, of the time and direction of the transmission.

7 Conclusion

In this paper, we proposed an educational qualitative diagnosis simulator based on an object-oriented approach to mental model formation. In our model, the structure, behavior and functions of the SCS system are the objects, and from the description of the causality relations between these objects, the student can determine the cause of his/her error, based on system structure judgment.

BEST COPY AVAILABLE

From educational strategy point of view, QUAD implements and supports a combination of learning methods, like "Reinforcement learning", "Learning by exploring", "Learning by asking", "Learning by applying", "Self-monitoring", and so on. From educational depth point of view, the QUAD system doesn't stop at the procedural surface level, but traces the structural implications, to gain a deep knowledge level.

For further research, we believe that, by expanding the current system, and identifying more precisely the mental model of the student, a more appropriate guidance system can be developed.

References

[1] B. Kuipers; Qualitative Reasoning: Modeling and Simulation with Incomplete Knowledge, Cambridge, MA: MIT Press (1994).

[2] T. Okamoto• O. Matsuda; About the mental model of the ITS based geometrical/ topological proof process, Japanese Journal of Education and Technology,Vol.4, No.15, pp.167-182 (1992)

[3] O. Matsuda, T. Okamoto; based on hypothesis inference/ deduction : about the ITS - student model and its recognition method, IEICE conference, A, Vol. J75-A, No.2, pp.266-274 (1992)

[4] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Japanese Journal of Educational Technology 20(4), pp. 207-226, (1997)

[5] T. Nishida; The basis of qualitative inference/ deduction, Journal of the AI society, Vol.4,No.5,pp.522-527,(1989)

[6] T. Okamoto; Education, Media and Artificial Intelligence, Journal of the AI society, Vol.10,No.3,pp.361 – 367 (1995)

[7] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Journal of the AI society, Vol.20, No.4, pp.207 – 226 (1997)

[8] T. Nishida; The common sense thinking way model of qualitative inference/ deduction• •Journal of the AI society, Vol.2, No.1, pp.30 - 43,(1989)

[9] T. Nishida; Towards applications of the thinking ways and intelligent problem solving techniques of qualitative inference/ deduction• •Journal of the AI society, Vol.32, No.2, pp.105 • •117 (1991)

[10] T. Nishida; Aspects of qualitative inference/ deduction, Asakura publishers (1993)

[11] K. Asai, H. Ohnishi, K. Kondo, K. Tanaka, O. Matsuda; Case base and Collaboration Application based on appropriate• • ‹(control) and the Internet system, technical Report of IEICE, ET97-24 (1997-05)

Development of Intelligent Learning Support System with Large Knowledge Base

Katsuyuki SUGAYA and Setsuo OHSUGA
Department of Information and Computer Science, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, Tokyo 169-8555, JAPAN
E-mail: {sugaya, ohsuga}@ohsuga.info.waseda.ac.jp

The objective of this paper is to present framework for developing intelligent learning support system with large knowledge base. Recently, the need for effective learning support and training is mounting, especially in industry or engineering fields, which demand the learning of complex tasks and expertise knowledge. Intelligent learning support system is being employed for this purpose, thus creating a need for cost-effective means of developing learning support systems. In this study, intelligent learning support system is assumed as a part of the intelligent knowledge management support system. The factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, a new design of the system and learner modeling technique are discussed as well as a way of generating specific intelligent learning support system.

Keywords: **Intelligent System Design, Large Knowledge Base, Learner Model, Model-based Diagnosis, Knowledge Management**

1 Introduction

The purpose of this paper is to introduce a new framework for developing intelligent learning support system using large knowledge base. This system is a part of the intelligent systems that is developing to enable the expertise knowledge management.

In daily life, human has to interact with and reason about a large number of systems. This includes physical devices as well as non-physical systems. Also in professional work a growing number of people has to be trained in operating and designing large complex systems such as airplanes, nuclear power plants, and enterprises. Consequently, the goal of education or teaching may vary from inducing insight in the physical principles underlying the behavior of the device to teaching behavior analysis in the context of system design, operation, and maintenance. In addition, recently systems in the real world are becoming larger and more complicated. Rapid progress in science and technology has created a need for people who can solve complex problems and operate and maintain sophisticated equipment. In these situations, we, human beings, have to solve various types of problems using expertise in the large and complicated systems. Therefore the need for effective learning support or training is rising, given the increasing complexity of the workspace, especially in engineering or industrial fields.

Many computer assisted instruction techniques exist that can present instruction, and interact with students in a tutor-like fashion, individually, or in small groups [3]. The introduction of artificial intelligence technology and expert systems technology to computer assisted instruction systems gave rise to intelligent tutoring systems. In the intelligent tutoring system, for example, intelligent tutors that can model the learner's understanding of a topic and adapt the instruction accordingly [2]. Although intelligent tutoring systems research has been carried out for over 15 years, few tutoring systems have made the transition to the commercial market. Authors consider that some serious problems exist in the current methodology of developing intelligent tutoring systems. As an example, each system is developed independently, and tutoring expertise is hard-coded into individual systems. In particular, the problem of learner modeling technique exists as a basic issue. The system must have learner model that represents an estimate of the

learner current understanding of the domain knowledge to be used by tutor in order to give adaptive guidance and explanations to the learner. A number of learner modeling techniques have been developed [8]. However, not every model can be called complete expressing the learning condition of the learner. Hence, the motivation for this study comes from the need for effective intelligent tutoring systems, particularly development of more complete learner modeling technique.

For these problems like above we consider that the factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, authors present a new framework of the intelligent learning support system those enough practical conditions. Several concepts are included in this study; expert knowledge management with large knowledge base, knowledge sharing, knowledge processing, model-based learner diagnosis, etc.

2 Expert Knowledge Management using Knowledge Base System

In this section, we introduce briefly the key concept of our knowledge base system. Our research groups have tried to solve various problems by knowledge-centered intelligent system. The main concept is Multi-strata modelling scheme [5]. This modelling scheme is applied many intelligent systems, and these systems rewarded with good results, e.g. automatic programming system [1]. And we considered that Multi-strata model is strongly support the development of intelligent tutoring systems [6][7].

2.1 Intelligent System with Large Knowledge Base

At first, we discuss to apply large knowledge base for the architecture of intelligent learning support systems, which can generate learning support systems for a wide range of domain.

In these days, with the developing of science and technology, the systems which human manages with are enlarged and more complicated. In particular, it is too difficult to transmit expert knowledge from expert engineer to novice engineers. In the engineering field, even a large system developed by many expert engineers. When the system grows lager and more complex, the knowledge that is needed to build the system is more specialized and subdivided. In these situations, some serious problems are occurred. For instance, it is difficult to communicate between expert engineer and another fields' engineers or novice one. In other words, it is too more expertise to transmission of expert knowledge from human to humans. For this reason, the expert knowledge hiding is occurred in some engineering companies.

When the knowledge is specified and subdivided, in the situation like classroom, it is not appropriate to transmit the knowledge from expert engineer to novice one e.g. next generation engineers. Therefore, we propose the transmission of expert knowledge through the large knowledge base system (Fig.1).

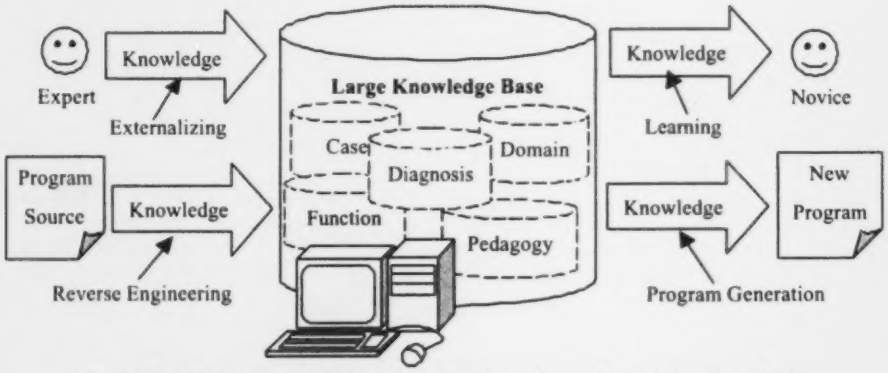


Fig.1: Knowledge Transmission using Intelligent Large Knowledge Base System

In this study, we consider that intelligent learning support system is a part of intelligent knowledge management support system. Moreover, we believe that knowledge management or learning support system is one of large and complex problem solving systems. The term problem is used here in a wide sense to mean what a person wishes to know or wants to do. There are various types of problems such as analysis,

design control, decision-making, planning, and teaching. Most of them are not well dealt with by conventional software method but require the system a capability to find a solution itself in a large space. Since the space is open, self-controlled exploration in the space is necessary. The system must be provided with the various methods to solve the different type of problems, each of which is represented by a specific knowledge chunk. Furthermore, a complex problem concerns different problem domains and since a problem requires domain specific knowledge, the system must be provided with a global knowledge base including the various type of domain knowledge.

In order to use knowledge effectively, the system must be able to extract only the necessary knowledge from the knowledge base referring to the type and the domain of the problem to be solved. For this purpose knowledge must be well structured. All used knowledge is accumulated in the large knowledge base (Fig. 1).

2.2 Necessity of Knowledge Processing Language

The whole of the problem solving process is from accepting external representation of problems to generating solutions. In order to represent problems in the system a processing language is necessary. The language has to meet two conditions: it has to be usable for representing problems; and it has to be processable by computer processor. In ordinary computers only the procedural language is used both for processing by the processor and for representing problems. The knowledge base system, on the other hand, introduces the second language to separate the above two aspects, as well as a conversion mechanism between them. The second language is a declarative knowledge representation language. The conversion either in the declarative forms or from the declarative to the procedural form is necessary. This is the inference. It can be implemented as a procedural program on conventional computers.

The specification for the second language must be decided so that it can represent these conditions. It had to be suited for representing predicate including data structure as argument and also for describing higher-level operation such as knowledge for selecting object knowledge. KAUS (Knowledge Acquisition and Utilization System) has been developed for the purpose by our research & development team.

3 Adaptability of Learning Support System

To meet the condition of adaptability, it is necessity to represent the learner's understanding of learning domain. In this section, we discuss a learner modeling method that is applied to diagnostic techniques in artificial intelligence.

3.1 Issues of Learner Model

The performance of intelligent learning support system depends largely on how well it knows why the learner fails to solve problems. Because of the sophisticated interaction requires information about the learner, the system has to maintain some kind of model of the learner. This model may include cases about what has been done before or information about what the learner is believed to know. The process of gathering information about the learner is mostly referred to as cognitive diagnosis. Ohlsson has given a widely accepted definition of cognitive diagnosis: "cognitive diagnosis is the process of inferring a person's cognitive state from his or her performance" [4]. We consider that the point of learner model is to represent knowledge state of learner, especially his/her fails to solve problem. To satisfy this requirement, we focus diagnosis techniques.

A diagnosis is defined in terms of one or more reasoning steps that the learner cannot have solved problem. A major advantage of this approach is that it can be based solely on a model of these correct reasoning steps; no knowledge is required about the specific misconceptions that learners may have about the domain of learning. Instead we model all primitive inferences that are required to arrive at the correct solution. In addition, our approach to diagnosis of learner behavior exploits results from model-based diagnosis as it is defined in the field of artificial intelligence.

3.2 Model-based Learner Diagnosis with Case Base

Model-based diagnosis is a prominent area within artificial intelligence and emerged in the last about 15 years. The technique of model-based reasoning has been widely researched and accepted as the principal

diagnosis in electronic circuit analysis, power station maintenance, medical diagnosis domains, etc. However, little emphasis has been put on its application to education or training system domain. The basic principle in model-based diagnosis is the description of system as a causal model. With the model at hand, the behavior predicated by the model is compared to the actually observed behavior. Since the predictions of the model are based on the assumption that the components work correctly, these assumptions may be partially dropped to accommodate for a detected behavior difference and thus diagnose faulty behavior.

However, there are some weaknesses in model-based diagnostic technique. The most serious weak point is the diagnosis time. It sometimes takes so much time to diagnosis. Therefore, we must be considering that it is necessary to model concerning the trade-off between the cost of a diagnosis time and its precision. Case-based reasoning, by contrast, excels in covering weak-theory domains, domains whose phenomena we do not yet understand well enough to record causality unambiguously. This feature allows case-based reasoning to be used in domains where model-based reasoning cannot be applied.

In the case-based reasoning, a reasoning engine remembers previous situations similar to the current one and uses them to help solve the new problem. However, case-based diagnostic technique has been criticized on many grounds. For example, that being specific to the system being diagnosed, they are non-constructive and that, having no analytic basis, the methods are restricted to specified faults and have a known level of competence. We think that the model-based diagnosis, being independent of the particular device descriptions, is intended to overcome these difficulties.

Therefore, we consider developing the approach of the model-based diagnosis system with case base. Model-based reasoning and case-based reasoning have the potential to complement each other quite well. However, no work has been done on specific issues of learner modeling using combine model-based reasoning with case-base. The outline of model-based learner diagnosis with case base is following. When the set of learner's behavior data input the diagnosis system, the diagnosis engine reasons the state of his/her knowledge consulting the diagnosis knowledge base include case base and object model base. The design of the model-based diagnosis system begins from describing the system as diagnosis object model. The system, which is a diagnosis object, is considered to be a set of domain models. The diagnosis object model that has knowledge of proper action, and the set of the behavior of learner as input value are given to a system. The first behavior of the system that received input is to seek whether there is a history about the same case in the case base. If the record to apply in the case is found, case base returns list of learner's knowledge, which should examine to diagnosis engine. Diagnosis engine does investigation about domain model of each record given to it, by comparing a simulation result in object model with the actual behavior of learner. Diagnosis process is finished if a trouble is recognized. When there was no record that complied with the input value in the case base, the process starts to use diagnosis domain object model. This domain object model has the hierarchical structure. A process begins from making the error model that one component in the extreme high class in the diagnosis object model is supposed to be out of order. The purpose of this process is to simulate using a made error model to examine whether the result of the simulation is the same as the behavior of learner. If there is no contradiction in the simulation result, the model-based reasoning is done again toward each domain knowledge model of the lower layer. In the same way, a diagnosis process is repeated until a trouble is recognized in knowledge component of the extreme lower layer. All process of diagnosis is knowledge processing by KAUS.

4 Discussion

The objective of this study was to develop a new intelligent learning support system, especially to focus two conditions; generality and adaptability. Authors in first propose the architecture of intelligent learning support system with large knowledge base to enough generality, which modeled by using multi-strata model. In second presented the model-based learner diagnosis to meet adaptability. All of the knowledge was represented by KAUS in intelligent learning support system that was assumed a part of the intelligent problem solving system. The issue of learner diagnosis is very important point to achieve adaptive instruction in intelligent learning support system. We proposed that fault diagnosis techniques be applied to infer the state of learner's knowledge. So we discussed the feature of diagnostic techniques, especially model-based reasoning with case base. Model-based reasoning appears to be a more promising technique than other knowledge-based methods because it can diagnose the faults that have not been pre-determined. Fails in learner's knowledge can be diagnosed automatically based on the models, which describe the correct behavior. However, because model-based approach reasons from the actual structure and function of knowledge, it is inefficient for some problems. Furthermore, obtaining domain models is sometimes either

difficult or too complicated, whereas most of the fails can be diagnosed based on past experience, which is very effective if the rule base or the case base is either comparatively small or well-indexed. A better solution is a hybrid approach integrating some of the diagnostic approaches. A case base will be provided to access the solutions to some fails diagnoses occurred previously, of which the domain models are unavailable. For some diagnoses, their solutions and contexts can also be stored in the case base for reuse later. Frequently occurring fails can be diagnosed efficiently even by a few of heuristic diagnostic rules. We believe that such a hybrid diagnostic approach will perform better than any of them does. In order to achieve this goal; we have considered the division of object model and problem type. On this part, it is necessary to carry out examination that will be more profound in future work.

References

[1] Aida, T. & Ohsuga, S., "Intelligent Systems Must Be Able to Make Programs Automatically for Assuring the Practicality", Lecture Note in Artificial Intelligence 1415, pp.47-56, (1998).

[2] Costa, E, New Directions for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1991).

[3] Mandl, H. & Lesgold, A., (eds.), Learning Issues for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1988).

[4] Ohlsson, S., "Some principles of intelligent tutoring", Instructional Science, Vol. 14, pp.293-326, (1986).

[5] Ohsuga,S., "Multi-Strata Modeling to Automate Problem Solving Including Human Activity", Proc.Sixth European-Japanese Seminar on Information Modeling and Knowledge Bases, (1996).

[6] Sugaya,K. & Ohsuga,S., "Design of Intelligent Education System using Multi-Strata Modeling Concept", Proc. The Sixth International Conference on Computers in Education, Vol.1, pp.305-311, (1998).

[7] Sugaya,K. & Ohsuga,S., "Framework for Developing Intelligent Tutoring System Using Multi-Strata Model", Advanced Research in Computers and Communications in Education, Vo.1, IOS Press, pp.832-835, (1999).

[8] Wenger,E., Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge, Morgan Kaufmann Publishers, Los Altos, California, (1987).

Educational Agents and the Social Construction of Knowledge: some issues and implications

Carolyn Dowling
Australian Catholic University
115 Victoria Parade, Fitzroy, Victoria 3065, AUSTRALIA
Phone: (61 + 3) 9241 4456
Fax: (61 + 3) 9241 4546
Email: c.dowling@patrick.acu.edu.au

The use of intelligent software agents within computer mediated learning environments is currently an important focus of research and development in both AI and educational contexts. Roles envisaged and implemented include those of tutor, of 'manager', of information seeker and of fellow learner. Each of these raises its own special challenges in relation both to the capabilities of the software and to our understandings in regard to the nature of the learning process. High on the list of factors currently believed to contribute to effective learning is social interaction in the service of knowledge construction. Within many electronic learning environments we are currently witnessing the emergence of a new participant in the social interactions that mediate learning. The substitution of computer programs possessed of varying degrees of intelligence, autonomy and 'personality', for certain dimensions of human presence within the computer based classroom raises a number of questions related to the processes through which knowledge is socially constructed, and to the qualities which are necessary to ensure successful participation in those processes. Through discussion of both theoretical perspectives and practical examples, this paper explores some of these issues.

Keywords: **AI in Education, Educational Agents, Intelligent Tutoring Systems, Interactive Learning Environments, Networked Social Learning, Teaching and Learning Process**

1 Introduction

Developments in computing and information technology in recent years have rapidly propelled the notion of intelligent software agents from concept to implementation. Today, whether or not we are always aware of them, they are an integral part of a growing number of computing environments. From the invisible armies of knowbots and related entities scurrying around the Net in the service of increasingly sophisticated search engines to the cheery little characters who pop up on our screens offering assistance with anything from formatting a date to constructing a complex multimedia presentation, or the 'personalities' with whom we interact in chat rooms in happy ignorance of their purely digital nature, intelligent agents are alive and well and are multiplying rapidly.

An early but still useful conception of a software agent is, "A character, enacted by the computer, who acts on behalf of the user in a virtual environment", useful in mediating " ... a relationship between the labyrinthine precision of computers and the fuzzy complexity of man [10, p. 355]. Later definitions tend to be expressed in more functional terms, such as, "An agent can be viewed as an object which has a goal and autonomously solves problems through interaction, such as collaboration, competition, negotiation and so on" [9]. This definition has some similarities with that offered by Maes [12] who defines an agent as:

"A computational system which:

- is long lived;

- has goals, sensors and effectors;
- decides autonomously which actions to take in the current situation to maximize progress towards its (time-varying) goals" [12, slide 5].

Summarising the writings of a number of researchers, Aroyo and Kommers [1, p. 237] identify four major characteristics of agents as being autonomy, responsiveness or reactiveness, pro-activeness and social ability. Other qualities frequently proposed, but not supported by all researchers or indeed by all users, include the ability to learn from experience and consequently to respond in flexible and possibly unforeseen ways to particular situations, and the possession of a believable 'character' or personality as a basis for social interaction.

It appears that a combination of factors has contributed to the current proliferation of software agents. Apart from the technical developments which have opened up the possibility of implementing what were previously largely theoretical conceptions, there is our very real need for assistance as we operate within computing environments characterised by rapid change, large quantities of extraordinarily complex information, and a lack of common organisational structures through which information may be accessed and managed. As Laurel predicted, there are now many situations in which, in the interests of efficiency, some form of 'intelligent' mediation is required between computer systems and the needs of users.

There are, of course, different forms that this mediation could have taken. The strong propensity for most users to accept assistance in the form of a more or less personified entity as largely unproblematic undoubtedly derives at least in part from the anthropomorphic elements implicit in most computer interfaces from the earliest days of computing. It can be strongly argued that a degree of personification has always been automatically and inevitably conferred as much by a program's use of language as a component of the interface as by our everyday understandings of the 'intelligence', albeit artificial, of computers. Intelligence and language use are, after all, key defining attributes of human beings.

Not only are we accustomed to interacting with computers as though they share with us a degree of 'humanity', but in a number of areas of activity we have been persuaded to value 'social' interaction particularly highly. Education is a good example, given the extent to which our current understandings of learning depend upon an acceptance of the belief that knowledge is to a large extent socially constructed. In the current drive to move teaching and learning online, the notion of agency in computing has found a strong ally and a vehicle for expansion. Unless the social interactions that mediate learning in face to face environments can be shown to have a digital equivalent, proponents of online courses will be forever 'on the back foot', with their products being regarded by most educators as second best. While courses incorporating the communications facilities of the Internet certainly go a considerable way in promoting interactions of various types between teacher and student and also between student and student, the possibility of using software agents to create an illusion of interpersonal interaction so convincing as to achieve pedagogical outcomes equivalent to those deriving from a relationship with another human being is extremely enticing to the designers of electronic learning environments.

2 Some examples of socially interactive pedagogical agents

Johnson [7] has proposed the following definition the role of a pedagogical agent as distinct from those designed for other purposes:

> "Pedagogical agents are autonomous agents that support human learning, by interacting with students in the context of interactive learning environments. They extend and improve upon previous work on intelligent tutoring systems in a number of ways. They adapt their behaviour to the dynamic state of the learning environment, taking advantage of learning opportunities as they arise. They can support collaborative learning as well as individualized learning, because multiple students and agents can interact in a shared environment. Given a suitably rich user interface, pedagogical agents are capable of a wide spectrum of instructionally effective interactions with students, including multimodal dialog. Animated pedagogical agents can promote student motivation and engagement, and engender affective as well as cognitive responses" [7, p. 13].

This is a comprehensive and optimistic vision, incorporating a number of possible roles for software agents within educational environments. Types of agents currently implemented in projects around the world include record keepers, information seekers, testers, facilitators of collaboration, tutors or instructors, fellow learners, and tutees. Of special interest in regard to this paper are those that contribute to the overtly social

dimensions of the learning environment. The last three listed most clearly fulfil this criterion.

2.1 Agents as instructors

There is a sense in which perceptions of the role of computers in the learning process have come full circle. Early models of the role of 'computer as tutor' in the form of drill and practice style of instructional software, generally based on Skinnerian principles and incorporating very limited interaction between user and computer, have long been rejected by most educators in favour of a range of other more acceptable guises including that of a learning tool, an information source, and a learning 'space'. With the development of agent technologies, as Johnson suggests, new possibilities now exist for incorporating computers within the learning environment in a range of socially interactive roles, including that of 'tutor', through modes of interaction more in keeping with current pedagogical theory.

It is commonly asserted that the presence of computers in classrooms has itself played a part in modifying the image of the teacher as the 'sage on the stage' in favour of a more collaborative model. Not surprisingly, these changing concepts are well reflected in many implementations of 'agent as teacher'. As Solomos and Avouris [18] write, for instance:

> "The user mental model of the system should be based on the metaphor of the "invited professor" rather than the "knowing everything own tutor". ... Our first findings confirm the observation that today's users, accustomed to hypertext-like interaction, are more likely to accept this collaborative teaching metaphor, according to which their tutoring system is viewed as an intelligent hypertext browser, offering links to other tutoring systems with the right content and at the right time" [18, p. 259].

The increasingly popular concept of the teacher as a facilitator of learning is also reflected in such statements as: "Each student working on the project will have an agent, operating in the background, watching progress, measuring it against the plan, and taking remedial action when necessary" [19, p. 362].

2.2 Agents as fellow learners

A style of agent of special significance in the context of socially constructivist theories of learning is the 'fellow learner', which to differing degrees might be presumed to include all participants within the learning environment. If agents are to gain widespread acceptance in the field of education. this is an important area for research and development. Since the 1980s Chan [2, 3] and colleagues have been working on a range of models of socially interactive agents for learning environments, perhaps the best known being the 'learning companion' – a software entity having limited knowledge of the domain in question, conceptualised as a fellow learner with whom the student may collaborate and even disagree. As in real life, some of these learning companions may be better informed than the student in the relevant domain of knowledge, while others may know less. Perhaps not surprisingly, in learning environments for younger students, animals are a popular choice of persona for such agents, as in this example of a networked learning environment for Taiwanese high school students, as described by Chan:

> "The Dalmation is having the same performance as the student. ... Another animal companion is Dragon, like one of those animal companions in Mulan, a Disney cartoon of this summer. This dragon will "learn" (mainly rote learning) from the student and also from other students on the Net and so may know more than the student. At certain point it'll stop learning and come back to teach the student. In a way, Dragon is protecting the student" [3].

An interesting development of this concept is presented by Sheremetov and Nunez [16, p. 310], who describe the function of a 'monitor agent' as being to modify the role, behaviour or expertise of learning companions from that of strong group leader to a weaker companion or even a passive observer, depending on its interpretation of the degree of guidance required by the learner.

2.3 Agents as pupils

We are all familiar with the common wisdom that we learn through teaching others. At the school level, many educators have long been familiar with the concept of the computer as 'tutee' through the use of the Logo programming language, in which 'teaching the turtle' was a familiar metaphor for the activity of programming. More recently, a number of researchers have explored the translation of this concept into electronic learning contexts where agents exist to be 'taught' by the student user, as in the example from Chan quoted above. A further example is described by Ju [8] who writes of a computer based peer tutoring

system employing two categories of agent – an 'expert', and a 'learner':

> "... students become active learners who are guided to learn by teaching a computer. After the students watch how the computer expert solves a set of linear equations [the program] helps the human student act as a teacher in order to learn more about the subject matter. At this time, the computer plays the role of a student ..." [8, p. 559].

3 Some issues for consideration

3.1 Multiple agents

Most agent based systems utilise a number of agents, many of them capable of a complex range of interactions with the student, with one another, and increasingly with agents associated with other programs. Their individual purposes derive from theoretical analyses of the component tasks and activities that are included in the larger scale pedagogical interactions of human beings. As educators, and indeed as students, we may simultaneously enact a range of roles within the educational environment. The apparently unitary activity of 'teaching' involves such elements as demonstrating, guiding, telling, questioning, explaining, testing, motivating, criticising – even learning! Many researchers consider that the electronic medium makes it feasible to identify and separate out these diverse functions. These can then be enacted through different configurations of agents working in relationships which ranging from collaboration to competition.

An example is the Multiple Agent Tutoring System (MATS) described by Solomos and Avouris:

> " MATS is a prototype that models a "one student-many teachers" learning situation. Each MATS agent represents a tutor, capable of teaching a distinct subject. All MATS tutors are also capable of collaborating with each other for solving learning difficulties that their students may have" [18, p. 243].

Strategies for most efficaciously combining the activities of multiple agents such as these necessitate a complex agent architecture, and understandably occupy a great deal of the research agenda in this area. Of interest in relation to their participation in the social construction of knowledge is the fact that one of the most common metaphors employed by a number of researchers and courseware designers is that of a 'society' of agents, a conception reminiscent of Minsky's *The Society of Mind* [14], Gardner's multiple intelligences [6] and other related theories of cognition and behaviour. In describing the different aspects of the design of their "multi-agent, computer-based interactive environment", for example, Costa and Perkusich [4, p. 196], drawing on the work of Franklin and Graesser [5] refer to their aggregation of agents quite specifically as a 'society'.

> "The society [of artificial tutoring agents] is an open multi-agent system made up of a collection of tutoring agents that co-operate among themselves to promote the learning of a certain human learner. This society is designed to be open and dynamic in the sense that it allows maintenance operations such as the entry and the exit of agents, besides eventual modifications in the knowledge and in the inference mechanisms of an agent. Each agent defines an expert tutor in some domain, having the necessary knowledge to solve problems in this domain. These agents are cognitive and possess properties like autonomy, goal-oriented, social ability" [4, pp. 197-198].

While on the one hand, the variety of functions of agents within a multi-agent environment must also be appreciated as an attempt to realise the type of rich user interface which Johnson suggests is necessary if the pedagogical interactions within electronic learning environments are to approximate to any degree to the face to face educational experience, some educators have concerns in regard to the assumptions underlying these practices. They argue that such developments are underpinned by a reductionist rather than a holistic understanding of the processes and relationships involved in teaching and learning. In separating out the different components of pedagogical interactions, are we enabling each part to be realised more effectively, or are we failing to acknowledge that the global act of human teaching may in fact be more than the sum of its component parts? It seems reasonable to suggest that firm judgments on issues such as this must await greater experience of the roles of agents within these learning contexts.

3.2 Personification

Another focus of debate concerns the degree to which personification is helpful in fostering fruitful pedagogical interaction between the human learner and software agents. This question clearly relates more

to the 'socially interactive' agents than to those fulfilling more tool-like functions, which arguably require far less in the way of 'personality'. As noted earlier in this paper, there are clear arguments for accepting that a degree of personification of computer interfaces is inevitable. As Shirk puts it:

> "Although there is some dispute among software critics concerning the advisability of having 'personalities' in computer programs, their presence seems unavoidable. Any time there is communication between a computer and a human, the information presented by the computer has a certain style, diction, and tone of voice which impact upon the human's attitude and response toward the software" [17, p. 320].

However the extent to which this should be deliberately fostered is less clear, although many feel intuitively that it should be an important element in the creation of an electronic learning environment characterised by interactions which can reasonably be described as 'social'.

An important aspect of the representation of 'character' or personality is visual appearance. Interestingly, both research and experience suggest that the relationship in the case of software agents is far from straightforward, and that a mismatch between realism in appearance and the apparent knowledge level of the agent can have a deleterious effect on credibility. The more visually realistic the representation, the higher the expectations of the user in relation to the appropriateness and 'intelligence' of utterances and actions. Agents that 'look' smart and 'act' or 'talk' dumb are poorly received by many users, who express a higher tolerance for the limitations of a 'character' more sketchily represented, for instance through cartoon-like graphics. As Masterton, writes, for instance, "A common problem with AI programs that interact with humans is that they must present themselves in a way that reflects their ability. Where there is a conflict between the ability of the system and the users' perception of that ability a breakdown occurs and users may either fail to exploit its full potential or become frustrated with its shortcomings" [13, p. 215]. He goes on to suggest the implementation of a degree of anthropomorphism intended to convey qualities such as friendliness and usefulness, without the implication of possession of full human capabilities [13, p. 211]. He describes the development and role of such an entity in the form of a VTA (Virtual Teaching Assistant) which is able to introduce topics and answer simple questions, the more complex types of exposition and interaction being left to the human teacher. In terms of a traditional scenario at university level, the VTA functions somewhat like a tutor or demonstrator as distinct from a lecturer. "In this way faculty is left free of the guiding and assisting issues of the course and is able to concentrate on more complex questions and higher level issues generated during the course" [13, p. 211].

Further instances of this principle are the examples of agents presented as animals discussed earlier in this paper. Our expectations in regard the cognitive skills of animals may well be more appropriate to the capabilities of software agents than are our experiences of human-to-human interactions.

3.3 Autonomy

Closely related to the 'intelligence' of software agents is the issue of autonomy, in particular the degree to which an agent should be furnished with pre-existing goals which might lead it to take particular action without instruction from the user, and even contrary to what the user might perceive as his or her interests and wishes. Exploring the implications of such entities existing and interacting within virtual reality environments, Loeffler [11], for instance, notes that the unpredictability resulting from significant autonomy might well result in agents who are less 'helpful' to us than we might hope or indeed expect. It is easy to slip from such considerations into the need for a contemporary version of Asimov's laws of robotics as conceived in fictional terms more than 30 years ago!

In educational contexts, the implications of autonomy, particularly in terms of control of and responsibility towards the learner, are potentially extremely complex and difficult to address without more exposure to these types of software, and indeed it is quite likely that such experience may cause community understandings in regard to appropriate relationships between the 'human' and the 'not human' in electronic contexts to develop and change over time. In the short term, current trends in educational thinking which favour giving more control and autonomy to the learner would appear to be more in line with the thinking of researchers such as Schneiderman who favour 'direct manipulation' over the development of interactive agents with a significant degree of independence of action. Where agents are involved, they may be programmed so as to exercise control over the learner on behalf of the creator of the learning environment, or they may be configured so as to be more sensitive to a user model, and more responsive to instruction from the user/student. In the latter instance, the agent would have a greater degree of responsibility to the needs and wishes of the learner, but this may not be in keeping with the pedagogical goals of the teacher.

Trust is another aspect of the teacher/learner relationship that is complicated by the degree of autonomy with which a pedagogical agent is endowed. To the extent that the programmer chooses to delegate certain functions and responsibilities to the agent, it is their problem, but it may also be an issue for students, particularly those with more insight into the nature of the agents with which they are interacting.

A further concern in regard to the autonomy of pedagogical agents relates to the issue of intervention in the learning process. Despite the finding of Aroyo and Commers [1] that pro-activity is a quality frequently sought after in agents, there is an important issue of balance to be addressed in relation to the educational process. It is well accepted that a high degree of unsought assistance whether from a human teacher or an excessively diligent and proactive agent can be quite detrimental, in particular to the metacognitive aspects of learning. Of course this is also an issue for teachers and learners in face to face educational contexts!

3.4 Level of participation in the social construction of knowledge

The belief that it is possible for agents to participate effectively in the social aspects of knowledge construction is central to the work of many theorists and researchers. Sheremetov and Nunez [16], for example, whose works derives overtly from the theoretical frameworks of Piaget and Vygotsky, argue that:
"The design of learning environments, virtual or not, aims to promote productive interactions. In this type of learning a student changes from being a passive information receiver to an active collaborator, interacting with the tutors and colleagues in the learning process. Learning does not only result from acquiring knowledge, solving problems or using tools, but also from interacting about these on-going activities with persons and agents"[16, p.305 – 306].

In relation to their specific project they write: "Our emphasis lies in the role of interactions in an artificial learning community as a group of real and artificial learners, tutors, and facilitators, working, supporting and learning from each other [16, p. 306]. But however personified and autonomous the software agent, can it really be said to participate fully in the social construction of knowledge? It has been argued quite extensively that even the most heavily personified of computer programs suffer from an intrinsic lack of ability to participate in the metacognitive aspects of learning. Pufall [15], for instance, expresses a strong belief that a computer program is unable at any level commensurate with human capacities to modify its own knowledge structures or cognitive processes, and so cannot be regarded as a co-constructor of knowledge in a meaningful sense. While this might well have been the case in relation to earlier computer based learning environments, can we continue to make the same claims with confidence today or in the future? The capacity of software to 'learn' and adapt to experience through the incorporation of new information, the appropriate modification of its representation of the context in which it functions (its 'world') and of its inference mechanisms, is undoubtedly increasing. One way of considering this question might be to look at it in terms of the type of distinction sometimes made between 'hard' and 'soft' notions of artificial intelligence. If our test of full participation depends on an understanding that the agent has 'learnt' in precisely the same way that the human has learnt, then we will have difficulty accepting the electronic entity as genuine co-constructor of knowledge. If, however, we make our claim on the grounds that it appears to the human learner that the agent has participated in the learning that has taken place, then perhaps we can at least tentatively admit such a piece of software to membership of the social milieu which has mediated the educational experience.

Conclusions

It is clear that developments in agent technology have created a range of new possibilities in terms of aligning computers more strongly with prevailing educational theories and philosophies. In considering the many issues which might be raised in relation to the nature and roles of pedagogical agents, there are three overarching questions. Firstly, do agents have the potential to enhance learning, or do they threaten to undermine those aspects of the educational enterprise that we most value? Secondly, to what extent might they assist in the replication of the social dimensions of face to face learning within online environments? Thirdly, do they go further than this, and create new possibilities in regard to the social mediation of learning? To the extent that visions such as those of Johnson [7] are able to be realised, we may be faced one day with the need to re-evaluate our attitudes regarding the relative merits of a human teacher and an electronic entity designed specifically for educational purposes. But while the rhetoric of developers often suggests an ideal surpassing the sometimes imperfect realities of human-to-human pedagogical interactions, the 'jury' of online learners and of educators is still out.

References

[1] Aroyo, L & Kommers, P., "Preface – Intelligent Agents for Educational Computer-Aided Systems", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[2] Chan, T.-W., "Learning companion systems, social learning systems, and the global social learning club", Journal of AI in Education 7 (2) (1996).

[3] Chan, T.-W. (1998), "The past, present, and future of educational agents", http://www.apc.src.ncu.edu.tw/apc/ppt_chan.html (accessed on February 3, 2000).

[4] Costa, E.deB. & Perkusich, A., "Designing a Multi-Agent Interactive Learning Environment", in Proceedings of International Conference on Computers in Education (ICCE '97), Kuching, Sarawak, Malaysia, December 2 – 6, pp. 196 – 203, (1997).

[5] Franklin, S. & Graesser, A., "Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents", Proceedings of the Third International Workshop on Agent Theories, Architectures and Languages, Berlin: Springer-Verlag (1996).

[6] Gardner, H., "Frames of mind: the theory of multiple intelligences", New York: Basic Books (1983).

[7] Johnson, W.L., "Pedagogical Agents", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp.13 – 22, (1998).

[8] Ju, Y. (1998), 'Development and formative evaluation of a computer-based peer tutoring system', Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 559 – 566, (1998).

[9] Kinoshita, T. & Sugawara, K., "Agent oriented computing", Tokyo: Soft Research Center (1995).

[10] Laurel, B., "Interface agents: metaphors with character", in Laurel, B. (ed.) The Art of Human-Computer Interface Design, Reading, Massachusetts: Addison-Wesley (1990).

[11] Loeffler, C.E., "Artificial Life of Agents", Proceedings of the IFIP World Conference on IT Tools, Canberra, Australia, September 2 – 6, pp. 48 – 55, (1996).

[12] Maes, P., "Software Agents Tutorial", http://www.media.mit.edu/people/pattie/CHI97 (1997), (accessed on March 18, 2000).

[13] Masterton, S., "Computer support for learners using intelligent educational agents: the way forward", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 211 - 219, (1998).

[14] Minsky, M., "The Society of Mind", London: Picador/Heinemann, (1985).

[15] Pufall, P., "Function in Piaget's system: some notes for constructors of microworlds", in Forman, G. & Pufall, P. (eds) (1988), "Constructivism in the Computer Age", Hillsdale, New Jersey: Lawrence Erlbaum Associates, (1988).

[16] Sheremetov, L. & Nunez, G., "Multi-Agent Framework for Virtual Learning Spaces", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[17] Shirk, H.N., "Technical writers as computer scientists: the challenges of online documentation", in Barrett, E. (ed.), "Text, Context and Hypertext: writing with and for the computer", Cambridge, Massachusetts: MIT Press (1988).

[18] Solomos, K & Avouris, N. (1999), "Learning from Multiple Collaborating Intelligent Tutors: An Agent-Based Approach", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[19] Whatley, J., Staniford, G, Beer, M. &Scown, P. (1999), "Intelligent Agents to Support Students Working in Groups Online", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

Facilitating Examples Understanding through Explicit Questioning

Isaac P.W. Fung and R.H. Kemp
Institute of Information Sciences and Technology
Massey University
Palmerston North, New Zealand
Fax: +64-6-3502259
P.W.Fung@massey.ac.nz; R.Kemp@massey.ac.nz

This paper describes a novel approach for promoting understanding of examples through explicit questioning. Whether being asked by the teachers or self-motivated, studying worked examples is an indispensable step for learners to acquire domain knowledge. The issue is: how could students use examples in the most effective way? Research findings indicate that the utility value of examples among different groups of learners varies dramatically. Effective learners keep self-explaining the solution statements when studying the examples while less effective learners often take each step of the statements for granted. In order to facilitate better understanding of examples, we propose to question the students explicitly on the examples content in order to stimulate their self-explanations. This paper presents the underlying computer model for generating different categories of questions from specific examples. The questions are subsequently used by a case-questioner to test the students on what they have read.

Keywords: **Artificial Intelligence, Conceptual Graphs, Intelligent Tutoring Systems, Case-based Reasoning**

1 Introduction

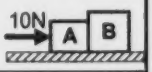
This paper presents a novel approach to facilitate the understanding of learning materials through explicit questioning. The notion we put forward in the paper forms one distinct feature of our current project: providing problem-solving advice in terms of relevant worked examples. When mapping out the project specification, there is an issue we are particular concerned with: to what extent the students benefit from the examples remains unknown. In her seminal work [2] Chi discovered the phenomenon of self-explanation among effective learners when they are presented with worked examples. Among this group of learners, they have a strong tendency to explain each example statement to themselves before moving on whereas the less effective learners tend to take the example statements for granted. In a follow-up investigation [3] Chi exploited her previous discovery in the context of learning. Not surprising, when students are deliberately prompted for self-explanation, they have shown a dramatic improvement in acquiring the knowledge. We believe the implication of Chi's study is very significant. Not only do the results shed light on understanding different learning behaviours, but the study also challenges instructors that merely informative examples do not guarantee good learning results. How the students use examples is a crucial factor in determining if they are really helping the students understand the subject domain.

As we are concerned with how the students use the examples presented, we decided not to take the present-and-go approach. Once a case (i.e. a relevant worked example) is retrieved for presentation, a case questioner will be automatically invoked to challenge the student's understanding on the knowledge embedded in the case. The questions generated are not explicitly stated in the problem statement. The rationale of this proposal involves encouraging the students to think more deeply while studying the worked examples. If the students have, in fact, understood the examples or related concepts within the domain, they should be able to answer the questions posed by the system. If not, the questions can trigger their attention towards certain aspects of the problem and stimulate their knowledge acquisition process.

2 Promoting Comprehension through Questioning

When studying worked examples, it is quite common for the students to take many solution statements for granted without trying to dig out the embedded tacit knowledge. Even if the students have the intention, they may lack the knowledge structure to find out the tacit knowledge. To put it simply, the student may know that it is helpful to self-explain the statements, but the problem is explaining what? There is research (e.g. [1], [4] and [7]) which indicates that questioning plays a significant role in understanding narrative text and therefore we argue that the same principle should also be applied in comprehending example solutions. If this argument is valid, one potentially pedagogically fruitful approach to tutoring in terms of providing examples is to question the learners on the content of the examples in a systematic way. Once the example is presented, the students will be asked questions driven by physical principles in order to detect what they know about the example and to help them discover meaningful relationships. To illustrate the argument, we consider the mechanics example shown in Figure 1.

Two blocks A & B are resting on a frictionless horizontal plane as shown. If an external force of 10N is acting on A, what is the acceleration of the blocks and the force of contact between them? (The masses of A and B are 3kg and 7kg respectively).



Solution :

$$\text{Net Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \quad \textit{(Applying Newton's 2nd Law on A\&B)}$$

$$\text{External Force}_{A\&B} = 10 = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$$

$$\text{Acceleration}_{A\&B} = (3 + 7)\ \text{Acceleration}_{A\&B} = 1\ \text{m/s}^2$$

$$\text{Net Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A} \quad \textit{(Applying Newton's 2nd Law on A)}$$

$$\text{External Force}_{A} + \text{Contact Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A} = 3 \times 1$$

$$10 + \text{Contact Force}_{A} = -7\text{N}$$

$$\text{Contact Force}_{A}$$

$$\text{Net Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B} \quad \textit{(Applying Newton's 2nd Law on B)}$$

$$\text{Contact Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B} = 7 \times 1$$

$$\text{Contact Force}_{B} = 7\ \text{N}$$

Figure 1: A typical Newtonian mechanics example and its solution

When presenting this example, the author must have already made many assumptions regarding the knowledge state of the reader. For instance, it will be assumed the reader knows that the weights of blocks are being cancelled by the reactions from the ground and thus the weights are not included in the calculation; the reader is also assumed to know that the acceleration of the whole system is the same as the acceleration of individual components; and that the external action on A is the same as the external action on the system as a whole in this case. However, these points may not have been mastered by some students. From the perspective of problem-solving, the solution presented is not the only way of tackling the problem. For instance, the contact force on B can be evaluated immediately by relating it to the contact force on A with which is formed an action-reaction pair. Alternatively, the problem can be tackled by solving three simultaneous linear equations with variables a, f_A and f_B which stand for the unknown physical quantities which are sought. This knowledge is not explicitly shown in the solution statements and the students whose self-explanation is less active may miss these knowledge units. Therefore, a fruitful tutorial dialogue can be created by conducting a series of question-answering episodes on the example presented.

3 A Taxonomy for Different Types of Questions

Before asking a question, the questioner must perform two steps: the first is to decide the *content of the enquiry*; and the second is to compose the *style of the queries*. To pose appropriate questions to the comprehender, the question designer must have a semantic category of questions. We have adapted the taxonomy for questions in narrative understanding originally developed in [8] into the context of physics problem-solving, and this is summarized below in Table 1. Note that except for question No.4, all the

questions are relevant to the example shown in Figure 1.

CATEGORY	SPECIFIC EXAMPLES IN THE DOMAIN OF PHYSICS
1. Verification	*Is the system in equilibrium?*
2. Disjunctive	*Is force a vector or a scalar?*
3. Concept Completion	*What is FORCE?*
4. Feature Specification	*What does a convex lens look like?*
5. Quantification	*How many external forces are acting on block A?*
6. Causal Antecedent	*What caused the blocks to accelerate?*
7. Causal Consequence	*What are the consequences of the external force acting on the blocks?*
8. Goal Orientation	*In the 4th line of the solution, why are the masses of A and B summed?*
9. Enablement	*The blocks have weights; what is needed to prevent them from moving downward?*
10. Instrumental/ Procedural	*How was the acceleration of the blocks evaluated?*
11. Expectational	*What will be the magnitude of the contact force acting on A, if the mass of B is increased but the external action remains unchanged?*
12. Judgmental	*Do you think the solution presented is the only possible method?*

Table 1: Twelve Semantic Categories in Question Taxonomy (Adapted from [8])

4 Questions Generation

4.1 Based on the Definition of Concept Types

The questions in the categories 1, 2 and 3 are related to the definition of some domain-specific terminology and hence are grouped together. These categories of questions require the comprehender to grasp the definition of the focal content of the questions. For the question "Is the system in equilibrium?", the focus is on testing the readers on the precondition of a system being described as "in equilibrium". The question "Is force a vector or a scalar?" assesses the student's knowledge of the difference between vector and scalar quantities. There are two ways of generating these categories of questions: by *traversing the type hierarchy* and by *projecting* the definitional graph of the focus type into the conceptual graph [9] representing the example [5]. Based on these methods, the following scenarios can be developed. Question: "Why is the system not in equilibrium?" If the student successfully answers the net force acting on the system is not zero, another question can be generated such as "Then how can it be put into equilibrium again?"

4.2 Based on the Chaining of the Graph Nodes

In Newtonian mechanics, there are causes that are well-defined, such as the cause of acceleration being a non-zero net force; the cause of a change in velocity being non-zero acceleration; the cause of a change in position being a non-zero velocity, etc. The whole process of deriving values for unknown variables from available data can be modelled as a node chaining process, a kind of causal chaining. Figure 2 shows two subgraphs that represent the corresponding example statements:

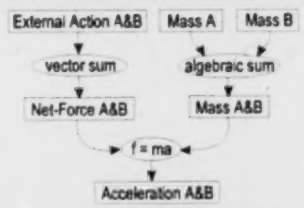
Solution Steps	Corresponding Conceptual Graphs
$\text{Net Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$ $\text{External Action}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$ $10 = (3 + 7) \times \text{Acceleration}_{A\&B}$ $\text{Acceleration}_{A\&B} = 1\ m/s^2$	

Figure 2: Part of the solution steps and its corresponding conceptual graphs

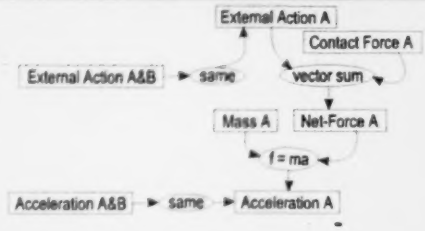
Solution Steps	Corresponding Conceptual Graphs
Net Force $_A$ = Mass$_A$ × Acceleration $_A$ External Action $_A$ + Contact Force $_A$ = Mass$_A$ × Acceleration $_A$ 10 + Contact Force $_A$ = 3 × 1 Contact Force $_A$ = - 7N	

Figure 2 (cont'd): Part of the solution steps and its corresponding conceptual graphs

The graphs shown on the right hand side of Figure 2 provide ample material to generate questions to test students' understanding of the solution steps such as "How was the acceleration of the system evaluated?"; "How many external forces act on the block A?"; "What is the relation between the acceleration of A and the acceleration of the whole system?"; "How was the contact force on B evaluated?", etc.

4.3 Based on Propagating Qualitative Values across the Graph

Regarding the expectational question depicted in the 11th category, one should see that it belongs more to the area of qualitative reasoning (QR) [11] and this kind of question is very common in testing the knowledge of students. A QR technique had been developed in [6] and the following type of questions are successfully generated. "If the external action decreases, what would be the contact force?" "If the bottom of block A is made rough to create friction between A and the ground, what would be the acceleration of the system and the contact forces?"

5 Conclusions

This paper proposes a questioning approach to handling examples, which is intended to stimulate the student's cognitive process of self-explanation. Representing worked examples by CG allows the system to generate different categories of questions during the questioning process. We have shown that definitional, procedural and qualitative questions can all be posed to students for tutorial purposes. Due to space limitation, we have not covered all categories of questions; for instance, feature specification and enablement. At the moment, this part of the work derives only from a computational perspective and lacks empirical support. The next phase of our project is to test posing the questions to students to see if this approach would stimulate self-explanations and subsequently enable them to acquire a better understanding of the subject domain.

References

[1] Anderson, R.C. & Biddle, W.B., "On asking people questions about what they are reading." In G. Bower (Ed.) The Psychology of Learning and Motivation (Vol. 9), NY: Academic Press, (1975).

[2] Chi, M.T.H. et al., "Self-Explanation: How students study and use examples in learning to solve problems, Cognitive Science, Vol.13, pp. 145-82, (1989).

[3] Chi, M.T. H. et al., "Eliciting self-explanation improves understanding" Cognitive Science, Vol. 18, pp.145-82, (1994).

[4] Dillon, J.T., "The multidisciplinary study of questioning" Journal of Educational Psychology, Vol. 74, pp. 147-65, (1982).

[5] Fung, P.W. "Designing an case-based intelligent learning environment in physics with conceptual graphs" Ph.D. Thesis, Dept. of Computation, UMIST, England, (1996).

[6] Fung, P.W. "Generating qualitative predictive problems in a case-based physics tutor" In Proceedings of AI-ED97, World conference on artificial intelligence in education, Kobe, Japan, (1997).

[7] Graesser, A.C. & Black, J.B., "The psychology of questions" NJ: Lawrence Erlbaum Associates, (1985).

[8] Graesser, A.C. et al. "A taxonomy for question generation" Questioning Exchange, Vol. 2, pp. 3-15, (1988).

[9] Sowa, J. "Conceptual structures: Information processing in mind and machine" Reading: MA: Addison-Wesley, (1984).

[10] Trabasso, T., et al. "A model for generating questions that assess and promote comprehension" Questioning Exchange, Vol. 2, pp.25-38, (1988).

[11] Weld, D.S. & deKleer, J. "Readings in qualitative reasoning about physical systems" CA: Morgan Kaufmann Publishers, (1990).

Generating interactive explanations by using both images and texts for Micro World

Kiyoshi Yoshikawa, Isamu Takahashi, Tatsuhiro Konishi and Yukihiro Itoh
Department of Computer Sciences, Shizuoka University
Johoku 3 - 5 - 1, Hamamatsu, Shizuoka, 432 - 8011, Japan
Tel: +81-53-478-1474 Fax: +81-53-478-1499
E-mail: {cs6098, i-takaha, konishi, itoh}@cs.inf.shizuoka.ac.jp

In this paper, we propose a method of constructing an intelligent Micro-World (MW) for high-school chemistry that accepts learners' questions and advises them whenever the learners are working in the MW. We also discuss the method generating explanations using both texts and images. At first, we argue on the interaction between a learner and such a system, and classify learner's typical demands and possible educational supports by the system. Next we show the ability necessary to deal with the demands, such as recognizing learners' plan, generating a plan to achieve a goal of an experiment, reproducing the state at any step of the change in MW, controlling the initiative of the interaction, and so on. Then we propose methods in order to realize the abilities. Moreover, we illustrate how to implement the abilities and introduce our prototype system.

Keywords: **Micro World, Interactive explanation, Mixed initiative**

1 Introduction

Micro-World (MW) has a problem that it is hard to support learners who are in impasse. We are developing an intelligent MW that supports the learners[1,2,4,5]. The domain subject of the MW is high-school chemistry. The MW has the following functions:

- Simulating changes in the world model of high-school chemistry.
- Recognizing the learner's plan by a sequence of his manipulations.
- Judging weather the learner is in impasse, by comparing the learner's plan with the standard plan that the MW generates. If the learner is in impasse, it assumes that the cause of the impasse might be lack of the knowledge necessary to perform the next manipulation which the learner should do.
- Giving the learner some advices by using texts. For example, the MW shows the knowledge which the learner doesn't understand, the manipulation that the learner should do next, and so on.
- Accepting learner's questions at any time when the learner is working in the MW• and answering by using texts.

Our MW uses only texts in giving advices. In general, it is effective to explain something by using both texts and images. CINESPEAK [3] is one of the systems which can show explanations using both images and texts. It can generate a 3D animation and texts of explanation. It also can select appropriate camera shot corresponding to the contents of explanation. However, It can not generate explanations interactively.

We think it is necessary to avoid showing the texts and images prepared beforehand like video movies with some captions. The reason is that the explanation should be shown interactively. In other words, an educational system must not explain anything one-sidedly, because the condition of a learner is changing moment by moment while the system explains to the learner.

When an idea flashes upon a learner's mind during the explanation, the system must allow him to say his idea and respond to his remark. For example, when the system explains how to solve some problems in MW

to the learner who is in impasse, if the learner requires doing continuation of the problem solving process by himself, the system should prepare MW and let him continue solving the problem on MW. Similarly, if the learner requires changing some conditions of MW and explaining the method of solving the problem, the system should stop explaining, re-plan a new method to solve the problem with new conditions, and explain it.

In this paper, we extend the user interface of our MW in order to make it more effective. The first extension is that the MW uses not only texts but also images when it shows the learners advices or explanations. The second one is that the MW generates explanations interactively. Our extended system can explain manipulations that a learner performed in a MW and the manipulations necessary to achieve a given goal by using both texts and animations simultaneously. Moreover it can explain interactively according to the learner's demand.

In the next section, we discuss the ability necessary for the system that generate explanations interactively. In section 3 we show our basic approach to realize the abilities. In section 4 we illustrate how to implement the abilities, and we introduce our prototype system and show examples of its behavior.

2 Interactive method to explain

In order to generate explanations interactively, the system should have the following two functions.
- When a learner does not express his intention, the system must be able to lead his learning.
- The system must be able to deal with a learner's demand whenever the system aids learning (even when it is explaining something to him).

The former is out of range of this paper, because it is the topic concerning to the teaching strategy in the field of Intelligent Tutoring System (ITS). Therefore, We concentrate the latter.

Learners' demands and the method to deal with them depend on what kind of educational supports can be provided by the system. Therefore, we must clarify:
1. the educational supports and learners' demands.
2. what kinds of ability are necessary to deal with the demands.

2.1 Possible educational supports and learners' demands

We can classify states of the system into the following two types:
- The system gives a goal and the learner manipulates the MW on his own initiative.
- The system takes the initiative then it shows advice or explanations to the learner.

We discuss learner's demands and methods to deal with them on each state.

2.1.1 Supports and learners' demands when learner has initiative

We think the major demand on this state is to require an advice to resolve a learner's impasse. Therefore, we deal with only such type of demands as the first step of our research. In order to discuss how to deal with the demands, we classify causes of learners' impasse into the following two types.
(A):• A learner cannot understand the current state of MW.
(B):• A learner cannot decide what to do in the next step.

The system can satisfy the demand of the learner who is in impasse because of (A) by showing the following explanations:
- Explanation of a sequence of manipulations that the learner performed in the MW and the effect of each manipulation.
- Explanation of the state after each manipulation has performed.

The demand of the learner who is in impasse because of (B) can be satisfied by various ways. For example, the system identifies misunderstood or lacked knowledge and shows him the knowledge, the system explains on the similar case and lets him remind his experience, and so on. In this paper, we adopt the simplest way that the system shows the actions to be performed in the following steps. If we take the other way, we need to extend some functions to decide contents of explanations. However, the mechanism to control interactive generation of explanations is commonly reused.

As a result, the type of demands of the first state is only a demand to require some advice, and the type of explanations that the system generates is only an explanation of manipulations and the state after each one. In order to explain a manipulation and the state after it has been performed, the system generates animation showing how to perform the manipulation in the MW and texts explaining the effect of the manipulation.

2.1.2 Supports and learners' demands when the system has initiative

First, we discuss typical demands of learners who are in impasse because of (A) mentioned in the previous section. When the system explains to the learner a sequence of manipulations that the learner performed and the state after each manipulation by using animations and texts, the learner may demand that the system shows him a previous state again or a following state intermittently. In case that the learner finds his own mistakes while the system is explaining something to him, he may demand that the system stops explaining, prepares the initial environment, and lets him re-try solving his problem on the MW again. If the learner fails to resolve his impasse in spite of some explanations generated by the system, he may demand that the system shows him the whole correct process to achieve his goal on the MW.

Then, we imagine typical demands of learners who are in impasse because of (B). In this case, the system explains him the action to be performed in the following steps. The learner may demand that:
- the system shows him the previous/following states.
- the system stops explaining in order to let him do continuation of manipulations.
- he rewrites some conditions of his problem and the system explains how to solve the problem with new conditions.

We don't argue on all of above-mentioned demands, but only ones with which our system can deal, considering possible actions by our system. Such actions are as follows:
(1) Explaining the sequence of actions which learners have performed.
(2) Explaining the sequence of correct actions by which the given goal can be achieved.
(3) Setting an environment for experiment to let learners try achieving the goal free.

Table 1. Examples of typical demands by learners

Actions of the system		type of the demand and the scene where the learner input the demand
Action before the demand	Action after the demand	
(1)	(1)	The learner wants to see another action than one shown in the current explanation on the sequence of his previous actions.
(1)	(2)	The learner can understand what he has done, and wants to see what he should do next.
(1)	(3)	The learner finds the mistakes he has made, and wants to re-try the experiment.
(2)	(1)	The learner understands correct actions, and wants to compare it with what he did.
(2)	(2)	The learner wants to see another action than one shown in the current explanation on the sequence of correct actions.
(2)	(3)	The learner understands the correct actions, and wants to re-try the experiment.
(3)	(1)	The learner loses the current state in the process of achieving the goal of the experiment. He wants to confirm the actions which he has performed.
(3)	(2)	The learner loses the way to achieve the goal of the experiment. He wants to see the correct actions.
(3)	(3)	He finds he has failed to achieve the goal and wants to re-try the experiment.

Then we can classify the demands according to which actions are performed before/after accepting the demand. Combinations of the actions are 3*3= 9 types such as "when system doing (1), a demand is input, then it does (1)", "when it doing (1), a demand is input, then it begins to do (2)", and so on. Examples of the typical demand of each type are shown in Table 1.

2.2 Abilities necessary to deal with learners' demands

In this section, we discuss abilities necessary to deal with the learners' demands mentioned in 2.1. Basically, MW should have an ability to simulate changes in the MW according to learners' actions.
In addition, in order to deal with the demands mentioned in 2.1.1, the system should have the following abilities.

(a) Ability to recognize learners' plan from a sequence of his actions.
In order to explain what learners have done by not only listing up the actions, but also showing the meanings of the sequence of the actions, the system needs the ability.

(b) Ability to generate a plan to achieve a goal of an experiment.
In order to explain correct actions which learners should perform, the system has to be able to generate plan.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.
The system had better be able to generate explanations using both texts and images. In order to generate visual explanations, the system should be able to operate MW in a similar way as learners do. In order to generate verbal explanations, the system should be able to generate texts from the result of planning or plan recognition.

In order to deal with the demands mentioned in 2.1.2, the abilities mentioned above are also necessary. In addition, the following abilities are needed.

(d) Ability to store the history of actions by learners or the system.
The ability is needed to do action (1) or (2) as a reaction of a demand in Table 1.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.
The ability is needed to do action (3) as a reaction of a demand in Table 1.

In addition, the following ability is necessary to realize mixed initiative. It is generally important to make interactive educational environment effective.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

3 Methods necessary to deal with learner's demand

The basic framework of the system as a MW can be seen in [5]. An extension in this paper is that the system becomes to have two individual environments: one is the environment for experiment used by learners, and the other is the environment for explanation. Our system operates the latter environment in its explanation. We add the latter environment in order to avoid that both a learner and the system try to operate a common one at the same time. The environment for experiment has an interface and functions to accept learner's actions, and reacts as soon as it accepts an action from a learner. On the other hand, the environment for explanation cannot accept manipulations from learners (though switches similar to the environment of experiment are displayed in its window, they are dummy).

We discuss how to equip such a framework of the system with the abilities mentioned in 2.2.

(a) Ability to recognize learners' plan from a sequence of his actions.
On this ability, please see our previous paper[illegible]

(b) Ability to generate a plan to achieve a goal of an experiment.
On this ability, please see our previous paper[illegible] too.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.
Simulation in MW is performed by using symbolic knowledge representation. States at each step of

MW are also represented in a symbolic way. Manipulations by learners are also translated to symbolic representations. The control method of the simulator is event-driven: as soon as a manipulation is input to the simulator, the inference engine generates symbolic representation showing the next state of MW. The system draws the state of MW on the basis of the symbolic representation. Therefore, the system can simulate changes in the MW according to the generated or recognized plan, because the system can generate the input of the simulator represented symbolically from the plan.

In addition, because states of MW, manipulations to MW, and changes in MW are commonly represented in a symbolic way, the system can generate explanations in natural language on every fact in MW.

(d) Ability to store the history of actions by learners or the system.

It is easy to store such history because all of states of MW, manipulations to MW, and changes in MW are represented in a symbolic way. The system records only the initial state and a sequence of having performed actions as the history. The system can reproduce all states and changes by simulating the change in MW again on the basis of the history.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The system can reproduce any states in an explanation on learner's previous actions, by performing the manipulations stored as the history sequentially. On the other hand, it can also reproduce any states in the process when correct actions are performed, by performing the manipulations in the plan generated by itself. Thus, the system can set any states of an environment which learners can manipulate, by copying such reproduced states in the environment for explanation to the one for experiment.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

We adopt the following strategies for controlling the phases:

- Basically, a learner takes initiative, and he acts freely in MW.
- Turn over the phase to the other phase where the system takes initiative, as soon as the learner inputs a question or demands that the system explains something.
- If the system finds that the learner is in impasse, ask him whether he hopes to turn over the phase where the system takes initiative. And if he does, turn over it.
- Accept interruption by learners whenever the system generates explanations.
- Decide the next action of the system according to the interruption. For example, if the learner demands that the system sets the phase where the learner takes initiative, set a suitable state of the environment and let him experiment freely. If he inputs a demand for the system to explain other topic than the current topic, continue explanation on the requested topic.

4 Implementation

We designed a prototype system. Figure 1 shows outline of our system.

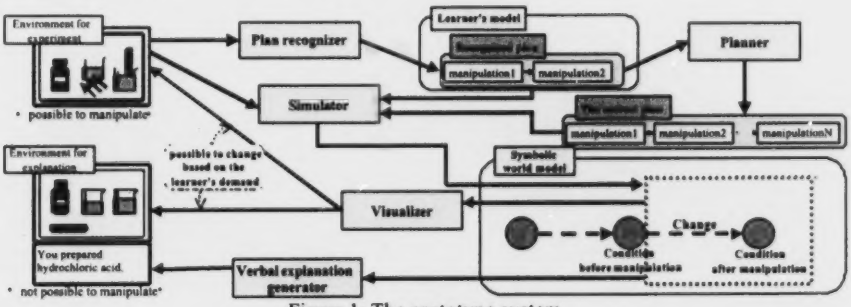


Figure 1: The prototype system

BEST COPY AVAILABLE

The system has *environment for experiment* and *environment for explanation*. The system sets a goal and a learner tries to achieve the goal by manipulating objects in *environment for experiment*. When the learner does an action in *environment for experiment*, the simulator reproduces a change in *symbolic world model*. Then the *visualizer* draws the state after the change in *environment for experiment*. At the same time, *the plan recognizer* monitors the learner's manipulations and recognizes his plan. When the learner becomes to be in impasse or requires some advice, *planner* generates a correct plan. Then the system visualizes environment for explanation, and starts explaining by using either recognized plan or the correct plan. In order to generate explanation, *simulator* reproduces states of the world model and *visualizer* visualizes the states in *environment for explanation*. Simultaneously *Verbal explanation generator* generates verbal explanation on the manipulation, the change, and the state.

The domain world model of this system is written by symbolic representation. In general, it is difficult to handle continuity of time and space by such representation. Therefore, our system handles time as a sequence of discrete segments of time. And it doesn't handle strict position of objects in the world, but only relative relations which can be represented by symbols, such as "chemical materials are in the same beaker". A change is also represented by symbols which shows the initial state, the actions causing the change, the changing state, and the state after the change. Most of the subjects in high-school chemistry can be handled in the above mentioned way.

This system is implemented by using Tcl/Tk and LISP (Kyoto Common LISP). This system can deal with the 5 subjects: method of preparing a solution of a certain molarity, acidic material, basic material, neutralization, and using indicator.

We show an example of the behavior of our system when a learner does an experiment of neutralization. Figure 2 shows a user interface for *environment for experiment*. In the environment, the learner prepares hydrochloric acid, prepares nitric acid, and sodium hydroxide, pours nitric acid into hydrochloric acid, prepares phenolphthalein, and mixes it into the mixed acid. Then he finds that he has not achieved his goal. In the case that he can't find the reason and inputs a demand for the system to explain his own actions, the system prepares an *environment for explanation* to start explaining the actions the learner has done. Figure 3 shows a user interface of *environment for explanation*. The interface has three windows: a window for displaying visual explanations and verbal explanations, a window showing a history of actions that have been taken place, and a window for inputting demands. In Figure 3, both visual and verbal explanations for the fourth action (marked in the list shown in the window for history). If the learner finds that he has made a mistake, and if he cannot find the correct way, he wants to demand that the system explains how to neutralize. He clicks on the button "*correct manipulation*" in the window for inputting demands. Then the system starts explaining the correct way (Figure 4). If he inputs a demand for the system to let him re-try the experiment, the system prepares *environment for experiment* and reproduces the state from which he wants to start experiment (Figure 5).

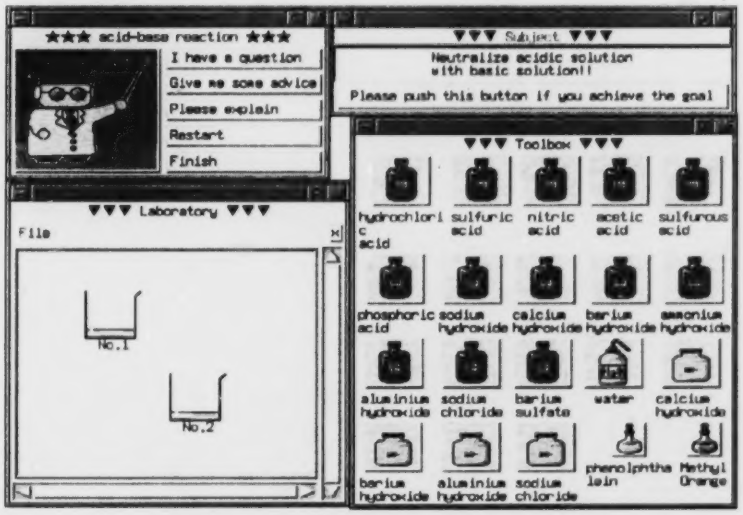


Figure 2: An example of environment for experiment

BEST COPY AVAILABLE

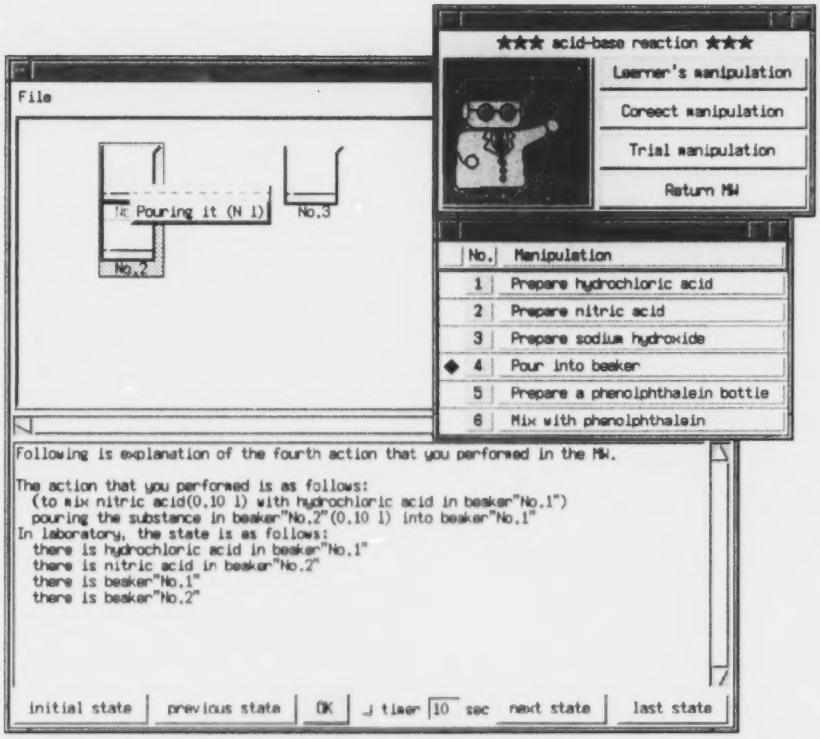


Figure 3: An example of environment for explanation (Explanations of a learner's actions)

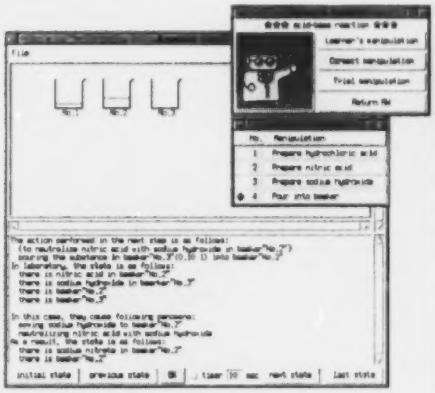


Figure 4: Explanations of corrects actions

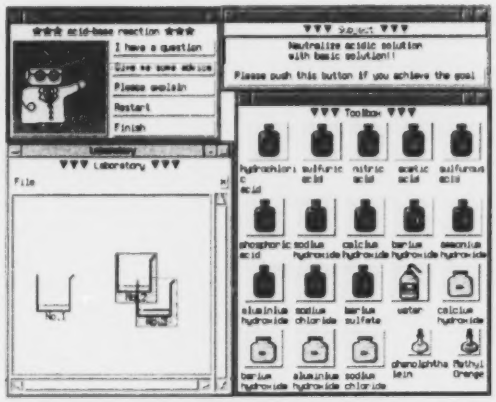


Figure 5: A reproduced environment for experiment

5 Conclusions

In this paper, we discuss a method constructing an intelligent and interactive MW generating explanations both images and texts. Our prototype system has relatively small domain knowledge base, so we have to make it larger in the future in order to increase subjects that our system can support.

When we will try to extend our system to handle other domains, the simulator underlying the system needs to deal with continuity of time and space. For example, if we deal with the field of electric circuit, the

BEST COPY AVAILABLE

simulator needs to handle topology. If we deal with the field of dynamics of physics, the simulator needs to handle coordinate system.

Our another future work is to evaluate the effectiveness of our system experimentally.

Acknowledgements

This research was supported in part by Grant-in-Aid for Encouragement of Young Scientists (12780125) from Japan Society for the Promotion of Science.

References

[1] Itoh,Y., Takahashi,I. and Konishi,T., "On Recognition of Student's Actions in ILE", Proceedings of the International Conference on Computers in Education(ICCE'95), Singapore, December5-8, pp.630-639,(1995)

[2] Itoh,Y., Takahashi,I. and Konishi,T., "On evaluating students' knowledge by observing their actions in ILE", Proceeding of Artificial Intelligence in Education(AI-ED'97), Kobe,Japan, August18-22, pp.595-597, (1997)

[3] Stuart G. Towns, Charles B. Callaway and James C. Lester, " Generating Coordinated Natural Language and 3D Animations for Complex Explanations", Proceedings of the Fifteenth National Conference on Artificial Intelligence (AAAI-98), Madison, Wisconsin, America, July 26-30, pp.112-119, (1998)

[4] Takahashi,I., Itoh,Y. and Konishi,T., "On a method to decide the order of knowledge shown as advice in ILE", Proceedings of the Sixth International Conference on Computers in Education (ICCE'98), Beijing, China, October 14-17, vol1, pp.373-380, (1998)

[5] Takahashi,I., Konishi,T. and Itoh,Y., "On a Framework of an Educational System which Acts both as ITS and Micro-World", Proceedings of the Seventh International Conference on Computers in Education (ICCE'99), Chiba, Japan, November 4-7, pp.954-957, (1999)

Intelligent Interactive Learning Environment: Design Issues

Siu-Cheung KONG* and Lam-For KWOK**
**Department of Information & Applied Technology, Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T.,Hong Kong. Email: sckong@ied.edu.hk*
***Department of Computer Science,City University of Hong Kong,Tat Chee Avenue, Kowloon, Hong Kong. Email: cslfkwok@cityu.edu.hk*

Interactive Learning Environment (ILE) provides interaction opportunities between learners and the virtual devices for productive learning. Intelligent ILE (IILE) provides quality feedback or authentic guidance to learners who need help in the ILE. This research aims to explore design implications of IILE by studying model of learner in the mathematics fraction domain. 169 primary four learners were invited to answer 10 open-ended questions on fraction addition and subtraction. A learner model on category of error and error pattern was formulated from the 423 erroneous responses. Results of the study indicated that researchers should study error patterns by understanding work of learners, distinguish careless mistakes from error patterns, and consider scaffolding support.

Keywords: **Intelligent Interactive Learning Environment, Learner Model**

1 INTRODUCTION

There are two categories of Learning Environment (LE): content-free and subject-specific [1]. A content-free LE allows participants and facilitators to formulate their own topics for discussion. Knowledge formulated from such interactions belongs to the learning community [2]. A subject-specific LE involves subject knowledge. Some subject-specific environments stress knowledge transfer like Intelligent Tutoring System (ITS) [3]. Other subject-specific environments such as Interactive Learning Environments (ILE), assisting learners to learn through exploration, put efforts on designing manipulative virtual learning devices [4]. No matter an LE is designed for knowledge transfer or knowledge formulation, subject matter of the learning domain should be carefully studied and incorporated in it [5].

1.1 Design Considerations of an ILE

The study of subject matters plays a crucial role in designing ILE involving knowledge exploration because learners are not obtaining knowledge directly from the ILE. Learners have to learn by analogy, that is, learners have to transfer knowledge from manipulating the manipulative virtual devices of the ILE to grasp the abstract concepts of the subject domain [4]. Expert teachers are skilful in predicting how learners will think and err [6]. This diagnostic ability is tied to an expert's special understanding of the subject and is undoubtedly derived from multiple opportunities to teach the same content [7]. This knowledge includes knowing which aspects of a topic are particularly difficult, what the common misconceptions are, and what representations are important for authentic learning. Shulman [8] termed this kind of knowledge as Pedagogical Content Knowledge (PCK). It is crucial to utilize teachers' expert knowledge, especially knowledge on representation for authentic learning, to design manipulative virtual devices of an ILE.

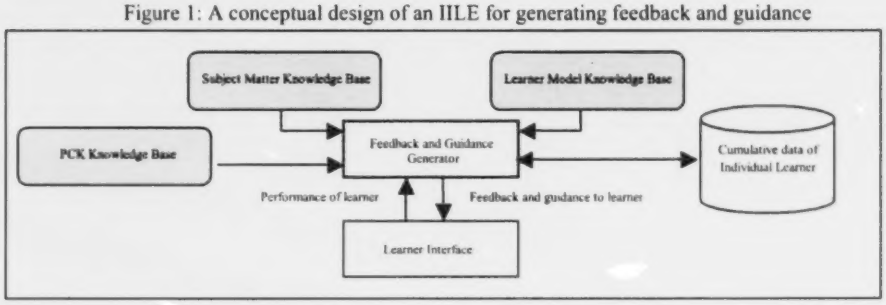
1.2 Design Considerations of an Intelligent ILE

An ILE may provide interaction opportunities between learners and the virtual devices for productive learning. Some learners may learn the subject matter well without the assistance of the virtual learning devices. Some learners may learn well with chances to interact with the interactive learning devices of the environment. However, some learners may need guidance to learn well in the ILE [9]. An Intelligent ILE (IILE) is an ILE that provide feedback or guidance to those learners who need such help in learning the subject domain. Those

learners who do not need help will not notice the existence of the auxiliary service. Learner model of learning in a subject domain may provide information about the behaviour of learners in learning the domain. Studying the learning model of learners may assist IILE designers to formulate design principles and obtain technical details such as formulating mal rules for understanding learning states of learners. A learner model thus may help to tailor-make an IILE for assisting various types of learners in learning the discipline. It is therefore important to study the learning model of learners in a specific subject domain for designing a useful and practical IILE to assist learners of various kinds in the learning process.

Three knowledge bases are therefore important for designing an IILE for learning subject-specific knowledge. They are the subject matter, the learner model of learning in the domain and the PCK of teachers in teaching the discipline. Subject matter knowledge base contains subject matter knowledge. It can provide subject matter advice and knowledge state of learners in the learning process. Learner model contains behaviour representations of learners. Learner model knowledge base may provide information about the learning state of learner. PCK knowledge base contains diverse guidance knowledge for different learning states of learners. It may provide learning advises based on PCK of experienced teachers of the subject domain who know how learners think and err in the discipline. Software agents will monitor the performance of learner in the learner interface. Software agents will determine proactive or reactive responses after a negotiation and communication process in the feedback and guidance generator. The negotiation will be a judgement of the knowledge state of the learner in the domain using both the learner model knowledge base and subject matter knowledge base of the IILE. Final decision will be an outcome after a consultation with the PCK knowledge base of the IILE and the cumulative data of an individual learner. The cumulative data records the historical learning states of each individual learner captured by the IILE. Figure 1 shows a conceptual design of an IILE for generating feedback and guidance.

Figure 1: A conceptual design of an IILE for generating feedback and guidance



1.3 Chosen Subject Domain

A review of literatures indicated that many learners have great difficulties in learning the concepts and procedural knowledge of mathematics fraction [10, 11, 12]. Streefland [11] further pointed out that the main cause of such difficulties is the inadequate and inappropriate teaching in the traditional approaches. As the teaching and learning of mathematics fraction is an internationally renowned difficult topic, it is considered as an appropriate exemplar to be investigated for automation.

2 AIM AND OBJECTIVES

The aim of this research is to study the knowledge of learners in a subject-specific domain and to investigate its implication for designing a subject-specific IILE. There are two specific objectives: (1) to understand the problems of learners in learning the topic; (2) to discuss design issues of an IILE. Such findings may inform the development of IILE for providing quality feedback and guidance to learners.

3 RESEARCH METHODOLOGY

A questionnaire for studying model of primary learners on learning fraction addition and subtraction was designed.

BEST COPY AVAILABLE

169 primary four learners from four different schools were invited to complete the questionnaire through their mathematics teachers. All learners had completed their learning of fraction addition and subtraction before the test. Learners were requested to do the questionnaire on individual basis in a mathematics lesson for about 35 minutes. No discussions were allowed. The answer sheets were not used for any form of assessment but returned to the researcher after the administration. All 169 answer sheets returned were used for data analysis.

4 RESULTS AND DISSCSSIONS

This section will report on the quantitative and qualitative analysis results of all errors responded by participants of the survey and will discuss their implications on designing an ITLE. The learner model formulated contains two areas: (1) knowledge of learners on category of error; and (2) knowledge of learners on error patterns of the domain.

4.1 Knowledge of Learner on Category of Error

Nine categories of error were identified and summarized from the 423 incorrect responses. Though incorrect response of each question may contain more than one error, this study selected the primary source of error for classification. Results were summarized in table 1. Categories were organized in descending order of percentage that account for the errors. The summarized result may serve as an important reference in designing a learner model of LE for fraction learning. Among the nine categories, categories 1, 2 and 9 directly related to the subject matter and accounted for nearly forty percent of the erroneous work. Categories 3 and 8 were common types of error in any mathematics exercise. It is interesting to investigate whether learners in this age group would commit these types of error like doing subtraction for addition at a certain level of unconsciousness. The study reflected that these factors might account for another twenty percents of errors.

Table 1: Category of error summarized from the learner model of the study

	Category of Error	Percentage Accounted
1	Improper handling of mixed number in fraction operation	20.4%
2.	Insufficient procedural knowledge for evaluating fraction	14.7%
3.	Calculation or careless mistake	13.5%
4	Unable to set up correct expression for solving word problem	11.6%
5.	Incorrect strategy for evaluating expression	11.4%
6.	Unable to identify error pattern for erroneous work	10.9%
7.	Not responding to question or the piece of work unfinished	8.5%
8.	Conducting subtraction for addition and similarly addition for subtraction	5.5%
9.	Incorrect simplification of answer to the simplest fraction form	3.6%

Though categories 4 and 5 can be purposely avoided, they do play a role in mathematics learning. Setting up expression for solving problems in a scenario may help to test whether a learner has grasped the taught concept. Strategies of evaluating numerical expressions may help to detect whether a learner has knowledge on magnitude of operands and order of evaluation on operators in an expression. The deficiency of this knowledge accounted for twenty percents of errors detected in this study. Categories 6 and 7 accounted for the last twenty percent of learners' work that might not be understandable or remain unfinished. Those 10 percent of learners' work could not be identified for any error pattern reflected that even human teachers might be unable to understand open-ended pieces of work like evaluating mathematics expressions.

4.2 Knowledge of Learner on Error Patterns

This section will report on knowledge of learners with problems in working with fractions on addition and subtraction. After careful analysing error patterns of learners in evaluating and solving simple fraction addition and subtraction problems, two categories were summarized: (1) concrete error pattern; and (2) vague idea on working with fractions. The first category includes some concrete error patterns that can be abstracted into mal rules. The second category contains error patterns that cannot be easily summarized into mal rules but reflect vague ideas and incomplete working procedures of learners. One of the most famous mal rules on fraction addition can be named as "Add numerators and add denominators". Learner with poor knowledge on fraction addition will adopt knowledge of arithmetic addition by adding the numerators of fractions in the fraction expression to give the numerator of the resultant fraction and similarly adding the denominators of

fractions to give the denominator of the resultant fraction. There were four learners committing this type of error in this study. This rule might explain 3% of the errors. The second category of error pattern to be analysed involves high-level abstraction. The group of learners in this category showed no concrete error patterns. However, the pattern illustrated that these learners have some vague ideas of doing fraction addition and subtraction. Examples were illustrated in table 2.

Table 2 Vague ideas for evaluating fraction addition and subtraction expressions

	Error 1	Error 2
Learner 1 (3 score)	$\frac{3}{8}+\frac{1}{6}=\frac{9}{18}+\frac{9}{18}=\frac{18}{18}=1$	
Learner 2 (6 score)	$\frac{1}{2}+\frac{1}{3}=\frac{3}{10}-\frac{2}{10}=\frac{5}{10}=\frac{1}{2}$	
Learner 3 (0 score)	$\frac{1}{2}+\frac{1}{3}=\frac{1\times3}{2\times3}+\frac{1\times3}{3\times1}=\frac{3}{6}+\frac{2}{6}=\frac{6}{5}$	$\frac{3}{8}+\frac{1}{6}=\frac{3\times6}{8\times6}+\frac{1\times6}{3\times6}=\frac{54}{18}+\frac{3}{18}=\frac{12}{18}=\frac{6}{5}$

These erroneous presentations reflected that learners did have vague ideas about the working procedures on fraction addition. They need assistance to organize the disconnected nodes into a semantic net. Result of the studies indicated that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work.

Identify Careless Mistake

The learner model of this study reflected that twenty percent of errors were derived from calculation or careless mistakes. Careless mistakes in this study mean transcription errors or simple computational mistakes form one step to another. The feedback and guidance will be different if an error is identified as a careless one. An IILE should handle not only problems generated from subject matters but also general problems of learner like careless mistake. An authentic guidance should provide not only advices or actions that can assist learners to formulate conceptual understanding of the subject domain but also offer help to learners derived from general problems such as careless mistakes. An IILE should attempt to distinguish careless mistake from other error patterns like human teachers.

Scaffolding Support

The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help learner much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive learning support should be an arrangement of a sequence of situations for facilitating knowledge construction [12]. The role of a mathematics-learning environment will be to help learners to learn, especially those fundamental concepts in mathematics, but not to replace mathematics learning in the conventional manner. Therefore it is fundamental for such kind of learning environment to provide scaffolding support to learner when assistance is needed. Support should gradually withdraw so that learner can stand on its own after leaving the system. Therefore a fraction IILE should be designed like a blank sheet for learner to work with fraction. Feedback and guidance are only provided when it is needed. On the other hand, learner working in the IILE who does not need support will not notice the IILE in behind.

5 CONCLUSION

Studying the learning model of learners may assist IILE designers to formulate design principles and obtain details for understanding learning states of learners. The learner model of this study modelled behaviour of learners in two aspects: error category and error patterns. Nine categories of error were identified. Forty percent of errors were derived from inadequate knowledge of learners on subject matters. Twenty percent could be explained by careless mistakes. Twenty percent involved general mathematics knowledge. The final twenty percent of erroneous work were difficult to be classified or work was not completed. Learner model of the study reflected that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work. Result of

the study indicated that IILE needed to apply a strategy to identify careless mistake so that appropriate guidance to learners can be provided. The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive scaffolding support should be an arrangement of situations for facilitating knowledge construction. The future work of the study is to design ways and means to understand work of students, to devise strategy to distinguish careless mistake from other error patters, and to plan scenarios for assisting learners to learn by exploration in an IILE.

References

[1] Vosniadou, S., Corte, E.D., Glaser, R., & Mandl, H. (Eds.), "International perspectives on the design of technology-supported learning environments", Hillsdale, NJ: Lawrence Erlbaum, (1996).

[2] Duffy, T., & Jonassen, D. (Eds.), "Constructivism and the technology of instruction: A conversation", Hillsdale, NJ: Lawrence Erlbaum, (1992).

[3] Chan, T.W., "An introduction to intelligent computer assisted learning systems research and development", National Science Council Monthly, Vol. 23, No. 5, pp. 456-468, (1995).

[4] Akpinar, A., & Hartley, J.R., "Designing interactive learning environments", Journal of Computer Assisted Learning, Vol. 12, pp. 33-46, (1996).

[5] Wittmann, E.Ch., "Mathematics education as a 'design science' ", Mathematics education as a research domain: A search for identity, Dordrecht: Kluwer Academic Publishers, pp. 87-103, (1998).

[6] Berliner, D.C., "In pursuit of the expert pedagogue. Educational Researcher", Vol. 15, No. 7, pp. 5-13, (1986).

[7] Livingston, C., & Borko, H., "Expert-novice differences in teaching: A cognitive analysis and implications for teacher education", Journal of Teacher Education, Vol. 40, No. 4, pp. 36-42, (1989).

[8] Shulman, L.S., "Those who understand: Knowledge growth in teaching", Educational Researcher, Vol. 15, No. 2, pp. 4-14, (1986).

[9] Cheng, C.C., "Proactive guidance in computer-assisted language learning", Technical Report, LLL-T-24-95. Language Learning Laboratory, College of Liberal Arts and Sciences, University of Illinois, (1995).

[10] Behr, M.J., Harel, G., Post, T. & Lesh, R., "Rational number, ratio and proportion", Handbook of research on mathematics teaching and learning, New York: Macmillan, pp. 296-333, (1993).

[11] Streefland L., "Fractions in realistic mathematics education: A paradigm of developmental research", Dordrecht: Kluwer Academic Publishers, (1991).

[12] Ohlsson, S., "Knowledge requirements for teaching: The case of fractions", Teaching knowledge and intelligent tutoring, Norwood, NJ: Ablex Publishing Corporation, pp. 25-59, (1991).

Internet Video on Demand System of Classroom Teaching Cases

- Building "RAPSODY": An Intelligent Media-Oriented Remote Educational System for Self-Learning Support -

Hisayoshi INOUE and Toshio OKAMOTO
Graduate School of Information Systems
The University of Electro-Communications
1-5-1 Chofugaoka, Chofu-City, Tokyo, 182-8585 JAPAN
TEL: +81-424-43-5623
E-mail: {ino,okamoto}@ai.is.uec.ac.jp

Our study aims to accumulate information for teachers, about established teaching methodologies and techniques. For the purpose of our study, we construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education". In this paper, we describe the details of our video searching system, the design of the database tables, and we show an example of system operation.

Keywords: **Information Education, Teacher Education, Distance Learning, VOD, Rapsody**

1 Introduction

In now-a-days advanced information society, the demands about teachers' competence are high and diverse. Concretely, teachers are required to posses on one hand curriculum development ability, learning environment design ability, group learning, individual learning, simultaneous learning, and on the other hand the previous abilities should be supported by class practice ability, observation and evaluation ability, and last but not least, the ability to connect the textbook's world and the real world.

It is difficult to raise and form this complex set of abilities, with the help of only the presently available education and training methodology for teachers. Therefore, the necessity emerged [1] to examine the feasibility of a new systematic approach, for supporting the teachers' literacy progress, by building on their natural talents/ and abilities, and expanding these to reach the required width and breadth.

The information technology science is offering the tools for the development of an environment supporting the teachers' endowment progress. The knowledge concerning the teachers' education contents and methods is stored as multimedia information, in the form of pictures, videos and sound tracks. Moreover, by using the network environment, it is possible to make use of all resources over the net, without any constraints or restrictions of time and/or geographical location.

With this goal in mind, we are researching the development of an integrative distance education training system for supporting teachers' self-training, called RAPSODY (Remote and Adaptive System of Oriented Dynamic Teaching/Learning) . Up to now, the availability of video records and guidance plans about lessons was limited to education training centers or universities, etc. The present research intends to make the information on educational activities and practices public, and aims at joint usage and re-usage of teachers' self-learning and self-training methodologies and tools. Concretely, we develop a retrieval system based on dialogue patterns, by using a database of lesson videos.In order to jointly use the information in the distributed environment, or to be able to re-use it, we implemented a Video On Demand (VOD) system. The (teacher) user can control/manage the specification and stop/suspension of

the regeneration point for the distributed VOD.

The main purpose of our research is therefore to propose a distance-learning environment on the Internet, for improving the teachers' practical abilities. In this paper, we describe the video on demand system developed until now, the indexing method of the classroom teaching movie example database, the system's functions and the system's evaluation.

2 The outline of the system

2.1 The structure of the system

Fig. 1 shows the structure of the search system. The system is built of the following three parts:

- Web browser;
- Lesson video example database;
- Video distribution server.

The web browser has the role of the user interface. The search/retrieval mechanism searches the lesson example video database via three types of relational database files.

The video distribution server stores the lesson scenes' videos. The video distribution server performs the VOD function at the users' requests. The search functions performed for the user are of the following two types.

- Keyword Search
- Feature Oriented Search

The Keyword Search (fig. 1,) takes place as explained below.

a-1) The user designates the search conditions.
b-1) The search mechanism compares the search conditions input by the user, with the available class example video database.
c-1) The search mechanism extracts the record(s) matching the searching conditions.
d-1) The result is displayed as the search result.

The Feature Oriented Search process (fig. 1,) is done as shown in the following.

a-2) The system dialogue mechanism enquires about the video characteristics/features desired by the user.
b-2) The user can answer to the system's enquiry vaguely [2].
c-2) The decision making table (showed later on in table 6), obtained from the user, is the basis for the evaluation of the specific search conditions. The gathered search conditions are passed over to the search mechanism of the database.
d-2) The database search mechanism compares the search conditions resulting from the evaluation with the lesson example videos contained in the database.
e-2) This result is displayed as the search result.

The search result is formatted as an URL list that is shown to the user. These URLs perform the function of linking the search result and the actual videos on the VOD server. The (teacher) user chooses the URL that s/he wants to refer (Fig. 1,).When the URL is chosen, the VOD client software, embedded via the Web browser plug-in, starts, and the video playback begins.

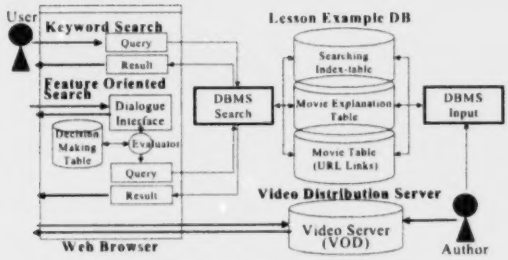


Figure 2 Sstem Organization

3. Database structure

3.1 Lesson (unit) database

The following three relational database files define the video lesson database.

- Searching Index File
- Movie Explanation File
- Movie File

In the following, we will explain in detail each database file type.

3.2 Searching Index File

The Searching Index File results from the comparison of the video database with the search items. The search items are organized in items for the Keyword Search and items for the Feature Oriented Search. In table 1, we show the Searching Index File for the Keyword Search, and in table 2, the Searching Index File for the Feature Oriented Search.

For the Keyword Search, the search conditions are given directly by the user. The Searching Index File slots are "lesson name (unit)", "learning contents (subunit)", "used information equipment/machinery/device(s)", "used tool(s) application(s)" and "class viewpoint".

In the Feature Oriented Search, the system generates the search conditions, based on the information obtained from the user. The Searching Index File (Feature Oriented Search) employs comparison of the extracted search conditions and the database, depending on the dialogue with the user. The slots of the Searching Index File for the Feature Oriented Search mechanism are "teacher activity " and "student activity ".

Table 1 Searching Index File (Keyword Search)

index frame database basic search key

record fields	value type
ID (primary key)	*numerical value type*
lesson name (unit)	*text type (menu selection)*
learning contents (subunit)	*text type (menu selection)*
used information equipment/ machinery/ device(s)	*text type (menu selection)*
used tool(s) application(s)	*text type (menu selection)*
class viewpoint	*text type (menu selection)*

Table 2 Searching Index File (Feature Oriented Search)

index frame database feature search key

record fields	value type
ID (primary key)	*numerical value type*
teacher activity	*text type (menu selection)*
student activity	*text type (menu selection)*

3.3 Movie Explanation File

Table 3 shows the contents of the Movie Explanation File, regarding the movie features. When the user is about to commence the lesson, the points, which need his/her attention, are explained via the contents of the Movie Explanation File. These explanations are used when displaying the search results.

Table 3 movie explanation file

movie feature description video feature information)

record fields	value type
camera angle	*text type (menu selection)*
equipment existence	*text type (menu selection)*
equipment usage	*text type (menu selection)*
number of teachers	*text type (menu selection)*
teachers' movements	*text type (menu selection)*
existence learning supporter(s)	*text type (menu selection)*

number of students	*text type (menu selection)*
students' movements	*text type (menu selection)*
existence of a central student	*text type (menu selection)*

The explanation information in the Movie Explanation File (table 4) resumes the lesson scenes compiled by the video registrants, and the information on how the checkpoints, necessary for the lesson, were estimated. The slot of table 4 called "teacher's aim", corresponds, for instance, to the classification 8 presented later on in table 7.The "checkpoints 1 to 3" express the free description of the image, from the points of view shown below.

Checkpoint 1 the movie preconditions to be considered;
Checkpoint 2 what should be extracted/ understood from the current movie;
Checkpoint 3 the necessary forecast of the movie's following development.

Table explanation file

4 movie
movie explanation database

record fields	value type
ID (primary key)	*numerical value type*
teacher's aim	*text type (menu selection)*
checkpoint 1	*text type (item description · within 100 characters)*
checkpoint 2	*text type (item description · within 100 characters)*
checkpoint 3	*text type (item description · within 100 characters)*

3.4 Movie File

Table 5 shows the Movie File. The Movie File contains pointers to the real videos. The VOD server houses the real videos. Table 5 contains the Movie File slots called "thumbnail picture (still picture)", "previous movie", "movie URL (movie file name)", and "next movie".

Table 5 movie file

movie database

record fields	value type
ID (primary key)	*numerical value type*
thumbnail picture (still picture)	*text type (still movie file name)*
previous movie	*text type (URL type input)*
movie URL (movie file name)	*text type (URL type input)*
next movie	*text type (URL type input)*

For the discrete movie time-series {P(t)}, the following relationship exists:
$[P(t-1),P(t),P(t+1)]$ = [previous movie, movie URL, next movie];$P(t=0)$ ={still picture};where t is the time.

4 The system's behavior

Figure 2 shows the search conditions input interface (for Keyword Search). Figure 3 shows the search result display interface. After the (teacher) user specifies the conditions for the desired video search via the search conditions input interface, the search starts. The result of this is displayed in the search result display interface [3] [4]. This interface shows the value of the slots called " still picture", "lesson contents (subunit)", "teacher's aim", "checkpoints", "teachers' activity" and "students' activity". The "still picture" can be seen in figure 3 (). Next to being a significant snapshot of the lesson video, the still picture has also the role of a pointer to the real video (a link to the VOD video file), so describes the URL (figure 3,). By clicking on the still picture, the video starts (figure 3,). The "teacher's aim" (fig. 3,) and "checkpoints" (fig. 3,) are, as mentioned before, the most important information for image explanation. The figure also presents the (teacher) user with help/support information about other items and record fields.

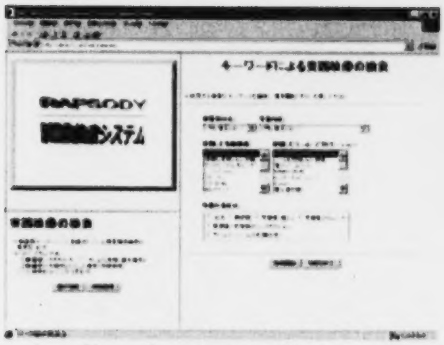


Figure 2 search conditions input picture

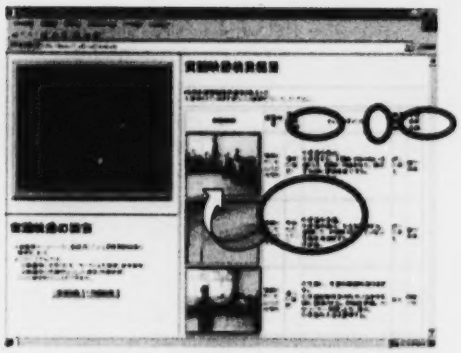


Figure 3 search result display picture

5 Conclusions

We construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education".We have presented in this paper the summary of the video search VOD system we have developed, moreover, we have shown the database organization and the system's behavior.As for the future tasks and research, we are planning to investigate about building a flexible key for the video search mechanism. We are studying at present the dialogue mechanism, with the immediate goal of using the search result's negative feedback information to the user's request, to serve as a new search key.

References

[1]Okamoto, T. (research representative/delegate) : "1998. Advanced Information Society; synthetic research on the contents, system and form of teachers' education – midway report", 1997, 9 year research funds foundation of the Ministry of Education, A)(1)09308004 stage report.

[2]Stain, A, Gulla, J.A, Muller, A. and Thiel, U.: "Conversational Interaction for Semantic Access to Multimedia Information", Intelligent Multimedia Information Retrieval, pp. 399-421, MIT Press, 1997.

[3]Noguchi, H.: "Data representation and management in image databases", IPSJ, Vol.33, No.5, pp. 457-465, 1992

BEST COPY AVAILABLE

Is a Learning Theory Harmonious with Others?

To form Effective Collaborative Learning Groups with Ontological Engineering

Akiko Inaba, Thepchai Supnithi, Mitsuru Ikeda, Riichiro Mizoguchi, and Jun'ichi Toyoda

I.S.I.R., Osaka University

8-1 Mihogaoka, Ibaraki, Osaka, 567-0047 Japan

inaba@ai.sanken.osaka-u.ac.jp

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. We propose possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

Keywords: **Ontology, Collaborative Learning, Distributed Learning Environments**

1 Introduction

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures educational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10, 11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15, 16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22, 23], Sociocultural Theory[25, 26], Zone of proximal development[25, 26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. However, it is difficult to understand all theories because these theories are derived from a wide research area including pedagogy, sociology and psychology. Moreover, we can expect different educational benefits based on these learning theories, and observe various kinds of interaction between learners through collaborative learning process. Due to the diversity, it is difficult to list the learning theories effective to gain a specific educational benefit for a learner, and to compare the theories to form a suitable collaborative learning group for the learner.

Therefore, we have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12, 14, 24]. We call the system of concepts "Collaborative Learning Ontology". Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on "Learning Goal Ontology" which is a part of the Collaborative Learning Ontology.

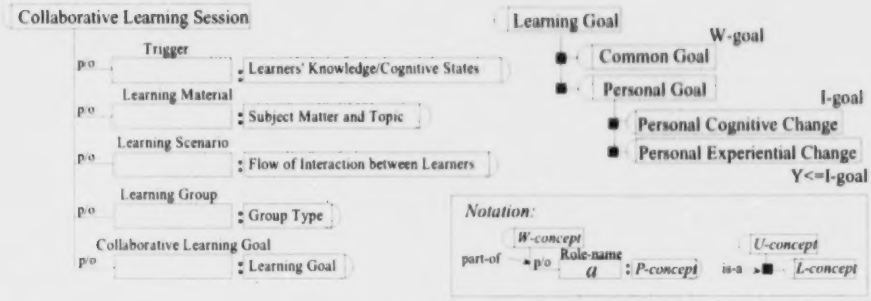


Fig. 1. Collaborative Learning Ontology

The concept "Learning Goal" is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

To help a learner obtain a specific educational benefit we can find several learning theories useful for the purpose and form different learning groups according to the theories. If the groups are merged into one, we may form a better learning group which is guaranteed its effectiveness by multiple learning theories. So, we also discuss the combination of learning groups supported by different learning theories.

This paper is organized as follows: we first show briefly the structure of our "Collaborative Learning Ontology" and "Learning Goal Ontology". Then we summarize advantages and remaining tasks: how can we narrow down candidates of learning groups into one? Finally we propose a new learning group formation formed by combining multiple learning theories.

2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 1 shows the conceptual structure of Collaborative Learning Ontology.[1] Here, we concentrate on the concept"Learning Goal" which is one of the most important concepts for forming a learning group, because each learner joins in a collaborative learning session to attain some learning goals. The "Learning Goal" can be specified as two kinds of goals: "common goal" as a whole group and "personal goal" for each learner. The concept "personal goal" can be specified as two kinds: the goal represented as a change of a learner's knowledge/ cognitive states, and the goal attained by interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal, Y⇐I-goal, and W-goal, respectively. I-goal, which is described as G:I, represents what a learner is expected to acquire. Y⇐I-goal, which is described as G:Y⇐I, represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain Y⇐I-goals and we describe the goal as G:W. W-goal is a common goal characterizing the whole group.

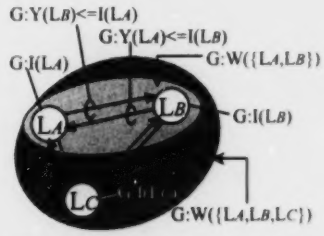


Fig. 2. Learning Goal Ontology

Fig. 2 represents learning goals in a group where three learners: L_A, $L_B$and $L_C$are participating. Learner $L_A$has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 2 as G:I(L_A). Both $L_B$and $L_C$have I-goals, and they are represented as G:I(L_B) and G:I(L_C) respectively. G:Y(L_B)⇐I(L_A) is a Y⇐I-goal between $L_A$and $L_B$observed from L_A's viewpoint. In other words, it means the reason why $L_A$interacts with L_B. Concerning this interaction between $L_A$and L_B, there is also a Y⇐I-goal observed from L_B's viewpoint. That is, it is the reason why $L_B$interacts with L_A. This Y⇐I-goal is represented as G:Y(L_A)⇐I(L_B). Both G:I(L_A) and G:Y(L_B)⇐I(L_A) are personal goals of

[1] Notation: the schemata define the W-concept and the U-concept. The W-concept has entity a, which is an instance of the concept P-concept, as a part. The entity a plays a specific role (Role-name) in the W-concept. The concept P-concept has a semicircle on the right sides. It means the concept is defined in other schema. The L-concept is a specification of the U-concept, and the U-concept is a generalization of the L-concept.

Table 1. W-goals

		W-goal	Definition	Src.
Singleton W-goal	M-P x S-S	Setting up the situation for Peer Tutoring PT	Setting up the situation where a learner teaches something to another learner.	[6, 7]
		Setting up the situation for Anchored Instruction AI	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
	S-P x M-S	Setting up the situation for learning by Cognitive Apprenticeship CA	Setting up the situation to learn knowledge or skill as an apprentice	[5]
		Setting up the situation for sharing (Meta-) Cognitive function between learners SC	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
		Setting up the situation for sharing Multiple Perspectives CF	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
	M-P x N-S	Setting up the situation based on Distributed Cognition DC	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
		Setting up the situation based on Cognitive Constructivism CC	Setting up the situation where full participants discuss problems	[19]
CW-goal		Setting up the community for Legitimate Peripheral Participation LPP	Setting up the the community of practice for peripheral participant	[15, 16]
		Setting up the situation for Observational Learning OL	Setting up the situation to share other learners' learning processes	[2]

Note: ** means an abbreviation for the W-goal.
e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

L_A. G:W($\{L_A, L_B\}$) is a W-goal of the learning group ($\{L_A, L_B\}$). G:W($\{L_A, L_B, L_C\}$) is a W-goal of the learning group ($\{L_A, L_B, L_C\}$).

We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology, Y⇐I-goal Ontology, and W-goal Ontology with justification based on learning theories.[2] We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Noman's work[15] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[15]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the Y⇐I-goal "Learning by being Taught[5]", while some learners could take another Y⇐I-goal "Learning by Observation[2]".

Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*,Three kinds of singleton W-goals and one Composite W-goal) according to their structures. To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of Y⇐I-goals. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

A learning theory generally argues the process that learners, who play a specific role, can obtain educational benefits through interaction with other learners who play other roles. The theories have common characteristics to argue effectiveness of a learning process focusing on a specific role of learners. So, we represent the focus in the theories as Primary Focus and Secondary Focus.

Primary Focus (P): a learner's role that is mainly focused in the learning theory. The learner who plays this role (P-member) is expected to gain the main educational benefit.

[2] The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.

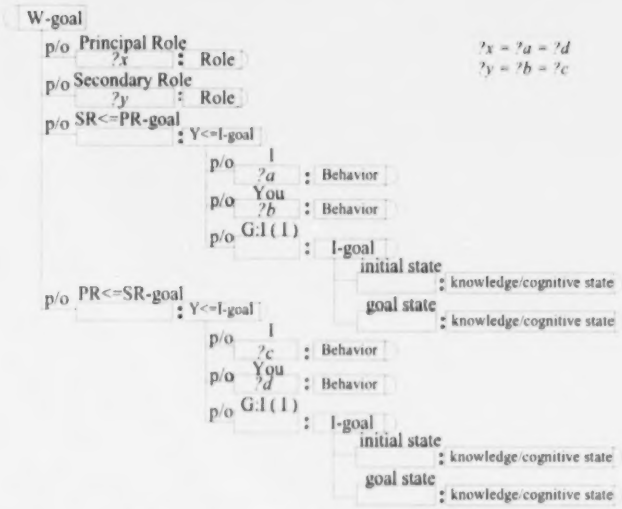


Fig. 3. Conceptual Structure of a W-goal

Secondary Focus (S): a learner's role that is weakly focused in the learning theory. The learner who plays this role (S-member) is needed as a companion to enable a P-member to attain his/her learning goals.

We classify the W-goals into the following four kinds depending on the number of the components P and S.

Singleton W-goal: Each Singleton W-goal can exist independently.

Multiple-P x Single-S: The W-goal of M-P x S-S type can have multiple P-members and single S-member.

Single-P x Multiple-S: The W-goal of S-P x M-S type can have single P-member and multiple S-members.

Multiple-P x No-S: The W-goal of M-P x N-S type has only one role for its members. In this group, each learner plays a role of companion for the other learner, while he/she gains main educational benefit.

Composite W-goal: The CW-goal includes another group as its component S.

For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6, 7]. So, P is identified as *Peer Tutor* and S is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. The number of members who play *Peer Tutee* (S) should be single, the number of members who play *Peer Tutor* (P) can be multiple, and the W-goal **PT** is identified as a M-P x S-S type.

A group attaining a W-goal(W_i) can have another group, which has another W-goal(W_j), as the component S of the W-goal(W_i). We call the W-goal(W_i) "**CW-goal**" which means a composite W-goal. Fig. 4 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has *Observers* as its component P.

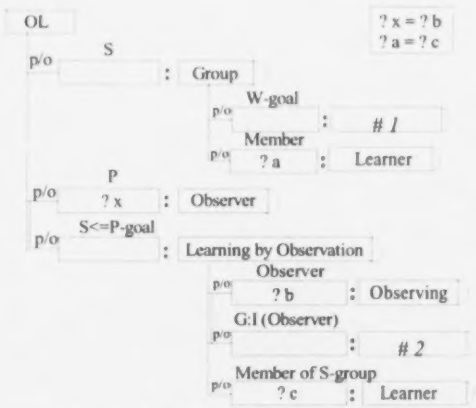


Fig. 4. An Example of CW-goal: OL

The *Observers* require a group (*i.e.*,its component S) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For example, if accretion of content-specific knowledge is set in #2 as *Observer*'s I-goal, the W-goal **PT** is recommended as S's W-goal (#1).

A W-goal has two kinds of goals of interaction as follows:

S⇐P-goal: a Y⇐I-goal which means how and for what purpose the P-member interacts with the S-member.

P⇐S-goal: a Y⇐I-goal which means how and for what purpose the S-member interacts with the P-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the S-member also has an I-goal, and the P⇐S-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y⇐I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y⇐I-goals referred to by S⇐P-goal and P⇐S-goal consists of three components as follows:

I: a role to attain the Y⇐I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y⇐I-goal.

You: a role as a partner for the I-member.

G:I: an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y⇐I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

3 Advantages and Remaining Tasks of Learning Goal Ontology for Forming an Effective Learning Group

In a traditional classroom, sometimes a teacher divides students into several subgroups, and then the students start collaborative learning in the subgroup all at once. Such collaborative learning does not ensure educational benefits for every student, because it depends on a student's knowledge/ cognitive state whether collaborative learning is effective or not, and progress in learning differs from student to student.

So, we have been proposing a network-based new learning environment to support individual learning and collaborative learning dynamically. In the environment, each learner is solving problems individually with an ITS. When the ITS detects a desired situation for a learner (triggered-learner) to shift from individual learning mode to collaborative learning mode, the ITS forms an effective learning group for the learner, and then the members of the group start a collaborative learning session. In the group, not triggered-learner but every member should be ensured to attain individual learning goals through specific interaction with the other members. To encourage the interaction, every member is assigned a specific role in the group. When the members attain their learning goals, they close the session and return individual learning mode. We call the idea of dynamic group formation *"Opportunistic Group Formation (OGF)"*.

With our Learning Goal Ontology we can represent the several group formations whose effectiveness is ensured by learning theories. It means that the ontology brings the following benefit: When a personal goal for a learner (*i.e.*,I-goal or Y⇐I-goal) is decided, we can identify learning theories which propose learning groups to facilitate that the learner attain the personal goal. And then, we can form a specific group and identify roles assigned to the members of the group according to the theory.

If there are many theories to enable a learner to attain a specific personal goal, we can form many learning groups supported by the theories as candidates. Then, we have to narrow down the candidates to one. How can we select one?

Each learner plays a specific role in collaborative learning session. Every role has necessary conditions which should be satisfied by a learner who plays the role. The conditions will work as constraints to narrow down the candidates. If there are still some candidates after checking the conditions for role assignment, there are no rules for conflict resolution between all possible learning theories.

One might want to select one of the most profitable theory-based learning groups for a learner to attain a personal goal. Every theory expresses a different learning situation. The differences between theories do not mean the differences of the degree of effectiveness, but diversity of means to attain a goal. So, it is hard to compare a theory with the others on the effectiveness for helping a learner attain a personal goal.

There is another solution of the problem for narrowing down the candidates to one. Are learning theories exclusive each other? If the candidates can be integrated into one, a stronger learning group will appear: a learner is expected to attain a personal learning goal through some kinds of interaction, and each interaction is justified by a learning theory.

4 Is a Learning Theory Exclusive or Harmonious with Other Theories?

In actual learning environment, teachers often adopt the style of collaborative learning. If the group includes a member L_A whose knowledge base and/or experiences are relatively poor, it would be difficult for L_A to discuss with other members and to solve a problem collaboratively. L_A is expected to grow into a senior through practice in the group. This type of learning group is similar to the group based on the theory "LPP" which describes a process in which a newcomer grows into a senior[15, 16]. Fig. 5 shows typical learning group formation the W-goal "LPP" where three learners: L_A, L_B and L_C are participating. As a whole group, all members solve a problem collaboratively, and L_A is regarded as a **Peripheral Participant** and $\{L_B$ and $L_C\}$ are regarded as **Full Participants**.

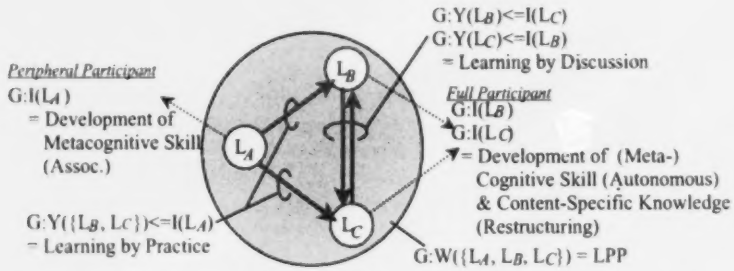


Fig. 5. An Example of Group Formation: LPP

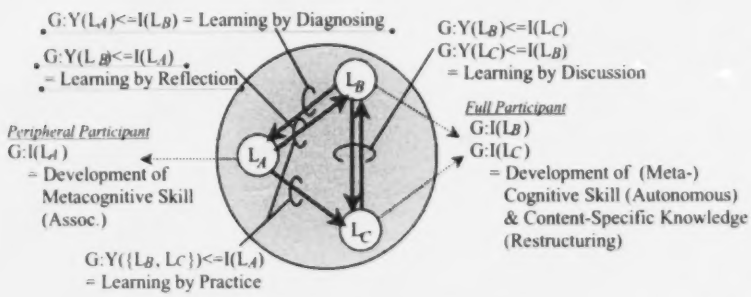


Fig. 6. An Example of Actual Learning Group

In this case, many skillful teachers will arrange for an excellent learner (*e.g.*, L_B) to help L_A in the group. For example, when a new student comes to our laboratory, a senior student may work as a tutor for the new student. Fig. 6 shows this type of learning group formation. We can find additional Y⇐I-goals between L_A and L_B in Fig. 6 as compared with Fig. 5. The teacher will expect different types of interaction between L_A and L_B, which bring additional educational benefits to them. This type of group formation can not be interpreted by a single learning theory.

In a learning group supported by "LPP", can all Peripheral Participants grow up into full participants? According to the theory "LPP", a learner (*i.e.*, Peripheral Participant) can acquire knowledge on the community and develop his/her (meta-) cognitive skills only by the learner's own practice. It is not assumed the other learners (*i.e.*, Full Participants) help the Peripheral Participant grows up. It seems that there is a gap between the Peripheral Participant and the Full Participant. Especially concerning the development of (meta-) cognitive skills, a Peripheral Participant can observe not the process in which

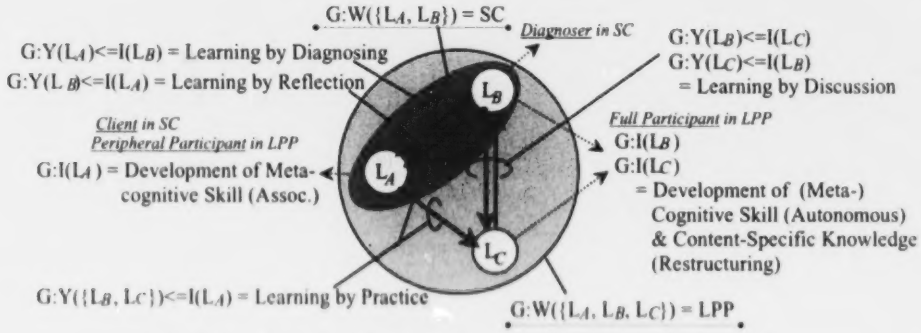


Fig. 7. An Example of Combined Learning Group: W-goal LPP & SC

a Full Participant uses the skill, but input and output for using the skill. It is difficult to learn the process by observing only input and output.

Concerning the W-goals, both W-goals "AI"[4] and "SC"[26] assume to have a "poor learner" who engages to solve a problem and a "helper" for the learner. The W-goal "AI" has a **Problem-Holder**, who has a difficulty in solving a problem, and an **Anchored Instructor**, who diagnoses the Problem-Holder's problem and gives advice to him/her. Similarly, the W-goal "SC" has a **Client**, who externalizes his/her own thinking process, and a **Diagnoser**, who diagnoses the Client's thinking process and evaluates the process. In both W-goals, a "poor learner" is expected to attain his/her I-goal, by a "helper"'s advice. Each of these W-goals can be combined with one of the other W-goals. That is, if it is difficult for a learner to attain an I-goal, we can combine the W-goal "AI" or "SC", and one of the other W-goals to help the learner attain the I-goal.

In the case of Fig. 6, we can interpret the group as a combination of two groups. One group ($Group_i$) consists of two Full Participants ($L_B$and L_C) and one Peripheral Participant (L_A). The W-goal of $Group_i$ is "LPP". Another group ($Group_j$) consists of a Client (L_A) and a Diagnoser (L_B), and the W-goal of the group is "SC". Fig. 7 shows the combination of two groups. In this learning group, $L_A$is expected to participate in the session more easily thanks to the help of L_B. For L_B, it is an opportunity for diagnosing L_A's authentic problems and helping $L_A$to participate in the collaborative learning session. Through the experience, we can expect $L_B$to develop his/her cognitive skill in two ways. For L_C, he/she will be able to get the same educational benefit with participating in the group shown in Fig. 5, because his/her activity is equal between the both groups.

For the combination of theory-based learning groups, the role of ontology is to clarify principles of combination. In combined groups, it should be guaranteed that all members can attain their own learning goals. At this stage, we store possible patterns of combining some theory-based learning groups as a pattern library. The ontology should not only represent the patterns, but also the principles which express the design rationale why the groups can be combined into one. When we can clarify the principles, an intelligent educational support system will be able to infer an effective learning group formation based on the principles opportunistically: The group formation is not picking up an appropriate one from the static pattern library. In this paper, we have described the possibility of combination the W-goal "AI" or "SC", and other W-goals. We have to consider the other types of combination.

5 Conclusions

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal, Y⇐I-goal and W-goal. In this paper, we described the outline of Learning Goal Ontology, and summarized advantages and remaining tasks for the ontology. We proposed possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

BEST COPY AVAILABLE

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*,motivation, familiarity. It is also our future work how to treat these factors.

References

1. Anderson,J.R. "Acquisition of Cognitive Skill", Psychological Review, vol.89(4), pp.369-406, (1982).
2. Bandura, A. "Social Learning Theory", New York: General Learning Press, (1971).
3. Bransford, J. D., Vye, N., Kinzer, C., & Risko, R. "Teaching thinking and content knowledge: Toward an integrated approach", In. B. Jones & L. Idol (Eds.) Dimensions of thinking and cognitive instruction. Hillsdale NJ: Erlbaum. pp. 381-413, (1990).
4. Cognition and Technology Group at Vanderbilt. "Anchored instruction in science education", In: R. Duschl & R. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice. Albany, NY: SUNY Press. pp. 244-273, (1992).
5. Collins,A. "Cognitive apprenticeship and instructional technology", In: Idol, L., & Jones,B.F. (Eds.) Educational values and cognitive instruction: Inplications for refoem., Hillsdale, N.J.: L. Erlbaum Associates, (1991).
6. Cooke, N.L., Heron, T.E., & Heward, W.L. "Peer tutoring: Implementing classroom wide programs", Columbus, OH: Special Press, (1983).
7. Endlsey, W.R. "Peer tutorial instruction", Englewood Cliffs, NJ: Educational Technology, (1980).
8. Fitts,P.M. "Perceptual-Motor Skill Learning", In: Melton,A.W. (Ed.), Categories of Human Learning, Now York: Academis Press. pp.243-285, (1964).
9. Flavell, J. H. "Metacognitive aspects of problem-solving", In L.B. Resnick (Ed.), The nature of intelligence. Hillsdale, NJ: Erlbaum. pp.231-235, (1976).
10. Ikeda, M., Hoppe, U., & Mizoguchi, R. "Ontological issue of CSCL Systems Design", Proc. of AI-ED 95, pp.234-249, (1995).
11. Ikeda, M., Go, S., & Mizoguchi, R. "Opportunistic Group Formation", Proc. of AI-ED 97, pp.166-174, (1997).
12. Inaba, A., Ikeda, M., Mizoguchi, R., & Toyoda, J. "The Learning Goal Ontology for Collaborative Learning", http://www.ai.sanken.osaka-u.ac.jp/~inaba/LGOntology/, (1999).
13. Inaba, A. & Okamoto, T. "The Intelligent Discussion Coordinating System for Effective Collaborative Learning – What is the role of artificial intelligence in supporting collaboration? –", AIED 97: Workshop Notes IV, pp.26-33, (1997).
14. Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., & Toyoda, J. "How Can We Form Effective Collaborative Learning Groups? – Theoretical justification of "Opportunistic Group Formation" with ontological engineering –", pp.xx-xx, (2000).
15. Lave, J. "Cognition in practice: Mind, mathematics and culture in everyday life", Cambridge University Press, (1988).
16. Lave,J. & Wenger, E. "Situated Learning: Legitimate peripheral participation", Cambridge University Press, (1991).
17. Mizoguchi, R., & Bourdeau, J. "Using Ontological Engineering to Overcome Common AI-ED Problems", IJAIED, 11, (2000).
18. Mizoguchi,R., Ikeda,M., & Sinitsa,K. "Roles of Shared Ontology in AI-ED Research", Proc. of AI-ED 97, pp.537-544, (1997).
19. Piaget, J., & Inhelder, B. "The Psychology of the Child", New York: Basic Books, (1971).
20. Rumelhart, D.E., & Norman, D.A. "Accretion, Tuning, and Restructuring: Modes of Learning", In: Cotton, J.W., & Klatzky, R.L. (Eds.) Semantic factors in cognition. Hillsdale, N.J. : L. Erlbaum Associates., pp.37-53, (1978).
21. Salomon, G. "Distributed cognitions", Cambridge University Press, (1993).
22. Spiro, R. J., Coulson, R., L., Feltovich, P. J., & Anderson, D. K. "Cognitive flexibility: Advanced knowledge acquisition ill-structured domains", Proc. of the Tenth Annual Conference of Cognitive Science Society, Erlbaum, Hillsdale, NJ, pp.375-383, (1988).
23. Spiro, R. J., Feltovich, P., J., Jacobson, M., L., & Coulson, R. L. "Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquistion in ill-structured domains", http://www.ilt.columbia.edu/ilt/papers/Spiro.html (1995, accessed on March 2000).
24. Supnithi, T., Inaba, A., Ikeda, M., Toyoda, J., & Mizoguchi, R. "Learning Goal Ontology Supported by Learning Theories for Opportunistic Group Formation", Proc. of AIED99, (1999).
25. Vygotsky, L.S. "The problem of the cultural development of the child", Journal of Genetic Psychology, vol.36, pp.414-434, (1929).
26. Vygotsky,L.S. "Mind in Society: The development of the higher psychological processes", Cambridge, MA: Harvard University Press, (1930, Re-published 1978).

Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

Feng-Hsu Wang
Department of Information Management
5, The-Ming Road, Gwei Shan District, Taoyuan County 333, Taiwan
Tel: +886-3-3507001 ext. 3446
Fax: +886-3-3294449
E-mail:fhwang@mcu.edu.tw

One of the creative capabilities of scientists is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data mining approach to designing learning tools in educational environments for creative science education. Specifically, students can experience knowledge discovery by engaging in collaborative data mining activities that enable students to cooperate both with the computer and the other students. Data mining process is typically made up of a set of activities such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. The learning process is modeled as a set of learning protocols that properly distribute the data-mining work among students and computers. Based on these protocols, we design and implement a set of learning tools in a web-based learning environment for global climate exploration.

Keywords: **Learning protocol, knowledge discovery, data mining, learning environment, collaborative learning, science education.**

1 Introduction

Among the creative capabilities of scientists, the most important one is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data-mining approach to creative science education in learning environments. In this data-mining supported environment, students could observe real world data in different perspectives, derive their own classification rules and test the rules collaboratively, such that they can experience knowledge discovery by engaging in collaborative data-mining activities.

In this paper, we adopt learning protocols [9] to describe the learning processes. Learning protocols are a set of constraints, rules, or processes for structuring learning processes, and are externalized as executable methods, with roles, events, and actions made explicit. Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. In this paper, we will devise a set of learning protocols that properly distribute the data-mining work among students and computers.

Based on the collaborative data-mining protocols, we design and implement a set of learning tools in the CILSE-GCE learning environment [7, 8]. CILSE-GCE is a web-based collaborative learning environment for global climate exploration. The task domain, global climate exploration, is inherently a scientific classification problem. Students are expected to induce classification rules by making observations under a couple of climatic features. These tools are designed with the intention not only to teach students the target knowledge, but also the scientific ways of study skills. We believe the students will achieve higher learning goals through the collaborative process of creating knowledge by themselves.

2 The CILSE-GCE Learning Environment

The target domain draws sources from the instructional material in the geographic climate course of senior high schools in Taiwan. One of the domain knowledge is the classification of each climate pattern, which is recognized as a specific set of the climatic attributes. In this paper, we focus on the construction of the climatic classification knowledge. Three components of the CILSE-GCE learning environment were built. They are the Virtual Classroom, Visualized Data Viewer, and Intelligent Tutor, respectively, which are outlined below.

The Virtual Classroom serves as the origin where teachers and students coordinate and collaborate. Through the Virtual Classroom, students could access the multimedia coursebase, the climatic GIS database (via the Visualized Data Viewer) and the historical literature database. These rich data sources allow students to observe, search and collect related information in different aspects regarding to the problems at hand. The CILSE-GCE environment also provides an intelligent tutor to help students induce the classification rules. During the rule induction process, a student has to identify what the settings of the relevant attributes are by exploring resources of all kinds. When he/she determines a specific set of attribute values, the intelligent tutor would evaluate the student's answer, and give suggestions to guide the student's further exploration.

A set of rich data sources are needed to allow students to observe, search and collect related information in different aspects regarding to the problems at hand. In the Visualized Data Viewer, rich climate information could be displayed in different layers of maps covering the globe. Students could select, resize and combine different information layers for display to investigate the climate attributes in different perspectives. Hotlinks to climatic data and statistical graphs associated with the typical cities are also provided to allow students to do some measurements and inferences. Up to now, we have collected more than 1700 city records of various kind of climatic information, such as latitude, temperature, precipitation, height above sea level, etc. This database is the main data source that students can collect related data and perform data-mining process to discover the classification knowledge. Figure 1 shows a snapshot of the Visualized Data Viewer.

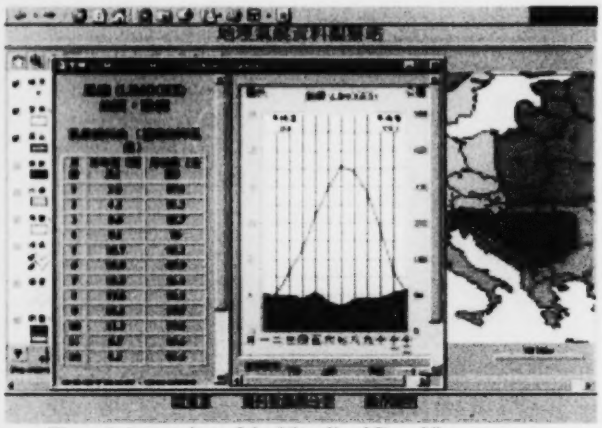


Figure1 A snapshot of the Visualized Data Viewer system.

3 Collaborative Data Mining as Knowledge Discovery

For creative science education, students are asked to acquire the learning skills of knowledge discovery, such as making observations and data collections, performing data analysis, generating hypotheses, testing hypotheses, and making conclusions. Standing from the viewpoint of knowledge discovery [2], we model the learning process as a data-mining process. Figure2 shows the set of data-mining activities, such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. Some steps of the data-mining process can be handled well with computer supports, especially those involving tedious computations and comparisons. Other steps are more suitable to be learning tasks for human students. In this section, we propose the framework of collaborative

BEST COPY AVAILABLE

data mining within which each student member first applies the data-mining process to generate his/her private knowledge base, and then all students collaboratively integrate their private knowledge bases to a more general knowledge base, a result of social consensus process.

The first step in the data-mining process is to select a target data of interest from database, and to possibly sample the target data. The learning skills required of the students are the capability of observation and data collection. Based on the aspects they observe data, students can select all relevant attributes they think might be important to the classification problems at hand. Besides, there are so many samples in the database that students have to learn the sampling skill by selecting as typical samples as they can.

Secondly, the preprocessing and data cleaning step handles noises and unknown values, as well as accounting missing data fields. This step can be dealt with quite well with computer software. Thirdly, the data reduction and transformation step involves checking relevant features depending on the goal of the learning task and certain transformations on the data such as converting one type of data to another (e.g., discretizing continuous values), and/or defining new attributes. It is this step that testifies the hypothesis of attributes that students generated at the previous data observation step.

In the knowledge formulation step, students may apply one or more knowledge discovery techniques and tools on the transformed data set to extract valuable patterns. In this step, students can learn domain-dependent skills as well as the ability to work with computers, as is practiced by most scientists nowadays. Finally, the knowledge evaluation step involves interpreting the result with respect to the goal/task at hand. And as is often the case, students may get back to previous steps based on the evaluation results. Well-designed OLAP (OnLine Analysis Processing) tools are required for students to practice such kind of data analysis tasks. Note that the data-mining process is not a linear one. It might involve a variety of feedback loops, because any one step can result in changes in preceding or succeeding steps.

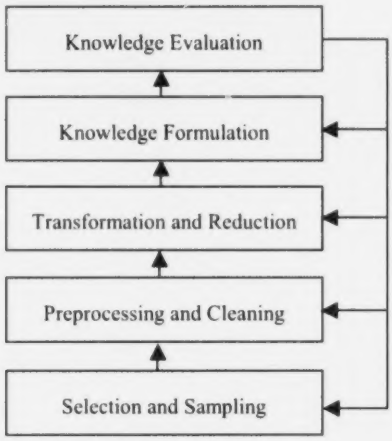


Figure2 The data-mining process.

4 Learning Protocols for Collaborative Data Mining

Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. A learning protocol consists of a set of components. First, a protocol has a name signifying the situation type to which the protocol can be applied. Secondly, a protocol consists a set of states and transitions. In each state the users can perform actions such as communicate or manipulate artifacts. A transition to another state is triggered by an action or a specific condition. Actually, a learning protocol can be represented as an event-driven state-transition graph. Thirdly, a protocol includes different roles pertaining to the persons involved in the enactment of the protocol. Finally, a protocol may contain various types of artifacts, such as text documents, graphical objects, test forms, etc. In the following, we design a set of learning protocols for the collaborative data mining process.

4.1 The protocol to construct member knowledge

The protocol shown in Figure 3 outlines the actions of personal data-mining process and coordinates the interactions between a student and the computer. There are totally ten states in the protocol. Each state and transition is described as follows. In the Observing Data state, the student observes the data in all aspects he/she consider important to classify the climatic patterns. The main data source is the Visualized Data Viewer. The student then defines a set of attributes (in the Defining Attribute state) that will be used to classify the climatic patterns. In the Sampling state, the student starts to collect data (cities) and fill in all the details of the climatic attributes that he/she had defined. Since some of the attributes are numeric values, the student has to transform them into symbolic ones (like temperature is high or low) in the Discretizing Attributes state for more data understandability.

In the Mining Rule state, students have to extract and write down the classification rules hidden in the collected data. For this purpose, we design a set of data analysis tool that depicts the distribution graph or dependency graph of the climatic data based on the attributes specified by the students, such as the ones shown in Figure 4.

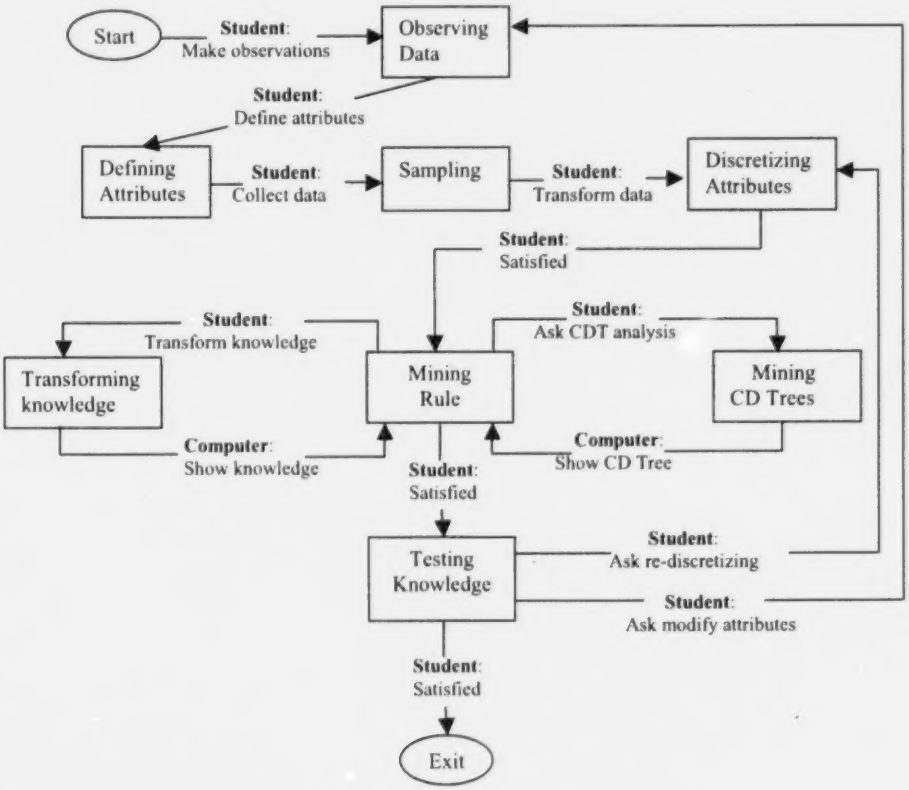
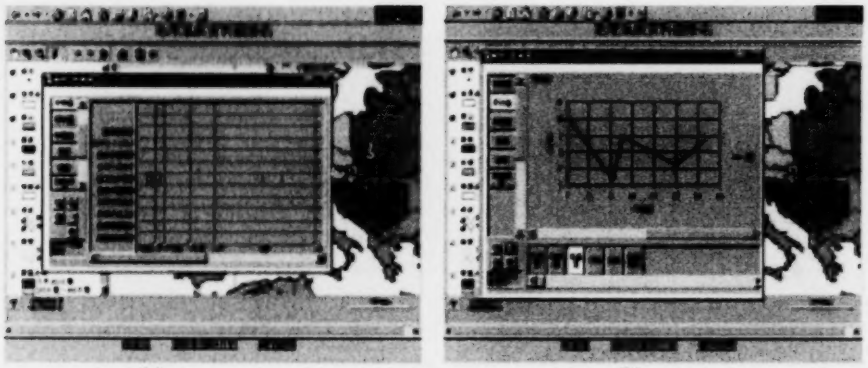


Figure3 The personal data-mining learning protocol.



(a) (b)

Figure4 (a) A data-mining support tool for comparing frequency distributions. (b) A data-mining support tool for depicting data dependency graphs.

Nevertheless, it would be still difficult for some students to discover the hidden knowledge (rules) without further computer supports. Hence, we design and implement another tool to facilitate the data-mining process in the Mining Decision Tree state. This tool uses a variation version of ID3 algorithm [4] to devise a Composite Decision Tree (CD Tree) out of the collected data. A As shown in Figure 5, students can use the CD tree to select and compose classification rules that are of more accuracy, stability and understandability. While rules provide a good local view of each knowledge unit, CD Trees provide another view that facilitates the comparison of different rule structures. . In the Transforming Knowledge state, the student can exchange the knowledge format from CD Trees to Rules, and vice versa. At last, the student can test his/her classification knowledge against the city cases in the Testing Knowledge state, and decide whether to further revise the knowledge.

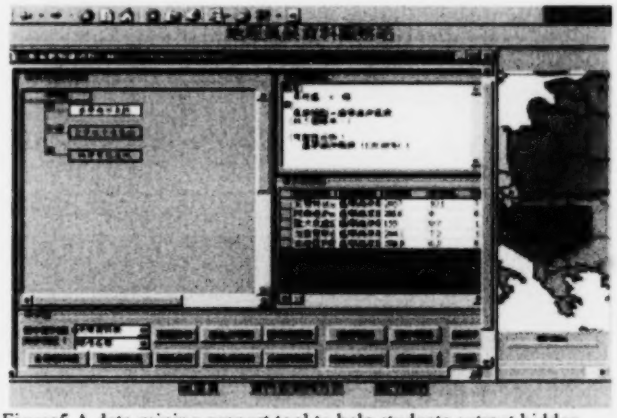


Figure5 A data-mining support tool to help students extract hidden knowledge (classification rules) from data.

4.2 The protocol to integrate group knowledge

After each student member establishes his/her own knowledge, the student group starts to perform the knowledge integration task collaboratively. The students achieve the knowledge integration goal by solving the classification problem collaboratively, trying to reach a consensus, which is the group knowledge. The corresponding learning protocol is shown in Figure 6. In the Presenting Cases state, a Coordinator (a software agent) selects a city case from the database for the student group to identify its climatic pattern. In the Classifying Case state, each student member applies his/her knowledge to solve the problem, and shows the applied rule and related information (such as the symbolic terms for each numeric attribute) in a shared

BEST COPY AVAILABLE

working space. With the information shown in the shared working space, each student member starts revising his/her own knowledge by references to the correct answers and the colleagues' knowledge. Detail of the Revising Knowledge state is described in next protocol. Each time the member knowledge is revised, a new applied rule is sent once again to the shared working space. This process will loop until a temporary consensus is reached. At last, the Coordinator store the final rule set into the integrated knowledge base (i.e., the group knowledge). We adopt the Blackboard Architecture [3] to implement this learning protocol.

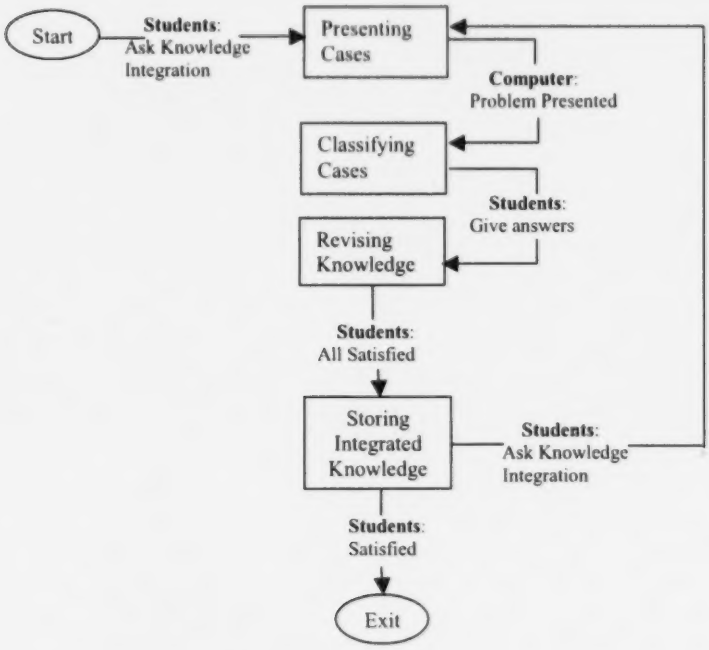


Figure6 The collaborative knowledge integration learning protocol.

4.3 The protocol to revise member knowledge

When students ask to revise his/her private knowledge, the knowledge revising learning protocol, as shown in Figure 7, is entered. In this protocol, two kinds of knowledge operations, the knowledge generalization and knowledge specialization operations, are supported. Each student member can revise his/her private knowledge by applying the two knowledge operations and/or exchange knowledge through the Group Chatting state that involves chatting-support tools. Each kind of knowledge operation can be applied to the various artifacts such as rule structures, numeric attribute intervals, and attributes. Specifically, in Knowledge Generalization state, students can delete conditions from rules, reduce numeric attribute intervals or delete some attributes from the attribute set, while in Knowledge Specialization state, the students can add conditions into rules, extend some numeric attribute intervals or add new attributes into the attribute set. To facilitate both kinds of knowledge revision, an automated rule testing and warning subsystem is implemented to list the rules that are potential for further generalization or specialization based on the test result against any data set.

5 Conclusions

In this paper, we have proposed and implemented a collaborative data-mining support tools for knowledge discovery in creative science education. These functional extensions are being integrated to our previous Web-based learning environment, CILSE-GCE. This collaborative process fosters all the constructive design

principles mentioned in [1, 5], such as observation, interpretation construction, contextualization, cognitive apprenticeship, collaboration, multiple interpretations, ownership of knowledge, self-awareness of construction process. In this collaborative learning model, students would experience the process of looking for patterns collaboratively. Besides, we find that learning protocols are very effective ways to the description and implementation of learning processes. Finally, it is indicated that during free exploration of a problem space, greater learning occurred if students adopted more systematic strategies for rule induction [6]. Further evaluation tests will be conducted to provide beneficial evidences of such kinds of discovery learning.

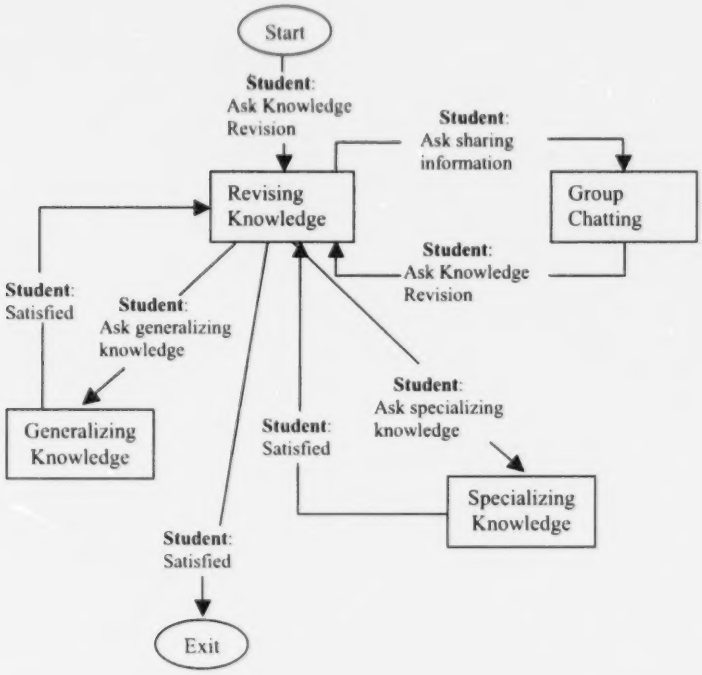


Figure7 The knowledge revising protocol.

References

[1] Black, J. B. & McClintock, R. O., "An interpretation construction approach to constructivist design". In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design" (pp. 25-32), Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[2] Fayyad, U. M., "Data mining and knowledge discovery: Making sense out of data", IEEE Expert, Vol.10, pp. 20-25, (1996).

[3] Nii, H. P., "Balckboard systems: Blackboard application systems from a knowledge based perspective", AI Magazine, Vol. 7, No. 3, (1986).

[4] Quinlan, J. R., "Induction of decision trees", Machine Learning, Vol. 1, No. 1, pp. 81-106, (1986).

[5] Honebein, P.C., "Seven goals for the design of constructivist learning environments", In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design", (pp. 11-24). Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[6] Vollmeyer, R., Burns, B. D. & Holyoak, K. J., "The impact of goal specificity on strategy use and the acquisition of problem structure", Cognitive Science, Vol. 20, pp.75-100, (1996).

[7] Wang, F. H. & Chen, C. H., "CILSE-GCE: A collaborative intelligent learning support environment on world wide web", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 264-269, (1999).

[8] Wang, F.H., "On the design of an intelligent exploratory environment for geographic climates on WWW", Computer Networks and ISDN Systems, Vol. 30, pp. 699-700, (1998).
[9] Wessner, M., Pfister, H. R. & Miao, Y., "Using Learning Protocols to Structure Computer-Supported Cooperative Learning", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 471-476, (1999).

Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language

Peter Schmidt
Department of Computer Science, University of Bonn
Römerstr. 164, 53117 Bonn, Germany
E-mail: peter@uran.informatik.uni-bonn.de

A restricted natural language is presented which is suitable for formulating mathematical proofs in the domain of calculus. A line of a proof according to the language consists of three parts: A marking, a proof statement, and a foundation of the statement. Foundations include among others the name of a theorem, the name of a concept, or a formula manipulation operation. It is demonstrated how mathematical proofs worded in that language may be automatically monitored and checked for correctness and completeness by a computer program. For that, techniques of the fields of theorem proving and of formula manipulation are applied; the lines of the original proof are transformed into a quantifier free form and checked line by line; an internal knowledge base of concepts and theorems allows for verifying proof statements which are founded by concept definitions or theorem applications. The described methods may be used in virtual or face-to-face universities for the purpose of proof exercises by students or for the purpose of automatically checking and scoring student proofs. The approach together with a medium-grained XML representation of concepts, theorems, and proofs may form the core of a learning environment which gives students the opportunity of an intensive interactive occupation with mathematical proofs.

Keywords: **Calculus Proofs, Verifying, Restricted Natural Language**

1 Introduction

Finding and constructing mathematical proofs are standard activities of persons who study mathematics or disciplines of science. For learning purposes, it would be desirable to have an interactive software system into which students could enter a mathematical proof in the usual way utilizing the natural language and the software system would monitor and verify the student's proof or provide help if needed.

From the side of the field of mechanical theorem proving, techniques and procedures are available to automatically prove theorems or check a given proof, if the theorem or the proof are worded in a formal language like first order logic or the quantifier free clause form (see e.g. [1], [5]). The main bottleneck to reach the above mentioned goal is the difficulty of processing and correctly understanding natural language input. As a solution to the problem or as a compromise we here suggest a restricted natural language to formulate proofs. The language results from an inquiry into mathematical proofs which occur in mathematical textbooks of the domain of calculus (see e.g. [8]). We chose the domain of calculus because of the importance of calculus for the edifice of mathematics and for many practical applications and because calculus belongs to the first fields which are studied at the universities.

Secondly, we discuss how proofs utilizing that restricted language may be automatically monitored and checked for correctness and completeness by a computer program. To monitor a proof, the proof is transformed into an internal form which includes the quantifier free notations of the occurring logical expressions. A proof is checked line after line like a human would do who tries to verify a given proof. The checking for correctness of the single statements relies on the techniques of the fields of theorem proving and of formula manipulation and of their combinations. Regarding the theorem proving techniques we utilize methods which are similar to the methods of Bledsoe, Boyer and Henneman to automatically prove limit theorems ([2],[3]).

Apart from providing opportunities of doing proof exercises, the described methods may be used in virtual or face-to-face universities for the purpose of automatically checking and scoring proofs of students.

Thirdly, we shortly discuss the extension of the approach to an extensive learning environment.

2 Mathematical Theorems and Proofs in the Domain of Calculus

The *subjects of calculus* include among others limits of sequences and functions, derivations of functions, determination of properties of functions, integrals, the study of special classes of functions, and many practical applications of theoretical results.

Proof methods used in calculus are multifarious and include direct proofs using the analytical definitions of concepts like limit, continuous or differentiable (epsilon-delta notation), inductive proofs, indirect proofs or proofs by counter-examples, or direct proofs utilizing chains of inferences of already proven theorems.

A large set of proofs in the domain of calculus follows a recurrent pattern. One characteristic of those proofs is the use of analytical definitions of the main concepts to establish the proof. A further characteristic of many proofs is that they employ formula manipulation methods as a central technique to establish the proof. Proofs often consist of a construction process. Those characteristics allow for monitoring proofs without a long chain of logical deductions.

3 A Restricted Natural Language to Formulate Proofs

The restricted language to word proofs is here informally described mostly by examples so that persons who are familiar with proofs of the domain of calculus can understand the scope of the various allowable statements. The language is not supposed to be exhaustive, but the current version of the language covers a large set of calculus theorems and proofs in textbooks and in collections of exercises.

The usual structure of a natural language proof in a textbook consists of a series of statements which are substantiated by one or more foundations. The statements may have a reference to other statements of the proof. The restricted language reflects that structure by dividing a proof into proof lines. Each proof line consists of up to three parts: a marking, a proof statement, and a foundation of the proof statement. By clearly separating the three parts of a proof line from each other, the variety of natural language wording reduces to a simple and easily comprehensible structure.

3.1 The wording of a proof

Basic elements of the language. There are a series of basic elements which may occur in a proof including numbers, variable names, function names, the universal quantifier (ALL), the existential quantifier (SOME), and the logical operators of negation (NOT) and of conjunction (AND). R denotes the real numbers. *Keywords* of the language generally consist of capital letters. *Intervals* play a central role in proofs and may be designated in the usual way, e.g. [a,b] for a closed interval of the real numbers, (a,b) for an open interval, or ALL x WITH |x-a|< delta for an interval with the point a in the middle of it. *Partitions of intervals* are often used in various contexts. They usually define end points and a list of intermediate points and fix the length or a maximum length of the resulting part intervals (see an example below). *Iterations* may be used in the usual way, e.g. i=0,...,n or j=1,2, ... to denote a finite or infinite sequence.

Proof statements. The current version of the language comprises the following proof statements which are described in the next paragraphs:

(1) Assignment statements. Assignment statements allow for defining new variables or functions. An assignment statement starts with the keyword LET. Examples are

LET delta = min(delta1,delta2),

where min denotes the minimum function and delta1 and delta2 are earlier defined variables, or

LET h(x) = f(x)+g(x) ALL x IN [a,b] , where the new function h(x) is defined, or

LET f : [a,b] -> R , where a function and its domains are defined.

(2) Choice statements. Choice statements describe a choice of an entity from a set of possibilities. A choice may e.g. refer to a number chosen from an interval or to a partition of an interval. A choice statement starts with the keyword CHOOSE. The format of such a statement depends on the choice situation. Simple examples are

CHOOSE eps > 0 or CHOOSE x IN [a,b].

An example which covers the choice of a partition of an interval is

CHOOSE PARTITION p OF [a,b] WITH $a=x_0 < x_1 < ... < x_n=b$ AND ($|x_i-x_{i-1}| <$ delta , i=1,...,n) ,

where [a,b] is an interval, x_i are points in the interval, and the mentioned restriction of the lengths of the intervals $[x_{i-1},x_i]$ holds.

(3) Relational statements. Relational statements, i.e. equations and inequalities, frequently occur in calculus proofs. The statements often include constraints on the appearing variables. Typical recurrent examples relate to analytical definitions of concepts and formula manipulation operations. An example which states the definition of continuity is: ALL eps > SOME delta >0 ALL x WITH |x-a| < delta: |f(x)-f(a)| < eps. Often a chain of equations and inequalities appears like ALL x IN [a,b]: |f(x)+g(x)| <= |f(x)| + |g(x)| <= M+N < INFINITY . Another simple example of a relational statement is eps/2 + eps/2 = eps , where eps is a given variable.

(4) Property statements. Property statements describe a property of an entity, e.g. the property of a function to be continuous in an interval. An example is: f IS continuous IN [a,b]. Other properties which often occur in calculus proofs are e.g. uniformly continuous, monotonously growing, or differentiable.

A series of **further statements** which often appear in a proof more or less drive or structure the proof.

(5) Proof type statements. A *proof type statement* characterizes how the proof is done, e.g. by finding a contradiction. The statement starts with the keyword PROOF TYPE and is followed by the name of a proof method from a list of proof methods, e.g.
by DIRECT, DIRECT_BY_DEFINITION, DIRECT_BY_A_CHAIN_OF_THEOREMS, INDIRECT, COUNTEREXAMPLE, SPECIALIZATION, COMPLETE_INDUCTION. The classification of the proof may be relevant regarding several aspects which are mentioned below. An example of a proof type statement is: PROOF TYPE INDIRECT.

(6) To prove statements. *To prove statements* are used to specify what must be or will be proven. There are two variants which may precede a statement: *to prove* or *sufficient to prove*. Here are examples: Let us assume that the conclusion of a theorem is: 'The function f(x) is bounded in an interval [a,b]'. Then the first line of a proof may be e.g. TO PROVE SOME m > 0 ALL x IN [a,b]: |f(x)| < m or the first line of the proof may be e.g.

SUFFICIENT TO PROVE ALL x IN [a,b]: |f(x)| < 1 . In the first case the keywords are followed by a statement which is equivalent to the conclusion of the theorem. And in the second case the keywords are followed by a statement from which the conclusion of the theorem may be inferred.

(7) Assume statements. *Assume statements* are mostly found in indirect proofs. They then state the negation of the statement of the theorem. The statement starts with the keyword ASSUME and there follows another statement. An example is ASSUME NOT [c] , where [c] denotes the marking of the conclusion of the theorem (see an example in Theorem 2 below).

(8) Contradiction statement. A *contradiction statement* states the contradiction of statements occurring in the proof. The statement starts with the keyword CONTRADICTION and its foundation contains the contradicting statements in one or the other way. An example is CONTRADICTION {[4],[6]}. The statement says that the statements marked by [4] and [6], respectively, are contradictory (see an example in Theorem 2 below).

(9) Anchor statements and **induction step statements.** *Anchor statements* and *induction step statements* serve the purpose to structure induction proofs. The statements start with the keywords ANCHOR and INDUCTION STEP, respectively. Examples are ANCHOR n = 1 and INDUCTION STEP n TO n+1.

(10) Proof finishing statement. The *proof finishing statement* consists of the keyword QED and states that the proof is assumed to be complete.

Markings. *Markings* serve the purpose to mark statements so that other parts of the proof may refer to the marked statement. The markings consist of letters and digits embraced by brackets, e.g. [A].

Foundations. A *foundation*, possibly together with other foundations, substantiates a proof statement. There are a couple of possibilities of denoting a foundation: A foundation may consist of the name of a theorem, of a formula manipulation operation, of a property of an object, or of a line number which denotes a logical line of the current proof or of the theorem. The foundation of a logical proof line is enclosed in curled brackets whereby the single foundations are enclosed in brackets and separated by commas, e.g. {[4], [5]}.

3.2 Examples of user proofs

The following examples illustrate the use of the language to formulate proofs. Note the more often occurring *double points*, e.g. one in the proof line which is marked by [2]. That double point is necessary for reasons of uniqueness to separate the prefix containing the quantified expressions from the inequality. An alternative would be to use an IF ... THEN ... statement. The foundations starting with the letters *fm* refer to formula manipulation operations, e.g. {[fm: rewriting]} in line [7]. The theorems are here not worded according to the language. A corresponding wording is necessary when the theorems and the proofs are automatically processed by a monitoring program.

Theorem 1 (Sum of continuous functions)
Let
  [p1] f: R->R, g: R->R, a in R,
  [p2] f is continuous at the point a
  [p3] f is continuous at the point a
Then
  [c] f+g is continuous at the point a

Proof:
[1] PROOF METHOD DIRECT_BY_DEFINITION
[2] TO PROVE
    ALL eps > 0 SOME delta > 0 ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a) + g(a))|< eps {[c]}
[3] CHOOSE eps > 0
[4] SOME delta1 > 0 ALL x with |x-a| < delta1 : |f(x) - f(a)| < eps/2 {[p2]}
[5] SOME delta2 > 0 ALL x with |x-a| < delta2 : |g(x) - g(a)| < eps/2 {[p3]}
[6] LET delta = min(delta1,delta2)
[7] ALL x IN R : |(f(x)+g(x)) - (f(a) + g(a))| = |(f(x) - f(a)) + (g(x) - g(a))| {[fm: rewriting]}
                <= |(f(x) - f(a)| + |g(x) - g(a)| {[fm: triangle inequality]}
[8] ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a)+g(a))| <= |(f(x)-f(a)| + |g(x)-g(a)| {[7]}
                < eps/2 + eps/2 {[4], [5]}
                = eps {[fm: simplification]}
[9] QED {[2],[8]}

Theorem 2 (Global Monotony)
Let
  [p1] f: [a,b]->R is continuous
  [p2] f is differentiable in (a,b)
  [p3] for all x in (a,b): f'(x) > 0
Then
  [c] f is strictly monotonously growing in [a,b].

Proof:
[A] PROOF METHOD INDIRECT
[B] ASSUME NOT [c] {[A]}
[C] SOME x1 IN [a,b], SOME x2 IN [a,b] : x1 < x2 AND f(x1) >= f(x2) {[B]}
[D] (f(x2) - f(x1)) / (x2 - x1) <= 0 {[C]}
[E] SOME x0 IN (a,b) : f'(x0) = (f(x2) - f(x1)) / (x2 - x1) {[Mean-value theorem]}
                > 0 {[p3]}
[F] CONTRADICTION {[D], [E]}
[G] QED

4 Monitoring and Checking User Proofs

A user may enter a proof of a given theorem utilizing the above described language. The natural language proof is then transformed into a quantifier free version. That version is suitable for applying techniques of theorem proving and of formula manipulation. Each step of the user proof is checked by one of several special procedures (see below). We will first discuss the quantifier free version of the above mentioned theorems. Then we will describe the special procedures in the context of checking the proof statements of Theorem 1 and of Theorem 2.

4.1 Quantifier Free Version of a Theorem and a Proof

To check a user proof the natural language proof is transformed into a quantifier free form. Generally, the known methods of the field of mechanical theorem proving apply to get a quantifier free version (see e.g. [1], [5]), but one has to take into account some particularities which result from the fact that the proof representation exceeds first order logic:
(i) The *choice statement* corresponds to a quantification. The identifier succeeding the element CHOOSE has to be treated as a universally quantified variable, if the constraint attached to the variable represents an interval. If the constraint represents an assignment, the variable corresponds to an existentially quantified variable. An example is: A statement "CHOOSE eps > 0" has to be treated as "ALL eps > 0".
(ii) The ranges (scopes) of the quantifiers are not explicitly given in the proof. They have to be determined according to the following rule: The range ends when another quantifier with the same variable name appears or with the last appearance of the variable name.

After having dealt with those exceptions one can apply the usual transformation procedures to the proof lines which contain quantifiers. The statements of the example proofs which contain quantifiers take the following forms (an 'a' or an apostrophe is here added to the markings of the original proof lines):

The quantifier free form of Theorem 1. Figure 1 essentially shows the quantifier free form of the proof of Theorem 1 according to the transformation procedure. We assume that the reader is in general familiar with that procedure and we only mention some modifications and specific aspects which relate to the example proof.

(i) According to the transformation procedure the quantified variable names must be replaced by unique names and the existentially quantified variables are replaced by Skolem functions. In the example, the variable *eps* of line [3] is renamed into *eps0*; *delta1* and *delta2* are replaced by the Skolem functions *d1(eps0)* and *d2(eps0)* which depend on *eps0*; *delta* of line [6] is renamed into *delta0* and defined as *min(d1(eps0),d2(eps0))*; the various variables *x* are not renamed here in the example because of readability.

(ii) The equations and inequalities are assigned a corresponding interval of validity. With that we follow the proceeding of Bledsoe et al. [2].

In addition to the quantifier free version, the monitoring program utilizes a table of the occurring objects, i.e. the functions, variables, constants, and their characteristic properties. We do not here mention further details.

```
[2a] |(f(x)+g(x)) –(f(a)+g(a))|< eps                          ; x IN ( a-delta , a+delta ),
[4a] |f(x) - f(a)| < eps0/2                                   ; x IN ( a-d1(eps0) , a+d1(eps0) ) ,
[5a] |g(x) - g(a)| < eps0/2                                   ; x IN ( a-d2(eps0) , a+d2(eps0) ) ,
[7a] |(f(x)+g(x)) –(f(a)+g(a)) |= |(f(x)-f(a))+(g(x)) –g(a)) | ; x IN R
     |(f(x)-f(a))+(g(x)) –g(a)) |<= |f(x)-f(a)|+|g(x) - g(a)|  ; x IN R
[8a] |(f(x)+g(x)) –(f(a)+g(a)) |<= |f(x)-f(a)|+|g(x)-g(a)|     ; x IN ( a-delta0 , a+delta0 )
     |f(x)-f(a)|+|g(x)-g(a)| < eps0/2 +eps0/2                  ; x IN ( a-delta0 , a+delta0 )
     eps0/2 +eps0/2 = eps0
```

Figure 1: Quantifier free version of the proof of Theorem 1

The quantifier free form of theorem 2. Figure 2 essentially shows the quantifier free form of the proof of Theorem 2. The quantities x0, x1, and x2 are existentially quantified.

```
[C'] f(x1) >= f(x2)  AND  x1 < x2
[D'] ( f(x2) - f(x1) ) / ( x2 - x1 ) <= 0
[E'] f'(x0) = ( f(x2) - f(x1) ) / ( x2 - x1 )
       (f(x2) - f(x1) ) / ( x2 - x1 ) > 0
```

Figure 2: Quantifier free version of the proof of Theorem 2

4.2 Checking a proof for correctness and completeness

The monitoring procedure of the user proof consists of checking one line of the proof after the other. The whole procedure of checking a proof falls into several special subprocedures which process the different kinds of proof statements. There are the following subprocedures which generally utilize the quantifier free versions of the original statements to process the original user statement:

PROCdef: checks the correspondence between a concept and its analytical definition
PROCfm: checks formula manipulation operations
PROClogic: checks logical manipulations
PROCassume: checks the different kinds of assume statements
PROCtoprove: checks whether the succeeding statement corresponds to the statement of the theorem
PROCtheorem: checks whether a theorem may be employed in a special situation
PROCcontradiction: checks contradicting statements
PROCqed: checks whether the theorem is in fact proven

We will describe some features of the procedures in the context of checking the example proofs and mention some more details which are not immediately related to the examples. It should be obvious that the subprocedures also apply to analogous proof steps of other theorems. With the description, we use the line markings of the original proofs (like [2] or [C]), and we do not additionally mention the corresponding line markings of the quantifier free versions (like [2a] or [C']), although the procedures actually utilize the transformed statements.

Checking Theorem 1.

Line [1] states the proof method as 'DIRECT_BY_DEFINITION'. That information will be used later when the 'QED' statement of line [9] occurs (see below).

Line [2] consists of a 'TO PROVE' statement and mentions the analytical definition of the continuity of the function f(x) + g(x) at the point a and as the foundation the conclusion *[c]* of the theorem. The subprocedure *PROCtoprove* uses the subprocedure *PROCdef* to verify that the user statement and the analytical definition of continuity correspond to each other. To check that statement, *PROCdef* uses an internally provided analytic definition of the concept of continuity. The user statement and the analytical definition are compared in the quantifier free form by a unification process. The user statement is regarded as correct when a unification is possible. *PROCtoprove* utilizes the foundation of the line [2] to establish the connection between the concept of continuity and the user definition. Line [2] is internally marked and used later when the 'QED' statement is processed (see below).

A 'TO PROVE' statement may also appear in a proof e.g. to state a lemma which will be used later in the proof. In that case no foundation would be needed and a connection to the conclusion of the theorem would not be established.

Statements which explicitly state the analytical definition of a concept or vice versa infer the concept from an analytical definition are frequently found in calculus proofs. They are all treated by the subprocedure *PROCdef* in a similar way.

Line [3] mentions the choice of an *eps* > 0. That statement corresponds to a universally quantified variable *ALL eps > 0*. The statement results in an entry into the table of the entities of the proof. No further operation happens.

The lines [4] and [5] reflect the analytical definitions of continuity of the functions f and g, respectively. The foundations {[p2]} and {[p3]} trigger the comparison with the definitions of the continuity of f and of g, respectively. The subprocedure *PROCdef* establishes the correctness of the user statements as in the case of line [2]. In order to deal with the *eps/2*, in contrast to the usual *eps* without any factor, a generalized version of continuity is used: *SOME M >0 ALL eps>0 SOME delta>0 ALL x WITH |x-a|<delta: |f(x)-f(a)| < M* eps*. A suitable factor of *eps* in the middle of the proof is often the key with continuity proofs to assure a neat < *eps* without a factor when the proof is finished. The reader will know that.

Line [6] defines the variable *delta* and its value by an expression. The statement results in an entry into the table of the entities of the proof. No further operation happens.

Line [7] gives rise to an equation and an inequality. According to the mentioned foundations, the subroutine *PROCfm* uses a simplification process to check the first equation and a *triangle inequality* subprocedure to check the second relation. Formula manipulation operations play a central role with proofs in the domain of calculus, so corresponding methods need to be available.

Line [8] divides into three relations. The first inequality is an immediate consequence of [7]. *PROCfm* checks their correspondence by standardizing the inequalities and by establishing that the interval mentioned in the line [8] is contained in the interval R of [7].

The second statement resulting from [8] establishes the statements of [4] and of [5] as foundations. *PROCfm* uses *evaluation heuristics* to handle the check of the correctness.

The third relation resulting from [8] only needs simplification which is also done by *PROCfm*.

Line [9] states that the theorem is proven. In the case of a *direct proof* one expects that the conclusion of the theorem will explicitly or implicitly occur as an inference within the proof, usually at the end of the proof. The subprocedure *PROCqed* processes the proof type of the line [1] and uses the preceding 'TO PROVE' statement which was already recognized as equivalent to the statement of the theorem to check whether the relation of the line [2] is fulfilled by the statement of line [8]. Therefore *PROCqed* uses *PROCfm* and a unification process is again employed. *PROCqed* recognizes that the proof is complete.

Checking Theorem 2.
Line [A] states the proof method as 'INDIRECT'. That information will be used later when the 'QED' statement of line [G] occurs (see below).

Line [B] mentions an 'ASSUME' statement which contains a negation of the conclusion of the theorem. The subprocedure *PROCassume* recognizes that one part of the contradiction, i.e. the part referring to the conclusion of the theorem, is established.

An 'ASSUME' statement may also be used to state something which will be proven later. That corresponds to an alternative use of the 'TO PROVE' statement.

The statement of line [C] is an immediate inference of the mentioned foundation [B]. The subprocedure *PROClogic* verifies that the statement of line [C] logically follows from the logical formula NOT [c] .

The statement of line [D] is an immediate consequence of its foundation [C]. *PROCfm* uses *evaluation heuristics* to handle the check for correctness.

Line [E] divides into two relations. The first relation consists of an application of the Mean-Value Theorem. The subprocedure *PROCtheorem* proves the correctness of the line by checking whether the premises of the mentioned theorem are fulfilled. *PROCtheorem* uses an internally provided version of the theorem. The second relation is an immediate consequence of the premise [p3] and checked by *PROCfm*.

Line [F] is founded by the statements of the lines [D] and [E]. The subprocedure *PROCcontradiction* uses *PROCfm* to check the contradiction.

Line [G] states that the proof is complete. In the case of an indirect proof one expects that a contradiction occurs and that one part of the contradiction is an inference of the negated conclusion of the theorem and the other part is a valid statement which was inferred. *PROCqed* processes the proof type of the line [A] and uses the preceding 'ASSUME' and 'CONTRADICTION' statements to verify that the proof is complete.

Error handling. In a *positive* case, a user proof can be recognized as correct and complete, that means that the occurring statements can be inferred using the corresponding foundations and that the sequence of statements actually proves the conclusion of the theorem. In a *negative* case, several types of light or severe errors may occur. From the perspective of a monitoring system which checks the various proof lines there may happen three cases in connection with each proof line:
(i) *The correct case*: The monitoring program can recognize that a statement can be inferred by using the given foundations. That positive case includes the possibility that a minor error occurred which can be clarified by a dialogue between the system and the user. The list of minor errors includes syntactical errors (e.g. regarding the language or any mathematical formula) or a lacking foundation which can be completed by the system. The completion may be possible e.g. in the case that the foundation of an obvious formula manipulation operation is missing or a reference to a preceding proof line is missing.

(ii) *The error case*: The monitoring program detects e.g. a logical error, an incorrect formula manipulation transformation, an unallowed application of a theorem, a premature 'QED' statement or no 'QED' statement. In that case the system can supply a hint to the user and the user gets the opportunity to correct the error.

The feedback in the case of multiple errors in a single statement depends on the way in which the errors are interconnected. Generally, the error possibilities are multifarious. Some multiple errors can be handled one after the other, e.g. when there are two errors in a formula. The hint that the formula is not correct may make the user rectify one error, so that only one is left.

Let us consider another example: A user enters the wrong name of the theorem which he applies and the application of the theorem is also wrong. The system would try to apply the mentioned theorem and two outcomes are possible: (a) The theorem cannot be applied or (b) the theorem can be applied. In the case of (a), a hint that the theorem is not applicable could help the user to recognize that he entered a wrong theorem name. In the case of (b), the system would state the conclusion of the theorem application. The user might then also recognize that the theorem name is wrong. In those cases the double error is reduced to one error.

(iii) *The unclear case*: The monitoring program cannot decide the correctness of a proof line. Various reasons may be responsible for that. One reason is that an important foundation is missing, e.g. a reference to the theorem which was used , so that the monitoring program cannot infer the user statement. Other reasons refer to the performance of the mentioned subprocedures: They may not be able to verify a correct statement or falsify a wrong statements in certain situations. Such a case suggests to expand the monitoring program.

5 Applications and Extensions and Pragmatics

The above described approach may be utilized for different purposes by different groups in educational institutions. Students have the opportunity to occupy themselves with mathematical proofs and do exercises which may be immediately checked for correctness and completeness.

On the other hand virtual or face-to-face universities may employ such methods in automatic on-line test systems. Proofs delivered by students could be automatically checked and scored. While students construct a proof the system might give hints in the case that foundations are missing, that there are syntactical errors, that the sequence of inferences is not complete, that a statement is just wrong, or that the student is lacking an idea how to prove the theorem. Dependent upon the amount of hints or help provided the software system might decrease the score gained.

The language as it was described above does not contain a set of symbols which are frequently used in theorems and proofs, as e.g the notation for limits, sequences, sums, integrals, or the faculty function. To integrate them one may use the notations of MathML [9]. A closer look at the proofs which are found in the text books of calculus suggests that a large set of the proofs can be worded using the above outlined language when one assumes that the usual mathematical symbols are available and some more extensions are done.

The described approach of verifying proofs demands an internal knowledge base of the concepts and theorems of calculus when proof statements are founded by concept definitions or theorem applications. Such a collection will sensibly use XML as a representation language (see e.g. [6]). See an XML representation of a theorem and of a proof on the website [7]. By utilizing that knowledge base an extensive learning environment which deals with mathematical proofs may be developed. Some aspects related to getting support with finding and constructing proofs are: One may retrieve theorems having the premises which may be used with the proof. One may retrieve a list of proof ideas of the domain and discover the one which may be useful in the current context. The roughly outlined approach to a learning environment stresses the personal proof finding and proof construction activity. A different approach to a learning environment in the field of mathematical proving relies on a general, interactive theorem prover [4].

It is obvious that one has to get used to entering a proof in the restricted natural language. An adequate interface may help to reduce the cognitive overload. Another option is to further develop the language, so that the proofs may be entered in a less restricted way and look more like textbook proofs. Such proofs might then be transformed into the restricted natural language. It is clear that the students would use such a verifying system only when the advantages outweigh the disadvantages. Some advantages are the confirmation of correctness and completeness or the detection of errors and the option of getting help.

6 Conclusions

A restricted natural language to formulate mathematical proofs in the domain of calculus was presented. It was demonstrated how mathematical proofs worded in that language can be transformed into an internal representation and checked for correctness and completeness. Some educational applications were mentioned. The extension to a learning environment was roughly outlined.

Our current prototype of verifying proofs includes an interface to enter natural language proofs, some procedures of theorem proving and an own formula manipulation system. The prototype will be further developed with respect to the methods and the knowledge bases.

References

[1] Bibel, W., "Automated Theorem Proving", Vieweg, Braunschweig, Germany, (1987).

[2] Bledsoe, W.W., Boyer, R.S., Henneman, W.H., "Computer proofs of limit theorems", Artificial Intelligence 3, pp. 27-60, (1972).

[3] Bledsoe, W.W., "Non-resolution Theorem proving", Artificial Intelligence 9, pp. 1-35, (1977).

[4] Buchberger, B., Jebelean, T., Vasaru, D., "Theorema: A System for Formal Scientific Training in Natural Language Presentation", Proceedings of the Tenth World Conference on Educational Multimedia and Hypermedia (ED-MEDIA/ ED-TELECOM 98), Freiburg, Germany, June 20-25, pp. 174-179, (1998).

[5] Chang, C.-L., Lee, R.C., "Symbolic Logic and Mechanical Theorem Proving", Academic Press, NY, (1973).

[6] Goldfarb, C.F., Prescod, P., "The XML Handbook", Prentice Hall PTR, Upper Saddle River,NJ, USA, (1998).

[7] XML representation of a theorem and of a proof, http://www.cs.uni-bonn.de/~peter/ICCE2000example.html

[8] Smith, K.T., "Primer of Modern Analysis", Springer Verlag, New York, (1983).

[9] Mathematical Markup Language (MathML) 1.01 Specification, http://www.w3.org/TR/REC-MathML.

Multimedia Intelligent Tutoring System for Context-Free Grammar

Rhodora L. Reyes, Carlo Paolo T. Galvey, Marie Christine D. Gocolay, Eden M. Ordona and Conrado del Rosario Ruiz
Software Technology Department, College of Computer Studies
De La Sane University, Manila
2401Taft Ave., Manila
Tel: (632) 5244402, (632) 5364278
Email: ccsrlr@dlsu.edu.ph

CFG-MINTS is a multimedia intelligent tutoring system that teaches context-free grammar. The tutor model of his ITS is composed of a set of teaching strategies and an algorithm that determines which teaching action to be deployed given the goals of the system and the current state of the student model. The student model uses the Constraint-Based Modeling (CBM) approach in diagnosing the learner. CBM reduces the complexity of student modeling by focusing on the difference of the student' s solution to the ideal solution only and the analysis is reduced to pattern matching. The assumption here is that there can be no correct solution of a problem that traverses a problem state, which violates the fundamental ideas, or concepts of the domain. The system also includes features for simulating the created context-free grammar to aid in teaching.

*The paper was not available by the date of printing.

Natural Language-like Knowledge Representation for Multimedia Educational Systems

Eva Heinrich and Ray Kemp
Institute of Information Sciences and Technology
Massey University, Palmerston North, New Zealand
E-mail: E.Heinrich@massey.ac.nz R.Kemp@massey.ac.nz

The appropriate use of multimedia is becoming increasingly important in computer teaching systems. Not only are students stimulated by being presented with information in a variety of forms, but such an approach also more closely resembles the real world where they have to assimilate what they see and hear, abstracting out what is relevant. With the diversity and amount of multimedia material that may be present in these systems, a powerful form of knowledge representation is required to support navigation and knowledge retrieval. The (human or computer) tutor may wish to refer to document segments, to recap important points, provide feedback, give hints and so on. The student also may wish to refer to items previously seen or heard. The Flexible Structured Coding Language, FSCL, is a natural language-like, formalised description language which allows the formulation of rich yet structured sentences. These sentences are attached to segments of multimedia documents. FSCL provides an easily accessible approach for knowledge representation, precise and rich description of complex contents, correct and complete retrieval within the descriptions, and retrieval across data of different media types. FSCL can be extended to integrate ontologies, inference of knowledge and freeform querying performed by the learner.

Keywords: **Multimedia, knowledge representation**

1 Introduction

Computer-based educational systems have developed from standalone applications, using mainly text and graphics, which focused on teaching a restricted set of subjects or skills. Today's multimedia systems are often distributed across the web using a client-server approach and aim to integrate teaching material from multiple subjects areas. These systems collect feedback on the progress of the learner and attempt to provide material at the appropriate levels. An example of such a system is GENTLE [5].

Beside the technical challenges of managing such a system, a number of conceptual ones arise. One of these is knowledge representation and the related issue of knowledge retrieval. One problem with supplying a learner with a flexible learning environment is the need to provide a mechanism for locating appropriate information. This is a non-trivial task considering the vast amount of diverse material stored and the complexity of the concepts incorporated into the learning material. Another requirement is to give the learner a mechanism for questioning the system. This can be for retrieving specific material or for asking conceptual questions concerning the subject area.

To illustrate some of the requirements for a computer-based educational system, consider a small scenario. Imagine a web-based teaching module on the use of machinery. This module could consist of a number of multimedia documents: for example, a video showing an instructor demonstrating the use of the machinery, a set of images displaying various technical features of the machinery or a set of text documents explaining various procedures. These multimedia documents, annotated with appropriate knowledge representation mechanisms and generic domain knowledge, have to be stored. Based on this information a range of material could be retrieved: a segment of the video document showing the instructor demonstrating a specific task; additional information from images or text documents relating exactly to this task; the status of

the machinery at a specific position in the video inferred from the domain rules.

After a brief overview on current approaches to knowledge representation in computer-based educational systems, we consider how the Flexible Structured Coding Language, FSCL [9,11], may be applied to this problem. We will first describe FSCL in the form it is used in its original context of studies of human behaviour and then discuss the advantages of using FSCL in computer-based educational systems. We then suggest some modifications to FSCL to provide extended support for computer-based educational systems and conclude the paper by summarising the contributions this natural language-like approach to knowledge representation can give us.

2 Current approaches to knowledge representation

To access the appropriate information in a computer-based educational system, a knowledge representation scheme is necessary. This provides a meta-level description of the contents of the educational system. In this paper, we consider the format of this meta-level description, not its technical realization in a database or file system. Before we describe some common approaches to meta-level description, we want to briefly discuss why a meta-level description is necessary and why it is not possible to extract the information directly from the learning material.

The retrieval of information from documents directly has limited scope both on a technical and on a conceptual level. Technically, searching through text based documents is easy and allows for identification of keywords, phrases or sentences. Achieving the same level of retrieval for video documents is much harder. Techniques exist to automatically parse video documents to detect scene changes [8, 23] and objects [6, 17]. However, a number of problems still have to be overcome to provide sufficient access to video content [13].

Setting the technical difficulties in accessing video or audio documents aside, there are still conceptual considerations which will demand some meta-level description of content. Retrieving appropriate information from a collection of documents will, in many cases, require access to the semantics of these documents. Searching through these documents on a keyword (or object) basis is unlikely to produce satisfactory results [2]. The transition of factual ('she was smiling', a smiling face, a sunny picture) to conceptual (happiness, pleasant atmosphere) information has to be made to access the semantics of a document. This is not possible without some meta information or description of these documents.

A number of approaches are used to facilitate the access to the semantics of documents in preparation for information retrieval. Ontologies provide a modelling scheme for a specific domain creating a shared vocabulary for the description of contents [4]. Topic maps [22] create organising principles for information by defining topics, the associations of topics and the occurrence of topics in documents. Conceptual graphs [20,21] capture knowledge about a specific domain and make this knowledge accessible to deduction using first order logic.

In the analysis of data in the social sciences, a *description* approach is common. Codes or annotations, called descriptions, are attached to specific locations of multimedia documents to assist retrieval. These can contain any kind of factual or semantic descriptions of the documents' contents. Domain specific codes or freeform textual annotations are common in analysis programs like The Observer [16], Nudist [18] or its successor, NVivo [19]. All the approaches mentioned above have been proposed to overcome the technical and conceptual difficulties of accessing the information contained in multimedia documents and to facilitate the retrieval of appropriate information. In this paper, we propose the use of FSCL as a meta-level description mechanism. In the next section we introduce the main features of FSCL. We follow this by a discussion of its advantages for knowledge representation and retrieval, and indicate how FSCL can be combined with ontologies and conceptual graphs.

3 Knowledge representation using FSCL

FSCL is a natural language-like description language. It aims to combine the expressiveness and flexibility of natural language with the rigour of formalised approaches. The main components of FSCL are its *vocabulary*, *grammar* and *categories*. The vocabulary can be freely defined by the author of the teaching material. Any word can be used and the vocabulary can be extended at any point of time. Whereas the vocabulary is likely to be defined for a specific domain, the grammar is generic. It is designed to formulate 'subject - verb - object' and 'concept - object' sentences and combinations of these elements, including

conjunctions, prepositions, adjectives and adverbs. The role of the categories is to bridge the vocabulary and the generic grammar. The grammar is defined on the categories. Each word of the vocabulary has to belong to exactly one category. This construct allows for the structure of the description language to stay the same across applications in different domains. The categories of FSCL have been defined in accordance with the word classes of the English language. The categories are: Person/Thing, Activity, Concept, Conjunction, Preposition and Descriptor (which combines the word classes adjective and adverb).

FSCL has been incorporated into an information system to support the analysis of multimedia documents, called PAC [12]. Sentences formulated with FSCL can be, in a system like PAC, attached to a segment of a multimedia document. The sentences, together with document identifiers and segment specifications are stored in a database and later used for retrieval. Because the structure of the FSCL sentences is well known, it is possible to access the semantics of the information stored. The retrieval of information from FSCL descriptions is achieved using the Flexible Structured Query Language, FSQL [9].

FSQL provides three layers for querying: the first layer is based on the properties of FSCL and allows the correct and complete retrieval of information from the description sentences; the second layer provides for Boolean combinations within sets of description sentences; the third layer accesses the properties of the multimedia document segments attached to the FSCL sentences and facilitates time and position comparisons. More detailed information on FSCL and FSQL can be found in [9]. Specific information about information retrieval across multiple media formats is given in [10].

4 Advantages of using FSCL

The most convenient and expressive language available to us is natural language. Yet looking at knowledge retrieval with computer systems, natural language poses a range of well known and not yet fully solved problems. The main problem lies in the vast amount of implicit knowledge necessary to see words in the right context and to fully understand a sentence [21]. Various large scale projects are underway to attack these problems, like WordNet [15], an ontology for natural language processing, and the Cyc system [14], attempting to construct a 'complete' ontology of the world. Our approach is far less ambitious. We acknowledge that using full natural language for knowledge representation and retrieval would be highly desirable. Yet with the enormous difficulties associated with this approach we were looking for a much simpler solution. FSCL provides us with a number of advantages:

- We have a natural language-like notation. Any FSCL sentence can immediately be understood by a human reader. The importance of this is confirmed in the discussion of the five principles of knowledge representation by Davis *et al* [3].

- We have a language and can deduce the structure of our sentences. We have therefore more power than with the keyword approach commonly used in information retrieval, which suffers from low precision and low recall [21].

- We can build a powerful vocabulary by integrating the FSCL categories with ontologies.

- Of special interest to computer-based educational systems is that we can link our form of knowledge representation with multimedia documents.

FSCL has been successfully used to support the study of behaviour recorded in multimedia documents. It has given analysts the possibility to create rich descriptions of behaviour and to analyse the descriptions in a precise way [9]. We want to keep the main features of FSCL in formulating natural language-like, structured and flexible sentences attached to multimedia documents. Further, we want to adapt FSCL for a more general use in knowledge representation and retrieval. Our ideas in this direction are presented in the next sections of this paper.

5 Proposed extensions

We want to indicate several areas of possible changes and extensions to FSCL: changes to its categories and grammar forms; extensions to include ontologies; conversion of FSCL sentences to conceptual graphs to facilitate inferencing; and the introduction of freeform querying.

5.1 Changes to categories and grammar of FSCL

As described in section 3, the FSCL categories and grammar have been designed to formulate sentences of the forms 'subject - verb - object' and 'concept - object' in the context of studies of behaviour. To simplify the construction of the vocabulary, adjectives and adverbs have been combined in the FSCL category 'Descriptor' [9]. Adhering to the general FSCL principle of having a formal grammar on fixed, defined categories we are currently investigating a number of changes to FSCL to adapt it to a more general use in knowledge representation. The exact format of the changes has to be determined through applying FSCL in a range of web-based educational systems. Our current thinking centres around the following topics:

- We are investigating changes to the FSCL categories. Merging the categories Person/Thing and Concepts to a more general category, Noun, would address the potential conflict between abstract and concrete terms (see the discussion about the abstract term 'students' and the specific individuals in section 5.3). The category 'Descriptor' could be split up into separate categories of 'Adjectives' and 'Adverbs'. The grammar of FSCL had to change accordingly to accommodate the different roles of adjectives and adverbs within a sentence. The advantage over the current approach in FSCL would be that with this change adverbs could be positioned correctly as in natural language English sentences.

- In natural language, words occur in different grammatical forms in different roles in a sentence ('the instructor *starts* the motor'; 'the motor is *started*'). The current FSCL has a strict separation between its categories. While a word can be defined in its derivations in multiple categories (Activity: starts; Descriptor: started), it is not possible to create a semantic link between the different word forms. We are looking at introducing such a link together with a meta-level grammar to be able to detect semantic equivalence between sentences with word derivatives in different parts of speech.

- The grammar of FSCL could be extended to recognise a wider range of sentence structures. Clausal variations like imperatives ('Start the motor!') or questions ('Is the motor running?') can be introduced. Conditional sentences of the form 'if C then S' would support inference as outlined in more detail in the following section. A wider range of sentence structures recognised correctly by FSCL would increase the potential for knowledge retrieval and inference.

5.2 Extension to use ontologies

FSCL uses hierarchies to define the words of the vocabulary. These hierarchies are defined within the FSCL categories. They are used to group related words and to allow for a retrieval of information on different levels of granularity. These hierarchies, as they are currently used in FSCL, can be seen as simple forms of ontologies. While a number of issues have to be addressed to base FSCL on more substantial ontologies, none of these seems to pose a real problem.

- Users of FSCL define the vocabulary they need for their particular domain. The experience, so far, as reported in [9], show that users define their vocabulary as multiple hierarchies within each FSCL category. These hierarchies could be joined under the FSCL category name to build one ontology within each FSCL category.

- An ontology typically moves from the abstract to the concrete, from concepts to instances. The vocabulary in FSCL is organised in the same way. In a study on 'learning to read', e.g., individual students' names were grouped under the term 'students', individual teachers' names under the term 'teachers' [9]. A term like 'students' contains two components: it has an abstract component in describing a group of the population in general with the property of 'attending school to learn'; it has a concrete component in grouping together specific, named individuals. In the current uses of FSCL this distinction has not caused any problems.

- Not all FSCL categories contain vocabulary which necessarily should be structured as ontologies. While it can be of advantage to organise the vocabulary in the FSCL categories 'Conjunction' and 'Preposition' in hierarchies these words will not build ontologies as they not define 'categories of the world'. Yet the coexistence of ontologies and hierarchies in the vocabulary of FSCL should not create a difficulty.

5.3 Conceptual graphs and inference

FSCL is an easy to understand and effective scheme for an author to create their own vocabulary and use it

together with the grammar for describing the contents of a multimedia document such as a video. Currently, knowledge retrieval is performed using the complementary query language FSQL. FSQL addresses the grammatical structure of FSCL sentences, takes advantage of the hierarchy information built into the vocabulary, and offers Boolean, time and sequence query options. However, there is no deductive feature in this scheme which would allow us to be able to infer facts or relations that are not explicitly stated. For example, given the statements:

If anyone starts the motor then the motor is running

The instructor starts the motor

which describes the situation in a training video then we may wish to be able to answer the question:

Is the motor running?

To be able to function at this level, we need the power of a first order logic system. Conceptual Graphs, CG, [20] give us this power.

Our proposal is that the user should describe their domain in terms of FSCL. The statements in this language can then be automatically translated into a CG format. This process is quite straight forward since FSCL is unambiguous, allowing many of the problems of natural language translation to be circumvented.

When a query is made, or some information needs to be located within the document segment then an initial attempt can be made to do this by using FSQL. If this fails then the deductive power of the CG representation is invoked. Standard theorem proving techniques within CG would enable us to check the veracity of a statement. As a bonus, we would get a step-by-step justification of the result proved, similar to the explanation given in expert systems.

5.4 Freeform Querying

Based on a limited yet flexible vocabulary and on a limited grammar, as offered by FSCL and FSQL, a query system can be developed which allows the user to pose questions to the educational system. As the structure and the vocabulary of these questions is known, the educational system can 'understand' these questions. Questions can be mapped against a repository of previously asked questions. If a semantically equivalent question is stored, the corresponding answer is retrieved and presented to the user. If a semantically close question is stored, this previously asked question can be used to facilitate the answering of the new question. As questions and knowledge representation are constructed by the same underlying mechanisms a mapping from question to knowledge representation is possible. This can be used to assist the answering of questions based on the knowledge descriptions and to find the appropriate segments of the multimedia teaching material.

The approach presented here does not attempt to answer any natural language question but a restricted set. The vocabulary is restricted to allow the construction of meaningful questions in a particular domain. The grammar is restricted to allow the construction and comparison of meaningful questions based on the vocabulary. The grammar is generic as it is based on categories which are used to organise the vocabulary across domains. The restriction of vocabulary and grammar distinguishes this approach from the AskJeeves [1] search mechanism. The existence of a grammar distinguishes this approach from keyword based search mechanisms as used in library systems or by internet search machines.

The general idea is to provide the user with specific answers to questions. These answers are retrieved from a body of stored answers only if semantic equivalence can be guaranteed. If semantic closeness is detected the relevant questions with their answers are given to a human operator who then decides on the suitability of the match.

6 Conclusions

In this paper we have considered the need for a knowledge representation mechanism for computer-based educational systems. We have first indicated a number of commonly used mechanisms and have then discussed the Flexible Structured Coding Language, FSCL. We have suggested that FSCL provides an effective mechanism for knowledge representation and subsequent knowledge retrieval, based on the nature of FSCL as a natural language-like description language which allows for flexible, rich yet structured description of learning concepts. As extensions to FSCL we have suggested the integration of more substantial ontologies, the conversion of FSCL sentences into conceptual graph structures and the introduction of freeform querying.

References

[1] AskJeeves, http://www.aj.com/index.asp (accessed on February 2, 2000).

[2] Davenport, G., "Indexes Are 'Out', Models Are 'In'", IEEE Multimedia, Fall 1996, Vol. 3, No.3, pp.10-15, (1996).

[3] Davis, R., Schrobe, H. and Szolovits, P., "What is knowledge representation?" AI Magazine, 14:1, pp. 17-33, (1993).

[4] Decker, S., Erdmann, M., Fensel, D. and Studer, R., "ONTOBROKER: Ontology Based Acess to Distributed and Semi-structured Information", Proceedings of Eighth Working Conference on Database Semantics, Semantic Issues in Multimedia Systems, R. Meersman, Z. Tari and S. Stevens (Eds.), Kluwer Academic Publishers, Boston, (1999).

[5] GENTLE, www.gentle-wbt.com (accessed on April 10 2000).

[6] Gong, Y., Zhang, H. Chuan, H. C., Sakauchi, M., "An Image Database System with Content Capturing and Fast Image Indexing Abilities", Proceedings of the International Conference on Multimedia Computing and Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

[7] Grossmann, R., "The Existence of the World, An Introduction to Ontology", London: Routledge, (1992).

[8] Hampapur, A., Jain, R., Weymouth, T. E., "Production Model Based Digital Video Segmentation", Journal of Multimedia Tools and Applications, 1, 9-46, Kluwer Academic Publishers, Boston, (1995).

[9] Heinrich, E. A., "Multimedia Information System for the Support of Studies of Behaviour", Doctoral Dissertation, Massey University, Palmerston North, New Zealand, (1999).

[10] Heinrich, E. and Kemp, E., "Description and Retrieval across Multiple Media Formats", 4th International Workshop on Query Processing and Multimedia Issues in Distributed Systems, DEXA'00, IEEE Computer Society Press (2000).

[11] Heinrich, E., Kemp, E. and Patrick, J.D., "A Natural Language Like Description Language", 10th Australasian Conference on Information Systems (ACIS), B. Hope and P. Yoong (Eds.), School of Communications and Information Management, Victoria University of Wellington, Wellington, New Zealand, pp. 375 – 386, (1999).

[12] Heinrich, E., Patrick, J.D., and Kemp, E., "A Multimedia Information System to Support the Analysis of Human Behaviour Recorded on Video", Computers in Psychology, Conference Proceedings, CTI Centre for Psychology, University of York, York, (1998).

[13] Jiang, H., Montesi, D., Elmagarmid, A. K., "Integrated Video and Text for Content-based Access to Video Databases", Journal of Multimedia Tools and Applications, 9, pp. 227-249, Kluwer Academic Publishers, (1999).

[14] Lenat, D.B. and Guha, R.V., "Building Large Knowledge-Based Systems; Representation and Inference in the Cyc Project", Addison-Wesley Publishing Company, Reading, Massachusetts, (1990).

[15] Miller, G.A., "WordNet: a lexical database for English", Communications of the ACM, 38:11, pp. 39-41, (1995).

[16] Noldus Information Technology, "The Observer Video-Pro, Version 4.0 for Windows". Wageningen, The Netherlands, (1998).

[17] Palhang, M., Sowmya, A., "Learning Object Models from Real Images", Proceedings of the First International Conference on Visual Information Systems, Victoria University of Technology, Melbourne, Australia, (1996).

[18] QSR Software, QSR NUDIST 4 Overview, http://www.qsr.com.au/Software/N4/qsrn4.htm (accessed on June 22 1998).

[19] Richards, L., "Using NVivo in Qualitative Research", Melbourne: Qualitative Solutions and Research Pty, (1999).

[20] Sowa, J.F., "Conceptual Structures: Information Processing in Mind and Machine", Addison-Wesley, Reading, Massachusetts, (1984).

[21] Sowa, J.F., Knowledge Representation; "Logical, philosophical, and Computational Foundations", Brooks/Cole, Pacific Grove, CA, (2000).

[22] Topic maps. ISO/IEC JTC1/SC34 - Document Description and Processing Languages. http://www.ornl.gov/sgml/sc34/document/0058.htm, (accessed on February 8 2000).

[23] Zhang, H., Gong, Y., Smoliar, S. W. and Tan, S.Y., "Automatic Parsing of News Video", Proceedings of the International Conference on Multimedia Computing Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

Strange Creatures in Virtual Inhabited 3D Worlds

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jerners Vej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +4598156279 Fax: +4598142444
E-mail: jensf@hum.auc.dk

This paper discusses the strange creatures that currently populate 3D cyberspace and3D Internet. First, the concept of Virtual Inhabited 3D worlds are discussed and defined. Next, some of the key elements or basic entities that can be found within the horizon of Virtual, Inhabited 3D Worlds are identified and denned. Among these basic elements are objects and agents, differentiated by whether or not their primary function is to carry out an action. Agents (denned as entities, which primary function is to carry out actions) have two main forms, which have been described as relatively sharply differentiable polar opposites. This is done based on questions such as: who is controlling the agents? ' who is doing the driving?' On the one hand there are agents that react independently of the user, but which are controlled by software or AL, the so-called ' autonomous agents' or ' bots' . On the other hand, there are agents, which directly represent and are controlled by users, the so-called ' avatars. Although there is then, in principle, a differentiation, in terms of definition, between bots and avatars, the paper argues that both concepts cover a relatively wide spectrum of very different types of phenomena with differing degrees of control. There also seems to be a tendency toward the appearance of more and more hybrids- in the present context termed ' cyber-hybrids' - combining avatars and bots. Furthermore, these hybrid forms are in many ways the most interesting and most promising in the virtual worlds at the moment. Rather than considering avatars and bots as polar opposites, it may therefore be more productive to consider them as the outer points along a continuum, between which can be found all sorts of combinations or hybrids. Following this line of argument, the paper outlines a new typology of hybrid creatures, which currently populate the continuum between (objects) bots and avatars in Virtual worlds.

*The paper was not available by the date of printing.

The Application of Uncertainty Reasoning for an Intelligent Tutoring System

Hown-Wen Chen*, Teran Wu and Dong-Yih Bau
Institute of Information Management, Da-Yeh University
112, Shan-Jeau Rd., Da-Tsuen, Chang-Hwa, Taiwan
Email :hwchen@aries.dyu.edu.tw

The activity of test and evaluation is an important part of Computer-Assisted Instruction systems. In most systems, 「absolutely learned」 and 「absolutely unfamiliar」are often used to represent the status of a student in learning a novice concept. However, for each target concept, there are usually more than one related sub-concepts with different degrees of importance. Thus, it is quite difficult to instruct each individual student effectively according to his learning status in those conventional systems. A hybrid technology of fuzzy theory and uncertainty reasoning are thus used in the research. The proposed intelligent tutoring system was designed to illustrate: 1.automatically tracking and analyzing the current learning status of a pupil, especially detecting the formation of learning barriers or misconceptions; 2. autonomously leading pupils to visit assisted learning path and thus proposing tutorials to make the learning of students more effectively. 3.linguistically explaining the implicit behavior of a pupil during the whole learning process. In addition, the mathematical course of teaching Pythagoream Theorem was used as the content of our test-bed. A simulation by hand and positive feedbacks from teachers of junior high schools illustrate the reasonableness and applicability of the proposed tutoring system.

Keywords: **Pythagoream Theorem, Fuzzy Logic, Uncertainty Reasoning, Intelligent Tutoring System**

1 Introduction

Researches about Intelligent Computer Aided Instruction (ICAI) have incrementally grown since 1970, for example, standard intelligent tutoring systems [1], or participants in virtual environments [2], or a virtual instructor in a training environment [3]. However, as known, the effectiveness of education would depend on the local culture. But, there are few intelligent tutoring systems focusing on Taiwanese students have been reported. CORAL [4] was designed as an interface system, without any artificial intelligence module of teachers' expertise, to provide a long-distance collative learning environment of virtual learning. As discussed in lots of tutoring systems, the most challenging issue is how to evaluate and diagnose the learning of students. Tests are a typical and popular method of evaluation. Taking the GRE as an example, people have taken the test through computers since 1992. The IBM co. and Arthur Anderson Co. have begun to work on the development of a computerized testing system. Such systems, which change the form of tests from conventional paper-to-pencil to on-line, are proliferating rapidly. For ICAI, it becomes more popular that the evaluation of pupils' learning should not be simply classified as「absolutely learned」and「absolutely unfamiliar」. In addition, ways of leading each individual pupil to enjoy an efficient learning experience is also pursued. In the research, we proposed an intelligent tutoring system which can afford the most appropriate tutorials to each pupil according to his learning status and thus can prevent pupils to trap into a misconception too long.

2 The Organization of Tutorials and Maintaining Principles

Before implementing our tutoring system, some special issues and adopted techniques must be introduced.

Those topics include the organization of tutorials, a way of representing pupil's learning status, and the detection of any formed misconception.

2.1 The Construction of a Hierarchical Concept Tree

In general, tutorials would be organized as a tree hierarchy of curriculum in the order of chapter, section, sub-section, paragraph, etc. Since learning a complicate concept must depend on the success of learning all its related sub-concepts, the kind of structure cannot be claimed to be suitable for both learners and instructors. That is, too few containment or precedence information about curriculum is available. Thus, learning concepts and related tutorials are re-arranged as a hierarchical conceptual tree of containment here. According to literatures [5] and interviews with teachers of junior high schools, the concepts related to learning Pythagoream Theorem for native pupils can be analyzed and constructed as Figure 1. In the tree, the learning of any parent conceptual node must follow after at least one of its children nodes.

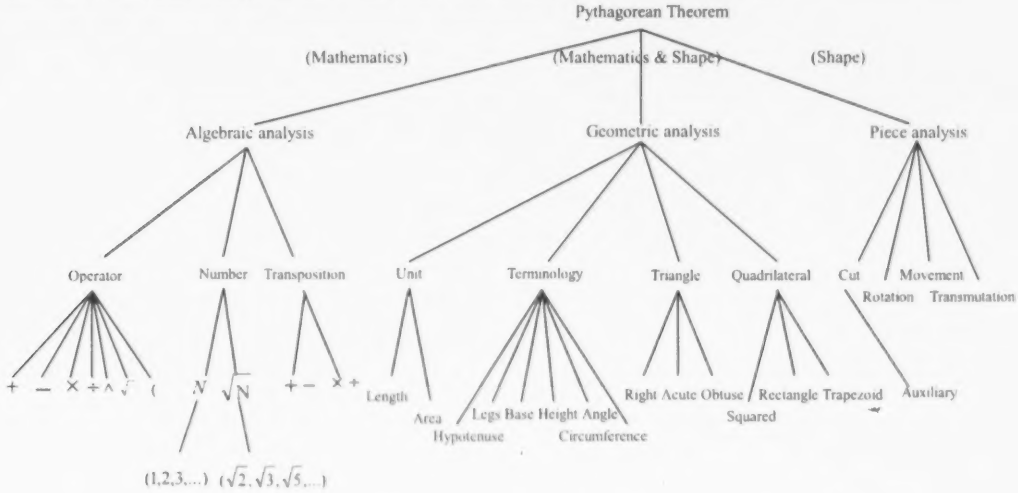


Figure 1. A hierarchical concept tree of Pythagorean Theorem

2.2 The Setting of Node Weights within the Hierarchical Concept Tree

To express the corresponding degree of importance, an integer is assigned to each testing question related to individual concept [5]. However, it is still a heavy burden even for an expert to quantitatively assess the extent. Besides, the estimated grade of importance is too subjective in general. In our system, the influence of each node on learning its parent node is defined through fuzzy theory as follows:

Step 1: Some teachers in junior high schools are asked to evaluate the relevance of nodes related to their parent node in the hierarchical concept tree.

Step 2: Fuzzy theory is included to quantify teachers' opinions in the designed questionnaire obtained in step 1. Five possible values for linguistic variables are used. Note magnitudes 0.0 and 1.0 are not adopted in the memberships because of product operations and symmetry.

Step 3: Murray's or Ishihawa's Max-Min method is used to fuzzily integrate those multiple expertise. After that, a defuzzification process to evaluate the mass centroid of fuzzy numbers is applied. The weights of nodes within the hierarchical concept tree are thus settled as shown in Figure 1.

2.3 The Maintenance of Belief Parameters

To increasing the expression power of the proposed system above "absolutely known" and "absolutely unfamiliar", a belief parameter m and another updating parameter λ described in Dempster-Shafer Theorem [6] are applied here to assess the familiarity degree of a pupil to a particular learning concept within the hierarchical concept tree. To describe the meaning of the updating parameters λ and θ ($\theta=1-\lambda$), two cases must be taken in account:

Case 1: Making a correct answer

λ and θ can be used to denote the belief degree of promoting to a higher level and of staying on the same level within the conceptual hierarchy, respectively.

Case 2: Making a wrong answer

λ and θ can be used to denote the belief degree of degrading to a lower level and of staying on the same level within the conceptual hierarchy, respectively.

As to defining the updating rules of the belief parameter m, a general sub-tree structure is considered. In the tree, a node f has three children nodes labeled as a, b, c, and the interconnection links are labeled as W_{af}, W_{bf}, W_{cf}

Case 1: *Making a correct answer in the test for the conceptual node a*

A promotion within the conceptual hierarchy must be activated. The belief parameters of the two relevant nodes a and f are thus modified as

$$m_f^t = (W_{af} \bullet \lambda) + m_f^{t-1}$$
$$m_a^t = (W_{af} \bullet \theta) + m_a^{t-1} \qquad \textbf{(eqn. 1)}$$

m_f^t, m_a^t : the magnitudes of belief after promotion

m_f^{t-1}, m_a^{t-1} : the magnitudes of belief before promotion

W_{af} : the weight of link between nodes **a** and **f**

Case 2: Making a wrong answer in the test for the conceptual node **f**

A degradation within the conceptual hierarchy must be activated. The belief parameters of the four relevant nodes, **f** and its children nodes **a, b, c,** are thus modified as

$$m_f^t = (\theta) + m_f^{t-1}$$
$$m_a^t = [\ W_{af} \bullet \lambda \bullet (1 - m_a^{t-1})\ ] + m_a^{t-1}$$
$$m_b^t = [\ W_{bf} \bullet \lambda \bullet (1 - m_b^{t-1})\ ] + m_b^{t-1} \qquad \textbf{(eqn. 2)}$$
$$m_c^t = [\ W_{cf} \bullet \lambda \bullet (1 - m_c^{t-1})\ ] + m_c^{t-1}$$

Case 3: If a correct answer is made in the topmost conceptual node, it is impossible to promote anymore. However, the belief of the topmost conceptual node is still updated with eqn. 1.

Case 4: If a wrong answer is made in the lowest conceptual node, it is impossible to degrade and the belief of the node is updated with eqn. 2.

2.4 The Strategy of Instruction

Several principles have been applied in the proposed system:

The instruction and assessment examination would only take place in the conceptual node with the largest belief. However, all assessment tests for its children nodes with weights larger than a pre-chosen threshold must be answered correctly. If the mentioned condition is not satisfied, the focus of instruction and assessment would be transferred to one of its children nodes instead.

According to Dempster-Shapfer Theorem, the procedure of normalization must be applied after each updating of belief.

There is an implicit relationship between the magnitudes of weights and belief parameter λ. To avoid the learning process to be not in progress, according to eqn. 2, the magnitude of belief updating in any child node (a) must be larger than that of parent node (f). Thus,

$$W \bullet \lambda \bullet (1) > 1 - \lambda$$
$$\Rightarrow \lambda > \frac{1}{(1 + w)} \text{ for all possible w}$$

2.5 The Analysis of Learning Traces and Detection of Misconceptions

Two kinds of traversal information would be recorded during the learning process: the weighted correct rate of answering testing questions for each conceptual node, and the traversal path of all visiting nodes.

First, the weighted correct rate can be used to indicate the current comprehension degree of a concept during the learning progresses. As known, the status near to the ending of learning should be emphasized. In other words, a pupil would be regarded as having been familiar with the concept if he can finally pass the

corresponding test independent of times of previous failures. To simulate the phenomenon, three kinds of information must be kept: the number of making wrong answers W, the number of making contiguous correct answers after the last wrong answer C, and the total number of answering T. The weighted correct rate is defined as 1-W / [(T-W-C)+W+2*C], i.e., 1-W/(T+C). The interpretation of the weighted correct rate would be based on fuzzy expression in our system.

Another important issue is the way of detecting the formation of a misconception. A misconception may be caused by some blind spots of learning and thus always makes the learning process trap into a loop. A good diagnosis module of a tutoring system must have such kind of detection capability and could inform the other tutorial guidance module to show some appropriate auxiliary tutorials. If the test of each child node has passed, i.e., the learner has traversed and correctly answer all questions related to the concepts of all children nodes, the conceptual node is marked as P (Passed). If a learner cannot pass the test of a conceptual node and all its children nodes satisfy one of the following two conditions, then the learner is identified as trapping in a misconception corresponding to the conceptual node. The two conditions are <i>the child node has been marked as P; or <ii>the weighted correct rate is absolutely 1 (100%).

3 The Development and Design of Our System

Based on those described ideas, a prototype tutoring system comprising a testing and evaluation module has been developed and demonstrated. Microsoft Visual FoxPro 6.0 is used under the platform of Microsoft Windows 98. There are four modules included in our system shown in Figure 2.

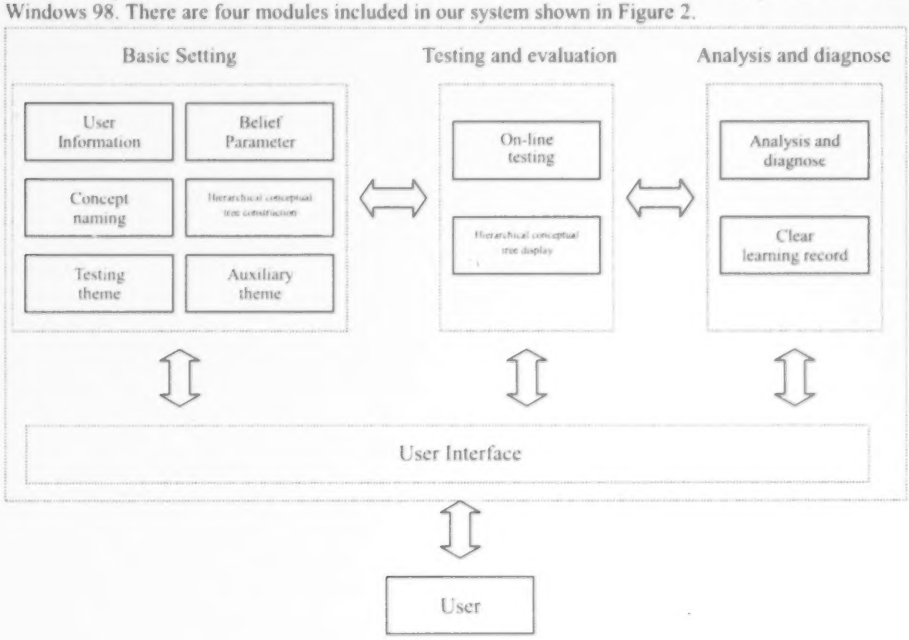


Figure 2. The architecture of the tutoring system

4 Conclusion and Future Work

In the research, techniques of fuzzy theory and uncertainty reasoning are applied to create a novel tutoring system. As demonstrated, the proposed tutoring system shows an excellent capability to present proper tutorials to guide pupils, precisely evaluates their learning status, and then shows auxiliary teaching materials to prevent pupils from trapping in any formed misconception. Finally, the traversal of learning would be analyzed and interpreted by fuzzy expressions.

Besides, some issues are worthy of deeper investigations through the study:

1. Some adaptive techniques of machine learning, e.g., genetic algorithm and artificial neural networks, should be applied to help instructors to automatically choose or tune parameters used in the tutoring system.
2. More applications about the proposed system should be examined to show its portability.

Acknowledgement

This study is supported by National Science Council of R.O.C. under contract number NSC88-2520-S-212-003

References

[1] Anderson, J.R,"Cognitive modeling and intelligent tutoring", *Artificial Intelligence*. 42, pp.7-49, (1990).
[2] Pimentel, K. and Teixeira, K, "Virtual Reality: Through thenewlooking glass", Blue Ridge Summit, PA: Windcrest/McGraw-Hill, (1994).
[3] Rickel, J. and Johnson W. L, "Pedagogical agents for immersive training environments", Proc. of the 1st International Conf. on Autonomous agents, New York, (1997)..
[4] Chien Chou and Chuen-Tsai Sun, "The design and implementation of a cooperative distance learning environment: The CORAL experience", Education Technology and Media, 26, pp. 13-21, April, (1997).
[5] C. S. Hsu, H. F. Dou and G. J. Huang, "The application of concept inheritance in learning diagnosis system", Proc. of ICCAI'98, pp. 602-609, (1998).
[6] Shafer, G., "Mathematical Theory of Evidence ", Princeton University Press , Princeton , New Jersey ,(1976).

The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS

Tsunenori Mine Akira Suganuma Takayoshi Shoudai
Graduate School of Information Science and Electrical Engineering, Kyushu University
6-1 Kasuga-kouen, Kasuga, 816-8580 JAPAN
E-mail:{ mine@is, suga@is, shoudai@i }.kyushu-u.ac.jp

Abstract

Many Internet technologies enable us to hold lectures with Web contents and even develop new lecture methods using the technologies. This paper proposes AEGIS (Automatic Exercise Generator based on the Intelligence of Students) that generates exercises of various levels according to each student's achievement level, marks his/her answers and returns them to him/her. In order to realize this feedback mechanism, we currently restrict the question-types which are generated to the following three types: multiple-choice question, fill-the-gap question, and error-correcting question. All question-types can be generated from the same tagged document. The aim of this system is to help the students understand the lecture with exploiting preexisting electronic documents.

Keywords: Artificial Intelligence in Education, Web-Based Learning, Exercise Generator

1 Introduction

As the Internet has come into wide use, WWW environments provide lots of opportunities to various fields. In the educational domain, Web data are being exploited as useful materials. We have been developing Web-based self-teaching systems and building the tools for helping students understand their subjects[1, 2, 3, 4].

We are currently focusing on the automatic student's achievement level evaluator that generates an exercise from tagged documents, presents it to students and marks their answer automatically. We call the system AEGIS (Automatic Exercise Generator based on the Intelligence of Students)[6, 7].

Creating exercises which are suitable for students is not easy. When we try to make some exercises for them in classes, we have to take at least their achievement level into considerations. The well-considered exercises are useful not only to measure the achievement level of students but also to improve their performance. It is not easy task for any teacher to make exercises of various difficulties according to their achievement level. Besides, it is very important to mark the students' answers and return the marked results to them for keeping their learning enthusiasms. This task becomes harder in proportion to the number of the students in a class[5].

This paper discusses AEGIS, which generates the three question-types from the same tagged data. Guessing the achievement level of each student from his/her trial history, AEGIS selects the most suitable question-type and exercise for him/her according to not only his/her achievement level but also the difficulty of the tagged data. After marking his/her answer, AEGIS returns it ,to him/her with its explanation.

The aim of this system is to exploit pre-existing electronic documents, in particular, our on-line documents shown at our Web site (http://cl.is.kyushu-u.ac.jp/Literacy) and to help students understand their lecture whose materials are set up as Web data so that they even at home can try exercises using AEGIS through the Internet.

The rest of this paper is constructed as follows: Section 2 shows related works to discuss the difference from AEGIS. Section 3 describes question-types that AEGIS deals with, considering both view points of students(answerers) and teachers(questioners) and Section 4 describes the exercise generating process by AEGIS. Section 5 shows the overview of AEGIS.

2 Related Works

A lot of automatic quiz generators have been proposed so far. Browning et. al. proposed Tutorial Mark-up Language(TML in short) to generate questions automatically[8, 9]. TML has a couple of tags to specify a question, a multiple-choice and a message. It requires a correct answer in a multiple-choice tag to mark a student's answer to the question. Carbone et. al. proposed CADAL Quiz[10], which generates a multiple-choice quiz from a question database. After marking a student's answer, CADAL Quiz returns the result to him/her and tutors. Both of them restrict the question type only to a multiple-choice quiz. On the other hand, ClassBuilder[11] generates many kinds of quizzes and grades a student's answer. However, all of them do not mention any effect of making the difficulty level of question-type change according to the students' achievement level. In order to improve their performance and keep their enthusiasm to challenge the quiz for a long time, it is indispensable to consider their performance level for generating their exercise. This point is the difference from other systems. AEGIS makes use of pre-existing electronic documents so as to embed tags into them, generates exercises automatically with tagged documents according to students' achievment levels, and reestimates both their levels and the difficulty level of the generated question through marking their answers.

3 Question-Types

There can be several types of a question in every subject. Since our aim is to get a computer generate an exercise and mark student's answer to it, we thus restrict to the following three question-types: multiple-choice question, fill-the-gap question, and error-correcting question.

Multiple-choice question. Students choose the correct answer from a given candidate list.

Example. Complete the sentence. Choose your answer from the following list.

Data structures need to be studied _____ order to understand the algorithms.

(1) an (2) in (3) on (4) at (5) by

Fill-the-Gap question. Students try to fill in the blank of a given sentence with the correct answer without any help.

Example. Fill in the blank with the right word.

Data structures need to be studied _____ order to understand the algorithms.

Error-correcting question. Students have to find the wrong expression in a given sentence and correct it.

Example. Right or wrong? Correct the sentence if it is wrong.

Data structures need to be studied an order to understand the algorithms.

All of these question-types can be constructed from a sentence by replacing one or more consecutive words with a blank or a wrong expression. We call the region replaced *hidden region*. We note that these three question-types have different difficulties even if they are constructed from the same *hidden region*. Figure 1 shows the tagged data to be used for generating the above three types of questions.

```
⟨QUESTION SUBJECT="idioms"⟩
Data structures need to be studied ⟨DEL CAND="an,on,at,by"⟩ in ⟨/DEL⟩ order to understand the algorithms.
⟨/QUESTION⟩
```

Figure 1: The tagged data to generate three question-types shown in Section 3

Students' View Point

Every multiple-choice question has surely the correct answer in its candidate list and contains the information that leads students to the correct answer. They can therefore make their choice with confidence from the list. In the case of a fill-the-gap question, they have to fill in the blank by themselves with their convinced answer without any information about the answer. Comparing both question-types, we can say

that a fill-the-gap question is more difficult than a multiple-choice one. In the case of an error-correcting question, it forces them to determine whether or not there is an error in the question sentences and to correct it if it is found. An error-correcting question gives no information leading them to its correct answer, and the wrong expression in the sentences is not clear for students. We can therefore say that an error-correcting question is the most difficult one for students among those question-types.

Teachers' View Point

Once teachers set a *hidden region*, the efforts that are required to make with the three question-types are similar. The process for making exercises is as follows: in the case of a fill-the-gap question, the teachers have nothing to do. There is no information that they have to add to the exercise paper. We can say that a fill-the-gap question is the easiest one which is made among these three question-types. In the case of an error-correcting question, teachers have to think of at least one wrong expression which can be replaced with the *hidden region*. In the case of a multiple-choice question, they have to prepare several distractors to construct a candidate list. We can say that a multiple-choice question requires more information than an error-correcting one. From their points of view, a fill-the-gap question is consequently the easiest one which is made, and an error-correcting question is easier than a multiple-choice one.

4 Automatic Exercise Generating

4.1 Exercise Generating Process

The exercise generating process from teaching documents is summarized as follows:

1. Setting a *hidden region*: teachers make clear their intention why they want to ask the question to their students, that is, they consider which of the *hidden regions* is the most suitable for their intention.

2. Selecting a paragraph or sentence(s) from teaching documents: the sentences before and after *hidden regions* are often of importance to ask their students the unique answer of the question. We call the paragraph or sentence(s) a *question region*. A *question region* may have more than one *hidden region*.

3. Constructing a candidate list: a multiple-choice question requires a couple of distractors to set up a list of answer candidates. Any distractor should be natural so as to be added to the list. This list depends on the teacher's intention.

These three steps are deeply related to the teachers' intentions. It is not easy to extract such intentions automatically from the teaching documents. AEGIS system thus deals with tagged documents that already have the information such as *hidden regions* and candidate lists.

4.2 Necessary Information for Generating Exercises

In order to embed the above three kinds of information into the teaching documents, we define the following three tags: QUESTION, DEL, and LABEL.

QUESTION surrounds a *question region*, that is, the statements between ⟨QUESTION⟩ and ⟨/QUESTION⟩ are a *question region*. In the region, there can possibly be some expressions that are related to a *hidden region*. They can be good hints to lead students to the correct answer.

SUBJECT is the unique attribute of QUESTION. Its value stands for the subject or topic of *question region*.

DEL indicates a *hidden region*, which is the word(s) or sentence(s) between ⟨DEL⟩ and ⟨/DEL⟩.

A fill-the-gap question can be generated only by replacing the *hidden region* with a blank.

CAND is one of DEL's attributes. It is used to specify a candidate list.

LABEL has an attribute NAME that specifies a dependency relation with a *hidden region*. The sentence/s surrounded by LABEL tags is/are presented as a reference for the answer of a question, which will be generated with the DEL tag whose REF's value is the same as that of the NAME of the LABEL.

⟨QUESTION SUBJECT="W_S"⟩ *question region* ⟨/QUESTION⟩		
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
⟨DEL CAND="CANDIDATE" LEVEL="PAIR" GROUP="ID" REF="ID"⟩ *hidden region* ⟨/DEL⟩		
CANDIDATE	::=	W_S | W_S,CANDIDATE
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
PAIR	::=	LOW,HIGH
LOW	::=	an integer between 1 and 10
HIGH	::=	an integer between 1 and 10
ID	::=	keyword
⟨LABEL NAME="ID"⟩ sentences ⟨/LABEL⟩		
ID	::=	keyword

Figure 2: Tags for exercise generations

4.3 Necessary Information for Adjusting Difficulty Level of Question

The additional three attributes of DEL, which contain the information on the difficulty of solving the exercise, are LEVEL, GROUP, and REF. They specify the difficulty of each *hidden region*, and the connections to other *hidden region*.

LEVEL specifies the difficulty of the exercise to be generated from a *hidden region* itself. The value of this attribute is a pair of integers between 1 and 10. These integers specify the lowest and highest achievement level of the students who can try the exercise. AEGIS system determines whether or not the *hidden region* is worth being transformed into the exercise by comparing the student's achievement level from the both values of LEVEL.

GROUP specifies the dependency relation between *hidden regions* and holds the uniqueness of the correct answer. This GROUP is used to adjust the exercise level. If we want to generate more difficult exercises, all the *hidden regions* that have the same values in GROUP are replaced with blanks or wrong expressions at the same time. On the other hand, for generating easier ones, some of the *hidden regions* in the group are not transformed because those regions help students answer the question as hints.

REF specifies the dependency relation between a *hidden region* and other expressions than the *hidden region*. Both the region and expressions are specified with LABEL. If a *hidden region* is connected to an expression, the value of REF in the *hidden region* is the same as that of NAME in the expression with LABEL.

5 AEGIS system

5.1 Overview of AEGIS

The AEGIS system consists of three databases: *Exercise DB* (**EDB** in short), *User Profile DB* (**UPDB** in short) and *Level Management DB* (**LMDB** in short), and three main database managers: *Exercise Generator* (**EG** in short), *Answer Evaluator* (**AE** in short) and *Level Manager* (**LM** in short). The overview of AEGIS is shown in Fig. 3.

Teaching documents with the tags are compiled into the **EDB** and **LMDB**. All of the *question regions* are indexed sequentially and each *hidden region* is labeled with its own subindex of the index of each *question region*. The level of a *hidden region*, which is deeply related to the level of the question to be generated from the *hidden region*, is stored in the **LMDB** together with the index of the *hidden region*. The level of each *hidden region* in **LMDB** is reexamined regularly. **UPDB** keeps students' trial histories with their current achievement level.

EG and **AE** make communications with the users (students) through Web browsers after being invoked through CGI (Common Gateway Interface).

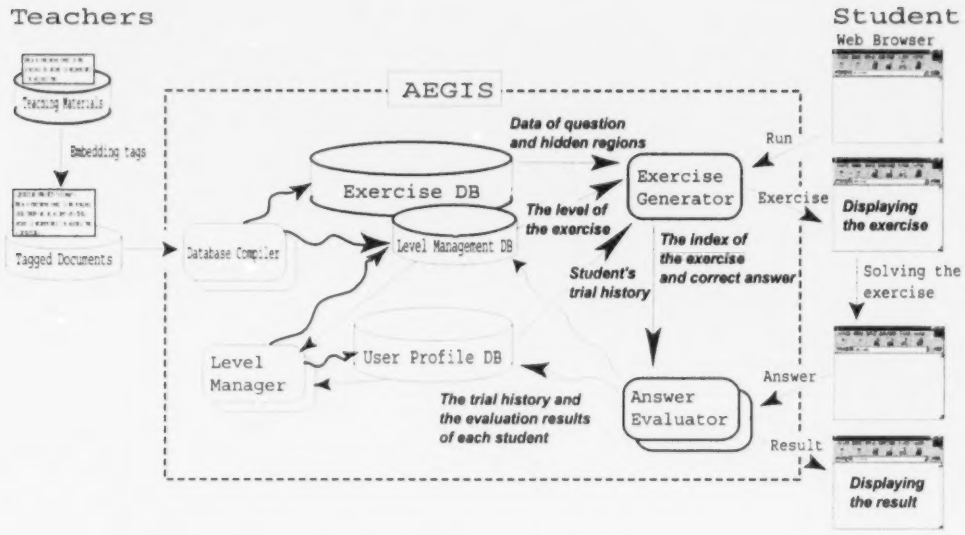


Figure 3: Overview of AEGIS

5.2 Exercise Generator(EG)

The exercise request from a student invokes **EG**. The **EG** searches the most suitable *hidden region* in **EDB** with looking over both the student's profile stored in **UPDB** and the level of the *hidden region* stored in **LMDB**, and determines the question-type of the *hidden region*. As mentioned in section 3, every question level has a relation to the question-type. **EG**'s decision process of the question-type thus employs the following strategy: If the student's achievement level is closer to the lowest number in LEVEL of the *hidden region*, **EG** selects a multiple-choice question as the question-type with high probability. On the other hand, if it is closer to the highest number in the LEVEL attribute, **EG** selects an error-correcting one.

Once **EG** determines the question-type of the *hidden region*, it is not difficult to generate the question. This is because the *hidden region* represents the correct answer of the question which is generated and teachers have already given the list of distracts explicitly with CAND attribute. Now, let's see how **EG** works when it generates the three kinds of questions:

- *Multiple-choice question*: **EG** randomly constructs one possible list for the multiple choice with both the correct answer and some distracts and outputs a question, which is generated by replacing the *hidden region* with a blank, with the list.
- *Fill-the-Gap question*: **EG** outputs a question which is generated only by replacing the *hidden region* with a blank.
- *Error-correcting question*: **EG** outputs a question which is generated by replacing the *hidden region* with one of the wrong answers specified in the CAND attribute.

Figure 4 shows an example of teaching documents with the tags. It is a piece of the teaching documents in the elementary course of Computer Literacy at our university. This course is taken by all first and second year students, about 2,300 students[5]. The teacher's intention in the example document is to teach how to use multiply and divide operations. Figure 5 shows the three question-types which are generated from the document.

5.3 Answer Evaluator(AE)

After outputting a question to the student, **EG** sends the following three kinds of information to ask **AE** to mark his/her answer: the index of a *hidden region*, the question-type, and the correct answer. After

BEST COPY AVAILABLE

In the previous section, we learned a program for adding two integers and showing the answer on the display. In the similar way, for all basic arithmetic operations including addition, subtraction, multiplication, and division, we can make a Pascal program in the following way.

```
⟨QUESTION SUBJECT="arithmetic operations"⟩
```

This program computes the multiplication and division for two input integers and shows the answer.

```
program enzan;
var x,y:integer;
   seki,shou:integer;
begin
   write('Input two integers : ');
   readln(x,y);
   seki:=⟨DEL CAND="x,xy,x×y,x mul y" LEVEL="1,5"⟩x*y⟨/DEL⟩;
   shou:=⟨DEL CAND="x/y,x÷y,xdivy,x mod y" LEVEL="1,5"⟩x div y⟨/DEL⟩;
   writeln('Seki:',seki);
   writeln('Shou:',shou)
end.

⟨/QUESTION⟩
```

The 7th statement multiplies x by y, and the 8th statement divides x by y. We note that the answer of "div" is an integer.

Figure 4: Example of teaching documents with the tags

(a) Multiple-Choice (b) Fill-the-Gap (c) Error-Correcting

Figure 5: Three questions generated from the document in Figure 4

marking his/her answer by matching with the correct answer, **AE** shows him/her the marked result and stores it with the index of the *hidden region* and the question-type into the **UPDB**.

5.4 Level Manager(LM)

Although the initial value of the level of each *hidden region* is specified by teachers, it continues to move up and down according to the students' achievement levels, which will change as time goes by. The supplement manager **LM** processes their achievement levels statistically, computes the revised level of each *hidden region*, and stores it into the **LMDB**. **LM** increases the difficulty level of a question if a student whose level is greater than the level of question answers it wrongly, and decreases if a student whose level is less than the level of question answers it correctly. The new difficulty level of a question is consequently determined as shown in Fig.6.

After updating **LMDB**, **LM** updates the student's achievement level according to the difficulty levels of all questions he/she correctly answered.

Now, we show the formal definition of calculating both the achievement level of a student and the difficulty level of a question. Let $s_{i,t}$ and $q_{j,t}$ be the achievement level of student S_i and the difficulty level of question Q_j at time t respectively, where $1 \leq s_{i,t} \leq 10$,$1 \leq q_{j,t} \leq 10$. $s_{i,t}$ is recursively calculated with $q_{j,t}$ at stated periods and vice versa. They are defined as follows:

BEST COPY AVAILABLE

$$s_{i,t} = \begin{cases} 1 & \text{if } m_{s_i,t} = 0 \\ \frac{1}{m_{s_i,t}} \sum_{j=1}^{m_{s_i,t}} q_{j,t} \cdot \delta_{i,j} & \text{otherwise} \end{cases} \qquad \delta_{i,j} = \begin{cases} 1 & \text{if } S_i \text{ answered } Q_j \text{ correctly} \\ 0 & \text{otherwise} \end{cases}$$

$$q_{j,t} = \begin{cases} q_{j,t-1} + \frac{\sum_{i=1}^{m_{q_j,T}} |s_{i,\tau \in T} - q_{j,t-1}| \cdot \xi_{i,j}}{\sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}|} & \text{if } \sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}| \neq 0 \\ q_{j,t-1} & \text{otherwise} \end{cases}$$

$$\xi_{i,j} = \begin{cases} -1 & s_{i,\tau} \text{ is less than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ correctly} \\ 1 & s_{i,\tau} \text{ is greater than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ wrongly} \\ 0 & \text{Otherwise} \end{cases}$$

Where $m_{s_i,t}$ stands for the number of questions that S_i tried by t and τ is the latest time such that S_i tried to answer Q_j and $t-1 < \tau \leq t$. T is the set of τ. $m_{q_j,T}$ stands for the total number of students who tried Q_j in T. $q_{j,0}$, which is the initial difficulty level of the question Q_j, is given with the attribute $LEVEL$ of DEL tag by teachers.

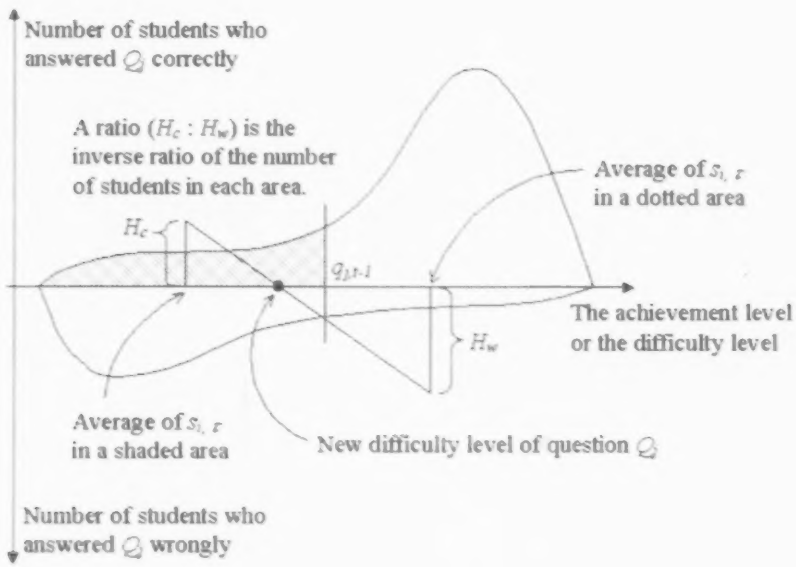


Figure 6: Renewing Difficulty level of Question based on Student's Achievement Level

6 Conclusions

We discussed our new Web-aided system AEGIS. The system is currently implemented in Perl scripts and CGI. We have a plan to evaluate this system by applying it to the real courses of Computer Literacy, which are taken by more than 2300 students at our university. We hope it will work fine as an educational tool for every student and help him/her to understand his/her subjects if teachers can make tags in their teaching documents. Also, we plan to implement a tagging tool and an algorithm to generate another kind of exercise that allows more than one correct answers.

Acknowledgments

We thank Dr. Teruko Mitamura at Carnegie Mellon University for her helpful comments to improve this paper.

This research was partly supported by the Grant for Special Academic Research P&P from Kyushu University and the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Encouragement of Young Scientists(A), No. 11780281, 2000.

References

[1] H. Sato, T. Mine, T. Shoudai, H. Arimura, S. Hirokawa: On web visualizing how programs run for teaching 2300 students. In *Proc. Int. Conf. on Computers in Education, ICCE'97*, pages 952–954, 1997.

[2] T. Mine, D. Nagano, K. Baba, T. Shoudai, S. Hirokawa: On-web visualizing a mechanism of a single chip computer for computer literacy courses. In *Proc. Int. Conf. on Computers in Education, ICCE'98*, volume 2, pages 496–499, 1998.

[3] R. Fujimoto, A. Suganuma, T. Mine: Development of a classroom management system on the web. In *Proc. Int. Conf. on Computers in Education, ICCE'99*, volume 2, pages 756–759, 1999.

[4] R. Fujimoto, Y. Tsutsumi, A. Suganuma: Cacce: Computer aided cooperative classroom environment. In *World Conference on Educational Multimedia, Hypermedia & Telecommunications*, page 1686, 1999.

[5] S. Hirokawa, T. Miyahara, T. Mine, T. Shoudai, M. Mori: Teaching 2300 students with www – practice and experience at kyushu university. In *Proc. ERI'96*, pages 59–63, 1996.

[6] T. Shoudai, A. Suganuma, T. Mine: AEGIS: Automatic Exercise Generator with Tagged Documents based on the Intelligence of the Students, Joint Conference on Knowledge-Based Software Engineering, to appear. JCKBSE2000, Brno, Czech Republic, 2000

[7] T. Mine, T. Shoudai, A. Suganuma: Automatic Exercise Generator with Tagged Documents

Considering Learner's Performance Proceedings of WebNet2000, San Antonio, Texas, to appear as a short paper, 2000

[8] P. Browning, J. Williams, D. Brickley, H. Missou: Question Delivery over the Web using TML http://www.ilrt.bris.ac.uk/netquest/liveserver/qbanks/demos/paul/lboro/ohp1.html, CAA, 1997

[9] P. Browning: TUTORIAL MARKUP LANGUAGE - A CBA SYSTEM http://www.soton.ac.uk/~ukgec/workshop/5-cba/minutes.htm#TUTORIAL, 1998.

[10] A. Carbone, P. Schendzielorz: A Web-Based Quiz Generator for Use in Tutorials and Assessment Global J. of Engng. Educ., Vol.I, No.3, 1997 http://www.eng.monash.edu.au/usicee/gjee/vol1no3/paper20.htm.

[11] ClassBuilder GradeBook And Exam Creation Software: http://www.classbuilder.com/

The Design of CAI with Thinking Activity to Progress Constructive Teaching
- An Example of Division-concept in Mathematics of Elementary School

Pou-Yah Wu*, Mei-chueh Shao, Kai-Ren Chen, Ying-Xin Zhong, Ting-Wei Lin and Cheng-Wei pan.
Department of Mathematics Education, National Tainan Teachers' College, Taiwan
**Pou-Yah Wu's e-mail:pywu@ipx.ntntc.edu.tw*

This study aims at establishing a computer assisted learning system of division-concept of networked elementary school mathematics course based on constructivism and stress on students' thinking activities. It explores how students' thinking manifest on network, how the thoughts of the learner and those of the students on-line transfer, and how the thinking of the virtual students' solving problems reflect, so as to develop a set of CAI system about constructive pedagogy. In the system, we provide the learners with diverse tools for thinking activity, letting him/her choose what he/she needs to solve problems. We use network technology to simulate the real learning situation and to make the learner and the user on the line and the virtual students to communicate and discuss immediately. By setting up the CAI system that is compatible with the mathematics education of the elementary school in Taiwan now, we expect the learner to establish the right concepts positively so as to attain constructive pedagogic concept.

Keywords: **Constructive pedagogy; Division of Mathematics; Elementary School; Networked CAI; Thinking Activity.**

1 Introduction

The course design of pedagogy in Taiwan before 1993 is based on objective theory of knowledge. However, the pedagogic design ignores the complex and interactive phenomenon practically. Therefore, mathematics of elementary school in Taiwan in 1993 adopts pedagogic theory of constructivism [6]. Constructive pedagogy improve the shortcomings of the traditional pedagogy; but it also cause the deficiency of pedagogic duration owing to the orders of discussion and reflection in case it is put into practice in the real pedagogic environment. With the popularity of network, provided constructive concepts are applied to the learning environment of network, CAI effect would be promoted further. This study aims to design networked pedagogic environment matching "basic division-concept in mathematics of elementary school" by the learner's thought, using network technology, letting the learner have an environment to learn at home. The traditional CAI system neglects the positive learning and the interaction between the learners. So, we take into how to facilitate the interactive relationship between the system and the learner. Through the transmission of the networked thought, the learners can real-time communicate, making up a whole constructive learning environment, hoping to attain the constructive pedagogic concept.

2 Principles of system establishment

2.1 Basis of learning theory

The pedagogy of constructivism lies in stressing "knowledge is constructed positively by the learner", so that pedagogic design should arrange activities of learning-orientation. In the process of learning, the teacher serves as "problem poser" whereas the students acts as "problem solver"; the teacher plays the role of assistance, and the learner should construct knowledge positively through the interactive discussion between the learners [2]. Each learner utilizes his previous concepts to expound the phenomena around, and then comes up with adjustment or assimilation toward his acquired cognitive structure to establish new concepts. Besides, the learning situation is also an important part of the content, functioning to help the learner to comprehend the differences between the perspective on conceptual traits. Thus, the learning activities ought to provide learners with quasi-actual experimental situation to manipulate, explore. By means of the cognitive conflict brought about by the students in the process of the activity, challenging his original concepts, he/she constructs the right concepts via the discussion and coordination with one another.

2.2 Basis of course content-concept of division

Division is the anti-calculation of multiplication. Both multiplication and division are thought of as the transformation of unity quantity. The so-called "transformation of unity quantity" refers to that using unity quantity as that described by calculating unit, transforming to another description by calculating unit using another unity quantity [1,3]. The situational mode of division question is categorized into two basic principles of including division and even division. Seen from the viewpoints of "transformation of unity quantity" to look at the questions of multiplication- division, the questions of multiplication is to reduce the quantity suggested in the units of higher layers (units accumulated by several units of lower layers) to the activity of transformation from the quantity suggested by units of lower layers; whereas the questions of division "including division" is on the contrary, that is, the quantity suggested by the units of lower layers changed into the transformation activity by the quantity suggested by the units of higher layers. As to even division, it is an activity of new unity quantity of high layers and unknown unity quantity.

2.3 Foundation of system establishment

This system is a learning environment constructed on the network, adopting three-tier client/server system architecture, and meaning adding a layer of service server on the original client-server two-tier client/server system architecture. In the structure of three-tier client/server master-slaver, the part of management of learning data is in the charge of database server, web server takes charge of teaching jobs, while the users of client proceed all kinds of learning activities via browser.

3 Pedagogic design of networked construction

3.1 Pedagogic design of constructive division of new course

The two questions types of division (including division and even division) should be reckoned as different ones, then helping students combine these two types of questions gradually. And by the activity of consecutive subtractions solving questions to communicate with the relationship, then introducing the format of division calculation. Thus, in the design of pedagogy, place the two combined types of characters, letting children solve problems by tangible objects or emblems and try to record the activity of solving questions. After solving the questions including division and even division successfully, try further to grasp the times of distribution including viewpoints of division when confronted with them again [4,5]. The number of unity quantity can be decided by the times of distribution to help students realize and construct the relationship containing two types of questions as to including division and even division. Finally they can introduce the processes of solving questions concerning the methods of many-steps subtraction recording including division and even division and discuss and form the formulas using " ÷ "taking notes of the common sense about the activity of solving questions including division and even division, letting children construct the whole meaningful concept of division.

3.2 CAI pedagogic design of constructive pedagogy by thinking activity

This system emphasizes the spirit of construction to help students establish the concept of division, thereby, expecting the system to become more congenial to the real pedagogic environment. We let the computer become a virtual teacher, besides posing problems, he/she can judge the students' types of solving problems and mode of operation, and providing the dialectics and clarification and discussion undertaken between the users or between the user and the virtual students. Thus, the design of the problems by this system is introduced by the ordinary ones of daily situation to make sure if students have grasped the messages of the problems and commu. cate and clarify the messages with each other through asking (As in Figure 1). After posing the problems and clarifying the messages, let the students solve the problems. In order to make the system grasp the process of solving problems and thinking, we design "tool table of operation of thinking activity", which contain tangible objects, representation, digits and the symbol of calculations and so on. For example, as shown in Figure 2, if learner choose "to bakery", then the tangible objects can be used to solve the problems. If the learner choose "drawing circles", then representation can be used as the tools of solving the problems (As in Figure 3); if the learner choose "to digital factory", then digits can be used as the tool of operation (As in Figure 4). By the tool of operation chosen by the user, the computer can grasp what he thinks. If the user fails to solve the problems by themselves, they can discuss with others on the line, or discuss by the activity of solving the problems of the virtual students (As in Figure 6and 7) to attain the cooperation and learning. At last, after the user solve the problems successfully, the computer will play the role of the virtual teacher, raising questions to let the user to fortify the concepts, avoiding no continual between the user's order of thought and the concept (As in Figure 5). Then posing problems again to judge the students' learning state in order to proceed another activity dynamically. In doing so gradually, the system expects the learner construct an overall meaningful concept of division.

4 Architecture and implementation of system

4.1 Design environment and tools

This system uses Windows NT server as server platform. The developing languages include HTML, JavaScript, ActiveX, ASP (Active Server page) and so on. Using ASP as the main way of control, and exercising ASP and ODBC (Open Database Connectivity) to go with it, making the user's management of teaching material simplified. In the aspect of editing course software, Authorware5 is a chief developing tool.

4.2 System flowchart

The system flowchart we designs just as Figure 8 shows, the general elucidation is as follows:

1. Pedagogic situation of networked construction: In the beginning, the system would ask the user to register data to set up the database of students' basic data. At the outset of the course, the system will judge the user's competence by the pretest; then according to the basis, the system can pose the problems. After clarifying the messages of the problems, the system lets the user proceed to solve the problems. After solving the problems successfully, it lets the user carry on a series of on-line discussion and communication with the students or virtual students. Based on the acquired knowledge, the students construct the concepts, and fortify or revise the concepts through the experience of reflection. Again, the system poses the problems to judge the students' learning situation, then it proceeds the next teaching activity.

2. Database of "student model": It consists mainly of three databases:

(1) Database of students' basic data: It is used to record the students' basic data such as name, age, the experience of using the computer and so on.

(2) Database of learning: It is used to record the course units the students have learned, the learning state and duration of each unit, and the students' learning results and so forth.

(3) Database of learning achievement: It records the students' assessment about answering and the mode of students' operation.

3. Database of "posing problems of constructive pedagogy": It stores the material content of division pedagogy. The content contains two types of division problems (including division and even division) and various types of processes pedagogic activities.

4. Database of problems: It stores the problems for pretests and posttests.

4.3 Function of on-line communication

Because the system aims at establishing a more compatible with the learning environment of real pedagogy, so that this system design a series of communicative mechanism on the line to help students proceed the learning activities to produce the learning effect. The details will be narrated as follows:

1. Group of discussion: It is an open but not synchronized function on the line. Once the user encounters the learning difficulty, he/she can put the problems on the discussion place, and when other users see them, they can put forth the ways of solving these problems.

2. Room for discussion: It is an open and synchronization for communication. This on-line unction can improve the fact that the single CAI system fails to undertake the defects of communication and discussion immediately. Take Figure9 for example, the user in the room for discussion can carry on the mutual discussion, communication to solve the problems with other users on the line for their learning difficulty.

3. On-Line call: This is a one-to-one synchronous communication way, enabling the learners to proceed one-to-one discussion and forward the brief introduction to other users on the line.

4.4 Operation flowchart for User

When the user enter the system by using browser for the first time, the system would demand the user to register, thereby getting the user's data to set up student model basic data for database, and letting the user accept the pretest to judge the user's level of operation, and recording the user's answering situation. Utilizing the user's answer for reference, modifying the connection dynamically, letting the user connect the courses properly. Afterwards, whenever the user enters the system, he has to register user name and password as the recognition. The system then will proceed next activity according to the user's previous record. When the user undertakes the learning activity, the system will take down the learning state each time, so as to analyze if the user's learning state will attain the expected aim and will be used as learning analysis.

5 Conclusions

With the approach of eased network age, the network will definitely become the trend. Thus, establishing CAI system on the network cannot be delayed. In the light of these, we hope the constructive pedagogy combine with network to make up for the deficiency of pedagogy, letting the learners have more learning space, so as to acquire the real mathematics concepts. This study proceeds to test by the pedagogic content of "division-concept" of elementary school, presently testing all the functions provided by the system, hoping to reassess pedagogic content and system in many months, looking forward to reaching the learners' interaction, fulfilling the pedagogic concept indeed, letting children construct whole mathematics concept.

References

[1] 南白強, "單位量的變換(一).正整數乘除法運思的啓蒙", 教師之友, Vol. 34, No 1, pp. 27-34, (1993).

[2] 南白強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看—", 科學教育學刊, Vol. 1, No 1, pp. 101-108. (1993).

[3] 南白強, "單位量的變換(二)", 教師之友, Vol. 36, No. 5, pp. 35-44, (1995).

[4] 楊瑞智, "國民小學數學新課程中年級除法教材的設計"八十二學年度數學教育研討會,嘉義,台灣,pp.119-136(1993).

[5] 楊瑞智, "國民小學實驗課程整數乘除算則的教材處理",八十六學年度數學教育研討會,嘉義,台灣 pp.98-113(1997).

[6] 蘇育任, "建構主義式教育的迷思與省思", 國民教育集刊, No. 5, pp. 121-139, (1997).

[7] 吳博雅, 王偉仲, 謝堅, 曾彥鈞, 陳詩茹, 牛晉媛, "網路建構式電腦輔助教學系統之研究—以國小數學科面積基本概念爲例", 1999 中華民國 CAI 研討會論文發表, pp. 159-165, (1999).

[7] Dalgarno, B. Constructivist Computer Assisted Learning: Theory and Techniques. WWW. 21Oct. 1997. Available: http://services.canberra.edu.au/~barney/articles/ascilite96/paper.htm (1997)

[8] Hiltz, S. R. Teaching in a Virtual Classroom. 1995 *International Conference on Computer Assisted Instruction ICCAI'95* Hsincku, Taiwan http://it.njit.edu/njIT/Department/CCC/VC/Papers/Teaching.htm

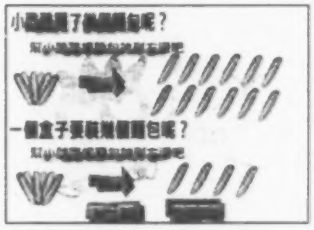


Figure 1:The Clarification of the problem

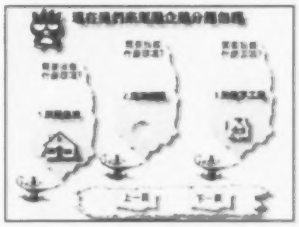


Figure 2:The choice of operation tool of problem solving

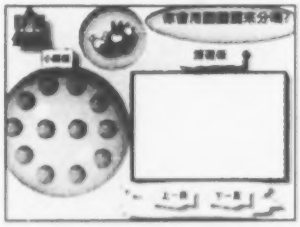


Figure 3:The presentation of thinking activity - representation

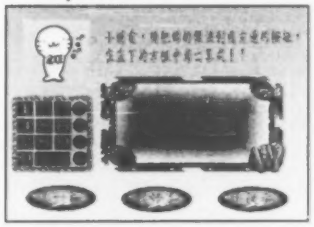


Figure 4:The presentation of thinking activity - digital and operator symbol

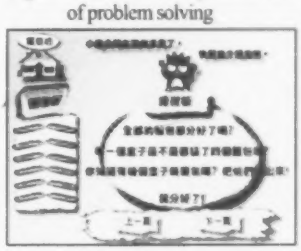


Figure 5:Reflection and discussion

Figure 6:The strategies of virtual students

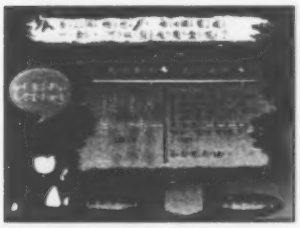
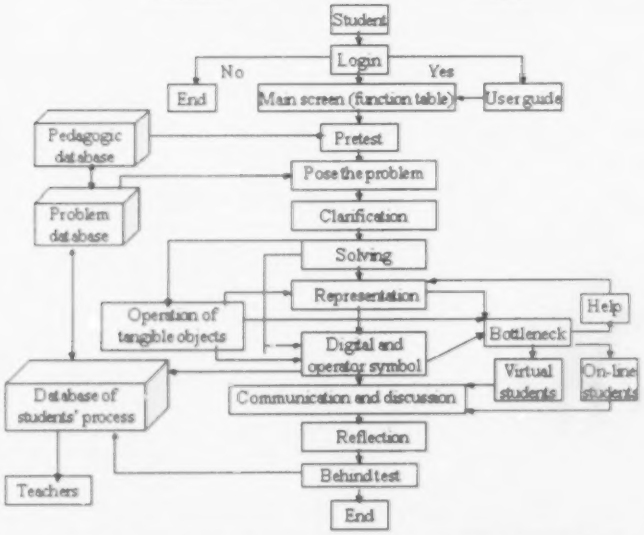


Figure 7: The communication of solving methods of virtual students

Figure 9: Group of discussion



Figurre8: The design of networked constructive pedagogy with thinking activity

BEST COPY AVAILABLE

The Estimation of Music Genres Using Neural Network and Its Educational Use

Yasuhiko TSUJI*, Kanji AKAHORI*, Atsuhiro NISHIKATA*
Graduate School of Decision Science and Technology, Tokyo Institute of Technology
2-12-1, O-okayama, Meguro-ku, Tokyo, 152-8552, Japan
Tel: +81-3-5734-2991
Fax: +81-3-5734-2991
E-mail:tsuji@ns.cradle.titech.ac.jp,
akahori@cradle.titech.ac.jp,
nisikata@cradle.titech.ac.jp

To develop a learning support system of music genre, a neural-network-based system was developed that can estimate the genre of music from partial information of a standard MIDI file of music. Standard MIDI files of 120 music titles has been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal after the Neural network of the system had been trained. Comparison shows that, the system developed, has a higher judgment rate than that of subjects. Next, the weight of the links were examined by an expert, 5 of the nodes in the Hidden Layer could be extracted.

Keywords: **Music Education, Neural Network, Intellectual Learning Support, MIDI**

1 Backgrounds and Objectives

Recently, popular music, for example *Beatles* etc, is included in recent music textbooks of Elementary, Junior High and High Schools in Japan. So, it is thought that music education using popular music will increase more and more in course of time. When students learn popular music, music genre of the music is an important factor[1]. In order to learn the musical feature of each genre, it is thought to be very effective. Systematic genres studying of popular music, in which students seems to be interested, is thought to be a way of the students' music experience enrichment.

An "Automatic Composition MAGIC (Music system for Arrangement and Intelligent Composition) Considering Music Style" was developed [2] by Minamikata in 1989 is one of the researches in the research field that treats plural genres of popular music. This System supports composition and adaptation using heuristic rules divided by music taste of genre. It is said that rule-based system like this is effective when the system reproduces a already-known music taste or rule for the system, but there is an anxiety that generated music is conventional, and it is a problem for an unknown taste.

It can be said that the genre of popular music is the combination of different music. Now, many researches have done the grouping of music. Concerning Neural Network-based research, the research of Sakamoto (1999) grouped the music according to the sensibility information by using SD method [3]. If consider the flexibility and generality grouping by neural network differs from that of grouping by rules or multiple different analysis. So, it is said that moderate result can be expected for any unknown input by the process of grouping by Neural Network.

Based on the above research, we aim to develop the learning support system which can provide feedback on "Feature as the genre" of an unknown music with the Neural Network training of the music of various genres. Based on the above-mentioned background, we conducted this research in the following way. At the beginning, reserve experiment was done by an expert of popular music to confirm the factor for the estimation of the genre. Based on the obtained finding, we trained the Neural Network. Here the Neural Network was composed using the partial information as input signal and genre of the music as output or

teaching signal. In order to use this system for education purpose in the future, the meaning interpretation for each factor of the Hidden Layer of the trained Neural Network was identified by an expert of popular music. Then, the genre estimation experiment was done using the subjects who seemed to have general experience of popular music. Lastly, the estimated average result of the subjects and the estimated result of this system was compared to show the effectiveness of this system.

2 Estimation of Music Genres by Expert

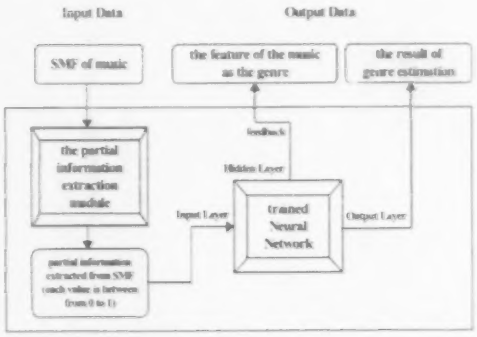
When music and genre are trained to the Neural Network, the problem is that we should take data to make an input signal from a long standard MIDI file. Therefore, we examine the mounting method of this system by knowing how the person judges the genre. For that, in the preliminary experiment we ask the expert about the factor of the genre estimation. The subjects had different musical instrument performance experience for ten years or more. The procedure was that they were made to listen ten in total of five genres. Also the factor to estimate the genre was interviewed. As a result, the following factors were found.

(1) The factor to estimate the genre is various according to the genre, and it's vague information.
(2) The factor to estimate the genre is local & partial information.

From (1), at first we got to the hypothesis that the estimation of music genre based on rules is very difficult and not proper. Under the above hypothesis, we propose to use Neural Network to deal with vague information in this research. As the input from (2), we judged that it was appropriate to extract partial information that seemed to be necessary for estimating the genre of music, and to assume it to be an input value of the Neural Network. The standard MIDI file (Hereafter, it is abbreviated as SMF) that is already a descriptive language was used as music.

3 Genre Estimation System

Figure.1 shows the composition of the genre estimation system. The flow of this system is as follows. When the user inputs SMF of music, the partial information extraction module extracts some partial information from the music. Then, it is put to the Input Layer of the Neural Network that has already been trained for music and the genre. The Neural Network feeds back the result of estimating the genre obtained from the Output Layer. Moreover, the feature of the music as the genre obtained from the Hidden Layer is planned to use as feedback in the future. If the module is developed, the user will be able to learn the genre.

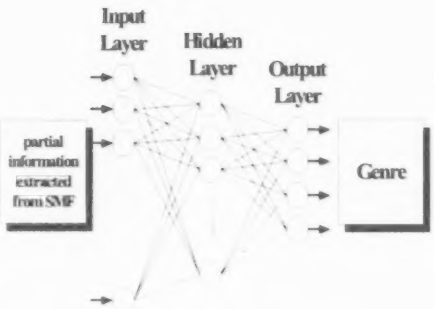


3.1 Extraction of Partial Information from SMF

SMF of the General Midi correspondence was used in this research. SMF includes various musical information such as Note-On (time of starting to ring each music sheet), Note-Off (time of finishing to ring each music sheet), Velocity (the strength of each attack), Note Number (pitch), and Program Number (kinds of musical instruments and tones) etc. The following three information of these score information were decided to use in the partial information extraction module.

BEST COPY AVAILABLE

1. Kind and tone of musical instruments extracted from Program Number (henceforth, we call it "Musical Instruments and Tones", which is expressed by an array of 128 Boolean type variable. Each valuable shows whether musical instruments (tones) of Program Number 1-128, were used in that music or not.).



Distribution of Rhythm extracted from the statistics of position of Note-On per a bar (henceforth, we call it "Distribution of Rhythm", which is expressed by an array of 16 integer type variable. Each variable shows the frequency for which Note-On event is held at the rhythm in one bar in the SMF.).

Distribution of Pitch extracted from the note number (henceforth, we call it "Distribution of Pitch", which is expressed by an array of 12 integer type variable. Each variable shows the frequency for which each pitch of 12 music scales is used in the entire music of SMF.).

3.2 Composition of Neural Network

Figure 2 shows the composition of the Neural Network. We adopted the Back-Propagation algorithm as the learning algorithm of the Neural Network. For the input signal, we used a combination of the values.

4 Outline of Genre Estimation Experiment using this system

4.1 Method

By the above-mentioned methods, the genre estimation experiment by this system was performed. 120 music titles of SMF which are composed of 30 titles each in Japanese popular ballad, Jazz, Hard Rock, and Heavy Metal, tried to be learned by the Neural Network. In this research, the combination of the following partial information was learned as an input data.

Musical instrument and tone 128bit
Distribution of rhythm 16bit
Distribution of pitch 12bit
Musical instrument and tone, Distribution of rhythm (+) 128+16=144bit
Distribution of rhythm, Distribution of pitch (+) 16+12=28bit
Musical instrument and tone, Distribution of pitch (+) 128+12=140bit
Musical instrument and tone, Distribution of rhythm, Distribution of pitch (+ +) 128+16+12=156bit

The number of units of Hidden Layer in each Neural Network is assumed to 10-30. The number of units of Output Layer is as many as the number of genres that the Neural Network learns. In this case, it requires four units in Output Layer, because there are four genres.

4.2 Result

The result of training is shown in Table 1. In the Table 1, "NN" means Neural Network, and - in NN means the Neural Network whose input information is described above. The result of training, NN was converged about 650 learning times, and

NN	Input Layer	Hidden Layer	Output Layer	Judgment Rate	Judgment Percentage	Learning Time
	128	20	4	119/120	99.2	X
	16	10	4	97/120	80.1	X
	12	10	4	103/120	85.8	X
	144	30	4	120/120	100	About 650
	28	30	4	111/120	92.5	X
	140	30	4	119/120	99.2	X
	156	30	4	120/120	100	About 1100

NN was about 1100 learning times, but other NN were not converged within ten thousand learning times. So, the trained Neural Network was able to judge the genre of learned music at 100%.

From this, it is suggested that the Neural Network like - that has single partial information in Input Layer can't finish learning, But the combination of those partial information make it enable to learn. This result supports the findings of experts at the preliminary experiment in Chapter 2 whose also says that the factor to estimate the genre is various according to the genre.

4.3 An Analysis of Hidden Layer

The Hidden Layer in the Neural Network is analyzed here. There is a heuristic method that each cell's tendency in which it is likely to make active or inactive is found by an expert, and then the meaning of factor is obtained[4],[5]. We used that method here.We focused on the weight of the link between Hidden Layer and Output that is above 10. Each unit from No.1 to 5 are activated by following genres.

Unit No.1: Hard Rock
Unit No.2: Hard Rock, Jazz
Unit No.3: Hard Rock, Jazz, Japanese Popular Ballad
Unit No.4: Heavy Metal
Unit No.5: Japanese Popular Ballad

Table 2. Analysis of Each Factor in Hidden Layer

Unit	Name of Factor
1	Hard Tone Factor
2	Synthesizer Tone Factor
3	Jazz-Acoustic Factor
4	Rhythm Tendency Factor
5	Combination Factor of Electric Instruments and Rhythm Tendency

Finally, each unit was named by a music expert. The summarized result is shown in Table 2.

5 Experiment by Subject

To investigate at how much rate can the subjects, twenty-five female university students were asked to listen to eight music titles of 4 genres of SMF with MIDI sound randomly, and to judge the genre and the factor for each music.The judgment rate of all the subjects was 66.5%.

To compare the judgment of subjects with this system, Neural Network was trained with 119 titles, and was made to estimate the genre of subtracted one as unknown music.

As a result, both Neural Network and have a judgment rate of 100% for eight unknown music titles. From this, the judgment of this system is higher than that of subjects with general experience of popular music.

6 Summary of Results

In this research, development and evaluation of genre estimation system ware performed aiming for the development of learning support system of music genre. The results are summarized as follows:

(1) The preliminary experiment for experts with an experienced popular music was performed, and a result that says that the factor to estimate the genre tends to be local & partial information was obtained.

(2) From this finding, genre estimation system using Neural Network was developed.

(3) 120 music titles have been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal at the rate of 100% by training the Neural Network to identify these 4 genres.

(4) The judgment rate was 66.5% as the result of the estimation experiment for subjects with general experience of popular music.

(5) This system was made to estimate 8 music titles, as an unknown music, out of 120 which were used in the genre estimation experiment by subjects. As a result, the estimation rate of 100% which is higher than that of the subjects (66.5%) was obtained.

(6) Each unit of Hidden Layer in trained Neural Network was enable to be named, and the factors of each unit were able to be extracted by the expert of popular music.

From this finding of 6, providing feedback on the features of the music from Hidden Layer becomes possible by the way of observing the result of meaning explanation of Hidden Layer in which the Neural Network has the feature of the music as a genre, observing the state of fire, and observing the input units which have tendency to make active to the fired units in the Hidden Layer.

From the result described above, the possibility of the development of a learning support system using this system for music genre is shown. And, it was thought that the trained Neural Network of this system has the application possibility not only to the learning support system but also to the supporting composition and adaptation.

Acknowledgement

The authors would like to thank Mr. UZZAMAN MD. ANIS and Assistant. Taizan SUZUKI for their cooperation.

References

[1]Hiroshi UEDA, Kazumi AKAIWA etc.: Hajimeteno ongakutsuu:50 genres 500 CDs, Ongakunotomosha,1993

[2]Junichi MINAMITAKA, Mayumi INO, Kunio SATO, Shigenori MORIKAWA: Automatic Composition MAGIC Considering Music Style, Collected lecture papers of the 39-th National Convention of Information Processing Society of Japan, No.3, pp.2242-2243,1989

[3]Takashi SAKAMOTO, Yoshinobu KAJIKAWA, Yasuo NOMURA: Classification of Group According to Tune's Impression Using Nonlinear Distinction Analysis in the Music Sensibility Space, Transactions of Information Processing Society of Japan, Vol.40, No.4, 1999

[4]Hisayoshi ITO, Hiroki ITO, Kanji AKAHORI: An Analysis for the Neural Network Supporting Users' selection of Menu Items,IEICE technical report, (Educational Technology) ,Vol.96, No.500, pp.53-60, 1997

[5]Michio MATSUBARA: Evaluation of Global Processing of Students in Electric Circuit, Transactions of Society Japan Science Teaching, Vol.39, No.1, 1998

The Externalization Support System of Self-explanation for Learning Problem-Solving Process

Kazuhide Kanenishi*, Takahiko Mendori, Masafumi Sawamatsu*** and Yoneo Yano*****

**Center for University Extension, Tokushima University,*
1-1, Minamijyousanjima, Tokushima, 770-8502 Japan,
mailto: marukin@is.tokushima-u.ac.jp

***Department of Information Systems Engineering, Kochi University of Technology,*
185, Miyanoguchi, Tosayamada-cho, Kochi, 782-8502 Japan,
mailto: mendori@info.kochi-tech.ac.jp

****Department of Information Science and Intelligent Systems, Tokushima University,*
2-1, Minamijyousanjima, Tokushima, 770-8502 Japan,
mailto: {yano, sawa}@is.tokushima-u.ac.jp

When a learner dose various tasks in the computer, the interaction of the learning support system is so a transition which happens inside the learner. At that time, educational effects such as knowledge structuring occurs due to externalization of representation. We developed the prototype system in so that externalization of self-explanation of the problem-solving process was supported. A learner externalizes the self-explanation "How do I solve the exercise?". At this time, she/he explains using not only words but also diagrams, in order to exploit the effect of diagrams. Self-monitoring happens with self-explanation, and the acquisition of a problem solving strategy on is learned. In this paper, we construct a model of "externalization on the computer," and we consider the occurrence of cognitive load. Learning is a kind of load, therefore any reduction of the load (as opposed to its extinction) is of assistance. We propose the presentation of an operation list as a method of load reduction. The memory dependent evaluation becomes more coherent by such a list. In other words, the cognition perspective improves. In this paper, it is shown in the prototype system how externalization is accomplished.

Keywords: **Self-explanation, Reflection, Externalization, HCI**

1 Introduction

Recently, the contents of interaction have been reconsidered in the context of the learning support system[1]. So far, a computer playing a teacher's role is aimed at the transfer of domain knowledge expressed by the system. The computer asks a learner several diagnostic questions. The computer is central to such interaction. The perspective "For whom is this interaction?" is absent. In this paper, we propose an learnig environment (externalization support system) that promotes the understanding of problem solving resulting from the externalization in the computer. The learner works independently on the computer with the interaction we propose, then the learner rewrites his internal state. Learning occurs at that time.

Recently, attention has focused on "externalization " and "meta-cognition." For example, a vague idea is sometimes clarified by writing text. Externalization promotes the arrangement of knowledge and learning. On the other hand, meta-cognition is a psychic activity of higher order, involving self-monitoring (reflection), and is concerned with deep level learning such as the acquisition of strategies, the transfer of knowledge.

We paid attention to the self-explanation of the problem-solving process, and we have researched that support[2][3]. At present, a learning support system that externalizes self-description of the problem-solving process has been utilized as an experiment. Exercises in statistical scales of geography were used. A learner expresses how she/he solved a problem. Geography though is considered mere memorization, the learner can acquire an understanding

of the problem-solving process by self-description. An example of this type of exercise is shown in figure 1.

We propose the usage of figure 1 as a method of externalization. We are constructing the environment where a learner can do self-explanation by writing memoranda. In this system a learner draws on the character and diagram of the explanation of the problem-solving process. Furthermore, the examination process of externalization is supported from the cognition perspective. The activities scrutinized are internal (understanding the behavioral reason of the learner) and are supported by the presentation of the operation history. This supports the self-monitoring that is crucial to meta-cognition

Idea support system, idea sketch, etc. are proposed in the HCI researches. However, we think learning involves a kind of load, and our purpose is to recommend support by control of the load, rather than by elimination of the load. The consideration of support by reduction of the load is a different point.

In chapter two, we describe the educational effect of externalization. We propose a support method of externalization targeting self-explanation of the problem-solving process in chapter three. The summary of our system is shown in chapter four. We present a summary in the final chapter.

2 The outline of externalization

2.1 The educational effect of externalization

Many researchers point to the educational effect of externalization[5]-[6]. The effect of diagram use in externalization has been acknowledged as well. The learner can acquire the educational effect if self-description is externalized by use of diagrams[7]-[8].

Externalization is the expression of internal psychic activities (images). We mention clarification of knowledge, structuring, etc. as a general effect. Moreover, internalization occurs by repeated externalization, and internal processing proceeds smoothly.

Self-description involves special explanation of a point[9]. Externalization is unique as well. Self-monitoring is enhanced by a learner's repeated externalization of the self-explanation.

2.2 Externalization model on the computer

We construct a model of externalization in this section; our objective is not to clarify the mechanism of externalization. In a sense, the model is to employ educational effect. Various models of externalization are available; we have elected to choose a model of externalization in the computer.

Externalization is considered to consist of several functional modules. The module described here is the functional unit that is comparatively independent.

The model of externalization and the state of repetition of each module are shown in figure 2. We classify modules of externalization into four ways.

(1) Image generation
(2) Expression form generation
(3) Operation sequence generation
(4) Examination (evaluation)

Module (1) is the creative impulse that forms an internal image. Externalization consists not only of the creative impulse of expression but also of the underlying representation. Though module (1) is a heterogeneous activity, it is a part of externalization. Creativity is a very complex psychic activity, and is beyond the scope of this paper.

Module (2) is the expression of vague internal images. Expression is based on the rule

Question: What are items(1),(2),(3)?

Item	Ranking	1	2	3	4
(1)	Exporting country Amount of export	U.S.A. 9,637	Australia 5,200	Poland 2,800	U.S.S.R. 2,000
	Importing country Amount of import	Japan 7,909	France 2,295	Italy 1,905	Canada 1,567
(2)	Exporting country Amount of export	Cuba 675	France 300	Australia 255	Brazil 253
	Importing country Amount of import	U.S.S.R. 672	U.S.A. 270	China 222	Japan 180
(3)	Exporting country Amount of export	Japan 1,612	West Germany 1,458	France 675	Belgium* 460
	Importing country Amount of import	U.S.A. 1,802	England 490	West Germany 483	Italy 460

(1) and (2) unit is 10,000 tons. (3) unit is 10,000,000 dollars. * Includes Luxembourg.
(1): 1982, (2): 1983, (3): 1980

Fig. 1 Example of geographical exercise.

BEST COPY AVAILABLE

of generation. As a case in point, form of presentation (rule) that has been configured freely and formalization that has already been completed, may be employed. For example, in the case of pictures, expression is free, and a person who draws a picture decides the form of presentation. On the other hand, when we illustrate a phenomenon with a formula, formalization is predetermined, and we must obey mathematical rules. As for externalization of writing memoranda, existing formalization and independent formalization are being used together. We can think of module (2) as consisting of the following three usage forms.

(a) Existing formalization
(b) Independent formalization
(c) Existing formalization + Independent formalization

The burden of usage of the existing formalization is that a learner must understands formalization. However, when a learner acquires existing forms, internalization progresses, and the representation in module (1) becomes simplified. For example, when a learner is skilled in the use of the Japanese abacus, she/he becomes capable of mental arithmetic using a mental image of the abacus. The effect of the Venn diagram in the understanding of the set theory is similar.

When externalization is done on the computer, the process of module (3) is remarkable. The rate of this part increases when the expression is done indirectly using the computer. Expression can't be generated if the computer lacks the appropriate software. Thus, a learner plans an operation sequence to configure expression, and she/he will move the mouse based on that plan.

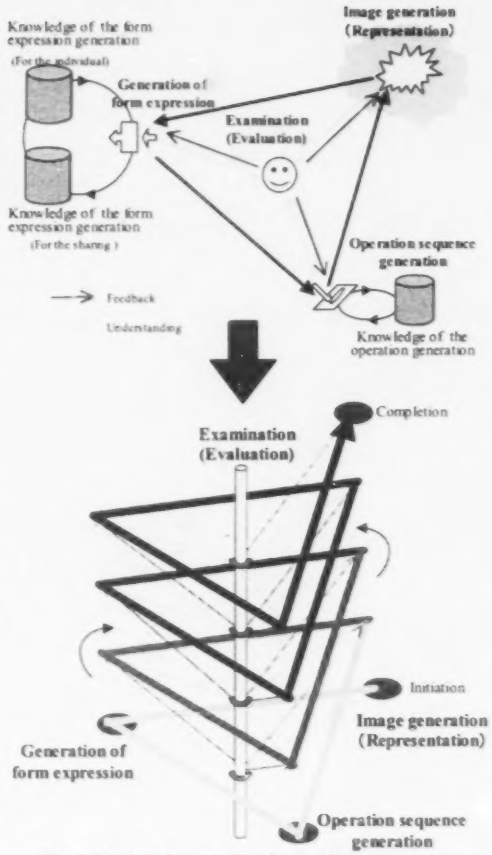


Fig. 2 Model of externalization on the computer.

Module (4) is different from the other modules. Examination is the evaluation of each process from module (1) to (3) with feedback. In other words, examination is a meta-level activity when compared with the other processes.

Modules (1) to (3) become a cycle. The processes from (1) to (3) are evaluated by process (4), which provides feedback. This cycle is repeated until a learner judges by examination. That the activity has been completed

3 Externalization support of self-explanation

3.1 The support of externalization by load reduction

The general support method of externalization is considered in this section. First, we remove the cognitive load intuitively for externalization support. However, the purpose of learning is to put load on the learner. Even if a computer estimates the intention of the learner (even if an explanation is formed automatically,) learning does not progress. Hence, removal of the load does not support learning.

The real nature of the load lies in the multiple combinations of the loads. The load is classified by cause and category, it is necessary to separate the load that aids learning from the load that does not. We aim to reduce the load. In other words, consideration of the relevant control of the load is necessary. Arrangement and classification of each load is necessary for its support.

3.3 Drawing method of the problem-solving process

Support of the expression form generation process serves to prepare for the effective expression method. We show

(by way of drawing) the problem-solving process following. Problem-solving is a process, and it has a certain structure. Diagram usage is effective to express structured information. Graph expression is a relevant method like Tweedier's indication as an informational expression that has a flowing structure[10]. For example, though various methods are proposed, a flow chart is still used for the expression of a program structure.

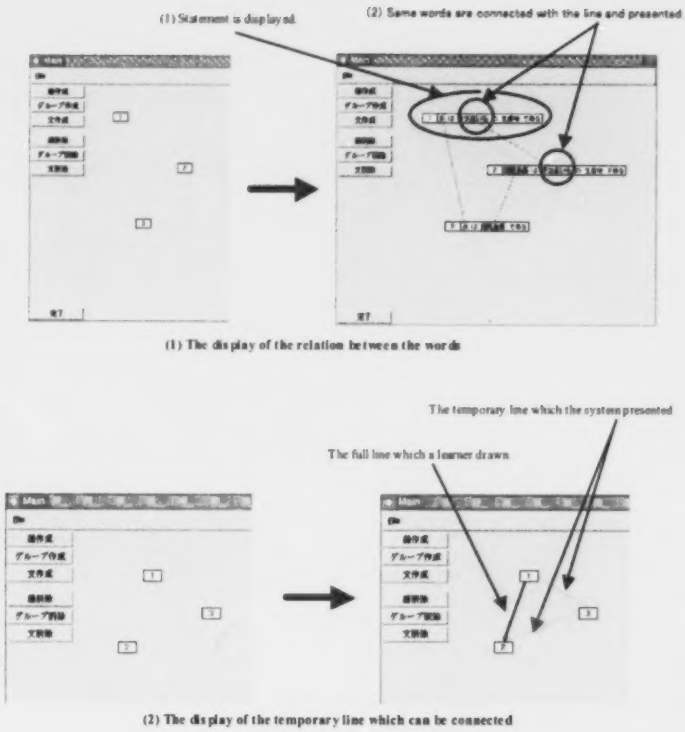


Fig. 3 Model of operation support.

We use a style that combines the use of words and figures. We propose the arrow diagram that expressed structure between statements was symbolically used with the text of the items together. The externalization task with our learning environment consists of two tasks: text creation and graph drawing. Expression is constructed in the following procedures:

(1) The Entering of a simple sentence
+
(2) Placement (migration)
(3) Connection
(4) Grouping
(5) Attribute addition to the object

First, a learner constructs the explanation of the character form. The explanation of the solution reflects the problem-solving process of the exercise. We exclude compound sentences and complex sentences, and use only simple sentences. Each simple sentence during expresses each state of the problem-solving process. A learner is conscious of the order, and notices that problem-solving proceeds by the items. The order of the explanation copes with the process of the problem-solving.

Next, each simple sentence is connected with an arrow line to form a "node". A learner is specifically conscious of the structure by drawing these lines. As for the structural expression of the explanation, each statement is associated with the arrow line toward the explanation of the expressed goal from the explanation of the initial state. A learner encloses some statement, and gives color attribute as a supplementary activity. The diagram drawn with the arrow line is completed by repeating the above activity.

The part that decides expression is first and the part in which a learner himself can determine expression are both present in the above expression method. Such a method guarantees freedom of expression for the learner, while at the same time accepting ambiguity. Thus a learner can write a memorandum of the meaning of the attribute appended by the learner. For example, the system asks a learner for a reason when a learner changes the color of the line. This function is actualized as a fraction of the support of the look-over.

3.4 The support of the operation sequence generation

We describe the support of the operation sequence generation in this section. The following function is provided because the learning environment should be made convenient.

(1) The simplification of the operation
(2) The intersection of the operation and the phenomenon

BEST COPY AVAILABLE

The operations of the learning environment are statement creation, statement delete, line drawing, line erasing, movement, grouping, and the color alteration of the object. It prepares only for easy operations. A phenomenon can be easily imagined from these identifiers. We achieve a single function in our system. An operation and a phenomenon correspond one-to-one, and the understanding of the operation becomes easy.

The learning environment is tailored to notify the learner of deficient explanations and feasibility of the expression by the following operation support. The state of the support is shown in figure 3.

(a) The display of the related word information
(b) The display of drawing line feasibility

A simple sentence is displayed on the learning environment as a symbolic icon. One component is made according to statement, a learner can focus on structure between the statements. On the other hand, a certain word sometimes has significant meaning for structural grasping of the explanation. The learning environment manages word information, and employs it for support.

The indication of related word information This is the method in which the structural understanding of the statement is accelerated. When the same word in is used several statements, the learning environment shows them. When the same word is shown repeatedly, the system is made conspicuous. The system displays a statement next to the statement icon, and gives color to that word. The same word in different statements is connected by a line.

The indication of connection feasibility This is the method in which drawing between the statements is supported. The system presents the link that can be connected in the statement nodes as a temporary line. The system estimates the statement that relate to other statements in the placement step (which the statement icon on the workspace finished). The feasibility a line drawn is high in the statement which satisfies the following conditions:

(A) The statement operated just before
(B) The statement that encompasses the same word

The system presents a temporary line to the learner according to the stage at which placement was finished. All candidates are displayed when some lines are presumed. When a learner chooses a temporary line, the system re-establishes that temporary line as a permanent line. Because drawing lines is a possible option, the work of drawing is reduced for the learner.

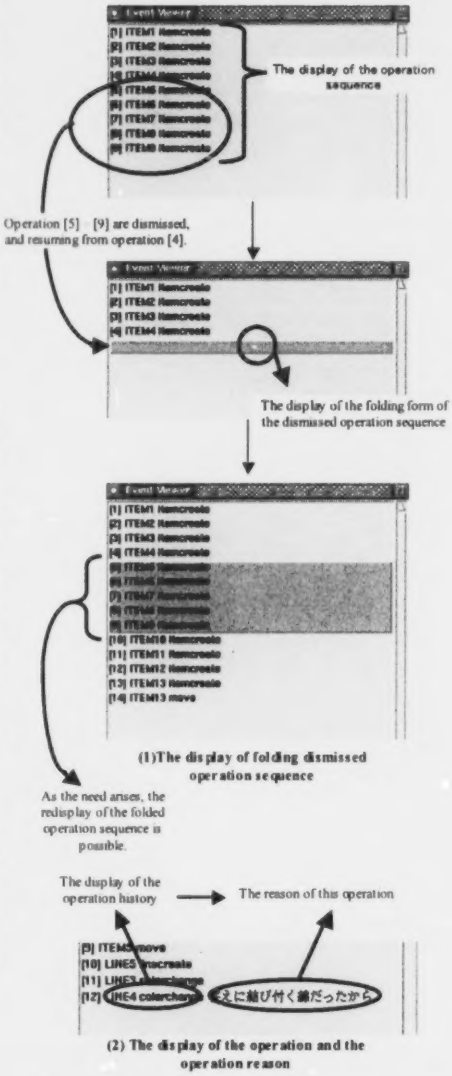


Fig. 4 Representation of the operation history list.

3.5 The support of the examination by cognitive perspective

We aim at the realization of the farsightedness of the cognitive perspective with the support of examination. Externalization is done so that a learner may learn about himself. We aren't aiming at deputy by the system. The approach of automating conception and drawing isn't embraced. Support toward examination of evaluating one's act is necessary. Therefore, we propose a method that assists the self-monitoring by the learner. The system uses the following two methods, as shown in figure 4.

(1) The display of the operation history
(2) The collection and display of the operation reason

Reflection on the personal task must depend on the current aspect of the activity subject and on memory. However, subject activity does not express variations in the middle of the task. Moreover, memory is often a temporal

BEST COPY AVAILABLE

effect, and often can't be extracted when necessary. Therefore the system preserves task history, and history and task process are reproduced to the learner. The system makes linear operation sequences and a learner can do an operation again from the arbitrary juncture of the operation sequence that is presented. In that case, a recent operation sequence occurs from the point that an operation was done again, and a previous operation sequence is dismissed.

However, when a learner reflects on an error, dismissed operational sequences encompass significant information. Because reflection support is critical, the system preserves all operation sequences. When a recent operation sequence occurs, the previous operation sequence is hidden temporarily from the learner. Then, if a learner requires, the previous operation sequence can be displayed. Cognitive perspective in the examination process improves due to the presentation of the operation history.

The display of the operation history provides an opportunity to look back at the operation. Furthermore, we not only present operation history but also present the reason of the operation. The system requires comment input at every operation. The set list of the operation and the reason are stored in the system. It is understood that comment is useful in order to reconsider program source. Ambiguity is present in expression, and the degree of freedom of expression is guaranteed. A learner himself sometimes forgets the intention of the figure on one side. A memorandum of the operation is useful in such a case as well. The presentation (collection) of the memorandum of the operation is not the active intervention of the system.

4 Self-explanation externalization support system

4.1 The configuration of the self-explanation externalization supporting system

Our system before this paper externalized a self-explanation only in character[3]-[4]. However, figures and text are mixed in the natural externalization. Drawing activity is separated from text creation activity in self-explanation, and it is unnatural to draw after text is written. Therefore our system was designed to enter text and to draw simultaneously.
We implemented three functions in the system.

(1) Explanation management
(2) Explanation structural management (visualization management)
(3) Operational history management

Module (1) manages information on the explanation sentence. This module is shared the entry of the explanation sentence and the display of the explanation sentence. A learner enters a simple sentence. The morphological analysis of each simple sentence is done by "Cyasen" developed with NAIST. Information on the word is extracted. By this processing, information on the noun and verb in a simple sentence is extracted. The system preserves the information with a simple sentence.

The order of the statement input can't be employed as an order of the explanation sentence. When a learner completes a drawing, the system decides the order of the explanation sentence based on the following information:

(a) Related to the arrow
(b) Grouping
(c) Related to the place
(d) Input order

First, the system gives priority to arrow line information. The beginning point and end point of the arrow shows a context. Next, simple sentences are grouped to the same level. The system fundamentally introduces the order of the input as the order of the explanation. When there is no grouping or arrows in the explanation figure, the system decides the order of the explanation sentence based on the co-ordinate information of the icon on the "canvas "screen. If there is a top-to-bottom relationship among icons, this relationship becomes the context. The order of input is used except in the case above. After the system shows the order, the alteration of the order by the learner is possible.

Module (2) manages the drawing task and the information acquired from this task. A learner enters a simple sentence, and next drawing becomes possible. Module (2) manages the whole drawing task on the "canvas", and it displays support information.

Module (3) presents the task history (operational history) of the learner. A learner sees this operation history, and adds various modifications to the externalized figure.

Various methods of presentation of the operation history are proposed. We think the list form is easy to understand. Various methods of Undo (Redo) are proposed as well[11]. We consider an operation to be a series of persistent sequences. We introduce the interface in which an operation can be done from an arbitrary part of the operation history list and the previous sequence folded under the recent sequence. The current sequence is important for the learner, so a dismissed sequence is rendered temporarily invisible. Hidden operation history can unfold the folded part if necessary (the icon indicates it has been folded.), but a learner only confirms a folded operation sequence, and a dismissed sequence can't be redone midway in the process.

4.2 Outlook of the system

We show how self-explanation is externalized on the system in this section.Six windows are displayed in the system that was manufactured. The screen configuration of the system is shown in figure 5.

(1) Canvas window (Operation button is encompassed.)
(2) Simple sentence input window
(3) Explanation sentence display window
(4) History panel
(5) Operation memorandum input window
(6) History display window

A learner does a drawing task on the canvas window (1), and then the drawing consequence is displayed. The learner starts an explanation through this window, and the explanation is written and modified. Various operation buttons are configured. This window performs the role of the console panel of the whole system.

The simple sentence input window (2) is a one-line editor for a learner to input a simple sentence. This window is invoked by the sentence-creation button on the canvas window, and closes when the input is finished.

The explanation sentence display window (3) displays an entered simple sentence with the items. Each sentence is displayed on this window by an entered order. When a learner estimates that externalization has been terminated (the stage in which the "completion" button is pushed), the order is evaluated, and the line of the explanation sentence is replaced. However, a learner can alter the line of the explanation sentence by using the mouse to "drag & drop".

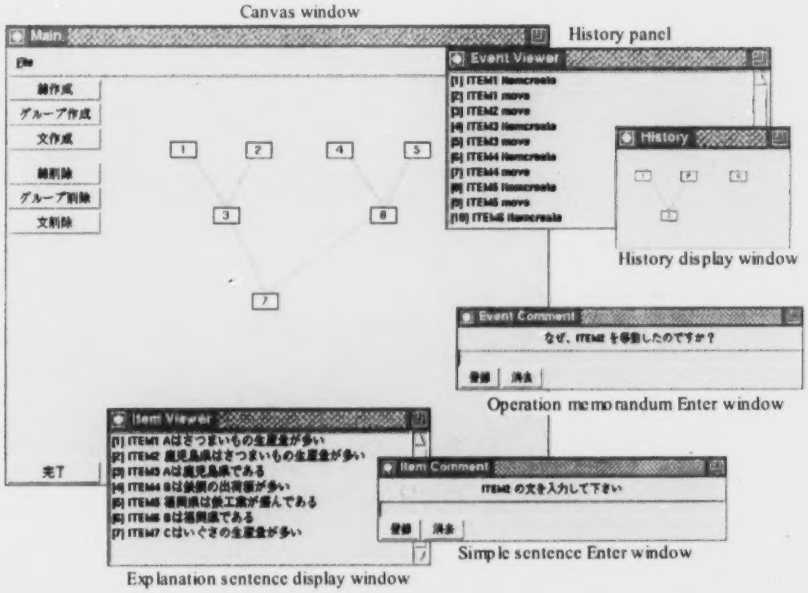


Fig. 5 Screen shot of the prototype system.

BEST COPY AVAILABLE

The history panel (4), the operation memorandum input window (5) and the history display window (6) are related mutually. The operation history of the learner and memoranda are displayed in the history panel. Though the memorandum input window is displayed at every operation, a learner doesn't necessarily need to enter memoranda. Entered comments are displayed in the history panel with the associated operation. When a learner chooses an operation from the operation history, the history display window displays the screen image when that operation is done. It is important to simultaneously present the screen image to support cognitive perspective. Moreover, if a learner chooses an operation from the operation history, she/he can redo the operation from there.

5 Conclusions

In this paper, we described a learning system in which externalization of self-explanation of the problem-solution process was supported. Recent attention is founded in the educational effect of externalization; however, the mechanism of externalization isn't clear, and the recommendation of the usage method isn't sufficient, either.

Therefore, we surveyed externalization first, and described the educational effect. Next, we considered the support method of externalization, and proposed the support method of externalization of self-explanation. The first is the method of externalization of self-explanation that employs expression by words and diagrams, such as memoranda. The other method is that of collecting the operation history and presenting it to the learner from the viewpoint in which the cognitive perspective is important for the examination process of externalization. Furthermore, we attempted a system that could leave operation reason when the operation history was collected. Self-monitoring becomes smooth by presenting operation and reason. Finally, an overview of our trial production system was shown. The state in which a learner externalized in that system was shown.

In the future, we will improve the system, targeting each operation to reduce user load, and we will evaluate the system.

Acknowledgment

This research was supported in party by the Grand-in-Aid for Science Research (A) No. 11780131 from the Ministry of Education, Science, Sports and Culture in Japan.

References

[1]Norman, D. A. :Turn Signals Are the Facial Expressions of Automobiles, Addison-Wesley, (1992).

[2]Metcalfe, J. and Shimamura, A. P. :Metacognition, MIT Press, Massachusetts, (1996).

[3]Kanenishi, K. and Yano, Y.: Guided Understanding for Problem Solving Process Using the Refining Self Explanation, Proceeding of HCI95(Vol.2), pp. 97-102 (1995).

[4]Kanenishi, K. and Yano, Y.: Development Self-Explanation Learning Environment Using the Explanation Refinement, Proceeding of IEEE SMC96(Vol.1), pp. 568-573, (1996).

[5]Stenning, K. and Oberlander, J. :A Cognitive Theory of Graphical and Linguistic Reasoning: Loginc and Implementaion, Cognitive Science, Vol. 19, pp. 97-140, (1995).

[6]Zhang, J. :The Nature of External Representations in Problem Solving, Cognitive Science, Vol.21, No.2, pp.179-217, (1997).

[7]Larkin, J. H. and Simon, H. A. :Why a Diagram is (Sometimes) Worth Ten Thousand Words, Cognitive Science, Vol.11, pp.65-100, (1987).

[8]Marcus, N., Cooper, M. and Sweller J. :Understanding Instruction, Journal of Educational Psychology, Vol.88, pp.49-63, (1996).

[9]Chi, M.T.H., Bassok, M., Lewis, M. W., Reimann, P. and Glaser, R. : Self-Explanations: How students study and use examples in learning to solve problem, Cognitive Science, Vol.13, pp.145-182, (1989).

[10]Tweedie, L.: Characterizing Interactive Externalizations, Proceeding of CHI'97 (ACM Conference on Human Factors in Computing Systems), pp. 375-382, (1997).

[11]Myers, B. A. & al.: The Amulet Environment: New Models for Effective User Interface Software Development, IEEE Transaction on Software Engineering, Vol. 23, No. 6, pp.347-365,(1997).

Traversing the Case Graphs A Computer Model for Developing Case-based Learning Systems

Isaac P.W. Fung & R. H. Kemp
Institute of Information Sciences and Technology
Massey University
Palmerston North, New Zealand
Fax: +64-6-3502259
P.W.Fung@massey.ac.nz; R.Kemp@massey.ac.nz

This paper presents an extended theory for representing cases in a case-based physics learning environment. There are two issues with which developers of case-based tutoring systems often contend: one is assessing and retrieving similar cases from the case library; the second one is delivering the case contents to the students. Whilst an earlier paper has addressed the former issue, this paper focuses on the latter by defining a computational mechanism that is used for delivering the case content. The mechanism is developed by defining a procedural semantics on the case graph which incorporates the dynamic modelling capability of petri nets. A case is initially opaque to the student. During case interaction, however, it will be made transparent gradually by engaging the students with problem-solving activities. The activities are modelled using the notions of marking places and firing transitions, where places and transitions represent case variables and operations, respectively. The idea is illustrated with an example of providing guidance to students solving problems in the domain of Newtonian mechanics.

Keywords: **Artificial Intelligence, Conceptual Graphs, Intelligent Tutoring Systems, Case-based Reasoning**

1 Introduction

This paper presents an extended theory of representing problem-solving cases proposed in [5] for the purpose of modelling instructional activities between the cases and the learners within the context of case-based tutoring systems (CBTS) [11]. In response to the classic criticisms [12] leveled at the first-generation of computer-assisted learning software that frequently have to go back to inflexible, pre-compiled problem solutions, CBTS is very attractive for several reasons. Two of them are particularly appealing to us. From an instructional perspective, students are highly influenced by past examples (i.e. real cases) to guide their problem-solving activities [1] or completing cognitive tasks [8]. Our project sponsor demands that the final system should faithfully reflect what students actually do when completing their homework. It is, therefore, our aim to ground our system design at the outset on sound psychological findings about pupils' learning behaviours. Secondly, from a technical viewpoint, case-based adaptation techniques are powerful in adapting interface components to the user's need [14].

Individual learner's needs, style and progress do differ substantially. Case-based reasoning technology [7] endows the system with the capability of inferring what is considered 'best' for the students by referring to their past learning histories. [5] proposed the use of conceptual graphs (CG) [13] for representing tutorial cases. While this method elegantly tackles the issue of assessing case similarity, how the case graphs are built remains a 'black-box'. The case users have no way to inspect the internal processes for constructing the graph. To ensure

the cases are useful in tutorial contexts, the knowledge components of the cases need to be 'available' to the students. What we mean by 'available' is making the case solution transparent, i.e. the system is capable of justifying each problem-solving step being shown to the students in terms of the underlying physical principles.

The procedural semantics defined on case graphs which forms the core contents of this paper, provides a way of making the solution procedures explicit to the students. The idea is to synthesize a CG and the actor graph defined in [13] into one single global graph instead of treating them separately. The resulting structure is a tripartite graph that has three types of nodes: concept nodes, symbolic relation nodes and mathematical relation nodes. The mathematical relation nodes are for handling mathematical calculations in the domain of Newtonian mechanics, the targeted subject domain of our project These calculations are important in many science and engineering applications. In making the synthesis, two important ontological commitments were made. Firstly, human cognitive functions in studying a concrete case are viewed as a process of constructing graphs. Relevant concept nodes are created and linked to each other via some appropriate relation nodes (whether symbolic or mathematical). A case represented by the graph consists of sets of concept nodes and relation nodes, but to what extent the students understand the case contents remains unknown until some observable actions are seen. Secondly, the process of building the graph is based on the notion of concept node marking. Initially, the sets of nodes in a case are all opaque to the users because they are not yet marked. The set of nodes representing the initially given physical quantities are marked first. Each problem-solving step is viewed as generation of new graph nodes, but they are implemented as the nodes states change from unmarked to marked. To mark a set of nodes, the mathematical relation nodes (or operators) which link the marked and the unmarked nodes have to be fired. The procedures of solving the problem are defined as the firing sequence for marking the target concept nodes. The subgraph associated with a particular fired node represents the semantics of the knowledge behind its firing.

2 Formal Definition of the Case Constituents

We represent a typical case abstractly by a directed graph which is composed of

* Three disjoint sets of vertices C, R *and* R_m (i.e. $C \cap R = \varnothing$; $C \cap R_m = \varnothing$; $R \cap R_m = \varnothing$ and $C \cap R \cap R_m = \varnothing$) where C represents the set of concept nodes; R represents the set of symbolic relation nodes; and R_m represents the set of mathematical relation nodes.
* A set of directed arcs E such that $E \subseteq (C \times R) \cup (R \times C)$. Each arc $e \in E$ connects a concept $c \in C$ to a symbolic relation $r \in R$ or vice versa.
* A set of directed arcs E_m such that $E_m \subseteq (C \times R_m) \cup (R_m \times C)$. Each arc $e_m \in E_m$ connects a concept $c \in C$ to a mathematical relation $r_m \in R_m$ or vice versa.

Shown in Figure 1 is an example case graph where

$C = \{c_1, c_2, c_3, c_4, c_5, c_6\}$;
$R = \{r_1, r_2, r_3, r_4\}$;
$R_m = \{r_{m1}, r_{m2}, r_{m3}, r_{m4}\}$;
$E = \{(c_1, r_1), (r_1, c_2), (c_3, r_2), (c_4, r_2), (r_2, c_2), (c_5, r_4), (r_4, c_2), (c_6, r_3), (r_3, c_1)\}$; and
$E_m = \{(c_1, r_{m1}), (r_{m1}, c_2), (c_2, r_{m2}), (c_2, r_{m3}), (c_5, r_{m3}), (r_{m2}, c_3), (r_{m3}, c_4), (c_3, r_{m4}), (c_4, r_{m4}), (r_{m4}, c_6)\}$.

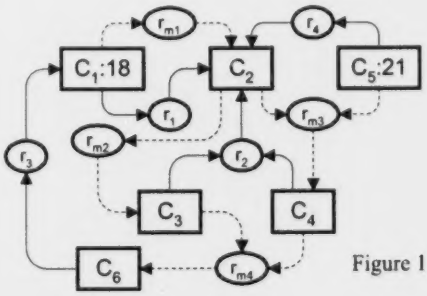


Figure 1

* For every $r_m \in R_m$, there exist an input set $I_r(r_m)$ and an output set $O_r(r_m)$ such that

$I_r(r_m) = \{ c \in C \mid (c, r_m) \in E_m\}$; (c, r_m) is called the input arc of r_m, and c is called the input concept of r_m; and
$O_r(r_m) = \{ c \in C \mid (r_m, c) \in E_m\}$; (r_m, c) is called the output arc of r_m, and c is called the output concept of r_m.

For example, the input/output set of the node r_{m3} in Figure 1 are $I_r(r_{m3}) = \{c_2, c_5\}$ and $O_r(r_{m3}) = \{c_4\}$ respectively.

* For every $c \in C$, it is defined as *marked* if it is being instantiated to a specific individual. In Figure 1, c_1 and c_5 are marked whereas the others are non-marked.
* The marking μ of a graph G can be represented by a *n-vector*: $\mu = (\mu_1, \mu_2, \ldots, \mu_n)$, where each $\mu_i \in (T, F)$. For example, the graph in Figure 1 has the marking $\mu = (T, F, F, F, T, F)$.
* A mathematical relation node $r_m \in R_m$ is *enabled* whenever each concept $c \in I_r(r_m)$ is marked. In Figure 1, only r_{m1} is enabled at that marking.

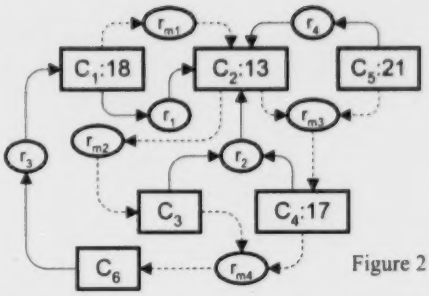


Figure 2

* When a mathematical relation node is enabled, it can be fired at any time and every time a mathematical relation is fired, every $c \in O_r(r_m)$ will be marked[1].
* For every $c \in O_r(r'_m)$, where r'_m is the fired mathematical relation, the content of c is evaluated according to the formulas inscripted in the respective $r'_m \in I_c(c)$.
* Supposing the formulas inscripted in r_{m1} is $c_1 = c_2 + 5$ and r_{m3} is $(c_2 + c_5) / 2$, the firing of r_{m1} will mark c_2 which enables r_{m3} because c_5 has already been marked. If r_{m3} is fired later, a new marking (shown in Figure 2) will be formed and become $\mu = (T, T, F, T, T, F)$.

3 Representing Mechanics Problem-solving Cases

In our application domain, Newtonian mechanics, two categories of physical entities are identified with respect to the cases we use for tutoring: *physical objects* and *physics concepts*. Both are represented, however, as rectangular-shaped concept nodes. In each case, a number of physical objects are involved, such as a block, a car, a plane, a spring, etc., but they are normally described abstractly just as a physical object. Various meaningful relations obtain between the objects, which essentially represent the physical configuration between them. For instance, it makes sense to represent the 'rest_on' relation that holds between a block and a plane whenever the block is on the plane. Other meaningful relationships are: 'above', 'contact_with', 'moves_on', and so forth. There are attributes, intrinsic and motion-related, of the physical objects which refer to one object only. For example, 'acceleration'(a motion-related attribute) and 'mass' (an intrinsic attribute) applies to a single physical object on its own. In representing a physical situation, there are some other domain-related ideas such as external force or friction, which characterize the case being described. All these concepts are categorized as physics concepts as they are used to describe the state of the world depicted by the case. Figure 3 shows a typical case adopted from a standard physics textbook.

Two blocks A & B are resting on a frictionless horizontal plane as shown. If an external force of 10N is acting on A, what is the acceleration of the blocks and the force of contact between them? (The masses of A and B are 3kg and 7kg respectively).

[1] The notion of marking and firing is borrowed from the petri nets formalism [9]

Solution: Apply Newton's 2nd Law on A&B

$$\text{Net Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$$
$$\text{External Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$$
$$10 = (3 + 7)\ \text{Acceleration}_{A\&B}$$
$$\text{Acceleration}_{A\&B} = 1\ \text{m/s}^2$$

Apply Newton's 2nd Law on A

$$\text{Net Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A}$$
$$\text{External Force}_{A} + \text{Contact Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A}$$
$$10 + \text{Contact Force}_{A} = 3 \times 1$$
$$\text{Contact Force}_{A} = -7\text{N}$$

Apply Newton's 2nd Law on B

$$\text{Net Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B}$$
$$\text{Contact Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B}$$
$$\text{Contact Force}_{B} = 7 \times 1$$
$$\text{Contact Force}_{B} = 7\ \text{N}$$

Figure 3: A typical Newtonian mechanics case and its solution

As the complete graph representing the case occupies too much space, the whole graph is divided into several subgraphs. To illustrate the idea, three representative subgraphs are shown in Figure 4, 5 and 6. The subgraph in Figure 4 represents the physical objects involved in the case and their relationships. The (component) nodes encodes the part-whole relationship between the whole system A&B and its constituents A and B. The tuple [Blocks: A&B] → (component) → [Block: B] depicts the block labelled as 'B' as part of the whole system labelled as 'A&B'. The other relation nodes essentially represent the spatial relationships between the objects.

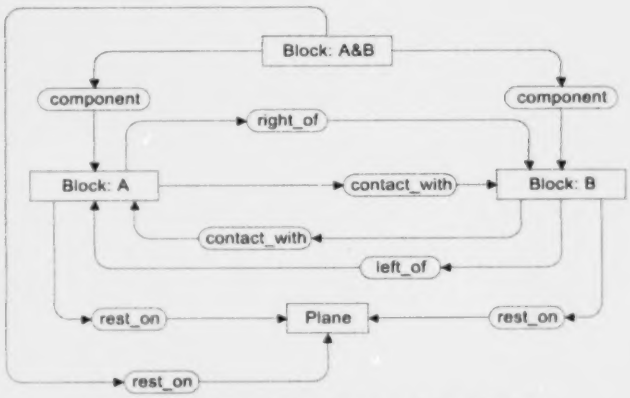


Figure 4: The subgraph showing the physical objects involved in the case and their relationship

The subgraph shown in Figure 5 concerns the attributes, both intrinsic and motion-relationed, of block A, and other relevant physical concepts centred around it. The absurd type [T] as the agent of the Net_Force_A and External_Force_A indicates it is something that is of no relevance to us. In Figure 6, those concept types that participate in some sort of mathematical relations are shown. Note that most of the arcs in Figure 6 are dotted indicating they are different from the usual symbolic relations.

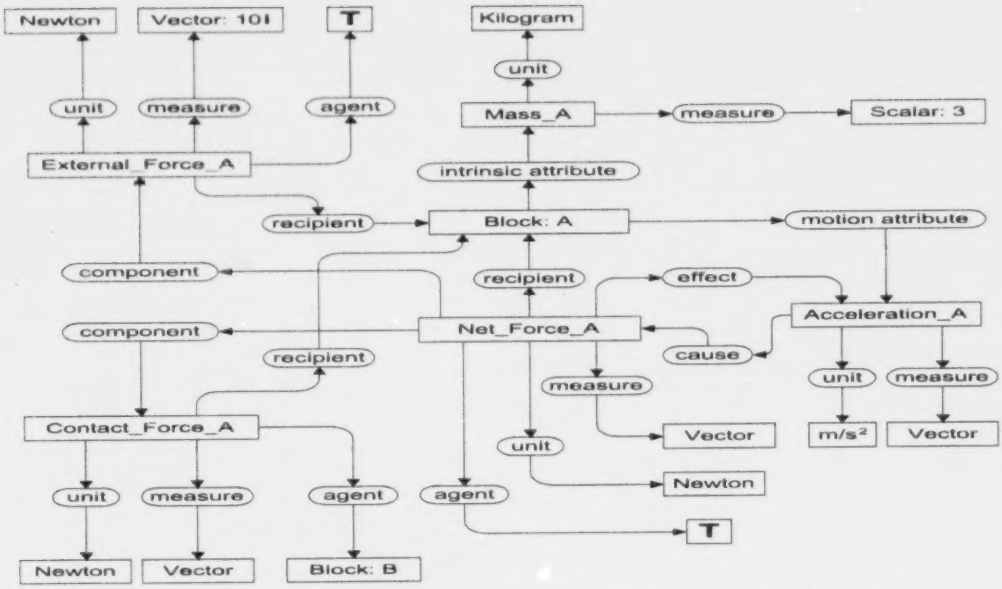


Figure 5: Subgraph showing the attributes of block A and other relevant physical concepts.

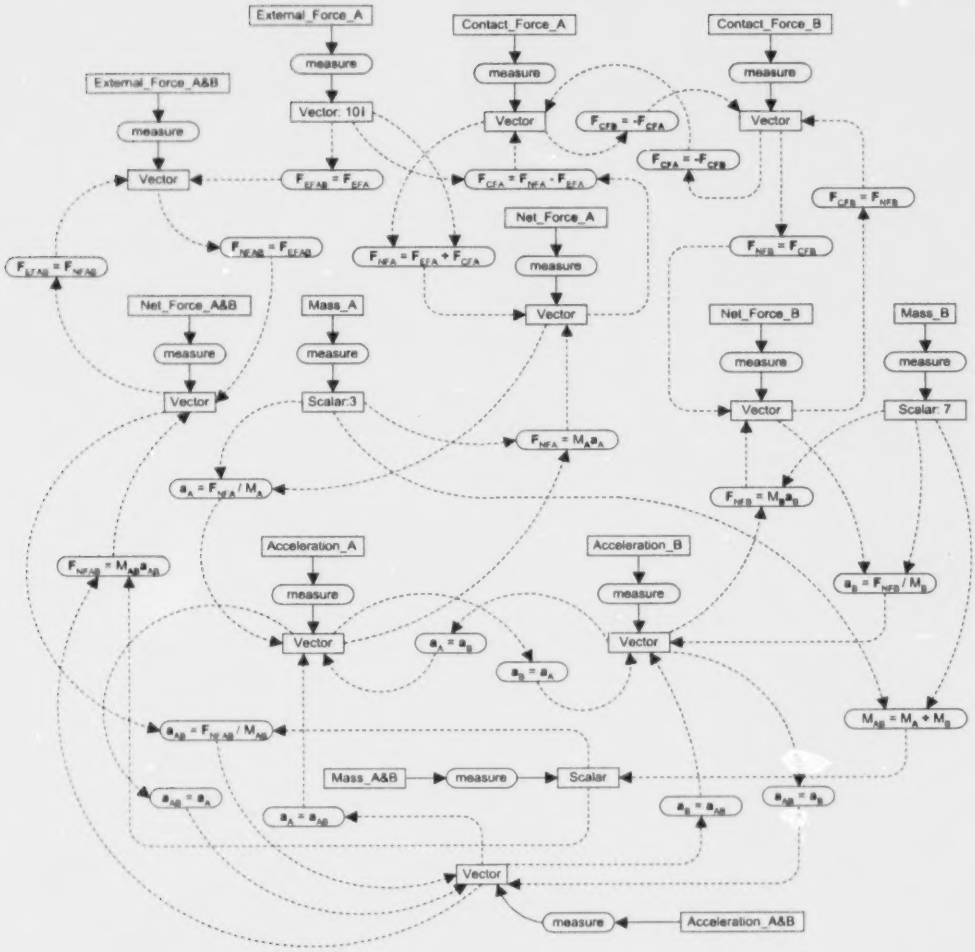


Figure 6: Subgraph showing the mathematical relationships between the relevant concept types

4 Modelling Variables Instantiation as Node Marking

Once a case has been encoded with the formalism, problem-solving activities can be modelled. When given a problem to tackle, the students will generally be asked for a new value from a set of given data. This is modelled as marking the concept nodes such as C_1 and C_5 in Figure 1. The goal is to get the concept node C_6 marked. At the initial marking, only r_{m1} is enabled and therefore any attempt to trigger other mathematical operations is not allowed and, thereby, invites tutorial intervention. The whole process of creating successive markings can be illustrated with a search tree (see Figure 7). The tree

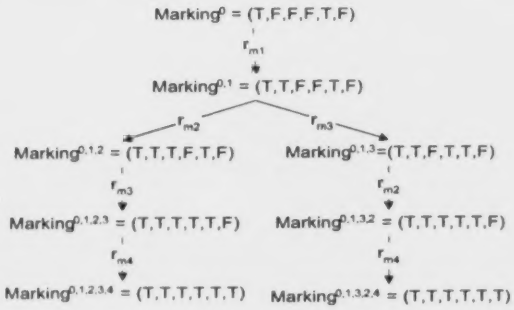


Figure 7

BEST COPY AVAILABLE

indicates the student can gain access to a large solution space for him/her to explore but in the mean time the tutor can keep track of what can/cannot be done.

5 CLASP: A Case-based Learning Assistant System in Physics

A system called CLASP, has been developed to implement the idea. At the current stage of development, two types of activities associated with examples have been identified: providing solutions for studying, and exercises with answers; hence the modes of interaction in the CLASP prototype are also designed around these two themes. When the users issue a request (in terms of the problem description of their own problems) the system will search through its whole case library and provide them cases which match their request. The style of presenting the case will follow the user's wishes, but only two modes of interaction (solution studying and guided-problem-solving) are available. This is to reflect the common way of using examples in physics textbooks. In the study mode, the system presents the whole case (i.e. both the problem and solution statements) for the user to study. This looks like an electronic reference book and the student may browse through the relevant cases. In the guided-problem-solving mode, the system only presents the problem situation to the users, but appropriate system guidance will be provided in solving the problems. The schematic architecture of CLASP is shown in Figure 8. The students interact with the system with the support of the back-end knowledge base.

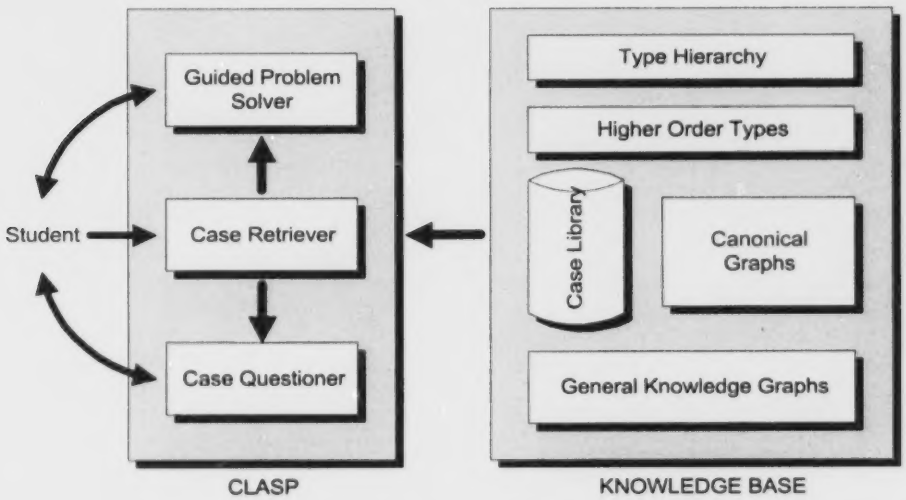


Figure 8: Schematic description of the CLASP architecture

Problem-solving in CLASP is modelled as a graph search. When a problem situation, such as the one shown in Figure 3, is encountered, the initial data are represented as concept nodes being instantiated to specific values and they are displayed to students on the working pad (Figure 9). Now the problem-solver can start tackling the problem by searching through the graph and seeing what additional information can be inferred from the initial given data. For the system to perform the tasks, the expertise has already been encoded in the case graphs, therefore the next step to be taken is searching the graph to find out which operators can be fired. The inferred steps may be unfolded or kept hidden for a while as a hint to advise the student. The intelligence of the system's problem-solving ability comes from its inference engine, being implemented by different graph search methods.

Problem Space	System's Comments:
External_Force_A: 10N Mass_A: 3 kg Mass_B: 7 kg	Initial Conditions: M_A = 3kg; M_B = 7kg; and External Force $_A$ = 10N.

Figure 9: The working pad and the corresponding system responds

The explanatory capability of the system comes from the matching of the input-operator-output nodes with the consequences of the general knowledge graphs. Whenever an operator is fired, the associated nodes will be matched against the consequences of the general knowledge graphs. If one is found, and it should be, then that particular graph will be tagged. If the student requests a justification of the step taken, the system can explain the graph in general terms. For example, the firing of an algebraic summation operator on the values of masses of two physical objects will match the consequence of the general knowledge graph in Figure 8 so the whole graph can be retrieved for explanation (Figure 10). The working pad, showing the problem space, and the explanation combinations supply the integration of what and why the step happened and the whole process becomes transparent to the student.

Problem Space	System's Comments:
	Step 1: For a system comprising two components, the mass of the whole system is evaluated by the algebraic sum of the masses of their individual components. $M_{A\&B} = M_A + M_B$

Figure 10: The working pad and the corresponding system responds

6 Conclusions

Case-based reasoning (CBR) is a versatile AI technology and can been found in many industrial applications [2] but its potential in training and education is still not fully explored. The work reported here may serves to strengthen the position of CBR in developing instructional systems.

The contribution of the paper to the endeavour of computer-assisted learning is twofold. Firstly, technically, a formal framework for representing cases for learning purposes has been developed. Its formal basis provides a solid foundation for developing robust computer-based instructional systems. With this methodology, the developers only have to concentrate their effort on collecting and encoding the cases. The rest (generating relevant instructional activities from the cases) will be taken care of by the system. This approach offers another advantage for rendering the cases amenable to further analysis. This may be used for providing tool to verify the case-base for internal consistency. Secondly, educationally, our approach paves the way for systematic educational software engineering because it is built on the needs of users, not the technical skills of the developers. Often, educational software developers have adopted a technically-driven design philosophy. Such systems run the risk of losing sight of what is actually happening in the real learning setting.

Our approach avoids the temptation of jumping onto the hi-tech bandwagon but, instead, concentrates firstly on what the students really need. The reason we developed a case-based learning system was not due to the existence of the technology and trying to find what role the technology can play in learning. Rather, we choose

to develop a case-based approach to learning because students do learn from referring to past cases. This principle we consider crucial in determining if the final system proves itself useful to our students. Other features of the system have not been described due to space limitation. They include generating different categories of questions from a case graph [6] to promote self-explanation from the students. The model proposed in this paper can also perform qualitative reasoning [4], and causal order between system variables can be represented succinctly.

References

[1] Anderson, J.R. et al., "Learning to Program in LISP", Cognitive Science, Vol. 8, pp.87-129, (1984).

[2] Bergmann, R. et al., "Developing Industrial Case-based Reasoning Applications", Springer-Verlag, (1999).

[3] Fung, P.W., "Designing an Intelligent Case-based Learning Environment with Conceptual Graphs", PhD Thesis, Dept. of Computation, UMIST, England, (1996).

[4] Fung, P.W., "Generating Qualitative Predictive Problems in a Case-based Physics Tutor" In B. du Boulary & R. Mizoguchi (Eds.) Artificial Intelligence in Education: Frontiers in Artificial Intelligence and Applications Vol. 39, Ohmsha: IOS Press, (1997).

[5] Fung, P.W. & Adam, A., "Conceptual Graphs for Similarity Measurement in a Case-based Physics Problem Solver" In Proceedings of AI-ED 95 – World Conference on Artificial Intelligence in Education. Washington D.C, (1995).

[6] Fung, P.W. & Adam, A., "Questioning Students on the Contents of Example Solutions" In Proceedings of European Conference on Artificial Intelligence in Education, Lisbon, (1996).

[7] Kolodner, J. "Case-Based Reasoning" San Mateo, CA: Morgan Kaufmann Publishers, (1993).

[8] LeFevre, J.A. & Dixon, P., "Do Written Instruction need Examples?" Cognition and Instruction, Vol.3, pp.1-30, (1986).

[9] Peterson, J.L., "Petri Net Theory and the Modeling of Systems." Englewood Cliffs. NJ: Prentice-Hall Inc. (1981).

[10] Sanders, K.E., Kettler, B.P. & Hendler, J.A. "The Case for Graph-Structured Representations" In D.B. Leake & E. Plaza (Eds.) Case-based Reasoning Research and Development. Lecture Notes in Artificial Intelligence, Vol. 1266, pp. 245-54, Springer-Verlag, (1997).

[11] Schank, R.C., "Case-based Teaching: Four experiences in Educational Software Design." Report No.7, The Institute of Learning Sciences, Northwestern University, (1991).

[12] Self, J., "Student Models in Computer-aided Instruction." International Journal of Man-Machine Studies, Vol. 6, pp. 261-76, (1974)

[13] Sowa, J., "Conceptual Structures: Information Processing in Mind and Machine" Reading, MA: Addison-Wesley, (1984).

[14] Specht, M. & Weber, G., "Episodic Adaptation in Learning Environments" In Proceedings of the European Conference on Artificial Intelligence in Education, Lisbon, pp.171-176, (1996).

Use of abstraction levels in the design of intelligent tutoring systems

Ruddy Lelouche
Département d'informatique
UNIVERSITÉ LAVAL Québec G1K 7P4 CANADA
Tel.: (+1-418) 656 2131, ext. 2597 Fax: (+1-418) 656 2324
e-mail: lelouche@ift.ulaval.ca

In problem-solving domains (mathematics, physics, engineering, and most "exact science" disciplines), the knowledge to be acquired by the student is twofold: the knowledge describing the domain itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an educational system in such a domain encompasses three knowledge types: the domain knowledge and the problem-solving knowledge, i.e. the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process. In this paper, we show how these three knowledge types can be modelled, how they should interact with one another in order to fulfil the system educational purpose, and above all how abstraction levels can shed a uniformizing light on the system operation and make it more user-friendly. We thus hope to bring some contribution to the general and important problem of finding a generic architecture to intelligent educational systems.

Keywords: **Intelligent tutoring systems, Abstraction, Complexity, System Design**.

1 Introduction

Teaching is a very complex process in itself. Teaching strategies and activities vary considerably: by the role and autonomy they give to the learner, by the type of interactions they trigger with him/her, by the evaluations they enable, by the relationships they make between theory and practice, etc. From that last perspective, teachable domains can be classified according to the type of knowledge to be acquired by the student: "know", "know-how", and "know-how-to-be". Examples of such domain types are respectively: anatomy or a language grammar, the skill to solve a mathematical or medical problem, and the capability to adapt to one's environment or to deal with personal relationships. We are more particularly interested in the second type.

Moreover, almost all teachable domains vary in complexity, from simple basics to relatively complex problems to solve or situations to deal with. Thus, a student should learn and master the basics of such a domain before being taught wider notions. And when a human tutor detects errors or misunderstandings, s/he usually draws the student's attention on a small subset of the involved knowledge, so that s/he may correct his/her errors and/or misunderstandings, focusing either on a given set of the domain knowledge or on the scope of knowledge involved by a given problem.

Problem-solving (PS) domains are the ones in which we are interested here. In such a domain, the knowledge to be acquired by the student is twofold: the domain knowledge itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an education-oriented system in such a domain, which we here call a PS-ITS, must encompass three knowledge types: the domain knowledge and the problem-solving knowledge, constituting the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process.

This paper has two goals: to present each of the three types of knowledge involved in a PS-ITS, and for each type of knowledge, to show how abstraction and complexity levels appear and how we think it is possible to deal with them.

To do so, we present in section 2 our domain knowledge modelling and how we exemplify it in a few PS domains . Next, in section 3, we focus on the advantage of separating the problem-solving knowledge from the domain knowledge in a PS-ITS, and we present some problem-solving activities in various domains. In section 4, we briefly describe some principles of tutoring knowledge modelling in a PS-ITS. In each of these three sections, we show how to use abstraction and complexity levels, exemplifying them in a few typical domains.

Finally, section 5 presents the educational interests of using abstraction and complexity levels when modelling the three types of knowledge involved in a PS-ITS.

2 Domain knowledge

In order to describe the domain knowledge, we first present its characteristics in a general PS-ITS (section 2.1). We then show how we model it in a few PS domains (section 2.2), and how such an approach lets us introduce the notions of abstraction and complexity levels (section 2.3).

2.1 General

The first type of knowledge involved in every ITS, the *domain knowledge* (DK), contains all theoretical and factual aspects of the knowledge to be taught to the student. Although its specific structure can be varied, it typically may include concepts, entities, and relations about the domain [Brodie & al., 1984], object classes and instances [Kim & Lochovsky, 1989], possible use restrictions, facts, rules, [Kowalski, 1979; Clocksin & Mellish, 1981], semantic or associative networks [Findler, 1979; Sowa, 1984], etc.

The main system activities centred on this knowledge type are:

- providing the student with theoretical presentations and explanations about the various knowledge elements and their relationships in the teaching domain;
- providing the other modules of the ITS, i.e. problem-solving and tutoring, with the necessary background of domain knowledge that they need.

2.2 Application to a few domains

In the particular domain of **cost engineering**, Lelouche and Morin [1997; Morin, 1998] represent this type of knowledge with concepts, relations, and a special case of relations modelled as concepts, the factors.

Concepts can be basic entities like investment, interest, investment duration, present and future values, compounding, compounding period, interest rate, annuity, etc.

Concepts are linked to one another by various types of *relations*: either usual knowledge-representation relations, like *subclass of*, *element of*, *sort of*, etc., or numerical relations represented by formulæ. Such a formula is:

$$F = P \times (1 + i)^n \tag{1}$$

which, given the present value P of an investment over n periods at interest rate i, computes the corresponding future value F of that investment.

A formula such as (1) can be rewritten as:

$$F = P \times \Phi_{PF,i,n} \text{ where } \Phi_{PF,i,n} = (1 + i)^n \tag{2}$$

$$P = F \times \Phi_{FP,i,n} \text{ where } \Phi_{FP,i,n} = (1 + i)^{-n} \tag{3}$$

thus introducing the *factors* $\Phi_{PF,i,n}$ and $\Phi_{FP,i,n}$. Factors allow us to separate their definition (rightmost equalities above, a quantitative aspect) from their possible uses in the application domain (leftmost equalities, a qualitative aspect).

Similarly, the factor $\Phi_{AP,i,n}$ converts a series of identical annual amounts A into a unique present value P:

$$P = A \times \Phi_{AP,i,n} \text{ where } \Phi_{AP,i,n} = \frac{(1+i)^n - 1}{i\,(1+i)^n} \tag{4}$$

Actually, $\Phi_{AP,i,n}$ is a sum of Φ_{FP} factors (see details below). The factor $\Phi_{PA,i,n}$ does the reverse process:

$$A = P \times \Phi_{PA,i,n} \text{ where } \Phi_{PA,i,n} = \frac{i\,(1+i)^n}{(1+i)^n - 1} \tag{5}$$

There exist other factors converting gradient and geometrical series of amounts into a present or future value; such factors are also computed as a sum of $\Phi_{FP,i,n}$ factors.

In **geometry**, *concepts* are basic elements like point, line, segment, and later more elaborate elements like angle, then square, rectangle, circle, ellipse, polygon, solid, polyhedra, etc. Examples of *relations* between concepts are adjacency (of segments or angles), parallelism (of lines or line segments), complementarity (of angles), etc. Upper-level, more abstract concepts are then defined using lower-level ones, as well as relations between these lower-level concepts (e.g. a triangle is a set of three segments adjacent pairwise).

In **mechanical physics**, we similarly introduce *concepts* like time, distance, velocity, acceleration, mass, force, and later angle, angular velocity, angular acceleration, moment of inertia, torque, etc. We also introduce *relations* like the one defining velocity as the variation in distance per unit of time, or the one stating that the acceleration a is proportional to the force F that is applied. Introducing a generalization from linear to rotational movement, another relation defines angular velocity as the angle variation per time unit, and another one states

that the angular acceleration α of a solid body is proportional to the torque τ that is applied to it. More precisely, we have:

for a linear movement $F = M \times a$ where M = total mass of the body (6)

and for a rotational movement $\tau = I \times \alpha$ where $I = \sum (m \times r^2)$ (7)

Equation (6) expresses Newton's second law. In equation (7), I is the moment of inertia and is expressed in terms of the mass m of each of its particles and of its distance r to the rotation axis. Obviously M in equation (6) and I in equation (7) play the role of factors as in cost engineering.

Although formulæ like (2-7) related to factors essentially involve quantitative aspects, the similarities and differences between them, and the circumstances regulating the use of either one, are of a deeply qualitative ground. In **cost engineering**, if the *value* of factors is indeed calculated from two or three numerical parameters, the *context* in which they are defined depends on whether we have to timewise move a unique amount or a series of amounts, identical or not, or conversely to compute an equivalent annual amount, etc. In fact, this context corresponds to the type of conditions that govern the investment, or *investment conditions type*, without respect to the amounts and durations involved, and is thus essentially qualitative. Similarly, in **physics**, the proportionality between force and linear acceleration, or between torque and angular acceleration, expresses a qualitative relationship. Only if the need arises, the exact relationship can be expressed by using the actual mass M in formula (6) or the result of the computation of the moment of inertia I in formula (7), which in the general case involves a simple or double integral. Indeed, did not the use of qualitative reasoning originate with qualitative physics?

2.3 Towards the notions of abstraction and complexity levels

In most PS-domains, abstraction most obviously appears in the *definition of the domain concepts* themselves, like we showed in all three domains above.

If *factors* are used in the domain, it also appears that every factor introduces an additional intermediate abstraction level between the concepts implied in the equation defining it. For example, in the case of formula (1), or equivalently formulæ (2) and (3) in **cost engineering**, or in the case of formula (6) and (7) in **physics**, we have (see figure 1):

- at the bottom of the hierarchy, basic concepts "making technicalities explicit" if necessary: the interest rate and the number of periods in cost engineering, the distribution of mass within the body volume in physics ;
- above them, concepts more fundamentally related to the problem being solved, namely in cost engineering the present and future values of the investment, and in physics the force and acceleration, or the torque and angular acceleration;
- between these two levels, an intermediate level created by the introduction of the factor (Φ_{FP}, Φ_{PF}, M, or I).

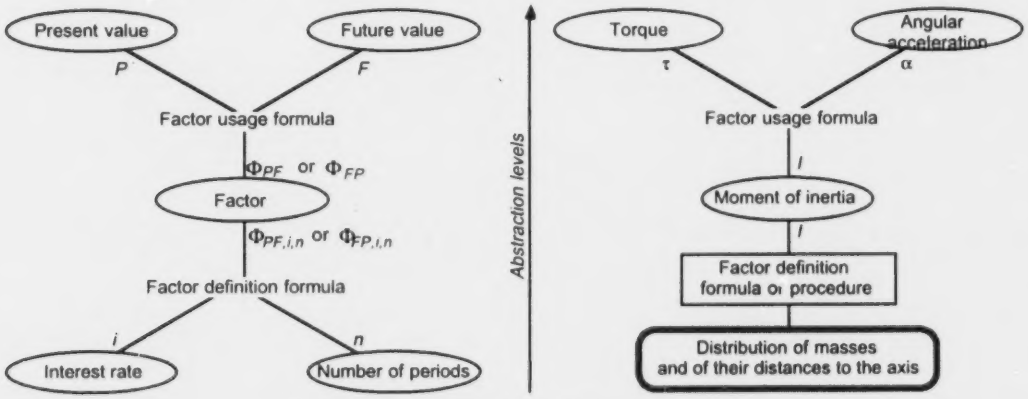


Figure 1 — Representation of a factor as a concept.

That intermediate status of the factor, originally just an intermediate variable in computations [see formulæ (2) and (3) or (6) and (7)], makes it appear as a pedagogically oriented concept, which clearly separates

- the computational, quantitative aspect of the factor definition,
- from the practical, qualitative aspect of the factor usage in a domain problem.

This follows the theory [Lenat & al., 1979; Malec, 1989] according to which the use of multiple *abstraction levels* eases the modelling process and simplifies inferences which may be made on the domain concepts.

Most interestingly, our scaffolding approach can be made more general, at least in certain domains, where we may present and use higher-level factors built upon these first ones. Indeed, in cost engineering, "above" Φ_{FP} and

Φ_{PF}, the factors used to express the present and future values of a series of identical amounts (and vice versa) are a first way to generalize this concept hierarchy. For example, the Φ_{AP} factor is indeed a sum of Φ_{FP} factors:

$$\Phi_{AP,i,n} = \sum_{k=1}^{n} \Phi_{FP,i,k} = \sum_{k=1}^{n} (1+i)^{-k} = \frac{(1+i)^n - 1}{i\,(1+i)^n}$$

where the last expression results from computing the geometrical series shown. This example constitutes a proof of (4), but also and mainly shows that the Φ_{AP} factor is at a higher level than Φ_{FP}. Note that this refers to a *complexity level* rather than an abstraction level, since it is due to the way the Φ_{AP} factor is defined and computed. Similarly, the moment of inertia of a complex body can be (and often is) computed as the sum of elementary moments of inertia, and therefore is at a higher complexity level.

3 Problem-solving knowledge

In order to describe the problem-solving knowledge, we now present the general characteristics regarding problem-solving knowledge modelling in a PS-ITS (section 3.1). As we did in section 2, we then examplify our model in the cost-engineering and physics domains (section 3.2).

3.1 General

The second type of knowledge is specific to PS-domains [Ganeshan & al., 2000; Gertner & VanLehn, 2000], henceforth to PS-ITSs. We call it *problem-solving knowledge* (PSK). It contains all inferential processes used to solve a problem resulting from the instantiation of a practical situation based on the domain knowledge [Kowalski, 1979; Patel & Kinshuk, 1997]. In other words, in order to be able to solve a problem, the problem-solving knowledge needs a theoretical background, which is found in the domain knowledge. The processes stored in PSK may be represented in various ways, using any or all of: logic [Kowalski, 1979], procedural networks [Brown & Burton, 1978], semantic networks with procedural attachments, (augmented) transition networks, production rules [Goldstein, 1979; Anderson & Reiser, 1985], etc.

The main system activities centred on this knowledge type are:
- providing the inferential tools for problem solving, by the system or by a student;
- providing the inferential tools for coaching a student in a problem-solving session.

The main advantage of separating the problem-solving knowledge from the domain knowledge is that it emphasizes the distinction between the domain itself and the skills used to solve a practical problem in that domain, thus simplifying the learning process. That knowledge separation into DK and PSK is common to all PS-domains; this is why we believe that PS-ITSs, which are aimed at helping the student to learn how to solve problems, should display the same knowledge separation.

Besides, following [Lelouche & Morin, 1997], we can use — we believe in a novel way — that separation between DK and PSK to define four *generic operating modes* in a PS-ITS, based on the type of knowledge involved (DK or PSK), and on who "generates" that knowledge (the system or the student).
- In *domain-presentation mode*, the student asks the system some information about a domain theoretical element, and the system reacts by transferring to the student the required information or knowledge. The knowledge involved in this category is always DK, system-generated.
- In *demonstration mode*, the student asks the system to solve a practical problem or to coach him/her while s/he solves a problem. In the first case, the problem typically comes from the student him/herself, whereas in the latter one the problem typically comes from the tutoring system. In either case, the main level of knowledge involved is PSK, system-generated.
- In *domain-assessment mode*, the system prompts the student to develop a domain element, and the student thus expresses his/her understanding of that element. If judged necessary, the system may then intervene to correct that understanding. The knowledge involved in this mode is essentially DK, student-generated.
- Finally, in *exercising mode*, the system prompts the student to solve a practical problem. The student then solves it step by step, showing what s/he understands of the involved problem-solving knowledge and of the associated domain knowledge. If necessary, the system may decide to intervene in order to help him/her reach his/her goal or to correct it. The knowledge involved in this mode is naturally PSK, student-generated.

3.2 Application to a few domains

Several problem-solving activities are domain-independent, like:
1. identify and instantiate the given problem data;
2. identify and instantiate the expected result(s);
3. apply a formula;
4. apply a theorem.

Every PS-domain also has its own domain-dependent activities. For example, in **cost engineering**, we have:

5. draw a temporal diagram to represent the relevant events;
6. compare amounts located at the same date;
7. compare amounts located at different dates;
8. add amounts situated at the same date;
9. add amounts situated at different dates;
10. choose a reference date;
11. move an amount from one date to another;
12. collapse a series of periodic amounts into one single amount;
13. explode an amount into a series of periodic amounts.

Similarly, in the subset of **mechanical physics** refered to above, some activities would be:

14. compute a torque;
15. compute an angular acceleration;
16. compute a moment of inertia.

In many cases, a PS activity can be rephrased into, restated as, a different one, of a lower *abstraction level*, because more immediate, more down-to-earth, closer to the problem to be solved. For example, in **mechanical physics**, assuming that the torque and the moment of inertia of a given solid body are known (either given or previously computed), the activity "compute the angular acceleration" (activity 15) would be expressed as, or translated into "apply formula (7)", an instance of the lower-level activity 3. A PS physics tutor is presented in [Gertner & VanLehn, 2000].

Sometimes, a PS task may also be divided into smaller ones, letting us use again the notion of *complexity levels* in these tasks. For example, in **cost engineering**, comparing two amounts situated at different dates implies:

- first, choosing a reference date at which to make the comparison;
- then, moving either (or both) amount(s) from its (their) present date(s) to the reference date;
- finally, comparing the amounts, now both located at the same reference date.

These subactivities (of types 10, 11, and 6 respectively in the sample list above) thus appear to be of a lower complexity level than the initial one (of type 7). However, it is interesting to note that, although activity 7 turns out to be more complex than activity 6 (the latter is part of the former), both are stated using the same *abstraction level*.

It may also happen that some lower-level activities can *only* appear as components of a higher-level one. For example, still in **cost engineering**, the activity "drawing a temporal diagram" (type 5 above) implies the following tasks, which can only be accomplished as part of that activity (hence their identification in this paper from 5a to 5d):

5a. draw a timeline to encompass all periods implied by the problem data;
5b. draw arrows representing the amounts involved in the problem data;
5c. if necessary, split an amount (or each amount in a series) to simplify the computations;
5d. qualitatively draw a special arrow to represent the expected result of the computations to be made.

In that case, activity 5 is both of a higher complexity level and of a higher abstraction level than any of its subactivities.

4 Tutoring knowledge

We now briefly present the *tutoring knowledge* (TK) in order to help the reader to better apprehend the relationships of that knowledge with DK and PSK. This third type of knowledge contains all tutoring processes enclosed in the ITS. It is not directly related to the teaching domain or to problem solving, but is there to help the student understand, assimilate, and master the knowledge included in DK and PSK [Gagné & al., 1992; Gagné & Trudel, 1996].

The main system activities using TK are:

- ordering and formatting the topics to be presented to the student;
- monitoring a tutoring session, i.e., triggering the various tutoring processes according to the system tutoring goal and the student's actions; such monitoring may imply giving explanations, asking questions, changing to another type of interaction, etc.;
- in a PS-domain, while the student is solving an exercise, monitoring the student's PS activities: understanding and assessing these activities, giving advice to correct or optimize them, giving hints or partly solving the exercise at hand (as required by the student or by the tutoring module), etc.;
- continuously analysing the student's progress in order to improve the efficiency of the tutoring process.

The advantage of separating the tutoring knowledge from the knowledge of the domain to be taught has been emphasized long ago [Goldstein, 1977; Sleeman & Brown, 1982; Clancey, 1986; Wenger, 1987], and lies in the reusability of TK in various domains. In the case of PS-domains, the domain to be taught clearly encompasses both DK and PSK; indeed, the term "domain knowledge" applies to DK if referring to the knowledge type, and to DK + PSK if referring to the knowledge to be acquired. Therefore, as shown in the introduction, in a PS-ITS, knowledge ends up being separated into three categories rather than two.

We believe that the tutoring processes are triggered by *tutoring goals* which depend on the current educational setting and learning context. The role of tutoring goals has been discussed in several works, some of the most recent ones dealing with task and instruction ontologies [Mizoguchi, 1999]. In the current state of our research, our assumption is the following: the underlying hierarchy or hierarchies governing the way tutoring processes interact with one another is not related to these processes *per se*, but rather to the *current goal* to be attained when they are invoked. The current goal varies during the session, depending on the student's actions or difficulties, following a dynamically built abstraction-based hierarchy. If our assumption turns out to hold, then the *dynamic structure of educational goals and subgoals* — which itself depends on the student's desires or abilities, the main underlying objective of the tutoring system, the student's state (e.g. of tiredness, etc.) and performance, etc. — will determine the succession of tutoring processes activated and tutoring interactions taking place. To our knowledge, the use of abstraction levels to induce a dynamic hierarchy of tutoring goals is new, as is the assumption that such a hierarchy will play a major role in activating the various tutoring processes and student–system interactions. Learning goals have been used by Towle [2000], but only for educational simulations, not for tutoring processes in general.

5 Educational interests of abstraction and complexity levels

In the above sections, we have sketched a complexity– and abstraction–level approach to help model the three types of knowledge involved in a PS-ITS. In this section, after clarifying these notions in section 5.1, we present the educational interests of our model. Sections 5.2 to 5.4 focus on the type of knowledge respectively presented in sections 2 to 4. Section 5.5 summarizes that discussion with some overall pedagogical interests of our approach.

5.1 An informal definition of abstraction and complexity levels

In the first three sections, we only refered to abstraction and complexity levels. Here, we try to define these notions better and in a more generally applicable way. Both notions are based on the common notion of *refinement*, but differ in how the refinement is made: in a general way, abstraction is based on, or refers to, *expressiveness* or *scope*, whereas complexity is based on, or refers to, the *number of components*.

For *concepts*, taking geometry as an example, a polygon has a higher abstraction level than a triangle or a square, because the number of sides in a polygon is indefinite, but a lower abstraction level than a set of segments, because these segments in a polygon are forced to be pairwise adjacent; a square has a higher complexity level than a triangle, because it has more sides, and also because there are constraints (re. size and angles) between these sides. In cost engineering, we saw that the factors Φ_{FP} and Φ_{AP} are expressed at the same abstraction level, although Φ_{AP} has a higher complexity level, because of the way it is defined and computed. A similar distinction between abstraction levels and complexity levels holds for the *relations* they express.

For *problem-solving activities*, we have similar distinctions, as shown in section 3.2 with several examples.

Finally, the same holds for *tutoring processes*, or student–system interactions. For instance, the ITS task of tutoring a student while s/he is solving a problem will turn out to be of a higher complexity level if the student encounters more difficulties, although the abstraction level of this process does not depend on the particular student being tutored or on the particular problem being solved. On the other hand, reacting to a student request for hint, or for explanation, is of a lower abstraction level than the previous one; however, there again, the complexity of that task will depend on the specific student request (some simply formulated questions may have quite complex answers!), and will eventually depend also on the way the student is or is not satisfied with the initial system response.

Such level-based distinctions have also been made, for example, by Mizoguchi [1999]. Note that, although the statement "A has a higher abstraction level than B" is clear and may be true, we think that the number of abstraction levels between A and B is not defined, because that number would depend on the modelling effected; for the same reason, it would be even more meaningless to try to assign a numeric value to these levels.

5.2 Domain modelling

The definition of concepts from the simplest to the most complex induces a long-time known *presentation order* for the subject matter. Similarly and in addition, the factor hierarchy described in section 2 for cost

engineering lets us derive an *order for the presentation of factors* to the student, from the lowest (simplest) level up to the highest, i.e. with increasing understanding complexity. That does not imply that such an order is unique, or even the best (e.g. a student's personal interests might make another order more motivating for him/her), but it is justified by our model. This presentation order may itself induce, like for domain concepts, a possible *order for prerequisites*; e.g., if a student experiments difficulties to deal with Φ_{AP}, has s/he well mastered Φ_{FP}, a conceptually simpler factor?

Moreover, the factor-induced intermediate abstraction levels will permit the ITS to exhibit a *sharper modelling of conceptual errors*. For example, the source of an understanding error concerning one of the two relations in equation (2) or (3) or (7) (see also figure 1) is much easier to identify using the corresponding factor, either as a definition error or as a usage error, than an error concerning the global equation (1), where the definition and application relationships are not made explicit, and therefore are impossible to distinguish. Similarly, an error using a Φ_{AP} factor may be diagnosed as possibly resulting from an insufficient mastery of the simpler factor Φ_{FP} as concept (which in turn will be diagnosed as related either to its definition, or to its usage). Similarly in physics, if the student stumbles on concepts like angular acceleration or moment of inertia, has s/he mastered the simpler although similar concepts of acceleration or mass?

Abstraction and complexity levels on domain elements (concepts and relations, possibly including factors) can then be used to introduce various abstraction levels of explanations. Such explanations can then be tailored to the student's questions, and adapted to the reminders possibly needed by the student.

5.3 Problem-solving modelling

The problem-solving activities briefly presented in section 3 naturally display abstraction and complexity levels. Indeed, a standard problem can usually be divided, possibly in more than one way, into major steps, which can then be split into simpler substeps. As explained in 5.1, each subactivity in that case may be either simpler (lower complexity level) or more concrete (lower abstraction level) than the original one, or both.

In a first development stage, these abstraction and complexity hierarchies, both for domain elements and for problems to be solved, can ease the *definition of exercise types* to be implemented into the ITS, and can ease the tutor module task of *choosing the exercise type* to challenge the student with. Later, once that basic system is operational, the same hierarchies can help develop an automatic *exercise generator* dealing with the domain elements to be mastered by the student. That approach will then help the student to acquire a better critical mind about the relative importance of *problem–solving* knowledge vs. *domain* knowledge.

As for domain elements, abstraction and complexity levels can be used to introduce various types of *explanations* about the problem to be solved, varying both in abstraction (focus level, terms used, references made) and in complexity (quantity of details, possible references to the problem substeps). Moreover, our approach will lead the student to focus specifically on the *activities* for which s/he needs more tutoring, with the abstraction and complexity levels appropriate to his/her individual case.

5.4 Tutoring modelling

Functioning mode		Domain-presentation mode	Demonstration mode	Domain-assessment mode	Exercising mode
Main type of knowledge involved		Domain knowledge	Problem-solving knowledge	Domain knowledge	Problem-solving knowledge
Student's main goal		To learn (acquire or improve knowledge)		To assess his/her learning	
Direction of the knowledge transfer		System → Student		Student → System	
Typical interaction	Trigger (start)	The student asks the system... some information about a domain theoretical element	to solve a practical problem or to coach him/her in problem solving	The system prompts the student... to develop a domain element	to solve a practical problem
	Knowledge exchange	The system presents... the requested element	a possible solution to the requested problem	The student presents his/her view of... the requested element	a possible solution to the given problem
	Result (closure)	The student expresses his/her understanding... of the element	of the problem solution	The system assesses the student's answers, and possibly corrects them	

Table 2 — Characteristics of the four typical operating modes of a problem-solving ITS.

As presented in section 3.1, the distinction between DK and PSK leads to the natural definition of four operating modes. Their main characteristics are recalled in Table 2.

The successive tutoring goals aimed at by the system (see section 4) are likely to result in a chain of recursive calls of the tutoring processes invoked. This recursivity will or will not be direct, depending on the tutoring interaction types being chained: the system might decide to temporarily change between interaction types, e.g. to respond to the student's actions or requests. However, the potential length of this chain is only apparent: because of the abstraction hierarchy of tutoring goals, each newly invoked process will be called with a *narrower scope* and/or a *lower complexity*, which eliminates the risk of "forgetting" the initial tutoring goal or of running into an infinite loop.

More generally, tutoring the student may take the form of explanations, guidance, hinting, or even partially solving the exercise on which the student is currently working. The level at which these will be conducted will depend on the current tutoring goal (see section 4). We think our approach is close to that of VanLehn and his colleagues [2000], although they focused their attention on fading and deepening (a particular result of the tutoring interactions) rather than on the current pedagogical goal (the cause for these interactions).

5.5 Overall interests of these abstraction and complexity levels

Abstraction levels are certainly not new. What we think is new is to use them in a systematic way to shed a uniformizing light on the ITS design and operation, and to make it more user-friendly once implemented.

First, they may help to give a better tailoring to the system tutorial interventions to fulfil the student's needs and the system tutoring goals, thus improving its conviviality and efficiency.

Then, all the capabilities presented above should result in smoother, more "natural", human-like interactions with the student. This improved ability to reproduce a human teacher's behaviour contributes again to make the system more user-friendly, and more likely to be used by the student.

Finally, although that aspect is not in the scope of this paper, our refinement of the three types of knowledge as described in sections 2 to 4 paves the way to the conception and the implementation of a structured error model, and eventually of a structured student model.

6 Conclusion

This presentation of a possible knowledge structure for PS-domains, which emphasizes the separation between domain knowledge and problem-solving knowledge, shows how a general functioning theory of such an ITS — namely the four operating modes described in sections 3.1 and 5.4 — can naturally be derived.

Moreover, the abstraction and complexity levels highlighted throughout this paper can be used as a common guideline to help finding an appropriate representation for each one of the three knowledge type, and thus can help creating more efficient ITSs. More generally, this guideline can shed a uniformizing light on the system design, although it has never been used in a systematic way in the design or implementation of an ITS.

We thus hope to bring some contribution to the general and important problem of finding a generic architecture for intelligent tutoring systems.

References

[1] Anderson John R.: *Cognitive Modelling and Intelligent Tutoring*. Washington, DC: National Science Foundation (1986).

[2] Anderson John R. & B. J. Reiser: "The LISP Tutor". *Byte* **10**, no. 4, p. 159-175 (1985).

[3] Brodie Michael L., John Mylopoulos & Joachim W. Schmidt, eds.: *On Conceptual Modelling, Perspectives from Artificial Intelligence, Databases, and Programming Languages*. New York: Springer Verlag (1984).

[4] Brown John S. & Richard R. Burton: "Diagnostic models for procedural bugs in mathematical skills". *Cognitive Science* **2**, p. 155-192 (1978).

[5] Clancey W. J.: "Qualitative student models". *Annual Review of Computer Science* **1**, p. 381-450 (1986).

[6] Clocksin William F. & Christopher S. Mellish: *Programming in Prolog*. Berlin: Springer-Verlag (1981).

[7] Findler Nicholas V., ed.: *Associative Networks*. Orlando, FL: Academic Press (1979).

[8] Frasson Claude, Gilles Gauthier & Alan Lesgold, eds.: *Intelligent Tutoring Systems*, Proc. of the *3rd International Conference, ITS'96*, Montréal (Canada), 12-14 June 1996. LNCS 1086, Berlin: Springer (1996).

[9] Gagné Denis & André Trudel: "A highly flexible student-driven architecture for computer-based instruction". [Frasson & al., 1996], p. 66-74 (1996).

[10] Gagné Robert M., Leslie J. Briggs & Walter W. Wager: *Principles of Instructional Design*, fourth edition (1st edition published in 1974). Orlando, FL: Harcourt Brace Jovanovich (1992).

[11] Ganeshan R., W.L. Johnson, E. Shaw & B.P. Wood: "Tutoring diagnostic problem solving". In [Gauthier & al., 2000], p. 33-42 (2000).

[12] Gertner A.S. & K. VanLehn: "ANDES: a coached problem-solving environment for physics". In [Gauthier & al., 2000], p. 133-142 (2000).

[13] Goldstein Ira P.: *The Computer as Coach: an Athletic Paradigm for Intellectual Education*. AI Memo 389, AI Laboratory. Boston, MA: Massachusetts Institute of Technology (1977).

[14] Goldstein Ira P.: "The genetic epistemology of rule systems". *International Journal of Man-Machine Studies*, Vol. 1, No. 1, p. 51-77 (1979).

[15] Gauthier Gilles, Claude Frasson & Kurt VanLehn, eds.: *Intelligent Tutoring Systems*, Proc. of the *5th International Conference*, Montréal (Canada), 19-23 June 2000. LNCS 1839, Berlin: Springer (2000).

[16] Kim Won & Frederick H. Lochovsky, eds.: *Object-Oriented Concepts, Databases, and Applications*. ACM Press, Reading, MA: Addison-Wesley Publ. (1989).

[17] Kowalski R.: *Logic for Problem Solving*. Berlin: North-Holland (1979).

[18] Lelouche Ruddy & Jean-François Morin: "Introduction of pedagogical concepts in domain modelling for an ITS". *European Journal of Engineering Education*, Vol. 23, No. 2, p. 255-271 (June 1998).

[19] Lelouche R. & J.-F. Morin: "Knowledge types and tutoring interactions in an ITS in a problem-solving domain". *FLAIRS 1997, Proc. of the 10th International FLorida Artificial Intelligence Research Symposium*, Daytona Beach (Florida, U.S.A.), 10-14 May 1997, p. 62-66 (1997).

[20] Lenat D., F. Hayes-Roth & P. Klahr: *Cognitive Economy*. Working Paper HPP-79-15, Stanford Heuristic Programming Project, 46 pages. Stanford, CA: Stanford University (June 1979).

[21] Malec J.: " Knowledge elicitation during dynamic scene description ". *ACM–SIGART Newsletter: special issue on knowledge acquisition*, No. 108, p. 162-163 (April 1989).

[22] Mizoguchi Riichiro: "Ontology-awareness for intelligent instructional systems". Invited talk. *Advanced Research in Computers and Communications in Education, Volume 1* (G. Cumming, T. Okamoto & L. Gomez, eds.), Proceedings of the *7th International Conference on Computers in Education, ICCE 99*, Chiba (Japan), 4-7 November 1999. Amsterdam, Netherlands: IOS Press, p. 45-52 (1999).

[23] Morin J.-F.: *Conception of an intelligent tutoring system in cost engineering: knowledge representation, pedagogical interactions, and system operation*. Master Thesis, Département d'Informatique. Québec, Canada: Université Laval (1998).

[24] Patel Ashok & Kinshuk: "Intelligent tutoring tools in a computer-integrated learning environment for introductory numeric disciplines". *Innovations in Education and Training International*, Vol. 34, No. 3, p. 200-207 (1997).

[25] Sleeman D. H. & John Seely Brown, eds. : *Intelligent Tutoring Systems*. London: Academic Press (1982).

[26] Sowa John F.: *Conceptual Structures*. Reading, MA: Addison-Wesley (1984).

[27] Towle B.: "Using student task and learning goals to drive the construction of an authoring tool for educational simulations". In [Gauthier & al., 2000], p. 173-181 (2000).

[28] VanLehn K., R. Freedman, P. Jordan, C. Murray, R. Osan, M. Ringenberg, C. Rosé, K. Schulze, R. Shelby, D. Treacy, A. Weinstein & M. Wintersgill: "Fading and deepening: the next steps for ANDES and other model-tracing tutors". In [Gauthier & al., 2000], p. 474-483 (2000).

[29] Wenger, Étienne: *Artificial Intelligence and Tutoring Systems*. Los Altos, CA: Morgan Kaufmann (1987).

Using Decision Networks for Adaptive Tutoring

Peng-Kiat Pek* and Kim-Leng Poh**
** Singapore Polytechnic*
500 Dover Road, Singapore 139651
E-mail: baiychen@magix.com.sg
*** National University of Singapore*
10 Kent Ridge Crescent, Singapore 119260
E-mail: isepohkl@nus.edu.sg

This paper reports a research project that uses dynamic decision networks in providing teacher with information on students' misconceptions and students with online tutoring. A set of Bayesian networks models the conditional dependencies between learning objectives and goals which are associated with the curriculum. Student's responses to test items are recorded and transformed as evidence into a relevant Bayesian network to compute his likely state of knowledge mastery. The personalized Bayesian network is then converted into a dynamic decision network by adding utility and decision nodes. Tutoring policy is followed through and necessary responses from the student are solicited using additional test items. The student Bayesian network is updated when new evidence arrives, and is again converted to a decision network to determine the next tutoring policy. This process is repeated until the pre-requisites are achieved. The results generated by the system and future directions are discussed.

Keywords: **Adaptive Tutoring, Decision Network, Student Model, Tutoring Strategy**

1 Introduction

Tutoring of students is an ill-structured problem that is characterized by:
(a) Uncertainty of student's knowledge mastery.
(b) Preferences, judgements, intuition, and experience of teacher.
(c) Criteria for decisions are occasionally in conflict, and highly dependent on the teacher's perception.
(d) Decisions must be achieved in limited time.
(e) The student's mental states evolve rapidly.

This study attempts to address these issues by using an intelligent *decision-theoretic* approach. The framework of this research has contributed to the development of an intelligent decision support system called *iTutor*, for tutoring Engineering Mechanics at Singapore Polytechnic.

Probabilistic or Bayesian networks [9] and decision analysis [5] have shown to be capable of solving many real-world problems involving reasoning and decision marketing under uncertainty. Bayes's nets allow for efficient reasoning and inference about combination of uncertain evidence. Student modeling with Bayes's nets for intelligent tutoring had achieved successes, see for example in [16], [11], and [2]. The differences in these works lie mainly in the choice of variables and granularity of the models.

In Villano's Knowledge Space Theory, the basic unit of knowledge is an *item* (in the form of a question). The student's knowledge state is defined as the collection of items that the student is capable of answering. The collection of all feasible states is called the *knowledge structure*, and it is connected by the *learning path*. By incorporating uncertainty at each node, the knowledge space can be transformed into a Bayes's net. The Bayes's net then constitutes a student model where probabilistic reasoning can be performed when evidence is available. Reye on the other hand, uses pre-requisite relationship of domain knowledge and *dynamic belief network* for modeling student's mastery of a topic. Finally, Conati and Vanlehn make use of teacher's

solution(s) as the ideal model to track student's faulty knowledge as the student solves a problem.

Our work here differs from others in that we construct relevant Bayes's nets by modeling learning objectives (**L**), evidence (**V**) from student responses, application of knowledge to different situations (**C**), and learning goal (**G**). A decision network [3] is then formed by adding decision and utility nodes to the Bayes's net. As it is computationally intractable to track student's solution in real time, we use sequential decisions to generate tutoring strategy that anticipates students' responses.

This paper is organized as follows: Section 2 provides an overview of the conceptual framework for the decision theoretic intelligent tutoring system called *iTutor*. The transformation of student's responses to evidence is discussed in Section 3. Section 4 illustrates how the student model is constructed from a set of Bayes's nets, while Section 5 presents the tutoring strategy model using two-step look-ahead decision network. The results of a typical *iTutor* session are illustrated in Section 6. It emphasizes the automation of decision network construction and shows that when student's responses are available, the system is able to diagnose student's misconceptions and to provide adaptive tutoring using the generated strategy. Finally, we conclude by discussing future directions.

2 Framework of Adaptive Tutoring

Figure 1 shows the essential components of adaptive tutoring in *iTutor*.

The ***Evidence Model*** converts the student response (x_{ijk}) to item i into evidence of knowledge mastery for a relevant learning objective (v_{jk}).

The ***Student Model*** consists of a set of Bayes's nets with nodes that are either Evidence, Case, Learning Objective, or Goal. These nodes are initialized with prior information from the teacher's judgement and theoretical probability models. The student model can be subsequently updated to reflect a student's knowledge mastery when evidence is available.

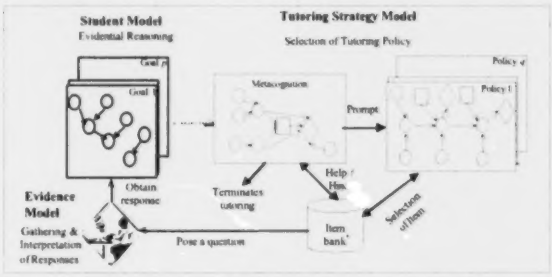


Figure 1: Inferencing Kernel of Adaptive Tutoring

The ***Tutoring Strategy Model*** uses decision-theoretic approach to select *satisfying* [14] learning objectives for tutoring student. The metacognition sub-module determines the appropriate tutor's action: providing more help or hint, prompting another question, or stop the tutoring session. Dynamic Decision Network (DDN) provides approximate solutions for partially observable Markov decision problems, where the degree of approximation depends on the amount of look-ahead. If the decision is to obtain evidence of mastery on a learning objective, an item of difficulty b_i that matches the student's ability θ will be selected. Student's response is collected, evaluated, and transformed into evidence at the relevant nodes in the student model. The *chance* nodes in DDN are updated and a decision policy is generated. In this way, the system is able to adapt tutoring to the needs of the student and achieve the objectives of the curriculum.

3 Evidence Model

The student's responses are processed in the evidence model. Let V_{jk} be the evidence node that indicates the student's (j) mastery state of learning objective k. Let X be the set of responses and $x_{ijk} \in X_{ik} \subseteq X$ be the response to item i which tests the kth learning objective, then

$$\Pr(v_{jk} \mid x_{ijk}) \propto \Pr(v_{jk}) \prod_i \Pr(x_{ijk} \mid v_{jk})$$

where $\Pr(v_{jk})$ is the prior probability which can be obtained statistically from past data. $\Pr(x_{ijk} \mid v_{jk})$ is the likelihood of correct-answer score. An example of the likelihood function is $\delta_{ik} \exp(-b_i v_{jk})$ where δ_{ik} is the importance of knowing learning objective k so as to answer item i correctly and b_i is the difficulty index for item i.

4 The Student Model

The Student Model consists of a set of Bayes's nets, and each Bayes's net models the student' s mastery of a key concept (*goal*). In Section 4.1, the structure of the student model is defined. The construction of Bayes's net and the conditional probability assignment are discussed in Section 4.2. Instantiation of an evidence node activates a message passing process in the Bayes's net. This process results in the updating of marginal probabilities at the nodes. Most commercial software for developing probabilistic network possesses efficient algorithm [1] for implementing the message passing process.

4.1 Semantics of the Student Model

The Student Model is a directed acyclic graph (DAG) that represents a joint probability distribution of a key concept and several learning objectives. A node represents the learning objective as a random variable, and an arc represents possible probabilistic relevance or dependency between the variables. When there is no arc linking two nodes, it indicates probabilistic independence between the variables. In this study, the variables are classified into four types Evidence, Case, Learning Objective, and Goal as shown in Figure 2.

Symbol	Name	Function
N_v	Evidence Node	It contains knowledge states based on student' s response.
N_C	Case Node	It contains knowledge states that reflect ability to apply knowledge in different situations (cases).
N_L	Learning Objective Node	It contains knowledge states of key learning objectives (defined in the syllabus).
N_G	Goal Node	The concept student is expected to know. Each Bayes's net must have at least one Goal node.

Figure 2: Types of Nodes in Student Model

More formally, a student model in *iTutor* is a DAG $\mathfrak{I} = (N, \psi)$ where $N = N_v \cup N_L \cup N_C \cup N_G$ are the nodes such that N_v is a set of evidence nodes, N_L is a set of learning objective nodes, N_C is a set of case nodes, and N_G is a set of goal nodes.

$\psi = \psi_{pL} \cup \psi_{pC} \cup \psi_{pG}$ are the arcs such that $\psi_{pL} \subseteq N \times N_L$ are arcs into learning objective nodes, $\psi_{pC} \subseteq N_v \times N_C$ are arcs from evidence nodes to case nodes, and $\psi_{pG} \subseteq (N_L \cup N_G) \times N_G$ are arcs from learning objective or goal nodes to the goal nodes.

Notice that evidence nodes have no parent node and only evidence nodes could be the parents of case nodes. Goal nodes are always sink nodes and they have parents that are either learning objective nodes or goal nodes. This signifies that mastery of a concept (goal node) is dependent on the mastery of learning objective(s) and/or pre-requisites (other goal nodes).

4.2 Construction of a Bayes's Net

Figure 3 shows a Bayes's net on mastery of a hypothetical concept (*goal*) "XYZ". Each node has three knowledge states: *non-mastery, partial-mastery,* and *mastery*. The granularity of Bayes's net depends on the number of nodes and its states. However, as the granularity becomes finer, the number of entries in the conditional probability table grows exponentially.

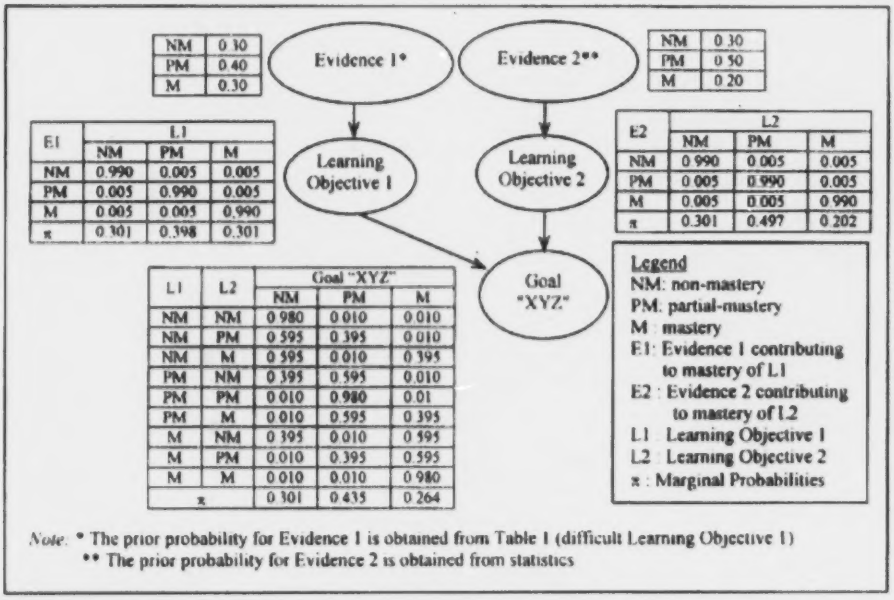
Table 1 Category of Difficulty in Mastering the Learning Objective

	Probability values		
Category	NM	PM	M
very easy	0.001	0.009	0.99
easy	0.01	0.09	0.90
fairly easy	0.05	0.15	0.80
Neutral	0.10	0.20	0.70
fairly difficult	0.20	0.30	0.50
difficult	0.30	0.40	0.30
very difficult	0.40	0.50	0.10

Values at the root nodes are known as *prior* probabilities while that at other nodes are *conditional* probabilities. To use the probabilistic network the random variables must be initialized with prior probability values. These values may be based on teacher's belief or past statistics. An intuitive method is to generate a probability table based on seven-category of the difficulty of learning objectives (see Table 1). These probability values are to be input as the prior probability of the related evidence. The teacher also has the flexibility to amend the values based on their belief and context of usage. On the other hand, the probability values can be obtained from statistics of previous tests/examinations. A simple procedure for the use of past statistics is:

a) Assigned learning objectives to each question;

b) Enter student's responses (in terms of percentage) for the questions that she has answered;
c) Compute the average number of students (in percentage) for each mastery category: 0-40 (non-masterystate), 40-70 (partial-mastery state), and 70-100 (mastery state).



NM	0.30
PM	0.40
M	0.30

NM	0.30
PM	0.50
M	0.20

E1	L1		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.398	0.301

E2	L2		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.497	0.202

L1	L2	Goal "XYZ"		
		NM	PM	M
NM	NM	0.980	0.010	0.010
NM	PM	0.595	0.395	0.010
NM	M	0.595	0.010	0.395
PM	NM	0.395	0.595	0.010
PM	PM	0.010	0.980	0.01
PM	M	0.010	0.595	0.395
M	NM	0.395	0.010	0.595
M	PM	0.010	0.395	0.595
M	M	0.010	0.010	0.980
π		0.301	0.435	0.264

Note. * The prior probability for Evidence 1 is obtained from Table 1 (difficult Learning Objective 1)
** The prior probability for Evidence 2 is obtained from statistics

If a probability distribution function is able to describe the statistics, it can be used. In Figure 3, the values Pr(E2=non-mastery) = 0.30, Pr(E2=partial-mastery) = 0.50, and Pr(E2=mastery) = 0.20 are obtained from statistical data for this particular evidence. It is acceptable for another person to assign different probability values so long as it is consistent with the probability axioms [12]. Since the decision theory approach is normative rather than descriptive, it is able to explain the actions of the decision-maker.

For any node n_q, the conditional probability required to specify the Bayes's net is computed based on the relative importance (*weights*) of the parent nodes $pa(n_q)$ to itself.
If the state of n_q and $\mathrm{pa}(n_q)$ is the same, then $\Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} (w_{pq} - (c-1)\kappa)$

$$\text{else } \Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} \kappa \qquad (1)$$

where c *is the number of states and* $0 \le w_{pq} \le 1$.

κ is a constant and a measure of uncertainty such as careless errors, lucky guesses, changes in the student knowledge state due to learning and forgetting, and patterns of student responses unanticipated by the designer of the student model. The weights w_{pq} are either assessed based on the teacher's subjective judgment or past students' responses to closely related items.

Referring to Figure 3, since Learning_Objective_1 is dependent only on Evidence_1, $w_1 = 1$. Let Learning_Objective_1 has greater influence on mastery of goal "XYZ" than Learning_Objective_2, $w_{1g} = 0.6$, and $w_{2g} = 0.4$. Assigning $\kappa = 0.005$, the conditional probability tables can be computed using equation (1).

5 Tutoring Strategy

When a student logon to *iTutor*, the system automatically searches his ability index from the database. The

ability index is either computed from the tests taken previously by the students, or from her knowledge states in the student model (see Section 5.1). Human tutors consider the student's emotional state in deciding how to respond. Similarly in *iTutor*, the system considers factors such as response time, response pattern, student knowledge structure to determine tutoring actions: give more hint, help, ask another question, or stop the tutoring session. If the decision is to prompt another item, a learning objective and an appropriate item will be selected to coach her (see Section 5.2). Section 5.3 discussed the generation of tutoring strategy based on student's response.

5.1 Mapping of Knowledge State to Student Ability

Let the student's ability be $\theta_j = (\theta_{j1}, \theta_{j2}, .. \theta_{jm}, .. \theta_{jp})$. A function $f: v_{jm} \rightarrow \theta_m$ where v_{jm} is the evidence at the goal node (g) of mth Bayes's net. An example of such function is:

$$\theta_{jm} = \begin{cases} N\,(1.5, 0.6) & v_{jm} \geq 0.7 \\ N\,(0.5, 1) & 0.4 < v_{jm} < 0.7 \\ N\,(-1, 1.2) & v_{jm} \leq 0.4 \end{cases}$$

where N (μ, σ) denotes a *normal* distribution with mean μ and standard deviation σ

The computed ability index is then used to categorize (Advance, Intermediate, or Beginner) the student. An appropriate learning objective is selected based on the heuristic shown in Table 2. Value assignment is used to compute the path length of Bayes's net and is used as preference for tutoring policy generation. They are as follow:

$$\begin{aligned} &\text{value}(\mathcal{G}) = 0 \text{ for } \mathcal{G} \in \{\text{Goal nodes}\} \text{ and } \text{ch}(\mathcal{G}) = \phi \\ &\text{value}(\text{ch}(\mathcal{N})) = 0 \text{ if } \text{ch}(\mathcal{N}) = \phi \\ &\text{value}(\mathcal{N}) = \text{value}(\text{ch}(\mathcal{N})) + 1 \text{ for node } \mathcal{N} \\ &\text{where } \text{ch}(\mathcal{N}) \text{ is the child node of } \mathcal{N} \end{aligned} \qquad (2)$$

Table 2 Search Heuristic for Identifying Learning Objective for Coaching

Category	Identification of first Learning Objective for tutoring
Advance	25% of pathLength*
Intermediate	50% of pathLength
Beginner	75% of pathLength
New#	50% of pathLength ($\lceil$pathLength/2$\rceil$)

Note:

- pathLength denotes max(value($\mathcal{N}$)) $\forall \mathcal{N} \in$ Bayes's net.
  The value($\mathcal{N}$) assignment is stated in equation 2
- # The category *New* refers to students who login to the system the first time

5.2 Item Selection

Each item is tagged with an index (b_i) that estimates the minimum ability to answer it correctly with 0.5 probability. The items are assumed to be independent and the index obtained through statistic of past students' attempts or assigned using teacher's belief. Subsequent update of item difficulty index may be performed through item response theory [4] such as Rasch model [10].

From the set of items related to a learning objective, an item i is selected based on: $\theta_j - b_i < \varepsilon$ where ε is a

Table 3 Utility of Various Outcomes

Condition / Expression	Preference
Decision: Stop	
$S(\mathcal{N})$ = "M" & value($\mathcal{N}$) = 0	1
$S(\mathcal{N})$ = "N" & value($\mathcal{N}$) = 0	0
k = number of $\mathcal{N}_k \in \{(\mathcal{N}_k, S_k)\}$ with same S_k	$1 - k/5$
number of tries, n, for the same learning objective	$1 - n/5$
Decision: Ask item on same $\mathcal{N}$	
$S(\mathcal{N})$ = "M"	0
$S(\mathcal{N})$ = "N"	1
$S(\mathcal{N})$ = "P"	$\left(1 - \frac{\text{value(N)}}{\text{pathLength}}\right) \times \eta$ where η is a constant
Decision: Ask item on ch($\mathcal{N}$)	
$S(\mathcal{N})$ = "M"	1
$S(\mathcal{N})$ = "N"	0
$\gamma = \max(\Pr(S(\text{ch}(\mathcal{N})) = \text{"M"} \mid x = 1) - \Pr(S(\text{ch}(\mathcal{N})) = \text{"N"} \mid x = 0)$	
Decision: Ask item on pa($\mathcal{N}$)	
$S(\mathcal{N})$ = "M"	0
$S(\mathcal{N})$ = "N"	1
$\gamma = \max(\Pr(S(\text{pa}(\mathcal{N})) = \text{"M"} \mid x = 1) - \Pr(S(\text{pa}(\mathcal{N})) = \text{"N"} \mid x = 0))$	

Remarks: $S(\mathcal{N})$ denotes the knowledge state of node $\mathcal{N}$
ch($\mathcal{N}$) denotes child node of node $\mathcal{N}$

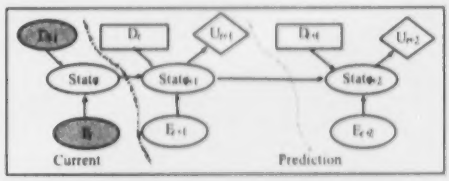


Figure 4: Dynamic Decision Network

Table 4 Utility Values for Item Difficulty Level Selection

Current Knowledge State ($State_t$)	Current Response (E_t)	Next Question Typ (D_{t+1})		
		Easy	Ave.	Diff
Non-Mastery	Correct	-0.2	1	0
	Wrong	0.4	-0.2	-0.4
Partial Mastery	Correct	-0.4	0.2	1
	Wrong	0.4	1	-0.2
Mastery	Correct	-0.4	-0.2	-0.2
	Wrong	-0.2	0.2	-0.2

pre-defined small value. This ensures selected item is challenging and likely to be solved by the student. Teacher's solution will be displayed upon student's request so that she can learn from her mistake. This strategy assumes student's ability is dynamic and can be raised to higher levels through self-paced computer-aided tutoring.

5.3 Tutoring Policy Generation

To bring the probabilistic network one step closer to being a useful *intelligent tutoring system*, automated decision-making capability has been added. When asked to provide a tutoring policy for the student, the system generates a course of action based on her current mastery states. The tutoring policy aims to use a series of items with differing difficulty to determine more precisely her mastery of specific learning objectives. Items are categorized into *easy*, *average* and *difficult*. In this project, a two-step look-ahead dynamic decision network is recommended so as to compromise between the need to invoke policy generation routine for a decision and the long computing time to generate policy with many decisions.

Define a Bayes's net with nodes N,
E_t be the evidence at time t,
$Bel(N)$ be a vector of probabilities (updated over time),
d_t be the decision at time t, and
α be the normalization constant.

Prediction 1: $Bel^*(N_{t+1}) \leftarrow \sum_{N_t} Pr(N_{t+1} \mid N_t, d_t) Bel(N_t)$

Estimation 1: $Bel(N_{t+1}) \leftarrow \alpha Pr(E_{t+1} \mid N_{t+1}) Bel^*(N_{t+1})$

Prediction 2: $Bel^*(N_{t+2}) \leftarrow \sum_{N_{t+1}} Pr(N_{t+2} \mid N_{t+1}, d_{t+1}) Bel(N_{t+1})$

Estimation 2: $Bel(N_{t+2}) \leftarrow \alpha Pr(E_{t+2} \mid N_{t+2}) Bel^*(N_{t+2})$

Expected Utility: $\sum_{N_t} Bel(N_t) \max_{d_t} \sum_{N_{t+1}} Pr(N_{t+1} \mid N_t, d_t) \times \max_{d_{t+1}} \sum_{N_{t+2}} Pr(N_{t+2} \mid N_t, d_t, N_{t+1}, d_{t+1}) \times U(N_t, d_t, N_{t+1}, d_{t+1}, N_{t+2})$

Figure 5: Prediction-estimation Process

Figure 4 shows a dynamic decision network (DDN) used in this study. In addition to the decision nodes for current and future time steps, the DDN also contains the previous decision, D_{t-1}, as an evidence node. When the evidence for state t arrives, the probability distributions of $State_t$ are updated [1] using the prediction-estimation process (see Figure 5). After the initial prediction of probabilities (Bel*), $State_{t+1}$ estimates the new belief based on projected evidence [13]. This process repeats for $State_{t+2}$. Eventually, the expected utility is evaluated by a sequence of summations and maximizations. Tables 3 and 4 show the utility functions for node U_{t+2}. Selecting the outcomes with maximum expected utility value constitute the tutoring policy.

6 An Illustration

6.1 Construction of a Decision Network

In this project, the construction of all probabilistic networks is performed using Netica API [7]. A module leader enters the learning objectives and the weights of the key concept *Forces* using Microsoft Access [6]. The probabilistic values shown in Figure 6 are entered based on past examination results. By clicking the button "Model Construction", a Bayes's net (see Figure 7) and a decision network (see Figure 8) on "Forces"

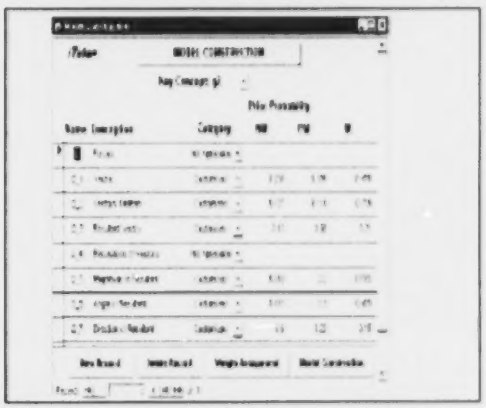


Figure 6: A Snapshot on Data Entry for Model Construction

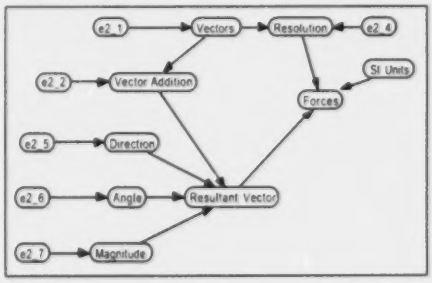


Figure 7: Bayes's Net on *Forces*

will be created. Teachers who are familiar with Netica application [8] can use the generated Bayes's net to perform *what-if* analysis. For example, a teacher may want to determine the likely student's improvement if he provides remedial instructions on "Resolutions of Vectors". He can do so by instantiating the evidence node *e2_4* to "Mastery" state, and observe the probability of mastery in the goal node labeled *Forces*.

6.2 Diagnosis of a Student's Misconceptions

The items to be presented to the students are coded by the teacher using Scientific Notebook [15]. With *iTutor*, the teacher is able to monitor student's progress through the database management tool. Figure 9a shows a snapshot of a student who had answered item "Force_001" correctly and partially correct for item "Force_004". The teacher can track a student's mastery states by clicking the "Advice" button. The system transforms the responses to evidence, and instantiates the evidence nodes in the Bayes's net as shown in Figure 9b. The posterior mastery states are displayed (see Figure 9c). The output also provides the teacher information on specific learning objectives to tutor. In addition, he can also examine the detailed strategy by clicking the "Tutorial Strategy" button. This action causes the generation of a decision network (see Figure 9d). Figure 9e shows items to be posed to the student if she continues with the online tutorial. At any stage, the teacher may intervene by providing personal coaching.

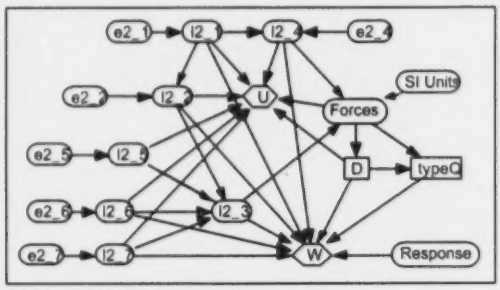


Figure 8: Decision Network on *Forces*

7 Conclusions

Presently, the students' knowledge states remain unchanged until additional evidence is available. The system also uses a constant learning rate for all students. One future direction is to include additional parameters to model student forgetting and learning rates. Another area is to provide a user interface for teachers not familiar with Netica application to perform *what-if* analysis. In this way, the teacher will be able to focus on student's issues rather than to learn another software tool. The next future direction is to include probability functions other than *Normal* distribution. This is essential when the ability distribution of student cohort is not symmetric.

A significant result of this project is the use of Bayesian networks to generate sound probabilistic inferences. Another contribution is the automation of decision networks construction. The recommended strategy is used in adaptive tutoring. With *iTutor*, teacher is able to monitor the student's progress and yet had time for lesson preparation and coaching of weaker students. In addition, the teacher has accessed to the student's knowledge states and actions taken by *iTutor* at every stage of the tutoring process. Moreover, it enables students to have tutorials customized to their needs.

References

[1] Castillo, E., Gutiérrez, J. M., & Hadi, A.S., "Expert Systems and probabilistic network Models", Springer-Verlag, (1997).

[2] Conati C. & Vanlehn K., "Teaching meta-cognitive skills: Implementation and evaluation of a tutoring system to guide self-explanation while learning from examples", Proceedings of AIED '99, 9th World Conference of Artificial Intelligence and Education, Le Man, France, (1999).

[3] Deam, T. L. & Wellman, M. P., "Planning and Control", Morgan Kaufmann, San Mateo, California, (1991).

[4] Hambleton, R.K., Swaminathan, H., & Rogers, H. J., "Fundamentals of Item Response Theory", Sage Publications, Inc, (1991).

[5] Howard, R.A. & Matheson, J.E. "Readings on the Principles and Applications of Decision Analysis", Menlo Park, California: Strategic Decisions Group, (1983).

[6] Litwin, P., Getz, K., & Gilbert, M. , "Access 97 Developer's Handbook", 3rd edition, Sybex Inc, (1997).

[7] Norsys, "Netica API Programmer's Library Reference Manual", version 1.06, Norsys Software Corp., (1999)

[8] Norsys, "Netica Application Reference Manual", version 1.12, Norsys Software Corp., (1999).
[9] Pearl, J., "Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference", Morgan Kaufmann Publishers, Inc, (1988).
[10] Rasch, G., "Probabilistic Models for Some Intelligence and Attainment Tests", Danish Institute for Educational Research, (1960).
[11] Reye, J., "A belief Net Backbone for Student Modeling, Proceedings of Intelligent tutoring Systems", Third International Conference, ITS '96, Springer-Verlag, (1996).
[12] Ross, S., "A First Course in Probability", Prentice-Hall International, Inc., 5th edition, (1998).
[13] Russell, S. & Norvig, P. , "Artificial Intelligence: A Modern Approach", Prentice Hall, (1995).
[14] Simon H.A., "The New Science of Management Decisions", New York: Harper & Row, (1960).
[15] TCI Software Research, "Scientific Notebook version 3.00 Build 939", Brooks / Cole Publishing Company, (1998).
[16] Villano, M., "Probabilistic Student Models: Bayesian Belief Networks and Knowledge Space Theory", Proceedings of Intelligent Tutoring Systems: Second International Conference, ITS '92, Springer-Verlag, (1992)

Proceedings

Content

▸Full & Short Papers (Cognition and Conceptual Change)

A Method of Creating Counterexamples by Using Error-Based Simulation
An Interactive Game System to Stimulate Word Associations
Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching
Collaborative Learning vs Cognition
Impacts of Unintellect Factores on the Design of CAI Courseware
Meta-Knowledge Agent: Creates the context for thoughful instructional systems.
Microgenetic Analysis of Conceptual Change in Learning Basic Mechanics
Scientific revolutions and conceptual change in students: Results of a microgenetic process study
The Effect of Virtual Reality Learning with Different Cognitive Style
The externalization support system of self-explanation for learning problem-solving process
The Use of Animation as a Tool for Concept Learning

▲HOME

Proceedings

Content

▸Full & Short Papers (Collaborative Learning)

A Comparative Study of Applying Internet on Cooperative and Traditional Learning
A Distributed Backbone System for Community-Based Collaborative Virtual Universities
A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community
A Flexible Transaction Model for Virtual School Environments
A study of collaborative teaching for creative learning in an engineering class
A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics : Through a Practice of Three Junior High Schools
Agent-based Collaborative Learning Environment for Intelligent Tutoring Systems (ITS)
Agent-oriented Support Environment in Web-based Collaborative Learning
An Effectiveness Study of Web-based Application for Mailing List Summary and Review
An Implementation of Campus Distance Learning System Using Multicast
Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming
Building Mathematics Collaborative Learning Web Sites
Collaborative Learning using GSS on the internet
Design and Implementation of Cooperative Monitoring Agent using Mobile Agent
Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments
Development of the Web-based classroom system which a teacher can apply
Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.
Domain Specific Information Clearinghouses - A Resource Sharing Framework for Learners
Everything in Moderation? Developing successful collaborative projects between European initial teacher education students.
Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers
Group Composition Methods for Cooperative Learning in Web-based Instructional Systems

Initial Evidence for Representational Guidance of Learning Discourse

Is a Learning Theory Harmonious with Others?-To form Effective collaborative Learning Groups with Ontological Engineering-

Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

Peer Help for Problem-Based Learning

Promoting Student Learning and Development in Computer-Based Cooperative Learning

Proposal of an XML-based Knowledge Sharing and Management system supporting Research Activities

rTable : A Collaborative Problem-solving Environment for Synchronous Discussion

Scientific revolutions and conceptual change in students: Results of a microgenetic process study

The Distance Ecological Model to Support Self/Collaborative-Learning in the Internet Environment

The Impact of Learning Style on Group Cooperative Learning

The Project-based Cooperative Learning on Internet -- A Case Study on Geology Education

Tracking and Guiding Tools for learning Groups in a Web Collaborative Learning System

What kind of interaction and reflection emerged in a teachers' learning community?- Development and evaluation of computer supported collaborative learning (CSCL) software for teacher education-

▲HOME

A Comparative Study of Applying Internet on Cooperative and Traditional Learning

Weichung Wang*, Yannjiun Tzeng and Yuan Chen
Department of Mathematics Education, National Tainan Teachers College
Tainan 700, Taiwan
**E-mail: wwang@ipx.ntntc.edu.tw*

The Internet-based cooperative learning has become a new trend in education, thanks to the rapid development of the technologies. This study evaluates the effects of utilizing the Internet on cooperative and traditional learning. Aiming on an elementary school natural science topic, this study compares learning performance of two pupil groups that contains 36 twelve-year-old pupils for each group. We found the learners who adopting Internet-based cooperative learning outperform the other group on Memory-demanding, integration, and deduction type problems. Furthermore, the Internet-based cooperative learning group has uniform performance on the three types problems and is generally more aggressive. In contrast, the Internet-based traditional learning group tends to perform better only on Memory-demanding type problems and has relatively passive learning attitude. Based on the experience, we encourage using the Internet in cooperative learning for nature science. Teachers also need to compose a complete plan and familiarize learners with an Internet browser before conducting the course.

Keywords: **cooperative learning; traditional learning; Internet-based cooperative learning; difference of significance**

1 Introduction

Rapid progress of the Internet has greatly changed the way of teaching and learning. The Internet not only overcomes the space and time limitation of a closed environment such as a classroom, the Internet also contains many useful educational resources that motivate and attract students. This new environment demands teachers to adapt new teaching methods by using applications like World Wide Webs (WWW) and E-mail. Therefore, the means by which teachers efficiently take advantage the new technology is an essential education subject.

While many teachers have started integrating the Internet into their classrooms, little systematical researches has focused on using the Internet in cooperative learning. Aiming to combine the Internet with cooperative learning concept, we conducted this study to (1) evaluate feasibility and efficiency of Internet-based cooperative learning, (2) develop strategies that can help students to learn actively and independently by Internet-based cooperative leaning, and (3) compare students' performance while applying the Internet on cooperative and traditional learning methods.

This study designed a way merging the Internet into a cooperative learning environment. The designed course focused on Sixth grade Natural Science (for twelve-year-old pupils) in Taiwan. Our study demonstrated the feasibility of Internet-based cooperative learning. We showed that pupils leaning in an Internet-based cooperative learning environment can outperform those who learn in an Internet-based traditional learning environment. Pupils' performances were evaluated by questions requiring their problem solving capability in memory demanding, integration, and deduction. All the findings are supported by statistical quantitative analysis results with significant difference.

In other words, this study focuses on the following questions:

(1) What kind of role does the Internet play in Internet-based cooperative learning and Internet-based traditional learning?
(2) Do pupils have enough computer literacy for Internet-based learning?
(3) Is there any learning efficiency difference between Internet-based cooperative learning and Internet-based traditional learning?
(4) If such difference really exists, which one is better?
(5) Do these two teaching methods have significant difference in student's problem solving capability? Especially in the aspect of memory demanding, integral, and deductive ability.

1.1 Literature review

We now survey literatures related to our study.

1.1.1 Using the Internet in learning environment

With the popularity of the WWW, a great deal of interest and enthusiasm has being expressed among teachers concerning the use of the WWW as a learning tool.[2,7] The main reasons are that the Internet offers a new learning environment that is quite different from the traditional classroom, and teachers can utilize Internet resources to enrich their teaching.

The Internet offers a learning environment that can be characterized by the following [6]:
(1) It has no limitation on place or time. That is, students can learn all kinds of knowledge at any place and any time.
(2) It is interactive and flexible. Students can choose different contents based on their learning conditions.
(3) The Internet integrates global educational resources.
(4) Students can communicate and discuss subjects with each other on the Internet. They also benefit from cooperative learning
(5) Multimedia effects of the Internet enhance students' motivation in learning.

In addition, Donald and LeuDeborah [3] suggested instructional strategies including Internet Workshop, Internet Activity, Internet Project, and Internet Inquiry.

1.1.2 Roles of teachers and students in cooperative learning

In order to achieve a better result in the cooperative learning process, teachers and students need to be fully aware of the role they play. Wang [13] claimed that, in most cases, cooperative learning should be practiced by a small group of students. The students' ability to cooperate are emphasized in the learning process. By group discussion, students can learn actively and build their own knowledge. Cooperative learning stresses that students play a major role in all learning activities and learn independently. According to the mission, students do their own literature search and then read, analyze, organize, and experiment with their material. Students establish learning concepts and share what they have learned via discussion with group members. Cooperative learning also emphasizes heterogeneous group learning. Teachers need to understand the profiles, difficulties, and expertise of learning of each student in order to group student in the best way. Therefore, teachers need to be well prepared and have a good plan on course work before performing cooperative learning.[9]

Some authors also pointed out that cooperative learning is more than just having a group of students solve problems in a cooperative way. Most importantly the following factors need to be included in the process of achieving a common goal [14]:
(1) Group members need to understand that they are a part of a team sharing a common goal.
(2) Group members need to realize that the problem is for the whole group and they share the success or failure with the whole group.
(3) Students need to talk to each other and join the discussion after accomplishing the common goal.
(4) Every group member needs to be fully aware of the fact that his or her contribution has a direct effect on the success of this group.

1.1.3 Comparison between cooperative learning and traditional learning

Colonel Paker first introduced the concept of cooperative learning in late nineteenth century. The concept has further become an active research subject in the last three decades. [1] One main topic of this research

field is to compare the efficiency of cooperative learning to that of traditional learning. Many experimental results showed that cooperative learning is superior to tradition learning.[4,5,8,10,11] Actually, Slavin [10] further pointed that:
(1) 63% of studies had showed that cooperative learning is superior to traditional learning,
(2) 33% of studies had showed no significant difference between these two methods, and
(3) 4% of studies had showed that traditional learning is superior to cooperative learning.

1.1.4 The way of communication of traditional learning and Internet-based learning

Advantage of computer network mediated communications can further enhance the advantage of using the Internet in cooperative learning. Traditional learning allows only one-way communication between student and teacher. Tyan and Hong [12] mentioned in their recent study: "The way of communication in traditional learning has many limitations. It has to be simultaneous in space and time; it is only a one-way broadcast communication from teacher to whole students as a group; its messages are is by oral in most cases; special arrangement, such as tape recording, note taking, and etc., are needed to record the teaching material."

In contrast, computer network mediated communications are more versatile. It can be simultaneous or non-simultaneous in space and time. It allows multilateral communications between a teacher and students and between students. In addition to broadcast from a teacher to the whole class, it also allows private dialogue. Finally its messages are textual and graphic information displayed by a computer, which can be automatically stored in a computer.

1.2 Organization of the paper

We state the methodology and the process of the study in the next section. Experimental results are demonstrated and analyzed in Section 3. Findings and inducing suggestions are elaborated upon in Section 4. We conclude the paper and provide further direction in Section 5.

2 Methodology

2.1 The presumptions of this study

We assume that students are capable of using the Internet while engaging in Internet-based learning, and the Internet-based cooperative learning group is trained to have skills for cooperative learning. In addition, a suitable site is designed by teachers based on the learning goal. Teachers needs to be prepared before perform the Internet-based learning.

2.2 Flow chart of this study

Figure1 shows the flow chart designed for this study.

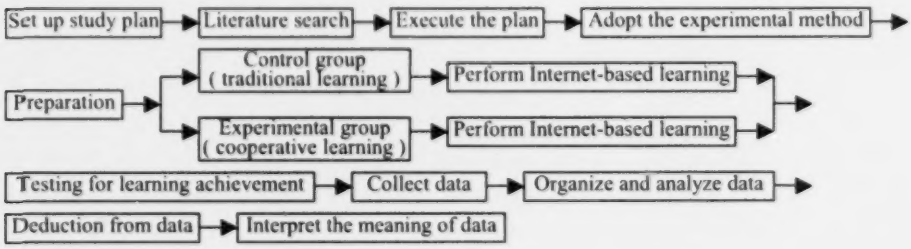


Figure 1. The flow chart for the process in this study.

2.3 The process of this study

2.3.1 The subject of this study

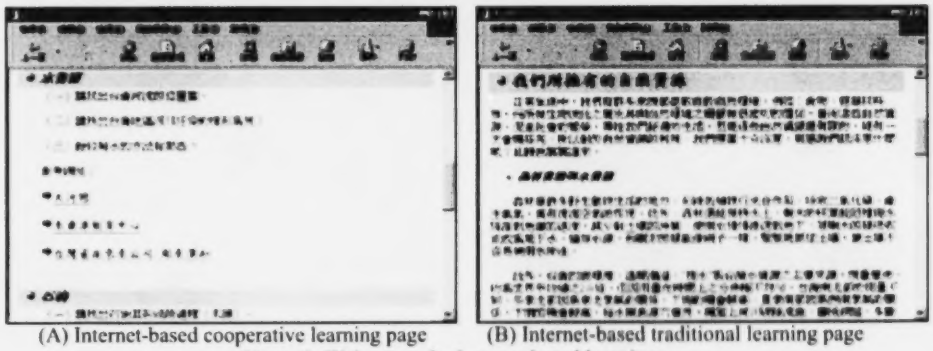
Two Sixth-grade "Computer Experimental Classes" of Hai-Tung Elementary School (Tainan, Taiwan) are the subjects of this study. Both classes have a normal distribution in students' learning capabilities. Each of these two classes has 36 student subjects.

We group the students by the following mean. All 72 students are listed sequentially according to their learning capability. Students with odd numbers are assigned to the experimental group; those with even numbers are assigned to control group. Students in each group are further divided into subgroups. Each subgroup has 3 members who have low, average, and high learning capability respectively.

2.3.2 The tool of this study

In this study, computers are the basic tool for both two groups. For the purpose of this study, a web site has been designed based on the twelfth volume of the nature science textbook for elementary school. Figure 2 shows some snapshot examples of the web. The Internet-based cooperative learning page contains only topics and possible URL links, but the Internet-based traditional learning page describes whole the knowledge for this course. The Internet-based cooperative learning group get knowledge about the topics from relative URLs and discuss with their members. However, the Internet-based traditional learning group only get knowledge from Internet-based traditional learning page. While the learning is proceeding, teachers need to help students to cooperate and make them more aggressive.

The experimental group receives Internet-based cooperative learning; on the other hand, the control group receives Internet-based traditional learning. An "Activity Page" (See Figure 3) is used to evaluate the achievement of these two groups and it contains memory-demanding, integration, and deduction problems that is designed based on the learning goal. For example, we design an integration problem about natural resource recycle to test students' ability to integrate the fractional knowledge thsy learned. The idea of letting student groups browse the Internet according to the "Activity Page" and then discuss and present the findings in a workshop is also suggested by Donald and Deborah.[3]



(A) Internet-based cooperative learning page (B) Internet-based traditional learning page

Figure 2. Web pages for Internet-based learning.

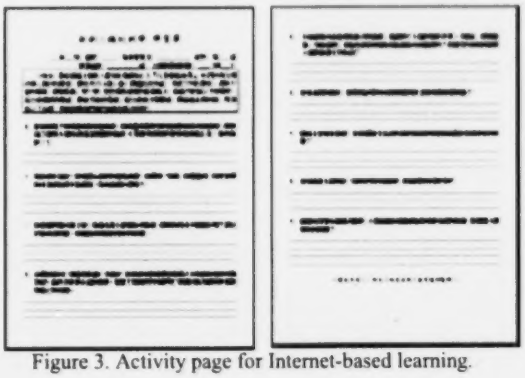


Figure 3. Activity page for Internet-based learning.

BEST COPY AVAILABLE

2.3.3 Data analysis

Figure 4 shows the flow chart for the data analysis. The data was obtained from the examination given after the learning experiment. The data was analyzed for statistically significant difference of 0.05 and 0.01. In order to investigate students' problem solving capabilities for different types of problems, the examination contains memory-demanding, integration, and deduction problems. We defined these three types of problems as follows:

(a) Memory-demanding type: this kind of problem is given to test students' ability to memorize the fractional knowledge they learned;

(b) Integration type: this kind of problem is given to test the students' ability to integrate the fractional knowledge they learned;

(c) Deduction type: this kind of problem is mainly to test the students' ingenuity and creativity after comprehending the knowledge they learned.

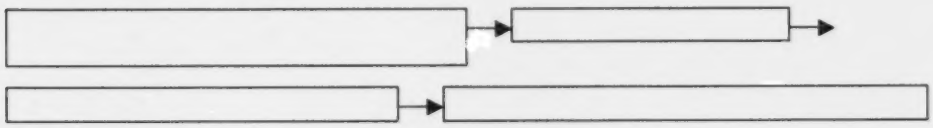
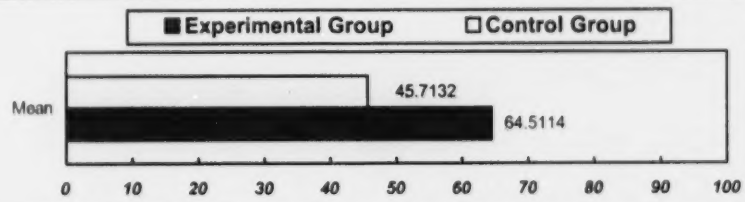


Figure 4. Data analysis flow chart.

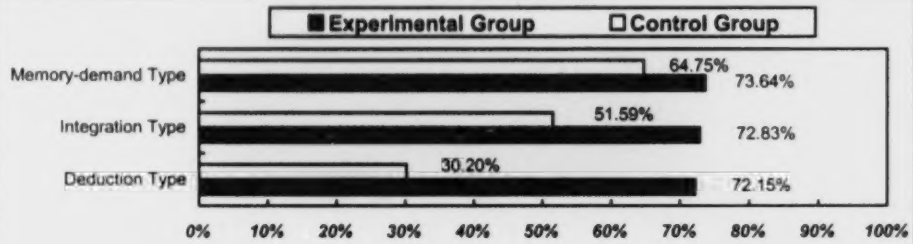
3 Experiment results

Both the experimental group(Internet-based cooperative learning group) and control group(Internet-based traditional learning group) are subjected to have a same examination for evaluation. Figure 5 shows total test scores for experimental group and control group, and Figure 6 shows a comparison on scores of memory-demanding, integration and deduction problems.



item / group	Samples (N)	Mean ($\overline{X}$)	Standard deviation (SD)	t-value	p-value
Experimental Group	36	64.5114	14.6882	4.5540	< 0.01
Control Group	36	45.7132	19.7863		

Figure 5. Total test scores for experimental group and control group.



Problem Type \ Item		Mean	Standard deviation (SD)	t-value	p-value	Ratio of correct answers
Memory-demand	Experimental Group	24.3007	4.0356	1.8285	< 0.05	73.64 %
	Control Group	21.3678	8.7102		> 0.01	64.75 %
Integration	Experimental Group	40.0590	7.4270	5.6315	< 0.01	72.83 %
	Control Group	28.3768	9.9087			51.59 %
Deduction	Experimental Group	7.9370	4.4192	4.589	< 0.01	72.15 %
	Control Group	3.3216	3.6473			30.20 %

Figure 6. Scores on various types of problems for experimental group and control group.

4 Findings and suggestions

4.1 Findings

Based on the data obtained and the observation made during the experimental process, the following conclusions can be drawn. Besides, due to the restriction on experimental samples, the excessive inference should not be draw from these conclusions.

(1) Internet-based learning is feasible in an elementary school nature science course.

This study shows that either Internet-based learning method can fulfill the learning goal after the analysis of examination according to "Activity Page". Most sixth grade students can easily adapted themselves to Internet-based learning environment. Hardware equipment is not an issue in Taiwan, on the other hand. Since the Taiwanese government has greatly prompted information education in recent years, all levels of schools are equipped with personal computers.

(2) There is a significant difference in students' total examination scores for Internet-based cooperative learning and Internet-based traditional learning.

The t-value of this difference is 4.554 that can be regarded as statistically significant at the level of 0.01. Therefore, Internet-based cooperative learning is greatly superior to Internet-based traditional learning.

(3) The Internet-based cooperative learning group has better learning results on Memory-demanding type of problems.

Students in the Internet-based cooperative learning group performed better in this type of problem than those in the Internet-based traditional learning group. The different is considered as level of significance of 0.05, but less than the level of significance 0.01. It means that the learning efficiency of Internet-based cooperative learning is superior to Internet-based traditional learning, but not in a large significance.

(4) On integration type of problems, the Internet-base cooperative learning group significantly outperforms the Internet-based traditional learning group.

Students in the Internet-base cooperative learning group need to piece together information from various Internet resources. During the process of integration, they build new models and images in their minds. By

merging new models and images with old knowledge, they can form new knowledge. New and old knowledge is then integrated into a full concept. This is the reason why the Internet-based cooperative group had better learning efficiency on integration type of problems than the Internet-based traditional learning group.

(5) Students in the Internet-based cooperative learning group have higher scores in deduction type of problems.

In deduction type problems, students in the Internet-based cooperative learning group outperformed those in the Internet-based traditional learning group by 72.15% versus 30.20% in the ratio of correct answers. This reflects that students in the Internet-based traditional learning group lack logical inference capability. On the other hand, the Internet-based cooperative learning group had better logical inference ability and more creative ability.

(6) The Internet-based traditional learning group performed best in the memory-demanding problems.

In traditional learning, the teacher delivers teaching material and its highlights directly to students. Since the teacher has organized his material before class, the teaching method is more suitable for Memory-demanding type of problem. This is why students in the Internet-based traditional learning group score higher in memory-demanding problems than other types of problems.

(7) Students in the Internet-based cooperative learning group scored evenly in all kinds of problems.

Students in the Internet-based cooperative learning group score 73.64%, 72.83%, and 72.15% on memory-demanding, integration, and deduction problems. Thus, this teaching method is suitable to all kinds of evaluation methods.

(8) Students in the Internet-based cooperative learning group are more aggressive in learning than those in the Internet-based traditional learning group.

In dealing with problems, students in the Internet-based cooperative learning group acted cooperatively and aggressively in searching for answers using Internet resources. On the other hand, those in the Internet-based traditional learning group are less aggressive in overcoming difficulties, and give up at an early stage.

4.2 Suggestions

(1) Elementary school natural science courses can better utilize Internet resources to perform cooperative learning.

The massive resources on the Internet are an important and attractive factor motivating students to learn actively. Thus, teachers need to better utilize such resources to improve learning efficiency.

(2) During the process of Internet-based cooperative learning, a teacher needs to develop students' capability in cooperative learning.

The success of cooperative learning depends heavily on students' capability in cooperative learning. Teachers thus need to develop students' capability to learn cooperatively during their regular teaching. They should also make students understand the spirit and meaning of cooperative learning which is that each group member is willing to share their knowledge with others.

(3) Before performing Internet-based cooperative learning, teachers need to have a complete plan regarding the learning environment.

An effective cooperative learning relies on teachers' full preparation before the class, which includes: students properly divided into groups; teaching related material, such as web sites; increase initiation factor for cooperation; improve group members' contribution; develop students' ability to browse the Internet; and so on. These entire things require teachers to communicate with their students to reach a consensus before the class.

(4) Both teachers and students need to be aware of the roles they play in Internet-based cooperative learning process.

Though students learn by using Internet resources in Internet-based cooperative learning, the teacher still plays a crucial role. Like a navigator in a voyage, the teacher prevents students from being overwhelmed by the massive information on the Internet and guides them to reach their learning goal according to a series of stages. Students need to have the spirit of a trail-blazer in daring to make all kinds of trial effects. They also need to share the learning experience with others.

(5) During Internet-based cooperative learning, a teacher needs to increase students' consciousness on cooperation.

In cooperative learning, knowledge is obtained through cooperation between group members. Hence, group members should realize that the goal of the group is their own learning goal. Group power can be used to overcome learning difficulties, and develop a learning method that is suitable to the whole group. This allows each group member to experience the joy of learning.

5 Conclusions

This paper describes that cooperative learning and traditional learning can be combined with the Internet in an elementary school nature science course, and the learning efficiency will not be reduced. In addition, Internet-based cooperative learning is greatly superior to Internet-based traditional learning in learning efficiency. Since this paper is the plot study of Internet-based learning, we only focus on the learning efficiency of applying Internet on cooperative and traditional learning. It is likely that future replications of the study will in turn lead to discovery of comparison between other learning methods, such as cooperative learning, traditional learning, Internet-based cooperative learning and Internet-based traditional learning. Furthermore, we intend to develop different teaching strategic to lead students' interaction in the future.

References

[1] Chen, S. J., "The Effects of Pairing Learning Methods and Cooperative Training on Concept Learning", Journal of Pingtung Teachers College, Vol. 11, pp. 25-54, (1998).

[2] Chu, Y. M., "The integration of Internet cooperative learning and traditional instruction", The 7th International Conference on Computer-Assisted Instruction (ICCAI 1998), Kaohsiung, Taiwan, pp. 551-557, (1998).

[3] Donald J. Leu, Jr. & Deborah Diadiun Leu., "Teaching with the Internet: Lessons from the Classroom", Norwood, Massachusetts, 1999 Edition, (1999).

[4] Hooper, S., "Cooperative learning and computer-based instruction", Education Technology Research and Development, Vol. 40, No. 3, pp. 21-38, (1992).

[5] Johnson, D. W., & Johnson, R. T., "Cooperative learning and achievement", In Sharan, S. (Ed.) Cooperative learning: Theory and research, pp. 23-38, (1990).

[6] Lin, C. S., "Computer Network and Education Reform", Friends of Elementary Education, Vol. 49, No. 1, pp. 5-12, (1998)

[7] Oliver, R., Omari. A. & Herrington. J, "Exploring Student Interactions in Collaborative World Wide Web Computer-Based Learning Environment", Journal of Educational Multimedia and Hypermedia, Vol. 7, No. 2/3, pp. 263-287, (1998).

[8] Sharan, S, "Cooperative learning in small groups: Recent methods and effects on achievement, attitude, and ethnic relations", Review of Education Research, (1980).

[9] Slavin, R., "Research in cooperative learning and achievement: What we know, what we need to know", Contemporary Educational Psychology, Vol. 21, pp. 43-69, (1996).

[10] Slavin, R. E., "Cooperative learning", NY: Longman, (1983).

[11] Slavin, R. E., "Cooperative learning: Theory, research, and practice", NJ: Prentice Hall. (1990).

[12] Tyan, N. N. & Hong, M. F., "Computer-Mediated Communication and Collaborative Learning in Higher Education", Journal of National Taipei Teachers College, Vol. 11, pp.1-22. (1998).

[13] Wang, C. H., "Cooperative learning", The Educator, Vol. 364, pp.34-38, (1997).

[14] Wang, W. C., "Cooperative learning in Mathematics", Friends of Elementary Education, Vol. 49, No. 4, pp.17-23, (1998).

A Distributed Backbone System for Community-Based Collaborative Virtual Universities

Qun Jin *, Jingde Cheng **, Hiroaki Ogata * and Yoneo Yano *****
** School of Computer Science and Engineering, University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan E-mail: jinqun@u-aizu.ac.jp*
*** Department of Information and Computer Sciences, Saitama University, Urawa, 338-8570 Japan E-mail: cheng@ics.saitama-u.ac.jp*
**** Department of Information Science and Intelligent Systems, Tokushima University, Tokushima, 770-8506 Japan E-mail: {ogata, yano}@is.tokushima-u.ac.jp*

In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge

delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

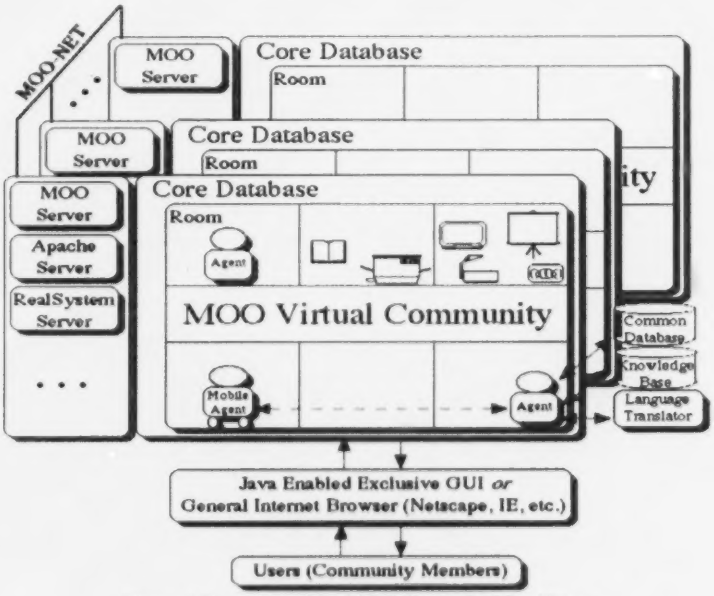


Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by "*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a

special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

Acknowledgments

This work has been partly supported by 1998--1999 and 2000-2002 Japanese Ministry of Education Grant-in-Aid for Scientific Research Contract Nos. 10780195 and 12558012, 1999 HITOCC Research Grant No. 99-12, 1999 University of Aizu Research Grants Nos. R-9-1, P-17 and P-22, and 2000 University of Aizu Research Grants Nos. R-9-2, P-9 and G-25. The authors wish to express their gratitude.

References

[1] R. Chellappa, A. Barua and A.B. Whinston, "An Electronic Infrastructure for a Virtual University," Commun. ACM, Vol.40, No.9, 1997, pp.56-58, (1997).

[2] L. Harasim, "A Framework for Online Learning: The Virtual-U," IEEE Computer, Vol.32, No.9, pp.44-49, (1999).

[3] P. Wallace, The Psychology of the Internet, Cambridge University Press, (1999).

[4] L. Lau, Distance Learning Technologies: Issues, Trends and Opportunities, Idea Group Publishing, (2000).

[5] Q. Jin and Y. Yano, "Design Issues and Experiences from Having Lessons in Text-Based Social Virtual Environments," Proc. IEEE/SMC'97, pp.1418-1423, (1997).

[6] Q. Jin, "A Framework for Community-Based Collaborative Virtual Universities," Proc. ICCE'99 Tutorial and Workshop, pp.70-74, (1999).

[7] Q. Jin, "Collaborative Virtual Environments for Information Exchange and Knowledge Organization," Journal of Three Dimensional Images, Vol.13, No.3, pp.54-58, (1999).

[8] P. Curtis, LambdaMOO Programmer's Manual, Version 1.8.0p5, 1996.

[9] A. Wilson, MOO-net Overview, available at URL http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/overview.html (accessed on August 15, 2000).

A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community

Brian Hudson*, Ahmed El-Gamal, Amal Gouda**, Eric Knutsen***, Merja Ruotsalainen****, Antti Peltonen****, Minna Pesonen**** and Tarja Te rvola******

**Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria*

***Pedagogy and New Technologies Research Group, School of Education, Sheffield Hallam University, Sheffield S10 2BP, United Kingdom*

B.G.Hudson@shu.ac.uk

a.e.gamal@shu.ac.uk

a.gouda@shu.ac.uk

****Hope Valley Community College, Hope Valley, Derbyshire S33 6SD, United Kingdom*

knutsen@dircon.co.uk

*****Research Unit for Educational Technology, P.O.Box 2000 90014 University of Oulu, Finland*

Merja.ruotsalainen@oulu.fi

antti.peltonen@oulu.fi

mpesonen@oulu.fi

ttervola@ktk.oulu.fi

This paper outlines the background to the development of a European Masters programme in *Multimedia Education and Consultancy*. The development arises from an Advanced Curriculum Development (CDA) Project supported by the European Commission under the SOCRATES programme, which involves nine institutions in seven different European countries. The aims and outline of the Masters programme are described together with the pedagogical approach adopted. A key feature of the latter is a virtual learning environment that is underpinned by the use of the concept of "metaphor". This is intended to convey how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users. A pilot unit/module on *ICT in Open Learning Environments* is outlined together with some of the key features of the learning environment. This was trialled by a group of students based at locations in Finland, Austria, the Netherlands and the UK during the second semester of the academic year 1999-00. Evaluations are provided by a participating tutor, an observer and from two participating students. Finally some reflections are outlined which focus on the innovative aspects of this learning environment and of our experiences as teachers and learners in a multinational virtual learning community.

Keywords: **Collaborative Learning - Web-Based Learning - Networked Social Learning - Teaching and Learning Processes**

1 Introduction

This paper reports on experiences as teachers and learners in a multinational virtual learning community, which have resulted from our involvement in a pilot unit as part of the development of a European Masters

course. The pilot unit is entitled *ICT in Open Learning Environments* and our involvement has taken place between February and May 2000.

2 Background to the development

The background to the development is the Advanced Curriculum Development (CDA) Project *TRIPLE M: Masters in MultiMedia Education and Consulting* that is supported by the European Commission under the SOCRATES programme (29268-IC-2-97-1-AT-ERASMUS-CDA-1) over the period 1998 to 2001. The *TRIPLE M* project is co-ordinated by Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria and involves a number of departments and research units with experience and expertise in teacher education and the use of Information and Communication Technology (ICT). The current participating institutions in the *TRIPLE M* project are:

- Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria (Co-ordinating institution)
- Charles University, Prague, Czech Republic
- Hogeschool Arnhem and Nijmegen, Netherlands
- Liverpool Hope University College, United Kingdom
- Pädagogische Akademie Vienna, Austria
- Sheffield Hallam University, United Kingdom
- Umeå University, Sweden
- University of Oulu, Finland
- University of Santiago de Compostela, Spain

A sub-group of the TRIPLE M Consortium has formed the *European Association for Multimedia Education and Consultancy*™ (*EAMEC*™) with the intention of offering a validated Masters programme in for *Multimedia Education and Consultancy* from September 2000. Initially this will be offered as a part-time route with a plan to run the programme on a full-time basis from September 2001.

3 Programme aims and outline

The academic aims of the programme have been developed in response to the needs of the 'Information Society' phenomenon related to the rapid development of high technology use in all sectors of society. The programme aims to meet the needs of teachers in schools and further and higher education especially. Specifically the programme seeks to develop the profile of the 'problem solver'/team co-ordinator at the interface of pedagogical, technological and organisational/cultural dimensions of development. In summary the programme aims to support the development of individuals who are able to:

- demonstrate and communicate knowledge and critical understanding of pedagogical issues as applied to the use of multimedia in new learning environments
- critically understand the social, organisational and cross-cultural phenomena related to new learning environments in trans-national and cross-cultural contexts
- appreciate and be responsive to the social and cultural impact of the Information Society in relation to values and working practices
- act as effective mediators and facilitators at the interface between the needs of users and providers
- co-ordinate the efforts of multi-disciplinary teams in terms of problem analysis, design and implementation issues
- be aware of the staff development needs of new users and appreciate the support structures and strategies for continuing development
- demonstrate a critical understanding of (educational) research and its role in a context of rapid change
- remain open to critiques of the Information Society with particular regard to the social and cultural implications

The programme is made up of six units/modules that together make up 90 European Credits (ECTS). These are as follows:

- Open Learning Environments (*OLE* - 10 ECTS)
- Digital Media Applications (*DMA* - 10 ECTS)
- Communication and Consultancy (*CC* - 10 ECTS)
- Research Methodolgies (*RM* - 10 ECTS)

- Project Studies (*PS* - 20 ECTS)
- Dissertation (*DS* - 30 ECTS)

The four more structured units (OLE, DMA, CC and RM) all follow a common pattern of:

- Telematic-based Studies (50%) e.g. Web-based work and discussions, multi-point videoconferencing sessions, and
- Local and Independent Studies (50%) in national groups e.g. day workshops and tutorials plus independent study.

4 Pedagogical approach

The pedagogical approach involves Telematic-based Studies in Web-based work, discussions and multi-point videoconferencing sessions in multinational learning communities. It is seen as crucial that these studies are supported by Local Studies - in national groups e.g. day workshops, practical activity, project work, research activity and tutorials and Independent Studies including literature reviews, independent project work, research activity, writing etc.

The use of ICT as a medium for learning and communication is fundamental to the underpinning philosophy of the programme and is an integrated and all pervasive aspect of the pedagogical approach, both in terms of learning about it and as an essential part of the learning process. Students need to use the Internet as an essential part of the learning and communication process.

The platform for the net-based learning environment is *LC Profiler – Learning Community Profiler*. This is the product of *LCProf Oy*, which is a Learning Service Provider (LSP) and a 'spin-off' company of the University of Oulu. The services are based on the methodology and system developed at the University of Oulu in a range of domestic and EU R&D and education projects during the last 5 years (e.g. Telematics projects T3: Telematics for Teacher Training, SCHEMA: Social Cohesion through Higher Education in Marginal Areas). The implementation of the system is based on the principle of creating a distributed community of learners and supporting the tutors to enable them to create their own learning communities. This means that the tutors also belong to a unique learning community of their own, which aims to support ongoing professional development.

5 The role of metaphor

The concept of metaphor plays a fundamental part in the underlying design of the *LC Profiler* environment and also in signifying key functions to the user. In their paper Pulkinnen and Peltonen [1] use the concept of "metaphor" to "explain how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users". This paper is also one of the Core Readings for all students on the OLE unit/module. Their analysis combines ideas about knowledge, the structure of knowledge and learning with social aspects to do with the organisation of learning such as practical arrangements connected with "time, place and repetitive rituals". Their overall metaphor which captures the nature of the *LC Profiler* environment is of "a place of studying (virtual space) created with the help of ICT". The three "cornerstones" of their analysis of the learning environment are the individual whether as teacher or learner, the technology and the culture as fully outlined in Pulkkinen and Ruotsalainen [2]. They describe these as providing the "cross-disciplinary basis for the elements that are necessary for learning" and identify these elements as pedagogical functions, appropriate technologies, and the social organisation of education

6 The pilot unit/module

As part of the curriculum development process, two units have been piloted during the period from February to May 2000. These are *ICT in Open Learning Environments* (February to May) and *Digital Media Applications* (March to May). The former is based on an existing unit/module at the University of Oulu and forms the model for the development of the Masters programme as a whole. The full unit/module is worth 10 ECTS M Level credits for which 5 ECTS is available for successful completion of the telematics-based component. This was trialled as part of the TRIPLE M project with a group of about 25 Finnish, 9 Austrian, 4 Dutch and 2 UK students

The course outline is seen as one of the most important navigation tools, referred to as an "orientation metaphor". The introductory screen is shown below in Fig 1.

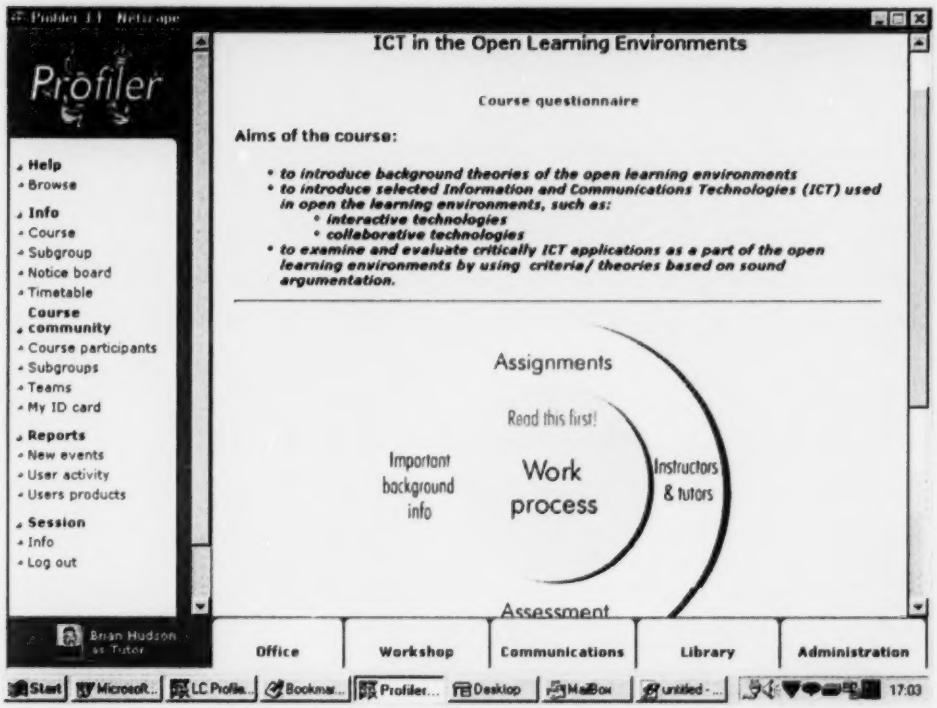


Figure 1

This screen includes a statement of the aims of the course and also conveys some of the metaphors that underpin the design of the system. (NB The use of the term "course" here is equivalent to the terms "unit/module" used previously and is a reflection of the diversity of the use of these descriptors across and within different systems) The most apparent metaphors are those which are to do with orientation to place or virtual working place. The Project Office, Workshop, Communications Centre, Library and Administration Centre refer to "working" and not to the technology and tools being used e.g. e-mail, chat, documents etc. This aspect is seen to be a particularly important issue in relation to signifying metaphors to users that refer to pedagogical practices. The metaphor of "project" is used to convey "the basic essence of learning" and the course flow orientates the user to time. This includes phases on the work process e.g. orientation, planning etc and also milestones, which are outlined in part in Figure 2.

BEST COPY AVAILABLE

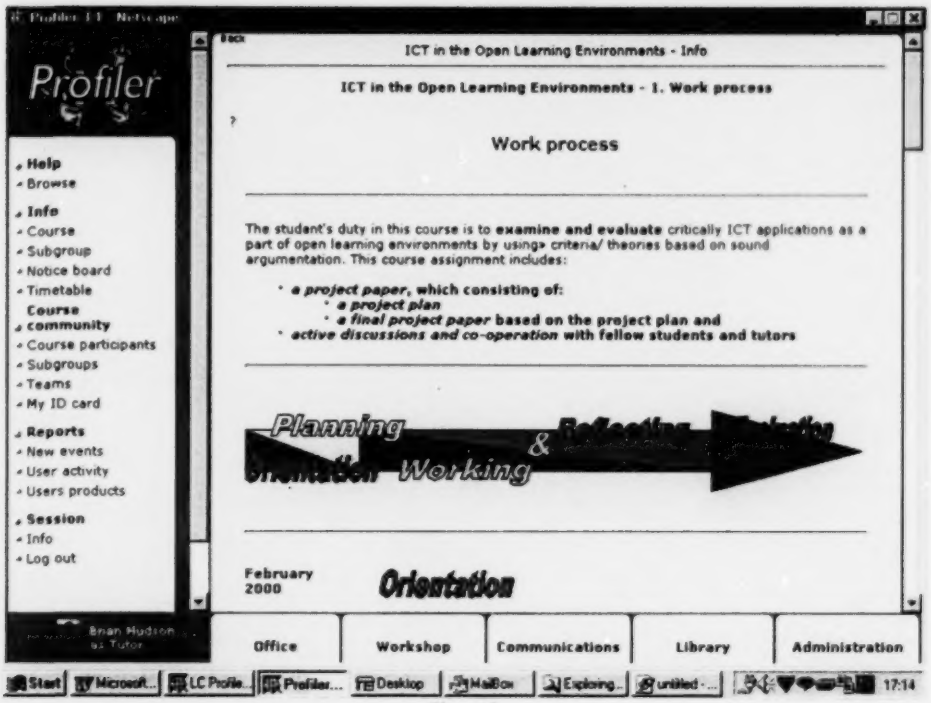


Figure 2

7 Experiences as teachers and learners

This section includes accounts and evaluations from a participating tutor (Brian Hudson), an observer (Ahmed El-Gamal) and from two participating students (Eric Knutsen and Amal Gouda).

As a particpating tutor I was immediately struck by the very clear sense of purpose that the course outline engendered with a very clear sense of the different phases, milestones and overall timescale. The active participation in discussions was not an option but a necessary requirement with comments being expected within fixed timescales and core readings, project plans of peers etc. As a result the level of communication on the course was very high - an analogy might be made with lighting a wood and coal fire - a little slow at the start but then bursting into flames from all sides!

Another key observation was of the role of the two main moderating tutors. Both could be characterised as being "on task" throughout the course of the unit/module. In general their responses to questions were very swift and they dealt with technical, pedagogical and social issues. The two tutors also interacted with each other in a very effective way by following up on each others comments, questions and prompts - so engendering a relaxed yet lively ambience around the discussions.

An example of the extent of the student discussions can be gleaned from the screen in Figure 3 below:

BEST COPY AVAILABLE

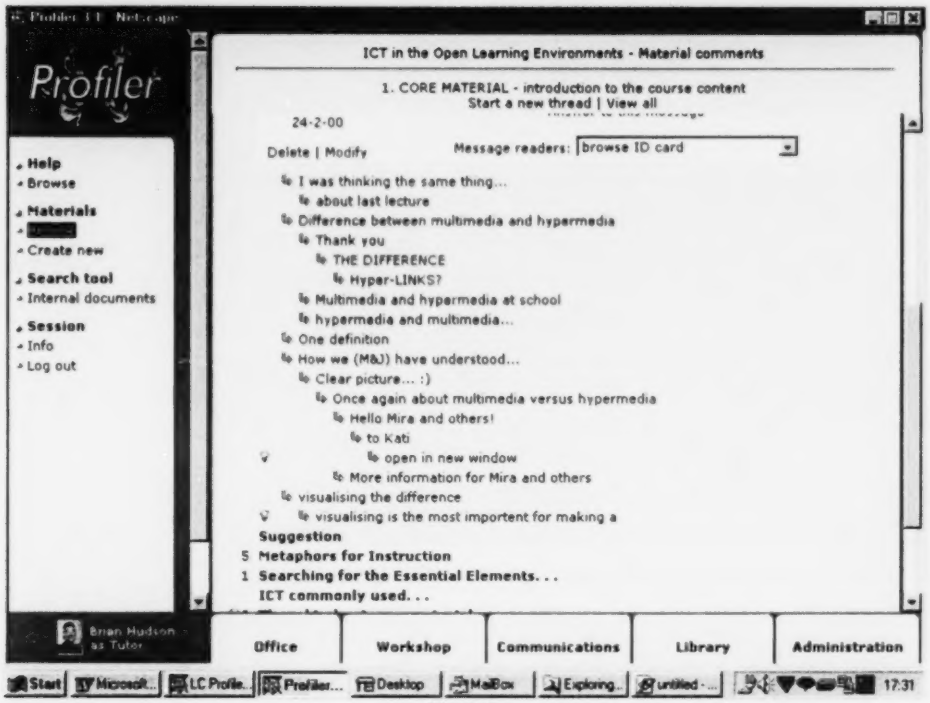


Figure 3

The particular thread started outlined above was started by student H on 24-02-00 with the comment:

Could some of you tell me what is the difference between multi- and hypermedia? Is there any difference, do they mean the same thing? The difference between these "words" was explained in the first core text but I just couldn't find the basic idea which might help to separate them.

These questions resulted in a rich, intense and well-informed discussion with around twenty contributions over a ten-day period, which seemed to conclude in an agreed consensus. Overall discussions were by no means restricted to technical matters but this particular thread was notable for its richness and intensity. A notable feature of this environment is the very clear way in which the threads are laid out and also the way in which the links are revealed when a thread such as the one above is opened.

Ahmed El-Gamal had the role of being a Local Tutor and was given access to *LC Profiler* as an observer. He is a staff member of Menofia University in Egypt on a PhD scholarship supported by the Egyptian Ministry of Education and Culture. He has chosen to cluster his comments around characteristics that he noticed about the learning environment in overall terms. This is a summary of his comments on these charactersitics:

Organization: The whole unit is well organized e.g. timetable, assignments, activities..etc. If there is any misunderstanding the student can post a question to the others.

Adaptability:Most of students adapted easily with this learning environment. Sometimes they have some technical problems e.g. the speed and the difficulty in using some tools, but they soon found assistace from the tutors and their peers.
Flexibility:It is a very flexible learning environment - students worked at different times in different countries, yet they have the opportunity to discuss the same topics.
Some students from different countries were able to create teams to conduct the same project.

Collaboration: Students collaborated with each other in solving some technical problems, clarifying some aspects in the references, developing teams and developing their project plans.

BEST COPY AVAILABLE

Conversation and discussion: Students were discussing different issues that were relevant to the course. All the participants have the opportunity to contribute to the discussion. They wouldn't end the discussion until they reached an agreement about the topic e.g. the discussion about the difference between Multimedia and Hypermedia was about 20 comments.

Social interactivity: Most of students have some social interactivity, by talking to the other students in the on-line café and by posting messages. Some friendships have been developed during the course.

Amal Gouda has studied to Diploma level in Educational Technology at Cairo University and is continuing her Masters studies at this time. She has chosen to group her evaluation around features of the studying process:

The studying process in OLE could be defined as an integrated process, which integrates the different resources and the different parts of the OLE to achieve the desired goals. The studying process in OLE is accomplished through the following parts:

Office: Every student can manage almost all his/her study through using the office and all the information about the course and other students are available on the office, in addition to the timetable and the framework of the course.

Workshop: Every student has developed his/her project plan and he/she has published it to the other course participants. This gave his/her opportunity to have the other students comments on it.

Communications: It gave the international students the opportunity to freely discuss different topics related to the course. It also allows them to discuss their project plans and the other students' project plans. Moreover, there are different categories for discussion e.g. questions and urgent message, general discussion about the study process..etc. In online café, the students can have a social chat with their peers.

Library: It has most of references that are related to the course, also it has a hyperlinks to enable students from browsing more materials. It was advised to write comments on these materials, in order to encourage the students to read them carefully.

Local studies: Every student met with his/her tutor many times to discuss the different topics and activities that seem to be unclear and to guide him/her through the course. The most important feature in the studying process in OLE is that it gave the opportunity to study and discuss different topics at any time during the day.

Eric Knutsen works in a secondary school and is in his first year of teaching as a teacher of ICT. He has chosen to respond to the aims of the course and to evaluate the extent to which these were met for him as a student:

- to introduce background theories of the open learning environments

This was done in a straightforward manner utilising the OLE of LC Profiler. It was useable as one would use a library in the traditional environment of a physical learning environment. The added value here was the amount of material referenced via the web. Using the expertise of the instructors on the course, I was able to make use of the varied written material and discuss other students' and my own opinions on the content. Being done in an asynchronous way, there was no need to be present physically or virtually for such discussion. Yet, I had the advantage of dozens of other opinions from which to draw my own conclusions. This took my learning beyond that previously possible via ...traditional learning ...

- to introduce selected (ICT) Information and Communications Technologies used in open learning environments, such as interactive technologies and collaborative technologies

One aspect of having been introduced to the background theory in the way it was done is the ability to review tens of project proposals and final project papers in light of the theory examined. This made the theoretical come to life, especially when undertaking my own individual work. This meant looking critically at the variety of components comprised with-in the environment being examined ...What made this a more lively introduction to the ICT was the regular use of LC Profiler and the success of the discussions taking place.

- to examine and evaluate critically ICT applications as a part of the open learning environments by using criteria/ theories based on sound argumentation

Given the foundation above ... it was straightforward to see the relevance of the theory when examining the OLE at hand. Especially of interest was the use made of LC Profiler as an OLE by all members of the course and the social interaction made possible by all areas of LC Profiler, not isolated to the on-line cafe. This even fed the theoretical side to my thoughts about my assignment.

8 Conclusions

The experience of participating in this pilot unit has provided a real example of the transformative potential of the use of ICT. This is in spite of several years experience of using the *First Class* conferencing software which seems quite limited by comparison with *LC Profiler*. In McConnell's [3] terms *First Class* can be seen to be simply an example of "unstructured groupware" or an "electronic space". Some experiences result in real and lasting changes - for myself this experience has transformed my own pedagogical thinking and practice. Whilst being a vital component, the learning environment of itself is not the main ingredient for experiencing this transformation, although many people at this time are looking for the "quick fix" and simple solutions. However it has been the experience as a participant in a community of practice (Hudson [4]; Lave, [5] and Lave and Wenger, [6]) that has been fundamental. This process takes time and is about changes within (the person) and developing new ways of relating to other people. In general terms such high levels of on-line communication also necessitate the need to develop a more relaxed attitude towards committing ideas into print, for seeing such comments as transient and not permanent and being accepting of the need for "repairs" to communication as one would in more traditional forms of communication.

References

[1] Pulkkinen, J. and Peltonen, A. (1998) Searching for the essential elements of Web based learning environments, *3rd International Open Learning Conference*, 2-4 December 1998, Brisbane, Queensland, Australia.

[2] Pulkkinen, J. and Ruotsalainen, M. (1998) Evaluation study of a telematic course for technology teachers (T3 Project). Paper to the *Teleteaching' 98 Conference of the 15th IFIP World Computer Congress*, 31 August - 4 September 1998, Vienna and Budapest.

[3] McConnell, D.: 1994, *Implementing Computer Supported Co-operative Learning*, Kogan Page, p37.

[4] Hudson, B. (1999) A social perspective on teaching and learning in the context of Computer Mediated Communication in teacher education, *Journal of Information Technology in Teacher Education*, 8, 2 (In press)

[5] Lave, J.:1996, Teaching, as learning, in practice, *Mind, Culture and Activity*, 3, 3, 149-164.

[6] Lave, J. and Wenger, E.: 1991, *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press.

A Flexible Transaction Model for Virtual School Environments

Woochun Jun*, Sukki Hong**
**Dept. of Computer Education*
Seoul National University of Education
Seoul, Korea
E-mail: wocjun@ns.seoul-e.ac.kr
***Dept. of Business Administration*
Konkuk University
Chungju, Korea
E-mail: skhong01@kku.edu

Recent advances in Internet technologies have led to the advent of virtual schools. However, existing technologies have many limitations when applied to virtual school implementation. Especially, existing transaction models are not suitable for supporting virtual schools. In this paper, we present a new transaction model in order to support virtual school environments. First, we introduce the general characteristics of the virtual school environments. Then, we discuss transaction model requirements for virtual schools. Based on those requirements, we propose a new transaction model. We also show a locking-based concurrency control scheme for supporting collaboration works among students. Finally, we give conclusions and future research issues.

Keywords: **Collaborative Learning, Virtual School**

1 Introduction

Recently interests in virtual schools have been increasing due to advances in Internet technologies. The virtual school, which is based on distance learning, can overcome time and space limitations in the traditional schools. But, in order to complement lack of face-to-face communication in virtual schools, multimedia-based education is becoming popular. This multimedia-based education emphasizes the students' self-control. That is, multimedia- based education encourages interactions between teachers and students and also interactions among students. In the meanwhile, object-oriented databases become popular for supporting multimedia resources.

In the literature, many transaction models have been proposed for object-oriented database environments [5,7,8]. But, those transaction models have not reflected requirements in virtual schools. In this work, we propose a new transaction model that supports virtual school environments. The proposed model considers all those requirements.

This paper is organized as follows. In section 2, we discuss the transaction requirements in virtual school environments. Based on the discussion, we propose a new transaction model in Section 3. In Section 4, we present a locking-based concurrency control technique based on our model. Finally, we give conclusions and future research issues.

2 Transaction Requirements in Virtual School Environments

In this section we discuss transaction requirements in virtual school environments.

First of all, all transactions should maintain the correctness of database. One of the characteristics of database systems is manipulation of shared data. In this case, concurrency control technique is required to

synchronize accesses to the database so that the consistency of the database should be maintained. Concurrency control technique requires an application-dependent correctness criterion to maintain database consistency while transactions are running concurrently. Serializability is a widely used correctness criterion [1,6]. But, serializability is too harsh for most applications so that we need user-defined correctness criteria, which is less restrictive than serializability.

Second, the length of transactions must be flexible. Usually, transaction length in virtual school environment is long since transactions are navigating on various multimedia information in database systems [2]. For long transaction case, the following problems might occur. That is, if locking-based concurrency control is adopted, long transaction blocks other transactions to run concurrently due to conflicting access. This will, in turn, degrade overall performance. Also, if a long transaction is aborted during its execution, it may waste execution time and resources it used.

Third, in virtual school environments, students' behavior is unpredictable. That is, since they are working in on-line way, it is hard to predict what kinds of actions they might take. Thus, they must be given some kind of self-controls.

Fourth, the transaction model reflects interactivity. Especially, it must support collaborative works between students and teacher or among students. Those collaborative works require common data to be shared among users in order to achieve common goal. In some cases, unlike traditional transaction model, uncommitted result by one student may be open to other students.

Finally, transaction model may need to support parallelism in order to reduce overall transaction response time. Especially, the parallelism can be used in object-oriented databases as follows. In object-oriented database, objects are accessed by means of methods. A method is nothing but a procedure to read or update attributes in objects. Two methods can run concurrently if they access different attributes in an object. Thus, transaction response time can be reduced by adopting parallelism.

3 The Proposed Transaction Model

Our transaction model reflects all requirements of transaction in virtual school environments as discussed in Section 2.

Our model is based on both Split/Join transaction model [4,9] and nested transaction model [7]. But, none of them support all those requirements of transactions in virtual school environments. Our model is to combine these two models. Our model also extends the previous model [3] so that we achieve higher parallelism as below.

The Split/Join transaction is summarized as follows. The Split/Join transaction is to restructure in-progress transaction dynamically so that it supports efficient resource management as follows. The Split transaction can be divided into two serializable transactions during its execution. In this case, two divided transactions can proceed independently with their own resources. Thus, the Split transaction model provides flexibility in resource management so that it can overcome the disadvantage of long transaction. On the other hand, the Join transaction can merge two on-going serializable transactions into one transaction. In this case, the transaction model is used to combine collaborating works into one in virtual school environments.

The nested transaction model is summarized as follows. A nested transaction consists of concurrently executable top-level transactions. In turn, a top-level transaction consists of one or more steps. Each step is either atomic operation or subtransaction. This subtransaction can run concurrently with top-level transactions or other subtransactions. In the meanwhile, a subtransaction can invoke another subtransaction. Thus, unlike flat transaction model, nested transaction model can exploit internal parallelism.

The basic structure of the proposed transaction model is shown in Fig. 1.

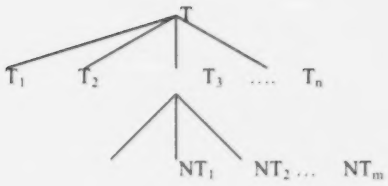


Fig. 1. The transaction model

T represents global transaction, which can be merged or split in various form during its execution. Also, depending on its nature, it can be committed without any restructuring. T_1, T_2, ,,,,T_n represent subtransaction or merged or split transaction. Also, NT_1, NT_2,,,NT_n represent subtransactions started by a nested transaction. In our model, we adopt open nested transaction [8]. In open nested environment, intermediate results of a subtransaction can be seen by other subtransaction as well as top-level transactions. This will increase parallelism further.

4 The Proposed Concurrency Control Technique

In this Section, we present a concurrency control technique based on our model. The proposed model is based on locking-based scheme. Our aim is to let two conflicting transactions go to negotiation stage if the lock requesting transaction requests a conflicting lock on a data item with a lock held by other transaction. In that case, the lock holding transaction and the lock requesting transaction can negotiate for conflicting lock types. If negotiation is successful by those two transactions, the lock requesting transaction can get a lock successfully and access the data. Otherwise, the lock request is blocked until the lock holding transaction release its locks. By doing so, the parallelism can be maximized among collaborating users. Assume that a transaction requests lock (L_R) on a data item already locked by other transaction with lock type (L_H), the following algorithm can be applied.

If L_R and L_H are compatible then grant L_R
    Else negotiate between lock requester and lock holder;
        If negotiation is successful then grant the lock
            Else block the lock request;

5 Conclusions and Future Works

In this paper, we first introduce the general characteristics for virtual schools. Then, we present all possible requirements for transactions in virtual school environments. Those requirements are user-defined correctness, flexible transaction length, the unpredictability, interactivity and internal parallelism. Based on those requirements, we propose a transaction model and a locking based concurrency control technique.

The immediate research issue is to apply real-time concept in transaction management. In that case, each transaction must have real-time deadline. Since all transactions are on-line based in virtual school environments, the transaction response time is very critical. Thus, we will develop the real-time priority assignment scheme and real-time transaction processing scheme for virtual school environments.

References

[1]Eswaran, K. P., et al, "The Notions of Consistency and Predicate Locks in a Database System", Communications of the ACM, Vol. 19, No. 11, pp. 255-265, (1976).

[2]Finkelstein, R., "The Jasmine Object- Oriented Database Solution for Online Interactive Transaction Processing (OLIP) and Electronic Commerce, Jasmine White paper , (1998).

[3]Jun, W. C. and Hong, S. K, "A Transaction model that Supports Virtual Universities", The Journal of Korean Association of Information Education, Vol. 2, No. 2, Nov. pp. 174 – 182, (1998).

[4]Kaiser, G. E. & Pu, C., "Dynamic Restructuring of Transactions", in Chapter 8, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California. pp. 265 - 295, (1992)

[5]Khoshafian, S., Dasananda, S. & Minassian, N., "The Jasmine Object Database", USA: Morgan Kaufmann Publishers, (1999).

[6]Korth, H. F. & Silberschartz, A., "Database System Concepts", Singapore: McGraw Hill, 2nd Edition, (1991).

[7] Moss, J. E. B., "Nested Transactions: An Approach to Reliable Distributed Computing", Cambridge, Mass.: MIT Press, (1985).

[8] Muth, P., et al., "A Transaction Model for an Open Publication Environment", in Chapter 6, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California., pp. 159 – 218, (1992).

[9]Pu, C., Kaiser, G. E., & Hutchinson, N., "Split-transaction for Open-ended Activities", Proceedings of the 14th Very Large Data Bases Conference, Los Angeles, California, USA, pp. 26- 37, (1988).

A study of collaborative teaching for creative learning in an engineering class

Jiunn-Chi Wu[*], Pei-Fen Chang[**], Shu-San Hsiau[***] and Tse-Liang Yeh[****]
Dept. of Mechanical Eng., National Central University, Chung-Li, Taiwan
[*]Tel: +886-3-4267335, junwu@cc.ncu.edu.tw
[***]Tel: +886-3-4267341, sshsiau@cc.ncu.edu.tw
[****]Tel: +886-3-4267339, tlyeh@cc.ncu.edu.tw
[**]Center for Teacher Education Program, National Central University, Chung-Li, Taiwan
[**]Tel: +886-3-4227151~3853, pfchang@cc.ncu.edu.tw

We synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of creativity knowledge and skill via web courseware. This paper discusses three main themes of creative learning: 1) the effectiveness of collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via creativity contest and design project. Several findings were observed based on qualitative evaluation of this class. First, the most rewarding course topics identified by the students is the creativity contest and design project because it provides ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, adapting dissimilar teaching style of our collaborative teaching generated anxiety to a number of students, which suggest the structure and sequence of the course development are need to be modified in order to fit students' level of capacity and readiness. Finally, we have demonstrated how problem solving and engineering design procedures can be closely integrated and taught, and what are the necessary knowledge and skills to enhance students' ability to become creative as well as effective problem solvers.

Keywords: **Collaborative teaching, Creative learning, Web-based learning**

1 Introduction

Creativity is inherent and a native intelligence. Many studies, show that the creative cognition can be trained and learned [1, 2]. Therefore, proper education and nourishing environment can foster creativity. *Creative problem solving* (CPS) is referring to use creativity or creative thinking for problem solving, which is a learning model being actively studied [3, 4]. It helps student use systematic method to solve a complex and realistic problem, possibly with multiple solutions. Students brainstorm to generate all possible solutions, categorize and evaluate solutions, develop implementation plan, and finally execute the plan [3]. CPS emphasizes the practice of creative thinking, implementation of creativity, and stresses on the creative leaning process. It can be regarded as a learning model for knowledge synthesis.

It is our responsibility and challenge as teachers to educate student who will be able to succeed in the high-tech environment. To educate students to cope with the rapidly changing world, they must not only to actively acquiring new knowledge, but also to have the skill of creative problem solving. In reflecting such responsibility and challenge, the course of "*Open-ended Creative Mechanical Engineering Design*" was offered in Department of Mechanical Engineering, National Central University for the last three years. The spirit of this course is asking students use their creativity to work as industrial engineers, form several mission-oriented teams, communicate and cooperate with other people, and deal with real industrial open-ended problems.

We wish to demonstrate how problem solving and engineering design procedures can be closely integrated and taught and what are the necessary knowledge and skills to enhance students' ability to become creative

as well as effective problem solvers. Hence, we synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of CPS knowledge and skill via web-based courseware. An integrated web-courseware [5] is constructed for above purposes. In the following sections, four main themes in our study will be introduced: 1) the collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via contest and design project.

2 Collaborative teaching and course modules

2.1 Collaborative teaching

Based on the experiences for the past three years, we perceive the need for professionals from other disciplines to stress the importance of communication as well as teamwork skills for engineering students. More importantly, a scientific evaluation of the course and its effects on the students' learning of creativity must be done in cooperating pedagogical experts with engineering ones. The analysis of student outcomes can give information about the success of the innovative course in achieving our objectives.

But the question is: how can professors with engineering background to integrate their technical knowledge with an educational-oriented perspective? Engineering faculties may understand the cognitive and emotional conflict that students encounter, but couldn't verify their teaching approaches in order to take into account students' different learning styles. Besides, an engineering course taught by faculty of non-engineering background face a challenge of given students the new perspectives without accommodating the technology orientation of engineering students.

With above forethought, we propose and implement the collaborative teaching from four professors of interdisciplinary backgrounds: thermal/fluid sciences, mechatronics, education, and network-based learning. Collaborative teaching is a novel teaching approach, it allow teacher deliver lecture in a more efficient way and share mutual teaching experience, improve teaching deficiency, and understand learning difficulty of students. In devising the design-oriented courseware, besides compose the materials for hands-on creativity project, we also strengthen educational idea of cognitive psychology, learning strategy and learning evaluation. Such collaborative teaching team up with the expertise of education and engineering is hoping to build a nourishing environment for rising student's learning motivation, encouraging student to develop mature, diversified cognition and thinking, and then be able to perform higher level of creative thinking.

2.2 Course modules

The contents and modules (see Table 1) are designed to develop competence in mechanical engineering, creativity, and teamwork. Five major units are emphasized: 1) Introduction of creativity, 2) Basic principles of CPS process, 3) Hands-on learning activities to inspire creativity, 4) Engineering design process, 5) Creativity contest and design project. In the first one-third activities is centred on the development and inspiration of creativity and creativity education, and the next one-third of the units enable students to practice the creative mechanical engineering design. The last one-third of the activities finishes the implementation of creativity phase so as to show off student's imagination with the creativity contest and design project.

We use creativity contest and design project as a tool to enhance creative learning of students. One creativity contest is hold in every semester in order to incubate students' learning interest. It is all up to students to decide the material, procedures, requirements, and rules for the creativity contest with teacher's facilitation in order to develop the environment of freedom.

The design project could relate basic principles and concepts to real problems and to improve students' understanding, motivation and creativity [6]. Implementing a project is a way to encourage students to look deeply and laterally at individual topics and consider how they can be applied to real situation. They motivate students to confront both familiar and unfamiliar situations with confidence, providing a sense of achievement and satisfaction. Each team member is expected to be aware of the specific skills of others in order to achieve effective and collaborative working relationships. More importantly, each member needs to take other people's views into account.

3 Tools for fostering creative learning

We construct three tools to assist the creative learning process: 1) the creative activity board, 2) the search engine, 3) the engineering courseware of domain knowledge.

The creative activity board, which is a web-BBS, is employed as the main interface for creative activity. Students are encouraged to actively utilize their own web-BBS for discussing their design projects with teachers and with classmates. They can announce important messages (e.g., resource acquiring) and post their current executing status of their project. More importantly, this board can be used to share their ideas and problem-solving approaches at any times with anyone who is interested in the topic. For convenient discussion of the creative ideas via network, particularly in the format hand-made sketches or the design charts, a FTP (download/upload) function is added in this board. Every user can participate the creative activity through web. The evolution and implementation of creativity can be recorded and exhibited. Properly application of this board can encourage students' morale for continually performing their design projects.

Students may encounter many problems when they execute the design project. The related information may be found in the courseware of domain knowledge or discussed in the creative activity board. Through the search engine, students can find useful knowledge and retrieve information from the integrated courseware more effectively by using appropriate keywords.

The creative activity cannot be successful without domain knowledge as its foundation [7]. When students are working on their team design projects, they need to integrate their domain knowledge based on the previous courses. There are four course modules materials are integrated: 1) Machine Design Course, 2) Electric Circuits and Electronics with Laboratory, 3) Innovative Application of Engineering Software, 4) Creative Mechanical Design. See [8] for detail description of content of these course modules.

4 Results: interaction on the web-environment

In the beginning whether students invest themselves in the class or not, depends on the development of the feedback from teachers. We use the web-BBS as the interaction interface with the students. After each team reported their project status, we will comment their idea and improvement of design prototype. Next, their status report will be upload in the creative activity board, and allow peers to review and comment. Encourage and endorsement from peers and teachers goes to those active teams. All interactions on the web are transparent and will inspire student if teachers can give feedback just-in-time, and guide each team to post their suggestion. In this way, both students and teachers will not be trapped in the classroom, and once the obstacle is encountered, it can be posted in the web and then exchange message. The more people to view these obstacles, the more possibility for the problem can be solved. Since not only teachers can help, peers can assist too. This is what we observed in this class when student performing their design projects. Positively and timely feedback from teacher and classmates enrich the value of the board.

We made surveys based on interviews, questionnaires, and articles of creative activity board. The most rewarding course content identified by the students is the creativity contest and design project because they provide ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, others are disturbed by the open-ended nature of the course materials. They claim that it is tiresome to cope with various teaching styles of four individual teachers. The evidence from our research also suggests that students' problem solving processes were affected by their understanding of the rationale of interdisciplinary course development. Therefore, teachers need to assist students to make their own links with the material they are engaging with in order to eliminate the negative impacts of the course content. For instance, increase the teaching topics involving mechanical hands-on activities might provide students more practice and appreciate the CPS process.

The issues of students' learning difficulties are complex and dependent on several factors, including course organization and development, the subject or topic being taught, teaching style, and students' expectations [9]. Although students see the new learning experience as an opportunity to broaden their scope, some others claim that the challenge of finding a design topic themselves was beyond their ability to manage. In order to set the stage for project design, our data showed that it is crucial that team members to accommodate each other and to devote their personal commitment. It is clear from our interview that failure to do so did

influence the students' motivation to finish the project.

5 Conclusions

We have created a learning environment that facilitates students' development of problem solving abilities, enhances their confidence for cooperative creativity, and finally, provides students knowledge and skills for mechanical engineering design. The collaborative teaching is a novel experience to both of teacher and our student. Each member contributes their expertise and become the tutor to the other members. More importantly, the effort of compromising one another on the process serves as a role model for their students to work cooperatively.

The results of this study suggested significant concern for the students' anxiety created by the need to meet the special requirements of four individual teachers. It leads us to speculate whether the structure and sequence of the course development are appropriate to the students' level of capacities and readiness. Rather than viewing these problems as collection of obstacles and difficulties, we believe that we can make a difference in the learning of our students and chose to conceptualize those dilemmas and challenges in a constructive guide. Hence, we are currently adopting a new teaching approach by dividing the class into expert versus observer groups. The emphasis of the approach is to take responsibility as a learner and to develop the ability to ask questions about the projects done by other groups. We also conduct a peer-evaluation to encourage student to evaluate each other's projects critically and objectively. We wish students to believe, as we did, that creative learning is within reach of anyone who is willing to exert himself and take responsibility.

Acknowledgement

This research work is supported by the Ministry of Education of the Republic of China in Taiwan under grant: Grand Project for Excellence, 89-H-FA07-1-4.

References

[1] Bransford, J. D. and Stein, B. S., *The ideal problem solver: A guide for improving thinking, learning, and creativity* (2nd ed.), New York: W. H. Freeman and Company (1993).
[2] Chance, P., *Thinking in the classroom: A survey of programs*, New York: Teachers College Press (1986).
[3] Sternberg, R. J., & Lubart, T. I., *Defying the crowd: Cultivating creativity in a culture of conformity*, New York: Free Press (1995).
[4] Lumbsdaine, E.& Lumbsdaine, M., *Creative Problem Solving*, McGraw-Hill (1995).
[5] CEdesign, http://lisant.src.ncu.edu.tw/cedesign/ (in Chinese).
[6] Blicblau, A. S. and Steiner, J. M., "Fostering creativity through engineering projects," European Journal of Engineering Education, vol. 23, pp. 55-65 (1998).
[7] Jonassen, D. H., "Instructional design models for well-structured and ill- structured problem solving learning outcomes," Educational Technology Research & Development, vol. 45, pp. 45-94 (1997).
[8] Hsiau, S. S., Wu, J. C., Yeh, T. L. and Tsai, S J., "The web-based learning environment for creative design course," Proceeding of 2000 Internatinal Conference on Engineering Education, Taipei, Taiwan, Aug .(2000).
[9] Pirrie, A., Hamilton, S. and Wilson, A., "Multidisciplinary education: some issues and concerns," Educational Research, vol. 41, pp. 301-314 (1999).

Content Outline	Learning Activities
Orientation to creativity	1. Introduce the importance of creativity to learning
Cognitive process of creative problem solving	2. Illustrate four stages of CPS skills
Thinking styles and contexts for developing creativity	3. Demonstrate pros and cons of various thinking style
Creative personality and teamwork experience	4. Film-viewing to illustrate the characteristics of creative people 5. Interview team members and identify their personality

Principles and strategies of lateral thinking	6. Analogy 7. Simulation activities
Conventional engineering design process	8. Discuss basic rules for invention 9. Apply rules to improve the design of commercial product 10. Brainstorm potential ideas for creativity contest via web
Problem solving in electric circuits and electronics (E&E)	11. Problem solving a case to illustrate the E&E concepts relate to project design
The creativity contest (by individual)	12. Peer-evaluate and select the top three most creative rubberband-powered vehicles
Research for proposal (RFP) of creative design project (by group)	13. Develop a RFP based on all information gathered 14. Oral presentation to class

Table 1 The course modules of the *CEdesign* web-class.

A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics :Through a Practice of Three Junior High Schools

Masahiro NAGAI*, Yasuyuki OKABE, Jyunichiro NAGATA*** and Kanji AKAHORI***

**Tokyo Institute of Technology, Graduate School of Decision Science and Technology, Dept. of Human System Science 2-12-1,O-okayama,Meguroku-ku,Tokyo,152-8552,Japan Tel.+81-3-5734-3233 nagai@math.e.chiba-u.ac.jp, akahori@ak.cradle.titech.ac.jp*

***Sumiyoshi School Attached to Department of Human Development,Kobe University 5-11-1,Sumiyoshiyamate,Higashinada-ku,Kobe,658-0063,Japan Tel.+81-78-811-0232 yokabe@kobe-u.ac.jp*

****Junior High School attached to Department of Education,Chiba University 1-33,Yayoicyo,Inage-ku,Chiba,263,Japan Tel.+81-43-290-2493 nagata@jr.chiba-u.ac.jp*

The topic of Internet for educational purposes is currently hotly pursued but there are still not many observations on the effectiveness of it in school mathematics. In this paper, we discuss the findings of Web-based collaborative learning in school mathematics conducted with three junior high school in Japan, March 2000. Students performed asynchronous collaborative learning using bulletin-board type database installed in a Web server set at the Koshikawa laboratory in Chiba University. Students solved several mathematical problems presented on a Web page while discussing with other students in the database. In classes using the Internet, 3 or more methods of the problem solving emerged in the database as compared with a traditional class, and students could study many mathematical views and conceptions as a result of it. Moreover, a research of the student's opinions after the lessons indicated that students wanted to hear the other students' ideas and views and have collaborative learning, breaking down the traditional concept of the classroom wall barrier.

Keywords: **Web, Bulletin Board, Collaboration, School Mathematics**

1 The background and intention of this research

It is now believed that mathematical knowledge is created through collaborative learning, rather than something individual. This is based on social constructivism in recent years. And teachers have come to accept their new position of an advisor to the students as shown by Vygotsky's "Zone of proximal development".

Through using a distributed network such as the Internet, its very features are effectively utilized and allows the externalization of the student's knowledge. These knowledge can then be shared and this learning method is in accordance with the present idea of how learning occurs[4]. Thus, we have researched on web-based collaborative learning on school mathematics from 1998 focusing on this point[1][2]. With Web-based collaborative learning, it efficiently and effectively overcomes whatever physical differences the students may have and thus widely used for science and social studies lessons.

In mathematics, objectivity is the rule and therefore, there is no need for students to be able to express regional difference clearly and there are not many investigations into web-based collaborative learning of school mathematics. In this paper, we describe the qualities and reasons for conducting Internet based

collaborative learning of school mathematics. We also describe the results of the questionnaire distributed to the students after the lesson.

2 The method of collaborative learning

In this research, we used the "bulletin board[1]" system that can be downloaded free from the Web site. As shown in Fig.1, the discussion progresses by entering in one's idea and posing questions to the others' idea or opinion. Students build their knowledge positively and share them in this process. The discussion is displayed by a tree structure whereby a reply to a question or comment is indicated with a new line, separated from the previous note with a slight space. Each new reply is so indicated, forming a tree structure. The symbol[2] is given to each utterance so that the kind of utterance may be understood. This database was installed in the Web server "Topo" at Koshikawa laboratory, Faculty of Education, Chiba University, and linked to the web page that we refer to as "The Page of Mathematics Teaching-Materials Research[3]". Students used this system for its school mathematicsFig.3. Fig.2 shows the notes which students have entered. Students study, choosing between the two screens, i.e. Fig.1 and Fig.2.

Fig. 1

Fig. 2

3 The outline

The Web-based collaborative learning was performed as follows.

O Student participants

Nagaura Junior High School, 1st grade 2 class

Sumiyoshi Junior High School, 1st grade 3 class

Junior High School attached to Chiba University, 1st grade 3 class

O Term March 2000

O Instruction plan

Each junior high school had a 2 hours lesson.

The 1st hour …Students read the problem and produce their own ideas.
And, they enter in their questions and opinions.

The 2nd hour…Students read the others input and enter in their ideas.
And they continue the discussion.

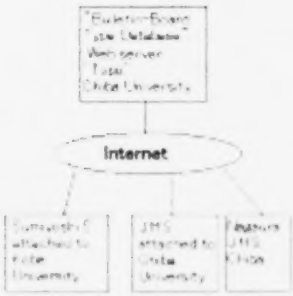


Fig. 3

3.1 Problems given to students

[1] raib-g 2.04 (wakatiai program)

[2] Question="質問"，My Theory="私　考　", etc.

[3] The author's page. http://www2.ak.cradle.titech.ac.jp/nagai/math_room/math.asp

The Grant-in-Aid for Educational Research, Chiba Prefecture(1997), and the Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science(Encouragement Research B, subject numbers 10913006,1998 and 11913005,1999) are granted to this page.

BEST COPY AVAILABLE

The two following problems were shown on the Web page at the beginning of the collaborative learning. Students solved the problem given to them with instructions from the teacher.

○**Problem1**
This year is A.D. 2000. Let's make the following formulas.
(1) The answer is set to 2000, using all the number of 1,2,3,4,～,19, and 20 at least once.
(2) Each number can be used only once.
(3) You may change the sequence of numbers.

○**Problem 2**
How to find, among a set of twelve balls, one which is lighter than any of the other equally-weighted eleven? You have only three chances to use a pair of balances. (Please also consider the reasons and enter it in.)

3.2 The student's activity

First, students read the given problem and create their questions and ideas about the problem. Next, they access the database and enter their notes. They read the others' writing, and if something attracts them, they will write a reply. The activity was performed over 2 hours and problem solving was carried out. A questionnaire shows that students participated in this collaborative learning positively. The teacher's role is only to support the computer operations of the students or problem solving when needed. In the beginning, although there were many students who took time in deciding what to enter or how to operate the database, they got used to it gradually.

4 Analysis and consideration of the collaborative learning

These were two problems and the students solved either one or the other collaboratively. Three junior high schools tackled the problem using the Web-based collaborative learning for 2 hours. Another class was asked to solve the problems not using the Web-based collaborative learning method i.e. traditional method. We describe the difference in the learning produced from the difference between these two methods of instruction. We also analyzed the results of the questionnaire.

4.1 Regarding problem 1

With problem 1, students find as many formula as they can whose answer is 2000 using all the integers from 1 to 20. In the collaborative learning using the Web, students invented 14 kinds of the following methods.

Formulas obtained from the collaboration using the Web (14 methods)

1. 20×10×5×2+(1+3-4)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
2. 20÷10×(19-9)×(18-8)×(17-7)×(16-6)÷(15-5)×(14-4)÷(13-3)×(12-2)÷(11-1)=2000
3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000
4. (3+5+7+8+11+12+13+14+15+16+17+18+19)×(6-2-4)+20×10×(9+1)=2000
5. 10×20×5×2-(9+6)+(8+7)-15÷3+(1+4)-(11+19)+(12+18)-(13+17)+(14+16)=2000
6. (19-18+17-16+15-14+13-12+11-9+8-7+6-5+4-3+2-1)×10×20=2000
7. 20×10×(1+2+3+4)+(13-6-7)×(5+8+9+11+12+14+15+16+17+18+19)=2000
8. 20×10×5×2+(4-3-1)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
9. (1+3+7+9)÷2×(20+15+5)÷4×(6+14+12+8+11+19+13+17)÷10×(18-16)=2000
10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
11. {1+2+3+4+6+7+8+9+10+11+14+16+17+18+19-(5+12+13+15)}×20=2000
12. 20×10×2×5+1×(19+17+16+7+9+3+15-4-6-8-11-12-13-14-18)=2000
13. (1+2+3+4)×10×20+5+6+7-18+8+9-17+16+13-14-15=2000
14. {(11-1)+(12-2)+(13-3)+(14-4)+(15-5)-(16-6)-(17-7)-(18-8)-(19-9)}×10×20=2000

Next, in the traditional class, only four kinds of formulas appeared.

Formulas obtained by the ordinary class (4 methods)

3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000

10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
15. (11-1)×10×20+12-2-4-6+8-3-5+16-7-9+14+15+19-13-17-18=2000
16. (2×3+4+5+6+7+8+9+10-11+12+13+14+15-16+17-18+19)×20÷1=2000

4.2 Regarding problem 2

With problem 2, students find the lighter weight out of 12, using only a pair of balances and within 3 steps. The following four methods of solving the problem appeared in the collaborative learning using the Web. The notation shows how to divide the 12 weights first. For example, "4 4 4" means to divide the 12 weights into three groups containing four weights in each group first.

◇The first division found in the collaboration using the Web class

(6 6) (4 4 4)
(3 3 3 3)(5 5 2)

◇The first division found in the traditional class

(6 6) (4 4 4)
(3 3 3 3) (5 5 2) (2 2 4 4)

As shown above, four kinds of methods appeared in the collaboration using the Web and five appeared in the traditional class.

4.3 Analysis and consideration of the data

In problem 2, the variety of methods for solving the problem did not differ much between the Web-based collaboration and the traditional class. However, in problem 1, the number of methods on collaborative learning using the Web was 3 or more times as compared with the traditional class(Exact Probability Test, $p<.05$). For mathematics problems with limited answers, there is not much difference seen between the two methods of instruction. On the contrary, for problems with many possible answer, students achieve better results when they can do the problem solving with the other students through the Web. We definitely believe that the students are able to solve problems by referring to the other student's notes. This can be seen from the student's interaction. For problem 1, five formulas generally represented as "0 × m+2000(m is an integer)" were produced in the collaborative learning using the Web. This is the formula not produced from the traditional class. We consider that the students become aware of this general formula by referring to the others formulas, and they utilize this general formula to solve the problem. Moreover, the students are also influenced by notes such as those below.

First, 20 ×(4+6) ×(19-9) etc. is calculated, and it is made 2000. Then, it will be set to 2000 if the number which remains is set to 0. Example 20 ×(4+6) ×(19-9)+(18-17+16-15+14-13+12-11+10-8-5-1) ×(2+3) =2000.

2000/03/14 Tuesday 09:25 [9]

Although the formula of this student's example lacks a necessary "7", it is considered that the explanation which means 0xm+2000 was very helpful. This can be read also in the following response to the note " ".

This is a good idea. Every number which is multiplied with 0 is 0. 2000/03/16 Thursday 11:12 [93]

Such examples show that there were some students who didn't only enter their formula, but the strategy as well, and it became a support to other students.

As mentioned above, in collaborative learning using the Web, since the others idea remains on record and can always be referred to, students could utilize this and solve the problem. Problem 1 is asking for many possible formulas whose answers are 2000. That is, we claim that collaborative learning using the Web is effective especially with problems which demand exemplification. And students were able to access many mathematical views and conceptions. This appears also in the result of the questionnaire shown as "Many students' ideas can be known. 49 persons." and "Various methods and ideas which are easy to understand can be known. 36 persons.", and it turns out that the student's incentive and understanding can be improved. These educational effects are obtained by the realization of collaborative learning using the Web, and cannot be obtained in the class which is traditional. We emphasize that the effectiveness of the collaboration using the Internet on school mathematics is demonstrated.

5 Conclusion

In this paper, we referred to the educational effect and influence of the collaboration of three junior high schools using the Web. As we have shown, it has been indicated that students can utilize many mathematical knowledge and conceptions when we use the Web with due consideration given to the type of problems the teacher thinks can extract the most out of the students. This shows that collaborative learning using the Web is useful to train various views and ways of thinking currently emphasized by the Ministry of Education in Japan and National Council of Teachers of Mathematics(NCTM)[3],U.S.A. We emphasize that the database on the Web is effective as an environment where students can tackle open-ended problems in mathematics.Considerations for the future include the improvement of the student's computing skills, the improvement of the system with regards to numerical expressions and careful selection of the kinds of mathematical problems to be given to the students. After all, according to a questionnaire, since it is indicated that 70 percent or more of students are supporting collaborative learning using the Web from various reasons, we want to continue the research wholeheartedly from its educational perspective.

Acknowledgement

We express our sincere thanks to Miss. Cheong. Meng. Mei and the following institution for assistance.
A part of this research is selected as a supporting plan in the Voluntary-Plan of the 100-School Networking Project (Phase II ,1998) and the School-Plan of the E square project (1999) of the Center for Educational Computing.

References

[1]Masahiro NAGAI and Hiroaki KOSHIKAWA . "A Development of Collaborative Learning on School Mathematics Using the Web I" The Mathematics Education Paper Publication Meeting 31, Japan Society of Mathematical Education. 1998 . pp.283-288

[2]Masahiro NAGAI, Yasuyuki OKABE, Junichiro NAGATA, Hiroaki KOSHIKAWA, Tadashi TAKAHASHI, Kanji AKAHORI . "A Design of the Environment Supporting Collaborative Learning on School Mathematics Using the Distribution Network" . The Plenary Session of TSG6(Distance Learning in Mathematics Education) ICME9 at Japan, August 2nd 2000.

[3]NCTM . "Curriculum and Evaluation Standards for School Mathematics" . 1989

[4]Yutaka SAEKI . "New Computer and Education" . Iwanami Pocketbook .1997

[5]Matthew B.Miles, A.Michael Huberman . "Qualitative Data Analysis" . SAGE Publications . 1994

Agent-Based Collaborative Learning Environment for Intelligent Tutoring System (ITS)

Teresita C. Limoanco and Raymund C. Sison
ccstcl@ccs.dlsu.edu.ph, ccsrcs@ccs.dlsu.edu.ph
College of Computer Studies, De La Salle University, Professional Schools Inc.
Manila, Philippines

This paper proposes a general architecture illustrating how students can learn through peer interaction in an interconnected environment. Three (3) predominant components comprise the architecture: *the student model*, *the tutor model* and *a pedagogical agent* known as *SPY*. The use of pedagogical agents is the essential part in the proposed architecture, in which information received from other students will be used as one of the tutoring strategies to assist students in learning. Collaborative/cooperative learning is achieved between students and the tutor, or among students, through pedagogical agent interaction. Moreover, the architecture supports a collaborative learning environment that helps improve students' comprehension.

Keywords: **collaboration, collaborative learning, agents, intelligent tutoring system**

1 Introduction

With the advancement in technology, computers have become essential tools in developing systems that cater to the different needs of users. Currently, many works have been done in the field of education. Systems known as *intelligent tutoring systems (ITSs)* were developed to teach students on specific topics, test their knowledge by giving exercises, and provide remediation on topics students did not perform well. An *intelligent tutoring system* is a computer program for educational support that can diagnose problems of individual learners. Such diagnostic capability enables it to adapt instruction or remediation to the needs of individuals [5]. Currently, the state of ITSs is focussed on one-on-one learning instruction. Specifically the kind of learning modality used is centered on *learning by being told* [2]. However, in reality, students can also learn through interactions with his/her peers or work in a team (or a group). The information students receive from his peers can help improve his comprehension on the topics at hand. A new learning paradigm has emerged aiming on this area and this new learning paradigm is known as *collaborative learning*. Collaborative learning emphasizes on how students function in a group and how the students' interaction with his peers or work in a team can help improve students' learning. This can be seen as either gaining new knowledge or verifying the correctness of what the students had learned so far.

Meanwhile, one of the major issues in Distributed Artificial Intelligence involves multi-agency. The agents in a multi-agent system are designed to solve a kind of problem. This is based on the fact that agents are autonomous and can recognize their own existence and the existence of other agents. Agents help each other in order to achieve a common purpose within a certain environment. Agents can assist each other by sharing the computational load for the execution of subtasks of the overall problem, or through sharing of partial results that are based on somewhat different perspectives of problem solving on the overall problem. Moreover, this form of cooperation addresses the nature of communication between cooperating agents.[1,6] Due to the social ability[1] and proactivity[2] of agents, many research, and works whether related on education (i.e., ITSs) or interface learning have been done with the incorporation of agents. Some works include defining software agents to analyze the collaboration in a virtual classroom [3]. [2] proposed a system that is a CSCW environment with

---

[1] Ability of agents to interact with other agents and human agents through some kind of an agent communication language. [3]

[2] Agents do not simply act in response to its environment, but they are able to exhibit goal-directed behavior by taking the initiative. [3]

artificial agents assisting students in their learning tasks. Furthermore, it uses a tutor agent partially replacing the human teacher. [4], on the other hand, showed that the tutoring knowledge in ITS can be designed and organized as a team of interacting pedagogical agents. These agents communicate with the student depending on the tutoring function they fulfill. Some tutoring functions include domain presentation, domain assessment, problem solving type of exercises, topic selection, problem-step solving, domain explanation, and the like.

This paper presents a new approach to collaborative learning using agents. The collaboration of agents is seen as sharing of information in the environment. The main thesis is that information received from other agents can be used as one of the tutoring strategies of other students learning in the network. The paper is organized as follows: Section 2 describes the general proposed collaborative learning architecture, the different components associated and their interrelations. Section 3 presents how artificial agents can support the learner and describes the kind of learning strategy each agent should posses in the system. The last section summarizes some issues that need to be considered in the proposed architecture.

2 Collaborative Learning Environment

The learning comprehension of a student on certain topics can be improved if the student is allowed to interact with his peers and not only with the tutor. This is because the way a student understands a topic can be applied as the same approach for other students who have difficulty comprehending the same topic. For example, two students (Student A and Student B) are studying at the same time on the same topic. They may be physically present but in different places. Student A is able to understand the topic well, but B is having difficulty with the topic. Instead of leaving the topic without fully understanding it (for the current topic may have an effect on the succeeding topics), B can either collaborate with his tutor or with A. Since B's tutor may use the same approach in explaining the topic as he did earlier, B "collaborates" with A. The collaboration may be in the form of using the same tutoring strategy used for A. With this, it is essential to develop ITSs that allows students' interaction that goes beyond the student-tutor relationship.

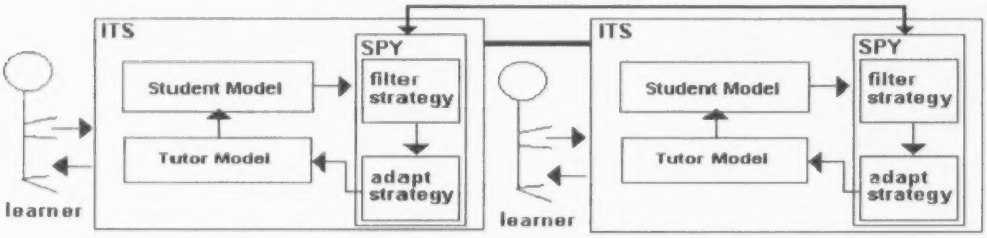


Figure 1: Agent-based Collaborative Learning Architecture

Figure 1 shows the proposed agent-based collaborative learning environment of an ITS system. The proposed architecture intends to illustrate collaboration that is not limited to student-tutor relationship but allowing students to interact directly or indirectly with his peers. In addition, this is done through interaction of the pedagogical agent SPY with the other agents of ITSs in the environment. It is assumed in the architecture that there can be several ITSs in the environment for a given domain. Though there may be the same set of tutoring strategies for the ITSs, it is possible that different tutoring strategies are used for the same topic. For instance, both student A and student B are currently studying lesson 1. However, the tutoring strategy used for A is presentation of lectures with illustrations, while B uses simple presentation of lectures. Furthermore, these ITSs are interconnected in a reliable network. The architecture can be implemented in either an Internet or Intranet infrastructure. Thus, it is good and useful for open and distance learning education.

There are three (3) main components in the architecture and these are the *tutor model, the student model* and *a pedagogical agent* known as *SPY*. Each of these is discussed below:

- ***Student Model:*** This module contains information about students' profiles and behaviors. Such information involves what the student has learned so far, has not learned, will be about to learn, and the possible misconceptions and their explanations on topics presented during the learning activity. Furthermore, the student model keeps track of the performance level of the students.

- ***Tutor Model:*** This module is responsible for the delivery of topics to students. Moreover, the tutor model also determines and delivers exercises to be solved by students. It is inherent in the tutor model that when presenting the exercise it considers student's level.

- ***SPY***: Each student is assigned an autonomous agent in the learning environment. This agent is responsible for gathering information such as the tutoring strategy used, the topic where the tutoring strategy is applied and the performance of students during his interaction with the ITS. Furthermore, SPY collaborates with other agents in the environment, with or without the presence of the student and the tutor. This means that SPY persists even if the student is not using the ITS. The information gathered will be used to determine the appropriate tutoring strategy for a particular topic for a student.

Specifically, the student interacts with the ITS in order to learn new concepts or to verify the correctness of what he has learned so far. During the learning activity, the student model monitors the performance of the student, keeping track of what the student has learned and is currently learning and his performance during the learning session. Any misconceptions the student may have are also being monitored. The tutor model presents topics according to the level of understanding of the student. The same approach is done when presenting exercises to students. The student's level of understanding can be determined from the student model. Information stored in the student model is then passed to the agent SPY, which in turn uses the information to determine which students have similar profile as its human student (i.e. relatively same performance, same learning style and relatively of the same level). From this interaction, the agent will gather data such as how other students were able to solve similar problems and how the topics were presented to them (i.e. tutoring strategy used). Moreover, SPY will keep track of the topics where the tutoring strategy was used and the student's performance. The rational behind this is that it is possible for SPY to determine in advance the tutoring strategy used for topics that are not yet presented to its human student. Consequently, this will allow the tutor model to adapt tutoring strategies depending on the status of its student.

The architecture illustrates two (2) forms of collaboration. The first is where the student collaborates with other students through communication medium and tools provided by the environment. These tools include chat, exchanging of emails/messages, discussion groups, newsgroups and the like. In this way, students can get actual explanations of how their peers understood the topics, concepts and solutions of problems presented during the learning activity. The second form of collaboration is where agents interact with other agents in the environment. Such interaction is abstracted from the students. The collaboration seen here is the sharing of information among agents about the students they are associated with.

To illustrate the second form of collaboration in the proposed learning architecture, consider this example: Students may or may not use the ITSs at the same time and study the same concepts or topics. In either case, the respective agents of each ITS in the network will still have to communicate and obtain information from other agents. Assuming there are two students, A and B who are present in the network and are interacting with their respective ITSs. Student A is currently studying topic 1 and student B is studying topic 2. Any interactions both students do during their learning activity are being monitored by their respective student models. While A is studying topic 1, his corresponding SPY agent is interacting with other agents (including the agent SPY assigned to student B) keeping track of topics other students have learned or is learning, the kind of tutoring strategy used, and the students' performance. By the time A is about to study topic 2, the tutor model A will adapt the tutoring strategy used for student B. This is with the assumption that the tutoring strategy used in B is effective (i.e., student B was able to understand topic 2 well, as this can be seen by his performance on that topic). If the adapted tutoring strategy is not appropriate to A (i.e., the student did not perform well in the corresponding exercises) another tutoring strategy will be used or by default will use the tutoring strategy of the tutor model.

It can be seen from the second form of collaboration that adaptation of tutoring strategies exists. Moreover, it is possible for the tutor model to change the current tutoring strategy used depending on the performance of the student during his interaction. The first form of collaboration allows students to directly apply what he/she has learned from the interaction.

3 The Pedagogical agent SPY

The agent SPY is introduced in order to allow students to share to their peers what they have learned and how they have learned the concepts. Specifically, SPY continuously communicates with other agents in the network keeping track of the approach or strategy used by other tutor models in teaching the concepts. Once information is gathered, SPY will perform 2 main operations: (1) filtering the strategies acquired from other agents and (2) transform the acquired strategy into a representation that can be adapted by the tutor model. The filtering of strategies is done in order to choose the appropriate strategy that can be applied to the current topic or concepts the student is studying. During the agent interaction, each agent can gather more than one kind of tutoring strategy possibly for the same topic or concept. These strategies can be arranged in many forms or classifications. For instance, strategies can be arranged according to its effectiveness based on students'

performance. This means the strategy with a student receiving the highest score will be adapted and used by tutor models of other students. If such strategy is not applicable to the current student, then the next highest scored student's tutoring strategy is applied. It is also possible for the agent SPY during the filtering of strategies to combine similar strategies into one strategy. Or better yet, arrange the different tutoring strategies according to the topics or concepts that have been presented or learned by students.

Once a strategy is selected, it will be transformed into a representation recognizable by the tutor model. This is done by following an adaption algorithm. The adaption algorithm should be flexible such that it can adjust to and apply any kind of strategies. However, it is possible that the adapted tutoring strategy is the same as the intended tutoring strategy of the tutor model. In this case, this will serve as a "confirmation" to the tutor model that the pre-planned tutor strategy is effective to its human student.

The objective of introducing a pedagogical agent in designing an ITS is to support the student in learning by adapting different approaches in presenting the topics. This is with the hope of improving students' learning comprehension. Furthermore, SPY assists the tutor model as to what kind of teaching strategy to use for certain concepts. In addition to being adaptive and reactive to the needs of students, SPY agents are proactive and goal-oriented in the sense that they act in the environment through its initiative.

4 Conclusion

In this paper, a proposed agent-based collaborative learning architecture for designing an ITS is presented. The architecture is general and at the moment no implementation has been made. The architecture has shown how a pedagogical agent can be used to model collaborative learning. There are three (3) main components in the proposed architecture and the predominant component is the inclusion of a pedagogical agent known as *SPY*. The agent *SPY* is introduced to assist the tutor model in determining which teaching strategy it will be used in presenting topics/ concepts to students. This also includes the presentation of exercises and possible remediation on topics students are having difficulty with.

This paper also showed a different form of collaboration that is not the same as the usual collaboration or teamwork that is seen in reality. The paper proposes a form of collaboration in which there is a sharing of information among the agents and students in the environment.

Certainly, much progress has to be made towards reaching the complete architecture in reality. Particularly, in-depth study and implementation of the said proposed architecture is needed to see if the architecture can provide improvement in student's learning comprehension. Moreover, there are several issues on the proposed architecture that needs to be studied carefully. Some issues include the learning capability of the tutor model to adapt new tutoring strategies from the SPY agent; representation and storage of strategies (i.e., how can strategies be represented in the form of rules and how to store them in each agent); filtering of strategies (i.e., how to determine which of the acquired strategies are useful and appropriate to the current performance of the students). In addition, a criterion needs to be defined on how to determine students with similar profile.

References

[1] Cammarata, Stephanie, McArthur, David, Steeb, Randall. "Strategies of Cooperation in Distributed Problem Solving". Readings in Distributed Artificial Intelligence. Morgan Kaufmann Publishers, Inc. San Mateo, California. pages 102-105. (1983)

[2] Florea, Adina Magda. "An Agent-based Collaborative Learning System". Advanced Research in Computers and Communications in Education, G. Cumming et al (eds), IOS Press, 1999. International Conference on Computers in Education '99, pages 161-164. (1999)

[3] Jaques, Patricia Augustin, de Oliveira, Flavio Moreira. "Software Agents for Analysis of Collaboration in a Virtual Classroom". Enable 99: Enabling Network-based Learning, Espoo, Finland, June 2-5. (1999).

[4] Lelouche, Ruddy. "An Interacting Team of Pedagogical Agents for Intelligent Tutoring of One Student". Advanced Research in Computers and Communications in Education. G. Cumming e al. (Eds). IOS Press. International Conference on Computers in Education 1999. pages 157-160. (1999)

[5] Sison, Raymund, Numao, Masayuki and Shimura, Masamichi. "Multistrategy Discovery and Detection of Novice Programmer Errors". Machine Learning, 38, 157-180. Kluwer Academic Publishers. (2000).

[6] Smith, Reid, Davis, Randall. "Frameworks for Cooperation in Distributed Problem Solving". Readings in Distributed Artificial Intelligence. Morgan Kaufmann Publishers, Inc. San Mateo, California. pages 61-69. (1981)

Agent-oriented Support Environment in Web-based Collaborative Learning

Tomoko Kojiri and Toyohide Watanabe

Department of Information Engineering,
Graduate School of Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8603, JAPAN

Phone: +81-52-789-2764, Fax: +81-52-789-3808
E-mail: {kojiri,watanabe}@watanabe.nuie.nagoya-u.ac.jp

Currently, the web-based learning support systems are one of interesting and hot topics in points of the utilization of Internet and the application of computers to education. In particular, the web-based collaboration is very applicable means to make unfamiliar students, who are unknown with each other, discuss together in the same virtual interaction space. However, there are some problems derived from the gap between the real world and virtual environment: coordination for discussions, cooperative reactions, comprehension of learning progress, etc. These problems may be dependent on the fact that the actions of students cannot be influenced from the behaviors of others directly.

In this paper, we address a coordination mechanism to promote cooperative actions/reactions for progressive discussions. Our idea is to apply an agent-oriented framework to this coordination mechanism and introduce two different types of agents. One is a coordinator and the other is a learner. The coordinator monitors the learning progress of group and promotes the discussion, if necessary, so as to reach their common goal successfully. The learners are assigned to individual students, and act as interaction mediators among students in place of the corresponding students. Of course, the coordinator is a passive entity and learners are active entities in our collaborative learning space.

Keywords: **Collaborative learning environment, coordinator, learning situation, learner, personal learning history**

1 Introduction

The fast and world-wide enlargement of Internet/Intranet has made it possible that every person can interact instantly without depending on their physical locations. Also, various applications, which are available on the web environment, have been developed with respect to the content-based resource sharing, in addition to the traditional message exchanges. The web-based collaborative learning is one of applications, based on such a hot topic, and has been applied as computer-support for virtual learning space. If their computers were connected mutually through the web-based learning environment, students can discuss their common solving process successively and exchange various solving methods/ideas cooperatively. However, there are some problems to encourage activated discussions among students and make it possible that individual students should understand the correct answer and solving process effectively:

1) students may not participate into the discussion interactively because of their hesitation, derived from the fact that they are unknown with each other;

2) students cannot grasp the behaviors of others directly or indirectly because only the direct actions and reactions are observable through the interactive interface.

These problems are radical drawbacks for collaborative learning.

In order to solve these drawbacks effectively, we propose an agent-oriented support environment for collaborative learning. Of course, the agent-oriented frameworks for the construction of collaborative

learning mechanism/environment have been already investigated until today. Florea[1] proposed a multi-agent collaborative learning environment in the web world. In this environment, three kinds of agents were introduced: personal agent which gets the information according to the requests of each student, tutor agent which generates advices when personal agents asked for the help, and information agent which acquires more information from Internet. Agents are activated by students' requests so that this system environment does not benefit passive students. Ogata, et al.[2] proposed mediator agents in the collaborative learning environment which assist students to find suitable collaborators. The mediator agent for each student holds the corresponding students' profile which indicates the understanding and interesting degrees about knowledge. When a student has problems, his/her mediator agent asks other mediator agents for the learning situations of their corresponding students and specifies appropriate students who may be able to help solving the problems. This research copes with the above problem 1) indirectly because this functionality supports to arrange appropriate learning group, but does not manage the progress of collaborative learning. Nakamura, et al.[3] and Liming, et al.[4] introduced respectively pseudo students which correspond to individual human students. These pseudo students have the same knowledge as the corresponding students and participate in the discussion in their ways if the corresponding students do not join in the discussion positively or cannot understand the discussion stage. These research viewpoints focus on passive students such as problem 1), but do not solve the problem 2). So, in spite of these various agent-based investigations, the previous drawbacks are not always overtaken.

In this paper, we address a collaboration learning environment, organized systematically under two different types of agents: coordinator and learner. The coordinator takes roles to monitor the discussion situation among students, grasp the learning progress and guide the learning process if necessary. The learners are virtual students corresponded possibly to individual students in our web-based collaborative learning environment. The coordinator and learner are complementary entities in the learning environment: the coordinator is a passive entity; and the learner is an active entity as the autonomy for practically participated student. In our investigation, we expect the collaborative learning of high school students who study mathematical exercises together, especially computation for the roots of equations. First of all, we show an overall framework of our collaborative learning environment in the web-world in Section 2. The functionalities about two different types of agents are stated in Sections 3 and 4, and then our prototype system is shown in Section 5. Finally, we conclude our paper in Section 6.

2 Collaborative Learning Environment

In the web-based collaboration learning environment, the actions/reactions of participated students are inherently different from their behaviors to be performed in the real world. Students in the physically constrained learning space can speak with each other by means of face-to-face, feel/recognize activities, occurred from the discussions of students, directly by various sensitive receptors and find out some new events/facts indirectly. Although these are not always implemented adaptively in the web-based virtual learning space, it is necessary to organize a collaborative learning environment in which the logical activities for support of interaction, discussion and comprehension can be implemented successfully and effectively.

Figure 1 shows our collaborative learning environment conceptually, which is characterized by two different types of agents: coordinator and learner. The coordinator places on the center of our virtual classroom (as a network server), monitors the interaction among students and generates advices if necessary according to the learning situation. This interaction is supported on the conversation means through the public communication line. The learner is a pseudo student in our virtual classroom and is assigned to the corresponding student one by one. The learner takes roles of the personal management of interaction interface for the corresponding student, the handshaking control of public communication line, the management of its own private learning history, and so on. In addition, the learner can communicate with other learners directly through the private talking line in order to exchange their personal learning histories.

Since students are studying with limited learning tools in the virtual web-based learning space, they sometimes do not able to communicate naturally. Furthermore, various students participate in the learning group and the learning process is not always completed successfully: i.e. some students are not able to solve the problem, some students are not able to understand the derived answering process after all, and so on. The coordinator solves such drawbacks in the virtual web-based learning space by managing the learning situation globally: the coordinator takes a place of teacher in our classroom activity. For the purpose of resolving inappropriate learning situation stepwisely and guiding

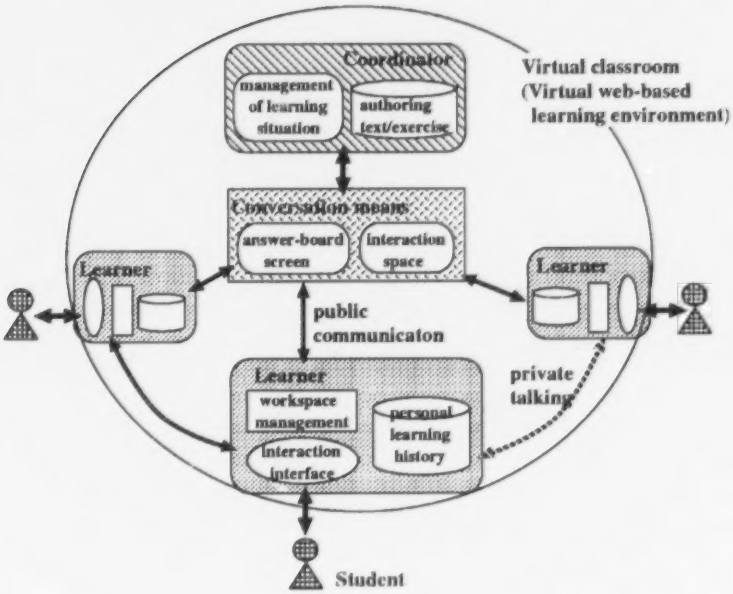


Figure 1: Collaborative learning environment

the learning group effectively, how to model and control learning situation is an important subject. If the coordinator grasps the learning situation appropriately, the advices which were generated from it may give appropriate hints in order for the learning group to proceed to the next phase of learning process. However, it is not always necessary to model the learning situation in detail precisely. This is, we think, because among the learning group students are able to help each other by discussion, so that the coordinator only has to detect the situation which the learning group cannot proceed the learning by itself.

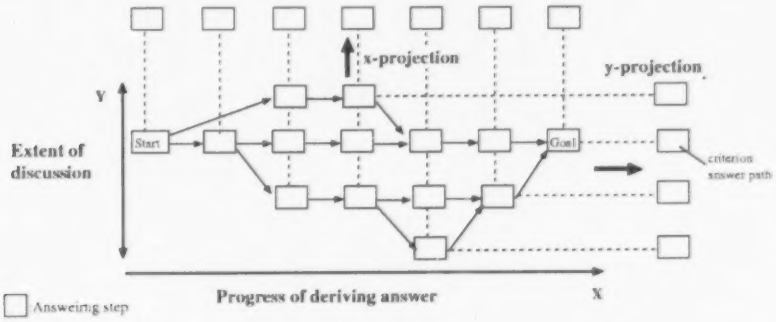


Figure 2: Answer space

The coordinator holds the right answer and the answering paths for an exercise as a knowledge to grasp the current learning situation. When the exercise has several answering paths for the goal, the answer space of exercise is expanded as 2-dimensional network structure, in Figure 2. In this figure, the learning progress along x-axis means the stepwise progress of deriving answer, whereas that along y-axis shows the extent of discussion. If the coordinator grasps the learning situation on the basis of the answering process of network structure as it were, it is very troublesome to manage the eventually

BEST COPY AVAILABLE

changeable conversation stages successively. Therefore, our coordinator manages the learning situation with respect to the following two viewpoints separately: ratio of derived step for a whole answering process and extent of discussion. By monitoring the learning situation under these points of view, the coordinator is able to grasp the learning situation easier and generate advices timely. In particular, it is necessary and sufficient to manage the learning situation of group globally, but not individually do that of each student.

The learner acts as a network client in place of the corresponding human student in the virtual web-based learning space. This provides not only the interaction interface for virtual learning space attached to the corresponding student, but also the function of indirect interaction among students, so as to judge the understanding levels or personalities of them, which we call the focus function. According to the focus function, students select the opinions of particular students whom they evaluate as key students. In order to realize the focus function, the learner needs to have the knowledge about the corresponding student and exchange it with other learners. Therefore, the personal learning history is prepared for learner, which represents understanding level and personality of corresponding student. The learner constructs and maintains the personal learning history according to the current situation. Exchange of personal learning history is one-to-one interaction so that public communication is not necessary for the focus function. Therefore, we introduce mobile agents called mediators as children of the learner, that take responsibilities for the exchange of personal learning histories among learners. The mediator moves among learners by requesting/carrying the personal learning history on the private talking line.

3 Coordinator

The coordinator grasps the learning situation from two viewpoints: ratio of derived step for a whole answering process and extent of discussion. For the ratio of derived step, which corresponds to the x-axis of answer space in Figure 2, we have already proposed the resolution derivation scenario which represents the phases of deriving answer stepwisely [5, 6, 7]. The scenario is generated by means of projecting the answer space onto x-axis and consists of ordered states which correspond to individual phases of deriving answer. Grasping an approximate learning situation makes it possible that the coordinator generates advices timely and effectively because each state corresponds to the individual ratio of derived step. On our scenario structure, the current learning state is pointed by the indicator *current*, which points out the currently discussing stage. The coordinator infers the current state from student inputs and moves the indicator to the corresponding state. However, the utilization of only one current discussion indicator is not enough to manage the learning state of group sufficiently. In addition to *current*, indicators *upper* and *lower* are prepared for the representation of current understanding levels of learning group. *Upper* points out the state of understanding level which is estimated that best understanding student reached to and *lower* points out the state of worst understanding student did. The coordinator is able to grasp the learning situation on the basis of the relationship among these 3 indicators (Figure 3).

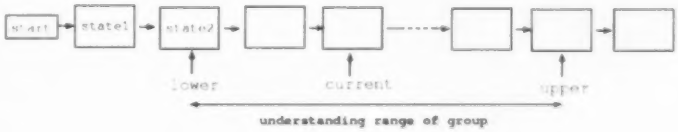
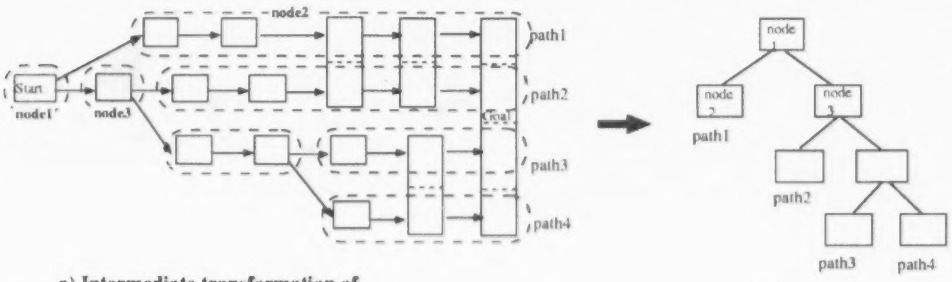


Figure 3: Resolution derivation scenario and indicators

On the other hand, the extent of discussion is estimated by the number of derived answering paths with different discussion viewpoints. The difference of discussion viewpoints among answering paths is defined as the ratio between common and uncommon answering steps. That is, if two answering paths contain large number of answering steps as common part, they are regarded as more similar paths; but if they have many different answering steps, they are judged as different paths. Common answering steps means that the answering methods which are used to derive those steps are the same. Once two answering paths were diverged, the following answering steps may be derived based on different answering methods so that they are regarded to be uncommon. From such viewpoint, the coordinator holds an answer tree which was transformed from whole answering paths as a tree structure. Figure 4

shows the construction of answer tree, derived from the answer space in Figure 2. The answering steps after the divergence are regarded as uncommon steps so that they are copied as different objects(Figure 4a). Then, the answer tree is transformed by means of collecting common answering steps for the purpose of grasping the difference among answering paths. The nodes in the tree are generated as a collection of answering steps that are common to particular answering paths and the path from root node to particular leaf node corresponds to each answering path. When the answer has been derived, the coordinator specifies derived/underived answering paths, calculates the differences between the derived answering path and other answering paths based on the answer tree, and estimates the extent of discussion.



a) Intermediate transformation of answer space corresnponds to Figure 2

b) Answer tree

Figure 4: Construction of answer tree

By grasping the learning situation from these aspects, the coordinator is able to handle the changeable learning situation and generate appropriate advices at the right time.

4 Learner

The learner is situated on each student's computer and acts as a pseudo student in the virtual web-based learning environment. The learner provides the interface to the human student and controls the private talking among students such as focus function. Since the learner connects the private talking line according to only corresponding student's request, it behaves independently with the coordinator that manages the public communication.

A personal learning history is the model of corresponding student which is held by the learner. The personal learning history represents the understanding level and the characteristic of corresponding student. Some data of personal learning history are prepared by the human student beforehand and others are gathered by the learner occasionally through the learning. Currently, the picture and utterances of students are collected as a personal learning history. The feature of student does not change through the learning, so the picture is set by each student before the learning starts. Utterances indicate the understanding level of student and also attitude toward the learning; i.e. active or passive, understanding or not-understanding, and so on. They are gathered and added to the personal learning history by the learner when corresponding student send their opinions to the public communication line.

In order to exchange the personal learning history through private talking line, the learner generates mediators for each communication. The mediator is constructed as a mobile agent which processes its tasks while moving through the network autonomously[8]. Figure 5 shows the movement of mediator for acquiring the personal learning history of other students. When the corresponding student requests to get the personal learning history of particular students, the mediators are generated by the learner respectively. Once generated, the mediators move to the target learners through the network and ask for the personal learning history, attended inherently to the target learners. After the acquisition of personal learning history of target learner, the mediators move back to their original learner and disappear autonomously, since their roles are to acquire the personal learning history from target learners. Under such mechanism, students are able to know other students' characteristics even in our virtual web-based learning environment without any direct interaction.

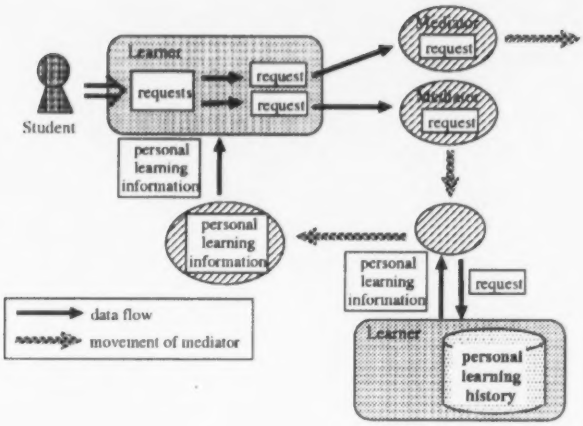


Figure 5: Mechanism for acquiring personal learning information

5 Implementation

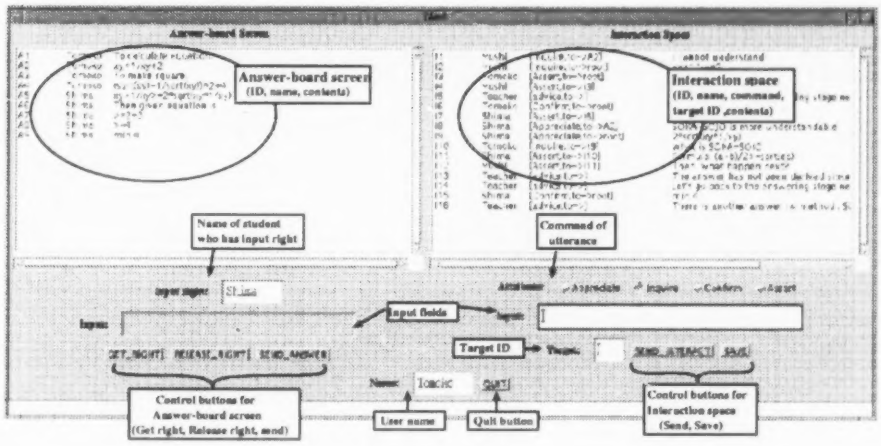


Figure 6: Interaction interface on student operation

We have implemented our prototype system on Internet using UDP protocol, since UDP protocol is suitable to control the frequent interaction of short messages. Figure 6 shows the interaction interface in our system. Two communication tools are prepared: answer-board screen and interaction space. The answer-board screen is a public communication tool which is used to arrange the group's answering process. Only one student is permitted to input on the answer-board screen at a time so that the input right is set. On the answer-board screen, ID, student' name, and contents of input is shown. The answer-board screen functions as a blackboard in our real world. On the other hand, the interaction space is prepared for free conversation so that all students are able to input freely. In order for the coordinator of our system to grasp the learning situation easily, commands that classify the opinions are introduced: Appreciate, Inquire, Confirm, and Assert. Students choose the commands when they input their opinions. In addition to the commands, students specify the target inputs which trigger off their opinions for the purpose of grasping the flow of conversation smoothly. Thus, in addition to the ID, student's name, and contents of input, command and ID of target input are also displayed on

BEST COPY AVAILABLE

interaction space.

As for the coordinator, we prepared several advices which indicate the states of learning situation when the learning is proceeded inappropriately. Currently, the coordinator generates advices when it detects the following learning situation:

- learning situation has not been changed for a long time,
- some students cannot understand currently discussing stage, and
- students have not derived all viewpoints of solving the exercise.

The coordinator's objective is to activate the discussion, so the advices are generated on the interaction space as the same style as all other students' utterances. Figure 7 shows an example of advices generated by the coordinator. As for the advice, the speaker name is set as "Teacher", the command of advice is "advice", and the ID of target input is nothing because the advice is generated for the learning group but not for individual students.

ID	Student's name	[Command -> target ID]	Content
13	Tomoko	[Assert,to->root]	Only multiply numbers.
14	Yushi	[Assert,to->13]	I understand
15	Teacher	[advice,to->]	Let's go back to the answering stage ne
16	Tomoko	[Confirm,to->root]	xy+1/xy+2
17	Shi[illegible]a	[Assert,to->16]	I understand
18	Shi[illegible]	[Appreciate,to->A2]	SOKA-SOIO is more understandable

Coordinator's advice

Figure 7: Advice example of coordinator on interaction space

The learners was implemented using AgentSpace[9] as a middle-ware to control the behavior of mediator. Figure 8(a) is an interface for generating requests. On the upper window, the causality of utterances on interaction space is arranged based on corresponding student's utterances. The arrangement of utterances on the upper window helps to decide the focusing students for generating requests. Once a student decides focusing students, he/she inputs IP addresses of focusing students, because mediators need IP addresses where they will work on beforehand in our current version. Then, he/she specifies the file name of focusing student's personal learning history. If a student wants to know only the particular utterances of focusing students, he/she sets the ID's of corresponding utterances shown on the upper window. Figure 8(b) is the result windows of requests for personal learning history. When requests have been completed successfully, the result windows are generated and the personal learning histories of focusing students are shown individually. Currently, the picture of focusing student is shown on the upper window and his/her utterances are shown on the lower window.

6 Conclusion

In this paper, we proposed a collaborative learning environment which contains two different agents: the coordinator and the learner. The coordinator monitors the public communication among learning group and generates advices so as to lead them to their learning goal. For this purpose, the coordinator grasps the learning situation globally from two viewpoints: the ratio of derived step for a whole answering process and the extent of discussion. Although the management structure of learning situation is simple, the coordinator may be able to find the most cases that students are not able to cope with inappropriate learning situation by themselves. On the other hand, the learner controls the private talking such as focus function. The learner holds the personal learning history of corresponding student as his/her characteristics and acquires other students' personal learning histories by generating the mobile agents called mediators. Currently, these agents function independently. However, for our future work, the interactions among coordinator and learners are necessary for the coordinator to generate more effective advices. In addition, the evaluation for the interaction interface of our prototype system and the preparation of more factors for personal learning history based on the result of the evaluation are also our future works.

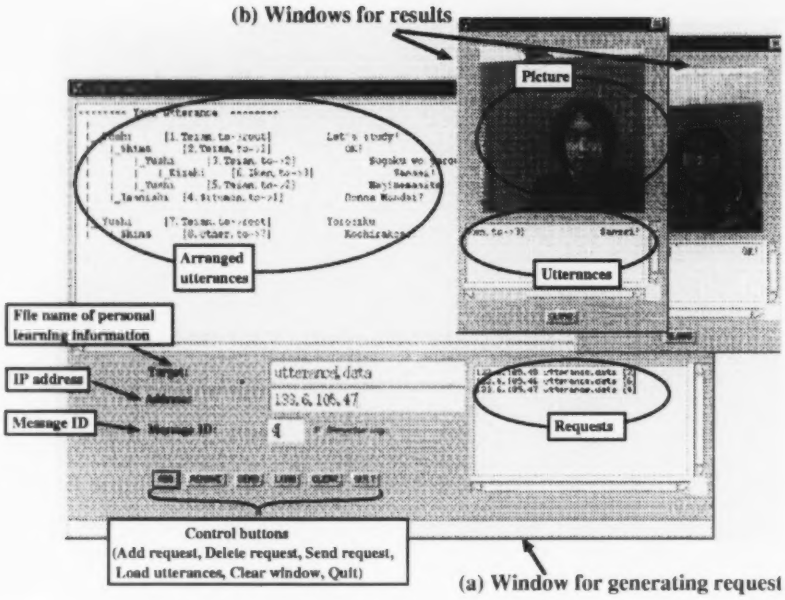


Figure 8: Interface for handling requests

Acknowledgments

The authors are very grateful to Prof.T.Fukumura of Chukyo University, and Prof.Y.Inagaki and Prof.J.Toriwaki of Nagoya University for their perspective remarks, and also wish to thank our research members for their many discussions and cooperations.

References

[1] A. M. Florea: "An Agent-based Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 161–164 (1999).

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano: "Knowledge Awareness Map for Open-ended and Collaborative Learning on World Wide Web", *Proc. of ICCE'99*, Vol. 1, pp. 319–326 (1999).

[3] M. Nakamura and S. Otsuki: "Group Learning Environment Based on Hypothesis Generation and Inference Externalization", *Proc. of ICCE'98*, Vol. 2, pp. 535–538 (1998).

[4] G. Liming, H. Minghua and Q. Yuhui: "A Web-based Multi-Agent Collaboration Learning System", *Proc. of ICCE'98*, Vol. 1, pp. 205–210 (1998).

[5] T. Kojiri and T. Watanabe: "Cooperative Learning Support Mechanism, Based on Scenario of Specifying Solving Process", *Proc. of ICCE'98*, Vol. 2, pp. 532–534 (1998).

[6] T. Kojiri and T. Watanabe: "Adaptable Learning Environment for Supporting a Group of Unspecified Participants in Web", *Proc. of SITE'99*, pp. 1937–1942 (1999).

[7] T. Kojiri and T. Watanabe: "A Management Method of Leaning Situation in Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 386–393 (1999).

[8] J. E. White: "Telescript Technology: Mobile Agents", *Software Agents (J. Bradshaw (ed.)), MIT Press*, pp. 437–472 (1997).

[9] I. Sato: "AgentSpace", *http://islab.is.ocha.ac.jp/agent/* (1999).

BEST COPY AVAILABLE

An Effectiveness Study of Web-based Application for Mailing List Summary and Review

Satoru FUJITANI* and Kanji AKAHORI**
**Mejiro University College.*
4-31-1, Naka-ochiai, Shinjuku, Tokyo 161-8539 Japan
Tel: +81-3-5996-3127 Fax: +81-3-5996-3125
E-mail: fujitani@mejiro.ac.jp
***The Center for Research and Development of Educational Technology,*
Tokyo Institute of Technology.
2-12-1, O-okayama, Meguro, Tokyo 152-8552 Japan
Tel: +81-3-5734-3233 Fax: +81-3-5734-2995
E-mail: akahori@ak.cradle.titech.ac.jp

This paper reports an effectiveness research of e-mail discussion review support system with summary extraction method. The support system we have developed can automatically extract summary sentences from the normal conversational style language in e-mail messages using reference relationship of e-mails that participants have discussed. One could use the summary sentences for looking back on discussion, and use them as an idea database at a glance. Japanese natural language processing technology has been applied in the proposed method. In order to evaluate the effectiveness of the system, we conducted experiments using a questionnaire and protocol analysis. We compared the two system; the system with and without summary sentences in the table of e-mail content. As a result, following fact-findings were obtained. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader pay attention to the detail information such as name of discussing member.
Finally, we concluded that the system with summary sentence is effective for understanding of relationship among various e-mail messages.

Keywords: **Mailing lists, Natural language processing, Distance learning, Learning environment, Summary sentence extraction, Collaborative learning, Factor analysis, Reading strategies**

1 Introduction

Collaborative learning support environments for network-based discussion appear to be investigated quite often [1][2]. For instance, e-mail is extensively used in the classes for learners' communication.

The research topic we reported here is collaboration support tools that intended for e-mail discussion. For the purpose of sharing of participants' activities on computer networks, we have proposed a summary extraction method along the development of mailing list discussions and an outline presentation tool for mailing list [3][4][7][9]. Japanese morphemes analysis system [8] is applied in our researches. This web-based tool supports reviewing the past discussion on the mailing list. As for results of the summary extraction method, we conducted comparative evaluation between the result of human summarization and of the method. The result suggests that the proposed method can detect major sentences in e-mail articles properly [4].

There is a number of preceding researches on the keyword and summary sentences extraction methods of documents [5][6][15]. But the most of extraction methods in preceding researches applied to well-

documented text, like the newspaper manuscript or research paper. On the other hand, this research targets on the conversational style language in text form. For identifying the outline of e-mail discussion, there are many difficult problems in e-mail messages. These are:

- E-mail messages are conversational style language and many summary extraction methods using syntactic information could be not applied.
- The title of e-mail might not be changed as the discussion continues, if so, the title is not meaningful as the summary of documents.
- The method should identify the flow of discussion corresponding with e-mails in order to grasp the topic.

Besides, most of evaluation experiments in summary extraction method with natural language processing technology focus on the validity of algorithm, like adaptability or reproducibility. About analysis of reading comprehension when additional information, e.g. summary, is given, we could refer Ausubel's research on the advanced organizer model [10]. The paucity of reports on sentence comprehension process encouraged us to investigate it.

The purpose of the present paper is to analyze how the summary sentences accomplishes to an actual comprehension process. In this paper we describe an experimental study of e-mail message reading process with or without the extracted summary sentences.

In the first experiment, we investigated e-mail message reading strategies using responses of questionnaire. We conducted comprehension test and reading process analysis. In the reading process analysis, the result was divided into seven factors using factor analysis. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader give attention to the detail information such as names of participating members.

In the second experiment, we analyzed peer discussion processes while reading e-mails on the World Wide Web (WWW) interface. We conducted the comprehension test of the e-mail messages. We also conducted protocol analysis of e-mail reading comprehension. Also hereupon, we compared the results with two conditions, one is a group to which the summary sentence of the e-mail messages was given, and the other is a group without summary sentence of e-mail messages. The results of protocol analysis show some difference in the number of utterance collected during the experiment.

2 Summary extraction method along development of discussion

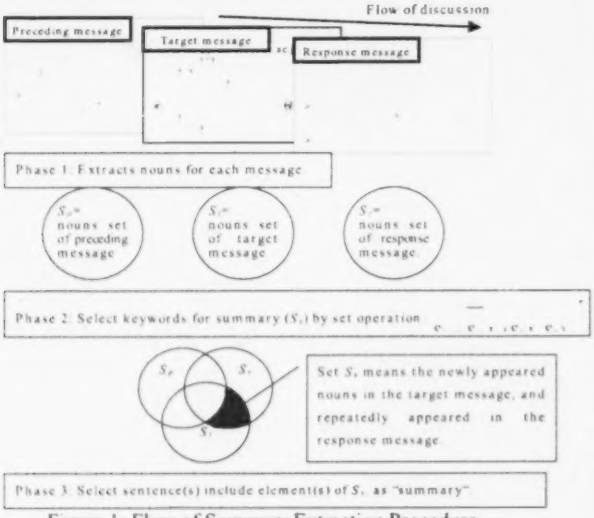


Figure 1: Flow of Summary Extraction Procedure from the target message.

The summary extraction method was discussed in our preceding research [3][4]. In this paper, we de-scribe the outline of the extraction method for better understanding by the readers.

2.1 Idea of the extraction method

We tried the extraction of keywords and summary sentences of the discussion from the document in the mailing list based on the preceding research [11] intended for the discussion such as Netnews. This key-word extraction method can be used in the discussion environment with the following features; (1) The change in the topic does not take place easily in a row. (2) There is a habitual practice that the participants do repeated revisions during the discussion, and

uses the quotation appropriately. But although it is limited in our case, e-mail discussion might develop in many ways, and the topic is changeable. The relationship of e-mail message for the keyword extraction between the target message and the past messages is little in e-mail discussion.

Then, in this paper, we set up a hypothesis: Although there was a dependency on the topic, e-mail messages with new information are tempted to encourage responses later. That is, we can treat them as topic making messages in the mailing list. We proposed a summary extraction method that enables pick up those new information as keywords and summary sentences in the messages [3][4]. Figure 1 shows flow of keyword and summary extraction by this method from the content of the message of the mailing list.

However, this summary extraction method supposes both preceding and response messages must be consecutive in the thread. Therefore, we set some assumptions for these exceptions. When the target message is the beginning message in the thread, the title of the message is also used and extracts common nouns among the title of the target message and the body of related messages. On the other hand, when the target message is the last message in the thread, we choose keywords only from the preceding and the target message, and common nouns in both messages is treated as keywords for the target message. Moreover, summary sentences are regenerated when there is a new message in the mailing list.

2.2 Summary generation and WWW display tool

We implemented summary generation and display tool using the proposed summary extraction method. This can be operated on the World Wide Web (WWW) to refer to past messages of mailing list [7]. Fig-ure 2 shows the display of Web page with and without summary sentences. These Web pages fulfill the role of table of contents (TOC) of mailing list. Readers look for contents from the list view with tree structure along continuity of e-mails. They can trace the body of each message from Web link. TOC shows serial number, writer, date of issue, and the title of the e-mail. In Figure 2(b), under the link to the body, summary sentence obtained by the noun set is displayed. When more than one sentence is extracted by the method, it becomes so complicated that the implication of TOC is diminished. So we referred to the procedure widely used in full-text search system [6], the number of displayed sentence is trimmed off to only one sentence that include maximum different number of chosen keywords. We treat that sentence as important sentence for TOC.

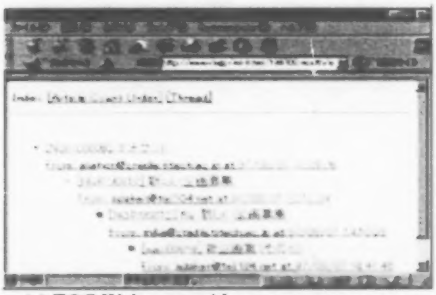
3 Evaluation experiment in the e-mail message comprehension

In this research, we carried out the evaluation experiment on effects of summary presentation while reading past e-mails on the mailing list. We conducted reading comprehension test and factor analysis of reading strategies.

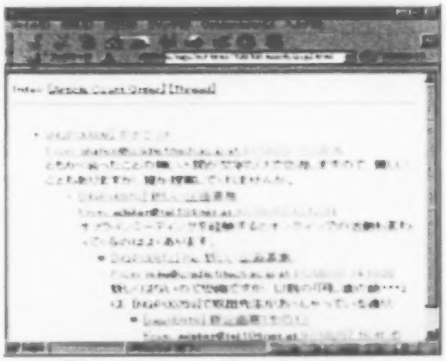
3.1 Methods

3.1.1 Subsubsections

In the experiment, we made the settings resembling the actual Web-based environment of the mailing list.



(a) TOC Web page without summary sentences

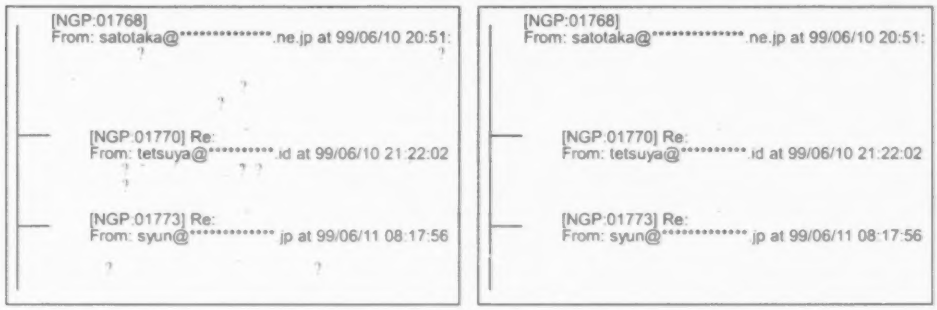


(b) TOC Web page with summary sentences.

Figure 2: "Table of contents" Web pages for review.

BEST COPY AVAILABLE

We printed out the several e-mail messages in a row, referred to as "thread", and the table of contents (TOC) for the e-mail messages in addition. Figure 3 shows the part of the experimental materials. To the semblance



(a) Printed TOC with summary sentences. (b) Printed TOC without summary sentences.

Figure 3: The part of the printed experimental materials

of Figure 2, the summary is generated from the proposed summary extraction method. It appeared in parallel beneath each entry in the TOC, or not appeared. E-mail messages for the summary extraction method consist of nine messages of mailing lists. The topic in the mailing list is the educational use of the Internet for foreign Japanese schools and domestic schools.

3.1.2 Procedures

Subjects of the experiment are 56 undergraduate students. None of the subjects know about the mailing list. The printed TOC as described above is affixed in front of the e-mail messages. The printed experi-mental materials were distributed to the subjects, and the researcher explained the experimental setting: "We are going to try to read past e-mails, and catch up with the exchange of the e-mail discussion." In addition, the participants were asked to use TOC positively.

The subjects read these documents for eight minutes. After the eight minutes, the researcher confirmed all the subjects had read the documents once. After that, the subjects were not allowed to read the docu-ments again, and they did the e-mail comprehension test. They had answered the following questions:
1. Write down the name of places which had appeared on the first e-mail as much as you remember.
2. Write down the episode of the first e-mail as much as you remember.
Later, they answered a questionnaire, which was consisting of 28 items with five-point rating scale and space for writing comments. The items were concerning the e-mail reading strategies. In order to make questionnaire, we referred the preceding research about sentence intelligibility [12] and our preceding researches.

3.1.3 Experimental Design

The factor of the experiment materials is presence of summary sentences in the TOC. We can divide the subjects into two levels. 56 subjects were randomly assigned to both two experimental settings of the materials, and were divided into the two groups of 28. Therefore, it is a between-subject experimental design with one factor.

3.2 Results

3.2.1 The comprehension test

In the question 1: "the name of places which had appeared in first e-mail", we compared the numbers of correct answers between two groups. We leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the number of correct answers

Table 1: Extracted factors and results of ANOVA

Name	Ratio	
1. Read the content in detail and memorize	21.5%	$^{**}p<.01$
2. Use Table of Contents	10.5%	$^{*}p<.05$
3. Think about the development of discussion	8.7%	
4. Combine their knowledge	7.1%	
5. Think about the theme of discussion	5.1%	
6. Read back and force	4.3%	
7. Write down a memo	3.9%	
Accumulated Explanation Ratio	61.1%	

(F(1,48)=1.065, p>.10).

In the question 2: "the episode of the first e-mail", we have chosen eight words from the message as answer words of the question beforehand. We compared the numbers of appeared answer words between two groups. We also leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the average number of the answer words (F(1,48)=.415, p>.10).

Table 2: ANOVA for Factor Scores

(a) ANOVA for Factor Score of factor 1.

Source	SS	df	MS	F	R^2
Factor	5.61	1	5.61	7.21	0.0098**
Error	38.11	49	0.78		
Total	43.72	50			

**p<.0

(b) ANOVA for Factor Score of factor 2.

Source	SS	df	MS	F	R^2
Factor	4.62	1	4.62	5.99	0.0180*
Error	37.78	49	0.77		
Total	42.39	50			

*p<.0

3.2.2 E-mail reading strategies

The factor analysis with major factor method and varimax rotation method was applied to the 28 questionnaire items concerning strategies of the comprehension for e-mail messages.

As we shown in Table 1, we sequentially named the seven factors. We extracted these factors from the change in the eigenvalue. The accumulated factor explanation ratio was 61.1%. Next, factor score of seven factors was calculated par subjects.
Table 2 shows results of ANOVA. As a result of ANOVA for seven factors, a significant difference was found in the first factor "Read the content in detail and memorize" (F(1,50) =7.212, p<.01) and the second factor "Use Table of Contents" (F(1,50)=5.988, p<.05).

In addition, we compare the score for each item in two groups.

As a result, the group with summary sentences could promote reading strategies such as "Usefully reading TOC help me to know the content of sentences" (t(51)=3.58, p<.01), and "Refer TOC to read the content in the messages" (t(52)=2.76, p<.01). Those who use summary sentences would have tendency that they try to know the relation between the content and the whole structure of the thread.

On the other hand, the group without summary sentences would take reading strategies such as "Pay attention to the participant's name or the name of places appeared on the e-mail while reading" (t(50)=2.34,p<.05), "Read the content carefully and memorize in detail" (t(51)=1.94, p<.10). Thus, they attempted to give attention to the detail information such as names of discussing members.

3.3 Summary of the experiment

In the experiment, there was a significant difference in the e-mail reading strategies while there was no significant difference in the recognition of e-mail contents. Our proposed method is a kind of new information presentation method for the support of e-mail reference. We might say our summary extraction method and display tool for mailing list could help readers to suppress consideration of detail information in the documents. On the other hand, these supports help to maintain the particular contents easier.

4 Protocol analysis of e-mail reading process

From the suggestion in the preceding section, adding summary sentences possibly provide a hint on the e-mail reading strategies. In this section, we examined changes of e-mail reading strategies when having the benefit of summary sentences using protocol analysis. To put it concretely, the subjects answer questions after reading the content of e-mail messages that is displayed on the WWW pages. We have observed the e-mail reading strategies while participants were reading e-mail messages.

4.1. Methods

4.1.1 Experimental materials

We have used 43 e-mail messages of the mailing list for the summary extraction method. Educational use of the Internet in foreign Japanese schools and domestic schools was focused in this mailing list.

Each e-mail message can be traced back and forth from TOC WWW page shown in Figure 2. We have set two conditions; one was in which summary sentences were given, and the other was in which it was not given.

4.1.2 Subjects

Subjects were 20 undergraduate students forming ten pairs. The reason for making group of two is that the subjects could discuss naturally with each other, and therefore, we could collect natural speech proto-cols easily from the conversation [13][14]. They were randomly assigned to two different experimental settings as described previously in this paper.

4.1.3 Procedure of the experiment

The two subjects were seated in front of the computer and were given an instruction for the present experiment by researcher. After the e-mail reading, the subjects were asked to answer some questions on reading comprehension. The subjects were allowed to start reading e-mail messages from anywhere. Then, they read e-mail messages through WWW pages for 20 minutes. After that, they were asked to answer some questions regarding particular content in the e-mail messages within 15 minutes. Finally, they were interviewed about the provision of advance information of the mailing list and the interest on the topic of discussion. None of the subjects know about this mailing list.

4.2. Analysis and Results

In this experiment, we recorded peer protocol with a digital video (DV). Then, we played the recordings and type in the conversation by listening the recordings. During the analysis of utterance, we identify sev-eral reading strategies or procedure for sentence comprehension. For each unit of procedure and strategy, the protocol was classified into the protocol categories [13]. For the classification, we have used the result of the factor analysis as we seen in Table 1. The categories "Read the content in detail and memorize" and "Use Table of Contents" were found to be significantly different on factor analysis. In the first cate-gory, we have considered utterances if the subjects read particular personal name and place name aloud. In the second category, we have considered utterances if the subjects read aloud the summary sentences or pursue continuity of the mailing list by pointing to the TOC. Some subjects pointed using mouse cur-sor's move or their fingers.

Table 3: Frequency of strategies appearance between two categories

Protocol category	With summary	Without summary
1. Read the content in detail and memorize	128	103
2. Use Table of Contents	35	22

Table 3 shows the comparative result with two protocol categories. As the number of subjects is very less, a clear conclusion could not be drawn. But as in Table 3, the frequency of category 1 was relatively higher than that of category 2. As a the result by means of summary display tool with e-mail messages has been suggested as a method to manage a lot of reading strategies easily. However, though the differ-ence of the frequency does not contradict the results of ANOVA in the previous section, it does not show a significant difference in the comparison of ratios ($\chi^2(1) = 0.67, p > .10$).

In this experiment, a significant difference was not seen in the frequency of the e-mail reading strate-gies. We need to add the number of experiments as well as study the influence of experimental design in peer conversation.

5 Conclusions

The results of this research may be summarized as follows:

1. We applied the summary extraction method for mailing list, and analyzed e-mail reading comprehen-sion and reading strategies for reference. Although the result is limited to the e-mail messages we used, the display of e-mail summary sentences affects experimental subjects' reading strategies. On the other hand,

the result of comprehension test does not show significant differences. We may con-clude at this point that the method of summary sentence extraction is effective in understandings of relationship of e-mail messages.

2. The influence of summary display on the e-mail reading strategies was examined from the analysis of utterance protocol. The use of Table of Contents WWW page along with e-mail summary sentences does not make a difference in the frequency of utterances, but preferential trend for the use of e-mail summary sentences was observed.

As a problem yet to be solved in the future, we are interested in examining the effectiveness of reading strategies when e-mail messages are posted and read in real time.

Acknowledgement

Our special thanks are due to Madhumita Bhattacharya, Ph.D., the National Institute of Education, Singapore, for reading the manuscript and making a number of helpful suggestions.

References

[1] Kusunoki, F. & Sayeki, Y., "We can learn because of the opinions different each other", Journal of Information Processing Society of Japan, Vol. 40, No. 6, pp. 564-568, (1999).

[2] Inaba, A. & Okamoto, T., "The Network Discussion Supporting System Embedded Computer Coordinator at the Distributed Places", Educational Technology Research, Vol. 18, Nos. 1-2, pp. 17-24, (1995).

[3] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method for Web-based Mailing List Review Application and Its Effectiveness Study", Advanced Research in Computers and Communications in Education (ICCE99), G. Cumming et al. (Eds.), IOS Press, Vol. 1, pp. 327-334, (1999).

[4] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method of E-mail Discussion and Its Web-based Application to Mailing List Review", Educational Technology Research, Vol.23, Nos. 1-2, *In printing*, (2000).

[5] Sasaki, I., Masuyama, S. & Naito, S., "Proposal on sentence extract method which pays attention to vocabulary coherency", Technical Report of Information Processing Society of Japan, 93-NL-98, pp. 65-72, (1993).

[6] Sumita, K., Tomono, T., Ono, K. & Miike, S., "Generation of Automatic abstract with document structural analysis, evaluations as retrieval presentation function", Journal of The Institute of Electronics, Information and Communication Engineers, D-II, Vol. 78-J, No. 3, pp. 511-519, (1995).

[7] Fujitani, S. & Akahori, K., "Improvement of content summary extraction method along with development of discussion about document of mailing list summary system", Proceedings of 14th annual conference of Japan Society of Educational Technology, 2pB02-3, pp. 691-692, (1998).

[8] Kurohashi, S. & Nagao, M., "Japanese morpheme analysis system "JUMAN" version 3.61", Graduate school of information science, Kyoto University, (1999).

[9] Ken'ichi Fukamachi, "fml" Mailing List Server Package, http://www.sapporo.iij.ad.jp/staff/fukachan/fml/index-e.html (accessed on August 1, 2000).

[10] Ikeda, S. & Tanaka, S., "improvements of experiment diagram in preceding organizer research", Reading sciences, Vol. 29, No. 2, pp. 41-55, (1985).

[11] Ishihara, M. & Akahori, K., "Developments of discussion summary system for discussion support with problem", Journal of Japan Society of Educational Technology, Vol. 22, No. 1, pp. 1-12, (1998).

[12] Uchida, N., "Is the sentence understanding process "top down" or "bottom up?" ": In Shun-ichi Maruno, some controversies in cognitive psychology, Kyoto: Nakanishiya publication, pp. 165-188, (1998).

[13] Kaiho, H. & Harada, E., "Introduction of protocol analysis", Tokyo: Shin-yo-sha, pp. 118-134, (1993).

[14] Madhumita, & Akahori, K., "An Evaluation Method for Audiovisual Software Based on Protocol Analysis", Media and Education, Vol. 1, pp. 19-27, (1998).

[15] Firmin, T. & Chrzanowski, M. J., "An Evaluation of Automatic Text Summarization Systems, Advances in Automatic Text Summarization", The MIT Press, pp. 325-336, (1999).

An Implementation of Campus Distance Learning System Using Multicast

Jiang Dongxing, Tao Chaoquan, Fang Guowei, Shen Peihua
Computer and Information Management Center of Tsinghua University
Qinghuayuan No.1, Beijing 100084, P.R.China
Tel: +86-10-62772150, Fax: +86-10-62782728, E-mail: jdx@cic.tsinghua.edu.cn

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The Campus Distance Learning System is an important way to solve the problem. This paper starts with an examination of some existing solutions, and then introduces the primary-secondary model multimedia network teaching system designed by researchers in the Computer & Information Management Center of Tsinghua University. The system is composed of three parts: the primary classroom system, the secondary classroom system, and the courseware management system. It fulfills real-time interactive teaching and learning, and multipoint communication, and at the same time records the teaching materials as courseware. The paper focuses on the constituents, structure and characteristics of the system, and expounds in detail the implement technology based on multicast. In the end, the paper points out some problems calling for further consideration.

Keywords: **Network distance learning; primary-secondary model; multicast**

1 Introduction

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The traditional resolution was videoing and then broadcasting through CATV. This used to play an important part in television education, but it can not support the interaction between the teacher and the students, and the information that is limited by TV is not sufficient for lectures. With the network becoming more and more popular, network education instead of CATV is being received by more and more people. Many companies and universities have developed different network distance learning systems, the following are several famous systems.

Remote Education System of VTEL: This system is an application of the VTEL videoconference system in education. It adopts a complete set of software and hardware developed by VTEL and can implement mulitpoint bi-directional interactive network education.

IP/TV of CISCO: IP/TV is software developed by Cisco company, supporting video on demand and video broadcast. It adopts the client/server model and is mainly used for transferring high quality video, audio and data via computer networks. The system supports three ways of video transferring: live, on-demand and scheduled.

Multimedia Distance Education System of SATCOM: This system includes a program courseware generation system and a courseware on demand system.

2 Primary-Secondary Model Multimedia Network Teaching System

2.1 System Constituents

The primary-secondary model multimedia network teaching system is composed of three parts: the primary classroom system, the secondary classroom system and the courseware management system (See figure 1).

The primary classroom is where the teacher stays. In this classroom, the video and slide of the lecture are recorded synchronously. The video and slide information is broadcast live through multicast, and at the same time the information is stored in the courseware library for asynchronous use.

The secondary classroom is the classroom without the teacher, maybe a remote classroom. Students in this classroom can join the lecture by registering and playing the composite stream courseware synchronously with the primary classroom.

The courseware management system provides the directory service, user register management, asynchronous courseware on demand, and other management functions of the coureware library.

The free terminal can join the lecture from anywhere of the campus network through registering. It can also play courseware on demand from the courseware management system.

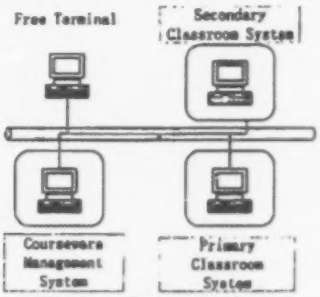


Figure 1 System constituents

2.2 System Structure

Figure 2 shows the structure of the primary-secondary model multimedia network teaching system. Its subsystems are as follows:

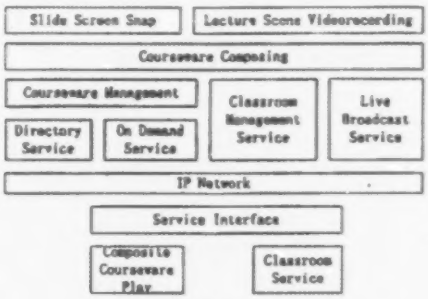


Figure 2 System structure

- Courseware synthesizing: The courseware synthesizing is the kernel subsystem of the primary classroom system. In this procedure, both the basic materials of the courseware – lecture scene videorecording and slide screen snaps are compressed into the composite courseware with synchronous timestamp. Afterwards, the courseware is stored into disks and multicast at the same time by the system.
- Lecture management service: The lecture management service is anther important subsystem of the primary classroom system, its main functions being registering new courseware in the courseware management system, requesting for the multicast address, configuring the multicast scope and lecture management.
- Directory Service: This is the kernel function of the lecture management system. It provides lectures and courseware lists and user management.
- On-demand Service and Live Broadcast Service: On-demand service is an asynchronous courseware service provided by the courseware management system while live broadcast service is a synchronous

BEST COPY AVAILABLE

service provided by the lecture management system. Both of them provide composite stream courseware to the user, the former using unicast and the latter using multicast.

- Lecture Service: This is an interactive supporting system provided by the secondary classroom system. With it students in the secondary classroom can participate in the discussion. The means of interaction may be keyboard typing, and speaking with a microphone.

2.3 System Characteristics

The main characteristics of the primary-secondary model multimedia network teaching system are the following:

1) It uses two streams to play the teacher's videorecording and slide screen snaps, and the quality of the slide screen snaps is the same as that of the slides in the primary classroom.
2) The lecture scene is kept in the archives in real time, and can be replayed at any time.
3) The teacher can discuss with students in remote classrooms through videoconference, and they can write on the same electronic white board.
4) The audience can have interlocution with the lecturer by text typing.

3 Implementing the System with Multicast

3.1 The Multicast Technology

By keeping routers informed about multicast hosts, multicast datagrams can traverse an internetwork and reach many hosts simultaneously. The ability to traverse an internetwork and reach an unlimited number of "member" hosts simultaneously without affecting others adversely is the linchpin of multicast. A Class D IP address in the range from 224.0.0.0 to 239.255.255.255 is a "multicast address." Each is also known as a "host group address," since datagrams with a multicast destination address can be received by all hosts that have joined the group that an address represents. Figure 3 shows the datagrams spreading abroad.

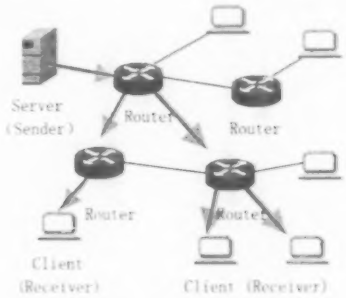


Figure 3 Datagrams sent only to hosts in a group

The mechanisms incorporated into WinSock 2 for utilizing multicast capabilities can be summarized as follows:

- Three attribute bits in the WSAPROTOCOL_INFO struct, which are used by **WSAEnumProtocols()** to discover whether multicast communications are supported for a given protocol;
- Four flags defined for the *dwFlags* parameter of **WSASocket();**
- One function, **WSAJoinLeaf()**, for adding leaf nodes into a multicast session;
- Two **WSAIoctl()** command codes for controlling multicast loopback and the scope of multicast transmissions (SIO_MULTICAST_SCOPE and SIO_MULTIPOINT _LOOPBACK).

We can benefit from using multicast to implement network teaching system, which can be described as the following:

1) Because the member of a multicast group is dynamic, and no authority is requested, the terminal can join or quit a group at any time;
2) All hosts belonging to a multicast group have a clear physics network topology;
3) All users in one subnetwork that join the same multicast group share the same stream over network, and this can greatly lighten the network load.

3.2 System Implementation

In the practical system, we adopt the combinative way of multicast and unicast: using multicast to broadcast information from the primary classroom, and using unicast to implement the interaction between the primary classroom and the secondary classroom. Figure 4 shows the structure of the practical system in detail.

The primary classroom system is composed of a server, a teacher's PC, a video recorder, two overhead projectors and an electronic white board. The teacher's PC is used to play slide of the lecture, and it projects the slide to the electronic white board. If the teacher writes something on the electronic white board, the teacher's PC will capture the written information and combine it with the slide. At the same time, the teacher's PC compresses the slide/written information and sends it to the server. The server takes charge recording the video/audio information, receiving the slide/written information from the teacher's PC, and broadcasting the information with multicast. At the same time, the server stores all information into special type file, which is the composite courseware.

The full function secondary classroom is made up of a server, a video recorder, two overhead projectors and an electronic white board. The server receives the video/audio and slide/written information from the primary classroom, and projects the video information on the white wall, the slide/written information on the electronic white board.

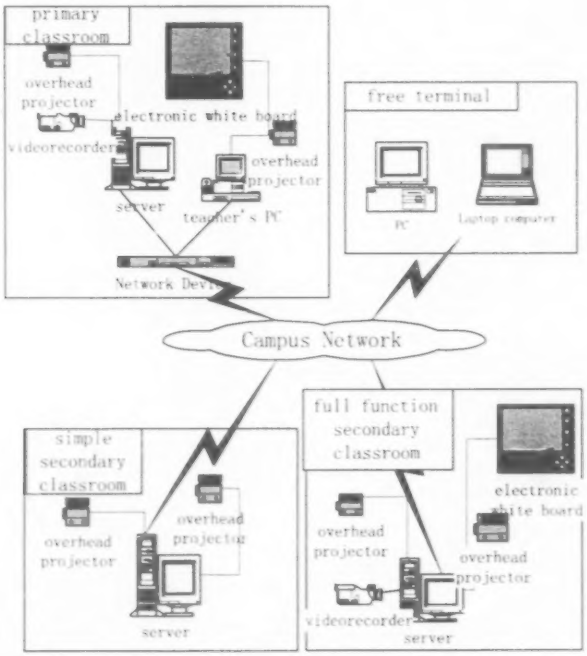


Figure 4 The topology of the primary-secondary model multimedia network teaching system

The simple secondary classroom is made up of a server and two overhead projectors. The server receives the video/audio and slide/written information from the primary classroom, and projects the information on the white wall separately.

The free terminal may be any PC connected to the network. It receives the video/audio and slide/written information from the primary classroom and displays it in different windows.

The teacher in the primary classroom and the students in the secondary classroom can discuss with each other. This is implemented with unicast. During the discussion, the server in the secondary classroom records the information of the students and sends it to the server of the primary classroom. The server of the primary classroom receives this information and projects it on the white wall. If students in the secondary classroom write something on the electronic white board, the servers will transmit the written information,

which will be shown on the electronic white board of the primary classroom at the same time.

4 Conclusions

In our experiments, we use lossless a compression algorithm and the slide screen snaps can be compressed to 1%~2%, it means that the slide screen snaps will take up 100~200Kbps bandwidth. In another side, the video information can be compressed into 128Kbps by MPEG-4 and all the information of this system can be fit in a 384Kbps channel. This system is available for long distance learning and of course for campus distance learning.

The primary-secondary model multimedia network teaching system has built a virtual network classroom system. It will play an important role in making better use of teaching resources and improving teaching efficiency.

References

[1] Jiang Dongxing, Lin Ehua, "Windows Sockets Network Programming", Tsinghua Univ. Press, (1999).

[2] Colin Perkins and Jon Crowcroft, "Real-Time Audio and Video Transmission of IEEE GLOBECOM'96 over the Internet", IEEE Communications Magazine, pp.30-33, (1997).

[3] Victor O. K. Li , Wanjun Liao, "Distributed Multimedia Systems", Proceedings of the IEEE, (1997).

[4] Song Yunxian, "The present and future of network education", Multimedia World, (1997).

Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming

Jun MORIYAMA
Department of Information and Technology Education,
Faculty of Education, Shinshu University
6 Nishinagano, Nagano City, Nagano, 380-8544, JAPAN
Phone: +81-26-238-4175
Facsimile: +81-26-232-5144
E-mail: junmori@gipwc.shinshu-u.ac.jp

The purpose of this study was to clarify the cognitive effects of collaborative learning on Junior high school students' Logo programming. Two experiments were implemented: *Experiment1* was an analysis of the relationships between interaction in pair activities and students' reflection. The effects of pair learning on students' promoting abilities of programming were analyzed in *Experiment2*. As the results of *Experiment1*, students' self-monitoring and self-control were supplemented each other through the interaction. Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

Keywords: **Collaborative Learning, Junior High School Students, Cognitive Effects, Logo Programming**

1 Introduction

In Japan, education about computer programming was placed in *Fundamentals of Information* of *Industrial Arts* at junior high school level from 1989. From 2002, programming, sensing and control will be placed in *Information and Computer* of *Technology* as an elective learning content (*Course of Study* published in 1998)[5]. Many technology teachers in Japan thought that teaching programming was not only for professional higher education. They didn't made points of understanding the function of software upon a computer system, but acquiring the problem solving skills through the programming activities.

Historically, many researchers suggested that one of the methods for acquiring the problem solving skills was collaborative learning. It was necessary for students to communicate and interact with someone who had same goal in collaborative environment (Deutsch 1949)[1]. In the recent past, it was supported that the experiences of solving the problem through the interaction made the processes of planning and decision making clearly each other, and would promote their self-control and self-monitoring when they would solve another problem all by themselves (SATOU 1996)[3]. In the case of learning about programming, KAGE (1997) suggested that 12-year old pupils showed vigorous verbal interaction, which led them to more sophisticated problem solving [4].

From these findings, it was predicted that acquiring the problem solving skills brought to promote students' programming abilities as a result of cognitive effects of collaboration.

The purpose of this study was to clarify the cognitive effects of collaborative learning on students' programming. For this purpose, two experiments by using Logo programming (Japanese Edition) were implemented. The aim of *Experiment1* was to clarify the relationships between interaction of collaborative learning processes and learners' reflection. The effects of collaborative learning on students' promoting abilities of programming were analyzed in *Experiment2*.

2 Methods

2.1 Experiment1

2.1.1 Subjects

Twelve 3rd grader Jr. high school students (6 males and 6 females) were divided into 6 pairs.

2.1.2 Instruments

"The Reflection Scale of Thinking Process on Computer Programming: RSTC"(MORIYAMA et al 1996) [2] and the modified LUTE (Link-UniT-Element) model (MORIMOTO et al 1997) [6] were used for measuring the level of reflection and analyzing the interaction, respectively. The RSTC was constructed from 4 factors as in Fig.1. Factor1 was the reflection of understanding the problems and enterprising how to make the program adequately. Factor2 was the reflection of designing the program and coding. Factor3 was the reflection of self-monitoring on each parts of the program on the local level. Factor4 was the reflection of self-monitoring on the whole program and renewal of problem representation.

Factor1 (6 items)	Factor2 (6 items)	Factor3 (5 items)	Factor4 (3 items)
Semantic understanding of the problem	Setting up the keywords	Predicting the result of running	Analyzing the bug
Imaging the command and grammar	Division of the program	Testing walk through the list	Renewal of problem representation
Comprehending the image of program	Setting up the functional unit	Checking the clerical error	Seeking the bug
Rhetorical understanding of the program	Connecting the functional unit	Checking the syntax error	
Seeking the semantically-related knowledge	Coding the functional unit	Checking the logical error	
Seeking the rhetorically-related skill	Checking the sequences of each commands		

Fig.1 The Reflection Scale of Thinking Process on Computer Programming: RSTC

The modified LUTE model was shown in Fig.2. There were categories for analyzing interaction of collaborative learning in this model, and this model had three abstract levels: element, unit and link level. The items of element level were categories for functions of protocols. The unit and link level categories were for phases and contexts in their programming activities.

Element Level (5 categories)	Unit Level (6 categories)	Link Level (6 categories)
Proposed	Phase of Analysis	Link for Formation of plan
Agreement	Phase of Plan	Link for Modification of plan
Question	Phase of operation	Link for Implementation of plan
Opposition	Phase of Edit	Link for Check of Implementation
Supplementary explanation	Phase of Checking the program list	Link for renewal of plan
	Phase of Checking the result of running	Link for renewal of implementation

Fig.2 The modified LUTE (Link-UniT-Element) model

2.1.3 Procedures

Subjects were asked to make the Logo program which draw the "*House*" constructed from triangular shapes, square patterns, circles and lines in pair. Their activities were recorded on a VTR. After they finished the task, they answered RSTC individually. Their protocols were extracted from the VTR and were categorized by using modified LUTE model. The level of reflection and the relative interaction in the collaborating pair were analyzed by ANOVA on mean scores of frequencies of link level categories and Coefficient of Correlation (r) between the RSTC scores and frequencies of the element and unit level categories.

2.2 Experiment2

2.2.1 Subjects

Sixty 3rd grader junior high school students (30 males and 30 females) were divided into 2 groups learning Logo programming. One was collaborative learning group (pair), and the other was individually learning group.

2.2.2 Instruments

The achievement tests and the RSTC were prepared. The achievement tests included both the coding test and the debug test. The coding test asked to make a program drawing "*Scarecrow*" on an answer sheet. The debug test asked to find three types of error, clerical error, syntax error, logical error from the program list which drew "*Spaceship*".

2.2.3 Procedures

The procedure was shown in Fig.3. At first, subjects had a coding test which draws the easy "*flag*" as a pre-test. Next, subjects were asked to make the program, which draws the "*House*" such as *Experiment1* and answered RSTC in every group as a middle-test. Finally, they had the achievement tests and answered RSTC individually as post-tests. The effects of collaborative learning on students' promoting abilities of programming were analyzed by using ANOVA and Coefficient of Correlation (r) between the RSTC scores and the Achievement tests' scores.

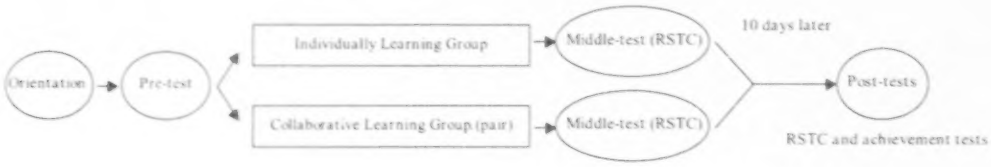


Fig.3 The procedure of *Experiment2*

3 Results and Discussion

3.1 Experiment1: Students' Reflections and Collaborative Programming

3.1.1 Contexts of Collaboration in the Pair Activities

There were differences of period of keyboard operation time in pair activities. In this analysis, long-operated learners were called *Learner A*, and the others (short-operated) were called *Learner B*. Mean scores of frequencies of link level categories were shown in Table.1.

Table.1 Frequencies of link level categories

Link Level Categories	Mean Score (S.D.)				ANOVA
	Learner A to B	*Learner B to A*	*Learner A to A*	*Learner B to B*	
Link for Formation of plan	1.75 (1.04)	2.00(1.77)	1.63(1.41)	3.50(2.73)	*n.s.*
Link for Modification of plan	3.35(2.12)	2.50(1.93)	0.25(0.46)	0.13(0.35)	$F(3,24)=8.397$, $p<.01$
Link for Implementation of plan	1.88(2.70)	15.63(5.80)	5.88(3.40)	2.75(2.49)	$F(3,24)=21.732$, $p<.01$
Link for Check of Implementation	3.75(1.49)	1.13(1.36)	1.00(1.07)	0.13(0.35)	$F(3,24)=13.055$, $p<.01$
Link for renewal of plan	0.38(0.52)	0.38(0.74)	0.13(0.35)	0.63(0.52)	*n.s.*
Link for renewal of implementation	0.63(0.92)	1.25(1.28)	0.25(0.46)	0.00(0.00)	*n.s.*

Results from Two-way Repeated Measures ANOVA showed that there were significant main effects of Links for Implementation of Plan from *Learner B* to *A* [$F(3,24)=21.732$, $p<.01$], and Links for Check of

Implementation from *A* to *B* [F(3,24)=13.055, p<.01]. Also, Links for Modification of Plan with interaction (*B* to *A* and *A* to *B*) were increased than that of individually links (*A* to *A* and *B* to *B*) [F(3,24)=8.397, p<.01]. These data indicated that the role of operation (*Learner A*) and the role of planning (*Learner B*) were shared in pair activities. However, it was suggested that consensus decision making through the interaction was important for building up their programming plans.

3.1.2 The Relationships between the Interactions and the Reflections

Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories were shown in Table.2. According to these data, when *Learner A* (operator) proposed something to operate, the reflection of designing the program (Factor2) was promoted in own thinking process [*r*=0.88, p<.01]. However, when *Learner B* (planner) proposed, the reflection of self-monitoring on each parts of the program (Factor3) was promoted in *Learner A*'s thinking process[*r*=0.88, p<.01]. Furthermore, opposition by *Learner A* correlated the reflection of self-monitoring (Factor3) in *Learner B*'s[*r*=0.71, p<.05]. Also, *Learner A*'s reflection of designing (Factor2) was promoted by the opposition of *Learner B*[*r*=0.77, p<.05]. These results indicated that the verbal communications on their interaction brought out their self-monitoring and self-control each other.

Table.2 Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories

Element Level Categories		Factor1		Factor2		Factor3		Factor4	
		Learner A	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*
Proposed	*Learner A*	0.41	0.26	0.88**	0.41	0.52	0.13	0.06	0.06
	Learner B	0.04	0.45	0.37	0.25	0.88**	-0.33	0.50	0.31
Agreement	*Learner A*	0.00	-0.10	0.31	-0.34	0.52	-0.66	0.26	-0.20
	Learner B	0.44	0.35	0.67	0.55	0.28	0.08	0.36	0.07
Question	*Learner A*	-0.32	0.56	0.27	0.28	0.56	-0.11	0.78*	0.23
	Learner B	0.40	-0.52	0.56	-0.29	0.00	0.02	0.03	-0.31
Opposition	*Learner A*	0.03	-0.30	0.27	0.08	0.13	0.71*	0.42	0.19
	Learner B	0.12	0.19	0.77*	0.23	0.52	0.27	0.68	0.00
Supplementary explanation	*Learner A*	0.72*	-0.35	0.61	0.13	0.03	0.40	-0.15	-0.01
	Learner B	-0.01	-0.34	0.32	-0.13	0.14	0.40	0.45	0.08

n=8, df=6, **p<.01, *p<.05

In addition, Coefficient of Correlation (*r*) between the RSTC scores and frequencies of unit level categories showed that, operation by *Learner B* as a planner conduced to *Learner A*'s self-monitoring on whole program[*r*=0.85, p<.01]. Also, task analysis by *Learner A* as an operator encouraged *Learner B*'s designing of the program[*r*=0.75, p<.05]. It was evident that one's reflective thinking was precipitated by the observation of the other's behavior which was supposed to be his own behavior.

These results of *Experiment1* suggested that students' meta-cognition (self-monitoring and self-control) were supplemented each other through the interaction of collaborative pair learning.

3.2 Experiment2: Effects on students' promoting abilities of programming

3.2.1 Acquisitions of Programming Abilities

In the pre-test, there are not significant differences between the pair learning group and the individually learning group [F(1,56)=0.65, *n.s.*]. Students who could get high scores were called *higher students* and the others were called *lower students* in this analysis (both 50% and n=30). In the middle-test, mean score of RSTC in the pair learning group (0.77) was higher than that in the individually learning group (0.56) [F(1,56)=32.40, p<.01]. This result supported findings of *Experiment1* because collaborative pair learning could promote students' reflections of thinking processes.

Mean scores of debug test were shown in Fig.4. Results from the ANOVA showed that the debugging scores of syntax error in the pair learning group was higher than that in the individually learning group [F(1,56)=4.75, p<.05]. But, there were not significant differences on the debugging scores of clerical and logical errors [F(1,56)=2.06 and F(1,56)=0.89, both *n.s.*]. These results indicated that collaborative pair learning could form students' debugging abilities against syntax errors, at least.

Mean scores of coding test were shown in Fig.5. The result from the Two-way Repeated Measures of ANOVA showed that there was significant interaction between *High-Low student* condition and *pair-individually* group condition [F(1,56)=10.46, p<.01]. Furthermore, from the results of Simple Main Effects Tests, the score of *lower students* in the pair learning group was promoted to the same level as *higher students* in both groups [F(1,56)=12.56, p<.01]. These results indicated that the coding abilities of Low-Ability students could be pulled up through the interaction with High-Ability students.

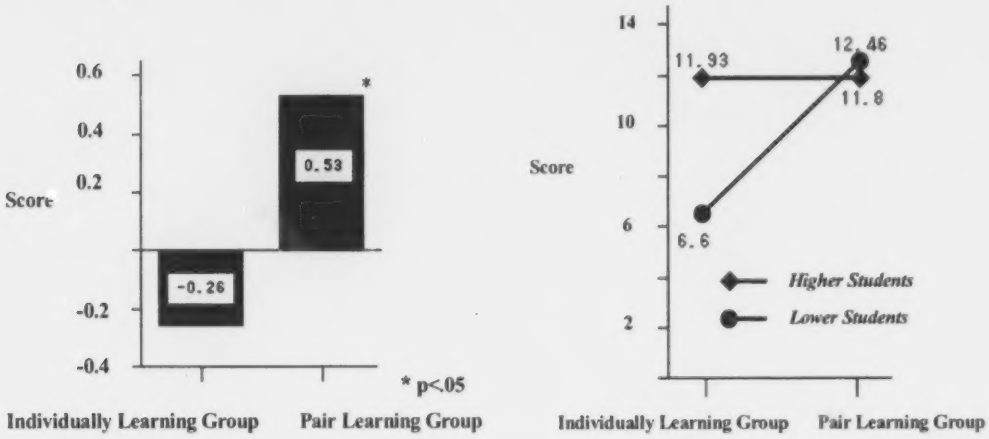


Fig.4 Mean scores of debug test (syntax error)

3.2.2 Acquisitions of Cognitive Strategies

Coefficient of Correlation (r) between the RSTC scores and the achievement tests were shown in Table3. According to these data, there were significant correlation between the coding test and the RSTC items: "Division of the program"(r=0.31, p<.05), "Coding the functional unit"(r=0.41, p<.01), "Connecting the functional units"(r=0.40, p<.01) and "Selecting the commands for each functional units"(r=0.40, p<.01) . Also, There were significant correlation between the debug test and the RSTC items: "Division of the program"(r=0.29, p<.05), "Checking the sequences of each commands"(r=0.33, p<.01). It was indicated that promoting these reflections were responsible for the development of the programming abilities. Furthermore, these items suggested the reflections of cognitive strategies for task division.

Table 3 Coefficient of Correlation (r) between the RSTC scores and the achievement tests

Items of RSTC	Achievement Tests	
	Coding Test	Debug Test
Division of the program	0.31 *	0.29 *
Coding the functional unit	0.41 **	
Connecting the functional units	0.40 **	
Selecting the commands for each functional units	0.40 **	
Checking the sequences of each commands		0.33 **

**p<.01, *p<.05

Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

4 Conclusion

In this study, it was clarified that students' meta-cognition and cognitive strategies could be acquired through the collaborative learning at junior high school level, also that the RSTC was useful for measuring students'

reflections in their programming activities. These findings will contribute to the researches of developments of collaborative learning systems.

For the future, learning processes and cognitive effects of more widely collaborative learning environment, for example, distributed programming by using CSCL system or long distance education for programming by using Internet, must be analyzed.

References

[1] Deutsch, M, An experimental study of the effects of cooperation and competition upon group process, *Human Relation*, 2: pp.199-232, (1949)

[2] Jun MORIYAMA et al, Structural Analysis of Thinking Processes on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 38-4: pp.255-262, (1996) (In Japanese)

[3] Kouji SATOU, Motivation for Learning and social context, *Cognitive Science 5: Learning and Development*, Tokyo University Press: pp.221-247, (1996) (In Japanese)

[4] Masaharu KAGE et al, Effects of Media and Learner Collaboration on Programming Education in Children, *Japan Journal of Educational Technology* 21-2: pp.93-105, (1997) (In Japanese)

[5] Ministry of Education, Science, Sports and Culture, Government of Japan, *Course of study for lower secondary schools in Japan*,(1989) (In Japanese)

[6] Shiro MORIMOTO et al, An analysis of Collaborative Discovery Learning Processes Based on Hierarchical Schema, *Cognitive Science* 4-2: pp.3-17, (1997) (In Japanese)

Note:

This study was revised and enlarged version of the following papers published in Japan:

Jun MORIYAMA, An Analysis of Collaborative Learning Process on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 41-4: pp.187-196, (1999) (In Japanese)

Jun MORIYAMA et al, Development of the students' abilities for Computer Programming through the Collaborative Learning, *Proceedings of the 42nd Annual Conference of Japanese Society of Technology Education*: p.21, (1999) (In Japanese)

Building Mathematics Collaborative Learning Web Sites

Weichung Wang*, Shiru Chern and Chiaming Liang
Department of Mathematics Education, National Tainan Teachers College
Tainan 700, Taiwan
**E-mail: wwang@ipx.ntntc.edu.tw*

How to make a good use of the Internet in teaching has become a kernel question for educators recently. Surveying research findings and exploring existed related web sites, we suggest three cornerstones of such kind of web site: usage of multimedia, online collaborative courses, and automatic material submitting system. Taking mathematics as our target subject, we build a mathematics collaborative learning website prototype.

Keywords: **Web-based collaborative learning, multimedia, constructivism, submitting system**

1 Introduction

The Internet has greatly changed the way of learning and teaching. For example, teachers and students now can communicate with each other by sending E-mail. They can access learning material and resources through the World Wide Web. Students can even complete a project by cooperating with other people form all over the world. The Internet has becoming the main medium to acquire and share educational information. [6, 12] However, difficulties do exist while applying the Internet toward education. One of the main difficulties is the lack of online resource. Because of the limited educational resource, students usually simply surf the Internet rather than learn knowledge from the net. [14]

This study intends to find some feasible ways to enrich the educational resource that suitable for the Internet. Each of the following three sections focus on one of such ways: (1) using multimedia learning resources, (2) embedding collaborative learning spaces, and (3) gathering web-based learning resources. In each section, we first survey related research findings and existing educational web sites. Our analysis induces important factors of a successful web-based learning space. Applying these suggestions, we build a prototype web that help elementary school students to learn mathematics.

2 Multimedia learning resources

Many researches showed that learning material should be demonstrated by multimedia to achieve better learning effects. C.S. Lin [7] indicated that online courses should be presented by multimedia like visualization, auditory, and even three-dimensional virtual reality. Such multimedia courses make students understand knowledge in a correct manner. Furthermore, multimedia courses often enhance user's long-term memory due to its elaborated and organized information. Blake and Sekuler [1] claimed that visual stimuli usually play an important role for providing various resources. Especially for mathematics and science subjects, combination of texts and images can effectively demonstrate the concepts to be learned. Paivio [10] proposed the Dual Coding Theory suggesting that peoples' memorization systems include verbal and non-verbal system. L.J. Lin [8] further showed that the knowledge encoded by both verbal and non-verbal system could be memorized easier than the knowledge encoded simply by verbal or non-verbal system alone. Y.R. Chen [2] argued that background music presented in computer-aided learning affects the feeling of the learners.

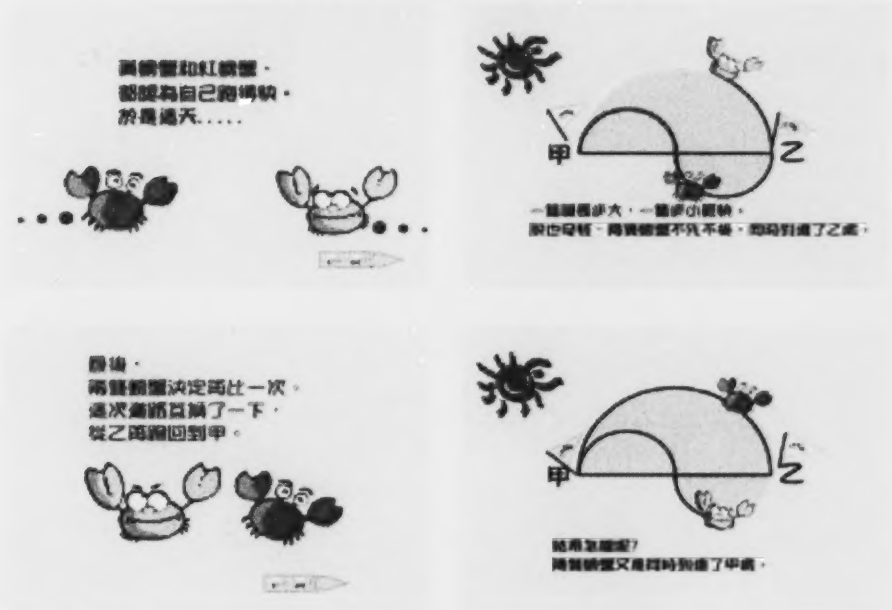
Many mathematics web sites provide mathematics related stories. However, based on our experience on the web sites listed on Table 1, most of them use only texts to present the stories, which is not coincidence with the research findings discussed above. In our web site, we composed mathematics stories by using

animations. The animations contain voice, background music, images, and texts. Each of the stories demonstrates a mathematical concept, question, or mathematician biography. As an example, Figure 1 demonstrates screen snapshots of a multimedia mathematics stories.

Table 1: List of some mathematics web sites.

Web site	Web Title
http://dns.eses.tnc.edu.tw/	The WWW of Er-shi elementary school
http://www.netvigator.com.tw/~goodmath/	Funny Mathematics Web
http://www.tacocity.com.tw/ghsghs/	The home of Su-Horng Math prince
http://www.enc.org/classroom/claslinx/nf_resmath.htm	Classroom Links-Math
http://www.mathpro.com/math/glossary/glossary.html	On-line Mathematics Dictionary
http://www.cut-the-knot.com	Interactive Math Miscellany and Puzzles
http://www.c3.lanl.gov/mega-math	Mega Mathematics
http://math.rice.edu/~lanius/frac	A Fractals Lesson
http://ois.unomaha.edu/drfreemath	Dr. FreeMath
http://group.estmtc.tp.edu.tw/math/	A Math amusement park on Internet
http://acorn.educ.nottingham.ac.uk/cgi-bin/daynum	About Today's Date
http://www.eduplace.com/math/brain/	Brain Teasers
http://www.cs.yale.edu/homes/tap/past-women-math.html	Past Notable Women of Mathematics
http://math.rice.edu/~lanius/frac	A Fractals Lesson
http://www.ed.gov/pubs/parents/Math/index.html	Helping Your Child Learn Math

Figure 1. Screen snapshots from a mathematics story named "A Strange Competition."
The story introduces the concept of distance.



3 Embedding collaborative learning spaces

Intensive researches have recently focused on how to use network to assist students' collaborative learning. Ho and Kuo [5] divided network-based learning into two models: collaboration and competition, since the Internet allows many people to use the net simultaneously to achieve a common goal. Chou and Sun [3] summarized advantages of collaborative learning over the Internet as following. (1) Students can learn different opinions and ideas, so that they can understand the topic in different viewpoints. (2) Collaborative

BEST COPY AVAILABLE

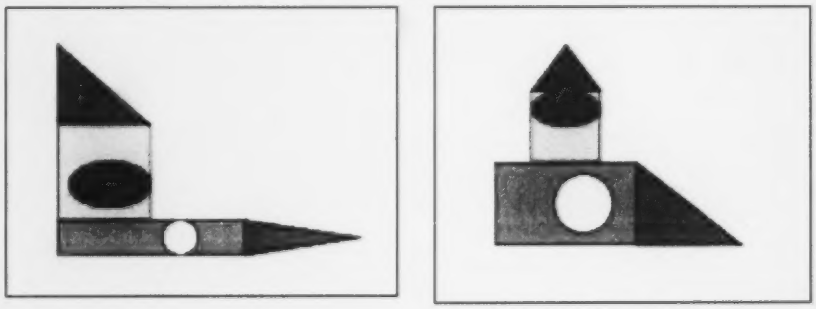
learning encourages communication and sharing of personal and team experience and knowledge. (3) Students need to demonstrate and explain the contents and knowledge that they have learned. Through this articulation process, old and new knowledge would be integrated and new knowledge can be expended to other applications. (4) Collaborative learning promotes the feeling of participation and identification. On the other hand, their paper also showed that competition style computer-assisted instruction systems motive students' learning better than traditional computer-assisted instruction systems. But the competition mode causes higher anxious feeling.

Since current curriculum in Taiwan emphasize learning in a group collaboratively, rather than to compete with each other. Research findings shown above also support collaborative learning over the Internet. We design a collaborative learning model on the Internet. Our model encourages collaboration but try to avoid unnecessary competition. Following example explains the model in detail.

This example helps students to learn colors and shapes. Learners can plot various shapes like triangles, squares, rectangles, and circles on the computer. He or she can then color each shape that just drawn. While the shape is drawn and color is chosen, their names are shown and read by the computer. In this way, learners learn the names of shapes and colors. After drawing the graph, learners may write a detailed description of what he or she just finished. The description is then sent it to his or her partner by E-mail. The partner then draws the graph according to the description. Due to the difference of reading and writing skills, two graphs may be in large diverse. Such differences also generate a lot of fun. See Figure 2 as an example. The system also provides synchronous and asynchronous communication tools. Synchronous tools are message passing and chat room; asynchronous tools are discussion board and E-mail. Learners can choose an appropriate way to learn.

During the learning process, learners should describe the picture in words, which means the learners must know the names of colors and shapes. This activity of learning on the Internet not only achieves the goal of collaborative learning, but also trains the ability of communication. It also develops learns' creation and thinking abilities. Furthermore, it makes learners get along with their partners better and happy.

Figure 2. Screen snapshots of the graphs that different learners drawing.



4 Automatic mechanism for gathering web-based learning resources

We have suggested composing multimedia mathematics stories and collaborative project on the web. To accomplish these tasks, however, can be very time consuming. Single person can produce very limited material and thus resource sharing becomes important. As suggested by Engkavahnish and Sujira [4], information exchange and resource sharing is very important nowadays. Vaughan and Sandrairene [11] also indicated that the society today usually share the resource to save precious timing and money.

Therefore, we construct a mechanism allowing people to submit their learning material to the mathematics learning web site. In this way, rich resources may be created quickly and then be widely shared. One of the important functionality of the system is to allow people to submit their works of multimedia stories or learning material. People can upload related files to the server via web browsers. The developer also needs to fill out simple forms, like subject of the work and type of the files, to assist classification of their works. The files will be stored and put online based on their properties. Such automatic process to classify works systematically not only save a lot of manpower, but also greatly increase the accuracy of classification. Once

the classification is done, learners can search the whole site in a systematic way to find what they want easily.

Classification is important for a database and automatic document classification is a kernel problem for improving the accuracy and efficiency of searching. Consider three ways to explore information from the Internet (surfing, browsing, and searching,) two of them (browsing and searching) need the data be organized first. Our system adopts Extensible Markup Language (XML) to implement the classification of the web pages. See [9,13] for more information about XML. Tags of classification fields are defined in the XML clip. Such technology improves the efficiency of data exchange and provides a metadata (data of data) of each of material web page.

5 Conclusion

Rapidly changes of technology affect each of us in all aspects. These changes affect students and their future significantly. In this study, we have suggested three essentials of a successful mathematics collaborative learning web site. We have implemented a prototype of elementary mathematics learning web using these three factors. We hope these suggestions may benefit the education community for building more and more better educational web sites.

References

[1] Blake and Sekuler, "Perception (3rd ed.)" New York, Alfred A. Knopf, (1994).

[2] Chen, Y. R, "The Applications of Audio in CAL", The 7th International Conference on Computer-Assisted Instruction(ICCCAI'98), R.O.C pp.170-177, (1998).

[3] Chou, C. and Sun, C.T, "Collaborative CAI by multimedia on the Internet", Teaching information and multimedia, Vol 21, pp.13-21, (1995) .

[4] Engkavanish and Sujira "Analysis of the effectiveness of communication and information sharing in virtual project organizations" DAI-A 60/04, Oct , pp 12-21 (1999).

[5] Ho and Kuo, "Using multimedia computer in teaching on the Internet", Information and Education,Vol 55. pp.25-31, (1996).

[6] Iseke-Barnes, J. M, "Issue of education uses of the Internet: Power and criticism in communications and searching", Journal of Educational Computing Research, Vol 15, No1, pp.1-24, (1996)

[7] Lin, C. S, "The design and application of Internet learning environment", Information and education, Vol50, pp.34-42 (1998).

[8] Lin, L. J, "Computer Animation for Different Learning", The 7th International Conference on Computer-Assisted Instruction(ICCCAI'98), R.O.C, pp.73-80, (1998)

[9] Liu, G. C, "Manage system and network via XML", Network information, pp.142-148, (1999).

[10] Paivio, A, "Mental representation: A dual coding approach", New York, Oxford University Press, (1990).

[11] Vaughan and Sandrairene., "Information sharing and cognitive centrality patterns in small decision-making groups of executives (small groups)", DAI-B 60/04, Oct, pp.19, (1999).

[12] Wu, M.L., "The revolution of information and education", Information and Education, Vol 66, pp.40-46, (1998).

[13] Wu, S.X., "Navigation Control in Web-based Courseware with XML", pp.45-52, (1999).

[14] Wu, T.S., The utilization of computer networks in school: a case study of Taiwan. The 7th International Conference on Computer-Assisted Instruction (ICCCAI'98), R.O.C, pp. 446-453, (1998).

Collaborative Learning using GSS on the Internet

Pen-Choug Sun, Nian-Tsz Liou, Ya -Wen Cheng, Hui-Chien Ni and Hui-Fen Lian
Alethia University
32 Chen-li street, Tamsui, Taipei county, Taiwan, R. O. C.
Tel: 02-2621-2121 ext 5531
E-mail: pcsun@email.au.edu.tw

In Collaborative Learning, students learn in a team and play a good roll in the. We use the GSS (Group Support System) to improve the efficiency of learning on the internet. This paper also introduces the implementation of a collaborative learning game on the Internet.

Key word: **Collaborative Learning, Group Decision System, Team-game.**

1 Introduction

Collaborative learning focuses on the function of the team to inspire the learning motivation and improve the learning performance. Many social psychology mechanisms of cooperation and competition are used in Collaborative Learning to achieve learning goal of a team. Collaborative Learning has been regarded as a positive way of teaching. In our Internet Collaborative Learning model, we use the GSS to improve the efficiency of learning. These systems were all proofed to be efficient on communication, task performance and process completion.

2 The Collaborative Learning on Internet

Slavin considers that Collaborative Learning as to put the learners into the team' s missions, offer the reason of cooperation and the motivation of group, and the collaborative behavior as a result.

The team of Collaborative Learning has five characters (Johnson,1994): (1)The positive dependence relationship (2)Personal responsibility (3)The skill of cooperation (4)Face-to-face interaction (5)Student' s reverse thinking. Usually, there are two ways to classify students in a team: (1)Student with the same ability in the same group (2)Student with the different ability in the same group.

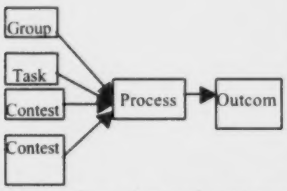
Traditional Collaborative Learning was restricted by time and distance. It can' t satisfy student' s abundant demands gradually. Collaborative Learning on the internet has various merits at traditional learning could not complete. Learning and communication on the internet is so popular that the internet become another fabricated society. According to the internet' s characters, the merits of learning on the internet are: (1) The users are the central of the Internet environment (2) More convenient and simple (3) The users can control the process by himself (4) Resources can be get and absorbable quickly (5) The content of course should be renewed and exchanging information quickly (6) Promoting users contract technology and using it to learn (7) In anonymous way to heave problem, and it can be answered by the other users (8)It offers new and interesting system.

As now the Internet technology, people can accomplish communication through CMC (Computer Medium Communication). According to Walther(1992) definitions that CMC is a computerized communication tool to proceed communication by synchronous or asynchronous. In a synchronous communication, users have to connect Internet in the same time. They can meet each other on the Internet through texts, pictures or voices such as Video Conference System. It' s not necessary for people to present on line in the same time when they do asynchronous communication. The asynchronous communication tools are quite popular such as E-mail, electronic board or news-group. The collaborative learning can be classified into two kinds when we consider the communication way that group member used. There is no limitation both in time and space for

internet communication. The scholars always look forward to doing the collaborative learning actives on the internet. Now it can realize on the Internet and also can practice diversely and exquisitely.

3 The study of GSS and Collaborative learning

Group support systems(GSS) is the information system that contain communications, technology, computer science and decision model. By lowering the communication problem between the members and guided group discussion systematic to improve the efficiency and functional of group missions. GSSs is based on the environment of information technology to support any kind of times, places and mission association of group meeting proceed. The definition of information technology environment contain many different kind constitution of software hardware degree, model any kind of group mission, including communication, plans, brain arousing, solving problems point discussing, negotiator discussion settling conflict and the other kind of group actives.GSSs have five characteristics: anonymity, parallel communication, group memory, coordinate function and medium effect.



The structure of GSS : Nunmaker brought up the the structure of GSS.
Group communication interface: With information technology developing, communication can use many different kinds of media, for example letters, oral conversation have different support effects. It also means that different GSSs characteristics need different medium.

In collaborative learning environment, it provides anonymity. The user can show his opinion without explore his ID, therefore he is no need to worry about others view and concentrate on discussion. During these years, the study of GSSs assist collaborative gradually attracts scholars interesting, but the result is not complete. If students using a GSS assist collaborative learning system , they will find it' s better than tradition collaborative learning.

Our system is basically a jungle game. It contains Astronomy and science, Land-organism, Ocean-organism, and Common sense of nature. The system interface include (1) Registration area (2) Role Selecting area (3)Game area (4)Score List (5) Public discussion area (6)Team private area.

4 Conclusion

In the collaborative learning environment, the strategies of GSS can help students improve their learning, the cognition of knowledge, and the ability to deal with problem. The GSS has been proofed to be a useful tool for the teamwork to smoothen the task. It provides a good environment where users can communicate with group efficiently and anonymously. The users can gather more useful information than ever. The information technology has made a lot of progress in these few years. If the characteristics of information technology can be well used by the educators, the students can also learn how to cooperate with each other while they accumulate knowledge.

In the collaborative learning, there is cooperation among members and competition between groups. The members of same group had to learn to solve problem together and get a high score together. The only way to defeat other groups is to stimulate one' s ability and to unite the whole team together. We hope that one day there are full of CAI games of collaborative learning on Internet. Then the children have chances to make friends and to do entertainment while they learn.

Reference

[1] Alavi, M. "Copmuter-Mediated Collaborative Learning: An Empirical Evaluation.", MIS Quarterly, 18(2), 159-174. (1994)

[2] Desanctis,G., & Gallupe, R.B.X. "A Foundation for the Study of Group Decision Support Systems." Management Sciences, 33(5), 589-609. (1999)

[3] Pen-Choug Sun, "The Personalized Learning Instructional Game Model", Advanced Research in Computers and Communications in Education, vol. 1, p. 1087, (1999)

[4] Jessup, L.M., & Valacich, J.S.(1993). "On the Study of Group Support Systems: An Introduction to Group Support System Research and Development." In L. M. Jessup & J.S. Valacich (Eds.), Group Support Systems: Newperspectives. (pp.3-7). New York: Macmillan Publishing Company

[5].Johnson, D.W., & Johnson, P.T. "Positive Interdependence: Key to Effective Cooperation. In R." Hertz-Lazaowitz & N. Miller (Eds.), Interaction in Cooperative Groups. (pp.174-199). New York : Plenum Press. (1992)

[6] Johnson, D.W., & Johnson, R.T. "Copperation and Competition: Theory and Research", Eduna,MN: Interaction Book Company. (1992)

[7] Johnson, D.W., & Johnson, R.T. "Learning Together and Alone: Cooperative, Competitive, and Individualistic Learning." (4th ed.), Needham Heights, Massachusetts: Allyn and Bacon. (1994)

Cooperative Monitoring System using Mobile Agent

Young-Gi Kim, Sun-Gwan Han, Jae-Bok Park
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1283
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
young7@compedu.inue.ac.kr {fish,jbpark}@eslab.inha.ac.kr

This paper is a study on the design and implementation of the cooperative monitoring system using a mobile agent for an educational portal site. Generally educational portal sites have many addresses of teacher's homepage related education. Therefore, portal site has a very difficult task with maintaining a consistent address of site as well as it is impossible that administration of portal examines all dead sites in searching education site and DB. In order to solve this problem, we designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. This monitoring system applies to the Korean educational portal site (KEPS) for elementary students and teachers. For efficiency this system, we made an experiment that compared a cooperative monitoring agent system with a stationary monitoring agent system.

Keyword: **Education Portal Site, Cooperative Monitoring System, And Mobile Agent**

1 Introduction

Today, the advent of the web that can easily be connected through the "Internet" is known to be an easy and popular method for teaching and learning. Web-based educational homepages are used in many computer assistance medias and also the numbers of educational sites are on the increase extremely.

An extremely increase in number of homepage raises a question whether a student can search appropriate homepage for learning. In case of finding educational contents using a general searching engines, the searched site can exist an irrelevant contents against a student's request. Moreover the result of searching content fell into learning confusion, because the contents are difficult to apply at learning intact.

In order to overcome this problem, an educational portal site was constructed to gather only educational homepages that had been made several times before. An advantage of educational portal site is that content is used correctly and rapidly in learning because searching site is well constructed. In addition student can easily get suitable contents. For gathering of an educational homepage, an educational portal system, called KEPS, was constructed by the EDUNET and Inchon National University of Education.

While walking past a type of the gathered homepage in KEPS, it can be seen as to make not by an expert institution or a special company but by a teacher and a private person. As a result, characteristic of the homepages have to be petty and is frequently updated. Because the educational homepage can disappear easily, portal site faces difficulty to maintain consistency of the site address. If a hyperlinked address of a portal site is not connected or the retrieval site is disappeared to user, then this portal site may bring discredit to student. In order to maintain consistency of portal, the administrator of portal site must validate all addresses of site. But this examination is impossible work that man completely manages and finds. Consequently, a monitoring of a site address for finding the dead site can be process by an intelligent agent instead of human.

A single agent needs comprehensive amount of time required for the monitoring of a portal site. If a single agent examines extremely a many site addresses, the monitoring work may be inefficient. Because a mobile agent is possible with decentralization and a parallel processing, the monitoring works using a mobile agent

can be process effectively [5].

Accordingly, this study designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. In the following section, the mobile agent and monitoring scheme will be surveyed and the overview of the structure of monitoring agent will be designed. And the next section will be focused on implementation and experimentation of monitoring agent system. Finally the conclusion and future works will be described.

2 Mobile Agent and Cooperative Monitoring

The agent is a program with intelligent characteristics to help the users with the use of computers and take the user's place. The intelligent agent perceives any dynamic stimulation or condition and interprets the data collected for a solution to the problem and exercises reasoning for a final decision. It also acts to change the conditions within its environment in order to perform assigned duties. It has autonomy, social ability, reactivity, pro-activeness and a cooperative relationship, learning, mobility, and so on [9].

Generally an agent divides a kind of two by the mobility, a stationary agent to be executed roles in single system, while the mobile agent is executed at various systems after moving through the networks. An execution example of the mobile agent is shown in figure 1 and the mobile agent based environment is viewed figure 2. The mobile agent server must be installed to act a mobile agent as figure 2.

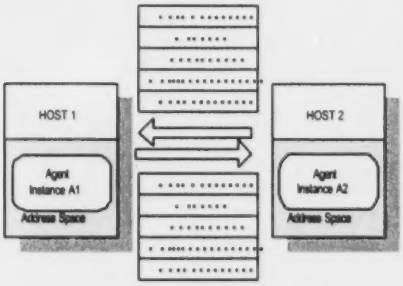


Figure 1. Execution of mobile agent

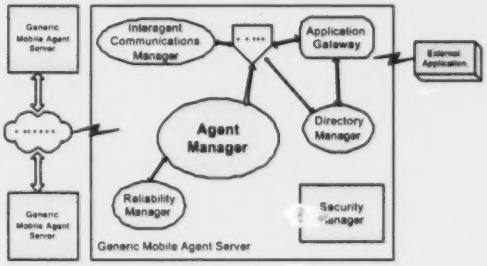


Figure 2. Mobile agent based environment

The mobile agent has a specific characters listed below compared with a stationary agent [5][6].

- The mobile agent reduces the network load.
- The mobile agent overcomes network latency.
- The mobile agent encapsulates protocols.
- The mobile agent executes asynchronously and autonomously.
- The mobile agent adapts dynamically.
- The mobile agent is naturally heterogeneous.
- The mobile agent is robust and fault-tolerant.

In the information retrieval, a monitoring work ascertains a state of gathering sites for the maintenance of data consistency. Generally, because the information of the web is changed frequently, a monitoring job by human is an impossible or inefficient work. This monitoring job can be processed by intelligent a computer program instead of a human. Such a program is called the web robot or an intelligent agent system [10][11].

In case of examining many sites in the monitoring work, if a single agent of the only server processes monitoring work, then the monitoring work may be needed long time and overloading of a monitoring server. The mobile agent has made possible cooperative and speedy monitoring job from distribution and parallel processing [8][11].

3 Cooperative Monitoring System

3.1 Overview of System

BEST COPY AVAILABLE

Overview of the KEPS system, including the temporary monitoring agent system is shown figure 3.

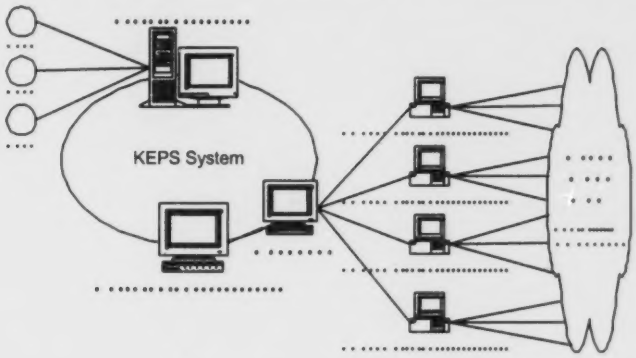


Figure 3. Overview of system

The portal system is consisted of four parts. There are the portal web server (PWS) and the monitoring agent server (MAS), the temporary monitoring server (TMS), a mediator. For using educational portal service, user must be connected with the Portal web server. Gathered address of an educational homepage is supported searching service of an education contents to user through the Portal web server. The Portal web server has searching engine, site DB and a query processor. The monitoring agent server has a stationary monitoring agent and a cooperative mobile agent, error DB, a mobile agent server. Also the monitoring agent server performs works as a creation and an allocation, a control, a gathering of the monitoring mobile agent. For the mobile agent perform it's task fully, each server is installed the mobile agent server necessarily.

The temporary monitoring servers are in existence out the KEPS system. In order to process a fast monitoring work, the TMS have function of distributed and parallel processing. The number of TMS is not fixed but dynamic by amount of monitoring job. Furthermore the TMS is used in temporary palace which mobile agent examines each a state of the registered site. At ordinary times, the TMS is not used usually for examining a state of the registered site. However the TMS can be only used when is requested by the mediator agent server.

The mediator is situated between the monitoring agent server and TMS, and acts as the role of mediation with the mobile agent and servers. All agents and agent servers must be registered in the mediator.

3.2 Design of KEPS System and Cooperative Work

The structure of the KEPS System is detail shown figure 4. The portal web server is consisted of searching engine and query processor, is shared the gathering DB of portal site. The searching engine provides searching service about education content and the query processor is shown the result searching at DB. The monitoring agent server is consisted of inference engine and agent manager, error DB. The monitoring system in monitoring agent server has a stationary agent and a mobile agent for distribution and parallel working. A stationary agent examines the state of gathering site and the confirmation of HTML documents through HTTP connection. After a failure sites are saved at temporary error DB, these will be deleted from site DB of portal web server. A permanent deletion of fail sites is executed by inference engine of the monitoring agent server.

When a monitoring agent server is overloaded or the stationary monitoring agent has difficulty processed by examination with many site, the monitoring agent server requests to the mediator about information of the registered TMS. If the number of the TMS is lacking, the monitoring agent server waits until the TMS becomes sufficient. Having sufficient number of the TMS, the mobile agent is created to divide as a suitable size of address by inference engine. And then the mobile agent has been created by a monitoring agent server, will be cloned with suitable number. Each mobile agent is allocated a monitoring work and will be dispatched to the TMS through ATP connection. The mediator agent can grasp each work states of an agent by using the agent finder.

Each agent is moved to temporary monitoring server and examines the allocated addresses of sites through HTTP. When a mobile agent is finished all checking of sites, it sends to the monitoring agent server with the result of observation. If the job of the mobile agent is occurred some problem, monitoring agent server creates a new mobile agent and re-dispatches to the TMS. All results gathers, result of examination saves at site DB and error DB. Finally, dispatching the agents retracted by the monitoring agent.

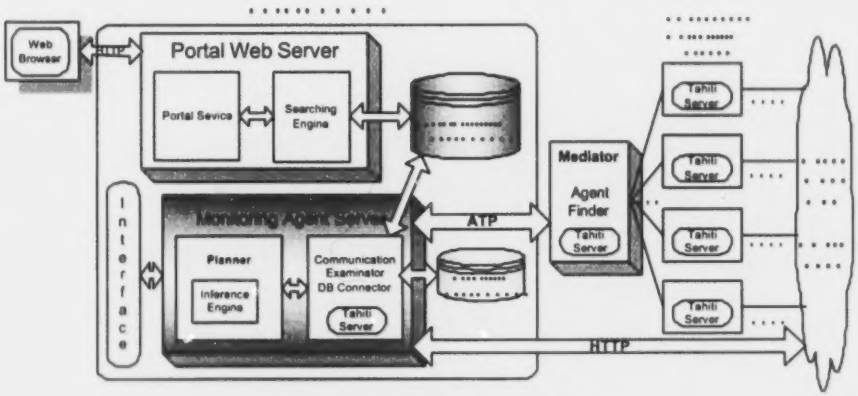


Figure 4. Structure of the KEPS system

The processing algorithm of execution about monitoring working is shown figure 5. The job of monitoring using the mobile agent has advantages that prevent an overloading of a single server and lessen monitoring time by distribution and parallel processing. Because agents are not used stationary server but are dynamically used in other servers, all servers performed share resources of monitoring system. Accordingly, each agent can do cooperative parallel processing using autonomous and society properties of agent.

4 Implementation and Experiment

4.1 Implementation and Application of System

The monitoring agent system proposed in this study was implemented two types. The stationary monitoring agent was implemented by using VC++ and CLIPS. Also the mobile monitoring agent system proposed in this study was implemented using JAVA based Aglet API and JESS. Aglet is the java class library for that can easily design and implement all the properties of the mobile agent. Moreover the Aglet provides with the Tahiti server and Agent finder for helping research of users.

The stationary monitoring agent interacts with the mobile agent of Tahiti server based environment. Inference engine of the stationary monitoring agent was used the CLIPS dynamic linked library and the mobile monitoring agent system was used the JESS class library. The CLIPS and JESS are rule based inference engine and was used to infer planning and allocation of the mobile agent. SQL was used for the gathering DB of portal site. ODBC and JDBC were used to connect the monitoring agent system and the gathering DB of site.

BEST COPY AVAILABLE

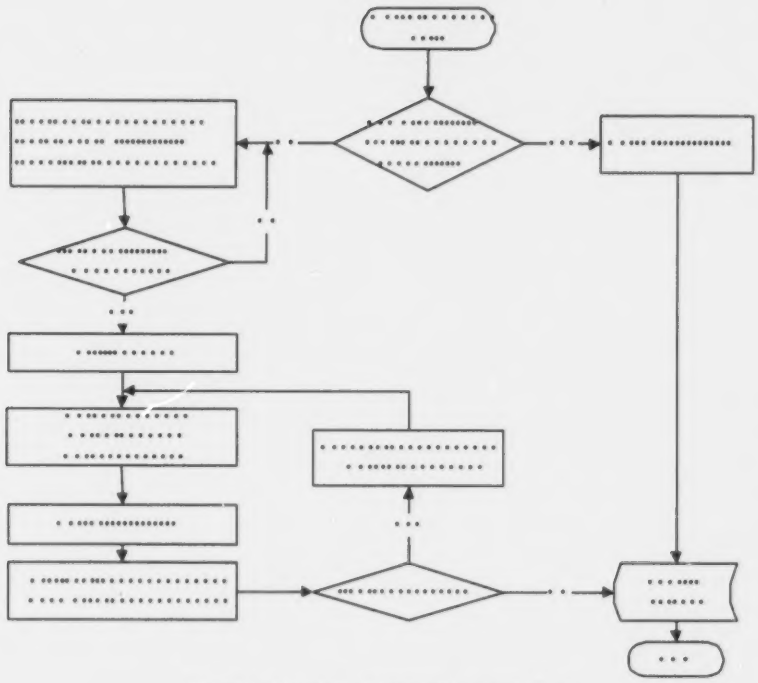


Figure 5. Algorithm of monitoring procedure

Figure 6 below is image of the interface of the stationary monitoring agent by making VC++. Figure is shown that the single monitoring agent is examining each site. The stationary monitoring agent was consisted of three parts mainly. The left screen of figure is represented list that the agent will examine site of DB. Also the center of screen is viewed results of a successful site and the right screen is represented results of a failure site.

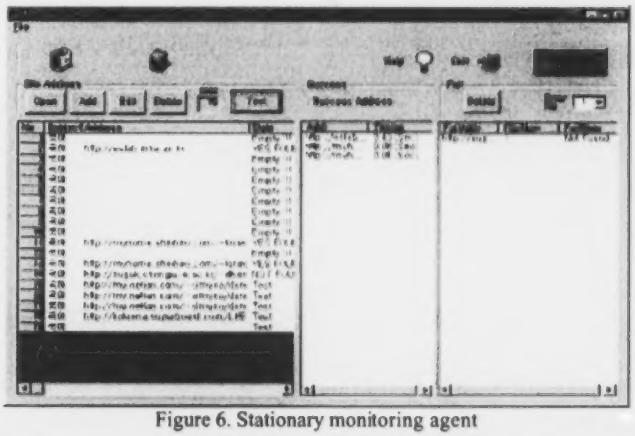


Figure 6. Stationary monitoring agent

Figure 7 is shown screen that the mobile monitoring agent is examining each site with distribution and parallel processing. If the numbers of sites are many in existence, the stationary monitoring agent executes the mobile agents to interact with the Tahiti server as followed image. Above window of figure is represented the stationary monitoring agent. Black screen below is viewed that mobile agent sever is executed by the stationary monitoring agent. Small screen below is shown the Aglet viewer. The Aglet viewer perform an important role as a creation, dialog, dispose, cloning, dispatching, retracting of a mobile agent.

BEST COPY AVAILABLE

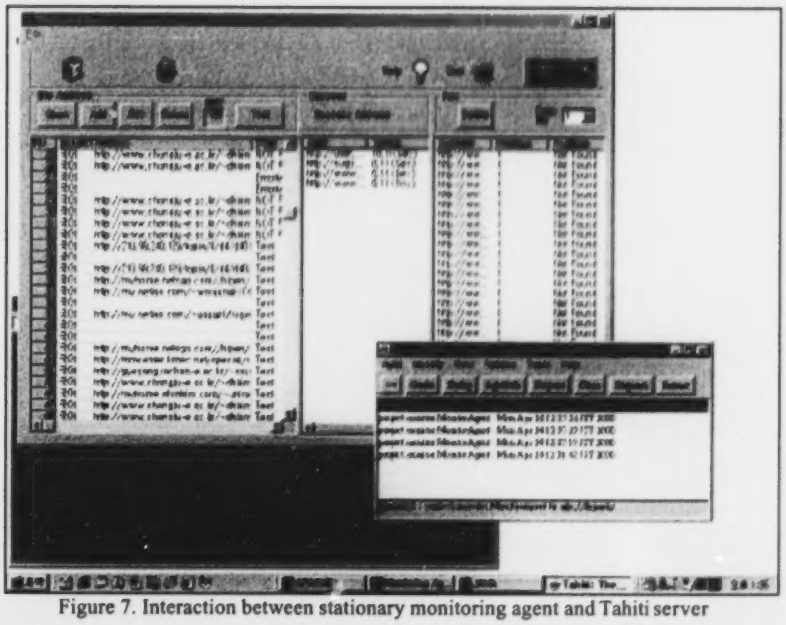


Figure 7. Interaction between stationary monitoring agent and Tahiti server

In order to use the implemented monitoring system in this study, we applied at the educational portal system and the KEPS system in the EDUNET server. Figure 8 is shown the searching screen of the web browser using KEPS system. This portal site in the EDUNET was constructed for the Korean elementary student and teacher. Also this site contains all contents about the curriculum of the Korean elementary school.

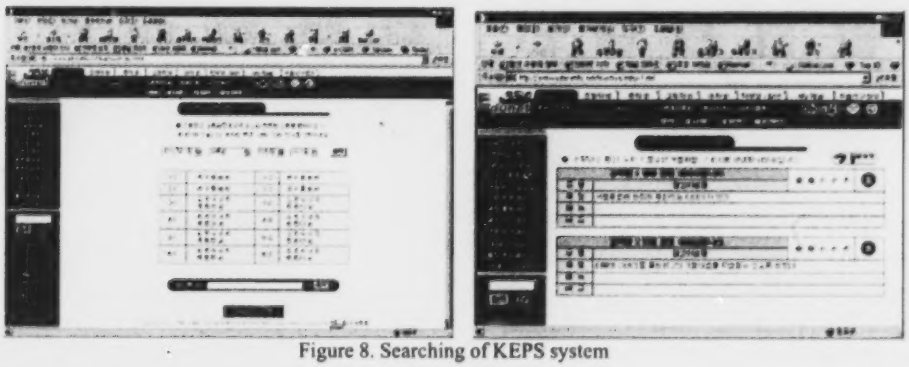


Figure 8. Searching of KEPS system

4.2 Experimental Results

For examining the efficiency of the cooperative monitoring system using the mobile agent, we compared and evaluated a monitoring time of each agent system. A comparative and estimative items listed below are as followed.

- Comparative item
  - *The single stationary monitoring agent vs. the cooperative monitoring agents.*
- Estimative items
  - *The monitoring time of the single monitoring agent*
  - *The monitoring time of the cooperative monitoring agents(3)*
  - *The monitoring time of the cooperative monitoring agents(7)*
  - *The number of sites: 10,30,50,70,90,110,130,150,170,190 ..etc.*

BEST COPY AVAILABLE

The experiment measures examination time of sites using a comparative and estimative items above. The estimative result is shown Table 1 and is represented figure 9 with form of graph. The horizontal axis of graph is represented the number of site and the vertical axis of graph is represented monitoring time of each agent.

In case of the number of an examine site is small, the result of experiment is viewed that the single stationary agent is faster speed of examination than the mobile monitoring agent. Also, when mobile agent is dispatched to three servers, speed of examination is faster than is dispatched to seven servers. The reason is caused by overtime occurred because the many mobile agents are created, allocated, gathered.

However, the more the number of site increases, the faster the mobile monitoring agent gets speed of checking than the single stationary agent. In particular, when the cooperative monitoring system using many agents, experimental result is shown that a speed of examination is very fast. If a single stationary agent processes very many sites, the result of execution can be useless though the result is very accurate.

Consequently, the cooperative monitoring agent can become higher execution speed by distributed and parallel processing and an overload of network by using a mobile agent can be decreased. If a server has an active environment of the mobile agent, the servers can be used with an active space of a searching agent and a monitoring agent.

Table 1. Result of monitoring time

Agent Type \ Number of Agent	10	30	50	70	90	110	130	150	170	190
Stationary Monitoring Agent	42	137	201	261	374	412	518	592	645	743
Mobile Monitoring Agent(3 Servers)	120	132	143	165	221	253	262	282	316	335
Mobile Monitoring Agent(7 Servers)	130	121	124	122	148	143	147	183	186	182

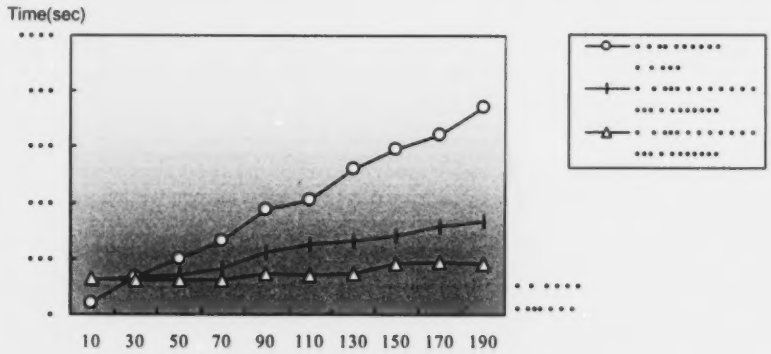


Figure 9. Graph of monitoring result

5 Conclusion and Future works

This study is on the efficiency of cooperative monitoring agent using mobile agent for educational portal site. The monitoring job has been getting difficulty processed by human. Thus, an intelligent agent can process the monitoring of the portal site instead of human. A monitoring work by using a single stationary agent needs long time for checking of many sites.

In order to overcome the problem in this study, the mobile agent is used in monitoring job. The monitoring job of educational portal site can be processed by collaborative method of decentralization and parallel using the mobile agent. The monitoring system was implemented by using the Aglet and Tahiti server. This system could execute cooperative monitoring job through an intelligent interaction between the stationary agent and a mobile agent. Also the KEPS system is possible with the mediation and the registration of agents by using the mediator agent between the monitoring server and the temporary agent sever.

BEST COPY AVAILABLE

The temporary agent sever is not fixed with the number but can be dynamically changed. Therefore all servers are by resources of monitoring job and each server can exe cute its role by inference.

More studies are required on research that constructs knowledge base for inference engine of the mobile agent. For effective portal site constructed, future work needs researches about not only intelligent monitoring but also intelligent searching and gathering of educational information. In order to interact between the mobile agents, we require research about KQML, language for sharing and exchange of knowledge between agent and agent.

References

[1] Akhil Sahai, Christine Morin INRIA-IRISA, • Mobile Agents for Enabling Mobile User Aware Applications• ; Just Research, 1998.

[2] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol 72, pp.329-365, 1995.

[3] Bryce L. Allen, Information Tasks: Toward a User-Centered Approach to Information Systems:, Academic Press, San Diego, CA, 1996.

[4] B.Venners,"Solve Real Problems with Aglets, a Type of Mobile Agent", Java World, www.javaworld.com/javaworld/jw-05-1997/jw-05-hood.html.

[5] Chang, D., Lange, D. "Mobile Agent: A new paradigm for distributed object compuing on the WWW. In Proceedings of the OOPSLA96 Workshop: Toward the Integration of WWW and Distributed Object Technology, ACM Press, N.Y., pp 25-32, 1996.

[6] Danny Lange and Mitsuru Oshima "Programming and Deploying Java Mobile Agents with Aglets", Addison-Wesley Longman, Mass., 1998.

[7] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[8] J.White, "Mobile Agents," in Software Agents, J. Bradshaw, ed., MIT Press, Cambridge, MA,1997.

[9] M. Wooldridge, M., Jennings, N. R., "Intelligent Agents: Theory and practice. The Knowledge Engineering Review, 10(2)", Springer-Verlag, pp 115-152, 1995.

[10] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[11] R. Tolksdorf, "Intelligent Information Agent: On Coordinating Information Agents and Mobility", Springer-Verlag, pp 396-411,1998.

Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments

Yam San Chee* and Yong Bing Khoo**
School of Computing, National University of Singapore
3 Science Drive 2, Singapore 117543
** E-mail: cheesy@comp.nus.edu.sg*
*** E-mail: khooyb@comp.nus.edu.sg*

Theoretical understanding that learners acquire is concretized through exploration and collaboration with other learners as they articulate their understanding and knowledge of the learning domain. Recognizing that knowledge building is a dynamic process that requires learners' active participation, there has been a shift from traditional teacher-centered instruction towards interactive, peer tutoring, as well as simulation-oriented collaborative group learning. Systems that allow users to engage in such activities are increasingly interesting to scientific communities and learning organizations.This paper shows how our system's design leverages off the Model-View-Controller (MVC) architecture to allow developers to share the behaviors and interactions of virtual objects. We also present our approach to partitioning different parts of our system's virtual environment as well as storing and synchronizing virtual worlds such that our system can support unlimited interactivity with virtual objects and encourage user interactions in quasi-immersive online learning communities.

Keywords: **Collaborative learning, virtual reality in education, simulation, experiential learning**

1 Introduction

Constructivist theory, based in part on the results of Piaget's research, is the most widely accepted pedagogical standpoint adopted among teachers today. Constructivism emphasizes the careful study of the learning processes and leverages learners' active participation in problem solving as well as in learning activities that promote creative and critical thinking. Rather than memorizing concepts through iterative rote learning, learners internalize new concepts through exploratory learning and develop their own understanding by integrating newly acquired knowledge with prior knowledge and experience. Peer tutoring among learners and interactions with experts facilitate such learning processes where "knowledge [is] directly experienced, constructed, acted upon, tested, or revised by the learner" [10].

The pedagogical consequence is that learning environments should support and stimulate further growth and development of learners' minds while encouraging learners' autonomy and initiative. This constructivist orientation requires a fresh perspective on the roles of technology in learning. Instead of viewing computers solely as a knowledge presentation device, we can also view them as tools for supporting a pedagogical focus on communications in collaborative learning ventures [4]. Suppose we are able to bring a group of people together to interact in a model of a real environment, then we also have a tool for constructivist learning. Imagine students steering ancient battleships and firing cannon balls at one another in order to explore the concepts of relative velocities and projectile paths. Or perhaps a chemistry class where students can mix and test chemical reactions in the safety of a virtual chemistry laboratory.

A successful Constructivist Learning Design (CLD) should provide familiar environments that reflect the

thinking processes of the participants; in such environments there must be trust and public sharing of knowledge in this environment [14]. Moreover, the Across-Schools Pedagogy Issues group [4] endorses the "necessity of large-area networks for particular contexts, instructional goals, and learner characteristics." Injecting constructivism into the educational system culminates in a revolution, from planning for teaching to designing for learning [14] and the "key to reinventing our educational system . . . lies in what our teachers believe about the nature of knowing" [1].

Increasing interest in virtual environments coupled with a recognition of their potential benefits from the use of simulation, experientially-grounded learning, and socialized learning have led to the development of many virtual reality (VR) systems. Working within the constructivist paradigm, we have developed a system that creates virtual collaborative learning environments. Our system supports user interactions that facilitate mutual tutoring and knowledge sharing. The system can be used by academic institutions that offer courses through distance learning, or it may be used as a complementary form of on-line collaborative learning. In particular, these institutions can conduct laboratory classes with visual demonstrations, simulations, and presentations. The system can also be used to create virtual towns where users can interact with one another and coordinate online meetings.

In subsequent sections of this paper, we critically evaluate related applications, present our research focus, and describe one of the virtual worlds in our system to demonstrate how users collaborate and interact in virtual environments. After the virtual world description, we discuss our approach to system design such that it is easily extensible by future developers. Next, we present the basic mechanisms used to implement our virtual environment system. The discussion on system architecture is followed by the conclusion and intended further work for our system.

2 Critique of Related Applications

There have been several attempts to create similar VR environments. *VR for Learning* [6] is based on Couch's multi-user virtual reality system. It is limited in that it does not store its data in a database. Moreover, avatars in the virtual environments are static. They do not adhere to any common structure, and they *float* in the virtual worlds rather than *walk*.

Active Worlds is a proprietary-standard virtual world browser that provides game-like 3D rendering of the world with user-selectable (first-person or third-person) views. In addition to the browser window, *Active Worlds* also comes with a chat window that supports user communications. Mouse- and keyboard-based navigation through virtual worlds is remarkably smooth. However, the joints of *Active Worlds* avatars have far fewer degrees of freedom than that possessed by humans. Hence, the avatars are capable of a smaller repertoire of actions compared to avatars that model humans more accurately.

Community Place, developed by Sony Corporation, is designed to be scalable and to support many "geographically dispersed users, interconnected through low bandwidth, high latency communication links" [5]. However, the chat and whiteboard windows are separated from the navigation window. This increases the semantic distance between the different components of the system.

blaxxun, by blaxxun interactive, has the advantage of using Humanoid Animation 1.0 (HANIM) [13] compliant avatars. However, *blaxxun* lets avatars float instead of walk. Avatars move very quickly, but realism is compromised.

3 Research Focus

In order for our system to benefit as many users as possible, our work is implemented using non-proprietary technology. We developed the system's virtual world browser using Java3D and implemented the other components in Java. Hence, our system is portable to hardware platforms that support Java3D and Java Virtual Machine (JVM). Moreover, the system is designed to support a large number of users while maintaining reasonable performance.

Considerable effort was devoted to designing an engaging interface so that the system is pleasurable to use. This is pertinent because the objective of our system is to help users actively participate in learning

environments and not in learning how to use the system. This will encourage users to engage in experiential learning and increase their familiarity with the learning context.

In order to support collaborative learning and to enhance learning experiences, interactions between users and virtual world objects must be supported. Moreover, each object should have unique behaviors and properties, or they should be able to share behaviors and properties with other similar objects in an Object Oriented (OO) fashion. In our system, virtual object states are modified by manipulating components of these virtual models directly. The system processes new object states and updates virtual worlds as well as a database of virtual world states. By storing virtual world states, users can collaborate in discussions that span several login sessions. Similar to most virtual environments, avatars are pertinent for promoting user interactions because they allow users to establish their presence in virtual worlds by creating sensations of "being there."

4 BattleShips World Description

One of the virtual worlds in our system is the *BattleShips* world (Figure 1). This world allows users to explore three physics concepts:

- the time taken for free-falling objects to reach level ground is independent of the objects' masses
- the relative velocity between two moving objects creates the illusion that the objects are moving at different individual speeds
- the trajectories of projectiles are parabolic

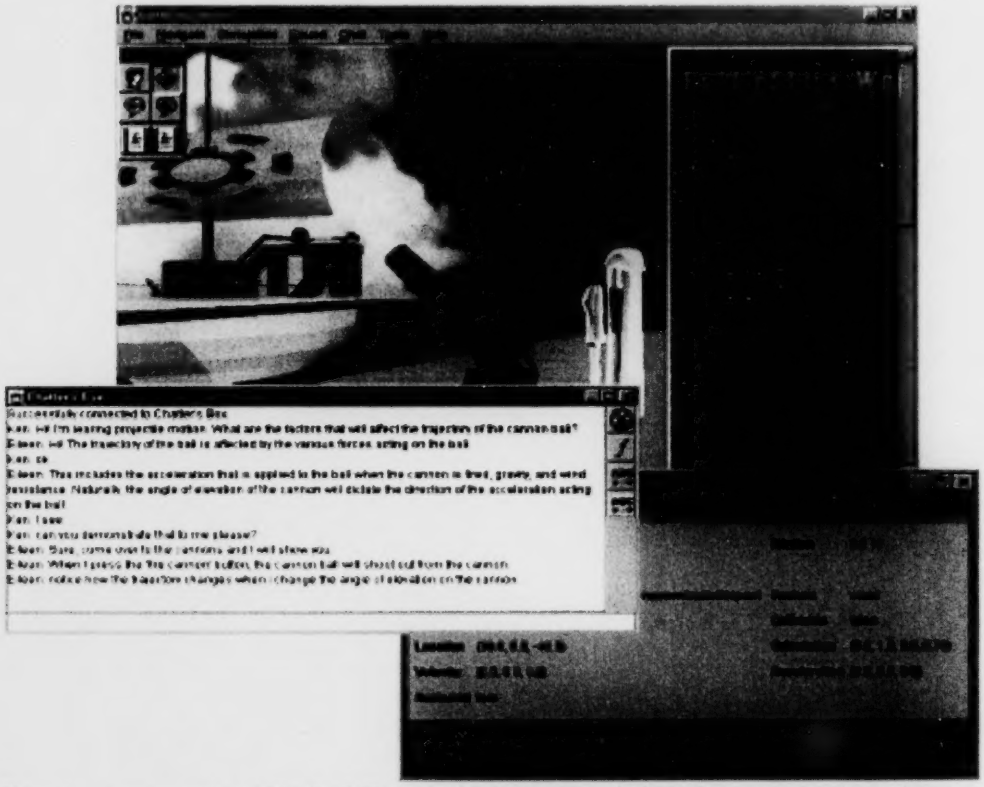


Figure 1 A screen capture of the *BattleShips World* with two cannon balls of different masses falling down towards the cannons

This world contains two battleships equipped with cannons on both sides of each ship. By default, cannon balls from each cannon have different mass. Users can change the mass of a ball by selecting the *Examine*

BEST COPY AVAILABLE

mode on the floating toolbar palette followed by the ball of interest. The system will pop up an *Inspector* window (where users can enter a new mass for the ball) at the position of the mouse click.

One of the battleships has two user-selectable objects in the crow's nest on top of the mast. When users activate the trapdoor at the bottom of the crow's nest by clicking on the remote control button provided, the selected objects will start to fall to the deck of the ship. Users are asked to find the object that will reach the ground in the shortest time given that each object has a different mass. (The heaviest object will reach the ground fastest due to air resistance. This is contrasted with the *VacuumChamber* virtual world where the time taken to reach the ground is independent of the mass of free-falling objects due to the absence of air resistance.)

Users can collaborate in controlling a ship. For example, one user may be navigating the ship to place it in a more strategic firing position (with respect to the other ship) while trying to stay out of the other ship's line of fire. Another user (on the same ship) may control the firing of cannons and the angles of elevation of the cannons. Users can engage in mutual tutoring and knowledge construction by communicating with one another using our system's text-chat facility.

Because both ships are moving, it is necessary to consider the relative velocity between the two ships when navigating and firing the cannons. In addition, trajectories of cannon balls in this virtual world illustrate that projectiles trace a parabolic path in contrast to the early intuitive (but mistaken) belief held by many novices that cannon balls drop vertically near the end of trajectories [7].

5 System Design

Our system is designed to be easily extensible by developers so that virtual worlds supporting new learning activities can be created more efficiently through reuse of existing implementation. Its design adheres to the MVC architecture, hence providing minimally coupled yet cohesive subsystems. In this section, we describe the Model, View, and Controller portions of the system. Following that, we discuss how we use a database to store virtual world states persistently and how events are propagated to other clients in order to maintain virtual world consistency (across different clients).

5.1 Model

In our system, the Model is represented by the *vtalk* package. *vtalk* models virtual objects (*VObject*), virtual worlds (*VWorld*), and laws that can be applied to each *VObject* and *VWorld*.

5.2 Virtual Object

Every virtual object (*VObject*) in our system is modeled as an OO class. This design allows virtual objects to inherit and share properties as well as behaviors easily. In this manner, objects can be placed in new virtual worlds and behave according to the conditions of the new worlds. For example, consider a virtual world where users are placed on a planet with lower gravity (compared to the Earth). Users can choose to insert a cannon into the virtual world (even though there are initially no cannons in this virtual world) and fire the cannon to observe the trajectory of the cannon ball. The main challenge, however, is to classify a potentially infinite number of objects into an extensible taxonomy. Our approach to the taxonomy is to categorize objects into *Living* and *NonLiving* things. The taxonomy for *Living* things is well defined by Parker [8].

On the other hand, the taxonomy for *NonLiving* things depends on the context in which the objects are placed. As such, *NonLiving* objects are classified according to generic behaviors (such as moving when a force is applied to it) and properties. For example, billiard balls, golf balls, bowling balls are placed as subclasses of the *Ball* class. This classification of *NonLiving* things is developed in the context of the scope of our intended experiments and is not meant to encompass all possible scenarios.

In order to minimize coupling, the Model communicates with the other parts of the system via messages encapsulated into events. Consequently, behaviors of each object generate events (such as velocity changed) that are propagated to the virtual world that contains the object and other Views (typically represented by a virtual world browser) rendering the object.

Virtual worlds (*VWorld*) are managers of *VObjects*. A virtual world delegates events generated by objects that the world contains, responds to events using implemented laws (such as Newton's Laws of Motion), and routes events to affected *VObjects* as well as the network component of the system. Each *VWorld* presents a rich set of cohesive simulations where users can modify attributes of virtual objects and observe the effects. For example, when users change the texture of a billiard table, a billiard ball on the table will be observed to roll at a different speed (compared to the speed before the change) when the users hit the ball with a cue stick.

5.3 Laws

Laws are implemented separately from *VObjects* and *VWorlds* because different laws are applicable to *VObjects* depending on the learning objectives (determined by *VWorld*). The consequence of incorporating laws in virtual worlds is that laws cannot be shared across virtual worlds. On the other hand, embedding laws within *VObjects* may result in ambiguity of applicable laws as well as prohibit sharing of laws. Hence, the separation of laws from *VObjects* and *VWorlds* allows *VWorlds* to determine applicable laws and the priority of laws to resolve conflicts.

5.4 View

A View denotes the portion of the system that listens for events. This approach allows the system to present different representations of the same model, for example a 3D virtual environment and a 2D plan view of the 3D environment. Currently, our system has one View component, *VBrowser*. Consider a cannon ball fired from a cannon, the ball will generate high-level events that inform *VBrowser* that its velocity and acceleration have changed. Subsequently, the view will apply Newton's Laws of Linear Motion at every uniform interval to compute the new location, velocity, and acceleration of the ball. The laws can be applied independently of the world containing the virtual objects.

Collision detection is necessary for most virtual environments especially in simulation-oriented systems. Ideally, collision detection should be implemented in the Model. However, only *VBrowser* has access to geometric data of all virtual objects necessary to compute collision accurately. For these reasons, our system detects collisions by leveraging off collision detection mechanisms available through the graphics engine of *VBrowser* [12]. When *VBrowser* detects collisions, it generates events of the collisions and routes them to the virtual world where the collisions occurred. Virtual worlds would then handle the collisions according to the implemented laws of each world.

5.5 Controller

Users generally interact with the Model using a Controller. Because users interact with virtual objects through direct manipulations, the Controller's interface is part of *VBrowser*'s interface. For example, users navigate through virtual environments by dragging the mouse across *VBrowser* (representing the View). However, the engine that handles the mouse movements is part of the Controller. In this case, the Controller updates the Model, and the Model, in turn, generates events that are received by *VBrowser*. *VBrowser* would then update the View presented to users.

Our system supports direct manipulation of objects such that users interact with the objects they see in virtual worlds directly. Because the types of possible (and logical) object interactions depend on the virtual world containing the object, introducing the allowed interaction types into the Controller or View would couple these two components undesirably to the Model.

In view of this, Controllers convey user intentions of manipulating objects to the Model which then decides the appropriate interaction types and pops up a toolbar containing valid actions that can be taken next to the object of interest. Users can then select the desired action (from the toolbar) to perform.

5.6 Network

The network component of our system propagates events from virtual worlds in order to synchronize worlds on different clients and to update the database storing virtual world states. However, if all virtual world events are propagated to other clients, the events will be "bounced" from client to client indefinitely. For example, when client A sends an event denoting that the location of object 1 is changed, this event will be

sent to client B. Client B updates its copy of object 1, thus triggering off another location changed event. This event would then be propagated back to client A, and so on.

Although this event looping situation can be circumvented by tagging every event with the originating client, a better design is to send only high-level events that result directly from user interaction. For example, a user moves a stick to strike a ball. The location changes of the stick (as the user manipulates it) are sent to all clients in the same world. However, events of collision between the stick and ball as well as subsequent location changes of the ball due to this collision are *not* propagated. It is not necessary to propagate such events because every client is able to detect the collision and handle the subsequent ball movements locally. This is similar to the dead-reckoning technique. As a result, bandwidth requirements are reduced because "update packets can be transmitted at lower-than-frame-rate frequencies" [9].

5.7 Database

The relational database in our system is used to store virtual world states and other data necessary to facilitate restoration of virtual worlds. Using the Java Reflection API and object serialization [11], we designed the database to handle objects of new virtual object classes without requiring any modification in the database code. As a result, other developers can create new virtual objects, by extending available virtual objects, without implementing ways to store the new objects.

In interactive collaborative virtual environments, two or more users may attempt to grab the same virtual object at the same time. By leveraging off concurrency control mechanisms of the relational database, our system prevents concurrent attempts by multiple users to grab the same virtual object through the use of "ownership" data in every virtual object's database tuple. A user who holds an object is considered to be the "owner" of the object until the user releases the object [9].

On the other hand, a user may attempt to grab an object that is already held (virtually) by another user. However, this scenario is unlikely to occur with the exception of virtual worlds where such actions are appropriate because socially acceptable norms discourage users from "snatching" other users' objects.

5.8 Flow of Events

Figure 2 illustrates a typical scenario representing the flow of control and events when the system is running.

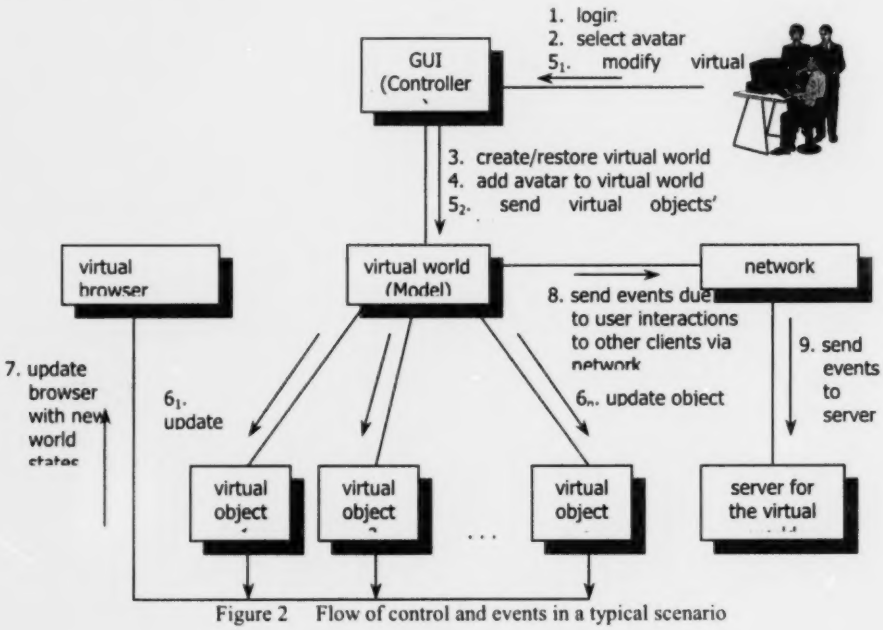


Figure 2 Flow of control and events in a typical scenario

When users interact with the objects in virtual worlds (Model), the Controller sends events to notify the associated virtual world of attribute changes. At the same time, the Controller also sends these events to other client machines via the network in order to synchronize virtual worlds on all clients. Every event is tagged with the time that the event occurred so that the order of events is preserved and consistent across all client machines. Because each client may have a different local time (such as in the case of client machines in different time zones), our system synchronizes the time of an event with the server's time.

The virtual world on every client machine will propagate the events encapsulating the changes to the virtual objects concerned. Upon receiving such events, the virtual objects will process these events representing the necessary updates and route the events to event listeners; that is objects that indicate interest in receiving virtual object events.

Finally, the View will interpret the events it receives from the Model and render the necessary changes by updating the geometric representations of all affected virtual objects.

6 System Architecture

In this section, we describe the basic mechanisms that we used to implement our system. We adopt a client-server architecture where there are multiple servers, with each server catering to several client machines (Figure 3). Although the system's server programs currently execute on one Sun workstation only, these programs can potentially reside on different physical workstations to support scaling beyond the processing power of one workstation.

Our system architecture is similar to the RING system [2]. Unlike the RING system, however, the servers in our system do not communicate directly with one another (although they share the same repository for virtual world states) because each server in our system handles only events from client machines in the same virtual world. Moreover, server programs may be hosted on different machines to distribute workload. When a user logs on to the system, the Controller retrieves the current states of the virtual world where the user is located from the database using JDBC. Using these states, the Controller instantiates the Model to represent the virtual world and all objects within the world. The Model then generates events to the listeners. One instance of a listener is the View (or *VBrowser*) that renders the virtual world as an interactive 3D environment on the monitor.

If the current states of the virtual world into which a user has entered are not available either due to a disconnected network or the fact that the world is newly created, then the virtual world is built locally according to the default layout of the world. If the world is new, then the Model will update the database with the default states of the virtual world. On the other hand, if the network is unavailable, the system is still functional because *vtalk* package's virtual network (*VNetwork*) is able to simulate the existence of a network connection. Hence, users can still engage in learning activities in virtual worlds in single-user mode. Changes made to objects in this mode are, however, not saved.

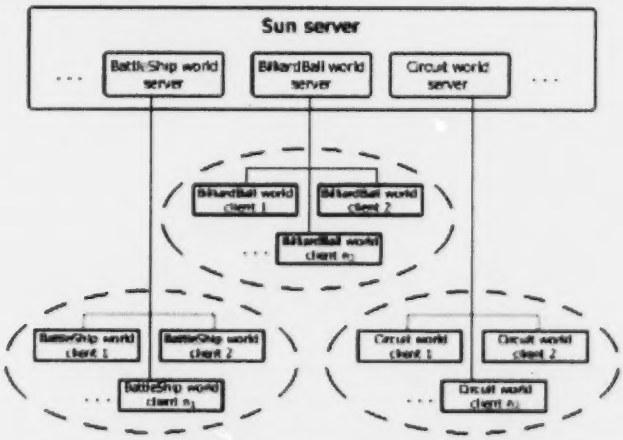


Figure 3 System architecture showing connections between virtual world servers and clients

BEST COPY AVAILABLE

The View of our system's virtual environment is generated using Java3D while the interfaces are created using Java Swing. The View is driven by events that are generated by virtual worlds and objects. Typically, these events are generic attribute changes (such as change in velocity) that affect the rendered view directly.

A possible event generation implementation is to use the Java Observer/Observable classes. Although these classes resemble the example code written by Gamma et al. [3], the Observer/Observable approach has the following disadvantages [15]:

- In order for event listeners to make use of the Observer/Observable classes, the classes modeling the event listeners have to be subclasses of the Observable class. However, it is usually difficult to meet this requirement because Java does not support multiple inheritance and the listeners may be subclasses of other classes already.
- Programmers need to understand details of how the update handler methods work.

Hence, the event generation mechanism of our system is based on the MVC architecture instead. Using this mechanism, each object that generates events stores its own list of event listeners [15]. When the attribute of an object changes, the object generates an event and routes it to every event listener in its list of listeners. Event listeners can be added and removed dynamically at run-time. As such, our system can create multiple views of the same model simultaneously. For example, it is useful to represent virtual worlds as 3D environments and also as a 2D plan view to aid navigation through large virtual worlds.

7 Conclusions

In this paper, we have explained the design of our simulation-oriented collaborative virtual environment based on the MVC architecture. We presented a description of our system's *BattleShips* virtual world where learners can explore physics-related concepts in an engaging and immersive fashion through interaction with objects in the world. Moreover, learners can participate in constructive online discussions as part of a learning community using our text-based chat facility. We further showed how different behaviors and laws can be shared and extended among virtual worlds and objects in an OO fashion. We also explained how our system is designed to support the addition of new virtual objects with minimal changes to the network and database. Finally, we presented the underlying system architecture of our current system to support collaborative learning distributed over geographic locations.

Our future work will include letting users see the actions and gestures of other users so that less time and effort is spent on prefatory remarks in online discussion (using text-chat). We will explore network topologies that afford greater scalability. We also intend to implement automatic distribution of load among several workstations and conduct formative and summative user evaluations.

References

[1] Fosnot, C., "Constructivism: Theory, Perspectives, and Practice", New York: Teachers College Press (1996).

[2] Funkhouser, T. A., "RING: A Client-Server System for Multi-user Virtual Environments", Proceedings of the 1995 SIGGRAPH Symposium on Interactive 3D Graphics. Monterey, CA: ACM SIGGRAPH, pp. 85-92, (1995).

[3] Gamma, E., Helm, R., Johnson, R., & Vlissides, J., "Design Patterns: Elements of reusable object-oriented software", MA, Addison-Wesley, (1994).

[4] Koschmann, T., Newman, D., Woodruff, E., Pea, R., & Rowley, P., "Technology and Pedagogy for Collaborative Problem Solving as a Context for Learning: Report on a CSCW '92 Workshop", ACM SIGCHI Bulletin, Vol 25, No. 4, October 1993, pp. 57-60, (1993).

[5] Lea, R., Honda Y., & Matsuda K., "Virtual Society: Collaboration in 3D Spaces on the Internet", Computer Supported Cooperative Work: The Journal of Collaborative Computing, Vol 6, pp. 227-250, (1997).

[6] Lim, K. P. E., "VR for Learning", National University of Singapore, Department of Information Systems and Computer Science, (1997).

[7] McCloskey, M., "Intuitive Physics", Scientific American, Vol 248, No. 4, pp. 122-130, (1983).

[8] Parker, S. P. (ed.), Synopsis and classification of living organisms, NY: McGraw-Hill, (1982).

[9] Singhal, S. & Zyda, M., "Networked Virtual Environments", ACM Press, pp. 119 & 142, (1999).

[10] Thompson, J.G. & Jorgensen, S., "How Interactive is Instructional Technology? Alternative Models for Looking at Interactions between Learners and Media", Educational Technology, Vol 24, (1989).

[11] Build an object database, http://www.javaworld.com/javaworld/jw-01-2000/jw-01-step.html (accessed on July 26, 2000).

[12] Extended Collision Detection for Java 3D, http://www.burrows.u-net.com/collisiondetectionJ3D.html (accessed on July 26, 2000).

[13] Specification for a Standard VRML Humanoid Version 1.0, http://ece.uwaterloo.ca:80/~h-anim/spec.html (accessed on July 26, 2000).

[14] Teachers' Perspectives on a Constructivist Learning Design, http://www.prainbow.com/cld/clds.html (accessed on July 26, 2000).

[15] The 'event generator' idiom, http://www.javaworld.com/javaworld/jw-09-1998/jw-09-techniques_p.html (accessed on July 26, 2000).

Development of the Web-based classroom system to be implemented by the teachers

Go Ota* and Kanji Akahori*
**Cooperative Research Center Saitama University*
***Tokyo Institute of Technology*
*E-mail: *gohome@jona.or.jp **akahori@cradle.titech.ac.jp*

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan from the year 2002. Accordingly, all the schools have been rushing to deploy the personal computers and prepared to connect to the Internet through 2001. While the scope of this project aims at covering 40000 or more schools, there exists the two major problems:1) The number of teachers who have expertise in handle the PC and the Internet, are too far short in proportion to the number required. 2) Dial-up networking prevents the students from having access to the Internet any time when they want. With a view to overcoming these problems, we have designed and developed the Intranet system or "micro Internet for classroom: mIc". The "mIc" is developed and designed to incorporate the various functions such as web-mail, electronic bulletin board "BBS", mailing list, search engine, web video conference and etc. Since "mls" consist of Microsoft Active Server Pages (ASP), it can be used from Web browsers and custom-tailored at ease.

Keywords: **Intranet, Collaboration, Video-conference, BBS**

1 Introduction

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan at both the elementary school and the junior high school in 2003 and at the high school in 2002 respectively. Accordingly, all the schools have been rushing to deploy the personal computers and are prepared to connect to the Internet through 2001. While the PC have been gradually and extensively, it seems quite obvious that far small number of the teachers can handle the PC and the Internet to the contrary.

The Minister of Education has been sending the computer engineers or other computer technical personnel to school since 1994 with a view to training the teachers about the computer and the Internet. They are also required to see to it that both the teachers and the students can implement the PC and the Internet smoothly without any problems. Additionally, The Ministry has been initiating their own training programs for the teachers as well. While the project is supposed to cover 40000 schools or more, it has been experiencing the extreme difficulties of the shortage in the engineers and the technical staffs to reach out all the teachers in 4000 schools or more. It has been experiencing the difficulties as well as that Dial-up networking prevents the students from having access to the Internet any time when they want.

Despite these difficulties, it seems quite viable that all the students will get accustomed to the computer and the Internet at the earliest convenience. We, therefore, have designed and developed the Intranet System(micro Internet for classroom: mIc)

2 Design of mIc

This system "mIc" is developed and designed for both the teachers with least knowledge about the PC and the Internet, and the students as well to learn the various functions.

(a) Simulation of the Internet.
We are of an opinion that the E-mail and Electronic Bulleting Board shall be viable tools for "collaboration" among the students. Should the students require any information from the Internet, the search engine shall be inevitable to learn as well. We, therefore, have designed to incorporate these functions in the system. The teachers simply use the system without any other programs and the students can experience those functions as if they were connected to the Internet.

(b) Web-based easy operation.
The teachers can use "mlc" from Web browser. Therefore, should the teachers use the system, they can create new BBS, mailing list and registration of the students on Web based. As far as the teachers will use solely "mlc", the profound knowledge about the Internet server and the program of CGI is not necessary.

(c) Customization.
The curriculum of "Information and Computers" varies depending on the computers deployed ,the network system applied, and the objective of the education for PC & the internet in each school respectively. The system "mlc" can be customized by merely changing the text-files.

3 Structure of mlc

Considering the Standardizing the server of the average school environment, "mlc" will be installed in WindowsNT server or Window98. Please take note that less than 10 people can work with Window98 simultaneously.

3.1 ASP and COM

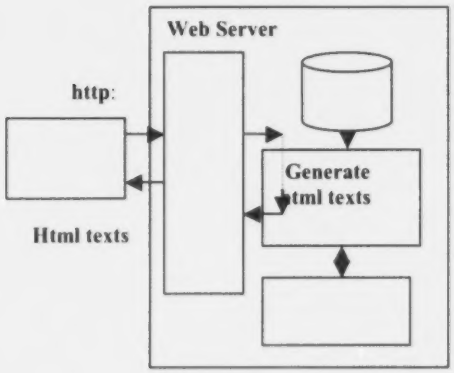


Figure 1: The Action of ASP

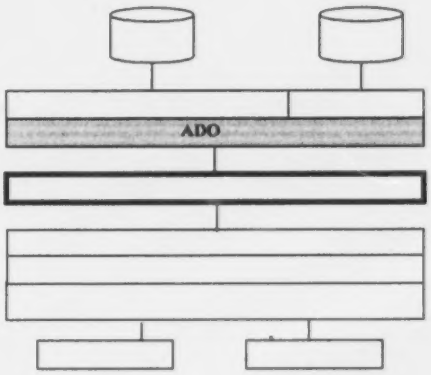


Figure 2: The structure of mlc

The system "mlc" consists of Microsoft Active Server Pages(ASP) which is the server-side execution environment. The ASP can run scripts and Component Object Model(COM) on the server . It can also easily create the dynamic contents and the powerful Web-based applications. The COM is the Microsoft software architecture that allows application to be built from binary software components. Windows itself and many other applications such as WORD, EXCEL and etc. are consisted of the COM.

Figure 1 shows the process of "mlc". ASP files appears to be the same as the HTML files but it includes additionally VBscripts or Javascripts, which call COM. At first, a browser makes a request to the server to send an ASP file in such a manner as to the HTML file. Secondly, the server executes ASP file and Bvscripts or Javascripts At last, the server send these to a browser. By using ASP, a browser only interprets common HTML without executing scripts in the client environment. Figure 2 shows the structure of "mlc". We have applied to some COM, which have access to a database, a browser, files, and a mail server. ADO is the database access COM and the system uses Microsoft Access or SQL Server.

3.2 Setup of mlc

The system "mlc" can be easily installed by simply copying the ASP files in such a manner as for HTLM files .The teacher will be required to edit the "mlc"' configuration file which contains such information as URL, the install path and etc. Should a teacher wish to display some comments enabling the students to take note for their reference, he simply input the comments in the text-file corresponding to the exact page. The "mlc" can build more than one system in one server by creating more than one data base file.

4 System function

The functions of "mlc" will be detailed as follows;

4.1 Registration

The teachers can register the students with the use of browser. They can register even many number of students at once with the use of EXCEL or ACCESS. If the teachers will use BBS and E-mail via other programs than "mlc", they will be required to register newly each time they change the application.

4.2 System Menu

Three different user modes are available in the menu , one for a teacher , one for students and one for a guest respectively. The teacher can customize the menu for each mode. Should the teacher not use the mailing list, he can simply edit the configuration file to turn off the flag of the mailing list and the menu eventually will not display the button of the mailing list.

4.3 Web mail

The system "mlc" has two different Web mail modes whose user interface are the same , the one simulation mode and the other SMTP/POP3 mode. While the simulation mode will not actually allow to send or receive mails via the Internet, it will allow to simulate the mail functions without the mail server. Should you have the mail server and use the SMTP/POP3 mode, it will allow to send or receive mails via the Internet as the regular web mail.

4.4 Electronic bulletin board (BBS)

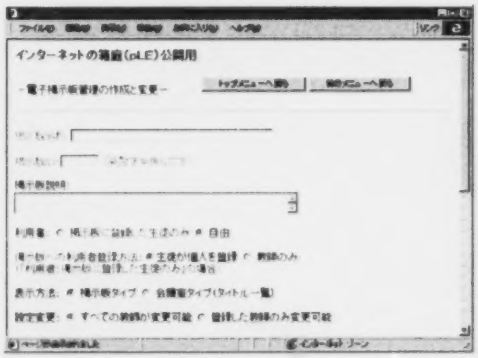


Figure 3: Screen image of Defining BBS

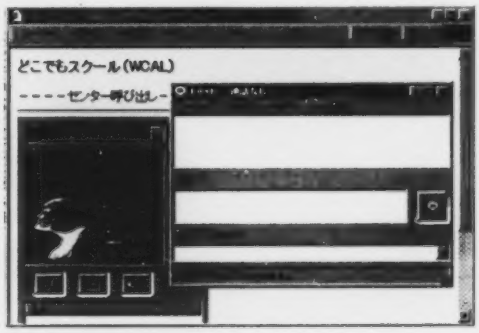


Figure 4: Screen image of Video conference

The system "mlc" allows to set up more than one bulletin board. Should the teacher wish to create a new BBS, he will be required to simply define the BBS on the browser and no new program will be necessary(Figure 3). "mlc" allows to set up the users' list covering the users who can have the access only in the BBS. The users' list can be selected in accordance with the student attribution such as Class , Group and etc.

BEST COPY AVAILABLE

4.5 Mailing list

The operation of the mailing list will follow the same manners as mentioned above for BBS.

4.6 Search engine

Since "mIc" has a directory service like "YAHOO" , the teachers and the students can add any new URL to the directory for their reference. If "mIc" is installed in WindowsNT server with Microsoft Index Server, the text-matching search engine can be used. The attention is drawn that "build-up of HP" has become one of the most important curriculum in Japan . The student can register their own HP's in the directory of "mls" and can subsequently search them in the classroom.

4.7 Web Video conference

Since the Video conference is very efficient and effective tool in term of the international communication, we have designed to incorporate the function "Web Video conference" in the system so as to suffice in this respect(Figure 4). A student can communicate with other students and visualize them via web video conference and refer to the data interactively via web data conference. Data conference allow the students to collaborate on "chat", "whiteboard" and "program sharing" without Video and Audio. Since the web videoconference is based on Microsoft Netmeeting 3.0 Active X, the multipoint data conference is possible and thus more than one student can participate the meeting simultaneously.

4.8 Generator of the questionnaire

Understanding strongly the importance of the questionnaire so as collect of the opinion from the students for various topics, "mIc" is designed to generate automatically the questionnaire in the form of HTML and ASP files. The teacher can easily make these files by filling in to the points raised as question on the web pages . The form filled in by the students can be saved to the text file in the form of the spreadsheet such as Excel.

5 Further development(future work)

We have already started to introduce the system"mIc" at schools ranging from the junior high school through the university . Having learnt from the experience, it seems very obvious that the teachers can make BBS and use search engines at ease. Through the continued experiments, we are prepared to improve the system further.

mIc Web Site (In Japanese)
URL www.jona.or.jp/~gohome

References

[1] Michael,G., Greg Merley, Distance Education A System View, Wadsworth Publishing Company, (1996)
[3] Go,O.,Kanji ,"Development of integrated Collaboration System with BBS and mailing list"(1999)
[2] Go,O.,Kanji, A.,"Development of School intranet system baeed on COM and ASP", (1999)

Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.

Jacques Viens*, *Université de Montréal*, **Geneviève Légaré****, *Université Concordia*

*Jacques Viens
Faculté des Sciences de l'Éducation, Université de Montréal,
C.P.6128, succursale Centre Ville
Montréal (Québec) H2C 3J7
Tel.: (514) 343-7033
E-mail: viens@scedu.umontreal.ca

**Geneviève Légaré
Department of Education, Concordia University
1455, boul. De Maisonneuve Ouest
Montréal (Québec) H3G 1M8
Tel.: (514) 848-2030
E-mail: legare@vax2.concordia.ca

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centered approach to a more genuine learner-centered approach. Using student interventions in telediscussions and the pedagogical scenarios as data sources, we outlined two general trends. First, students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their constructivist values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply constructivist principles to their productions, where the learners are truly at the centre of their learning.

Keywords : **On-line education, teaching and learning processes, pre-service teacher education, socio-constructivism**

1 Introduction

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centred approach to a more genuine learner-centred approach. To do so, we are using, as data sources, the student interventions in telediscussions and the pedagogical scenarios (hereafter integrative scenarios) that were produced on the web.

2 Context

Students registered in our teacher education programme have to take a minimum of two courses about the integration of ICTs in the classroom. The first course (ETA1700) is a general overview of the various technologies that could be integrated in a given learning environment. The final assignment consists of producing, as a team, a complete and fully working integrative scenario that will be available on the Web, for the benefit of their colleagues and the teaching community. To develop their scenarios, the students have access to our instructional model that favours a scaffolding strategy. The creation of the scenario includes the following steps : needs analysis, development of the content, selection of a learning approach and the development of a lesson plan. In a socio-constructivist approach, students are free to choose the subject-matter, the grade level, the pedagogical approach, the teaching tools and medium. As the teams develop their integrative scenarios, individual members are invited to participate in telediscussions. For the course ETA1700, four themes are provided : the impact of ICTs on society, the effective use of ICTs in educational settings, the changing role of teachers and learners and continuing education of teachers. Since learning to use the technology is a sub-goal of the course, students are requested to make at least one contribution for each theme, as well as offer one reply to one of their colleague.

The second course, PED2000, is a full year course, offered to second or third year students and mostly at a distance. Team members are free to meet as they please. Using the same scaffolding approach, students have to produce a more comprehensive scenario for a situation of their choice. However, prior to designing their scenario, students have to contact an in-service teacher who will let the students conduct their intervention in his or her classroom. The field experiment allows the teams to conduct a formative evaluation of their project. PED2000 students also have access to electronic forums of discussion, with the difference that no themes have been pre-determined. It is the students who create and launch topics of discussion. An on-line tutor is available to guide the students in their creative process.

3 Description of the project

3.1 Object of research

As we mentioned earlier, our goal is to understand better the perceptions that students might have about the impact of technology on their future role as elementary school teachers. Ultimately, the research results will be used to improve an to enrich our scaffolding approach, in order to help the students not only discuss the socio-constructivists principles but adopt them in practice. To do so, we explored the links between the discourse held in the telediscussions and the application of the principles in the integrative scenarios.

3.2 Sampling

For this paper, we used only the one of the multiple sections of the ETA1700 course. We selected four integrative scenarios representing 18 students, who contributed 80 messages on the two relevant themes (perception about the role of the teacher and effective use of ICTs in the classroom). Since our goal is to explore the factors influencing the application of socio-constructivist principles, we retained the projects that demonstrated some interdisciplinary and collaborative flavour.

3.3. Criteria for analysis

3.3.1 Integrative scenarios

To assess the students' perceptions about their changing role as teachers, we referred to some of the criteria described in Viens (1993) [1], as well as the general constructivist principles (Lave & Wenger, 1991; Brown, Collins & Duguid, 1989) [2] [3]. Even though we used a Likert scale to evaluate each criterium, our intention was not to cumulate frequencies. We rather used the scales to guide our critical analysis of the constructivist aspects of each scenario. Consequently, the results are more descriptive in nature.

The criteria are as follows :
Learning strategies . Notwithstanding the specific learning strategy to be used, we assessed whether the learner's during the instructional strategy was « directed », « guided », « rather guided », or «free ».

Team work. We examined whether the students planned to have their learners work individually, in teams but to conduct a fragmented task, or in teams to conduct a collaborative and collective task.
Content. Did the students determine a specific content or did they leave it completely opened for their learners to decide of their subject, as it is usually done in project-based learning?
Pedagogical goals. Aside from the usual well-stipulated instructional goals, did the students add other learning objectives such as transversal competencies? To what extent did they consider incidental learning?
Interdisciplinary. Did the students focus on one subject matter or did they use the opportunity to integrate several disciplines?
It is to be noted that all criteria were considered simultaneously in order to assess the global constructivist flavour of each scenario.

3.3.2 Forums

For the forums we proceeded differently. First, we focused on two aspects : the positive/negative attitude toward the ICTs. Secondly, we looked at the perception of the teacher' s role. In addition, we attempted to assess the student' s capacity to reflect critically, that is we observed whether the students were able to develop and support their thoughts rather than merely contributing an unsubstantiated opinion (Quellmaz, 1987; Ennis, 1987) [4] [5].

4 Preliminary results

4.1 Forums

Attitude towards ICTs
After conducting the preliminary analysis of the telediscussions for the course ETA1700, we noticed that the students positions about the integration ICTs in the classroom are not radical as one might expect. The majority seems relatively sensitive and cautious about technologies. In fact, several interventions were concerned about the fact that the computer will never replace the teacher and that the human factor is essential for the development of the pupils. In other words, aspects such as empathy, communication, emotional support are still essential for the learners development.

Perceptions of the role of the teacher
After listing all relevant interventions, we noted three recurrent themes that could constitute categories. Some interventions directly mentioned the role of the teacher, whereas others were more or less related to the topic, but still touched on the perceptions of the teacher' s role. The third group of interventions were concerned about more specific tasks of the teacher. We chose to use these categories to present the results about the perceptions.

Although not all interventions under the theme « Perception of the role as teacher » referred directly to the subject, it is interesting to discover that the perception of the role is indeed changing. The students did mention that the ICTs will help shift from a traditional role of « content deliverer » to one that assumes more guidance, more facilitation. Terms such as « facilitator », « animator », « councillor », « advisor » were used relatively frequently. However, we discovered that the students limited their intervention at the opinion level. They only named or listed the role without providing an explanation or a definition of what they meant by « facilitator » for example. Furthermore, they did not establish a priori what they view as a « traditional role ». Very few went as far as mentioning « content deliverer » or « lecturer ». In other words, students talk about the changing role without defining their assumptions. No one proceeded to compare and contrast the two positions or provide an illustration to support their thought. Indeed, the participants merely identified keywords and did not attempt to engage in a more critical discussion.

Some interventions were also addressing the issue of the changing role, but indirectly. Some students talked about the fact, for example, that the ICTs will provide the opportunity for the pupils to be more active in their learning process. Here, the guiding role of the teacher is implied in the discussion. Participants mention the possibility that ICTs will encourage the active construction process and consequently, will contribute to a more significant learning experience. In fact, in those indirect interventions, the learners are considered to be at the centre of their learning, actively engaged in the construction of their own knowledge and experience.

In sum, those students seem to think that ICTs can be used to favour collaboration between the learners as long as the learners' needs are respected. It seemed that participants perceive the ICTs as an integrated tool to teaching that favours self-learning.

The same group of students also discussed a specific aspect of teaching that will be affected by the technology : the impact of a broader access to information. Some students recognise the fact that a wider access to information will bring new tasks for their learners. One student mentioned that their pupils will have to « clarify their own research goals, define their information seeking strategy, make choices in the information, and sort the information ». This type of anticipation regarding « transversal » competencies was certainly an interesting discovery.

However, the same students who demonstrated their critical thinking abilities, still perceived themselves as the authority figure for their students. In fact, they mentioned that it will be their responsibility to assess the quality of information gathered on the Web as well as to judge the relevance of the source. Instead of making the link between the role of guide or facilitator as it would be expected in a constructivist fashion, it seems that the higher cognitive skills required, such as analysis and evaluation, will remain in the mind of future teachers, as their own territory.

4.1 Integrative scenarios

Two interesting trends have been identified in this analysis. First, the students who are more able to support their opinions by providing examples, using the literature, explaining their thoughts, seem to be more capable of producing a scenario that uses a genuine constructivist approach. In fact, if all the constructivist criteria are applied whenever it is reasonable to do so, the tone used to describe the learning activity is more opened, more respectful of both the freedom of the teacher and the learners. Here, we noticed that teams who produced a constructivist integrative scenario, were constituted of at least two members who demonstrated critical thinking abilities.

In the second trend, it seems that the students who claim that the role of the teacher is changing but who do not support their opinion, do not apply their values and perceptions in their integrative scenarios. In the telediscussions, they claim to be constructivist, but they fail to transfer their thoughts in practice. As we anticipated, the majority of the scenarios produced were meant to be constructivist. Some teams for example, will have their students work in teams but in a fragmented fashion (individual students will provide parts that will make a whole); the content will be determined and not opened for change; the learner will be rather guided in the learning process.

Two sources or information reveal the lesser constructivist approach : the instructional goal statement and the description of the lesson plan. Statements of the instructional goals in those scenarios tend to be highly fragmented, clearly measurable, well stated. Often, the students will refer to the Ministère de l'éducation du Québec programme to write the goals. There is no reformulation of the goals to suit their situation or needs. Also, there is no interpretation or critical analysis or re-evaluation of the goals. The students just take them as they come.

The design of the lesson plan is another indicator that a scenario might not represent a good application of constructivist principles. Lessons plans tend to be very organised and directed as well. The outcomes, ensuing the instructional goals, are well planned. In fact, the pre-service teachers, remain perfectly in control of the predetermined outcomes. Despite their good intentions, the students remain in control of the learning process. The steps are not only too well defined, that are also not flexible. The outcomes of the intervention using ICTs are still pre-determined and nothing else, that is no incidental learning is considered.

5 Conclusions

In this exploratory research we highlighted two trends. Students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply the constructivist principles to their productions. They will remain in control of their pupils' learning. The

next logical step will be to determine how we could support the development of critical thinking skills in the telediscussions, in order to encourage a better transfer of the socio-constructivist principles to the development of integrative scenarios.

References

[1] BROWN, A. L. The advancement of learning. *Educational Researcher*, November, 4-12, (1994).

[2] BROWN, J.S., COLLINS, A. & DUGUID, P. Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42, (1989).

[3] COGNITION AND TECHNOLOGY GROUP AT VANDERBILT. Anchored instruction and its relationship to situated cognition. *Educational Researcher*, August-September, 2-10, (1990).

[4] DEAUDELIN, C. et VIENS, J. Éditeurs *Nouvelles technologies et formation : impacts sur les contenus et les stratégies d'enseignement/apprentissage*. Actes du colloque du CIPTE tenu au sein du 64e colloque de l'Acfas à l'université McGill. *Educatechnologiques* Volume électronique. http://www.fse.ulaval.ca/fac/ten/reveduc, (1997).

[5] ENNIS, R. H. A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company, (1987).

[6] GERVAIS, F., GARANT, C., MAINGUY É. et VIENS J. "Nouvelles formules pédagogiques en formation des maî tres : mise en commun." dans Gervais C., Garant, C., Gervais, Fl. et Hopper, C. Formation des maî tres entre cours et stages... un partenariat INTRA-universitaire? Sherbrooke : Éditions du CRP, (144 p.), p. 114-125, (1998).

[7] LAVE, J., & WENGER, E. *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press, (1991).

[8] QUELLMAZ, E. S. "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105, (1987).

[9] RIOUX, S. et, VIENS, J. Les télédiscussions comme outil de construction des connaissances dans la formation des enseignants. *In Guir, R. (Ed.), La formation des enseignants et des formateurs aux nouveaux usages et aux nouvelles pratiques des technologies de l'information et des réseaux, Volume 2: Les implications sur la formation des enseignants aux TIC*. Paris : Éditions De Boeck, (à paraî tre , automne 2000).

[10] VIENS, J. *Vivre une expérience d'auto-apprentissage collaboratif*. Seconde édition de l'INFODUC, le répertoire Internet de l'éducation. Québec : Septembre Média, p. 264-269, (1998).

[11] VIENS, J. Modelisa, a constructivist learning environment to foster collaborative self-learning and metacognition. In Hilding Sponberg, Zdena Lustogova & Stanislav Zelena (Eds.) *Telecommunications for Education and Training*. Prague : Charles Uninersity. p. 156-163, (1997).

[12] VIENS, J. Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106, (1993).

[13] VIENS, J. et RIOUX, S. À propos du forum de discussion comme pivot d'une formule bi-modale d'enseignement. *Distance*. Automne 2000. 16 p., (à paraî tre).

[14] Site des Scénaristes : http://facvirtuelle.scedu.umontreal.ca/scenaristes

For example:

[1] VIENS, J. (1993). Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106.

[2] LAVE, J., & WENGER, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

[3] BROWN, J.S., COLLINS, A. & DUGUID, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42.

[4] QUELLMAZ, E. S. (1987). "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105.

[5] ENNIS, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company.

Domain Specific Information Clearinghouses – A Resource Sharing Framework for Learners

Wong Pei Yuen*, Yeo Gee Kin*, David Crookalland Lua Tse Min***
**Department of Information Systems*
School of Computing
National University of Singapore
Building S-15, Level 5, Room 12
3, Science Drive 2, Singapore 117543
Tel: +65 874 2908 Fax: +65 779 4580
E-mail: {wongpei1, yeogk, luatsemi}@comp.nus.edu.sg
***UNSA, Langues, 98 bd Herriot, BP 209, 06204 Nice cedex 3, France*
E-mail: crookall@jaydemail.com

The World Wide Web has presented researchers and learners all over the world with unprecedented opportunities to find and distribute information. An increasing number of valuable resources are made available online. This provides an excellent knowledge base for learners. However it is often very difficult to find these useful resources. This paper describes the framework of a domain specific information clearinghouse and how these clearinghouses can collaborate with one another to enable cross-domain learning. The resources in a domain-specific clearinghouse are submitted by trusted domain experts to ensure its quality. Learners with multiple domain interests can also effectively retrieve the information they need using the cross-domain collaboration framework presented. This is achieved with a union agent that manages the collaboration and sharing of resources between different domains. We also present a toolkit that facilitates the rapid deployment of such clearinghouses by domain experts.

Keywords: **Collaborative Learning, Educational Agent, Knowledge Construction and Navigation, Web-Based Learning, Domain Specific Information Clearinghouse**

1 Introduction

The tremendous success of the Internet and the World Wide Web has resulted in a global information revolution. With more and more information easily available online, people are now increasingly reliant on the Web for their information needs. They are constantly faced with the problem of finding relevant information that will suit their learning needs. Most commonly used tools for finding information, in particular search engines and Web directories, often return huge amounts of information which are neither useful nor relevant to the learners' needs. A more effective way of assisting these learners in finding information is lacking.

A possible solution would be the use of a domain-specific information clearinghouse managed by human domain experts. In a nutshell, a *Domain Specfic Information Clearinghouse*, or *DSIC*, is a Web-based clearinghouse and resource repository for information resources available on the Web. Learners would be able to find relevant and higher quality information from these resources. However, most information and research nowadays do not dwell on a single domain. Cross-domain learning requirements need to be met. This can be achieved through collaboration between multiple DSICs. With this cross-domain collaboration, we are able to discover and learn more about how each domain is related to one another.

In the following sections we will discuss the various approaches that are currently adopted by learners and

the concept of the Domain Specific Information Clearinghouse. Section 4 describes the framework of a Domain Specific Information Clearinghouse network to facilitate cross-domain learning. In Section 5, we describe a toolkit currently under development for the quick deployment of a domain-specific information clearinghouse. Finally, we would conclude with Section 6.

2 Current Approaches for Finding Information Online

The primary means by which learners find information on the Web are tools like search engines, Web directories and metasearch engines [1] [5].

Search engines operate by plowing through the Internet and indexing web pages. Typically, only keywords are indexed. Some examples of search engines are AltaVista[1] and Hotbot[2]. Using this method, a lot of information can be retrieved. However, there is a trade off between quantity and quality. In this huge list of results, though it may contain many relevant items, most of the search results are usually irrelevant. Learners will lose a lot of time following useless links.

Web directories like Yahoo![3] and Excite[4] are maintained manually by a dedicated group of catalogers. These directories contain user-submitted resources that are indexed categorically. These indices are usually human-created or computer-generated. They would usually include some description that helps the user in determining the usefulness of the resource. As the resources contained by Web directories are user-submitted, there is the problem of scalability: it is impossible to scale personnel to match the rate at which the Web is growing. Web directories are outdated rapidly due to the ever changing and ever growing Internet. Important resources for the different categories and topics are often missing.

Metasearch engines are web tools that poll multiple sources like search engines and Web directories. The compiled resources are then processed and returned as results to the user. Metacrawler[5] and SavvySearch[6] are examples of metasearch engines. However, as pointed out in [4], although metasearch engines can significantly increase coverage, they are still limited by the engines they use with respect to the number and quality of results.

After looking at the above approaches, the problem of finding relevant and useful resources is not solved. Although these approaches may be adequate for a casual Web user, they do not serve learners who require specific information from certain domains well. We shall discuss our proposed solution in the next section.

3 Domain Specific Information Clearinghouse

Figure 1 below depicts the DSIC model.

---

[1] http://www.altavista.com
[2] http://www.hotbot.com
[3] http://www.yahoo.com
[4] http://www.excite.com
[5] http://www.metacrawler.com
[6] http://www.savvysearch.com

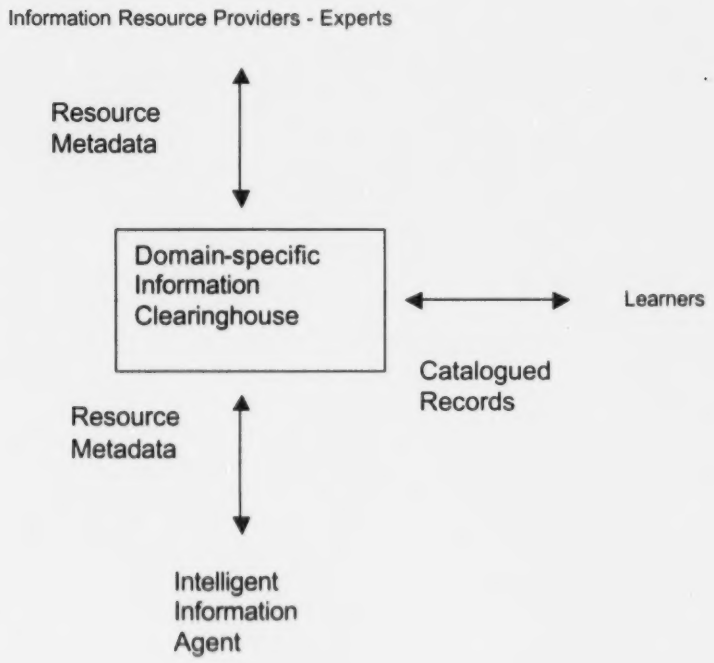


Figure 1: Domain-Specific Information Clearinghouse Model

As mentioned earlier, a Domain Specific Information Clearinghouse is a web-based clearinghouse and resource repository for domain-specific resources available on the web. One or more domain experts maintain the resources found in the clearinghouse. From now on, we will refer to *experts* as people who supply information to the clearinghouse and *learners* as people who access the clearinghouse for information.

The clearinghouse contains a classification of topics found in the domain and an intelligent information agent. With a good classification, the clearinghouse would be better organized and would increase learners' ease in finding the information they want. An intelligent information agent should be made available to facilitate the knowledge sharing and exchange both within and outside the clearinghouse.

An expert registers with the clearinghouse as a trusted information provider. He will then be able to submit resources that are in turn classified and cataloged. Using information found in these submitted resources, the intelligent information agent could scour the Web for more resources that can be added into the clearinghouse. The quality of these resources is much higher as they are being submitted by domain experts. What is useful and relevant to these experts are also usually useful to the learners as well. With all these information clearly classified, learners can then search or browse through the resource collection effectively in the domain specific clearinghouse.

4 Cross-Domain Learning

The DSIC caters to the needs of experts and learners in a single domain. However, learners often have not just one but multiple domains of interest. It would be useful for a learner with multiple domains of interest to be able to find the information he needs across all the different domains. Moreover, there are often no clear boundaries between domains, as the figure below shows. Resources from different but related domains may overlap.

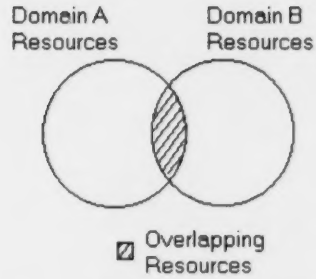


Figure 2: Overlapping Domain Resources

This potentially allows for different DSICs to collaborate and share resources with each other. To provide such a resource sharing framework, two issues needs to be addressed: distributed service and metadata exchange.

4.1 Distributed Service

The proposed framework for collaboration between multiple DSICs is essentially a distributed service. Domain experts maintaining each individual clearinghouse would register it with the *information union agent*, which is a central service that keeps track of all the existing clearinghouses that has been set up. This is illustrated in Figure 3 as follows:

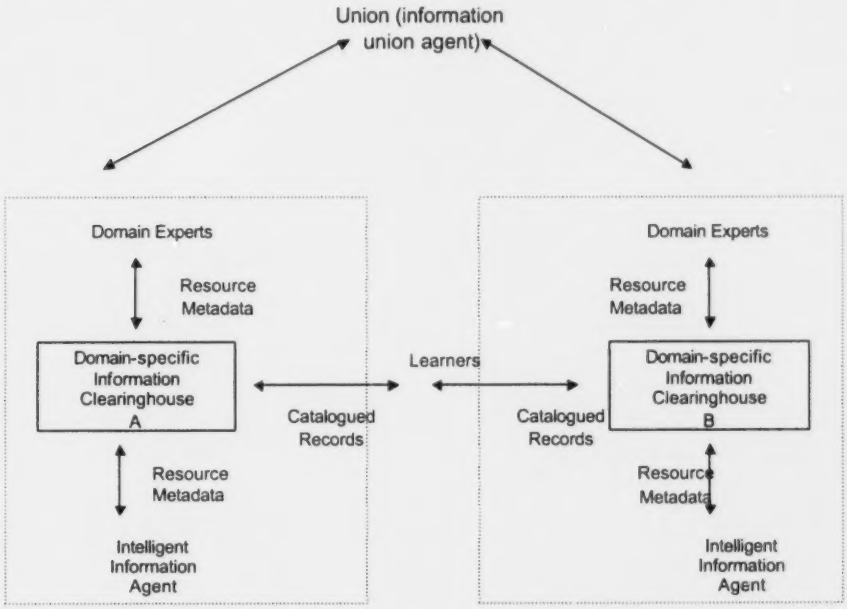


Figure 3: Multiple Domain Resource Sharing

Upon registration with the information union agent, each clearinghouse would declare the metadata attributes that are used to describe resources in that particular clearinghouse. Relationships with other domain clearinghouses are also declared. This information is then broadcasted to all the clearinghouses in the union to facilitate metadata exchange, which will be discussed in section 4.2

Besides maintaining the relationship links between the different domains, the information union agent would

also apply data mining techniques to learn and discover relationships between resources in the different domains. For example, when the number of similar resources that are found in two different categories of different domains exceed a threshold value, the union agent would automatically update the union with this relationship if it has not already done so. Through this process, the union agent can learn and discover new information and relationships between different clearinghouses in the union and update the respective clearinghouses with the new information. This allows the clearinghouses to provide learners with higher quality information.

4.2 Metadata Exchange

A DSIC union needs to provide a mechanism to facilitate the exchange of machine-understandable information among different DSICs. Being domain specific, each DSIC has its own set of metadata attributes and values. A mechanism needs to be provided for a DSIC to automatically interpret metadata that comes from another DSIC of a different domain and transform it to a human-readable form. This problem is non-trivial because classification schemes and metadata formats can vary widely between different DSICs.

The *Resource Description Framework* [7], or *RDF*, is an evolving specification developed by the World Wide Web Consortium. RDF's nucleus is an archetype for depicting named properties and their values. The properties are representations of resource attributes as well as the relationships between resources. This data model provides a syntax-independent means of representing RDF expressions.

We have developed a mechanism adapted from the RDF standard that would suit the needs of the DSIC union. We called this mechanism the *Metadata Schema*.

A metadata schema is simply a set of attribute names that is used to describe all the resources cataloged in a particular DSIC uniformly. Each DSIC is associated with exactly one metadata schema at any one time.

A metadata schema is unambiguously represented by an ordered n-tuple of the form

$$< N_1, N_2, N_3, \ldots, N_n >$$

In the above notation, each N_i, $i \in \{ 1, 2, 3, \ldots, n \}$ can be any sequence of alphanumeric characters, including spaces, that starts with a letter. Usually, these would correspond to attribute names such as "Author", "Company", "Description" and "E-mail Address".

The Metadata Schema, together with the information union agent, are the main mechanisms for interoperability between different DSICs. The following scenario illustrates how the Metadata Schema is being used.

A learner using a particular DSIC X to search for information can indicate that he wants to cross-search another DSIC Y. Through the union agent described in Section 4.1, DSIC X would already know the Metadata Schema of DSIC Y and would request DSIC Y for metadata records that correspond to the user's search request. DSIC Y would then respond with a set of results of the form

$$R = \{ R_1, R_2, R_3, \ldots, R_m \}$$

where each R_i, $i \in \{ 1, 2, 3, \ldots, m \}$ is an ordered n-tuple of the form

$$<V_1, V_2, V_3, \ldots, V_n>$$

Each element in the set R is then mapped to the known Metadata Schema of DSIC Y, after which the results are formatted and displayed by DSIC X.

The above scenario can be extended to more than 2 DSICs by simply requesting metadata tuples from each DSIC in turn. In this way, the DSIC union can be regarded as a single, distributed service with multiple access points, providing high quality cross-domain information to learners seeking such information.

5 An Example

An example of a domain specific information clearinghouse is the Simulation/Gaming eXchange [6]. This is a clearinghouse for resources in the simulation and gaming domain. Most of the resources in the clearinghouse are submitted by domain experts and are of high quality. Some entries are submitted by the *SGX Information Agent*, a software agent which uses techniques found in [2] and [3] to scour the Web and retrieve resource related to those submitted by the domain experts. A typical entry in [6] is show in Figure 4.

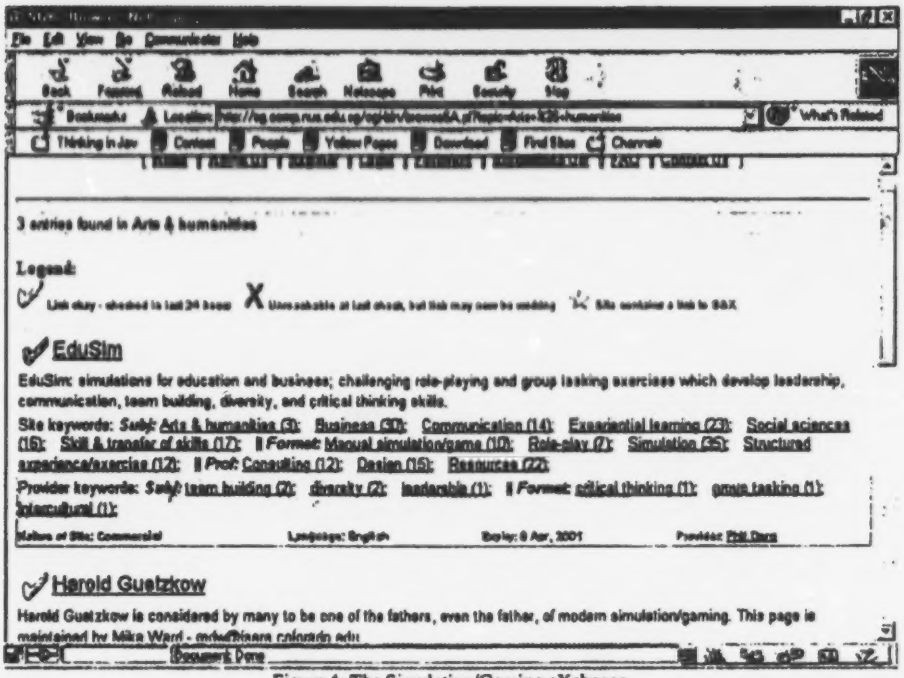


Figure 4: The Simulation/Gaming eXchange

Assuming that there is another information clearinghouse in the domain of CAI. This information clearinghouse also has its list of classifications and resources that have been submitted by experts. Upon registration into the union, the CAI clearinghouse will identify its relationship and links with the other clearinghouses that are already in the union. In this case, the CAI clearinghouse has to determine its relationship with the simulation/gaming domain. Some of the overlapping regions between CAI and simulation/gaming include edutainment, the use of simulations and virtual reality in learning. These resources can be applied to both the simulation/gaming domain and CAI domain when simulation/gaming is used as a tool in teaching using computers

Both CAI and simulation/gaming experts have submitted resources to their respective domain-specific information clearinghouses. Some of these resources are similar and will overlap each other. Using the overlapping regions as a starting point, the information agent in each clearinghouse will collaborate by sharing the resources they have. When a learner searches for virtual reality related resources in the CAI domain clearinghouse, he will be prompted that more resources are available in the simulation/gaming domain. He will also be linked and directed to these resources found in the simulation/gaming information domain. In this way, more resources can be retrieved without compromising on the quality of the results. This is very useful for learners with multiple domain interests. Furthermore, learners are also able to see how other domains relate to his domain interest. This sharing is done with the help of the union agent.

6 DSIC Toolkit

BEST COPY AVAILABLE

Although different domain specific information clearinghouses catalog resources in different domains, they have the same main functionality as follows:

- **Registration** – Users can register as information resource providers via online forms
- **Catalog** – Registered domain experts can login to the system and catalog resources. In addition, an automated information agent is used to gather resources from the Web automatically. Authors are identified by the agent and invited to refine the catalog of their own resources.
- **Browse** – Web users can browse through the resources cataloged in the clearinghouse using the classification scheme employed
- **Feedback** – A feedback mechanism must be provided for users to give feedback to the DSIC administrator
- **Administration** – An authorized administrator is allowed to make administrative changes to the system as an administrator

These similarities in different clearinghouses provide the foundation for the development of a generic, flexible toolkit for the rapid deployment of a domain-specific information clearinghouse. Domain experts with little or no Web development expertise but wish to deploy and maintain an information clearinghouse can make use of this toolkit to rapidly set up one.

The DSIC toolkit is designed as an integrated package with the following components:

- Web server
- Classification Scheme Editor
- HTML Template Editor
- Administration Module
- User Module
- Information Agent Module

A set of default templates are provided together with the toolkit so that a domain expert who wishes to set up a clearinghouse can selectively use the components of the toolkit and set it up in a short time span instead of having to start from scratch.

7 Conclusions

In this paper we have proposed a framework that allows learners to collaborate and share resources. With the use of domain specific information clearinghouses, learners are able to find useful, valuable and related resources. The clearinghouse union is a mechanism that allows different domains to come together and share their resources. This is especially useful for researchers and learners who have multiple domain interests. They are able to find resources across the different domains without compromising on the quality of the results.

Knowledge discovery and sharing is also made possible with the help of the union agent that overlooks all the domain clearinghouses in the union. The union agent not only helps learners retrieve related resources in other domains but also searches through the huge databank of resources to find hidden relationships about the different domains, giving us information on how different domains are linked and related to one another.

Finally, we also presented a clearinghouse toolkit currently under development for the rapid deployment of an information clearinghouse. Through the use of the toolkit, domain experts can quickly specify a classification scheme and set up a clearinghouse. The newly deployed clearinghouse is automatically registered with the union and start sharing resources with other clearinghouses already in the union.

References

[1] Loren T., Will H., and Brian A., "Constructing, Organizing, and Visualizing Collections of Topically Related Web Resources", in ACM Transactions on Computer-Human Interaction, Vol. 6(1), March 1999.

[2] Neri, F. and Saitta, L., "Machine Learning for Information Extraction", in Proceedings of the International Summer School on Information Extraction, SCIE '97 (Frascati, Italy, July 14-18, 1997.) Springer-Verlag Berlin Heidelberg, 1997, pp. 171 – 191.

[3] Theilmann, W. and Rothermel, K. "Domain Experts for Information Retrieval in the World Wide Web", in Proceedings of Second International Workshop on Cooperative Information Agents (Paris, France, July 4-7, 1998.) Springer-Verlag Berlin Heidelberg, 1998, pp. 216 – 227.

[4] Eric J.G., Steve L., William P. B. and C. Lee G., "Architecture of a Metasearch Engine that Supports User Information Needs", in Proceedings of CKIM 1999.

[5] http://www.usatoday.com/life/cyber/tech/review/crg842.htm

[6] http://sg.comp.nus.edu.sg

[7] http://www.w3.org/RDF

Everything in Moderation? Developing successful collaborative projects between European initial teacher education students

David Owen *, Brian Hudson*, Alison Hudson, Eila Jeronen***, Jan Morawski****, and Peter Schurz*******

**Pedagogy and New Technologies Research Group*
School of Education
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
Tel: +44 144 225 2448
Fax: +44 114 225 2324
D.H.Owen@shu.ac.uk *and* B.G.Hudson@shu.ac.uk

*** Centre for Multimedia in Education*
Learning and Teaching Institute
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
A.R.Hudson@shu.ac.uk

****Department of Teacher Education*
University of Oulu
P.O.B. 222
90571 Oulu
Finland
ejeronen@ktk.oulu.fi

*****Department of Education and Social Studies*
Hogskolan Darlana
S-781 88 Falun
Sweden
jmo@du.se

******Pädagogische Akademie des Bundes in Oberösterreich*
Kaplanhofstrasse 40
A-4020 Linz
Austria
schuerz@pa-linz.ac.at

Computer mediated collaborative projects have the potential to strengthen the European Dimension in teacher education whilst giving students an appropriate context to develop their computing and collaborative skills. This paper evaluates the success of such a project through the completion of a three-year action research enquiry involving student teachers from four European countries. The results of three cycles of development are presented. The project was evaluated using student questionnaire data, participation in tutor meetings, and analysis of students' web page development and bulletin board contributions. Results suggest that successful collaborative project work depends on ease of access to

reliable computer networks, giving equal weighting to resource production and levels of international communication, and effective moderation of the project by all tutors involved. The paper concludes by detailing future developments in European cooperation involving the partner institutions. These developments involve using the Ecoschool communication networks to discuss pedagogic and multi-media design issues involved in a cross-curricular CD-ROM which has been developed by the same group of partner institutions.

Keywords: **computer mediated communication, European co-operation, moderation.**

1 Introduction

This paper reviews a three-year cycle of telematics curriculum development and action-research in initial teacher education. The project has been made possible by funding via the SOCRATES European Module ECOSCHOOL (1997-2000). The project has two aims; to develop learning by using the World Wide Web (WWW) and email across Europe, and to learn about the social and economic aspects of the participant's home city. The outcomes of the project include the creation of a collaborative open learning course that teacher education students can follow as part of their training.

The Ecoschool developments originated from European collaboration on the EUROLAND project (1996-99). It brings together partners from Austria, England, Finland and the Netherlands in building the European Dimension into the curriculum of schools and teacher education courses (Hudson et al, 1997 and Hudson et al, 1999). Teacher education institutions and departments lead both projects in close collaboration with partner schools and teachers in each country. The resources that have been produced by both the Ecoschool and Euroland projects have been used as the basis for the development of pedagogic approaches with teachers on intensive in-service training courses, which have been supported under the Comenius 3.2 Action of SOCRATES.

The paper reports on four aspects of the Ecoschool project; the three year cycle of curriculum development, the tutor and student evaluation of the project, lessons learned regarding telematics pedagogy, and future developments that link the outcomes of the Euroland and Ecoschool projects.

1.1 Participants in the project

The participants are primary teacher education students from Linz and Sheffield together with students on an international teacher education course at Oulu. A more recent partner to this development is the University of Darlana in Sweden. This has led to the participation of a group of social studies student teachers from Falun in Sweden. English was used as the medium for communication and a total of eighty five students took part over the three years.

1.2 Collaboration and communication

A key aim of the project has been to promote the European Dimension and the use of Information and Communications Technology (ICT) in teacher education across Europe. The development of the European Dimension provides ample justification for collaborative communication but such projects can also reflect sound pedagogic principles. The pedagogical approach is based on a socio-cultural communicative perspective, which owes much to the works of Vygotsky (1987). Collaborative learning is at the heart of the Ecoschool project and has been used during the three cycles of student work. Many authors, including Hudson (1998) and English and Yazdani (1999) see such an approach as essential in developing students' learning skills when using ICT or learning without the aid of new technology.

2 Use of new technologies

The resources and tools being used are university email communications and the resources provided by the ProTo environment at the University of Oulu– *Project Learning Tools on the Web*. This is an open learning environment that has been developed at the University of Oulu. Students can access the ProTo system via

the World Wide Web. They have a password that allows them to create simple web pages and enter messages on a bulletin board. Students also created web pages using Netscape Composer and posted them on their home pages. In cycle three they used an electronic bulletin board as well as using ProTo and email.

Use of such technology is now a key focus in the education of teachers across Europe. Student teachers in England and Wales follow the National Curriculum for Initial Teacher Training (DfEE 1998). This curriculum requires students to show evidence of using and creating multi-media presentations, and of using web technologies to communicate with colleagues. In addition, recently published guidance detailing an ICT primary school curriculum (QCA, 1998), suggests that children aged ten should be able to design and evaluate simple multi-media presentations, and children aged eight should be able to take part in an email exchange. Clearly student teachers need the confidence and skills to develop these abilities in their pupils. The Ecoschool gives students this experience through their participation in a computer mediated collaborative project and by their evaluation of its potential use in their future educational roles.

2.1 Pedagogic approaches

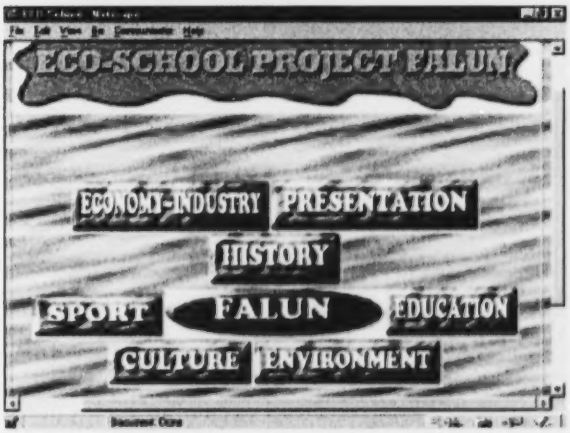
As previously stated the Ecoschool project uses a pedagogic approach that seeks to promote learning through 'electronic talk' in collaborative groups. These groups use a plan, do and review strategy as proposed by Kolb (1984) in his model of experiential education and by Schon (1987) describing the planning cycle used by reflective teachers and learners. The groups planned the construction of webpages, constructed and evaluated their own pages and those of other groups, then finally evaluated the whole project. Tutors developed their own pedagogy of distance learning during the project. The success of the tutors' approaches are analysed using guidance developed by McGee and Boyd (1995) to facilitate dialogue during computer mediated communication.

3 The three cycles of curriculum development

3.1 Cycle One

Focus : comparing students' home cities
Outcomes: web pages explaining local city

Figure 1: Work from the Swedish students posted to the ProTo learning environment.



Students in each country worked in collaborative groups to produce a short illustrated report on one of the following aspects of their home city. This involved a general description of the city, an explanation of the environmental situation and the employment structure of the city, and an analysis of the regional or national education system.

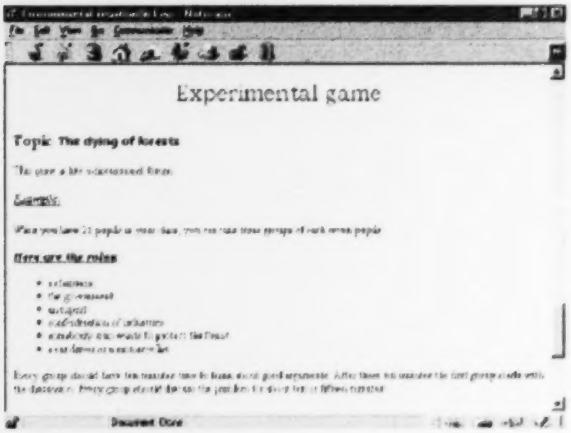
Subsequently they presented these reports as web pages by writing them in to the ProTo learning environment. Figure 1 shows a page produced by the Swedish students. They also emailed their work to other students in the partner countries who were presenting the same topic. Once all web pages were complete, they read their partner's pages, asked questions and made comments about them on the bulletin board. Each group evaluated their work using the same criteria designed by the tutors in each country. The tutors then read each group's pages, assessed the pages and provided feedback to the each group. The students' work was assessed against the criteria and graded A to C. The tutors posted written feedback on the bulletin board.

BEST COPY AVAILABLE

3.2 Cycle Two

Focus : Comparing lesson planning
Outcomes: web pages giving examples of lesson plans

Figure 2: Teaching and learning about the environment in Lin

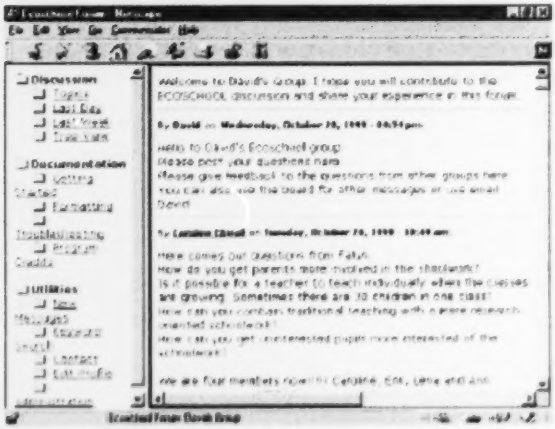


The aim of this round of co-operation was for students to share lesson plans and teaching ideas. Each group of students planned lessons with the aim of children learning more about their local town or city. Again, students presented these as web pages on the ProTo system or, in the case of the Swedish students, on their university home pages. Each group of students again evaluated the pages of their partner groups, responded to each other's questions, and received feedback from the tutors in each country. Students' work was again assessed.

3.3 Cycle Three

Focus: suggesting and solving educational problems
Outcomes: range of solutions to five educational problems

Figure 3 The Euroland and Ecoschool discussion and chat site.



The Ecoschool project ran during autumn 1999 with several new developments. The students were in internationally composed groups rather than from one single country and the focus of the project was to choose an educational problem and present a solution to this by co-operating using ICT. The students could use email, create their own web pages, use ProTo2 (a more sophisticated version), or use the Ecoschool bulletin board (see Figure 3). The majority of students chose to use the bulletin board to present their problem and solutions although some students did use the ProTo2 learning environment. Again tutors gave feedback to the students and responded to their questions although the work was not graded.

4 Methods of curriculum development and evaluation

Ecoschool developments have followed an action research model, as the aim of the project was to develop a successful curriculum for initial teacher education over the three years of the project. The Ecoschool curriculum was developed in face-to-face planning meetings and followed up by email communication between partners in Austria, Finland, Sweden and England. The results of student and tutor evaluation were fed into the curriculum planning at the end of each cycle. The following methods have been employed in gathering evaluation data:

BEST COPY AVAILABLE

Student evaluation questionnaire. All students completed a questionnaire by email or on paper. Many groups posted the results of their evaluation on the ProTo system or on the Ecoschool bulletin board. The questionnaire requested information on student expectations of the project, levels of interaction, the role of the tutor, use of new technology and ideas for the future.

Tutor evaluation. A tutor from each country completed a written evaluation of their experience at the end of each cycle and presented the document for discussion at the annual Ecoschool development meetings.

Web page analysis. The students created web pages of differing levels of complexity during cycles one and two. The web pages construction process is evaluated against the six components of infomedia literacy as proposed by Lee (1999, pp.147-149). These components are:

1. An understanding of the nature and functions of infomedia and their impact on individuals and society.
2. The development of critical thinking ability.
3. The skill of efficient searching and critical selection of information.
4. Knowledge of multi-media production using appropriate technology.
5. Aesthetic appreciation of hypertext, graphic design and visual images.
6. Social participation in influencing the development of infomedia technology.

ProTo communication log analysis. The record of tutor and student communication during cycles one and two was analysed using Boyd and McGee's (1995) guidance on facilitating dialogues using computer-mediated communication. They suggest that facilitators provide both technical and content-specific support; are responsible for regularly communicating with the group; communicate in ways that require a response; and model standards of high quality interaction

Ecoschool bulletin board observation. The Ecoschool bulletin board was set up in September 1999 and provided the student groups with a shared electronic space for presenting and discussing their ideas. Each group had a separate area for their own use. The frequency and quality of communication was analysed as well as the level of interaction between group members.

5 Evaluation Results

Student evaluation questionnaire data was collected from 12 of the 16 student groups over the three years. The key points arising were:

- In cycles one and two students who were apprehensive about using the technology felt that had been successful and the majority of students found that resource production was enjoyable and had developed their ICT skills.
- Communication between groups was successful in cycles one and two but sporadic in cycle three. This was attributed to pressure of work from other areas of their degree (Oulu), lack of clarity in terms of the aims of the project and technological problems in Linz and Sheffield.
- In cycle three, two of the five groups were critical of the lack of commitment of their partners.
- Students in Sheffield requested formal computer sessions where they could meet and use university facilities for the project. All students felt that their tutors had supported them in cycles one and two, but three groups wanted clearer guidance in cycle three.
- By cycle three the students from Falun and Oulu requested the use of chat and video conferencing technology in any future work. Individual students in Linz and Sheffield experienced technical difficulties during November 1999 due to network problems at their institutions.

Minutes of three *Tutor evaluation* meetings and five written reports state that:

- The role of the tutor was clear in cycles one and two but not in cycle three
- Cycle three was seen as a radical departure from previous work and was viewed as 'experimental'
- Students in Linz, Oulu and Sheffield were hampered by block teaching practices taking place during key times in the project.
- Tutors were pleased with the progress made by their students in cycles one and two and had discussed how work in cycle three could be improved.

Web page analysis using Lee's concept of infomedia literacy reveals:

- Only two groups took a critical approach to the sources they used when constructing pages about their

home city in cycle one.

- Three groups overtly discussed the problems of representing people and places on their web pages in cycle two.
- Four groups of students in cycle one saw the pages as similar to written text so did not exploit the advantages of hypertext fully.
- All students changed from passive users of web pages to active publishers of their own content.
- The students from Falun produced a website in cycle two that clearly demonstrated a collaborative approach and a high level of aesthetic appreciation in regard to page design.
- Students from Oulu and Falun were in general more adept at making critical comments about their own and other's work than the Linz and Sheffield students.

ProTo communication log and *Ecoschool bulletin board observation* using McGee and Young's guidance shows:

- In cycles one and two tutors adequately fulfilled the roles of moderator, mediator and facilitator.
- Tutors communicated with the participants by asking one or more questions, giving examples from their own experience to add to discussions and modelling high quality interaction.
- The cycle three work led to the production of questions and solutions but little discussion. In general tutors did not moderate the discussion effectively as they were unsure of their roles.
- The decision to limit the role of the tutor in cycle three had a negative effect on the level of interaction and quality of discussion. Student evaluations reveal uncertainty about technical issues as well as pleas for stronger leadership and rigid deadlines.

6 Discussion

The cycles of curriculum development and evaluation have identified many important features in the development of collaborative ICT projects. Establishing an international electronic community requires access to reliable technology for the students and also skill and commitment on the part of the tutors. Asynchronous communication is seen as one of the great advantages of electronic communication and university tutors may take their own ease of access for granted. In a study of barriers to student computer usage McMahon et al (1999) found that students identify real problems in accessing computers to complete course tasks. A Sheffield student reflects their conclusions when evaluating her experience in cycle three:

> *If we had been given time in our lectures to get together and a set routine with correspondence time every week then we would have got more out of it. As a group of people we are all in different (teaching) groups, so getting together is difficult and finding a PC when we have free time is also difficult.*

This highlights the question of computer access as well as the importance of study and group work skills in such a project. Very clear project goals and explicit expectations on student participation are also needed. Is it the students ' responsibility to meet and organise communication sessions during their own time, or will better levels of communication occur by booking computer access during student practical classes? If this is done are the benefits of asynchronous communication being demonstrated? An unexpected outcome of this project has been to highlight the importance of developing students' teamworking skills.

Once access is assured, the roles of the tutor as moderator, mediator and facilitator are crucial. A key finding from the evaluation is that communication was much more successful when the tutors had a strong moderating role in cycles one and two. When planning for cycle three, tutors limited the moderation role and gave the student groups much more independence. The majority of the students interpreted this as poor planning and one group described it as 'lack of leadership'. This highlights the complexity of the moderator's role and a recommendation from this project would be that the tutors spend time in the final evaluation meeting exploring their experiences in this role.

Developing a successful collaborative curriculum is dependent on creating a fine balance between resource production and communication. In cycle one the web pages produced were basic, but quality of interaction between students was high. In cycle two the web-based products were much more sophisticated but students paid less attention to communication, perhaps because more academic credit was gained for page development rather than communicating with fellow students. Student's work in the final cycle showed some evidence of sound international cooperation, but less in-depth critical analysis. Experiences gained

during the three cycles have led to the development of a formal curriculum unit (see http://www.shu.ac.uk/schools/ed/teaching/dho/). Students will gain high grades only by giving equal weighting to communication, resource production and critical evaluation in their group work.

Finally, teacher education students need to transfer their learning to a classroom situation. One student has already set up a similar project whilst on teaching practice. In this example infant school children communicated via email with children in Bermuda and compared their localities, hobbies and homes as part of English and geography learning. Tutors need to set up opportunities for students to use their newfound confidence and skill in the classroom. Nook Lane Primary School in Sheffield is now linked with partner schools in Linz and Oulu as a result of the project, and students can now contribute to the development of this partnership.

6.1 Future developments

As a result of ongoing evaluation the following developments have been planned for 2000-2001. A chat facility had been added to the Euroland/Ecoschool discussion area in addition to the bulletin boards. Building on the success of a trial video-conferencing session held in November 1999, students will be able to use this form of communication from September 2000 in all countries. Students and teachers can also now access the communication tools via the Hallam Geography Education web site as well as from the Euroland web pages. Finally, with the imminent completion of the Euroland CD-ROM, the two projects will be brought together. Students and teachers will be able to use the CD-ROM as a focus for collaboration and discussion in the areas of infomedia literacy and multi-media development, the pedagogy of computer-mediated collaboration and the comparison of European social and environmental learning.

7 Conclusion

The Euroland and Ecoschool projects represent successful examples of how an international perspective can be developed in the university and school curricula. Sustained and effective communication is the key to such initiatives, alongside ease of access to computing facilities and a focus on the crucial role of the tutor as moderator. Both projects have provided tutors, students and pupils with membership of an expanding European network, which is a solid platform for the development of further collaborative work.

8 References

DfEE (1998) High Status: High Standards Circular 4/98. HMSO.

English, S and Yazdani, M. (1999) Computer-supported co-operative learning in a Virtual University. *Journal of Computer Assisted Learning*, 15, 2-13.

Hudson, B. (1998) A social perspective on learning in the context of Computer Mediated Communication in teacher education. *Proceedings of ICCE 98: International Conference on Computers in Education*, Beijing, China, 14-17 October 1998, 627 – 632.

Hudson, B., Hudson, A. & Schürz, P. (1997), Euroland: A Collaborative European Cross-Curricular Project using CD-ROM. *Proceedings of ICCE 97: International Conference on Computers in Education*, Kuching, Sarawak, Malaysia, December 1997, 1006-1007.

Hudson, B., Schürz, P. and Hudson, A. (1999), The Euroland/Ecoschool projects: Promoting Collaboration in a European context using CD-ROM and the WWW, Paper to Subnetwork D: Powerful Learning Environments in Teacher Education. *Conference of the Thematic Network on Teacher Education in Europe (TNTEE)*, Lisbon, 1999, http://tntee.umu.se/lisboa/

Kolb, D.A. (1984) *Experiential Education: Experience as the source of learning and development*. Prentice-Hall.

Lee, A.Y.L (1999) Infomedia Literacy: An educational basic for young people in the new information age. *Information, Communication and Society*, 2, 2, 134-155.

McGee, P.A. and Boyd, V (1995) *Computer-Mediated Communication: Facilitating Dialogues* at http://www.coe.uh.edu/insite/elec_pub/html1995/173.htm. Visited 4/10/00.

McMahon, J. , Gardner J., Gray, C., and Mulhern. G. (1999) Barriers to student computer usage: staff and student perceptions. *Journal of Computer Assisted Learning*, 15, 302-311.

Schon, D.A. (1987) *Educating the Reflective Practitioner: towards a new design for teaching and learning in the professions*. Jossey-Bass.

QCA (1998) Information *and Communications Technology: A Scheme of Work for KS1and KS2*. QCA.
Vygotsky, L.S. (1987) *The Collected Works of L.S. Vygotsky*, Vol.1 Plenum Press, NY.

http://www.shu.ac.uk/services/lc/cmeweb/Euroland/chatgroups.htm
The Euroland and Ecoschool discussion and chat fora.
http://ProTo.oulu.fi/
The ProTo open learning environment.
http://www.du.se/~lmh98lae/
Ecoschool pages created by students form Falun, Sweden.
http://wwwedu.oulu.fi/homepage/ejeronen/eco/index.htm
All cycle one and cycle two work can be viewed at this location.

Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers

ROSEMARY LUCKIN AND BENEDICT DU BOULAY,
School of Cognitive & Computing Sciences
University of Sussex
Brighton BN1 9QH UK.
E-mail: *rosel@cogs.susx.ac.uk* and *bend@cogs.susx.ac.uk.*

In this paper we discuss our observations of a group of 10 and 11 year old children using an Interactive Learning Environment called the Ecolab. The design of this software was informed by our interpretation of Vygotsky s Zone of Proximal Development in which *Interaction* and *Collaboration* are definitive characteristics. The relationship between the differences in interaction/collaboration style and the learning gains made by the children are discussed. The results show that children can be grouped into profiles according to the differences and similarities in their use of the system and that common interaction features are influenced by the design of the software being used. We suggest that children are poor at managing their own learning experience with technology even when the software offers both opportunities to complete challenging activities and support to ensure success. The children in this study needed explicit direction towards activities which were beyond their ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity: a suggestion from the system about what and how to proceed is often sufficient.

Keywords: **Interaction, Collaboration, ZPD, ILE.**

1 Introduction

Computers are now an accepted part of classroom life for most young learners whether they are used for communication, visualization, simulation experience or simply for fun. But how do children actually interact with computers? Does the nature of their interactions vary from child to child in a way that could inform the design of the software which engenders these interactions? This paper explores children s use of an Interactive Learning Environment (ILE) called the Ecolab which was designed to help children learn about ecology. The system attempts to fulfill the role of a more able learning partner for the child and invites collaborative interaction. The collaboration is thus between the system and the child and not between children. Here we describe the nature of the interactions that a class of children had with this system. The nature of these interactions is considered in the light of pre- and post-test learning gains to explore the relationship between learning and interaction style. The Ecolab software has been designed using a framework derived from our interpretations of the Zone of Proximal Development (ZPD) [10, 11]. The ZPD describes the most fertile interactions which occur between the more and less able members of an educational culture and focuses attention on how the more able can help learners to learn. The ZPD offers a theory of instruction which emphasizes the inseparability of the teaching and learning processes and thus recognizes the inherent interactivity of children s learning with computer software. It also stresses the need for learners to have the help of a collaborative learning partner in the form of a peer, a teacher or in the case of the Ecolab, a computer. Within a Vygotskian, socio-cultural model of education human activity is mediated by tools and sign systems that have arisen through social interaction. Developmental explanations are used to address the complex internalisation process by which the interpsychological relations between partners in social interaction becomes intrapsychological

within the individual learner. Interaction and Collaboration are therefore definitive characteristics of the ZPD which form the linchpin of the socio-cultural framework and thus form the focus of our investigations of children using the software.

In this paper we provide a brief description of the Ecolab software before discussing an evaluation study of its use. We report the results with particular emphasis upon the nature of the Interaction and Collaboration profiles we were able to construct from our records of system use. We provide examples of individual learner s use of the system and discuss the relationship between the nature of the interactions and the learning gains recorded after system use.

2 Ecolab Software

Ecology is a subject that involves the study of relationships between organisms within our environment. These relationships can be extremely complex; they can also be introduced in a simplified manner through concepts such as food chains and food webs. These form the foundations of more complex ecosystems and are part of the curriculum for primary school children in the United Kingdom. The Ecolab software provides 10 and 11 year old children with the facilities to build, activate and observe the ecological relationships which exist between members of a simple food web in a woodland ecosystem. It provides a simulated ecology laboratory environment into which the child places the animals and plants of her choice. This environment can be viewed by the child from several different perspectives or *views*, including:

World - a picture of a woodland environment and the organisms the child has chosen to place within it.
Web - a traditional text book style diagram of the organisms in a food chain and food web.
Energy - a graphical representation of the energy levels of the organisms currently alive in the Ecolab.
History - a linear narrative of what has happened in the Ecolab world to date, which animal has eaten which other animal for example.

As we have already stated the nature of the relationships that can exist between organisms in the real world can be very complex. We wished to allow each of the children using our system to learn about relationships at a level of complexity that was appropriate to them. We therefore built the learning environment in a manner that would allow children to learn about relationships ranging from the simplest, between just two single organisms, to the much more complex network of relationships that could exist in a very simple ecosystem involving populations of organisms. The complexity of the relationships represented within the Ecolab can be varied at any stage during the child's interaction with it. It is also possible to alter the abstractness of the terminology used to describe the organisms in the Ecolab so that a snail, for example, can be described by the words "herbivore", "primary consumer", or "consumer" as well as the word "snail".

In addition to this simulated laboratory environment, the system acts as a collaborative learning partner for each learner which can provide assistance of the following sorts:

Extension of the learner s knowledge through increasing the complexity of the relationships she is asked to study and/or the abstractness of the terminology used to describe what is happening in the Ecolab.

Collaborative Support which can take the shape of *Activity Differentiation:* in the form of alterations to the difficulty of the activities the learner is asked to complete, or context sensitive *Help* of variable levels of quality and quantity.

At the start of this paper we discussed our use of the Zone of Proximal Development to underpin our system design and the importance of *Interaction* and *Collaboration*. In order to explore the nature of the interactions children had with our software, the collaboration that might occur between system and learner, and the relationship between interaction, collaboration and the changes in learning outcome recorded after system use, we varied the manner in which collaboration from the system was offered to the learner. The Ecolab consists of three system variations: VIS (Vygotskian Inspired System), WIS (Woodsian Inspired System) and NIS (Non-theoretically Inspired System). These three system manipulations implement different design elements in order to adjust the assistance they provide (see [4] and [5] for more detail). The way in which each of the system variations adopts a different approach is summarised in Table 1. In particular, VIS makes more decisions than WIS which makes more decisions than NIS. In other words NIS gives the learner most freedom of choice to the learner and VIS the least.

3 Interactions with the Ecolab

An exploratory evaluation of the Ecolab software was conducted with a class of children aged 10 and 11 years. We wanted to investigate the extent to which the system would be able to adjust to learners of differing abilities, and also the ways in which the interactions and collaborations between user and system varied with users of different abilities. The children's school assessments were therefore used to allocate each child to one of three ability grouping: High, Average and Low. Prior to using the software each child completed a written and a verbal pre-test, the latter of which was in the form of a structured interview recorded on audio tape. Each child used the Ecolab software as an individual for a total of 60 minutes over two sessions. In addition, a 20 minute initial session with a smaller 'demo' versionensured that all children were comfortable with the mouse skills required and the interface. After the system intervention subjects were given a written and verbal test, identical to the pre-test, and a short additional extension interview. A delayed post-test was conducted 10 weeks after the end of the original post-test. Of the 30 children who started the study only 26 completed all sessions between, and including, pre and post-test. The four who did not complete these sessions had either left the school or been absent during the evaluation period. Only 24 completed all sessions including the delayed post-test. Once again the reason for non-completion was absence from school.

Table 1 Collaborative Support within Ecolab

Collaborative Support within Ecolab			
	VIS	**WIS**	**NIS**
Levels of Help Available (different levels provide differing qualities of help - 5 represents the greatest and 1 the least)	5	5	2
Decision about Level of Help made by	system	system and child	child
Levels of *Activity Differentiation* Available	3	3	3
Decision about type of Activity and Differentiation level made by	system	child - system makes suggestions	child
Extent of Learner Model maintained by the system and used to make decisions about the support to be offered to the learner.	Bayesian Belief Network (BBN) of values representing the system's beliefs about child's ZPD formed from its knowledge about the amount of collaborative support used to date.	Record of help used to enable contingent calculation of next help level. Record of curriculum nodes visited maintained to permit suggestions.	Record of Curriculum nodes visited maintained to help child keep track.
Abstractness of Terminology selected by	system	child	child
Area of the Curriculum and complexity of the next activity selected by	system	child - system makes suggestions	child
Ecolab View selected by	mostly child	child	child

The results of the pre- and post-test were used to assess the efficacy of the three variations of the Ecolab software. This work is reported elsewhere [4, 5] and is not the main focus of the current paper. It is the character of the interactions between each child and the system that we will focus upon here. We wanted to investigate what sorts of interactions had resulted in the greater learning gains and which systems had supported and encouraged various types of interaction and collaboration in order to inform the design of our next system. For each child a summary record of their interactions was produced from the detailed logs maintained during their two sessions of system use and this was used to build up a picture of the types of interactions each child experienced with the system (for full information see [4]).

Cognitive or learning styles have been a subject of active interest in recent years [1, 3, 6, 8], for a brief review see [9]. The influence which a learner's style can have upon the way they interact with technology has also been

recognised [7]. Within this literature there are examples of classification systems which differentiate learners according to their learning preferences; for example, as serialists or holists [6]. The analysis of the annotated interaction summaries of children's experiences with the Ecolab software takes a fresh perspective on classification using only the styles of interaction or *Profiles* which can be found in the records of each child's system use and emphasizing our interest in the nature of *Interaction* and *Collaboration*. Characteristics were identified and children categorised through:

- **Interaction Profiles** according to the character of their interactions with the Ecolab.
- **Collaboration Profiles** according to the nature of the collaborative support provided by the system for the child.

4 Results

One aspect of the evaluation looked at whether the different variations of the Ecolab had been more or less effective in increasing the child's learning gain in terms of her understanding of the feeding relationships which exist in a food web as reflected in the pre- and post-test data. This indicated that the system variation (VIS, WIS or NIS) which the child used was relevant to her subsequent learning gain and a detailed discussion of these results can be found in [5]. Here we wish to concentrate upon the analysis of the records of interaction which was used to try and pinpoint the elements of VIS and WIS which led to their superior performance with particular ability groups.

4.1 Interaction profiles.

There were two characteristics which could clearly be seen as either present, or largely absent within the children s interactions. These were referred to as:

- **Busyness** and
- **Exploration**

Busyness was considered to be a characteristic of interactions in which the children completed an average or above average number of actions of any type, such as adding an organism to their Ecolab world or making one organism eat another. The interaction summaries of these children contained an above average number of events. The opposite of Busyness is referred to as **Quietness**.

Exploration was considered to be a characteristic of an interaction if the child had been involved in some sort of action which allowed her to experience more than one level of complexity or more than one level of terminology abstraction, beyond her initial starting levels. The opposite of Exploration is referred to as **Consolidation**.

Some children also switched frequently from one type of interaction to another. For example, they might switch from attempting to make one animal eat another, to looking at their organisms in a different view (i.e. perspective), to accessing a new activity entirely. Their interactions contained no or few series of repeated actions of the same type. They were particularly prone to frequent changes of view. These users have been characterised as **hoppers**. Other learners exhibited a more persistent approach, with sets of actions of a similar type grouped together. These users have been referred to as **persisters**.

These characteristics allow the children to be categorised , in principle, into 1 of 8 (2x2x2) possible Interaction Profiles.

The three parameters of categorisation: Busy/Quiet, Exploration/Consolidation and Hopper/Persister bear some similarity to features found in other categorisation systems. Pask's [6] differentiation of tendencies in learners towards being either "top-down" holists or being "bottom-up" serialists shares some common ground with the Hopper/Persister characteristic, for example. The differentiation of exploration from continuing activity at a level of consolidation is likewise similar to the challenge/safety division of [2]. However, the motivation for the analysis reported in this paper was not the presentation of a generally applicable categorisation system. The aim was twofold:

- To investigate the relationship between interaction style and learning gain.
- To examine how each of the system variations (VIS, WIS and NIS) of the Ecolab supported and encouraged particular learning styles.

Children fell into 6 of the 8 possible Interaction Profile groups. The distribution within these groups is illustrated in Table 2.

Table 2 Interaction Profile Membership

Profile Description	% of children in Profile group
Busy - Exploring - Persister (BEP)	28%
Busy - Exploring - Hopper (BEH)	12%
Busy - Consolidating - Persister (BCP)	8%
Busy - Consolidating - Hopper (BCH)	12%
Quiet - Consolidating - Persister (QCP)	20%
Quiet - Exploring - Persister (QEP)	20%

4.1.1 Examples of User Interaction Profiles

S10 (Gene) was a typical example of the *Busy - Exploring - Persister* style of interacter. Her first action was to switch from world view to energy view and then back to world view. She then added 15 organisms to the Ecolab and visited energy view again. Upon switching back to world view she made one of her organisms eat another, switching to energy view to see the effect. This pattern of making organisms act, either eating or moving and looking at the effect in an increasing number of different views continued. Introductory, investigative and rule-definition activity types were completed for the first two nodes in the curriculum before her first session drew to a close. She chose not to save her current Ecolab world which meant that at the start of her next session her first actions were the addition of organisms. Once again she added all 15 and then moved into the next phase of food web complexity and used more abstract terminology to view her organisms. Whilst the nature of the actions she completed was now more advanced and several instances of help were used, her pattern of activity remained one of initiating an action or actions appropriate to the evident goal. Actions were often completed in pairs and were followed by viewing the result from different perspectives (most commonly, energy, web and world). She did not experiment with writing a program or attempt to escape from completing the activities offered to her.

This profile group contains only high and average ability children from the VIS and WIS system user groups. In terms of performance at post-test there was a tremendous spread: A *Busy - Exploring - Persister* style learner attained the lowest learning gain, another, the second highest learning gain. The high ability children within the group all achieved an above average learning gain, but within the average ability children there was a wider spread of learning gain scores. Membership of this group was limited to VIS and WIS users, of whom the VIS users all achieved above average post-test learning gains, including the highest learning gain within this user group.

4.2 Collaboration profiles.

Two characteristics were found to be the most useful for differentiating collaborative style within the interactions: Amount of support and Depth of support used. These collaboration characteristics were used to group the children into one of four Collaboration Profile groups.

Amount of support: the average amount of activity differentiation (i.e. the degree to which the activity is presented in a simpler form) and the average number of help instances for the experimental group was calculated. An above average amount of either activity differentiation or instances of help was the criteria necessary for a child to be considered as using 'Lots' of collaborative support.

Depth of support: this characteristic was based upon the level of help and level of differentiation used. Once again the average levels used within the experimental group were calculated. Help or differentiation above the average level resulted in a child being considered as using 'Deep' or higher level support.

Interactions could be grouped into all 4 of the possible Collaboration Profiles. The first group was the largest and was further divided in accordance with the type of support which was most prevalent. The distribution of children into these groups is illustrated in Table 3.

Table 3 Distribution of children within Collaboration Profile groups

Profile Description	% of children in Profile	Profile sub-group Description	% of children in Profile sub-group
Lots and Deep (LD)	53%	Differentiation and Help	19%
		Differentiation	19%
		Help	15%
Lots and Shallow (LND)	12%		
Little and Deep (NLD)	16%		
Little and Shallow (NLND)	19%		

4.2.1 Examples of User Collaboration Profiles

S1 (Jason's) use of the available support was typical of the *Lots and Deep* profile group and of a user of above average amounts of both help and activity differentiation. He used level 4 help early in his first session of system use to achieve success in making organisms eat each other. His initial activities were completed with maximum differentiation of level 3. This was gradually reduced and then increased again. During his first session of system use he completed a range of activities for three nodes in the first phase of the curriculum. All instances of successful help were at level 4 or level 5. Fewer activities were completed during his second session. However, these activities were at a lower level of differentiation and there were fewer instances of help.

This Collaboration Profile group was the largest and was subdivided to account for the type of support used. Only VIS and WIS system users shared the profile. Jason was a member of the subgroup which used above average amounts and levels of both activity differentiation and help. This subgroup again consisted only of high and average ability children whose mean learning gain is above the average for the whole class (16% as compared to the class average of 11.5%). The subgroup of children who used greater levels of differentiation than help contained children from all ability groups. This second subgroup also produced above average learning gains at post-test (18% as compared to the class average of 11.5%). The last subgroup of children, who used greater amounts of help than differentiation, were all average ability children. Their average learning gain was well below the class average (3.9% as compared to the class average of 11.5%).

System variation had a greater impact upon the nature of the Interaction and Collaboration profiles than ability. A Pearson Chi-squared statistical test was also used to assess the relationship between the Ability groups, System Variation Groups, Interaction Profile Groups and the Collaboration Profile Groups. There was a significant association between System variation membership and Collaboration Profile membership (X^2 = 28.52, df = 6, $p < .0001$), and also between System variation membership and Interaction Profile membership (X^2 = 25.79, df = 10, $p < .01$).

So far little has been said about the NIS user group, they have not belonged to either of the Profiles used in the examples. In fact, all the NIS users belonged to a Consolidating Interaction profile; there were no explorers in this system user group. In addition, and as has previously been mentioned, no NIS users were in the Lots and Deep Collaboration profile group.

S9's (Tim's) Interaction profile which was that of a Quiet, Consolidating Persister, was typicalof a NIS system user. His initial session consisted of adding a single snail and then making 11 view changes to look at this organism from all perspectives. This initial stage was followed by a series of organism additions (commonly in blocks of 4); single actions, such as move or eat commands, in blocks of 1 to 5; and view changes which were almost always in pairs. In session 2 he adopted the commonly seen approach of adding a considerable number of organisms to start (in this case 12) and then once again completing single actions and view changes.

Likewise S26 (Karlie)s Collaboration profile reflecting low use of all types of help (Little and Shallow: NLND) was typical. She placed herself at the far extreme of food web complexity and started dealing with populations of organisms straight away. She only completed one type of action during both sessions of computer use: she built food webs using the *build web* command. Initially she made errors and used only occasional low level feedback, persisting until successful. The children in this profile group were all of high or average ability, but their average learning gains were well below average (5.2% as compared to the class average of 11.5%)

A further difference found within the NIS user group relates to the relationship between ability and learning gain. In the VIS and WIS user groups it was the higher ability children who achieved the greatest learning gains. By contrast, amongst the NIS users none of the high ability children made an above average learning gain, in fact the only learners who made above average learning gains were the low ability children. Whilst the numbers are small and the study exploratory this result is interesting and is certainly informing our current research. We had expected that of all three systems, the one which left most control within the hands of the learner would be most effective with the more able learners. Our results indicate that the opposite was in fact the case in our study.

5 Conclusions

This is an initial exploratory study with small numbers of children. However, there are several observations which are informative in building up a picture of the sorts of interactions which children experienced with the version of the system they used. VIS was the system which explicitly selected the next curriculum area for the child to complete and controlled the complexity and abstractness of the learning environment. Not surprisingly, all VIS users were members of profile groups with the 'Exploring' characteristic present. The split between 'Busy' and 'Quiet' was almost even. Only two of the VIS users scored a below averagdearning gain at post-test and both were in the same 'Quiet, Exploring, Persister' profile group. The majority ofWIS users were also 'Exploring' profile group members and only one did not belong to a 'Busy' profile group.However, whilst all the WIS above average learning gain achievers were members of 'Exploring' profile groups, the below average achievers were all members of different profile groups, with no common features between all of them. The WIS system variation did not set the curriculum area for the users, but did make suggestions which resulted in it being easier for a WIS user to avoid being an 'Explorer' thana VIS user. The NIS users were the children with the greatest freedom and the least finely tuned help system. It is perhaps not surprising therefore that none of them belonged to a profile group with the 'Exploring' characteristic. They were evenly split between being 'Busy' and 'Quiet' and the majority were 'Persisters'. Only two NIS users achieveabove average learning gains and unlike the WIS and VIS users, both were in profile groups which shared the 'Comfortable' characteristic, they were also both in the low ability group.

These results suggest that simply providing children with the means for extension through becoming involved in challenging activities is not enough to ensure that these challenging activities are undertaken. The child needs also to be explicitly directed towards activities which are beyond her ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity. The success of WIS indicates that a suggestion about what and how to proceed is often sufficient. The consistency within the high and average ability groups across the different systems for above average learning gain achievement to be linked to the 'Exploring' profile characteristic isnot reflected in the low ability group. The definition of the 'Exploring' characteristic may of coursebe too crude to encompass the possibility that the low ability children were 'Exploring' within interactions in a single phase of the Ecolab.

The manner in which each variation of the system collaborates with the child is a design feature of that variation and as such a big influence upon the resultant user Collaboration Profile. It was no surprise, therefore, that there was a significant association between system variation and collaborative support profile membership. However, it is possible, in principle, for a user of any of the variations to interact in line with any of the Collaboration Profiles described. In reality Collaboration Profile 'Lots and Deep' was exclusive to VIS and WIS users, whereas Collaboration Profiles 'Lots and Shallow' and'Little and Deep' were exclusive to WIS and NIS users. The only system which allocated both help and differentiation to users was VIS, so the fact that VIS users all used a high quantity and quality of help is unsurprising. WIS users often used a high level of assistance too, but in smaller quantities, they all belong to profiles where the support used was of a high level. In contrast, all NIS users are in profile groups in which the level of support is low. The choice of help

available to NIS users was admittedly more limited being of only two levels, however none of the users ever chose to use the higher level of help offered.

The absence of some forms of assistance from the interaction summaries of the less successful users offers support for the suggestion that it is the combination of being challenged, or extended, plus the provision of ample quantities and qualities of support which is important for learning. The lower ability children present a somewhat different picture as there is no apparent consistency between the use of collaborative support and learning gain. The only tentative conclusions are that this group responded to interactions in which the extent of the challenge was limited and that the nature of the assistance the system could offer was not effective for them. Those who were successful took up less different types of assistance and tackled less of the curriculum than their successful more able peers. There is also evidence that these children were not good at managing their own learning. The NIS Interaction and Collaboration profiles in particular would suggest that children who are given control for their own learning experience are not good at setting themselves challenging tasks or indeed seeking collaborative support. Our current work with children is investigating this issue in more depth.

Acknowledgments

This research was sponsored by the Economic and Social Research Council. Thanks are also due to David Wood and Yvonne Rogers for useful discussion and insightful comment upon this work, and to the children and teachers of Blacklands School, Hastings for being enthusiastic participants in the evaluation study.

References

[1] Goodyear, P. Njoo, M., Hijne, H. and van Berkum, J. J. A., Learning processes, learner attributes and simulations , *Education and Computing*, Vol. 6, No (3/4), pp. 263-304, (1991).

[2] Groat, A. &. Musson, T., Learning styles: individualising computer-based learning environments , *Association for Learning Technology Journal*, Vol. 3, No. 2, pp. 53-62, (1995).

[3] Kolb, D. A., *Experiential learning: Experience as the source of learning and development* , Englewood Cliffs, NJ: Prentice-Hall, (1984).

[4] Luckin, R., *Ecolab: Explorations in the Zone of Proximal Development* , (CSRP No. 486). School of Cognitive and Computing Sciences, University of Sussex, (1998).

[5] Luckin, R. & du Boulay, J.B.H., Ecolab: The Development and Evaluation of a Vygotskian Design Framework , *International Journal of Artificial Intelligence and Education*, Vol.10, No. 2, pp. 198-220, (1999).

[6] Pask, G., Styles and strategies of learning , *British Journal of Educational Psychology*, Vol. *46*, pp. 128-148, (1976).

[7] Riding, R. &. Rayner., S., The information superhighway and individualised learning , *Educational Psychology*, Vol. 15, No. 4, pp. 365-378, (1995).

[8] Riding, R. &. Read, G., Cognitive style and pupil learning preferences , *Educational Psychology*, Vol. 16, No. 1, pp. 81-106, (1996).

[9] Valley, K., Learning styles and courseware design , *Association for Learning Technologies Journal*, Vol. 5, No. 2, pp. 42-51, (1997).

[10] Vygotsky, L. S., *Mind in society: the development of higher psychological processes* , (M. Cole, V. John-Steiner, S. Scribner, E. Souberman, Trans.). Cambridge, MA: Harvard University Press, (1978).

[11] Vygotsky, L. S., *Thought and language* , Cambridge, MA:MIT Press, (1986).

Group Composition Methods for Cooperative Learning in Web-based Instructional systems

Yi-Hui Lee* and Nian-Shing Chen**
Department of Information Management
National Sun Yat-Sen University
** m8742618@mis.nsysu.edu.tw*
*** nschen@cc.nsysu.edu.tw*

The objective of this research is to find effective group composition methods to increase the interaction among students in asynchronous distance education using the theories of cooperative learning, group dynamics and social cognitive theory as foundations. The outcome can be a reference for the design of network cooperative learning activity and web-based instructional system in the future. This study is conducted in NSYSU Cyber University (http://cu.nsysu.edu.tw) using surveys and observations to investigate the influence of cognitive style on cooperative learning when different types of tasks are assigned. This research concludes that the choices of discussion tools in the chat room are different under intellective and decision-making tasks. Moreover, regardless of the task types, the heterogeneous groups outperform the homogeneous group during the cooperative learning process. Finally, the cognitive style is significantly related to group satisfaction in a cooperative learning environment

Keywords: **cooperative learning, web-based instructional system, cognitive style, group efficacy, group goal commitment**

1 Introduction

Group cooperative learning is defined as forming a group of two to six people with different abilities, genders or racial backgrounds. These differences may lead to effective interaction. If during the pursuit of personal goals, the group member can also consider other members and the group learning objectives, the learning efficacy can be improved [6]. Many of the previous researches use "gender" as group decomposition variable in investigating the effectiveness of cooperative learning under different task types. They find that the male groups usually outperform the female groups when computer is used in solving the tasks. However, "gender" should not be the only variable affecting the group performance. Thus, it is essential to conduct a research based on individual characteristics. Moreover, many scholars also point out that task types are one of the important variables in cooperative learning. When facing with different task types, the participants' discussion process evolved, skills required, communication tools used, and the communication methods adopted will all be varied.

From the social cognition point of view, group cognitive behavior, which is often ignored in-group performance experiment, is an important factor affecting group performance. In addition, group members' participation is another significant issue. The higher the participation rate, the more focused the members are in completing the tasks assigned. The group satisfaction will also increase [2]. Thus, this research chooses cognitive behaviors such as group participation rate, group efficacy and group goal commitment as important variables in cooperative learning. The objective is to find their impacts on group performance in different group types with different task types. Nunamaker et al. [5] point out that group; task, environment and technology are the four variables affecting the decision-making process in electronic meeting. In turns, they will affect the outcomes of the discussion. They are part of the input-process-output structure. This structure can be applied to this research on investigating the group cooperative learning in a web-based instructional system.

2 Literature Review

we consider those factors as follows• •

- Cognitive style - Theory of field-independence

  When individual is having perception judgment, he/she is field-dependent if he/she tends to make decisions based on the surrounding. Otherwise, he/she is field-independent, i.e. the judgment is resulted from some inner reference.
- Task types

  The task types in this paper are the intellectual and decision-making task types under the "choose" category. According to McGrath [4] and Johnson [3], Intellective tasks are tasks with a "correct" solution. The solution may be obtained from calculating, choosing or creating. Decision-Making tasks are tasks with the most appropriate solution instead of the best solution.
- Group efficacy

  Bandura [1] thinks that group efficacy directly influences the extent to which group members can mobilize and coordinate their skills, the amount of effort they will put into the task ,and their persistence when group efforts fail to produce results. In addition, individual efficacy theory is widely applied to management, computer skill training and education. It is found that the individual with high efficacy level performs better.
- Group goal commitment

  Goal commitment plays an important role in goal setting. When group members identify with the goal of the mission, the main purpose is then to achieve the appointed or self-set goals and improve the group performance. Thus, there is a positive relationship between group goal commitment and group performance.

3 Research Methodology

The research structure is modified from the Electronic Meeting System (EMS) proposed by Nunamaker et al.[5]. Task types and cognitive types are the independent variables. This research focuses on finding their effects on cooperative learning process and performance in a web-based instructional system.

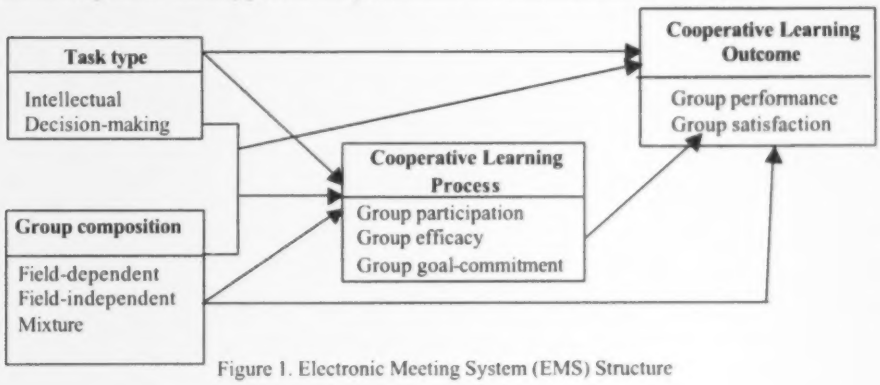


Figure 1. Electronic Meeting System (EMS) Structure

- **Samples**

  The samples are taken from master students of asynchronous Computer Networks and Internet course in NSYSU Cyber University. Most of the students are part-timed. The total number of students is 191. After rejecting students who did not complete the experiment, the valid sample size is 80 with an average age between 31 to 35. There are 59 males and 21 females. According to Group Embedded Figures Test, individual cognitive types are classified into two categories: field-dependent and field-independent. As a result, 35 people belong to field-independent category and the other 45 belong to field-dependent.
- **Group composition methods**

  Based on field-dependency, three types of groups are formed. They are groups with all field-independent individuals, all field-dependent ones and a mixture of the two. The average number in each group is about four or five. Since the field-independent samples are ten less than the field-dependent ones, there is a group with three field-independent and one field-dependent student.

For observation convenience, this group is classified as the 'all field-independent' class. Overall, there are six field-independent groups, seven field-dependent groups and seven mixtures, which add up to a total of 20 groups in this experiment.

- **Research procedure and its implement**

  At beginning of the semester, students are asked to complete a "Hidden Figural test" so that their cognitive types are known for later group composition. The experiment would start after groups are formed. There are three parts to the experiments where a task is assigned to each part. The sequence of the type of assigned tasks is intellective, decision-making and intellective tasks. All group members are new to each other. Thus, there is no previous interaction between them. The intellective task - 1 is therefore used as a warm-up exercise. Data from the other two tasks will be collected and analyzed. The samples are not informed of the difference between groups. The duration for each task would be one week. In addition, the cooperative learning process is sub-divided into two phases. After the tasks are given, the group members would have discussions on job assignment. This is called the "prepare phase". Each group member has to complete the group efficacy and group goal commitment surveys. After the groups complete the tasks and are aware of the group performance, the so-called "task complete phase" begins. Within this phase, each group member has to fill the surveys regarding the group satisfaction. Among the variables measured, group performance is graded after three experts have evaluated the task reports of each group.

- **Research Tools**

  Each group uses the discussion tools offered by NSYSU Cyber University for communication during the experiment. The tools available include group discussion board, chat room and mailing group. Group participation is measured based on the records of the use of the proceeding discussion tools. Regarding the group discussion board, the number of posting is recorded, whereas in the group chat room, the numbers of times individuals express themselves are recorded. In the mailing group, number of message sent is recorded.

- **Task Performance**

  Three experts review the outcomes of each group and they give each group an overall grade. Thus, the outcomes have a certain level of credibility.

4 Results and Analysis

This research uses t-test with independent variable - task type, to see if there is any difference between the average of group cooperative learning and its outcomes. The results show that the p-value for the group chat room category is less than 0.05. Thus, there is a significant difference. Since decision-making tasks encompass more areas than intellective tasks, more time and efforts are spent on them. Therefore, it is expected to find more frequent communication when this type of tasks is assigned. Many of the past researches find that groups communicate face-to-face outperform groups communicate via computers. This is not only because body languages can be used when members can see each other but also there can be instantaneous discussion on issues. Among the discussion tools, only group chat room is synchronous and allows instantaneous interaction. Group discussion board and group mailing list do not provide the same advantages.

When assigned with intellective tasks, there is a significant difference between the heterogeneous group (i.e. the mixtures) and the homogeneous groups in "group discussion board", "group chat room", group efficacy group satisfaction and group performance under the group cooperative learning category. This finding is consistent with the past researches because heterogeneous groups contain people with different characteristics and thinking pattern so that they can supplement and stimulate each other.

Our outcome shows there is a significant difference between heterogeneous group and the homogeneous groups in "group discussion board", "group chat room", and group efficacy when assigned with decision-making tasks. In the past, many researchers find that homogeneous group will perform better in communicative tasks but this is inconsistent with the finding of this paper. However, the paper is consistent with Johnson [3] who thinks that heterogeneous group outperform the homogeneous groups in creativity and decision-making tasks. In addition, it is found that there is a significant difference in goal commitment between field-dependence group and mixture during the cooperative learning process but not in Cooperative Learning outcome. According to the writer's experience in tutoring the class, it is concluded that the outcome may be affected by the performance of the previous intellective tasks. Part of the field-independent groups holds different opinions regarding the answers to the first and the third questions. This, in turn, affects the group members' answer to goal commitment survey in the decision-making tasks. This is related

to the characteristics of field-independent members who often have more autonomy over outside messages. They process and decode messages according to their own cognitive reorganization style. They will not accept answers that are doubtful and uncertain to them.

The interaction of different task types and cognitive style have no significant impact on there is no significant difference on cooperative learning.

It is respectively concluded that to intellectual and decision-making tasks group cooperative process and its outcome have the following in common:

- 1. There is a positive relationship between the number of posting during the group participation and group satisfaction level of group cooperation outcome.
- 2. There is a positive relationship between the group efficacy during the group cooperation process and group satisfaction level of group cooperation outcome.
- 3. There is a positive relationship between the group goal commitment during the group cooperation process and group satisfaction level of group cooperation outcome.

However, there is no significant positive relationship between group cooperation process variables and group performance when assigned with intellective tasks. This research concludes that since the intellective tasks have the one 'correct' solution, once the group members have deviation about the task, the group performance will be affected regardless of group efficacy or goal commitment.

5 Conclusion

From the survey, 86% of the participants agree that cooperative learning do increase the interaction among students. Moreover, 92% of the students are satisfied with the group discussion environment in the NSYSU Cyber University. This indicates that cooperative learning indeed reduces learning isolation and also heightens the students' learning motivation and willingness. Besides, it is concluded that heterogeneous groups outperform homogeneous groups in both group cooperative learning process and its outcomes within a web-based instructional system. However, field-dependent groups perform worse than the other two groups in both intellective and decision-making tasks. Since the field-dependent members are easily influenced by their surroundings and require the guidance of either teachers or well-performed students, they should not be grouped together when conducting cooperative learning in web-based learning environments. In addition, from the viewpoint of group dynamics and social cognition, group efficacy and goal commitment will affect the performance of the group cooperation. This research finds that there is a significant relationship between these variables. Under different task types, the group satisfaction is also significantly different. Thus, group efficacy and goal commitment can also be used as measurement in quantifying the outcome of group cooperation.

Acknowledgement

The Study is supported by the Program for Promoting Academic Excellence of Universities by Ministry of Education of R.O.C..

Reference

[1] Bandura, A.., "Social foundations of thought and action. A social cognitive theory", Englewood Cliffs, NJ. Prentice Hall, (1986).

[2] Cooper, M.R. & Wood, M.T., "Effects of Member Participation and Commitment in Group Decision Making on Influence, Satisfaction, and Decision Riskiness." Journal of Applied Psychology, 59(2),127-134, (1974).

[3] Johnson, D. W., & Johnson, F. P., "Joining together: Group theory and group skills", Boston: Allyn & Bacon, (1997).

[4] McGrath, J.E., "Group: Interaction and Performance", Prentice Hall, Englewood Cliff, NJ, (1984).

[5] Nunamaker, J.F. Dennis, A.R. Vslscich, J.S. Vogel, D.R. & George, J.F., "Electronic Meeting Systems to Support Group Work.", Communications of the ACM, 34:7,pp. 40-61, (1991).

[6] Spink, K. S., "Group cohesion and collective efficacy of volleyball teams", Journal of Sport and Exercise Psychology, 12, pp. 301-311, (1990).

Initial Evidence for Representational Guidance of Learning Discourse

Daniel D. Suthers
Department of Information and Computer Sciences, University of Hawai'i at Manoa
1680 East West Road, POST 303A, Honolulu, HI 96822 USA
Tel: 1-808-956-3890
Email: suthers@hawaii.edu

Little work to date has addressed the effects that problem/solution representations have on collaborative learning processes. This paper outlines empirical and theoretical reasons why the expressive constraints imposed by a representation and the information that a representation makes salient may have important effects on students' discourse during collaborative learning. It then reports initial results from a pilot study. Students worked together in pairs on hypertext-based "science challenge" problems. Pairs used either free text, matrix or graph representations of evidence, with two groups assigned to each kind of representation for a total of six groups. Analysis of discourse transcripts suggests that these representations have quite different effects on the extent to which students discuss evidential relations.

Keywords: **Collaborative Learning Discourse, Representational Tools**

1 Introduction

Decades of research into cognitive and social aspects of learning have developed a clear picture of the importance of learners' active involvement in the expression, examination, and manipulation of their own knowledge, as well as the equal importance of guidance provided by social processes and mentorship. Recently these findings have been reflected in software technology for learning: systems are now providing learners with the means to construct and manipulate their own solutions while they are being guided by the software and interacting with other learners. My work is within this spirit, providing representational tools in support of collaborative learning. *Representational tools* may range from basic office tools such as spreadsheets and outliners to "knowledge mapping" software. Such tools help learners see patterns, express abstractions in concrete form, and discover new relationships [4, 8]. These tools can function as *cognitive* tools that lead learners into certain knowledge-building interactions [3, 7].

For a number of years, my colleagues and I have been building, testing, and refining a diagrammatic environment ("Belvedere") intended to support secondary school children's learning of critical inquiry skills in the context of science. The diagrams were first designed to capture scientific argumentation, and later simplified to focus on evidential relations between data and hypotheses. This change was driven in part by a refocus on *collaborative* learning, which led to a major change in how we viewed the role of the interface representations. Rather than viewing the representations as medium of communication or a formal record of the argumentation process, we came to view them as resources (stimuli and guides) for conversation [12, 17]. Meanwhile, various projects with similar goals (i.e., critical inquiry in a collaborative learning context) were using radically different representational systems, such as hypertext/hypermedia [6, 9, 13, 22]; node-link graphs representing rhetorical, logical, or evidential relationships between assertions [11, 14, 19, 20] containment [1], and evidence or criteria matrices [10].

Both empirical and theoretical inquiry suggests that the expressive constraints imposed by a representation and the information (or lack thereof) that it makes salient may have important effects on students' discourse during collaborative learning. Specifically, as learner-constructed external representations become part of the collaborators' shared context, the distinctions and relationships made salient by these representations may influence their interactions in ways that influence learning outcomes. However, to date little systematic research has undertaken to explore possible effects of this variable on collaborative learning, except for [5].

This paper motivates and describes our research and reports initial results from such a study.

2 Representational Guidance

The major hypothesis resulting of this work is that variation in features of representational tools used by learners working in small groups can have a significant effect on the learners' knowledge-building discourse and on learning outcomes. The claim is not merely that learners will talk about features of the software tool being used. Rather, with proper design of representational tools, this effect will be observable in terms of learners' talk about and use of *subject matter concepts and skills*. We have begun investigations to determine what features have what kind of effect. This section develops an initial theory of how representations guide learning interactions, and applies this analysis to make specific predictions concerning the effects of selected features of representational tools. The discussion begins with some definitions.

Representational *tools* are software interfaces in which users construct, examine, and manipulate external representations of their knowledge. Our work is concerned with symbolic as opposed to analogical representations. A notation/artifact distinction [16] is critical to the theory, as depicted in Figure 1. A representational tool is a software implementation of a representational *notation* that provides a set of primitive elements out of which representations can be constructed. (For example, in Figure 1, the representational notation is the collection of primitives for making hypothesis and data statements and "+" and "-" links, along with rules for their use.) The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational *artifacts* in the tool. (For example, in Figure 1 the representational artifact is the particular diagram of evidence for competing explanations of mass extinctions.)

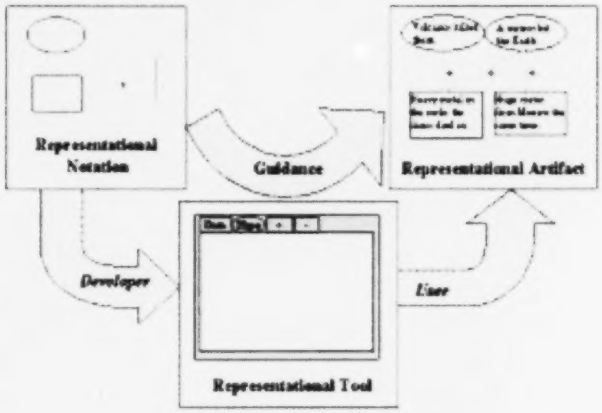


Figure 1 Representational Guidance

Learning interactions include interactions between learners and the representations, between learners and other learners, and between learners and mentors such as teachers or pedagogical software agents. Our work focuses on interactions between learners and other learners, specifically verbal and gestural interactions termed collaborative learning discourse.

Each given representational notation manifests a particular representational guidance, expressing certain aspects of one's knowledge better than others do. The concept of representational guidance is borrowed from artificial intelligence, where it is called *representational bias* [21]. The phrase *guidance* is adopted here to avoid the negative connotation of *bias*. The phrase knowledge unit will be used to refer generically to components of knowledge one might wish to represent, such as hypotheses, statements of fact, concepts, relationships, rules, etc. Representational guidance manifests in two major ways:

- *Constraints*: limits on expressiveness, i.e., which knowledge units can be expressed [15].
- *Salience:* how the representation facilitates processing of certain knowledge units, possibly at the expense of others [8].

As depicted in Figure 1, representational guidance originates in the notation, but affects the user through both the tool and artifacts constructed in the tool.

The core idea of the theory may now be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to articulate emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. Representational guidance constrains which knowledge can be expressed in the shared context, and makes some of that knowledge more salient and hence a likely topic of discussion. The discussion now turns to three predictions based on differences between representational notations.

BEST COPY AVAILABLE

On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

Hideo FUNAOI, Kazuyoshi BABA, Masatoshi SUZUKI, Makoto, ITAMI, Kohji ITOH
Department of Applied Electronics, Science University of Tokyo
Yamazaki 2641, Noda-shi, Chiba, 2788510, JAPAN
Tel: +81-471-24-1501 (ext.4232)
E-mail: {funaoi, kazuyosi, masatosi, itami, itoh}@itlb.te.noda.sut.ac.jp

Our mediabase system "ShareMedia" can facilitates collaborative learning, especially, inductive knowledge acquisition. In ShareMedia, learners in a community add, collaboratively, structured query to the electric data, which is to be registered in the mediabase. Structured queries consist of query units. Pieces of electric data express concrete knowledge or cases. Then they can navigate and retrieve pieces of electric data express by use of the queries. In other words, they can compare and examine the pieces of electric data and know their relationships. Consequently, they can acquire knowledge inductively. However, it is difficult for them to select suitable query units for a structured query. In this study, then we applied Latent Semantic Indexing to the supporting method. In our method, pieces of electric data and query units are represented as a vector space. The vectors are decomposed by Singular Value Decomposition, and then new vectors will be created. The piece of electric data that a learner wants to index is also processed with the same method. Then, the new electric data vector is compared with the new query unit vectors, and suitable query units will be selected. As a result of evaluation, our supporting method was proved to perform well.

Keywords: **indexing, navigation, collaboration, hypermedia, mediabase**

1 Introduction

In the field of education, teachers and researchers are, recently, more concerned about collaboration. Because of it, Many Computer systems are developed to support collaborative learning. For example, CSILE[1,2] facilitates knowledge building in a community, Collaboratory NoteBook[3] supports scientific inquiry activities in high school.

The mediabase system "ShareMedia[4,5]", which we are developing now, is such a system that supports learner's activities of description and accumulation, sharing, searching, selection of knowledge. In detail, it can not only promote the process of learner's browsing accumulated cases or knowledge and discovering their relationships, but also train their skills to share and use such cases and information in a community. Though we now assume that learners in high school geography class use ShareMedia, of course ShareMedia can be used in another domain.

ShareMedia needs not to link between nodes explicitly, and requires only indexing retrieval indices to media representations (see chapter 2). Then, ShareMedia enables learners to retrieve flexibly based on the semantics or concept of data by use of retrieval indices. Through the functions mentioned above, ShareMedia facilitates collaborative learning in a junior high school geography class to acquire generalized knowledge from individual cases and knowledge inductively and to index semantic indices to them in order to enable such activities.
ShareMedia supports learning activities as follows:

1) In a small community (e.g. a classroom or a group), learners collect electric media as individual knowledge or concrete cases and add indices express their concept to them. Then, learners store their shared mediabase with the electric media.

2) The learners browse the shared knowledge and compare pieces of the knowledge, which are extracted with indices, many times. As a result of this activity, the learners can abstract the pieces of the concrete knowledge and understand the relationships between them.

3) The learners discover inductively generalities or rules, which exist in the relationships, and deal with them as hypothesis.

4) The learners apply deductively the hypothesis to pieces of individual knowledge and can acquire then as generalized knowledge if their propriety is confirmed.

2 Mediabase system "ShareMedia"

The current version of ShareMedia (Fig.1) was developed on UNIX environment (Solaris CDE ver.1.3) with JAVA Development Kit ver.1.1.7 and K-Prolog Compiler ver.4.0. ShareMedia consists of several components. Above all, media representations, semantic frames, semantic indices and retrieval requests are important. Their details are as follows:

2.1 Media representation

Media representations (Fig.1.a) are electric data of pieces of individual knowledge or concrete cases. They are represent as texts, images, pictures, movies, sounds and so on. In this paper, however, only text form is dealt with because of presumption of semantic frames with natural language processing. Learners index a semantic index mentioned below to the block of a media representation and store the shared mediabase of ShareMedia with the media representation. After storing, learners can chose media representations from the list of them. With semantic indices, however, learners can navigate them more flexibly.

2.2 Semantic frame

Semantic frames (Fig.1.b) are used as query units and are primitive units of concept or semantics of media representations. They have slots that express subject, object, means, moment and so on. For example, "utilize" frame has "who", "what" and "to what" slots and "be factor" frame has "what" and "of what" slots. Learners should decide their form by mutual agreement in order to use them effectively in learning activities and store shared mediabase with them consistently.

2.3 Semantic Index

Semantic indices (Fig.1.c) are structured queries to express concept or semantics of media representations. Learners select semantic frames that are suitable to a media representation, which the learners will store mediabase with. Then, the learners combine them and link their relative slots. Like this, semantic indices are created by combining semantic frames and are indexed to media representations. They are used when learners retrieve or navigate media representations.

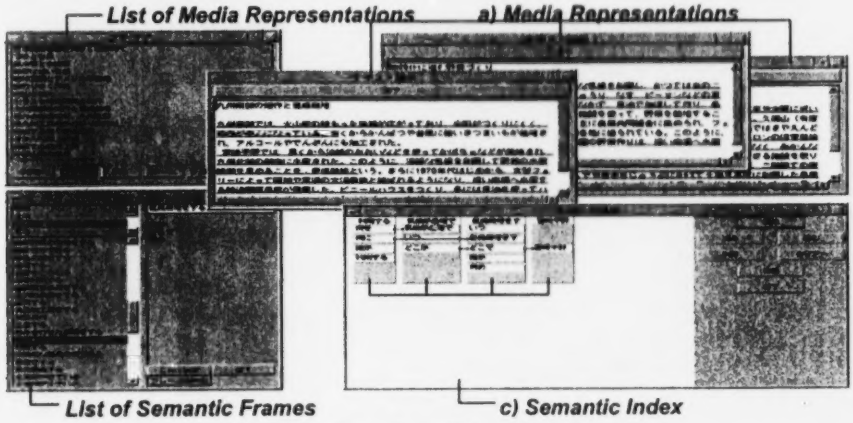


Fig.1. Interface of ShareMedia

BEST COPY AVAILABLE

2.4 Retrieval request

Retrieval request is used when learners retrieve or navigate media representations that are stored in shared mediabase. A learner creates it in the same way as semantic indices. Then, the learner submit it to ShareMedia, he will be presented media representations, which were indexed semantic indices that match the retrieval request. Owing to semantic indices and retrieval requests, learners can retrieve and navigate semantically.

These components mentioned above can facilitate learner's activities to navigate pieces of knowledge semantically, to understand their relationships inductively and to discover generalities, which exist in them, deductively. However, it is difficult for learners to select suitable semantic frames for a semantic index or a retrieval request.

3 Supporting learner's selection of semantic frames

In this study, we applied LSI[6] (Latent Semantic Indexing) to the supporting method for selecting semantic frames. Because LSI is one of statistical method, similarity of documents can be presumed without any dictionaries. In LSI, documents are dealt with a term by document matrix. Then, rows of it can be considered to be term vectors and columns to be document vectors. In addition, these vectors are decomposed by SVD (Singular Value Decomposition), as a result, terms and documents are abstracted.

In our method, media representations and semantic frames are represented as a vector space model. In training, the vectors are decomposed by SVD, and then new vectors will be created. In presumption, The media representation that a learner wants to index is also processed with the same method. Then, the new media representation vector is compared with the new semantic frame, and suitable semantic frames will be selected. Their details are as follows:

3.1 Training

Training needs a data set, which is a collection of combinations of paragraph and semantic frames. Here, paragraph is a part of media representation and contains one or more blocks, which are indexed parts of the media representation. And semantic frames are contained in the semantic indices, which were indexed to the blocks. First, Paragraphs are done morphological analysis with Chasen, which is one of Japanese morphological analysis tool. As a result, word lists of each paragraph are created.

Next, they are filtered in order to extract only the words, which have noun, verbal, and adjective morph. After filtering, they are sorted by frequent descending order. Based on them, a sorted list of all words is generated. On the other hand, based on the relation between the word lists and the semantic frames, sorted word lists of each paragraph collection, which relate each semantic frame, are created.

Then, word by semantic frame matrix is computed from these two type lists. This matrix can be divided to word vectors and semantic frame vectors. SVD decomposes them and creates new word vectors, new semantic frame vectors and the diagonal matrix of singular values. These vectors and matrix are used in presumption.

In addition, latent relationships will be available in presumption, because this decomposition abstracts the words and the semantic frames

3.2 Presumption

To presume the semantic frames that are suitable to a whole media representation or a block of it, the vector of these text strings is processed with new word vectors and diagonal matrix, which are created in training. As a result, new text vector is created. It is compared with each new semantic frame vector by computing cosine between them. The more cosine value is large, the more the semantic frame that corresponds to the new semantic frame vector is suitable to the text string. Then, a list of semantic frames, which are arranged by descending order of cosine values, is made. This list will support learners to select semantic frames, which is suitable to a media representation.

4 Experiment

2.1 Representational notations bias learners towards particular ontologies

The first hypothesis claims that important guidance for learning interactions comes from ways in which a representational notation *limits* what can be represented [15, 21]. A representational notation provides a set of primitive elements out of which representational artifacts are constructed. These primitive elements constitute an ontology of categories and structures for organizing the task domain. Learners will see their task in part as one of making acceptable representational artifacts out of these primitives. Thus, they will search for possible new instances of the primitive elements, and hence (according to this hypothesis) will be guided to think about the task domain in terms of the underlying ontology.

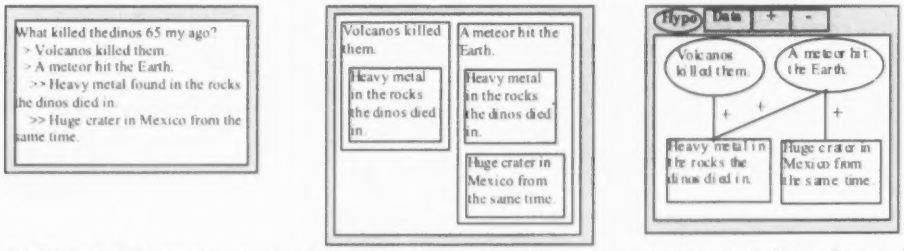
For example, consider the following interaction in which students were working with a version of Belvedere that required all statements to be categorized as either *data* or *claim*. Belvedere is an "evidence mapping" tool developed under the direction of Alan Lesgold and myself while I was at the University of Pittsburgh [18, 19, 20]. The example is from videotape of students in a 10th grade science class.

S1: So data, right? This would be data.
S2: I think so.
S1: Or a claim. I don't know if it would be claim or data.
S2: Claim. They have no real hard evidence. Go ahead, claim. I mean who cares? Who cares what they say? Claim.

The choice forced by the tool led to a peer-coaching interaction on a distinction that was critically important for how they subsequently handled the statement. The last comment of S2 shows that the relevant epistemological concepts were being discussed, not merely which toolbar icon to press or which representational shape to use.

2.2 Salient knowledge units are elaborated

This hypothesis states that learners will be more likely to attend to, and hence elaborate on, the knowledge units that are perceptually salient in their shared representational workspace than those that are either not salient or for which a representational proxy has not been created. The visual presence of the knowledge unit in the shared representational context serves as a reminder of its existence and any work that may need to be done with it. Also, it is easier to refer to a knowledge unit that has a visual manifestation, so learners will find it easier to express their subsequent thoughts about this unit than about those that require complex verbal descriptions [2]. These claims apply to any visually shared representations. However, to the extent that two representational notations differ in kinds of knowledge units they make salient, these functions of *reminding* and *ease of reference* will encourage elaboration on different kinds of knowledge units.



(a) Threaded Discussion: *limited representation of relation.*

(b) Containment: *Implicit representation of relations.*

(c) Graph: *Relationship as object of perception.*

Figure 2. Example of Elaboration Hypothesis

For example, consider the three representations of a relationship between four statements shown in Figure 2. The relationship is one of evidential support. The middle notation uses an implicit device, containment, to represent evidential support, while the right-hand notation uses an explicit device, an arc. It becomes easier to perceive and refer to the *relationship* as an object in its own right as one moves from left to right in the figure. Hence the present hypothesis claims that relationships will receive more elaboration in the rightmost representational notation.

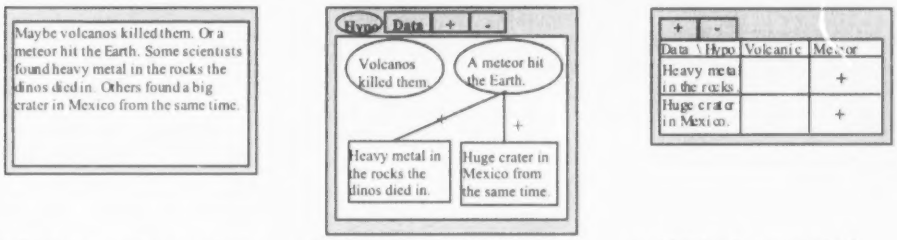
The opposite prediction is also plausible. Learners may see their task as one of putting knowledge units "in

their place" in the representational environment. For example (according to this competing hypothesis), once a datum is placed in the appropriate hypothesis container (Figure 2b) or connected to a hypothesis (Figure2c), learners may feel it can be safely ignored as they move on to other units not yet placed or connected. Hence they will not elaborate on represented units. This suggests the importance of making missing information salient.

2.3 Salience of missing units guides search

Some representational notations provide structures for organizing knowledge units, in addition to primitives for construction of individual knowledge units. Unfilled "fields" in these organizing structures, if perceptually salient, can make missing knowledge units as salient as those that are present. If the representational notation provides structures with predetermined fields that need to be filled with knowledge units, the present hypothesis predicts that learners will try to fill these fields.

For example, Figure 3 shows artifacts from three notations that differ in salience of missing evidential relationships. In the textual representation, no particular relationships are salient as missing: no particular prediction about search for new knowledge units can be made. In the graph representation, the lack of connectivity of the volcanic hypothesis to the rest of the graph is salient. Hence this hypothesis predicts that learners will discuss its possible relationships to other statements. However, once some connection is made to the hypothesis, it will appear connected, so no further relationships will be sought. In the matrix representation, all undetermined relationships are salient as empty cells. The present hypothesis predicts that learners will be more likely to discuss many relationships between statements when using matrices.



(a) Text: *No relation is saliently missing.* ***(b) Graph:*** *Partial salience of missing relations.* ***(c) Matrix:*** *Salience of all missing relations.*

Figure 3. Example of Salient Absence Hypothesis

2.4 Predicted Differences

Based on the discussion of this section, the following predictions were tested in the study reported below. The symbol ">" indicates that the discourse phenomenon at the beginning of the list (concept use, elaboration, or search) will occur at a significantly greater rate in the treatment condition(s) on the left of the symbol than in those on the right

Concept Use: {Graph, Matrix} > {Container, Text, Threaded Discussion}. The Graph and Matrix representations *require* that one categorize statements and relations. This will initiate discussion of the proper choice, possibly including peer coaching on the underlying concepts. The Container, Text, and Threaded Discussion representations provide only implicit categorization. Students may discuss placement of information, but this talk is less likely to be expressed in terms of the underlying concepts.

Search for Missing Relations: Matrix > {Container, Graph} > {Text, Threaded Discussion}. The matrix representation provides an empty field for *every* undetermined relationship, prompting participants to consider all of them. In Graphs or the Container representations, salience of the lack of *some* relationship disappears as soon as a link is drawn to the statement in question or another is placed in its container, respectively. Threaded Discussion does not specifically direct searches toward missing relationships.

The Elaboration hypothesis was not tested independently of the Search hypothesis in this study.

3 An Initial Study

This section reports on an initial study that was conducted to identify trends suggesting that there is a phenomenon worthy of further study; and to refine analytic techniques. Specifically, the study examined how the amount of talk about evidence and the amount of talk about the epistemological status of propositions (empirical versus theoretical) differed across three representational tools, and provided qualitative observations to guide further study.

3.1 Design

Six pairs (twelve participants) were distributed evenly between three treatment conditions in a simple between-subjects design. The three treatment conditions corresponded to three notations: Text, Graph, and Matrix. These notations differ on more than one feature, such as ontology, whether inconsistency relations are represented, and visual and textual notations. I intentionally chose this research strategy (instead of manipulating precisely one feature at a time) in order to maximize the opportunity to explore the large space of representations within the time scale on which collaborative technology is being adapted.

3.2 Method

3.2.1 Participants

Middle-school boys were recruited by my assistant (Cynthia Liefeld) from soccer practice. Two pairs of participants were run in each of the three conditions. Each pair consisted of boys who knew each other, a requirement intended to minimize negotiation of a new interpersonal relationship as a complicating factor.

3.2.2 Materials

Software. Three existing software packages were used: Microsoft Word (Text), Microsoft Excel (Matrix), and Belvedere (Graph). Groups using MS Word were not prohibited from using its typographical devices such as different typefaces, styles, lists, etc. We did not restrict participants' appropriation of typographical devices for organizing information, but neither did we encourage any particular use of the textual medium. Groups using MS Excel were provided with a prepared matrix that had the labels "Hypotheses" and "Data" in the upper left corner, and cells formatted sufficiently large to allow entry of textual summaries of the same. Participants were specifically told to enter hypotheses as column headers, data as row headers, and to record the relationships in the internal cells. The Graph condition used Belvedere. The version of Belvedere used (2.1) provides rounded nodes for hypotheses, rectangles for data, and links for consistency and inconsistency relations between them. Hypothesis and data shapes are filled with textual summaries of the corresponding claims.

Science Challenge Problems. Participants were presented with "science challenge problems" in a web-browser. A science challenge problem presents a phenomenon to be explained (e.g., determining the cause of the dinosaur extinctions, or of a mysterious disease on Guam known as Guam PD), along with indices to relevant resources. For example, one can obtain lists of articles posing possible explanations of the phenomenon, reporting empirical findings from fieldwork or laboratory work, or explaining basic domain concepts. These are relatively ill-structured problems: at any given point many possible knowledge units may reasonably be considered. The materials we used were modified from the classroom versions of science challenge problems developed by Arlene Weiner and Eva Toth.[1] The experimental version excluded hands-on activities, links to external sites and activity guide.

[1] Available at http://lilt.ics.hawaii.edu/belvedere/materials/index.html.

Computer Setup. The computer screen was divided in half as shown in Figure 4. The left-hand side contained the representational tool -- any one of Text, Graph (shown), or Matrix. The right hand side contained a web browser open to the entry page for the science challenge materials.

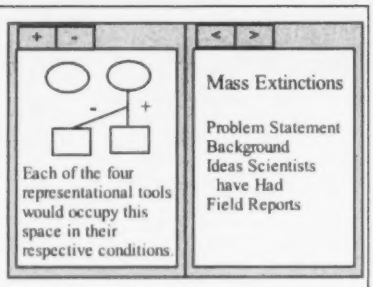


Figure 4. Screen Layout for Studies

3.2.3 Procedure

Participants were seated in front of a single monitor and keyboard. After an introduction to the study and signing of permission forms, participants were shown the software and allowed to practice the basic manipulations such as creating and linking nodes or filling in matrix cells. This training did not involve any mention of concepts of evidence or of the problem domain.

Participants were then presented with the problem statement in the web browser on the right. The problem solving session was initiated when they were instructed to identify hypotheses that provide candidate explanations of the phenomenon posed, and to evaluate these hypotheses on the basis of laboratory studies and field reports obtained through the hypertext interface. They were instructed to use the representational tool during the problem solving session to record the information they find and explore how it bears on the problem. Participants were responsible for deciding how to share or divide use of the keyboard and mouse. The procedure described in this paragraph was repeated, first with a "warm-up" problem, and then with the problem for which data is reported below (Guam PD). Sessions were videotaped with the camera pointed at the screen over the shoulder of one of the participants.

3.3 Results

Analysis was based primarily on coding of transcripts of participants' spoken discourse, and secondarily on participants' representational artifacts.

3.3.1 Coding and Analysis of Discourse

Pilot study videotapes from the six one-hour problem-solving sessions were transcribed and segmented. A segment was defined to be a modification to the external representation or a single speaker's turn in the dialogue, except that turns that expressed multiple propositions were broken into multiple segments. Segments were coded using the QSR Nud*ist software package.

The following codes provide the dependent variables of interest. *Epistemological Classification* codes discourse about the epistemological status of a statement, including classification as empirical (e.g., "that's data"), theoretical (e.g., "that's a hypothesis, isn't it?") or discussion of the choice (e.g., "do you want me to go data or hypothesis?"). In the present study we only wanted to see whether the tools differed in their prompting for making this choice, so did not discriminate these subcategories. Sub-dimension *Evidential Relation* is applied to segments where participants discuss or identify the nature of the evidential relationship between two statements. The codes are *Consistency* (e.g., "it's also for," "that confirms"), *Inconsistency* ("so that's against," "with this one, no, conflicts, right?"), or *Equivocal*, applied when participants raise the question of which relationship holds, if any, without identifying one specifically ("is that for or against?," "it can neither confirm nor deny"). In some cases, evidential relationships were apparently being expressed in terms of the representational primitives provided by the software (e.g., "connect these two"). These utterances were also coded with the appropriate Evidential Relation category, but marked with the Level code (discussed below) so that such "tool-level talk" could be distinguished during the analysis. Topic sub-dimension *Other Topic* codes segments not coded as one of the above topics. The "other" codes include *On-task* (e.g., "are we done with this?"), *Off-task* (e.g., "what's for lunch?"), or *Unclassifiable* (e.g., "uh," mumbles, etc.).

The remaining coding dimensions are used to select out relevant segments for particular analyses. *Mode* indicates whether the segment is coded for its *Verbal* content or for an action taken on the *Representational* artifact. The final two dimensions only apply to verbal segments. *Level* is applied only to Epistemological and Evidential Verbal segments, and indicates whether an utterance made direct use of epistemological or evidential concepts (e.g., "supports," "hypothesis": *Conceptual*) or was expressed in terms of the software

(e.g., "link to this," "round box": *Tool-based*). *Ownership* indicates whether the participant was merely reading text that we provided (Recited) or expressing their own ideas (Non-Recited).

Coding was performed by two of my assistants (Chris Hundhausen and Laura Girardeau). Questions of interpretation, problematic segments, etc. were discussed among the three of us during meetings, but the coding itself was done independently. Inter-rater reliability was computed using the Kappa statistic across all of the categories described above, producing a value of 0.92 (n=1942).

Table 1. Summary of Verbal Coding

Verbal segments tested: nesting indicates subset selection; % are of "Not Off-Task"	**Text**		**Graph**		**Matrix**	
	N	**%**	***N***	**%**	***N***	**%**
Non-Recited	778	*n/a*	626	*n/a*	537	*n/a*
..Not Off-Task	694	100	613	100	508	100
....Evidential Relation	4	0.58	32	5.22	100	19.69
.....Consistency	3	0.43	21	3.43	54	10.63
.....Inconsistency	1	0.14	6	0.98	35	6.89
.....Equivocal Evidential	0	0.00	5	0.82	11	2.17
.....Conceptual	3	0.4	9	1.47	43	8.46
.....Tool-Based	1	0.1	23	3.75	57	11.22
....Epistemological Classification	39	5.62	57	9.30	36	7.09
.....Conceptual	19	2.74	33	5.38	7	1.38
.....Tool-Based	20	2.88	24	3.92	29	5.71

Selected results of coding are shown in Table 1, focusing on segments coded as Mode=Verbal, and showing both counts and percentages for each of the three treatment groups. Percentages are taken relative to Non-Recited on task utterances, shown in the second row. Counts and percentages for Evidential Relation are broken down in two orthogonal ways: by whether the relation was Consistency, Inconsistency, or Equivocal; and by whether the talk about evidence was Conceptual or Tool-Based. Epistemological Classification was broken down by Conceptual or Tool-Based. Due to the small sample size we did not perform statistical testing in this preliminary study.

3.3.2 Qualitative observations

The document created by one Text group contained no expression of evidential relations, and the transcript of verbal discourse for this group contained no overt discussion of evidential relations. All of the discussion of evidence in Text occurred in the other group at the end of the session (the longest session in the pilot study), at which time they also added several expressions of evidential relations. A document produced by one of the Graph groups is notably linear, in spite of the fact that Graph is normally considered a nonlinear medium. A pattern of *identify information, categorize information, add it to the diagram, link it in* is typical of interactions in this transcript. This pattern of activity, which leads to the linearity of the graph, is consistent with the competitor to the Elaboration hypothesis: participants may feel that the primary task is to connect each new statement to something else, after which it can be ignored. Finally, the Matrix artifacts were especially striking because participants were not specifically instructed to fill in all the cells, yet they did so. The transcripts illustrated participants' systematic identification of evidential relations as they worked down the columns, and in one case their appropriate use of the table to rule out a hypothesis that they had proposed.

3.4 Discussion

Recall that the Search hypothesis predicts that participants will be more likely to seek evidential relations when using representations that prompt for these relations with empty structure (Text < Graph < Matrix). The row labeled "Evidential Relation" is relevant to the Search hypothesis. This row counts, for each treatment group, the percentage of verbal segments that were coded with any one of the three evidential values (Consistent, Inconsistent, Choice). The results appear to be consistent with the Search hypothesis: Text=0.58% < Graph=5.22% < Matrix=19.69%. This trend holds even when limited to Conceptual expressions of evidential relations: Text=0.43% < Graph=1.47% < Matrix=8.48%. Note however that a substantial portion of talk about evidence in the Graph and Matrix conditions is tool based (about two-thirds

of Graph and half of Matrix evidential utterances are tool-based). This is as expected, since these tools, unlike Text, provide objects that may be referred to as proxies for evidential relations.

The breakdown of Evidential talk according to the type of relation shows the influence of the exhaustive prompting of Matrix. In Text and Graph, participants focused primarily on Consistency relations, a possible manifestation of the confirmation bias. Treatment was more balanced in Matrix, with almost half of the talk about evidential relations being concerned with inconsistency or equivocal relations. This may be because Matrix prompts for consideration of relationships between all pairs of items: participants are more likely to encounter inconsistency or indeterminate relations when considering those they may have neglected in the Graph or Text conditions.

Addressing the Concept Use hypothesis, we found that 5.62% of Text, 7.09% of Matrix and 9.30% of Graph utterances were concerned with the classification of new information as *data* versus *hypothesis* or their equivalents. We believe that Text would have been lower, except that the instructions for all three conditions directed participants to consider and record hypotheses and empirical evidence. Text participants, like others, complied with these instructions, for example, by labeling propositions as "Data" or Hypothesis." Graph's greater proportion of epistemological classification talk is explained by its most explicit use of visually distinct shapes to represent data and hypotheses.

4 Conclusions

Overall, the results are encouraging with respect to the question of whether there is a phenomenon worth investigating. Differences in the predicted directions were seen in both talk about evidence and about the epistemological status of statements. However, this sample data cannot be taken as conclusive. Caveats, all of which are being addressed by ongoing work, include the small sample size (hence no test of significance), the lack of a learning outcomes measure, and the need for a more direct test of the claim that representational state affects subsequent discourse processes. Furthermore, analyses based on frequencies of utterances across the session as a whole fail to distinguish utterances seeking evidential relations from those elaborating on previous ones (i.e., between the Search and Elaborate hypotheses), or to show a causal relationship between the state of the representation and the subsequent discourse. A more sophisticated coding is required to test whether the representation or salient absence of a particular (kind of) knowledge unit influences search for or elaboration on that unit. All of these deficiencies are being addressed in a study underway at this writing. Pending the results of this study, plans for future work include attempts to replicate selected results in distance learning situations, both synchronous and asynchronous. This line of work promises to inform the design of future software learning environments and to provide a better theoretical understanding of the role of representational guidance in guiding learning processes.

References

1. Bell, P. (1997, December). Using argument representations to make thinking visible for individuals and groups. In Proceedings of the Computer Supported Collaborative Learning Conference '97, 10-19. University of Toronto.
2. Clark, H.H. & Brennan, S.E. (1991). Grounding in Communication. In L.B. Resnick, J.M. Levine and S.D. Teasley (Eds.), Perspectives on socially shared cognition (pp. 127-149). American Psychological Association.
3. Collins, A. & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. Educational Psychologist, 28(1): 25-42.
4. Goldenberg, E. P. (1995). Multiple Representations: A Vehicle for Understanding Understanding. In D. Perkins, J. Schwartz, M. West, & M. Wiske (Eds.), Software goes to school: Teaching for understanding with new technologies (pp. 155-171). New York: Oxford University Press.
5. Guzdial, M. (1997, December). Information ecology of collaborations in educational settings: Influence of tool. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.
6. Guzdial, M., Hmelo, C., Hubscher, R., Nagel, K., Newstetter, W., Puntambekar, S., Shabo, A., Turns, J., & Kolodner, J. L. (1997, December). Integrating and guiding collaboration: Lessons learned in computer-supported collaborative learning research at Georgia Tech. In Proceedings of the 2nd

International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.

7. Lajoie, S. P., & Derry, S. J. (Eds.). (1993). Computers as Cognitive Tools. Hillsdale, NJ: Lawrence Erlbaum Associates.
8. Larkin, J. H. & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. Cognitive Science 11(1): 65-99. 1987.
9. O'Neill, D. K., & Gomez, L. M. (1994).The collaboratory notebook: A distributed knowledge-building environment for project-enhanced learning. In Proceedings of Ed-Media '94, Vancouver, BC.
10. Puntambekar, S., Nagel, K., Hübscher, R., Guzdial, M., & Kolodner, J. (1997, December). Intra-group and intergroup: An exploration of learning with complementary collaboration tools. In Proceedings of the Computer Supported Collaborative Learning Conference '97 (pp. 207-214). University of Toronto.
11. Ranney, M., Schank, P., & Diehl, C. (1995). Competence versus performance in critical reasoning: Reducing the gap by using Convince Me. Psychology Teaching Review 4(2).
12. Roschelle, J. (1994, May). Designing for cognitive communication: Epistemic fidelity or mediating collaborative inquiry? The Arachnet Electronic Journal of Virtual Culture.
13. Scardamalia, M., Bereiter, C., Brett, C., Burtis, P.J., Calhoun, C., & Smith Lea, N. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.
14. Smolensky, P., Fox, B., King, R., & Lewis, C. (1987). Computer-aided reasoned discourse, or, how to argue with a computer. In R. Guindon (Ed.), Cognitive science and its applications for human-computer interaction (pp. 109-162). Hillsdale, NJ: Erlbaum.
15. Stenning, K. & Oberlander, J. (1995). A cognitive theory of graphical and linguistic reasoning: Logic and implementation. Cognitive Science 19(1): 97-140. 1995.
16. Stenning, K. & Yule, P. (1997). Image and language in human reasoning: A syllogistic illustration. Cognitive Psychology 34: 109-159.
17. Suthers, D. (unpublished). Designing for Internal vs. External Discourse in Groupware for Developing Critical Discussion Skills. Presented at the CHI95 Research Symposium, May 6-7. 1995, Denver CO. Available: http://lilt.ics.hawaii.edu/lilt/papers/chi95learning.ps
18. Suthers, D. & Jones, D. (1997, August). An architecture for intelligent collaborative educational systems. Paper presented at AI-Ed 97, the 8th World Conference on Artificial Intelligence in Education, Kobe.
19. Suthers, D., Toth, E., and Weiner, A. (1997, December). An integrated approach to implementing collaborative inquiry in the classroom. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 272-279). Toronto.
20. Suthers, D. and Weiner, A. (1995, October). Groupware for developing critical discussion skills. Paper presented at CSCL '95, Computer Supported Cooperative Learning, Bloomington, Indiana.
21. Utgoff, P. (1986). Shift of bias for inductive concept learning. In R. Michalski, J. Carbonell, T. Mitchell (Eds.) Machine Learning: An Artitificial Intelligence Approach, Volume II (pp. 107-148). Los Altos: Morgan Kaufmann.
22. Wan, D., & Johnson, P. M. (1994, October). Experiences with CLARE: a Computer-Supported Collaborative Learning Environment. International Journal of Human-Computer Studies.

Is a Learning Theory Harmonious with Others?

To form Effective Collaborative Learning Groups with Ontological Engineering

Akiko Inaba, Thepchai Supnithi, Mitsuru Ikeda, Riichiro Mizoguchi, and Jun'ichi Toyoda

I.S.I.R., Osaka University

8-1 Mihogaoka, Ibaraki, Osaka, 567-0047 Japan

inaba@ai.sanken.osaka-u.ac.jp

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. We propose possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

Keywords: **Ontology, Collaborative Learning, Distributed Learning Environments**

1 Introduction

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures educational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10, 11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15, 16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22, 23], Sociocultural Theory[25, 26], Zone of proximal development[25, 26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. However, it is difficult to understand all theories because these theories are derived from a wide research area including pedagogy, sociology and psychology. Moreover, we can expect different educational benefits based on these learning theories, and observe various kinds of interaction between learners through collaborative learning process. Due to the diversity, it is difficult to list the learning theories effective to gain a specific educational benefit for a learner, and to compare the theories to form a suitable collaborative learning group for the learner.

Therefore, we have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12, 14, 24]. We call the system of concepts "Collaborative Learning Ontology". Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on "Learning Goal Ontology" which is a part of the Collaborative Learning Ontology.

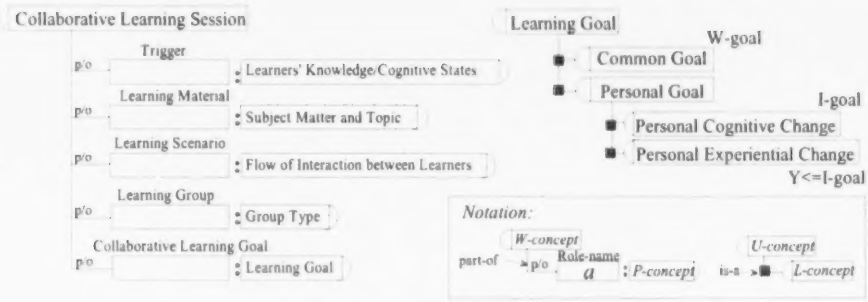


Fig. 1. Collaborative Learning Ontology

The concept "Learning Goal" is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

To help a learner obtain a specific educational benefit we can find several learning theories useful for the purpose and form different learning groups according to the theories. If the groups are merged into one, we may form a better learning group which is guaranteed its effectiveness by multiple learning theories. So, we also discuss the combination of learning groups supported by different learning theories.

This paper is organized as follows: we first show briefly the structure of our "Collaborative Learning Ontology" and "Learning Goal Ontology". Then we summarize advantages and remaining tasks: how can we narrow down candidates of learning groups into one? Finally we propose a new learning group formation formed by combining multiple learning theories.

2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 1 shows the conceptual structure of Collaborative Learning Ontology.[1] Here, we concentrate on the concept "Learning Goal" which is one of the most important concepts for forming a learning group, because each learner joins in a collaborative learning session to attain some learning goals. The "Learning Goal" can be specified as two kinds of goals: "common goal" as a whole group and "personal goal" for each learner. The concept "personal goal" can be specified as two kinds: the goal represented as a change of a learner's knowledge/ cognitive states, and the goal attained by interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal, Y⇐I-goal, and W-goal, respectively. I-goal, which is described as G:I, represents what a learner is expected to acquire. Y⇐I-goal, which is described as G:Y⇐I, represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain Y⇐I-goals and we describe the goal as G:W. W-goal is a common goal characterizing the whole group.

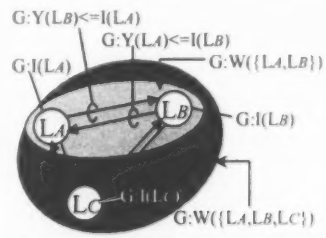


Fig. 2. Learning Goal Ontology

Fig. 2 represents learning goals in a group where three learners: L_A, L_B and L_C are participating. Learner L_A has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 2 as G:I(L_A). Both L_B and L_C have I-goals, and they are represented as G:I(L_B) and G:I(L_C) respectively. G:Y(L_B)⇐I(L_A) is a Y⇐I-goal between L_A and L_B observed from L_A's viewpoint. In other words, it means the reason why L_A interacts with L_B. Concerning this interaction between L_A and L_B, there is also a Y⇐I-goal observed from L_B's viewpoint. That is, it is the reason why L_B interacts with L_A. This Y⇐I-goal is represented as G:Y(L_A)⇐I(L_B). Both G:I(L_A) and G:Y(L_B)⇐I(L_A) are personal goals of

[1] Notation: the schemata define the W-concept and the U-concept. The W-concept has entity a, which is an instance of the concept P-concept, as a part. The entity a plays a specific role (Role-name) in the W-concept. The concept P-concept has a semicircle on the right sides. It means the concept is defined in other schema. The L-concept is a specification of the U-concept, and the U-concept is a generalization of the L-concept.

BEST COPY AVAILABLE

Table 1. W-goals

		W-goal	Definition	Src.
Singleton W-goal	M-P x S-S	Setting up the situation for Peer Tutoring PT	Setting up the situation where a learner teaches something to another learner.	[6, 7]
		Setting up the situation for Anchored Instruction AI	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
	S-P x M-S	Setting up the situation for learning by Cognitive Apprenticeship CA	Setting up the situation to learn knowledge or skill as an apprentice	[5]
		Setting up the situation for sharing (Meta-) Cognitive function between learners SC	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
		Setting up the situation for sharing Multiple Perspectives CF	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
	M-P x N-S	Setting up the situation based on Distributed Cognition DC	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
		Setting up the situation based on Cognitive Constructivism CC	Setting up the situation where full participants discuss problems	[19]
CW-goal		Setting up the community for Legitimate Peripheral Participation LPP	Setting up the the community of practice for peripheral participant	[15, 16]
		Setting up the situation for Observational Learning OL	Setting up the situation to share other learners' learning processes	[2]

Note: ** means an abbreviation for the W-goal.
e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

L_A. G:W($\{L_A, L_B\}$) is a W-goal of the learning group ($\{L_A, L_B\}$). G:W($\{L_A, L_B, L_C\}$) is a W-goal of the learning group ($\{L_A, L_B, L_C\}$).

We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology, Y⇐I-goal Ontology, and W-goal Ontology with justification based on learning theories.[2] We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Noman's work[15] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[15]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the Y⇐I-goal "Learning by being Taught[5]", while some learners could take another Y⇐I-goal "Learning by Observation[2]".

Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*,Three kinds of singleton W-goals and one Composite W-goal) according to their structures. To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of Y⇐I-goals. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

A learning theory generally argues the process that learners, who play a specific role, can obtain educational benefits through interaction with other learners who play other roles. The theories have common characteristics to argue effectiveness of a learning process focusing on a specific role of learners. So, we represent the focus in the theories as Primary Focus and Secondary Focus.

Primary Focus (P): a learner's role that is mainly focused in the learning theory. The learner who plays this role (P-member) is expected to gain the main educational benefit.

[2] The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.

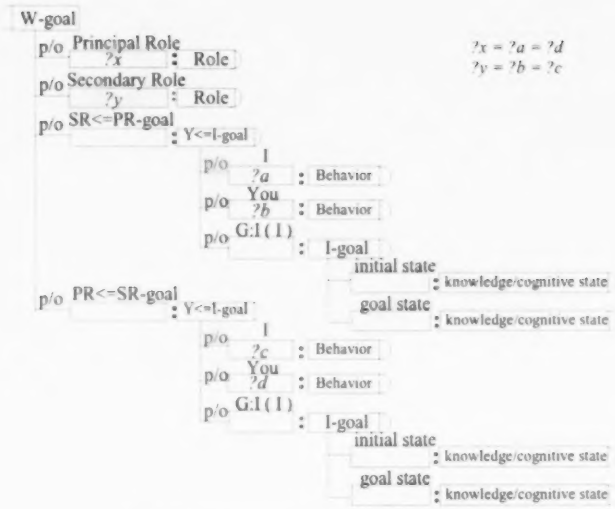


Fig. 3. Conceptual Structure of a W-goal

Secondary Focus (S): a learner's role that is weakly focused in the learning theory. The learner who plays this role (S-member) is needed as a companion to enable a P-member to attain his/her learning goals.

We classify the W-goals into the following four kinds depending on the number of the components P and S.

Singleton W-goal: Each Singleton W-goal can exist independently.

Multiple-P x Single-S: The W-goal of M-P x S-S type can have multiple P-members and single S-member.

Single-P x Multiple-S: The W-goal of S-P x M-S type can have single P-member and multiple S-members.

Multiple-P x No-S: The W-goal of M-P x N-S type has only one role for its members. In this group, each learner plays a role of companion for the other learner, while he/she gains main educational benefit.

Composite W-goal: The CW-goal includes another group as its component S.

For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6, 7]. So, P is identified as *Peer Tutor* and S is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. The number of members who play *Peer Tutee* (S) should be single, the number of members who play *Peer Tutor* (P) can be multiple, and the W-goal **PT** is identified as a M-P x S-S type.

A group attaining a W-goal(W_i) can have another group, which has another W-goal(W_j), as the component S of the W-goal(W_i). We call the W-goal(W_i) "**CW-goal**" which means a composite W-goal. Fig. 4 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has *Observers* as its component P.

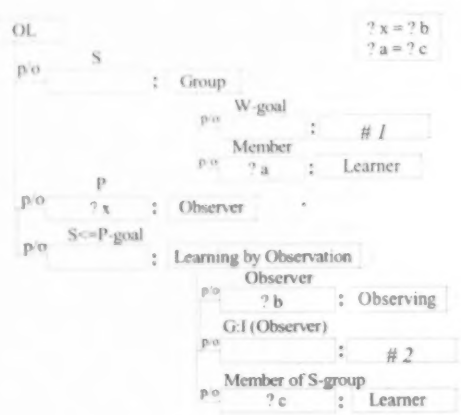


Fig. 4. An Example of CW-goal: OL

BEST COPY AVAILABLE

The *Observers* require a group (*i.e.*,its component S) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For example, if accretion of content-specific knowledge is set in #2 as *Observer*'s I-goal, the W-goal **PT** is recommended as S's W-goal (#1).

A W-goal has two kinds of goals of interaction as follows:

S⇐P-goal: a Y⇐I-goal which means how and for what purpose the P-member interacts with the S-member.

P⇐S-goal: a Y⇐I-goal which means how and for what purpose the S-member interacts with the P-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the S-member also has an I-goal, and the P⇐S-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y⇐I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y⇐I-goals referred to by S⇐P-goal and P⇐S-goal consists of three components as follows:

I: a role to attain the Y⇐I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y⇐I-goal.
You: a role as a partner for the I-member.
G:I: an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y⇐I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

3 Advantages and Remaining Tasks of Learning Goal Ontology for Forming an Effective Learning Group

In a traditional classroom, sometimes a teacher divides students into several subgroups, and then the students start collaborative learning in the subgroup all at once. Such collaborative learning does not ensure educational benefits for every student, because it depends on a student's knowledge/ cognitive state whether collaborative learning is effective or not, and progress in learning differs from student to student.

So, we have been proposing a network-based new learning environment to support individual learning and collaborative learning dynamically. In the environment, each learner is solving problems individually with an ITS. When the ITS detects a desired situation for a learner (triggered-learner) to shift from individual learning mode to collaborative learning mode, the ITS forms an effective learning group for the learner, and then the members of the group start a collaborative learning session. In the group, not triggered-learner but every member should be ensured to attain individual learning goals through specific interaction with the other members. To encourage the interaction, every member is assigned a specific role in the group. When the members attain their learning goals, they close the session and return individual learning mode. We call the idea of dynamic group formation *"Opportunistic Group Formation (OGF)"*.

With our Learning Goal Ontology we can represent the several group formations whose effectiveness is ensured by learning theories. It means that the ontology brings the following benefit: When a personal goal for a learner (*i.e.*,I-goal or Y⇐I-goal) is decided, we can identify learning theories which propose learning groups to facilitate that the learner attain the personal goal. And then, we can form a specific group and identify roles assigned to the members of the group according to the theory.

If there are many theories to enable a learner to attain a specific personal goal, we can form many learning groups supported by the theories as candidates. Then, we have to narrow down the candidates to one. How can we select one?

Each learner plays a specific role in collaborative learning session. Every role has necessary conditions which should be satisfied by a learner who plays the role. The conditions will work as constraints to narrow down the candidates. If there are still some candidates after checking the conditions for role assignment, there are no rules for conflict resolution between all possible learning theories.

One might want to select one of the most profitable theory-based learning groups for a learner to attain a personal goal. Every theory expresses a different learning situation. The differences between theories do not mean the differences of the degree of effectiveness, but diversity of means to attain a goal. So, it is hard to compare a theory with the others on the effectiveness for helping a learner attain a personal goal.

There is another solution of the problem for narrowing down the candidates to one. Are learning theories exclusive each other? If the candidates can be integrated into one, a stronger learning group will appear: a learner is expected to attain a personal learning goal through some kinds of interaction, and each interaction is justified by a learning theory.

4 Is a Learning Theory Exclusive or Harmonious with Other Theories?

In actual learning environment, teachers often adopt the style of collaborative learning. If the group includes a member L_A whose knowledge base and/or experiences are relatively poor, it would be difficult for L_A to discuss with other members and to solve a problem collaboratively. L_A is expected to grow into a senior through practice in the group. This type of learning group is similar to the group based on the theory "LPP" which describes a process in which a newcomer grows into a senior[15, 16]. Fig. 5 shows typical learning group formation the W-goal "LPP" where three learners: L_A, L_B and L_C are participating. As a whole group, all members solve a problem collaboratively, and L_A is regarded as a **Peripheral Participant** and $\{L_B$ and $L_C\}$ are regarded as **Full Participants**.

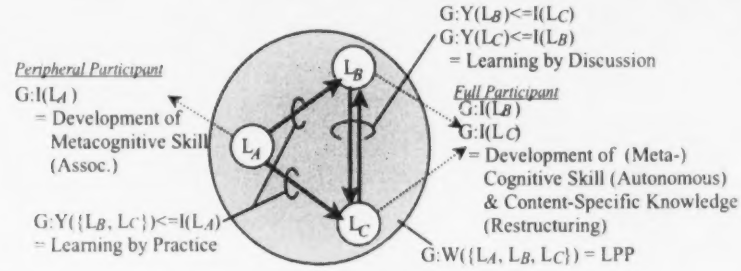


Fig. 5. An Example of Group Formation: LPP

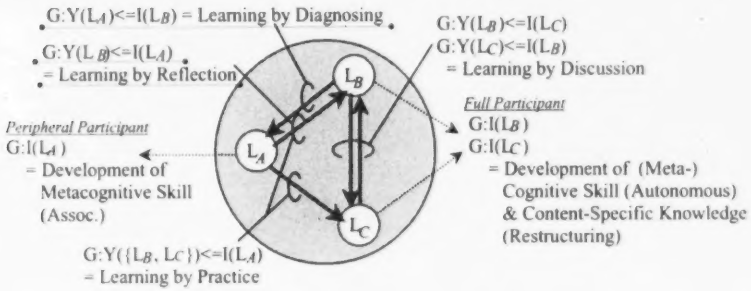


Fig. 6. An Example of Actual Learning Group

In this case, many skillful teachers will arrange for an excellent learner (*e.g.*, L_B) to help L_A in the group. For example, when a new student comes to our laboratory, a senior student may work as a tutor for the new student. Fig. 6 shows this type of learning group formation. We can find additional Y⇐I-goals between L_A and L_B in Fig. 6 as compared with Fig. 5. The teacher will expect different types of interaction between L_A and L_B, which bring additional educational benefits to them. This type of group formation can not be interpreted by a single learning theory.

In a learning group supported by "LPP", can all Peripheral Participants grow up into full participants? According to the theory "LPP", a learner (*i.e.*, Peripheral Participant) can acquire knowledge on the community and develop his/her (meta-) cognitive skil's only by the learner's own practice. It is not assumed the other learners (*i.e.*, Full Participants) help the Peripheral Participant grows up. It seems that there is a gap between the Peripheral Participant and the Full Participant. Especially concerning the development of (meta-) cognitive skills, a Peripheral Participant can observe not the process in which

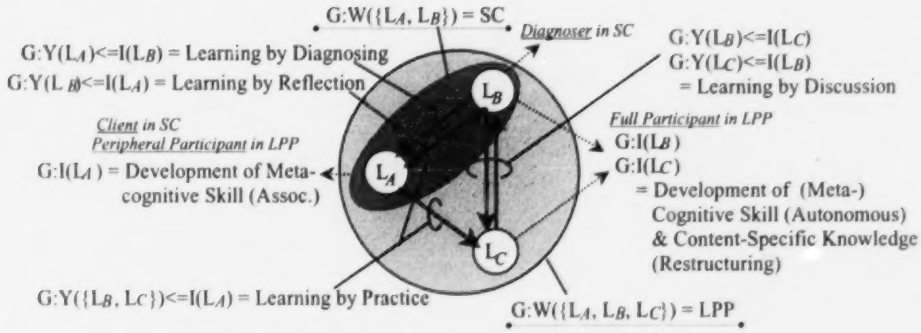


Fig. 7. An Example of Combined Learning Group: W-goal LPP & SC

a Full Participant uses the skill, but input and output for using the skill. It is difficult to learn the process by observing only input and output.

Concerning the W-goals, both W-goals "AI"[4] and "SC"[26] assume to have a "poor learner" who engages to solve a problem and a "helper" for the learner. The W-goal "AI" has a **Problem-Holder**, who has a difficulty in solving a problem, and an **Anchored Instructor**, who diagnoses the Problem-Holder's problem and gives advice to him/her. Similarly, the W-goal "SC" has a **Client**, who externalizes his/her own thinking process, and a **Diagnoser**, who diagnoses the Client's thinking process and evaluates the process. In both W-goals, a "poor learner" is expected to attain his/her I-goal, by a "helper"'s advice. Each of these W-goals can be combined with one of the other W-goals. That is, if it is difficult for a learner to attain an I-goal, we can combine the W-goal "AI" or "SC", and one of the other W-goals to help the learner attain the I-goal.

In the case of Fig. 6, we can interpret the group as a combination of two groups. One group ($Group_i$) consists of two Full Participants ($L_B$and L_C) and one Peripheral Participant (L_A). The W-goal of $Group_i$ is "LPP". Another group ($Group_j$) consists of a Client (L_A) and a Diagnoser (L_B), and the W-goal of the group is "SC". Fig. 7 shows the combination of two groups. In this learning group, $L_A$is expected to participate in the session more easily thanks to the help of L_B. For L_B, it is an opportunity for diagnosing L_A's authentic problems and helping $L_A$to participate in the collaborative learning session. Through the experience, we can expect $L_B$to develop his/her cognitive skill in two ways. For L_C, he/she will be able to get the same educational benefit with participating in the group shown in Fig. 5, because his/her activity is equal between the both groups.

For the combination of theory-based learning groups, the role of ontology is to clarify principles of combination. In combined groups, it should be guaranteed that all members can attain their own learning goals. At this stage, we store possible patterns of combining some theory-based learning groups as a pattern library. The ontology should not only represent the patterns, but also the principles which express the design rationale why the groups can be combined into one. When we can clarify the principles, an intelligent educational support system will be able to infer an effective learning group formation based on the principles opportunistically: The group formation is not picking up an appropriate one from the static pattern library. In this paper, we have described the possibility of combination the W-goal "AI" or "SC", and other W-goals. We have to consider the other types of combination.

5 Conclusions

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal, Y⇐I-goal and W-goal. In this paper, we described the outline of Learning Goal Ontology, and summarized advantages and remaining tasks for the ontology. We proposed possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*,motivation, familiarity. It is also our future work how to treat these factors.

References

1. Anderson,J.R. "Acquisition of Cognitive Skill", Psychological Review, vol.89(4), pp.369-406, (1982).
2. Bandura, A. "Social Learning Theory", New York: General Learning Press, (1971).
3. Bransford, J. D., Vye, N., Kinzer, C., & Risko, R. "Teaching thinking and content knowledge: Toward an integrated approach", In. B. Jones & L. Idol (Eds.) Dimensions of thinking and cognitive instruction. Hillsdale NJ: Erlbaum. pp. 381-413, (1990).
4. Cognition and Technology Group at Vanderbilt. "Anchored instruction in science education", In: R. Duschl & R. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice. Albany, NY: SUNY Press. pp. 244-273, (1992).
5. Collins,A. "Cognitive apprenticeship and instructional technology", In: Idol, L., & Jones,B.F. (Eds.) Educational values and cognitive instruction: Inplications for refoem., Hillsdale, N.J.: L. Erlbaum Associates, (1991).
6. Cooke, N.L., Heron, T.E., & Heward, W.L. "Peer tutoring: Implementing classroom wide programs", Columbus, OH: Special Press, (1983).
7. Endlsey, W.R. "Peer tutorial instruction", Englewood Cliffs, NJ: Educational Technology, (1980).
8. Fitts,P.M. "Perceptual-Motor Skill Learning", In: Melton,A.W. (Ed.), Categories of Human Learning, Now York: Academis Press. pp.243-285, (1964).
9. Flavell, J. H. "Metacognitive aspects of problem-solving", In L.B. Resnick (Ed.), The nature of intelligence. Hillsdale, NJ: Erlbaum. pp.231-235, (1976).
10. Ikeda, M., Hoppe, U., & Mizoguchi, R. "Ontological issue of CSCL Systems Design", Proc. of AI-ED 95, pp.234-249, (1995).
11. Ikeda, M., Go, S., & Mizoguchi, R. "Opportunistic Group Formation", Proc. of AI-ED 97, pp.166-174, (1997).
12. Inaba, A., Ikeda, M., Mizoguchi, R., & Toyoda, J. "The Learning Goal Ontology for Collaborative Learning", http://www.ai.sanken.osaka-u.ac.jp/~inaba/LGOntology/, (1999).
13. Inaba, A. & Okamoto, T. "The Intelligent Discussion Coordinating System for Effective Collaborative Learning – What is the role of artificial intelligence in supporting collaboration? –", AIED 97: Workshop Notes IV, pp.26-33, (1997).
14. Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., & Toyoda, J. "How Can We Form Effective Collaborative Learning Groups? – Theoretical justification of "Opportunistic Group Formation" with ontological engineering –", pp.xx-xx, (2000).
15. Lave, J. "Cognition in practice: Mind, mathematics and culture in everyday life", Cambridge University Press, (1988).
16. Lave,J. & Wenger, E. "Situated Learning: Legitimate peripheral participation", Cambridge University Press, (1991).
17. Mizoguchi, R., & Bourdeau, J. "Using Ontological Engineering to Overcome Common AI-ED Problems", IJAIED, 11, (2000).
18. Mizoguchi,R., Ikeda,M., & Sinitsa,K. "Roles of Shared Ontology in AI-ED Research", Proc. of AI-ED 97, pp.537-544, (1997).
19. Piaget, J., & Inhelder, B. "The Psychology of the Child", New York: Basic Books, (1971).
20. Rumelhart, D.E., & Norman, D.A. "Accretion, Tuning, and Restructuring: Modes of Learning", In: Cotton, J.W., & Klatzky, R.L. (Eds.) Semantic factors in cognition. Hillsdale, N.J. : L. Erlbaum Associates., pp.37-53, (1978).
21. Salomon, G. "Distributed cognitions", Cambridge University Press, (1993).
22. Spiro, R. J., Coulson, R., L., Feltovich, P. J., & Anderson, D. K. "Cognitive flexibility: Advanced knowledge acquisition ill-structured domains", Proc. of the Tenth Annual Conference of Cognitive Science Society, Erlbaum, Hillsdale, NJ, pp.375-383, (1988).
23. Spiro, R. J., Feltovich, P., J., Jacobson, M., L., & Coulson, R. L. "Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquistion in ill-structured domains", http://www.ilt.columbia.edu/ilt/papers/Spiro.html (1995, accessed on March 2000).
24. Supnithi, T., Inaba, A., Ikeda, M., Toyoda, J., & Mizoguchi, R. "Learning Goal Ontology Supported by Learning Theories for Opportunistic Group Formation", Proc. of AIED99, (1999).
25. Vygotsky, L.S. "The problem of the cultural development of the child", Journal of Genetic Psychology, vol.36, pp.414-434, (1929).
26. Vygotsky,L.S. "Mind in Society: The development of the higher psychological processes", Cambridge, MA: Harvard University Press, (1930, Re-published 1978).

Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

Feng-Hsu Wang
Department of Information Management
5, The-Ming Road, Gwei Shan District, Taoyuan County 333, Taiwan
Tel: +886-3-3507001 ext. 3446
Fax: +886-3-3294449
E-mail:fhwang@mcu.edu.tw

One of the creative capabilities of scientists is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data mining approach to designing learning tools in educational environments for creative science education. Specifically, students can experience knowledge discovery by engaging in collaborative data mining activities that enable students to cooperate both with the computer and the other students. Data mining process is typically made up of a set of activities such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. The learning process is modeled as a set of learning protocols that properly distribute the data-mining work among students and computers. Based on these protocols, we design and implement a set of learning tools in a web-based learning environment for global climate exploration.

Keywords: **Learning protocol, knowledge discovery, data mining, learning environment, collaborative learning, science education.**

1 Introduction

Among the creative capabilities of scientists, the most important one is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data-mining approach to creative science education in learning environments. In this data-mining supported environment, students could observe real world data in different perspectives, derive their own classification rules and test the rules collaboratively, such that they can experience knowledge discovery by engaging in collaborative data-mining activities.

In this paper, we adopt learning protocols [9] to describe the learning processes. Learning protocols are a set of constraints, rules, or processes for structuring learning processes, and are externalized as executable methods, with roles, events, and actions made explicit. Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. In this paper, we will devise a set of learning protocols that properly distribute the data-mining work among students and computers.

Based on the collaborative data-mining protocols, we design and implement a set of learning tools in the CILSE-GCE learning environment [7, 8]. CILSE-GCE is a web-based collaborative learning environment for global climate exploration. The task domain, global climate exploration, is inherently a scientific classification problem. Students are expected to induce classification rules by making observations under a couple of climatic features. These tools are designed with the intention not only to teach students the target knowledge, but also the scientific ways of study skills. We believe the students will achieve higher learning goals through the collaborative process of creating knowledge by themselves.

2 The CILSE-GCE Learning Environment

The target domain draws sources from the instructional material in the geographic climate course of senior high schools in Taiwan. One of the domain knowledge is the classification of each climate pattern, which is recognized as a specific set of the climatic attributes. In this paper, we focus on the construction of the climatic classification knowledge. Three components of the CILSE-GCE learning environment were built. They are the Virtual Classroom, Visualized Data Viewer, and Intelligent Tutor, respectively, which are outlined below.

The Virtual Classroom serves as the origin where teachers and students coordinate and collaborate. Through the Virtual Classroom, students could access the multimedia coursebase, the climatic GIS database (via the Visualized Data Viewer) and the historical literature database. These rich data sources allow students to observe, search and collect related information in different aspects regarding to the problems at hand. The CILSE-GCE environment also provides an intelligent tutor to help students induce the classification rules. During the rule induction process, a student has to identify what the settings of the relevant attributes are by exploring resources of all kinds. When he/she determines a specific set of attribute values, the intelligent tutor would evaluate the student's answer, and give suggestions to guide the student's further exploration.

A set of rich data sources are needed to allow students to observe, search and collect related information in different aspects regarding to the problems at hand. In the Visualized Data Viewer, rich climate information could be displayed in different layers of maps covering the globe. Students could select, resize and combine different information layers for display to investigate the climate attributes in different perspectives. Hotlinks to climatic data and statistical graphs associated with the typical cities are also provided to allow students to do some measurements and inferences. Up to now, we have collected more than 1700 city records of various kind of climatic information, such as latitude, temperature, precipitation, height above sea level, etc. This database is the main data source that students can collect related data and perform data-mining process to discover the classification knowledge. Figure 1 shows a snapshot of the Visualized Data Viewer.

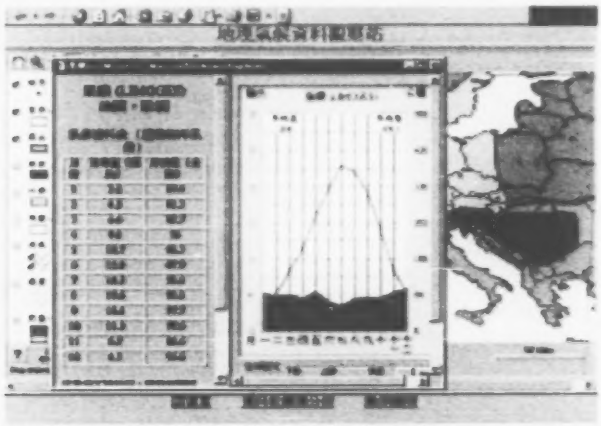


Figure1 A snapshot of the Visualized Data Viewer system.

3 Collaborative Data Mining as Knowledge Discovery

For creative science education, students are asked to acquire the learning skills of knowledge discovery, such as making observations and data collections, performing data analysis, generating hypotheses, testing hypotheses, and making conclusions. Standing from the viewpoint of knowledge discovery [2], we model the learning process as a data-mining process. Figure2 shows the set of data-mining activities, such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. Some steps of the data-mining process can be handled well with computer supports, especially those involving tedious computations and comparisons. Other steps are more suitable to be learning tasks for human students. In this section, we propose the framework of collaborative

BEST COPY AVAILABLE

data mining within which each student member first applies the data-mining process to generate his/her private knowledge base, and then all students collaboratively integrate their private knowledge bases to a more general knowledge base, a result of social consensus process.

The first step in the data-mining process is to select a target data of interest from database, and to possibly sample the target data. The learning skills required of the students are the capability of observation and data collection. Based on the aspects they observe data, students can select all relevant attributes they think might be important to the classification problems at hand. Besides, there are so many samples in the database that students have to learn the sampling skill by selecting as typical samples as they can.

Secondly, the preprocessing and data cleaning step handles noises and unknown values, as well as accounting missing data fields. This step can be dealt with quite well with computer software. Thirdly, the data reduction and transformation step involves checking relevant features depending on the goal of the learning task and certain transformations on the data such as converting one type of data to another (e.g., discretizing continuous values), and/or defining new attributes. It is this step that testifies the hypothesis of attributes that students generated at the previous data observation step.

In the knowledge formulation step, students may apply one or more knowledge discovery techniques and tools on the transformed data set to extract valuable patterns. In this step, students can learn domain-dependent skills as well as the ability to work with computers, as is practiced by most scientists nowadays. Finally, the knowledge evaluation step involves interpreting the result with respect to the goal/task at hand. And as is often the case, students may get back to previous steps based on the evaluation results. Well-designed OLAP (OnLine Analysis Processing) tools are required for students to practice such kind of data analysis tasks. Note that the data-mining process is not a linear one. It might involve a variety of feedback loops, because any one step can result in changes in preceding or succeeding steps.

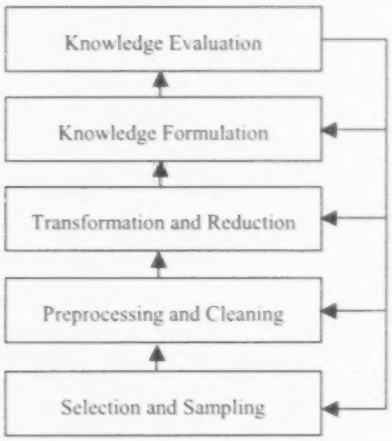


Figure2 The data-mining process.

4 Learning Protocols for Collaborative Data Mining

Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. A learning protocol consists of a set of components. First, a protocol has a name signifying the situation type to which the protocol can be applied. Secondly, a protocol consists a set of states and transitions. In each state the users can perform actions such as communicate or manipulate artifacts. A transition to another state is triggered by an action or a specific condition. Actually, a learning protocol can be represented as an event-driven state-transition graph. Thirdly, a protocol includes different roles pertaining to the persons involved in the enactment of the protocol. Finally, a protocol may contain various types of artifacts, such as text documents, graphical objects, test forms, etc. In the following, we design a set of learning protocols for the collaborative data mining process.

4.1 The protocol to construct member knowledge

The protocol shown in Figure 3 outlines the actions of personal data-mining process and coordinates the interactions between a student and the computer. There are totally ten states in the protocol. Each state and transition is described as follows. In the Observing Data state, the student observes the data in all aspects he/she consider important to classify the climatic patterns. The main data source is the Visualized Data Viewer. The student then defines a set of attributes (in the Defining Attribute state) that will be used to classify the climatic patterns. In the Sampling state, the student starts to collect data (cities) and fill in all the details of the climatic attributes that he/she had defined. Since some of the attributes are numeric values, the student has to transform them into symbolic ones (like temperature is high or low) in the Discretizing Attributes state for more data understandability.

In the Mining Rule state, students have to extract and write down the classification rules hidden in the collected data. For this purpose, we design a set of data analysis tool that depicts the distribution graph or dependency graph of the climatic data based on the attributes specified by the students, such as the ones shown in Figure 4.

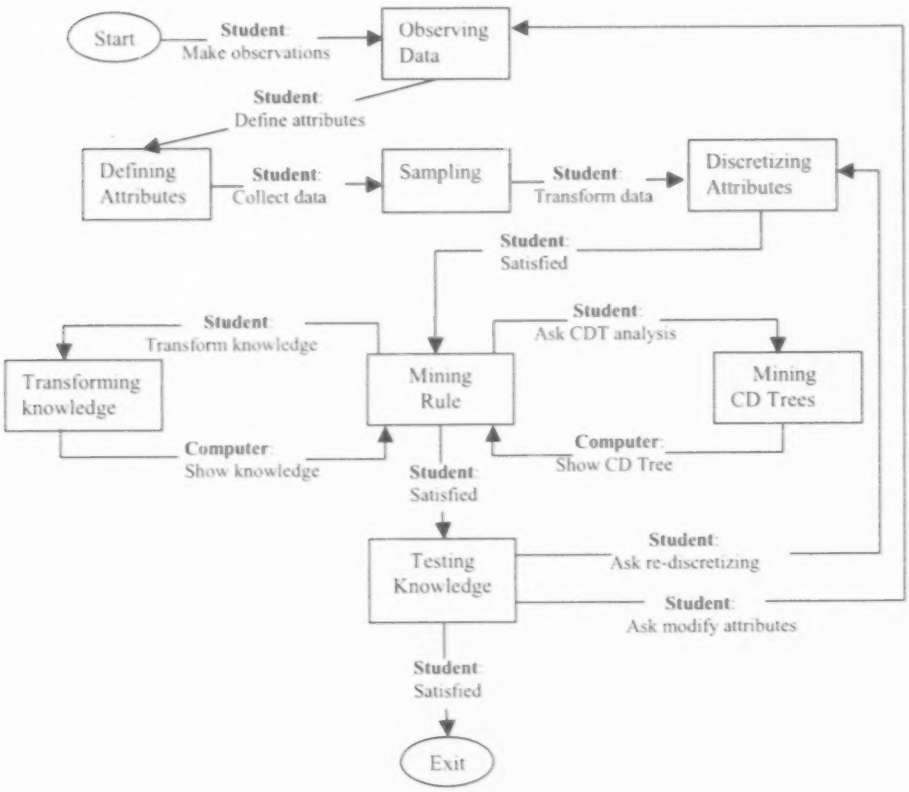
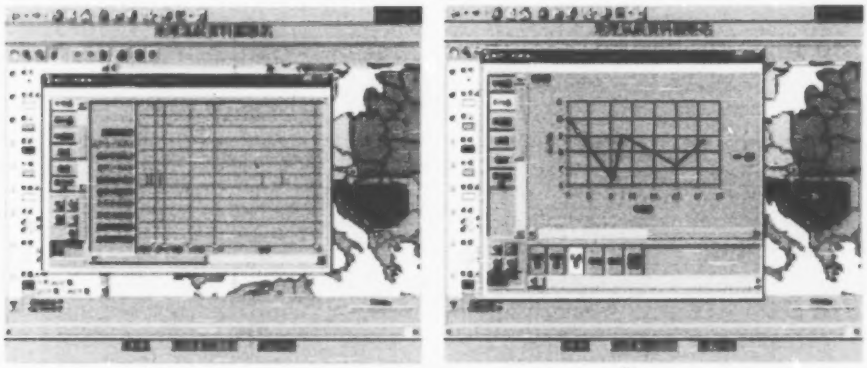


Figure3 The personal data-mining learning protocol.



(a) (b)

Figure4 (a) A data-mining support tool for comparing frequency distributions. (b) A data-mining support tool for depicting data dependency graphs.

Nevertheless, it would be still difficult for some students to discover the hidden knowledge (rules) without further computer supports. Hence, we design and implement another tool to facilitate the data-mining process in the Mining Decision Tree state. This tool uses a variation version of ID3 algorithm [4] to devise a Composite Decision Tree (CD Tree) out of the collected data. A As shown in Figure 5, students can use the CD tree to select and compose classification rules that are of more accuracy, stability and understandability. While rules provide a good local view of each knowledge unit, CD Trees provide another view that facilitates the comparison of different rule structures. . In the Transforming Knowledge state, the student can exchange the knowledge format from CD Trees to Rules, and vice versa. At last, the student can test his/her classification knowledge against the city cases in the Testing Knowledge state, and decide whether to further revise the knowledge.

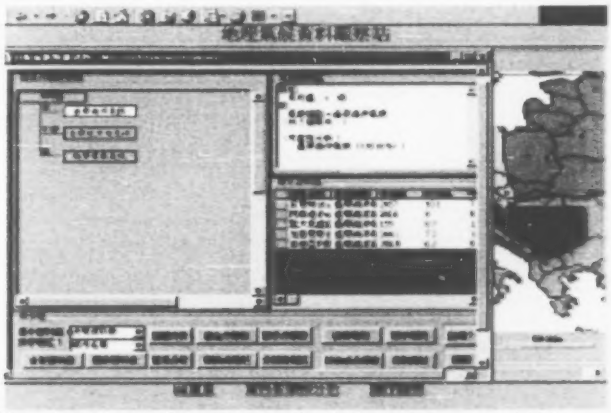


Figure5 A data-mining support tool to help students extract hidden knowledge (classification rules) from data.

4.2 The protocol to integrate group knowledge

After each student member establishes his/her own knowledge, the student group starts to perform the knowledge integration task collaboratively. The students achieve the knowledge integration goal by solving the classification problem collaboratively, trying to reach a consensus, which is the group knowledge. The corresponding learning protocol is shown in Figure 6. In the Presenting Cases state, a Coordinator (a software agent) selects a city case from the database for the student group to identify its climatic pattern. In the Classifying Case state, each student member applies his/her knowledge to solve the problem, and shows the applied rule and related information (such as the symbolic terms for each numeric attribute) in a shared

BEST COPY AVAILABLE

working space. With the information shown in the shared working space, each student member starts revising his/her own knowledge by references to the correct answers and the colleagues' knowledge. Detail of the Revising Knowledge state is described in next protocol. Each time the member knowledge is revised, a new applied rule is sent once again to the shared working space. This process will loop until a temporary consensus is reached. At last, the Coordinator store the final rule set into the integrated knowledge base (i.e., the group knowledge). We adopt the Blackboard Architecture [3] to implement this learning protocol.

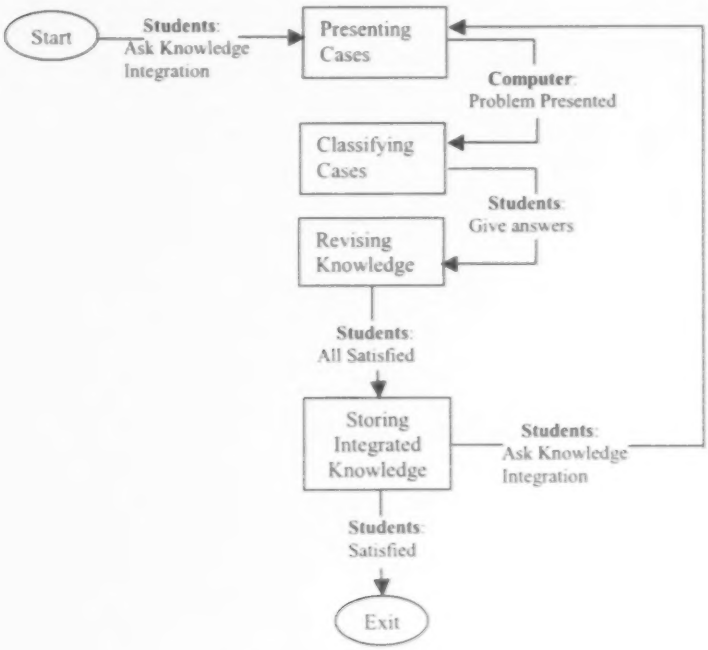


Figure6 The collaborative knowledge integration learning protocol.

4.3 The protocol to revise member knowledge

When students ask to revise his/her private knowledge, the knowledge revising learning protocol, as shown in Figure 7, is entered. In this protocol, two kinds of knowledge operations, the knowledge generalization and knowledge specialization operations, are supported. Each student member can revise his/her private knowledge by applying the two knowledge operations and/or exchange knowledge through the Group Chatting state that involves chatting-support tools. Each kind of knowledge operation can be applied to the various artifacts such as rule structures, numeric attribute intervals, and attributes. Specifically, in Knowledge Generalization state, students can delete conditions from rules, reduce numeric attribute intervals or delete some attributes from the attribute set, while in Knowledge Specialization state, the students can add conditions into rules, extend some numeric attribute intervals or add new attributes into the attribute set. To facilitate both kinds of knowledge revision, an automated rule testing and warning subsystem is implemented to list the rules that are potential for further generalization or specialization based on the test result against any data set.

5 Conclusions

In this paper, we have proposed and implemented a collaborative data-mining support tools for knowledge discovery in creative science education. These functional extensions are being integrated to our previous Web-based learning environment, CILSE-GCE. This collaborative process fosters all the constructive design

principles mentioned in [1, 5], such as observation, interpretation construction, contextualization, cognitive apprenticeship, collaboration, multiple interpretations, ownership of knowledge, self-awareness of construction process. In this collaborative learning model, students would experience the process of looking for patterns collaboratively. Besides, we find that learning protocols are very effective ways to the description and implementation of learning processes. Finally, it is indicated that during free exploration of a problem space, greater learning occurred if students adopted more systematic strategies for rule induction [6]. Further evaluation tests will be conducted to provide beneficial evidences of such kinds of discovery learning.

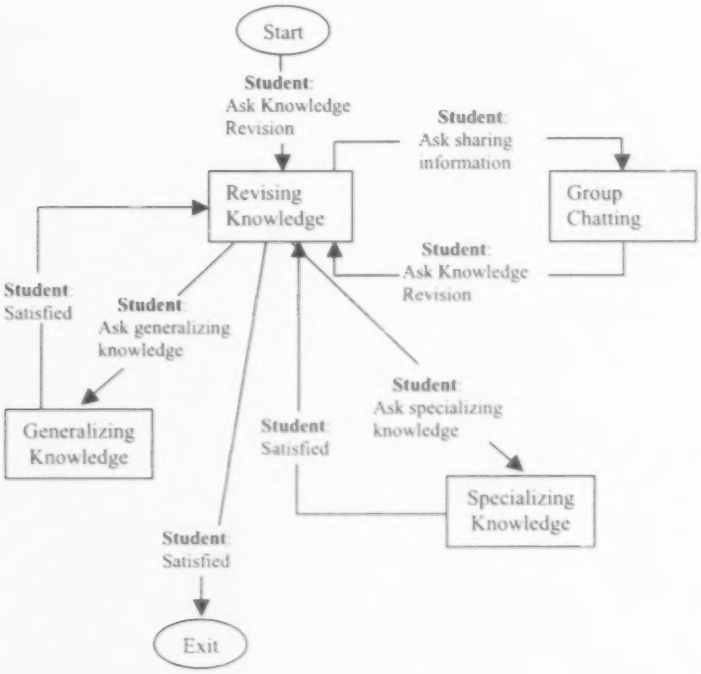


Figure7 The knowledge revising protocol.

References

[1] Black, J. B. & McClintock, R. O., "An interpretation construction approach to constructivist design". In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design" (pp. 25-32), Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[2] Fayyad, U. M., "Data mining and knowledge discovery: Making sense out of data", IEEE Expert, Vol.10, pp. 20-25, (1996).

[3] Nii, H. P., "Balckboard systems: Blackboard application systems from a knowledge based perspective", AI Magazine, Vol. 7, No. 3, (1986).

[4] Quinlan, J. R., "Induction of decision trees", Machine Learning, Vol. 1, No. 1, pp. 81-106, (1986).

[5] Honebein, P.C., "Seven goals for the design of constructivist learning environments", In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design", (pp. 11-24). Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[6] Vollmeyer, R., Burns, B. D. & Holyoak, K. J., "The impact of goal specificity on strategy use and the acquisition of problem structure", Cognitive Science, Vol. 20, pp.75-100, (1996).

[7] Wang, F. H. & Chen, C. H., "CILSE-GCE: A collaborative intelligent learning support environment on world wide web", Annual Meeting of ED-MEDIA, Seattle, WA, USA., Jun. pp. 264-269, (1999).

[8] Wang, F.H., "On the design of an intelligent exploratory environment for geographic climates on WWW", Computer Networks and ISDN Systems, Vol. 30, pp. 699-700, (1998).
[9] Wessner, M., Pfister, H. R. & Miao, Y., "Using Learning Protocols to Structure Computer-Supported Cooperative Learning", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 471-476, (1999).

On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

Hideo FUNAOI, Kazuyoshi BABA, Masatoshi SUZUKI, Makoto, ITAMI, Kohji ITOH
Department of Applied Electronics, Science University of Tokyo
Yamazaki 2641, Noda-shi, Chiba, 2788510, JAPAN
Tel: +81-471-24-1501 (ext.4232)
E-mail: {funaoi, kazuyosi, masatosi, itami, itoh}@itlb.te.noda.sut.ac.jp

Our mediabase system "ShareMedia" can facilitates collaborative learning, especially, inductive knowledge acquisition. In ShareMedia, learners in a community add, collaboratively, structured query to the electric data, which is to be registered in the mediabase. Structured queries consist of query units. Pieces of electric data express concrete knowledge or cases. Then they can navigate and retrieve pieces of electric data express by use of the queries. In other words, they can compare and examine the pieces of electric data and know their relationships. Consequently, they can acquire knowledge inductively. However, it is difficult for them to select suitable query units for a structured query. In this study, then we applied Latent Semantic Indexing to the supporting method. In our method, pieces of electric data and query units are represented as a vector space. The vectors are decomposed by Singular Value Decomposition, and then new vectors will be created. The piece of electric data that a learner wants to index is also processed with the same method. Then, the new electric data vector is compared with the new query unit vectors, and suitable query units will be selected. As a result of evaluation, our supporting method was proved to perform well.

Keywords: **indexing, navigation, collaboration, hypermedia, mediabase**

1 Introduction

In the field of education, teachers and researchers are, recently, more concerned about collaboration. Because of it, Many Computer systems are developed to support collaborative learning. For example, CSILE[1,2] facilitates knowledge building in a community, Collaboratory NoteBook[3] supports scientific inquiry activities in high school.

The mediabase system "ShareMedia[4,5]", which we are developing now, is such a system that supports learner's activities of description and accumulation, sharing, searching, selection of knowledge. In detail, it can not only promote the process of learner's browsing accumulated cases or knowledge and discovering their relationships, but also train their skills to share and use such cases and information in a community. Though we now assume that learners in high school geography class use ShareMedia, of course ShareMedia can be used in another domain.

ShareMedia needs not to link between nodes explicitly, and requires only indexing retrieval indices to media representations (see chapter 2). Then, ShareMedia enables learners to retrieve flexibly based on the semantics or concept of data by use of retrieval indices. Through the functions mentioned above, ShareMedia facilitates collaborative learning in a junior high school geography class to acquire generalized knowledge from individual cases and knowledge inductively and to index semantic indices to them in order to enable such activities.
ShareMedia supports learning activities as follows:

1) In a small community (e.g. a classroom or a group), learners collect electric media as individual knowledge or concrete cases and add indices express their concept to them. Then, learners store their shared mediabase with the electric media.

2) The learners browse the shared knowledge and compare pieces of the knowledge, which are extracted with indices, many times. As a result of this activity, the learners can abstract the pieces of the concrete knowledge and understand the relationships between them.

3) The learners discover inductively generalities or rules, which exist in the relationships, and deal with them as hypothesis.

4) The learners apply deductively the hypothesis to pieces of individual knowledge and can acquire then as generalized knowledge if their propriety is confirmed.

2 Mediabase system "ShareMedia"

The current version of ShareMedia (Fig.1) was developed on UNIX environment (Solaris CDE ver.1.3) with JAVA Development Kit ver.1.1.7 and K-Prolog Compiler ver.4.0. ShareMedia consists of several components. Above all, media representations, semantic frames, semantic indices and retrieval requests are important. Their details are as follows:

2.1 Media representation

Media representations (Fig.1.a) are electric data of pieces of individual knowledge or concrete cases. They are represent as texts, images, pictures, movies, sounds and so on. In this paper, however, only text form is dealt with because of presumption of semantic frames with natural language processing. Learners index a semantic index mentioned below to the block of a media representation and store the shared mediabase of ShareMedia with the media representation. After storing, learners can chose media representations from the list of them. With semantic indices, however, learners can navigate them more flexibly.

2.2 Semantic frame

Semantic frames (Fig.1.b) are used as query units and are primitive units of concept or semantics of media representations. They have slots that express subject, object, means, moment and so on. For example, "utilize" frame has "who", "what" and "to what" slots and "be factor" frame has "what" and "of what" slots. Learners should decide their form by mutual agreement in order to use them effectively in learning activities and store shared mediabase with them consistently.

2.3 Semantic Index

Semantic indices (Fig.1.c) are structured queries to express concept or semantics of media representations. Learners select semantic frames that are suitable to a media representation, which the learners will store mediabase with. Then, the learners combine them and link their relative slots. Like this, semantic indices are created by combining semantic frames and are indexed to media representations. They are used when learners retrieve or navigate media representations.

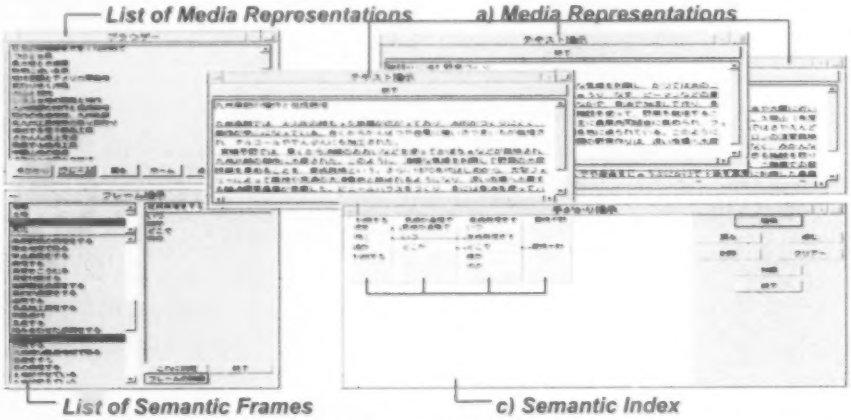


Fig.1 Interface of ShareMedia

BEST COPY AVAILABLE

2.4 Retrieval request

Retrieval request is used when learners retrieve or navigate media representations that are stored in shared mediabase. A learner creates it in the same way as semantic indices. Then, the learner submit it to ShareMedia, he will be presented media representations, which were indexed semantic indices that match the retrieval request. Owing to semantic indices and retrieval requests, learners can retrieve and navigate semantically.

These components mentioned above can facilitate learner's activities to navigate pieces of knowledge semantically, to understand their relationships inductively and to discover generalities, which exist in them, deductively. However, it is difficult for learners to select suitable semantic frames for a semantic index or a retrieval request.

3 Supporting learner's selection of semantic frames

In this study, we applied LSI[6] (Latent Semantic Indexing) to the supporting method for selecting semantic frames. Because LSI is one of statistical method, similarity of documents can be presumed without any dictionaries. In LSI, documents are dealt with a term by document matrix. Then, rows of it can be considered to be term vectors and columns to be document vectors. In addition, these vectors are decomposed by SVD (Singular Value Decomposition), as a result, terms and documents are abstracted.

In our method, media representations and semantic frames are represented as a vector space model. In training, the vectors are decomposed by SVD, and then new vectors will be created. In presumption, The media representation that a learner wants to index is also processed with the same method. Then, the new media representation vector is compared with the new semantic frame, and suitable semantic frames will be selected. Their details are as follows:

3.1 Training

Training needs a data set, which is a collection of combinations of paragraph and semantic frames. Here, paragraph is a part of media representation and contains one or more blocks, which are indexed parts of the media representation. And semantic frames are contained in the semantic indices, which were indexed to the blocks. First, Paragraphs are done morphological analysis with Chasen, which is one of Japanese morphological analysis tool. As a result, word lists of each paragraph are created.

Next, they are filtered in order to extract only the words, which have noun, verbal, and adjective morph. After filtering, they are sorted by frequent descending order. Based on them, a sorted list of all words is generated. On the other hand, based on the relation between the word lists and the semantic frames, sorted word lists of each paragraph collection, which relate each semantic frame, are created.

Then, word by semantic frame matrix is computed from these two type lists. This matrix can be divided to word vectors and semantic frame vectors. SVD decomposes them and creates new word vectors, new semantic frame vectors and the diagonal matrix of singular values. These vectors and matrix are used in presumption.

In addition, latent relationships will be available in presumption, because this decomposition abstracts the words and the semantic frames

3.2 Presumption

To presume the semantic frames that are suitable to a whole media representation or a block of it, the vector of these text strings is processed with new word vectors and diagonal matrix, which are created in training. As a result, new text vector is created. It is compared with each new semantic frame vector by computing cosine between them. The more cosine value is large, the more the semantic frame that corresponds to the new semantic frame vector is suitable to the text string. Then, a list of semantic frames, which are arranged by descending order of cosine values, is made. This list will support learners to select semantic frames, which is suitable to a media representation.

4 Experiment

4.1 Training data set

We prepared 304 media representations, 318 semantic frames and 318 blocks, which were indexed semantic indices by manual. A block, we call in here, is a part of a paragraph where semantic indices are indexed. A media representation contains one or more paragraphs. A block might extend through several paragraphs. Though media indices are indexed to blocks, we use paragraphs to training because of giving redundancy to the presumption. Media representations and semantic frames used in here were extracted from the Japanese geography area of Japanese junior high school geography textbooks. By making use of this data set, new word vectors, new semantic frame vectors and diagonal matrix were computed.

4.2 Evaluation

We use 93 blocks, which are used in training and chosen at random, in order to evaluate the presumption of our method. Each media indices, which were indexed to the blocks, have 3.63 semantic frames on the average. The method presumed suitability of each one of 318 semantic frames to each one of 93 blocks by computing cosine values

4.3 Result

We confirmed their propriety about top of 5, 10 and 15 semantic frames, which were arranged by descending order of presumed suitability to each one of 93 blocks (see, Table 1). In Table 1, "Suitable to Blocks" indicates the average number of frames which experimenter judged suitable to each block. In the same way, "Suitable to Paragraphs" indicates the average number of frames to each paragraph. "Indexed by Manual" indicates the average number of frames, which are indexed to each block by manual beforehand.

Table 1. Average numbers of semantic frames which experimenter judged suitable.

	Suitable to Blocks		**Suitable to Paragraphs**		**Indexed by manual**	
Top	average	precision	average	precision	average	recall
5	2.10	42.0%	2.78	55.6%	1.81	49.9%
10	3.13	31.3%	4.39	43.9%	2.44	67.2%
15	3.72	24.8%	5.32	35.5%	2.77	76.3%

4.4 Discussion

A glance at Table 1 will reveal that presumption of our method is good. For example, seeing top 10 row, the precision within the range of blocks is 31.3%, the precision within the range of paragraphs is 43.9% and recall is 67.2%. Take it into consideration, our method can extract many of semantic frames which should be indexed. In short, learners can easily extract many of necessary semantic frames by selecting from them, which our method presented.

To illustrate the performance more precise, however, we need to make another experiment, because this experiment used same data in both training and evaluation.

5 Conclusion

In this paper, we described the process that ShareMedia supports learning activities, abstract of main components of ShareMedia, our supporting method for learner's selection of semantic frames and it's performance. As a result of the experiment, our method proved to perform well. To judge the performance of our method more strictly, however, we need another experiment with data sets that differ in training and evaluation. And we will improve our supporting method based on the result of it.

References

[1] Scardamalia, M. and Bereiter, C., Technologies for knowledge-building discourse, Communications of the ACM, Vol.36, No.5, pp.37-41 (1993)

[2] Scardamalia, M. and Bereiter, C., Student Communities for the Advancement of Knowledge, Communications of the ACM, Vol.39, No.4, pp.36-37 (1996)

[3] Edelsen, D.C., Pea, R.D. and Gomez, L.M., The Collaboratery NoteBook, Communications of the ACM, Vol.39, No.4, pp.32-33 (1996)

[4] Kuroda, T., Funaoi, H., Takahashi, T., Uchida, A., Nagao, H., Itami, M. and Itoh, K., Evaluation of shared mediabase system that supports learning by comparison cases - on the effect of using shared indices in navigation, Japanese Society for Artificial Intelligence, Technical Report SIG-IES-9804-7, pp.39-43 (1999)

[5] Kuroda, T., Funaoi, H., Itami, M. and Itoh, K., Media database system that supports learning through comparing cases by using shared indices, Proceedings of 7th International Conference on Computers in Education, pp.308-311 (1999)

[6] Deerwester, S., Dumais, S.T., Furnas, G.W., Landauer, T.K. and Harshman, R., Indexing by latent semantic analysis, Journal of the American Society for Information Science, Vol.41, No.6, pp.391-407 (1990)

Peer Help for Problem-Based Learning

Susan Bull and Jim Greer
ARIES Laboratory, Department of Computer Science,
University of Saskatchewan, Saskatoon, SK S7N 5A9, Canada.
bull@cs.usask.ca, greer@cs.usask.ca

This paper describes the I-Help peer help network, where helpers and helpees are paired according to the contents of their user models. Although originally designed for large groups, in this paper we suggest ways in which I-Help may be used in a small group, problem-based learning curriculum. The use of I-Help will be very different in this context: it is not expected to be necessary for all students. However, some learners may experience difficulties with some aspects of problem-based learning, such as: scheduling of meetings; involvement in discussions; understanding roles; acquiring skills for problem-based learning; different interaction preferences; differences in cognitive styles. We describe how I-Help may be used to alleviate some of these difficulties, in particular: by putting groups into contact with other groups; or putting individuals into contact with someone outside their group who can advise, or who is facing similar problems, and would like to explore the issues jointly. At the same time, group cohesion is not disrupted.

Keywords: **peer help, problem-based learning, student modelling.**

1 Introduction

Problem-based learning (PBL) is used in many academic subjects (e.g. architecture, business, education, engineering, law, medicine). The first implementations were in medical education, and PBL is still used in many medical sciences courses today. We therefore focus on medical education in this paper, though many of the arguments are applicable to a range of subjects.

Medicine is a difficult subject to teach and learn: the knowledge to be acquired and integrated is broad and very complex. This knowledge is useful only if it can be applied to problems presented by real patients. Such problems are ill-structured, specified with partial information, and often complicated by diverse interacting factors. While acquiring basic domain knowledge is a fundamental activity in medical education, integrative problem-solving is also a fundamental goal.

PBL attempts to focus learning around authentic patient problems or cases, which bring together many interacting issues of a multidisciplinary nature. A core aspect of PBL is that problems should be only partially specified. PBL involves the student in a practical activity, carried out in small groups (usually 4-8, facilitated by a tutor) in which students identify and research their own learning issues [17]. Typically a group will meet to discuss a case, identify learning issues, and then research these individually using a variety of resources (e.g. print-based, web-based and people). They then meet again to report and discuss the case further.

Investigations into the benefits of PBL have produced mixed results, possibly in part because traditional assessment mechanisms are less appropriate measures of the goals of PBL [13,30]. It is stressed that there is, as yet, no evidence that a PBL curriculum is more successful than a traditional approach [27]. Nevertheless, PBL has been embraced by some as the preferred approach to medical education, advantages cited including: the self-directed nature of PBL [27]; a greater tendency towards a deep approach to learning [21]; and positive student attitudes [6]. Others suggest that acquisition of basic domain knowledge may not be well supported in PBL. Learners may later recall less factual knowledge, since they are spending time learning other skills in addition to content [30], and they may lack depth of knowledge [18]. Explanations generated by PBL students can be less coherent, and more frequently incorrect [23]. Learners may also become bored with the PBL process [29]. It has also been recognised that PBL may simply not suit all students' ways of learning [10]. While the peer help system described in this paper can assist in a number of areas, it is this latter aspect that we focus on here.

This paper is neither a critique nor an endorsement of PBL. However, we emphasise that in PBL (as in traditional education), there is a need for tools to support peer interaction for situations where learners need assistance. In this paper we describe how the I-Help (Intelligent Help) system can be used to support students who have difficulties with the PBL approach by putting groups into contact with other groups, or an individual into contact with another learner who may advise or collaborate.

Section 2 of this paper introduces existing examples of computer support for PBL, and describes other systems which mediate peer help. The advantages of I-Help in large groups are described in Section 3. Section 4 discusses how the large group implementation of I-Help may be adapted to support PBL students when they are experiencing problems with the PBL approach. Conclusions are presented in Section 5.

2 Computer support for problem-based learning and peer help

Computer support for group interaction in PBL has been implemented for the asynchronous distance education context; the synchronous distributed learning context; and the co-present small group situation. Kamin et al. [15] describe a combined Web/CD-ROM program containing a video patient case, for use by a group of third year medical students and tutor. It is designed to facilitate asynchronous PBL during a clinical course component, requiring independent and collaborative involvement. Cameron et al. [5] discuss a distributed problem-based learning project using conferencing software together with a web page, to support synchronous sessions aimed at enabling 'authentic PBL' to occur amongst distributed first/second year medical students and a tutor. Koschmann et al. [16] introduce a method of conducting PBL meetings between students and tutor in a face-to-face context, using connected individual laptops and a large shared display. This approach is close to that found in PBL meetings not supported by computers, but offers some advantages: parallel polling (to ascertain each group member's views before they hear the ideas of others); and a record of contributions.

Computer support for PBL may, or may not include actual cases within the program: students may be collaborating about computer-presented cases, or interacting through the computer environment about externally introduced cases. External cases may be provided by the tutor off-line, or may be drawn from a database of patient cases (e.g. PATSy [19]). Systems to support PBL may help to structure and focus PBL discussions. However, even where such systems are available to a student, we believe that additional support is needed by some learners, to help them cope with the PBL situation if they feel uncomfortable with some aspects of it.

While it is acknowledged that many learners benefit from collaborative work, it is also the case that collaboration will not suit all learners; or a particular instantiation of a computational or non-computational collaborative learning environment may not suit a learner who could potentially gain much from collaborative interaction. Thus more flexible means of facilitating peer interaction would be useful. This kind of support will differ from that provided by systems such as the above: students who find the PBL approach difficult may find it useful to be put into contact with a peer who can share experiences about specific aspects of PBL.

An increasing number of peer help systems are attempting to organise learner interactions according to the student models of the individuals concerned – i.e. they have a matchmaking component; or by learner selection of available helpers. The matchmakers in such systems can take account of a variety of factors, but they most often look at students' relative proficiencies in the target domain. A few examples are given below.

An example of a peer help environment is that of Yu et al. [31], where more advanced learners act as mentors. Mentors are selected according to their knowledge, with reference to the following criteria: students who have successfully completed the course; students with high grades in other courses; students who have finished assignments; students who have successfully completed the computer-based tasks about which others need help; teachers and teaching assistants. The assumption is that the group of mentors and the student group do not overlap (though Yu et al. suggest extending the system to allow student-student help). Students select mentors based on availability (mentors may be involved in up to three help sessions); and the current problem (mentors may only help on one problem area at a time).

The above example has the advantage that learners choose to receive help when they need it, and are not forced into a collaborative context if they prefer not to participate. Further, they are guaranteed a knowledgeable helper. Nevertheless, there are drawbacks to this approach outside the setting for which it was designed. The set-up is very rigid: currently only externally acceptable (i.e. tutor-selected) individuals may be mentors. This does ensure that helpers are knowledgeable, but it does not require that they are good helpers. It also does not take account of the fact that students may benefit educationally from giving help, as well as receiving it.

Hoppe [14] proposes integrating knowledge from individual student models to support group learning – i.e. to parameterize group learning. One of the benefits is that peer helpers may be selected for help sessions: a knowledgeable helper can be partnered with a less knowledgeable student. In Hoppe's work this occurs as follows: a learner issues a help request; a menu of potential suitable helpers is offered; the learner selects their choice of helper; the selected helper receives the help request; the helper accepts or rejects the request. This approach is claimed to avoid personal conflicts, as helpers are neither assigned, nor must they interact directly with the helpee if they wish to refuse. It also allows all participants the opportunity to be helpers, as long as they know about the topic. It does not guarantee, however, that selected helpers will be proficient at helping.

Ogata et al. [22] extend this notion of peer help networks, taking into account pre-existing social networks amongst individuals, claiming that these are at least as consequential in a help context, as more official organisational structures. Ogata et al.'s approach allows users to register their proficiencies and social networks, and it also automatically traces user relationships by logging email exchanges. This provides additional information on personal networks, and also on abilities of the user: if an individual answers a question posed by a peer, the helper is assumed to be knowledgeable. These relationships are taken into account when matching potential helpers with those requesting help.

The above approaches allow peer interactions to be initiated by a learner, as required. Helpers are contacted, and may choose to take up or reject interactions. The first example [31] does not require extensive student models, but is quite restricted. The second example [14] expects student models to be in place, though overlay models are sufficient to indicate knowledge levels of individuals. The final example [22] does not require detailed models of knowledge, since it relies on social closeness and self-evaluations together with assumptions about competence based on question keywords in a help request, that has been responded to by the individual being modelled. However, what is not present in these approaches is an ability to match students according to their preferences of interaction method, or individual cognitive style, or to take into account a helper's ability to *help*. Such issues may be just as important for peer interaction to be successful.

The following section describes I-Help: an environment based on multiple user models, to match students who have help requests with potential peer helpers. I-Help aims to accommodate a broader range of characteristics that might be important when pairing learners. Suggestions of how I-Help might be usefully applied in PBL are then given in Section 4. This includes the more common face-to-face PBL context, and use alongside software to support group interaction in PBL, such as described at the beginning of this section.

3 I-Help

I-Help is the integration of several information/help sources brought together through the metaphor of a help-desk [12], designed originally for large student groups. The two principal components are an asynchronous public discussion forum [3], and a one-on-one private discussion facility which may be used synchronously or asynchronously. In the case of the private discussions, multiple distributed user models are used [20] to match students who can help each other in their learning. Each user has a personal agent which uses its owner's student model as a source of information for negotiating help sessions with other users, through their respective personal agents [28]. (Some examples of agent personas are shown in Figure 1.) The following illustrates the sequence of events for a help request. (For an example see [11]).

1. A student contacts their agent to issue a request for peer help;
2. The student's agent negotiates with the agents of other learners, to find appropriate helpers;
3. The top five user-matches are emailed that there is a help request waiting for them in I-Help;
4. To ensure maximum immediacy of response, while not duplicating effort, the first helper to accept the request starts a one-on-one discussion. Requests to other potential helpers are thereby cancelled;
5. Upon completion of discussion, each learner receives an evaluation form through which they evaluate their partner, for student modelling purposes.

The I-Help student model is composed, as stated above, in part from peer evaluations given at the end of a help session by both helper and helpee, about the knowledge of the other participant. The student model also comprises self-evaluations of knowledge level in each of the domain areas. In addition, helpees rate the utility of the help received. Social issues are also considered: learners can add users to their 'friends' list–i.e. people with whom they will preferentially interact, be they 'real friends' or people they do not know, but who have been helpful to them in the past. Students may also add individuals to their 'banned' list–people with whom they wish to have no further dealings. Much information for the student model is easily captured, since it is user-given. It is continually updated as peers evaluate help sessions once they are completed.

Also modelled are individuals' cognitive styles. The identification of cognitive style is based on Riding and Cheema's classification [26], which comprises two dimensions: wholist-analytic and verbal-imagery. The wholist-analytic dimension refers to the extent to which an individual usually *processes* information in *wholes* or separate *parts*; the verbal-imagery style relates to the degree to which an individual tends to *represent* information during thinking in a *verbal* or *image* form. In I-Help this information is provided through a front-end questionnaire. The questionnaire is very short, designed for students who may not themselves be interested in the outcome. The aim is to encourage learners to provide at least some information. While recognising that this is not ideal, partial cognitive style information is considered preferable to no information at all.

Five question types were identified, requiring different cognitive style combinations of helper and helpee:

1. *How does this fit with other things?*
   The first choice of helper for this type of question is a wholist, regardless of the cognitive style of the helpee, because wholists will tend to be better equipped to provide a broader overview.
2. *What are the details of...?*
   For this question type an analytic helper is preferred, regardless of whether this matches with the cognitive style of the helpee, because analytics tend to grasp the details of a topic more readily than wholists.
3. *Can you recommend any good materials for...?*
   The aim is to match individuals on the verbal-imagery dimension, since a verbal learner will more likely recommend materials helpful to another verbaliser, and an imager will do likewise for another imager.
4. *Miscellaneous question*
   This category covers any questions not included in the above. The default is to match all learners on the wholist-analytic dimension. If possible, learners are also matched on the verbal-imagery dimension.
5. *Questions requiring simple answers*
   No cognitive style matching is undertaken for straightforward questions requiring a simple answer, as cognitive styles are likely to have little impact here.

When submitting a help request, the learner indicates the question type from the above selection.

In addition to self and peer user-given information, learner models are updated automatically based on observations of eagerness (browsing and active posting behaviour in the public discussion forums, and amount of help given in private discussions). Furthermore, personal agents note which cognitive style matches seem most successful for different question types, and update the user model accordingly. (This also helps to overcome potential inaccuracies in the initial self-report.) Figure 1 illustrates the sources of information for the student model (open arrowheads), and the differences between private and public discussions. In the private discussions a learner interacts directly with a single peer in each dialogue, to give and receive help. Public discussions take place in forums – there is no direct interaction between two people (solid arrowheads).

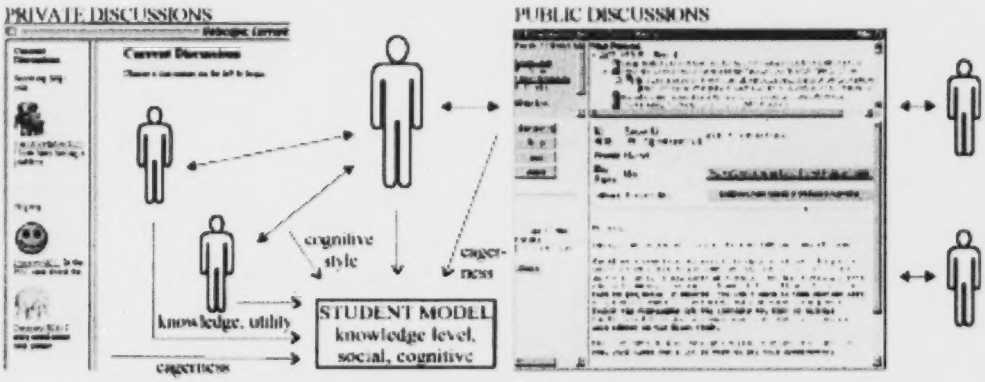


Figure 1: I-Help public and private discussions

In seeking partners, a personal agent tries to balance all relevant information (knowledge level of helpers; helpfulness of helpers; eagerness to help; preferential friends; exclusion of banned people; appropriateness of cognitive style). By default these issues are given equal weighting, but the learner may re-rank each component, as is important for them. For example, some learners may have more flexible cognitive styles. For such students, style may be a relatively unimportant factor. Other students will have more difficulty adapting to someone else's way of learning, and will assign greater importance to cognitive styles – perhaps even preferring this kind of match above the requirement that a helper should be very knowledgeable.

BEST COPY AVAILABLE

A variation on the peer help scenario involves permitting students to choose the kind of interaction they want, based on the S/UM system [4]. In addition to peer help, students may seek: peer feedback about work drafted or completed; collaborative learning; cooperative learning (i.e. X learns A & Y learns B, followed by tutoring or reporting). In addition to peer help, this allows students who wish to learn collaboratively or cooperatively the opportunity to find the most suitable partner. When a user sends an interaction request, they specify the kind of interaction they are seeking. Their agent negotiates a match with someone who also wishes to interact in that manner, and who has appropriate characteristics (e.g. a helper should have greater proficiency in the topic than the helpee; a collaborative partner should have a similar, non-expert, knowledge level).

In summary, the utility of I-Help increases with the number of users, as good matches become more feasible. Much of the user modelling is performed quickly and naturally by users (self- and peer-evaluations), and these models by themselves are sufficient even early during interactions, before additional system modelling has occurred. Student models contain content, cognitive and social information, which can be ranked in order of importance by learners. Further, I-Help can easily be applied across a broad set of courses: all that is required is a course description (in the form of course component labels) to be provided by the course tutor. Knowledge levels represented in user models, to contribute to matchmaking, are then related to these labels. Apart from reducing the load on tutors, from students requesting information, there are three major educational benefits:

- Students receive help when they have difficulties;
- Students learn through encountering the possibly conflicting viewpoints of others;
- Students will necessarily reflect on an issue when giving help on it.

Thus it is not only those receiving help, who benefit.

4 I-Help in problem-based learning

Due to the nature of PBL, students undertake a lot more research than traditionally educated learners, relying less on teacher-recommended texts. Many students use electronic resources more heavily than other resources [8], and they also use general library resources more extensively than their traditional counterparts [2]. I-Help provides additional human resources, forming a natural extension of this situation, and is likely to be useful to many students in PBL during the research phase. However, in this paper we focus on supporting those students who are uncomfortable with some aspects of the PBL approach itself.

Since PBL is focussed around small pre-established peer groups it is less obvious how I-Help might be applied, as opposed to in larger, traditional classes for which it was originally designed. Nevertheless, as illustrated in the following description, there are a number of situations in which I-Help could be useful in PBL.

There are a variety of potential difficulties to take into account in a PBL course. For example:

- It can be difficult for some students to find time to meet outside scheduled class hours;
- For a group to function effectively, individual team members should all be involved in group discussions;
- Students may not fully understand their role in the group;
- Students may lack the skills to make group interactions work;
- Students have different interaction preferences;
- Students have different cognitive styles.

Considering the first two of these issues, the public discussion forum of I-Help is a useful tool to keep all students in contact with their own group's discussions, but also allowing interaction between particular group members, should help or clarification be needed by some participants, on some group issue. At the same time, all students remain up-to-date with all interactions, at a time that suits them, thus freeing up part of meeting times for questions and group issues less easily handled through computer interaction.

Perhaps more unusual in the PBL context: there may be occasions when students could usefully interact *across* groups. As suggested above, it is not the aim to exclude any group members from any interaction important for group progress, but there may be situations where individuals from different groups could help each other, on issues perceived as not directly relevant to either group as a whole. For example, in some PBL contexts the various roles are divided amongst group members, often rotating. In such situations it might be helpful if individuals from different groups who are performing the same role (e.g. scribe; group leader; information analyst), could interact – especially if it is early in the rotation, and there is less group experience on which to draw. It will also be helpful for students finding their role difficult, who are part of a group whose members do not appreciate the learner's problems. Their personal agent could locate a helper who has successfully fulfilled the responsibilities of the role in the past, or find another student with similar problems, with whom they can

jointly explore aspects of the role. Where the whole group acknowledges a lack of understanding of any role, one of the group members may seek outside assistance on behalf of everyone.

I-Help's user models must therefore be extended to include information about student roles. I-Help must know the current role of individuals, in order to put students in touch with others facing the same tasks; and it should also remember the roles that individuals have previously held, and whether they were competent, and whether they are willing to offer help to novices in these roles. I-Help may then be used to pair individuals in interactions relating to role responsibilities, keeping such interactions amongst those for whom the discussion is currently relevant and/or helpful. As more students come to perform each role, previous help session archives may be accessed as help resources. In this manner, it is hoped that more students may develop an understanding of how to meet their various responsibilities, resulting in improved group functioning.

It has been commonly noted that many students entering the medical sciences do not possess the skills necessary for effective group interaction in PBL – e.g. discussion, decision making, conflict management, leadership, group feedback processes [24]. Although I-Help does not teach these skills, its ability to match students with others who are in a similar position, or who are able to help, provides a form of support not usually available. If a single individual has problems, the other group members may be able to compensate while also supporting the learner's development of the skill concerned. However, where group members recognise a general deficiency, they may use I-Help to put them in contact with a group that functions effectively with regard to the particular skill. They may be invited to observe, as the efficient group models the behaviour during their next meeting, or one of the effective group members may describe how their group tackles these issues. This will be especially useful where there are no resources (e.g. time, staff) for skills training.

Again the I-Help student model must be extended, to accommodate information about group interaction skills. This will involve all groups in a group evaluation process in order that they may provide skills information for the user model, which in itself will be a useful reflective activity. The main difference in the structuring of the model in this case is that skills information will relate to *group* functioning, and not to specific group members. Thus I-Help must also know which students belong to which groups. Skills information need then only be given by one learner.

A potential difficulty encountered by a student who might otherwise do well in PBL is that other group members may have different interaction preferences: some students gain much from brainstorming or spontaneous discussion, while others prefer to reflect and organise their thoughts before communicating. The combination of face-to-face meetings and the public discussion forums helps to cater for all students, while the possibility also exists to arrange collaboration, cooperation and feedback through the private discussions.

Students also have different cognitive styles. Some individuals understand verbal descriptions well, while others need pictures, diagrams, or demonstrations. Some learners deal well with abstract concepts and detail, while others tend towards a more general overview. Although a mixture of cognitive styles might sometimes be complementary in a group setting, and have a positive effect on group performance, some cognitive style combinations may lead to difficulties for some individuals. For example, if most members of a group are analytic, a wholist learner may have difficulty gaining the overview perspective they require to integrate information. Such an individual might find the situation very difficult as a learning experience. It is also possible that the other group members will not understand their difficulty. This is a problematic situation since all group members should be involved in group communications for a group to feel comfortable and function well. Full participation is essential in some groups to avoid resentment by other group members if they feel that one person is not contributing. I-Help private discussions should not, then, be used as an alternative to group interaction, as the group may suffer as a result. However, for students who have problems adapting to the way the other group members work, I-Help may provide a much-needed 'lifeline' by matching them with a student with a similar cognitive style, to support their PBL activities in a 'more comfortable' fashion. Thus they will continue to interact with their group to the best of their ability given the difficulties they experience, but they may also work with another learner outside the group context if they feel this to be useful. This need not detract from the group experience as a whole, since the learner may report back any findings. Taking the above example, such an individual's contribution may now be greater, since they will be able to provide the overview that the analytics lack. Therefore their group contribution may be stronger than any earlier contributions where they had not had this additional learning opportunity, and were interacting only within the confines of the particular group's interaction dynamics.

This section has suggested a number of ways in which I-Help might be useful in PBL. It is not suggested that all PBL students should use it (though the public forum is likely to be generally useful), but that I-Help could arrange peer support in cases where an individual is having difficulties with some aspect of the PBL approach.

Although it does not address the problem of group learning for an individual who prefers to learn alone, or in a different kind of group situation, it does at least provide them with some support that they would otherwise not have.

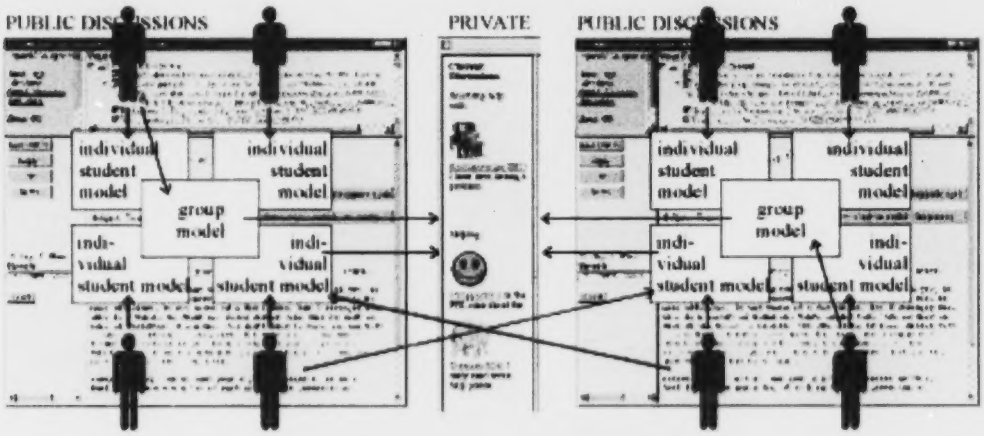


Figure 2: I-Help in problem-based learning

To introduce I-Help to the PBL setting, some additions to the user models are necessary. However, these are very easy to implement, having simplicity in common with the present representations. Currently I-Help user models contain: a quantitative measure of knowledge levels in the various domain areas; a quantitative indication of helpfulness; a quantitative measure of eagerness; a list of friends; a list of banned people; identification of cognitive style; a list of preferred interaction types. The additional information proposed above comprises: a list of roles successfully performed previously (to be added by the individual); the current role of the student (also added by the individual); a list of group membership (provided by one group member); a list of group skills (based on group evaluation, the result of which is entered by one group member). Thus minimal extensions could provide essential support to learners having difficulties in PBL. Provision of this information by students should also encourage them to think about factors that help to make group interaction successful.

Figure 2 illustrates how I-Help can support learners in a PBL setting. Students and peers provide student model information as occurs in large group uses. I-Help also performs some user modelling as described previously. The main difference with I-Help in PBL is that interactions for each group are focussed primarily around public discussions, with each person communicating with other members of their own group. There is less use of the private discussions. Where private discussions do occur, matching takes place according to the student models of individuals in the manner described in section 3. In addition to individual models, in PBL group models are required in order that groups may also be brought together where difficulties are recognised by the group as a whole. Information for the group model is obtained from one of the group members.

5 Conclusions

I-Help was initially designed to promote peer help amongst a group of learners in a large class situation. Some minor extensions to the system were suggested, to enable it to be effective also for students in PBL. Despite many successes claimed for this kind of collaborative interaction, not all students will function at their best with this type of curriculum. In this paper we focussed on PBL in medical education, but the arguments should be equally applicable to other academic disciplines and small group contexts, as long as the overall student numbers are large enough to enable sufficient choices of appropriate partners for cross-group interaction.

In addition to large and small group formal educational settings, I-Help might also be used beyond the classroom to support medical practitioners. For example, while some contexts have adequate funds to implement elaborate means of telemedicine (e.g. the U.S. Army [1]), remote areas which might benefit from access to various forms of telemedicine often find that the low population density does not provide sufficient demand to justify the expenditure required [25]. In rural locations a system like I-Help would provide a low cost means of obtaining expert help at least for some cases. Furthermore, practitioners requesting assistance do not themselves need to know who is the best person to contact. Similarly, I-Help might be useful in putting into contact physicians who

BEST COPY AVAILABLE

would like to hear experiences of other practitioners. For example, where ethical considerations are important to a case, such as conflicts between medical advice and parental beliefs [7]. I-Help might also be used alongside diagnostic decision support systems in cases where physicians remain unsure about hypotheses, since the advice offered by such systems may sometimes be misleading [9]. Experience with I-Help at university should encourage more individuals to register once they graduate and specialise.

Acknowledgements

This work is funded by the Canadian Telelearning Network of Centers of Excellence, Project 6.28. We thank the ARIES Lab members, in particular: G. McCalla, J. Vassileva, R. Deters, J. Cooke, L. Kettel and J. Bowes.

References

[1] Berry, F.C. "Telemedicine and the army", ARMY Magazine, April 1996.

[2] Block, K.J. "Problem-Based Learning in Medical Education: Issues for Health Sciences Libraries and Librarians", Katharine Sharp Review 5, 1997.

[3] Bowes, J. "Knowledge Management through Data Mining in Discussion Forums", MSc Thesis, Department of Computer Science, University of Saskatchewan, 2000.

[4] Bull, S. "A Multiple Student and User Modelling System for Peer Interaction", in R. Schäfer & M. Bauer (eds) 5 GI-Workshop, Adaptivität und Benutzermodellierung in interaktiven Softwaresystemen, Universität des Saarlandes, 61-7, 1997. On-line proceedings: http://w5.cs.uni-sb.de/~abis97/proceedings/

[5] Cameron, T., Barrows, H.S. & Crooks, S.M. "Distributed Problem-Based Learning at Southern Illinois University School of Medicine", in C. Hoadley & J. Roschelle (eds), Computer Support for Collaborative Learning, Stanford University/unext.com, 86-93, 1999.

[6] Camp, G. "Problem-Based Learning: A Paradigm Shift or a Passing Fad?", Medical Education Online 1(2), http://www.med-ed-online.org/ , 1996.

[7] Coward, H. & Hartrick, G. "Perspectives on Health and Cultural Pluralism: Ethics in Health Care Education", Workshop on Cognitive and Social Science Foundation for Medical Education and Training in the Information Age, Dunsmuir Lodge, Victoria, 2000.

[8] Deretchin, L.F., Yeoman, L.C. & Seidel, C.L. "Student Information Resource Utilization in Problem-Based Learning", Medical Education Online 4(7), http://www.med-ed-online.org/ , 1998.

[9] Friedman, C.P., Elstein, A.S., Wolf, F.M., Murphy, G.C., Franz, T.M., Heckerling, P.S., Fine, P.L., Miller, T.M. & Abraham, V. "Enhancement of Clinicians' Diagnostic Reasoning by Computer-Based Consultation", Journal of American Medical Association 282(19), 1851-1856, 1999.

[10] Gillespie, R.S. "Problem-Based Learning Redefines Medical Education", IMpact (Summer), American College of Physicians, 1995.

[11] Greer, J. & Bull, S. "Computer Support for Collaboration in Medical Education", Clinical and Investigative Medicine, in press.

[12] Greer, J., McCalla, G. Cooke, J., Collins, J., Kumar, V., Bishop, A. & Vassileva, J. "The Intelligent Helpdesk: Supporting Peer Help in a University Course", in B.P. Goettl, H.M. Halff, C.L. Redfield & V.J. Shute (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 494-503, 1998.

[13] Hmelo, C.E., Gotterer, G.S. & Bransford, J.D. "A Theory-Driven Approach to Assessing the Cognitive Effects of PBL", Instructional Science 25, 387-408, 1997.

[14] Hoppe, H.U. "The Use of Multiple Student Modeling to Parameterize Group Learning", in J. Greer (ed), Proceedings of World Conference on Artificial Intelligence in Education, AACE, Charlottesville VA, 1995.

[15] Kamin, C.S., Deterding, R.D., Wilson, B., Armacost, M. & Breedon, T. "The Development of a Collaborative Distance Learning Program to Facilitate Pediatric Problem-Based Learning", Medical Education Online 4(2), http://www.med-ed-online.org/ , 1999.

[16] Koschmann, T.D., Kelson, A.C., Feltovich, P.J. & Barrows, H.S. "Computer-Supported Problem-Based Learning", in T.D. Koschmann (ed) CSCL: Theory and Practice of an Emerging Paradigm, Lawrence Erlbaum Associates, Hillsdale, NJ, 1996.

[17] Koschmann, T. & Stahl, G. "Learning Issues in Problem-Based Learning", Panel at CSCW'98, 1998. http://www.cs.colorado.edu/~public.conferences/1998/cscw98/cscw_workshop.html

[18] Lee, R.M.K.W. & Kwan, C-Y. "The Use of Problem-Based Learning in Medical Education", http://www-fhs.mcmaster.ca/mdprog/pblart.htm , 1999.

[19] Lum, C., Cox, R., Kilgour, J., Morris, J. & Tobin, R. "PATSy: A Multimedia Distributed Web-Based Resource for Aphasiologists in Research and Education", Aphasiology 13(7), 573-579, 1999.

[20] McCalla, G., Vassileva, J., Greer, J. & Bull, S. "Active Learner Modelling", in G. Gauthier, C. Frasson & K. VanLehn (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 53-62, 2000.

[21] Newble, D.I. & Hejka, E.J. "Approaches to Learning of Medical Students and Practising Physicians: some empirical evidence and its implications for medical education", Educational Psychology 11(3-4), 1991.

[22] Ogata, H., Sueda, T., Furugori, N. & Yano, Y. "Augmenting Collaboration Beyond Classrooms through Online Social Networks", in G. Cumming, T. Okamoto & L. Gomez (eds), Advanced Research in Computers and Communications in Education, ICCE '99, IOS Press, Amsterdam, 277-284, 1999.

[23] Patel, V.L. & Groen, G.J. "Reasoning and Instruction in Medical Curricula", Cognition and Instruction 10(4), 335-378, 1993.

[24] Peterson, M. "Skills to Enhance Problem-Based Learning", Medical Education Online 2(3), http://www.med-ed-online.org/ , 1997.

[25] Puskin, D.S., Mintzer, C.L. & Wasem, C. "Telemedicine: Building Rural Systems for Today and Tomorrow", in P.F. Brennan, S.J. Schneider & E. Tornquist (eds), Information Networks for Community Health, Springer, New York, 1997.

[26] Riding, R. & Cheema, I. "Cognitive Styles–an Overview and Integration", Educational Psychology 11(3-4), 193-215, 1991.

[27] Spencer, J.A. & Jordan, R.K. "Learner Centred Approaches in Medical Education", British Medical Journal 318, 1280-1283, 1999.

[28] Vassileva, J., Greer, J., McCalla, G., Deters, R., Zapata, D., Mudgal, C. & Grant, S. "A Multi-Agent Design of a Peer-Help Environment", in S.P. Lajoie & M. Vivet (eds), Artificial Intelligence in Education, IOS Press, Amsterdam, 38-45, 1999.

[29] Wilson, B.G. & Cole, P. "Cognitive Teaching Models", in D.H. Jonassen (ed), Handbook of Research in Instructional Technology, Scholastic Press, New York, 1996.

[30] Woods, D.R. "Problem-Based Learning: Helping your Students Gain the Most from PBL", McMaster University, 1996.

[31] Yu, Y-T., Shan, H-L., Chou, C-Y. & Chan, T-W. "WWW-Based Mentoring System", in Z. Halim, T. Ottman & Z. Razak (eds), Proceedings of ICCE, AACE, 381-389, 1997.

Promoting Student Learning and Development in Computer-Based Cooperative Learning[1]

Fu-Yun Yu
Graduate Institute of Education
National Cheng-Kung University
No. 1, Ta-Hseuh Rd., 701, Tainan, Taiwan, R. O. C.
Tel: +886-6-275-7575 ext. 66225
Fax: +886-6-276-6563
E-mail: fuyun@mail.ncku.edu.tw

The purpose of this study was to determine the impacts of different types of external contingency built within computer-based cooperative learning on student learning outcomes, and to further investigate whether various cooperative strategies produced discernible efficacy for male or female students. A 3X2 factorial design involving nine intact classes was adopted. In total 341 fifth-graders in Tainan City constituted the sample. Participants randomly assigned in dyads worked through three originally developed computer-based science programs for three consecutive weeks. Posttests and a post-session self-report questionnaire were used for data collection. Results indicated that students in cooperation with inter-group competition condition performed significantly better on posttests than students in cooperation without inter-group competition or cooperation with inter-group cooperation condition. Results also revealed that inter-group competition enhanced student attitude toward the subject matter studied better than the other two goal orientation structures. The results of this study, however, failed to show that inter-group competition within cooperation negatively influenced peer relations, and that the more pervasive the cooperation, the greater the interpersonal attraction. Lastly, females performed significantly better their males in academic achievement, and perceived their peers more positively than males. Based on the results yielded from the present study, it was suggested that embedding inter-group competition within computer-based cooperative learning situation might be an effective alternative instructional strategies to adopt so as to maximize performance and affect without sacrificing social benefits of cooperation.

Keywords: **Cooperative learning, Computer-based instruction, Competition, Learning outcomes.**

1 Introduction

The topic of how to group students to work together effectively and efficiently has been under heavy investigation in the past decades. Research findings tend to support the use of cooperative learning, as compared to competitive, or individualistic instructional methods [2, 10, 12, 15, 18, 19, 22]. Since then, several cooperative learning models have been developed and used by researchers and practitioners in an attempt to maximize student learning with the support of peers. The models vary in a number of respects. One of the dimensions in which the models vary lies in whether they embed the element of competition in their cooperative learning structures.

[1] The study was partly supported by National Science Council of the Republic of China (NSC 88-2520-S-006-001)

Competition has been suggested as one effective alternative to increase the motivational appeal of initially uninteresting, or overly simple educational activities, and as a way to foster learner involvement and excitement in the activity [17, 25, 26]. Adding an element of competition between individuals or groups is widely believed to be a motivational-enrichment strategy in play, work, and education [3, 4, 17]. Commonly held opinions aside, several researchers have examined the effects of cooperation with versus without inter-group competition on educational outcomes. Some have found that positive effects for achievement, motivation and/or interpersonal relationships when competition was not implemented within cooperative learning environments [5, 6, 8, 11, 16, 24, 27], whereas others have reported the opposite or that cooperation with and without inter-group competition was equally effective [6, 16, 20, 25, 28]. As the evidence is limited and mixed, at best, and the majority of existing research on this area were done in traditional classrooms with Non-Asian Students; thus, one main focus of the present study was to test whether embedding an external contingency of the element of inter-group competition into computer-based cooperative learning would promote student learning and development.

In addition, based on their 1986 findings on interpersonal relationships, Johnson, Johnson, Warring, and Maruyama leaned toward the position that the more pervasive the cooperation, the greater the interpersonal attraction. Therefore, the author was interesting in finding out "would increasing widespread peer interaction and tutoring among all learning groups via establishing an external contingency of the element of inter-group cooperation within cooperative learning enhance student cognitive and affective outcomes as well." Hence, a second focus of the present study was to investigate the impacts of cooperation with inter-group cooperation on student learning outcomes as compared to cooperation with inter-group competition versus cooperation without inter-group competition condition.

Finally, as competitive learning has been reported to have an especially negative impact on female student achievement and attitudes toward the subject area being studied [12, 13], any interaction effects gender differences might have with different treatment conditions were also examined in the present study. In summary, the study intended to examine the effects of gender difference and different types of external contingencies introduced within computer-based cooperative learning on student academic achievement, attitudes and interpersonal relationships.

2 Method

2.1 Design and Participants

A 3x2 factorial design was used for this study, with learning strategies (cooperative with inter-group competition, cooperative without inter-group competition, cooperative with inter-group cooperation) and gender (male versus female) as the independent variables. The dependent variables were performance, attitude toward the subject studied (i.e., science), and interpersonal relationships both among and within the dyads.

Due to scheduling and other administrative problems, nine classes (N=341) randomly selected from one elementary school in Tainan were randomly assigned to different treatment conditions. All subjects were attending a weekly 40-minute computer literacy class and were being taught basic computer skills such as word processing, graphics and Internet surfing at the time of the study.
In all treatment conditions, students were randomly assigned to groups of two to work on computers. In the study, students participated in three instructional sessions in three consecutive weeks. The first session was essentially a training session on cooperative learning techniques aiming to help prepare all participants to work cooperatively with dyads on computers and be familiarized with navigating buttons and tools in the modules.

2.2 Materials

Three computer-assisted instructional modules on science topics were developed for the study. The first module dealt with "Recycling and Its Impacts on Environments." The second module dealt with "Seed Structure and Germination." The third module dealt with "Movements of the Earth and Four Seasons." All the modules were field tested prior to the actual study with a small group of fifth graders ranging from high to low computer and academic abilities. Revisions were made accordingly to ensure clarity for subjects and ease of navigation.

2.3 Experimental Treatment and Procedures

All treatment conditions incorporated essential cooperative elements, such as, positive inter-dependence, face-to-face interaction, and individual accountability [9, 21]. Positive interdependence was established by averaging dyads' scores on posttests. Face-to-face interaction was promoted by instructing dyads to discuss information and their responses to practice items. Individual accountability was established by having each member of a dyad independently complete the posttests upon completion of the second and third module. Conditions for different treatment conditions were set up as follows.

In the cooperation with inter-group competition condition (Treatment A), the component of competition was intentionally introduced, and emphasis was placed on which groups would achieve the top three highest scores on the posttests in the class. Students in different teams were instructed to work cooperatively with their dyads to ensure that everyone on the same team understood and learned the material presented by the computer, while, at the same time, competing against other teams in the class to be among the top three highest scoring teams based on the posttest score. The members of the final winning teams would all receive a "surprise prize" at the end of the session. To further emphasize the competitive nature of the learning situation, posters with words like "Be the best" were placed around the computer lab.

In the cooperation without inter-group competition condition (Treatment B), no element of competition was introduced in the learning process, and emphasis was placed on how well the learning group would achieve on the posttests using a fixed standard of performance for excellence. The student dyads were encouraged to share information and ideas with their dyads to master the assigned contents so as to reach the excellence level. Dyads' average score on the posttests being at least eighty points (i.e., answering at least sixteen out of twenty test items correctly) was the standard for excellence for this treatment condition. If the learning group would score at an average of at least eighty points based on the average of the posttests, each member of the dyad would receive a "surprise prize" after completion of the experiment. To further emphasize the cooperative nature of the learning situation, posters with words like "Work cooperatively with your teammate to reach the excellent level of performance" were placed around the computer lab.

In the cooperation with inter-group cooperation condition (Treatment C), emphasis was placed on how well the entire class would achieve. Like the cooperation without inter-group competition condition, no element of competition was introduced in the learning process, and a fixed standard of performance for excellence was introduced. However, the entire class scores, not mere the individual dyad's scores on the posttests, were used as the basis for determining whether the excellence level of performance was reached. An average score on the posttests being at least seventy points (i.e., answering at least fourteen out of twenty test items correctly) was the standard for excellence for this treatment condition. If the entire class scored at an average of at least seventy points based on the average of the posttests, the entire class would receive a "surprise prize" after completion of the experiment. To further emphasize the cooperative nature of the learning situation, posters with words like "Work cooperatively to reach the excellent level of performance" were placed around the computer lab.

An instructor's guide including complete oral script as well as an orientation training program was provided to two implementers to ensure experimental fidelity before initiating the treatments in the classroom. Moreover, a pilot study was conducted prior to this study to determine whether the experimental procedures and measurement instruments were reliable and appropriate.

2.4 Criterion Measures

Two 20-item, multiple-choice written posttests and a 38–item post-session self-report questionnaire with established reliability and validity were used to test the differential effects of the three treatment conditions on student academic achievement, attitudes and interpersonal relationships.

2.5 Data Analysis

Data were analyzed using the 3x2 analysis of variance technique (ANOVA) on each of the dependent variables. Scheffé multiple comparison tests were conducted when a univariate test indicated a significant main effect for different learning strategies. Alpha was set at .05 for all statistical tests.

3 Results

3.1 Performance

Based on the data analysis conducted on posttest scores, the study found a significant main effect for type of cooperative learning strategy, $F(2,310)=7.726$, $p<.001$, and gender, $F(1,310)=12.213$, $p<.001$. ANOVA did not reveal an interaction between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition ($M=55.5446$) performed significantly better on posttests than those assigned to cooperation without inter-group competition ($M=47.5227$) and those assigned to cooperation with inter-group cooperation ($M=49.0714$).

3.2 Attitude Toward Science

According to the data analysis conducted on attitudes toward science, the study found a significant main effect for types of cooperative learning strategy, $F(2,319)=12.283$, $p<.001$. ANOVA did not reveal an effect for gender or an interaction between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition ($M=49.0392$) rated more favorably toward science than those assigned to cooperation without inter-group competition ($M=44.4414$) and those assigned to cooperation with inter-group cooperation ($M=41.2054$).

3.3 Interpersonal Relationships

Data analysis done on subject perception toward their own dyad revealed a significant main effect for gender, $F(1,314)=15.576$, $p<.001$. ANOVA did not reveal an effect for type of learning strategy or an interaction between learning strategy and gender.

Finally data analysis on subject perception toward other dyads yielded a significant main effect for type of learning strategy, $F(2, 314)=4.018$, $p<.05$, and gender, $F(1, 314)=35.751$, $p<.001$. ANOVA did not reveal an interaction effect between learning strategy and gender. Scheffé multiple comparison tests revealed that subjects assigned to cooperation with inter-group competition ($M=40.4700$) perceived other dyads more positively than those assigned to cooperation with inter-group cooperation ($M=37.5804$).

4 Discussion

Results of the study indicated that students assigned to the cooperation with inter-group competition condition performed significantly better on posttests than students assigned to the cooperation without inter-group competition or cooperation with inter-group cooperation conditions. In addition, results of the current study also revealed that different types of external contingency built within cooperative learning had a significant influence on subject attitude toward science. Subjects that received cooperation with inter-group competition reported significantly more positive ratings toward the subject matter studied (i.e., science) than those in the other two treatment conditions. The beneficial effects of inter-group competition within computer-based cooperative learning on participant performance and attitudes found in the present study corroborated with other studies with different types of learning tasks and subjects ranging from college students to high school students to elementary students [6, 16, 20, 25, 28].

While learning strategy influenced significantly subject performance and attitudes in this study, it did not have a significant impact on student perception toward their own dyads. The non-significant results of this study provided empirical evidence for Bossert's 1989 argument that cooperation with inter-group competition maximizes performance without sacrificing social benefits of cooperation [1].
Furthermore, subjects in the cooperation with inter-group cooperation condition scored significantly lower on posttests, attitudes toward science and perception toward other dyads than subjects in the cooperation with inter-group competition and/or cooperation without inter-group competition conditions. The obtained result was somewhat surprising, especially in light of Johnson et al. 1986 study that indicated, "the more pervasive the cooperation, the greater the interpersonal attraction" [14]. The results of this study did not support the work of other researchers who reported that inter-group cooperation was better for performance and/or interpersonal relationship among the learning groups [7, 14, 23]. The decreased academic, attitudinal and social gains might be explained through direct observation. Observation noted that dyads interacted mostly with their partners during the instructional sessions and rarely cared for comments or

suggestions from other dyads. To attain their personal goal, dyads in the cooperation with inter-group cooperation not only needed to assist their own dyads to excel, but also was held accountable for other dyads in the class. This kind of arrangement, for most participants, was "too much of a task" that they never exposed to before, as aired informally during class sessions.

Though encouraging widespread peer interaction and tutoring among all learning groups via adding an extra element of inter-group cooperation into cooperation situation, theoretically speaking, might have a positive effect on student learning, it did not enhance participant cognitive, affective and social gains in the present study. Contrary to the researcher's expectation, inter-group cooperation negatively influenced participant performance, attitudes and perception toward other dyads. It was possible that longer experimental period might allow participants to get accustomed to this kind of arrangement so as to benefit from constructive interactions among the learning groups.

Lastly, the current study found that females outperformed males and perceived their classmates more favorably in all treatment conditions. The obtained results that the inclusion of inter-group competition within cooperation did not negatively influence females' cognitive and social gains in this study was understandable considering the fact that all treatment conditions of the study emphasized the importance of "cooperative behaviors." The potential negative effects that competition might have on females' learning and development might be somewhat mitigated by cooperative encounters cultivated continuously within the learning groups in all treatment conditions.

5 Conclusions

In the present study, competition within computer-based cooperative learning environments was found to maximize performance and affect without sacrificing social gains. Based on the results yielded from the present study, it was suggested that embedding inter-group competition within computer-based cooperative learning situation might be an effective alternative instructional strategies to adopt. There are, however, several limitations on the interpretation and generalization of the results of this study. Firstly, because it was implemented in a naturalistic classroom setting, it was not possible to randomly assign individual subjects to different treatment conditions. Though at the beginning of the first, third and fifth year of the participating school all subjects were re-assigned to different classes to make every class comparable to each other, classroom differences might have confounded the study's findings.

Secondly, the restrictions of time only allowed students in the selected school to participate in three instructional sessions for the study. The time constraints might not have allowed the full influence of cooperation with inter-group cooperation to manifest its beneficial effects on student learning and development.

In spite of this study's limitation, it provided practical information regarding the efficacy of different type of external contingencies within computer-based cooperative learning situations. Future studies employing longer periods of experiment time and random assignment of subjects into different treatment conditions may be desirable. Finally, as the present study tested mainly recall and memorization in science-related topics and employed only fifth-graders, studies involving different types of measures, content areas as well as populations may be needed to warrant wider generalization.

References

[1] Bossert, S. T., "Cooperative activities in the classroom", Review of Research in Education, Vol. 15, pp. 225-250, (1989).

[2] Dalton, D., Hannafin, M. & Hooper, S., "Effects of Individual and cooperative computer-assisted instruction on student performance and attitudes", Educational Technology Research and Development, Vol. 37, No. 2, pp. 15-24, (1987).

[3] Deci, E. L., Betley, G., Kahle, J., Abrams, L. & Porac, J., "When trying to win: competition and intrinsic motivation", Personality and Social Psychology Bulletin, Vol. 7, pp. 79-83, (1981).

[4] Deci, E. L., Vallerand, R. J., Pelletier, L. G. & Ryan, R. M., "Motivation and education: the self-determination perspective", Educational Psychologist, Vol. 26, No. 3&4, pp. 325-346, (1991).

[5] Dunn, R. E. & Goldman, M., "Competition and non-competition in relationship to satisfaction and

feelings toward own-group and nongroup members", Journal of Social Psychology, Vol. 68, pp. 299-311, (1966).

[6] Garibaldi, A. M., "Cooperation, competition and locus of control in afro-American students", Unpublished doctoral dissertation, The University of Minnesota, MN, US, (1976).

[7] Goldman, M., Stockbauer, J. W. & McAuliffe, T. G., "Intergroup and intragroup competition and cooperation", Journal of Experimental Social Psychology, Vol. 13, pp. 81-88, (1977).

[8] Hammond, L. K. & Goldman, M., "Competition and non-competition and its relationship to individual and group productivity", Sociometry, Vol. 24, pp. 46-60, (1961).

[9] Johnson, D. W. & Johnson, R. T., "Cooperation and competition: Theory and research", Edina, MN: Interaction Book Company, (1989).

[10] Johnson, D. W. & Johnson, R. T., "Computer-assisted cooperative learning", Education Technology, Vol. 26, No. 1, pp. 12-18, (1986).

[11] Johnson, D. W., Johnson, R. T. & Maruyama, G., "Interdependence and interpersonal attraction among heterogeneous and homogeneous individuals: a theoretical formulation and a meta-analysis of the research", Review of Educational Research, Vol. 53, pp. 5-54, (1983).

[12] Johnson, R. T., Johnson, D. W. & Stanne, M. B., "Comparison of computer-assisted cooperative, competitive, and individualistic learning", American Educational Research Journal, Vol. 23, No. 3, pp. 382-392, (1986).

[13] Johnson, R. T., Johnson, D. W. & Stanne, M. B., "Effects of cooperative, competitive, and individualistic goal structures on computer-assisted instruction", Journal of Educational Psychology, Vol. 77, No. 6, pp. 668-677, (1985).

[14] Johnson, D. W., Johnson, R. T., Warring, D. & Maruyama, G., "Different cooperative learning procedures and cross-handicap relationships", Exceptional Children, Vol. 53, No. 3, pp. 247-252, (1986).

[15] Johnson, D. W., Maruyama, G., Johnson, R. T.. Nelson, D. & Skon, L., "Effects of cooperative, competitive and individualistic goal structures on achievement: a meta-analysis", Psychological Bulletin, Vol. 89, pp. 47-62, (1981).

[16] Julian, J., and Perry, F., "Cooperation contrasted with intra-group and inter-group competition", Sociometry, Vol. 30, pp.79-90, (1967).

[17] Malone, T. W. & Lepper, M. R., "Making learning fun: a taxonomy of intrinsic motivations for learning", Aptitude, learning, and instruction (Vol. 3): Cognitive and affective process analyses, Hillsdale, NJ: Erlbaum, (1987).

[18] Nastasi, B. K. & Clements, D. H., "Research on cooperative learning: implications for practice", School Psychology Review, Vol. 20, No. 1, pp. 110-131, (1991).

[19] Rysavy, S. M. & Sales, G. C., "Cooperative learning in computer-based instruction", Educational Technology Research and Development, Vol. 39, No. 2, pp. 70-79, (1991).

[20] Shaw, M. E., "Some motivational factors in cooperation and competition", Journal of Personality, Vol. 26, pp. 155-169, (1958).

[21] Slavin, R. E., "Student team learning: Theory, research, and practice", Englewood Cliffs, NJ: Prentice Hall, (1991).

[22] Theodore, S., "What do we really know about small group CBT?", Proceedings of the 33rd Annual Conference of the Association for the Development of Computer-Based Instructional Systems, St. Louis, MO, pp.11-44, (1991).

[23] Warring, D. Johnson, D. W., Maruyama, G. & Johnson, R., "Impact of different types of cooperative learning on cross-ethnic and cross-sex relationships", Journal of Educational Psychology, Vol. 77, pp. 53-59, (1985).

[24] Weigel, R. H., Wiser, P. L. & Cook. S. W., "The impact of cooperative learning experiences on cross-ethnic relations and attitude", Journal of Social Issues, Vol. 31, No. 1, pp. 219-244, (1975).

[25] Whittemore, I. C., "The influence of competition on performance: an experimental study", Journal of Abnormal and social Psychology, Vol. 19, pp. 236-253, (1924).

[26] Wynne, E. A., "Cooperation-competition: An instructional strategy", Bloomington, IN.: Phi Delta Kappa Educational Foundation, (1995).

[27] Yu, F. Y., "Competition or non-competition: its impact in interpersonal relationships in a computer-assisted learning environment", Journal of Educational Technology Systems, Vol. 25, No. 1, pp. 13-24, (1996-97).

[28] Yu, F. Y., "The effects of cooperation with inter-group competition on performance and attitudes in a computer-assisted science instruction", Journal of Computers in Mathematics and Science Teaching, Vol. 17, No. 4, pp. 381-395, (1998).

Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

Kyoko Umeda*, Takami Yasuda and Shigeki Yokoi***
**Graduate School of Human Informatics Nagoya University,*
***School of Informatics and Sciences Nagoya University*
Furo-cho Chikusa-ku Nagoya-City 4648601 Japan
umeda@info.human.nagoya-u.ac.jp

The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even if they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can collectively work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

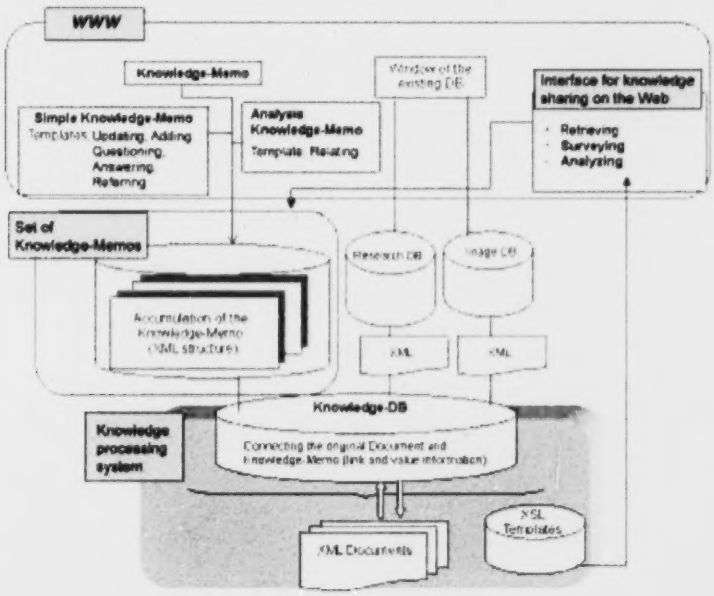


Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re-analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2• Collection and accumulation of Knowledge-Memo

BEST COPY AVAILABLE

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used:• •<key> for keywords, • <hi> for highlights, •
 for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

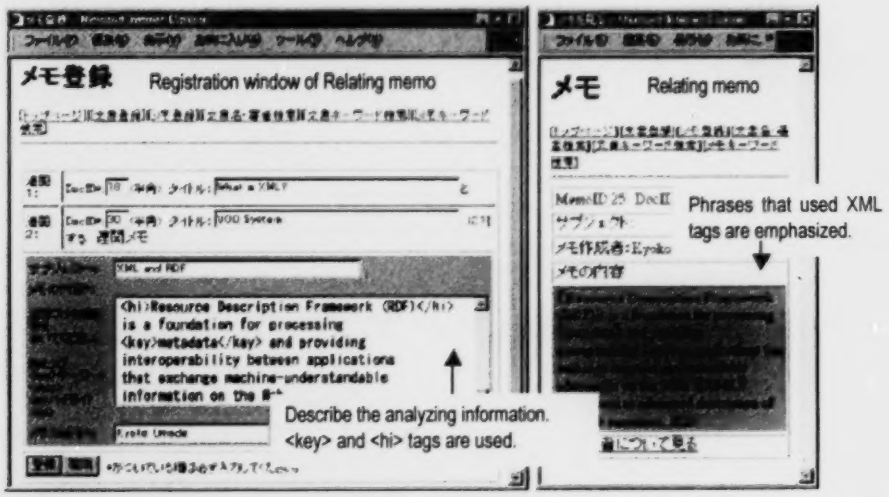


Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage

BEST COPY AVAILABLE

information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

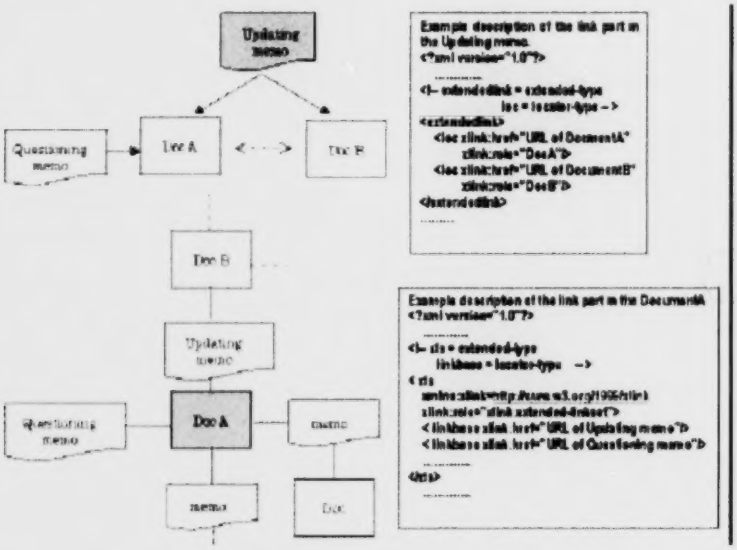


Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. It can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

BEST COPY AVAILABLE

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memo randums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities. .

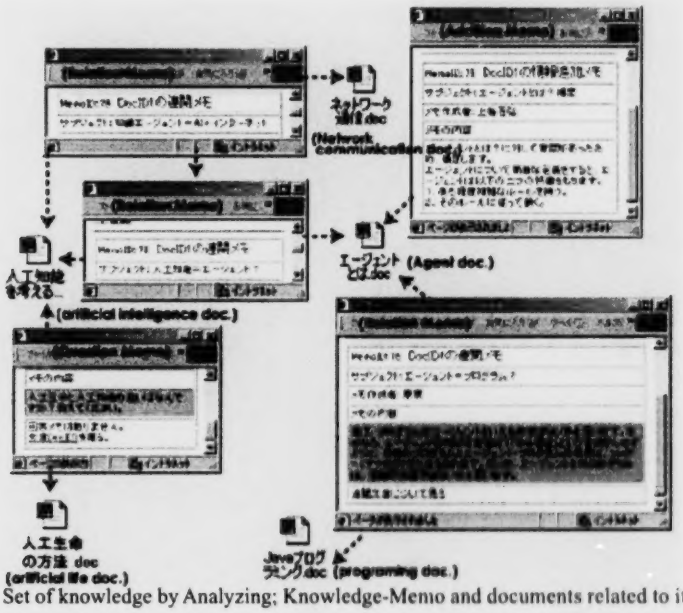


Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memo randums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A's report. . He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

BEST COPY AVAILABLE

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.

(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.

(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.

(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;

- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.

(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.

(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.

(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

References

[1] D.K. O' Neill, L.M. Gomez, "The Collaboratory Notebook: a Networked Knowledge-Building Environment for Project Learning", Proc. of Ed-Media 94, pp.416-423 (1994)

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano, "Knowledge Awareness Map fro Open-ended and Collaborative Learning on World Wide Web", Proc. of ICCE99, pp319-326 (1999)

[3] I. Nonaka, "The Knowledge-Creating Company", Harvard Business Review, November-December1991, pp96-104 (1991)

[4] J. Oshima, "Students' Construction of Scientific Explanations in a Collaborative Hyper-Media Learning Environment", Proc. of CSCL97, pp187-197 (1997)

[5] N. Pitts-Moults, C. Kirk, "XML Black Book", The Coriolis Group. Inc. (1999)

[6] P. Bell, E.A. Davis, M.C. Linn, "The Knowledge Integration Environment: Theory and Design", Proc. of CSCL95 (1995)

[7] S. Puntambekar, "An integrated approach to individual and collaborative learning in a web-based learning environment", Proc. of CSCL 99, pp458-465 (1999)

[8] T.H. Davenport, "Integrating Knowledge Management into the Organization", Diamond Harvard Business, August-September 1999 pp26-36 (1999)

[9] Knowledge Forum 2.0, http://www.motion.com/lim/kf/KF1.html (accessed on August 1, 2000)

[10] XML Linking Language (XLink) Version 1.0, http://www.w3.org/TR/2000/CR-xlink-20000703/ (accessed on August 1, 2000)

rTable : A Collaborative Problem-solving Environment for Synchronous Discussion

Toshihisa Nishimori*, Jun Nakahara*, Yoshimasa Sugimoto*, Noriaki Urashima* and Keizo Nagaoka**

**Communication & Media Lab. Dept. of Advanced Human Sciences, Graduate school of Human Sciences, Osaka University.*

***National Institute of Multimedia Education*

**Address: 1-2, Yamadaoka, Suita, Osaka 565-0871, Japan*

E-mail: tosihisa@mmgate.hus.osaka-u.ac.jp

This paper describes a prototype of "rTable"(r means Round and Role) that supports collaborative problem solving through a synchronous group discussion. Firstly we take up two general problems concerned with organizing discussion. One is the difficulty to facilitate productive discussion. The other is the difficulty to promote all members' participation. And then two prior systems that support collaborative learning are reconsidered in terms of these problems. Secondly we explain our new design concept: "playing roles by turns", and describe a prototype of our system. In this system, users discuss a problem, taking four roles by turns and visualizing a flow of a discussion. The roles include *the chair* who presides a discussion, *the proposal* who formulates a topic, *the question* who makes first statement on a topic and *the summary* who arranges statements. These roles are expected to prompt users to argue and aim at directing them to equal participation. Results of the pretest show the system design of rTable has possibility of being a solution to two general problems in supporting collaborative problem solving.

Keywords: **collaborative problem-solving, synchronous discussion, role**

1 Introduction

Recently, in Japan, an educational reform has been carried out. "Period for Integrated Study" aims at helping children develop capability and ability to discover problems by themselves and solve those problems properly (Mombusho 1998). These activities are expected to achieve through various learning styles, group learning, cross-grade learning and so on. Thus it is important that learners cope with problem solving activities via discussion and dialogue with other people in the future education. However there are many difficulties to manage group discussion in educational setting. We have developed rTable that is a network-based learning environment to support synchronous discussion for collaborative problem solving. The purpose of this paper is to describe rTable design, functionality and its evaluation through pretest.

2 Problems

We focus on two of general problems in organizing group discussions. One is the difficulty to make group members focused on content-related dialogues and coherent subject matter discussion, and putted forward constructive argument. One of the reasons this problem arises from is a lack of rules that members share in respect of advance a discussion. Hesse and Hron (1999) found that the groups given the rules for discussion showed grater orientation to the subject matter and less off-task talk, compared with a control group.

The other problem is concerned with the equal participation of group members. Eichinger and Anderson (1991) pointed this problem out based on their analysis in the process of collaborative problem solving. In their observation, only the students who were already most skillful at constructing scientific argumentsgot substantial practice and feedback. They suggested that some kind of collaborative problem solving had in it the potential for continuing the inequities of the present system, in which students came to view and success in science as reserved primarily for articulate, intellectually aggressive boys. Therefore Eichinger and Anderson were concerned about finding ways to make sure that all students

could get benefits from their participation in the group problem solving (Eichinger and Anderson 1991).

Our system is aimed at trying to solve or reduce these two problems. In this paper, we begin with reconsidering two representative Computer Supported Collaborative Learning• CSCL• environments in terms of those problems.

3 The prior two representative CSCL systems

Collaboratory Notebook: The Collaboratory Notebook was created by the Learning Through Collaborative Visualization (Covis) Project. This system is a shared hypermedia database. It allows users to create a shared workspace called a notebook within that users create pages. Every page in a notebook is assigned a page type by its author(s). The eight page types include questions, conjectures, evidence for, evidence against, plans, and commentaries. The hypermedia links enable users to connect pages together according to the relationships between them. The genre defined by the page labels and links is designed to provide students with a framework for conducting and communicating about the inquiry process that encourages them to be systematic and reflective. It provides students with a structure for their activities designed to reduce their need to focus on the challenges of organization so that they may focus more on the content of their activities (Edelson, D. C. et al 1995).

SenseMaker: The SenseMaker is one software component of the Knowledge Integration Environment (KIE).• SenseMaker provides a spatial and categorical representation for a collection of Web-based evidence. The SenseMaker software allows small groups of students to organize and annotate a collection of evidence associated with a project that can then be shared with others. Within the software, students work with evidence dots representing individual pieces of evidence on the Web and claim frames corresponding to evidence. Claim frames can be interrelated by hierarchically nesting one inside of another. Students place evidence dots within the claims that they are interpreted as supporting (Bell, P. 1997).

Both the systems are based on the same method that users classify their own opinions or evidences for theory using common representations and categories that the systems provide. This way encourage users who have never established standards for discussion to exchange opinions each other and to make a productive discussion. So this method may solve or reduce the first problem, concerned with making members putted forward constructive argument. But with regard to the second problem, related to making members participated equally, and Collaboratory Notebook and SenseMaker systems are not likely to consider. This is illustrated by a fact that, in a study of Collaboratory Notebook use, there was reliable correlations between the number of different pages and answers of students to the question: "I enjoy classes in science." and between the connectedness of page in cluster or tree and the same answer (Edelsen, D. C. et al 1995). Besides, as far as synchronous discussions are concerned, it is desirable to accept member's off-task talks out of categories that systems provide them in a certain extent in order to promote vigorous discussions.

4 Playing roles by turns as an alternative design

We introduce the concept of *playing roles by turns* into development of supporting system for collaborative problem solving. We got the idea from "Question-Asking-Reading" procedure for learning to read. In this procedure, students play five roles by turns to read texts (Cole and Engestrom 1993). Although this procedure is aimed at acquiring full act of reading, it has also the potential that the procedure can facilitate the progress of discussion. Because giving a clear role to a student may facilitates participation of an activity, and taking turn may helps participating equally.

The rTable provides users 4 roles including *the chair, the proposal, the question* and *the summary*. Users cope with their problems in corporation playing roles by turns through discussions. The concept of *playing roles by turns* is expected to solve or reduce above those two problems. On the first problem, these four roles are related to the progress of a discussion work for constructing a productive one. And they don't restrict user's statements directly and strongly, so user can make statements without heavy loads. Regarding the second problem, because the roles are assigned in turns by system, all users are encouraged to participate in a discussion without staying on the same roles.

5 Prototype design and functionality

4 to 6 participants can discuss on rTable simultaneously. After log in the server, the names, roles and characters of participants are appeared on the left side of main window (see Figure 1.). There are a textbox into that a user types his/her statement and a history of statements on the bottom of the window. Discussion flows which participants make are

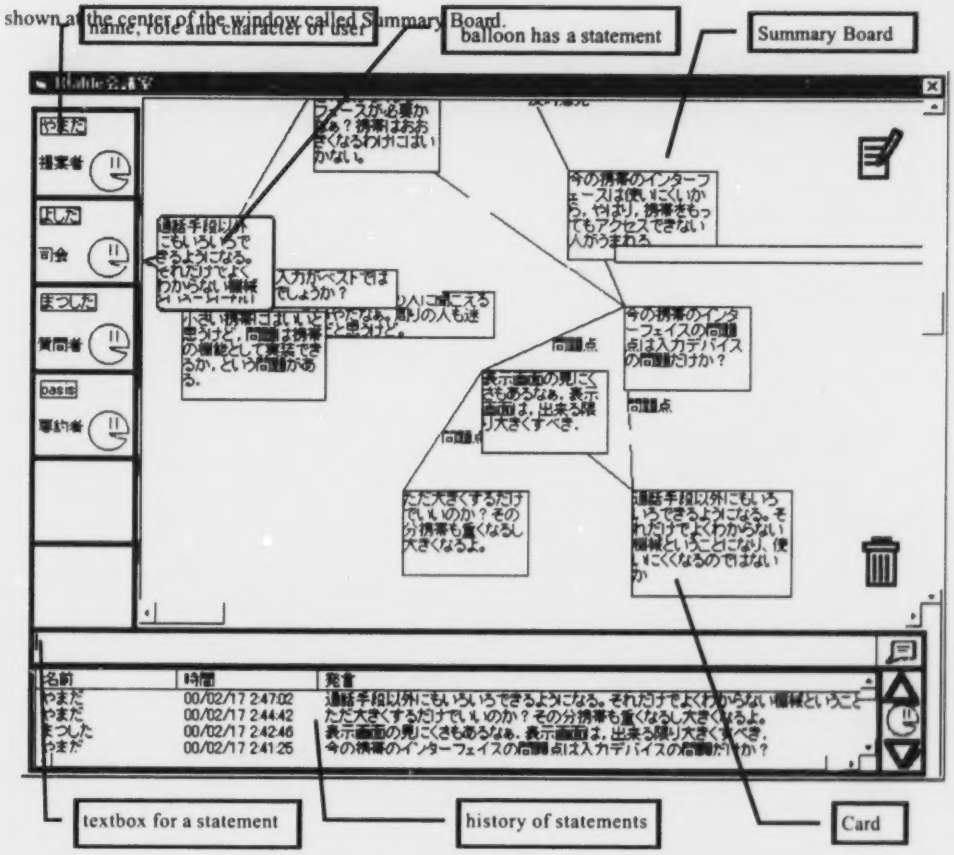


Figure1. Main window of the prototype

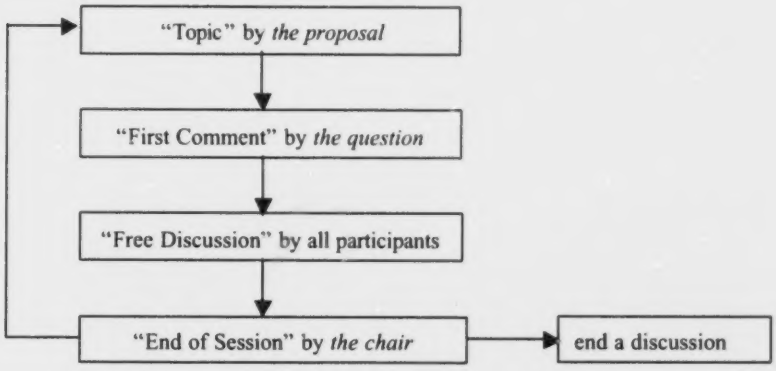


Figure 2. A Session

A discussion on rTable is divided into units of the Session shown at Figure 2. A Session consists of 4 steps. First step is "Topic" by *the proposal*. The second step is "First Comment" by *the question*. The third step is "Free Discussion" by all participants. The fourth step is "End of Session" by *the chair*. Four roles are assigned randomly and automatically by the system at the beginning of a session. But *the chair* switches his/her role to *the proposal* in the next session.

To put it concretely, in the first step "Topic", *the proposal* is required to formulate a topic that participants should discuss in this session. In the second step "First Comment", *the question* is required to give a comment firstly about the topic in order to start discussion. After that, all participants discuss freely in the third step "Free Discussion". *The chair* is required to preside at the discussion through a session. *The chair* can control a voice, so that he/she is able to nominate one to talk suitably. For clarifying a flow of discussion with visualization, *the summary* is required to pick up important statements• from discussion and place them on Summary Board. The participants except *the summary* are not able to write anything on Summary Board.

To write comments on Summary Board, *the summary* just clicks a balloon, which has a participant's statement, or clicks a statement in the column of the history of statements. And then a Card written the statement appears on Summary Board. *The summary* also makes links (every link has a tag that the summary write something on) to connect a Card with another Card, and makes labels to take notes. Summary Boards of all participants are synchronous, so participants can grasp the discussion flow by looking at them.

The chair needs to decide the end of a session referring the progress of discussion and the discussion flow with visualization. If *the chair* wants to finish the session and to change the topic, he/she is able to declare "End of Session". At the same time *the chair* is required to pick a Card that he/she considers as the source for next topic. If participants judge that there is no necessity to continue the discussion ahead, *the chair* can end the discussion. After *the chair* chooses a Card, the system giving users new roles, the new *proposal* who is the old *chair* is required to formulate a topic from the card. When a new topic is formulated, a Card written the topic is made automatically. Cards chosen as sources for next topics by *the chairs* and Cards written topics are colored.

6 Pretest

We report here our pretest to measure validity of the system design. In this pretest, one undergraduate and three graduate students used the prototype of rTable. The pretest has two objects. Firstly, we want to know whether the system can encourage users to participate discussions. Second is whether the roles restrict user's statements.

After we explained and demonstrated the usage of rTable to students, students discussed two subjects including a mathematical problem and a social problem for 80 minutes using rTable. There were 4 sessions. We analyzed the number of statements and user's answers to a questionnaire after discussion. The questionnaire included "Did you work on discussion freely?" "How far were you conscious of your roles?" and "Were you encouraged by playing roles in turns?"

Results: Table 1 shows the number of statements per person and per category of statement. "Task-focused" are statements related to the subject or the topics. "Off-task" are statements related to participant's state, feeling, and the like. For example, "Now, I' m thinking." and "It looks like difficult."

Table 1. The number of statements per participants and per category of statement

Persons		Category of statements	
A	42 (27.6%)	Task-focused	142(93.4%)
B	41 (26.9%)	Off-task	10(6.6%)
C	36 (23.7%)		
D	33 (21.7%)		
	152		152

Encouragement users to participation: The total number of statements is 152, and each participant wrote 27.6%, 26.9%, 23.7% and 21.7% of total statements respectively. There is not significant difference between persons (χ^2 (3) =1.42). Also almost user answered "Playing the chair or playing the summary promoted my participation." regarding the question, "Were you encouraged by playing roles in turns?" The fact that almost equal participation rate by each and high agreement rate regarding of "playing the chair or playing the summary promoted my participation" would support that the system promote user's participation toward the discussion equally in the pretest.

Restriction on statements : All users responded, " I was conscious of playing my roles". They alsoanswered, "I did so." or " I did a little." regarding the question, "Did you work on discussion freely?" There were 10 off-task statements that seemed to make the discussion relaxed. These suggest that assigned roles hardly restrict on making statements.

7 Conclusions

Therefore, we may say that the system design of rTable has possibility of being a solution to two general problems in supporting collaborative problem solving: facilitating productive discussion and promoting all members' participation. There are some complaints in operation of prototype reported by users. We will revise the prototype system, and evaluate it in educational setting.

References

[1] Bell, P. "Using argumentation representation to make thinking visible for individuals and group". Proceedings of CSCL'97, Toronto, Ontario, Canada, October 10-14, pp. 10-19, (1997)

[2] Cole, M. & Engestrom, Y., "A cultural-historical approach to distributed cognition", Salomon, G. (eds.) Distributed Cognitions, Cambridge University Press (1993).

[3] Edelson, D.C., O'Neil, D. K., Gomez, L. M., & D'Amico, L. "A design for effective support of inquiry and collaboration." Proceedings of CSCL'95, Bloomington, Indiana, USA, October 17-20, pp.107-111,(1995)

[4] Eichinger, D.C. & Anderson, C. W., "An Illustration of the role of content knowledge, scientific argument, and social norms in collaborative problem solving", Paper presented at the annual meeting of American Educational Research Association, Chicago, Illinois, April (1991).

[5] Hesse, F. W. & Hron, A., "Dialogue structuring in computer supported synchronous discussion groups", Advanced Research in Computers and Communications in Education Vol.1 (proceeding of ICCE99), Chiba, Japan, pp350-354, (1999).

[6] Mombusho (Ministry of Education, Science, Sports and Culture, Government of Japan), "National Curriculum Standards Reform for Kindergarten, Elementary School, Lower and Upper Secondary School and Schools for the Visually Disabled, the Hearing Impaired and the Otherwise Disabled (Synopsis of the Report) (1998).

Scientific revolutions and conceptual change in students: Results of a microgenetic process study

Benson M.H. Soong* **and Yam San Chee****
School of Computing, National University of Singapore
3, Science Drive 2, Singapore 117543
Tel: + 65-874-8090
Fax: 65-779-4580
**Email: soongmun@comp.nus.edu.sg*
***Email: cheeys@comp.nus.edu.sg*

A microgenetic process study of dyad learning was conducted with the objective of further understanding conceptual change as students learn. This paper describes the knowledge negotiation, co-construction, and problem-solving efforts between two student volunteers, both aged 15, in a computer-mediated-communication (CMC) environment. We illustrate protocols of the students' problem-solving processes, showing how the students manifested, expressed, defended, abandoned, conjectured, and eventually transformed their (mis)conceptions on various aspects of velocities and distances. In doing so, we address important questions raised about students, their concepts and (lack of) theories, and the types of conceptual change that take place as students learn. This paper provides empirical evidence to show that as long as students do not think in theoretical terms, conceptual change in students will be very different from scientific revolutions. It not only agrees with the theoretical shift to viewing *learning* as *conceptual change*; it also lends empirical evidence in support of this view.

Keywords: **Cognition and Conceptual Change, Collaborative Learning, and Knowledge Construction and Navigation**

1 Introduction

The study and understanding of conceptual change is a field that is significant to the research community [10]. An example of macro-level conceptual change is the paradigm shift [8] from the phlogiston theory to the oxygen theory (commonly dubbed the chemical revolution). There have been numerous attempts to compare and contrast between such scientific revolutions and conceptual change in children and students. For example, Carey [2] contends that the development of the concept *living thing* in a child is analogous to scientific revolution because her study shows that between the ages of 4 to 10, children undergo a cognitive restructuring of their *living thing* concept; this restructuring is tantamount to theory change (from an animist theory to a set of biological theories). On the other hand, Harris [5] argues that "children do not think in theoretical terms, but on the basis of working models or concrete paradigms that serve as a basis for predictions and explanation" (p.303). Given these two opposing viewpoints, it is natural for Thagard [21] to state:

> The questions remain: do children have theories, does conceptual change occur by replacement, and is theory replacement the result of considerations of explanatory coherence? An affirmative answer to each question is a precondition of an affirmative answer to the succeeding one. (p.256)

Before discussing whether conceptual change in students is as revolutionary as scientific revolution, we should be reminded that scientific revolution involves a paradigm shift from one theory (or theories) to another competing theory (or theories). At the risk of oversimplification, we define a theory to be a set of *explicit* and *well-coordinated* principles that yield *predictions* based on their *explanatory mechanisms*. Since

all "conceptual structures provide some fodder for explanation", "the distinction between theory-like structures and other types of cognitive structures is one of degree" [2, p.201]; theories embody deep explanatory notions.

Given the above, if students do not possess theories, not only is conceptual change in students fundamentally different from scientific revolution, but we must also offer negative answers to Thagard's questions.

2 Context of Study

This study describes how two student volunteers, Tim and Ming (both aged 15), engaged in meaningful knowledge negotiation and co-construction in a manner that allowed their conceptions and thought processes to be made overt for our analysis. Tim and Ming are schoolmates (but not classmates) in an academically average neighborhood secondary school. Both students have learnt physics in school for one year prior to this study and hence, are familiar with the terms velocity, acceleration, time, and distance. Prior to this, both students have not worked academically with each other.

Tim and Ming were placed in a large room that was partitioned in the middle. Each student occupied onepartition, and conversed with the other exclusively via a computer-mediated-communication (CMC) environment. The CMC environment consisted of a chatbox and whiteboard facility. The chatbox facility allowed the two students to converse via typed text, while the shared whiteboard allowed pictorial drawings and ideas to be depicted and discussed. Figure 1 shows a snapshot of this CMC environment, implemented via Microsoft NetMeeting™. Besides the standard furniture such as tables, chairs, and a computer, each partition housed two unmanned video cameras. The main data collection method comprised the video recordings of the students' interactions through the CMC environment. In each partition, a video camera was directed at the screen, capturing every interaction sequence performed on the computer, while the other video camera was directed at the student, capturing the student's physical gestures and reactions. To further aid the transcription process, both the shared chatbox and whiteboard were regularly "saved."

The questions that we posed to the students to solve were adaptations of the "Context Rich Problems" formulated by the Department of Physics, University of Minnesota (for more information, see http://www.physics.umn.edu/groups/physed/Research/CRP/crintro.html).

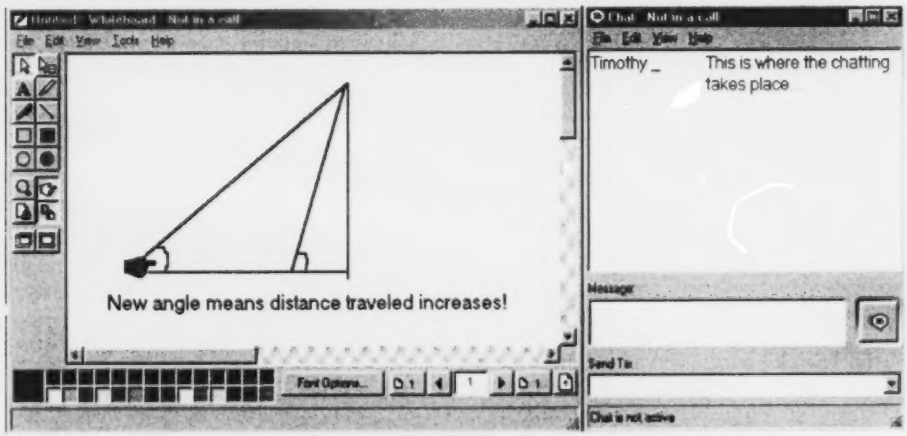


Figure 1: The CMC environment

3 Research Methodology

If we simply engage in endpoints analysis, we would not be able to understand conceptual change [10]. As such, we need to take into account the actual developmental process of conceptual change. A research methodology that focuses on microgenetic (developmental) processes is that of Ethnomethodology [4]. In short, ethnomethodology is interested in interaction sequences and requires that we focus on "participant categories" rather than "third person observer" perspectives [7]. It forces us to ask, "what questions can the data answer" rather than "what data do I need to answer these questions."

BEST COPY AVAILABLE

Since conversation analysis is the most productive and prolific form of analysis that has been developed with ethnomethodological concerns in mind [1], the protocol data obtained were transcribed into a log format, and then analyzed and annotated in accordance with the practices of conversation analysis (see also [6, 9, 12, 13, 17]). This was a time-consuming process as each tape had to be viewed and reviewed until the gaps in the data were resolved to the fullest extent possible.

4 Study Findings

In the following section, we illustrate portions of Tim and Ming's problem-solving processes through protocols collected in our study. Because this paper only presents portions of the protocols collected, see Soong [19] for full details. The question below details one of the problems attempted by Tim and Ming.

The cycling problem:

> You and your physics teacher are cheering your cyclist friends Alex and Bon who are taking part in a straight but uphill bicycle-racing contest. You and your teacher are watching the race from the side-lane just beside the racetrack, 132 meters away from the finish line. It so happened that both cyclists passed by in front of you at exactly the same point in time. Your teacher estimated Alex's velocity to be 12m/s and Bon's velocity to be 11m/s. Given your training sessions with Alex and Bon, you know that from this position, Alex will accelerate at the rate of $0.25 m/s^2$, while Bon will accelerate at the rate of $0.4 m/s^2$, for the next 10 seconds.
>
> - What is the final velocity of both cyclists at the end of that 10 seconds?
> - Who will reach the finish line first?

Comments in square brackets "[ ]" are remarks made by the author regarding the protocol statements. These comments aid understanding of the protocols by relaying contextual information not available to the reader. No attempts were made to correct the students' grammatical and spelling errors. Tim, Ming, and the author are represented by "T", "M", and "A" respectively.

```
4.    M: part a looks tha same as what we did in the last session
      [The first part of this question looks the same as what they previously attempted]
5.    T: yes....
6.    M: can we use that method?
  T: lets try
```

Both students drew structural similarity between Part A of this question and a question that they previously attempted. In that previous problem-solving session, T and M had agreed that "(acc. x acc. time) + initial velocity = final velocity". However, the reason they agreed on this formula was because "it's the only method where we could get the ans. so far". It is clear that the students lacked a conceptual understanding of the solution, but nonetheless that did not hinder them from solving the problem.

It is noteworthy that M referred to the problem-solving process as "that method", rather than "that theory" or even "that logic". It is clear that in this instance, the students did not think in theoretical terms. In fact, it was a mechanical application of the "method" that the students "did in the last session".

With this, the students worked collaboratively, using the formula *final velocity = (acceleration x acceleration time) + initial velocity*. They then obtained the (correct) solution that Alex's final velocity was 14.5 m/s while Bon's final velocity was 15 m/s.

```
11.   M: 12+2.5=14.5
12.   T: yes
13.   T: and bon = 11 + 4 = 15
17.   M: agree?
18.   T: yup
```

It was clear to both students that Bon was faster than Alex after the acceleration. However, both the students had the conception that an object with a higher final velocity travels further than one with a lower final velocity. This conception is true in some, but not all cases. This is a well-known misconception, and it has been documented extensively by Piaget [11], among others. In the context of our study, we will refer to this

as the "higher final velocity = winner" concept.

38. T: bon is faster after the acc.
39. M: yes
40. T: therefore if the speed be constant after the acc., bon would complete the race first
41. T: agreed?
44. M: agree.

Confident that their answer was correct, T checked their answer with the author, only to be informed that their answer was incorrect, since Alex will actually complete the race first. When T related this to M, he was surprised.

47. T: nope.....
48. T: wrong ans....
49. M: huh?
[M is surprised that their answer was incorrect]

When the author informed the students that their answer was wrong, the students tried again. T stuck to the concept that an object with a higher final velocity will travel further than one with a lower final velocity. Since T was basing his problem-solving attempts on this concept, he thought the only possible reason why Bon did not win the race was that his final velocity was lower than that of Alex's. To allow for this, he hypothesized that both bicycles returned to their initial velocities after the acceleration.

53. T: they will only acc. for that 10 s
54. T: after that their speeds will return to the same as b4

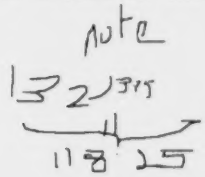
At this point in time, the author informed the students that the bicycles did not decelerate after that 10 seconds. Upon hearing this, both students felt that Bon should win. Their expression was totally consistent with their conception.

62. A to T: They did not decelerate after the 10 seconds.
65. T: the 2 didn't decelerate
66. M: then b should win
67. T: yah.....

In the episode above, T was trying to reconcile their findings via qualitative analysis of the situation. However, because their source of reasons came from their "higher final velocity = winner" (mis)conception, this yielded no alternative results.

The episode below shows M's attempt to obtain an alternative answer via mathematical formulations. In so doing, M unwittingly put aside the "higher final velocity = winner" concept.

84. [M writes on the whiteboard]



86. M: a travelled 118.25 to the checkpt
[M was referring to his workings on the whiteboard. See L88, L89 and L92 for an explanation of M's workings]
87. T: y is that so?
[T looks at M's drawing on the whiteboard]
88. M: 0.25+(2x0.25).....+(2.5)=13.75
89. M: the distance travelled during acceleration
[13.75m is the (additional) distance covered due to the acceleration]

The protocol above manifests another of M's misconception. M's workings imply that the bicycles gain speed instantaneously rather than incrementally. In short, M's workings imply that Alex's bicycle covered an additional 13.75 meters due to its acceleration of $0.25m/s^2$ for 10 seconds. We observe that this exact same working was also exhibited by M in one of his earlier problem-solving sessions.

```
90.   T: ok.....
91.   T: but i still dun get it....
      [T does not understand M's workings]
92.   M: 132(distance from check pt)-13.75=118.25
      [132m - 13.75m = 118.25m]
      [M is saying that the initial portion of Alex's velocity covered 118.25m]
93.   M: there/s no decceleration,then bon should reach first!
```

It is likely that, to M, the distance traveled by Bon due to Bon's higher acceleration was greater than Alex. Based on this method, Bon would have traveled 22 meters due to his higher acceleration. Hence, M drew the conclusion that Bon should reach the finish line first, since Bon was "faster". Clearly M's reasoning was flawed.

```
94.   T: how u get 13.75?
95.   M: 0.25+(0.25x2)+(0.25x3)+(0.25x4)...... +(0.25x10)=13.75
```

Upon further probing by T, M provided a fuller explanation of his conceptualization. M's formulation is as follows:

The velocity of Alex due to acceleration during the 1st second is = $0.25m/s^2$ x 1s
= 0.25m/s

Hence Alex, moving at 0.25m/s, travels 0.25m/s x 1s = 0.25 meters during the 1st second.

Likewise, Alex's velocity due to acceleration during the 2nd second is = $0.25m/s^2$ x 2s
= 0.5m/s.

Hence Alex, moving at 0.5m/s, travels 0.5m/s x 1s = 0.5 meters during the 2nd second. The same process was extended until the 10th second. As such, M conceptualizes that the summation of the distances from the 1st to the 10th second indicates the total distance traveled during the 10 seconds. Figure 2 and 3 pictorially illustrate M's conception and the actual acceleration process respectively.

Figure 2: M's Conception

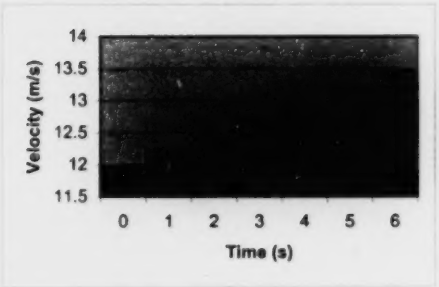
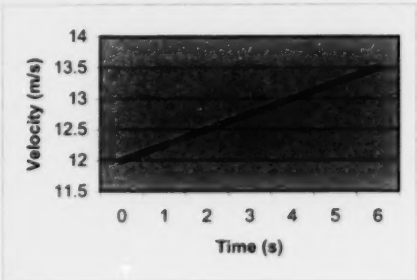


Figure 3: Actual acceleration process



T thought long and hard about M's formulation. After doing the math, he understood and agreed with M's conceptualization. This provides us with evidence that T had this misconception as well.

```
96.   T: [long pause (thinking)]
97.   T does the maths
98.   T: oic
      [This is a short form for "Oh, I see"]
```

Discussing the problem-solving process by qualitative analysis failed to provide new insights. As such, M started using mathematics as an alternative source of potential explanation. M's workings reveal that he had a misconception that the bicycles gain speed instantaneously rather than incrementally. We also see evidence that T suffered from the same misconception. Despite the use of both approaches, both students were unable to find any reason why Alex should win. Hence, they concluded that Bon would win. With this conclusion, they checked again with the author, only to be told that they were incorrect.

110. M: no.....
111. T: huh?
[T is surprised that the answer was incorrect]
113. M: that's no the ans..
114. T: i don't get it....
115. M: smae here.....

Faced with this bleak situation, both students, perhaps unwittingly, put aside their "higher final velocity = winner" conception. Evidence of this is shown when, without first thinking it through, M suggested that perhaps both bicycles arrived at the same time.

117. M: maybe they arrive at the same time?
118. M: assume
119. T: it may be possible but wat is the reasoning...?
120. M: thinking.....

Perhaps unknown even to M, he was putting aside the "higher final velocity = winner" concept by suggesting that "maybe they arrive at the same time". This suggestion was made without even an initial reason, and hence this suggests that the students did not think in theoretical terms.

Because the students had put aside the "higher final velocity = winner" conception, they were able to make progress in solving the question.

124. T: acc. = total dist travelled / total time taken
[T makes overt his thought process to M]
125. M: that's speed
[M corrects T]
126. T: aye.... yah hor.....
[Local expression for "Oh yes, you are right"]
127. M: acc=what formULA?
128. T: the gradient of the distance time graph....
[This is actually incorrect; acceleration is the gradient of the velocity-time graph]
129. M: huh?
[M was not expecting this]
130. T: the acc. is the gradient of the distance-time graph
134. M: could u find the time ?
135. A to M: Do you agree that "acc. is the gradient of the distance-time graph"?
136. M: acc.=changes in velocity/time taken
[After pondering over the author's question, M gives an accurate definition for acceleration]

As T searched broadly for answers, he drew upon the formula of acceleration. However, his definition was incorrect. This set M thinking about the actual formula of acceleration and "the time" (L134). M then started to use the formula *time = distance traveled / (velocity+acceletion)* in order to find the time taken for each bicycle to complete the final 132 meters. While M's actual workings were incorrect (there is no such formula), it nonetheless provided the students with an alternative answer suggesting the conclusion that Alex won the race. More importantly, it allowed the students to derive the relation between the time of race completion and the winner of the race.

151. M: a move faster than b.....reach first.....z???????
[M draws the relation between *time of completion of race* and *winner of race*]
156. M: 132/(12+0.25)=132/12.25=10.76
[132 is the distance traveled, 12 is the initial velocity, 0.25 is the acceleration]
157. M: A
158. M: 132/11.4=11.58
[132 is the distance traveled, 11 is the initial velocity, 0.4 is the acceleration]
159. M: B
160. M: i getting a little bit confused
[Perhaps M noticed that the formula he used made no sense]
161. T: oic/.....these ans are the time taken for the cylist,....

```
162.  T: therefore, A takes less time and b takes longer..
164.  T: so A will reach first
```

M's workings were incorrect. He had used a formula that had no basis, but nonetheless, T was able to make sense of it and concluded from M's answer that since Alex took less time than Bon, Alex will reach the finish line first. This provided the students with an alternative answer, and they were excited. M immediately asked the author if they were correct.

```
165.  M to A: Correct?
166.  A to M: The answer is correct, but the working is wrong
167.  M: working XXXXXXXXX
```

Upon hearing that the answer was correct, M deduced correctly that because Alex traveled faster initially, Alex was at a point ahead of Bon such that Bon could not overtake him despite Bon's higher acceleration. This provided the students with a reason why, despite his higher acceleration and final velocity, Bon lost to Alex.

```
172.  M: a travelled faster aT FIRST SO HE'S AT A POINT FURTHER THAN
   WHERE B COULD OVER TAKE EVEN THOUGH B ACCELERATE FASTR.
```

The above problem-solving endeavor took about 50 minutes. From here onwards, the students continued their problem-solving efforts. After considerable struggle, they eventually "corrected" their second manifested misconception (the "stepwise velocity increment" conception). They were also able to obtain a correct mathematical process to show Alex completing the race before Bon. The total time taken to solve this question was 130 minutes.

5 Results

The results of our study show that our student volunteers did not think in theoretical terms when attempting to solve the physics (kinematics) problems. Instead, they used a variety of methods such as simulations, conceptions, and even baseless conjectures. While these students certainly have concepts and based their reasons on these concepts, they were loose, unsystematic and highly fragmented. We may be tempted to call these students "naive learners", but further research by the authors reveal that the vast majority of elementary physics students who were studied worked in this fashion.

The students' "higher final velocity = winner" conception stemmed from their prior knowledge, and because their source of reasons came from this conception, they were unable to understand how it could be that Bon, who had the higher final velocity, did not reach the finish line first. Only upon putting aside this concept were they able to appreciate how it could be possible for an object with a higher final velocity to reach the finish line later than an object with a lower final velocity; it was because the slower object was at a point further than where the faster object could overtake. The protocols strongly support constructivist learning theory, which posits, among other things, that new knowledge is built (or constructed) from prior knowledge [15, 16]. Our study not only agrees with the theoretical shift to viewing *learning* as *conceptual change* [21]; it also lends empirical evidence in support of this. It also shows the conceptual change process (and hence learning process) to be continuous, but non-cumulative. This particular *feature* is strikingly similar in structure to scientific revolutions.

With respect to Thagard's request to "pin down the kinds of conceptual change that occur as children learn" [21, p.260], the kind of conceptual change that occurred here is that of "adding a new strong rule that plays a frequent role in problem solving and explanation" [21, p.35]. Initially, the students had the conception that an object with a higher final velocity (B) implied that it would travel further than one with a lower final velocity (A). Their problem-solving efforts added a new rule to this concept: B would travel further than A *only if* A is not at a point ahead of B such that B could not overtake A despite B's higher acceleration and higher final velocity.

6 Conclusions

Here in Asia (and in many parts of the world), the current method of teaching and assessing primary, secondary, and pre-tertiary students (aged 7-18), is still very much based on the over a century-old Western

pedagogy of teaching boys and girls nothing but *facts* [3]. Such a methodology is efficient for dissemination of information, but this decontextualised-content focus causes students to suffer from a lack of deep conceptual understanding of the domain being taught, and immensely decreases their exposure to expert problem-solving processes and strategies. As such, they do not look at problem solving through a "theoretical lens." Since "advancement in science is a continual dance between the partners of theory and experiment, first one leading, then the other" [14, p. 796], as long as students do not think in theoretical terms, negative answers should be offered to Thagard's opening quote.

Learning environments, computer-based or otherwise, should be designed to play a more *strategic* role with the *objectives* of the educational system as their core focus. Since the objectives of educational systems are rarely to produce unadaptable and inflexible graduates concerned only with egotistical benefits, then the learning environment, as well as the evaluation methodology, should be designed to reflect their intended objectives (also see [18]).

References

[1] Benson, D. & Hughes, J., "The Perspective of Ethnomethodology", Hong Kong: Longman, (1983).

[2] Carey, S., "Conceptual Change in Childhood", Cambridge, MA: Bradford/MIT Press, (1985).

[3] Dickens, C., "Hard Times", London: Collins, (1954), (original work published in 1854).

[4] Garfinkel, H., "Studies in Ethnomethodology", Englewood Cliffs, NJ: Prentice-Hall, (1967).

[5] Harris, P., "Thinking by Children and Scientist", In Hirschfeld, L. & Gelman, S. (Eds), Mapping the Mind (pp. 294-315), NY: Cambridge University Press, (1994).

[6] Have, P., "Doing Conversation Analysis: A Practical Guide", London: Sage Publications, (1999).

[7] Hung, D., "Epistemological change through peer apprenticeship learning: From rule-based to idea-based social constructivism", International Journal of Computers for Mathematics Learning, Vol 3, No. 1, pp. 45-80, (1998).

[8] Kuhn, T., "The Structure of Scientific Revolutions", Chicago: University of Chicago Press, (1970).

[9] Mehan, H. & Wood, H., "The Reality of Ethnomethodology", NY: John Wiley & Sons, (1975).

[10] Nersessian, N., "Conceptual Change", In Bechtel, W., & Graham, G. (Eds), A Companion to Cognitive Science (pp 157-166). Oxford, UK: Blackwell Publishers, (1998).

[11] Piaget, J., "The Child's Conception of Movement and Speed", London: Routledge & Kegan Paul, (1970), (original work published in 1946).

[12] Potter, J., "Representing Reality: Discourse, Rhetoric and Social Construction", London: Sage Publications, (1996).

[13] Psathas, G., "Conversation Analysis: The Study of Talk-in-Interaction", Thousand Oaks, CA: Sage Publications, (1995).

[14] Redish, E., "The Implications of Cognitive Science for Teaching Physics", American Journal of Physics, Vol 62, No. 6, pp. 796-803, (1994).

[15] Resnick, L. "Introduction", In Resnick, L. (Ed.), Knowing, learning and instruction. Essays in honor of Robert Glaser (pp 1-24), Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).

[16] Roschelle, J., http://netra.exploratorium.edu/IFI/resources/museumeducation/priorknowledge.html (accessed on Nov 1, 1999).

[17] Sacks, H., "Lectures on Conversation", Vols. I & II, (Ed.) Jefferson, G., Oxford: Basil Blackwell, (1992).

[18] Salomon, G., http://construct.haifa.ac.il/%7Egsalomon/edMedia2000.html (accessed on Jul 18, 2000).

[19] Soong, B., "A Novel CMC-assisted Constructivist Environment for Learning Physics", MSc. dissertation, National University of Singapore, (in preparation).

[20] Strike, K. & Posner, G., "A conceptual change view of learning and understanding", In L.H.T. West and A.L. Pines (Eds.), Cognitive Structure and Conceptual Change (pp. 211-229), NY: Academic Press, (1985).

[21] Thagard, P., "Conceptual Revolutions", Princeton, NJ: Princeton University Press, (1992).

A Distance Ecological Model to Support Self/Collaborative-Learning via Internet

Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5620; Fax: +81-424-89-6070
E-mail:okamoto@ai.is.uec.ac.jp

With the rapid development of information technology, computer and information communication literacy has become the main new ability required from teachers everywhere. For enhancing teaching skills and Internet and multimedia information literacy, a new teachers' education framework is required. Here we propose a Distance Educational Model, as a School-Based Curriculum Development and Training-System (SCOUTS), where a teacher can learn subject contents, teaching knowledge, and evaluation methods of the students' learning activities (subject: "Information") via an Internet based self-training system. We describe the structure, function and mechanism of the model, and then show the educational meaning of this model in consideration of the new learning ecology, which is based on multi-modality and new learning situations and forms.

Keywords: **Distance Education, Teacher Training System, Learning Ecology, School Based Curriculum Development**

1 Introduction

Recently, with the development of information and communication technologies, various teaching methods using Internet, multimedia appeared. Most of them emphasize, in particular, the aspect of collaborative communication between students and teacher during interactive teaching/learning activities. Therefore, now-a-days it is extremely important for a teacher to acquire computer communication literacy [1]. So far, there were many studies concerning system development, which aim at fostering and expanding teachers' practical abilities and comprehensive teaching skills, by using new technologies, such as computers, Internet, multimedia. In Japan, systems using communication satellites such as SCS (Space Collaboration System) are developed and used as distance education systems between Japanese national universities. In the near future, a teacher's role will change from text based teaching, to facilitating, advising, consulting, and his/her role will be more that of a designer of the learning environment. Therefore, a teacher has to constantly acquire/learn new knowledge and methodologies. We have to build a free and flexible self-teaching environment for them under the concept of "continuous education". At the same time, we build a collaborative communication environment to support mutual deep and effective understanding among teachers. In this paper, we propose a Distance Educational Model, which is based on the concept of School Based Curriculum Development and Training System, advocated by UNESCO and OECD/CERI (Center for Educational Research and Innovation), and describe the structure, function, mechanism and finally the educational meaning of this model. Based on such a background, it is necessary to construct an individual, as well as a collaborative learning environment, that supports teachers' self-learning/training, by using Internet distributed environments and multimedia technologies. A teacher can choose the most convenient learning media (learning form) to learn the contents (subject units) that s/he desires.

2 Distance Educational Model based on SCOUTS

Until now, when a teacher wanted to take a class on "IT-education", s/he had to leave the office or school. Now it is possible to learn various kinds of subject contents by building a virtual school on the Internet environment.

2.1 Distance Educational Model

Our Distance Educational Model is built on 3 dimensions. The first one is the subject-contents, which represents what the teachers want to learn. The second one represents the teaching knowledge and skills as well as the evaluation methods of the students' learning activities. From the third axis, the favorite learning media (form) can be chosen, e.g., VOD, CBR, etc. By selecting a position on each of the 3 axes, a certain cell is determined. A cell stands for a "script", which describes the instruction guidelines of the learning contents, the self-learning procedure, and so on (Fig. 1). In the following, I will explain the meaning of each axis in more details.

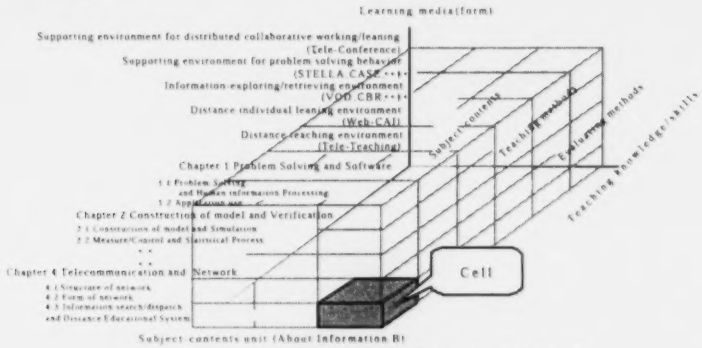


Fig.1 Structure of the Distance Educational Model

2.1.1 Subject –contents unit

In this study, we focus on the subject called "Information", which is due to be established as a new obligatory subject in the regular courses of the academic high school system in Japan. The subject "Information" is composed of three sub-subjects, "Information A", "Information B" and "Information C". The contents of each sub-subject are as follows.

Information A: *raising the fundamental skills and abilities to collect, process and transmit "information" using computers, the Internet and multimedia.*
Information B: *understanding the fundamental scientific aspects and the practical usage methods of "information".*
Information C: *fostering desirable and sound behavior of participation, involvement and contribution in an information society; understanding peoples roles, and the influence and impact of technology, in the new information society.*

2.1.2 Teaching knowledge/skills

On this dimension, we have represented sub-subject contents, teaching methods and evaluating methods for "information" classroom teaching. 'teaching methods' stands for how to use and apply IT, to enhance a student's problem solving ability, involving comprehensive learning activities, like problem recognition, investigation and analysis, planning and design, implementation and executing, evaluation, report and presentation. We aim at teachers acquiring the proper students' achievements evaluating skills, according to each of the above activities.

2.1.3 Learning media (form)

This dimension represents five different learning environments, as follows: 1) "Distance teaching environment (Tele-Teaching)" based on the one-to-multi-sites telecommunications 2) "Distance individual learning environment (Web-CAI)" based on CAI (Computer Assisted Instruction) using WWW facilities 3) "Information-exploring and retrieving environment" using VOD, CBR (Case Based Reasoning) 4) "Supporting environment for problem solving", by providing various effective learning tools 5) " Supporting environment for distributed collaborative working/learning" based on the multi-multi-sites telecommunications. Brief explanations for each environment are given in the following.

(1) ***Distance teaching environment (Tele-Teaching)****: This environment delivers the instructor's lecture image and voice information through the Internet, by using the real-time information dispatching function via VOD (Video On Demand).*
(2) ***Distance individual learning environment (Web-CAI)****: This environment provides CAI (Computer Assisted Instruction) courseware with WWW facilities on the Internet.*
(3) ***Information-exploring and retrieving environment****: This environment delivers, according to the teacher's demand, the instructor's lecture image and voice information, which was previously stored on the VOD server. For delivery, the function of dispatching information accumulated on the VOD server is used. In addition to it, this environment provides a CBR system with short movies about classroom teaching practices.*

BEST COPY AVAILABLE

(4) ***Supporting environment for problem solving****: This environment provides a tool library for performance support, based on CAD, Modeling tools, Spreadsheets, Authoring tools, and so on.*
(5) ***Supporting environment for distributed collaborative working and learning****: This environment provides a groupware with a shared memory window, using text, voice and image information for the trainees.*

2.2 • Cell" definition

The concept of a "cell" in the Distance Educational Model is quite important because it generates the training scenario, including the information to satisfy the teacher's needs, the subject materials learning-flow and the guidelines for self-learning navigation. The frame representation of the "cell" is shown in Table 1. These slots are used when the system guides the process of the teacher's self-learning.

Table 1 The frame representation of the "cell"

	Frame name	Slot-value
Slot-name	Learning objectives for a student	Subjects which should be understood Subjects which should be mastered
	Subject-contents	The unit topic
	Teaching method	The students' supervision method and instructional strategies
	Evaluating method	The students' evaluation method
	Useful tools	The software used for the training activity
	Operational manual of tools	The software operation method used for the training activity
	Prepared media	The learning media which can be selected
	Guide script	The file which specifies the dialog between the trainee and the system

3 Outline of the teacher training system

The system configuration of the teacher's training environment is composed of two subsystems based on the Distance Educational Model. One of the subsystems is the training system, where a trainee can select and learn the subject adequate for him/her guided by the script in the "cell". The other subsystem is an authoring system with creating and editing functions for "cell" description. The users of the second environment are, e.g., IT-coordinators or IT-consultants, who can design lecture-plans in this environment.

3.1 Training system

The training system aims to support teachers' self-training. The configuration of this system is shown in Fig.2. The role of this system is first to identify a "cell" in the model, according to the teachers' needs. Then, the system tries to set up an effective learning environment, by retrieving the proper materials for the teacher, along with the "guide script" defined in the corresponding "cell". Therefore, the system offers programs for both Retrieving and Interpreting. The training system works as shown in the following.

STEP 1: Record the teacher's needs.
STEP 2: Select a "cell" in the Distance Education Model according to the teacher's needs.
STEP 3: Interpret the "cell" in the guide WM (Working Memory).
STEP 4: Develop the interactive training with the teacher according to the "guide script" in the guide WM.
STEP 5: Store the log-data of the dialog (collect information on the learning histories and teachers' needs and behaviors).
STEP 6: Provide the needed applications for the user's learning activities and set up an effective training environment.
STEP 7: Give guidance-information, according to "cell" script guidelines, decide on the proper next learning step "cell".

The interpreter controls and develops the dialog process between user and machine according to the information defined in our "guide script" description language. This "guide script" description language (GSDL) consists of some tags and a simple grammar for interpreting a document, similar to the HTML (Hypertext Markup Language) on the WWW. The interpreter understands the meanings of the tags, and interprets the contents. An example of GSDL is shown below.

*(1)***<free>**	*Definition: description of the text (instruction)*
*(2)***<slot (num.)>**	*Definition: a link to a slot value in the "cell"*
*(3)***<question>**	*Definition: questions to a trainee*
*(4)***<choice>**	*Definition: branching control according to a trainee's response*
*(5)***<exe>**	*Call: to relevant "cells"*
*(6)***<app>**	*Definition: applications used for training activities (e.g., Tele-Teaching, etc.)*

BEST COPY AVAILABLE

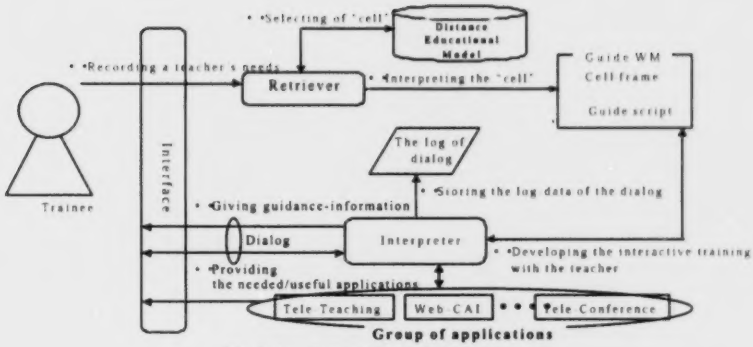


Fig.2 Configuration of Training system

3.2 Authoring system for creating and editing a "cell" description

The system provides an authoring module to create and edit the information in the "cell". This module also offers the function of adding new "cells", in order to allow supervisors (experienced teachers) to design the teachers' training program. The configuration of this system is shown in Fig.3. The tasks that can be performed by this system are: adding new "cells", editing the existing "cells", receiving calls for Tele-Teaching lectures, and managing the lectures schedule. This system is composed of the "cell" frame creating module, and the "guide script" creating module. A cell design can be performed as shown in the following.

STEP 1: Get the slot-values of "student's learning objectives", "subject-contents/teaching method/evaluating method", and "useful tools" from the "cell".
STEP 2: Substitute the return value of the slot of the prepared media with the training-contents corresponding to the user's needs.
STEP 3: Substitute the slot-value in the "cell" for the corresponding tag in the "guide script" template.
STEP 4: If "Tele-Teaching" as learning media is selected, then get some information about the lecture, by referring the lecture-DB and the VOD short movie-DB.
STEP 5: Add the new "cell" to the Distance Educational Model.

The lecture-database consists of "lesson managing files" containing user-profile data, lecture schedules, trainees learning records, lecture abstracts, and so on. The "guide script" template file contains tag-information, written in the "guide script" description language (GSDL), for all subject-contents items in the Distance Educational Model.

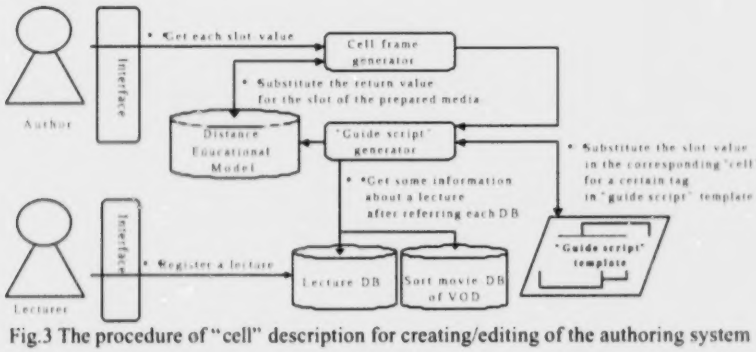


Fig.3 The procedure of "cell" description for creating/editing of the authoring system

4 Conclusions

This paper proposed the Distance Educational Model called the School Based Curriculum Development and Training System (SCOUTS). This model stands for the networked virtual leaning environment based on a three dimensional representation, which has on the axes 1) subject-contents, e.g., "information" for the training, 2) teaching knowledge, skills and evaluation methods and 3) learning and teaching media (forms). This represents a new framework for teachers' education in the coming networked age. We have mentioned the rationale of our system and explained the architecture of the training system via a 3D-representation model. Furthermore, we have described a "guide script" language. This system is superior to a simple rule-

based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. The aim of our system is to support teachers' self-learning, provided as in-service training. At the same time, we need to build rich databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" will be implemented. As a result, we trust that a new learning ecology scheme will emerge from our environment.With this system, we can construct various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalized knowledge-acquisition and knowledge-sharing, via the communication process, and support learning methods such as "Learning by asking", "Learning by showing","Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining"'. Among the learning effects expected from this system, we also aim at meta-cognition and distributed cognition, such as reflective thinking, self-monitoring, and so on. Therefore, we expect to build a new learning ecology, as mentioned above, through this system. Finally, we will apply this system to the real world and try to evaluate its effectiveness and usability from experimental and practical point of view.

References

[1]. Nishinosono, H.: A Teacher Education System for Information Education Teachers at High School Level in the Information Society. Proc. of the conference JET, pp.523-524 (1998)

[2] Collis, B.: Design, Development and Implementation of a WWW-Based Course-Support System. ICCE99, pp.11-18, IOS Press (1999)

[3] Seki, K., Takaoka, R., Matsui, T., Okamoto, T.: A Teaching Model in Distance Education based on Teacher's Needs. IEICE Technical Report, ET98-12, pp.49-56(1998)

[4] UNESCO Report: World Declaration on Higher Education for the 21 Century Vision and Action, Paris (1998)

[5] Salvador, L. G.: Continuing Education Through Distance Training. ICCE99, pp.512-515, IOS Press (1999)

The Impact of Learning Style on Group Cooperative Learning

Fang-yi Hu* and Nian-shing Chen*
** Dep. of Information Management, National Sun Yat-sen University*
70, Lian-hi Road, Kaohsiung, Taiwan 804
Tel: +886-7-5252510
E-mail: fyhu@power2.nsysu.edu.tw; nschen@cc.nsysu.edu.tw

Cooperative learning has been around a long time and there are many researches and practical uses of cooperative learning. This study is to examine students' attitude toward group cooperative learning processing with individual's underlying learning style. We use Gregorc's Learning Style Delineator to group students heterogeneously and use some factors of Social Cognitive Theory to measure group processing. The findings indicate students with concrete/sequential learning style are tentative to be lack of self-efficacy on setting their goals and therefore teachers should take more care of them while doing group cooperative learning activities.

Keywords: **Cooperative Learning, Learning Style, Social Cognitive Theory**

1 Introduction

Cooperative learning means students working together to accomplish shared learning goals and to maximize their own and their group members' achievements (Johnson & Johnson, 1994). Cooperative learning is widely adopted by the educators since 1980s. Students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). A vast amount of evidence from research in related areas suggest that in cooperative learning situations there is a positive interdependence among students' goal attainments.

Although cooperative learning makes students to learn much better than competitive learning and individual learning in groups, there are still many potential barriers to make group effective, such as lack of sufficient heterogeneity, lack of groupthink, free riding, and lack of teamwork skills (Johnson & Johnson, 1994; Johnson & Johnson, 1996). The basic elements of making cooperative group with high performances are positive interdependence, face-to-face promotive interaction, individual and group accountability, appropriate use of social skills, and group processing (Johnson & Johnson, 1996). Thus how students interacting with other group members and groups processing are the critical successful factors in cooperative learning. By considering individuals' underlying learning style, the purpose of the study is to examine students' attitude toward group cooperative learning processing.

In the Bostrom, et al. (1988) framework individual difference variables define the cognitive aspects of human activities. Thinking process is at the heart of all such activities including learning. Learning style is one of the cognitive traits, which are static aspects of information processing affecting a broad range of variables (Bostrom, et al., 1990). To aim for sufficient heterogeneous grouping, this study chooses learning style as the main variable concerning the impacts of group cooperative learning.

To examine individual's interaction during group processing, this study use Social Cognitive Theory (SCT) (Bandura, 1986), a widely accepted and empirically validated model of individual behavior (Compeau & Higgins, 1995), to reflect the cognitive aspects of students' learning activities, such as self-efficacy. SCT emphasizes the triadic reciprocal causation of behavior, cognitive and some personal factors and environmental events (see Figure 1). Three aspects of Social Cognitive Theory are especially relevant to the organizational field (Bandura, 1988; Wood & Bandura, 1989): the development of people's cognitive, social, and behavioral competencies through mastery modeling, the cultivation of people's beliefs in their capabilities so that they will use their talents effectively, and the enhancement of people's motivation

through goal systems.

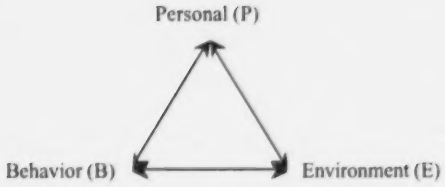


Figure 1. Schematization of the relations among behavior (B), cognitive and other personal factors (P), and the external environment (E) (Bandura, 1986; Wood & Bandura, 1989)

According to Social Cognitive Theory, many researches showed that past performance, self-efficacy and goal setting are the main personal factors effecting performance. Although there are many other factors in the range of the theory, we just discuss the impact of learning style on self-efficacy and goal setting in this study.

There are some other factors exerting considerable influence over group performance. For example, group cohesiveness and group norms. Cohesiveness means all forces (both positive and negative) that cause individuals to maintain their membership in specific groups. Group cohesion means the mutual attraction among group members and the resulting desire to remain in the group. Norms means the rules or expectations that specify appropriate behavior in the group and the standards by which group members regulate their actions (Johnson & Johnson, 1996). Group performance is affected by the combination of cohesiveness and group norms rather than cohesiveness alone (Langfred, 1998). In this study, we also investigate the impact of learning style in group cohesiveness and norms.

2 Method

2.1 Subjects

The subjects were 43 girl's senior high school students who participated in the AJET (Advanced Joint English Teaching, *http://ajet.nsysu.edu.tw*) project, which was supported by MOECC (Ministry of Education Computer Center, APNG-Education (Asia Pacific Networking Group) and I*EARN in Taiwan (*http://www.iearn.edu.tw*). Therefore there are no differences in sex and age among them. The subjects were run in groups and Table 1 is their proportion of learning style. We'll explain the types of learning styles later.

Table 1. Learning Style Frequencies

Learning Style	AR	CR	AS	CS	Total
Students Numbers	15	17	7	4	43

Every group was assigned a project to make English web pages about one topic: Signs or Foods in 6 weeks. Every week they had tow hours on learning how to make homepages by Microsoft FrontPage 98 and doing their group's project as exercises in the computer classroom. Before the experiment, they had learned some basic skills for building their own personal webs.

2.2 Procedure

During the 6 weeks, there were three 2-week sections in the experiment. In the first week, the subjects were asked to fill out the self-efficacy, goal setting and group cohesiveness questionnaires. The same questionnaires were conducted in every section. And in the second week, they were asked to fill out the group norm and satisfaction questionnaires after their performance measurement made by the teachers.

2.3 Measure

According to the procedure, this study assessed learning style and 5 constructs: group norms, group cohesiveness, self-efficacy, goal setting and satisfaction.

2.3.1 Learning Style

In this study, the Gregorc Learning Style Delineator was used to measure the learning style (Gregorc, 1982). Gregorc' s model is one of several models developed to improve understanding of the way students learn and the way teachers teach and is a cognitive model designed to reveal two types of abilities, perception and ordering. Perceptual abilities mean through which information is grasped, translate into two qualities; abstractness and concreteness. Ordering abilities are the ways the learner organize information, either sequentially (linearly) or randomly (non-linearly) (Leuthold, 1999). Thus there are four learning categories: abstract/ random (AR), concrete/random (CR), abstract/sequential (AS) and concrete/ sequential (CS).

2.3.2 Group Norms

Group norms was measured by 5 items on 7-point scales, which indicate the amount of effort put into work, the attitudes toward work load, the willingness to give up free time to work, the feeling of responsibility for work goal attainment, and the feelings of self-worth when work is accomplished well. This measure is developed based on the literature of group work norms (Langfred, 1998). The Cronbach alpha for the group norms measure was .839.

2.3.3 Group Cohesiveness

Group cohesiveness was measured by 6 items on 7-point scales, which defines the feeling of individual group members toward other members and the group. This measure is based on the literature of Langfred (1998). The Cronbach alpha for the group cohesiveness measure is .79.

2.3.4 Self-efficacy

Self-efficacy was measured by 8 items, which asked the respondents to rate their expected ability to accomplish the project with different levels of goal. For example, the respondents were asked whether they could accomplish fifty percent of the project and how much confidence they have. This measure is developed based on an extensive review of the literature of self-efficacy (Compeau & Higgins, 1995). The Cronbach alpha for the self-efficacy measure is .963.

2.3.5 Goal setting

Goal setting was measured by 4 items, which asked the subjects' commitment to their goal of the projects. This measure is developed based on the literature of goals (Locke, 1984). The Cronbach alpha for the goal setting measure was .68.

2.3.6 Satisfaction

Satisfaction was measured by 5 items on 7-point scales, which asked the subjects' satisfaction of the performance of their group project. This measure is developed based on the literature of satisfaction (Dennis, Kinney & Hung, 1999). The Cronbach alpha for the satisfaction measure was .913.

3 Results

Since the Cronbach alpha values of all experiment measures are .891, .8767 and .8646 respectively, this experiment was reliable. An overview of the data is displayed in Table 2, and the results are displayed in Figure 2, 3, 4, 5 and 6.

Table 2. The mean of every measure

Mean	Group Norms	Group Cohesiveness	Self-efficacy	Goal setting	Satisfaction
Section 1	5.16	4.90	529.77	5,66	4,94
Section 2	4.90	4.60	561.16		4,56
Section 3	4.86	3.76	574.42	5,60	5,05

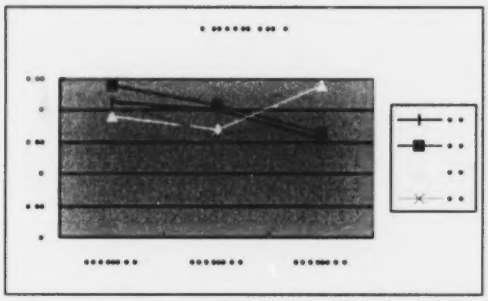


Figure 2. Effects of Learning style on group norms

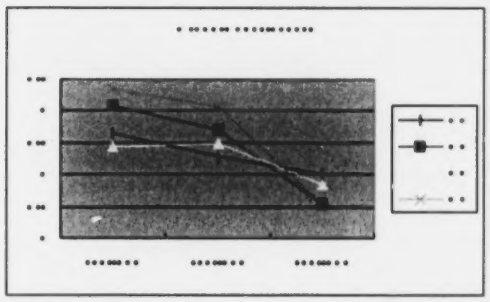


Figure 3. Effects of Learning style on group cohesiveness

The effects of learning style on group norms and group cohesiveness in the three 2-week experiments are not statistically significant, and the results are showed in Figure 2. Because the subjects were grouped since three months ago in the beginning of the semester, the group norms were already statically existed and were identified with group members.

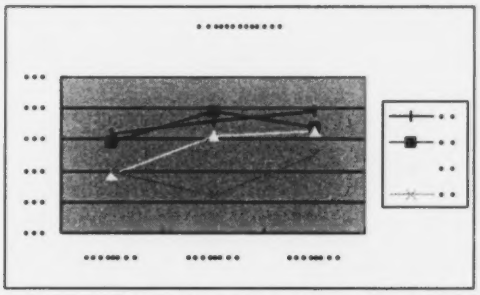


Figure 4. Effects of Learning style on self-efficacy

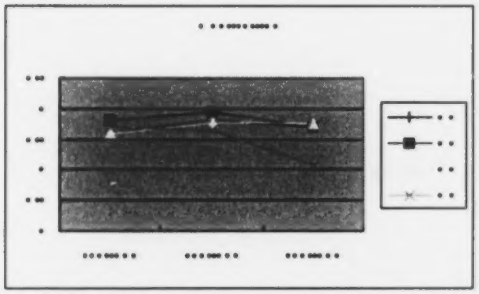


Figure 5. Effects of Learning style on goal setting

BEST COPY AVAILABLE

The effects of learning style on self-efficacy and goal setting are more significant than group norms and group cohesiveness. The results are showed in Figure 3. Students with concrete/sequential learning style had less self-efficacy during the experiment and were afraid to set their goal higher. Maybe the CS style students feel difficult to make web pages since it is somehow an abstract skill and needs to think randomly.

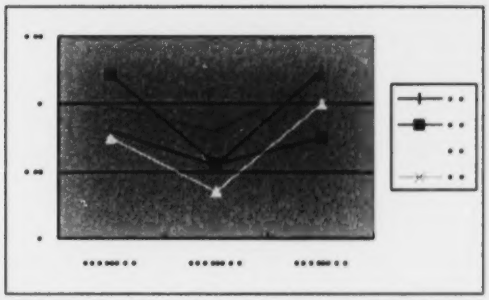


Figure 6. Effects of Learning style on satisfaction

The effects of learning style on satisfaction don't have significant differences, and the result is showed in Figure 4. It showed that all students enjoyed group cooperative learning and were satisfied in this way of learning.

4 Conclusions

In general, all students performed well in the group cooperative learning and felt satisfied with group processing. Although the students with concrete/sequential learning style were few and far between the subjects in this experiment, a quarter of general students would be this kind of learning style. Teachers should give them more encouragement to make them getting more self-efficacy and setting the right goal. Moreover, this study only uses Gregorc Learning Style Delineator to examine students' learning style. There are many other kinds of learning style evaluations, such Kolb's (1976) Learning Style Inventory (KLSI), Canfield's (1988) Learning Styles Inventory, etc. Future researches may use these questionnaires to examine which one is more suitable for cooperative learning.

And about the Social Cognitive Theory, there were many studies showed that the triadic aspects could form some models, which would affect each other in some relationships. Since the sample size is too small, this study doesn't prove the model by statistic methods. This is a limitation of this study. Understanding the effects between group norms, cohesiveness, self-efficacy and their performance will be an interesting research topic.

References

[1] Bandura, A., "Social Foundations of Thought and Actions: A Social Cognitive Theory", Englewood, Cliffs NJ: Prentice-Hall, (1986).

[2] Bostrom, R. P., Olfman, L. & Sein, M. K., "End User Computing: A Framework to Investigate the Training/Learning Process", Human Factors in Management Information Systems, H. M. Carey (ed.), Ablex Publishing Corporation, Norwood, NJ, pp. 221-250, (1988).

[3] Bostrom, R. P., Olfman, L. & Sein, M. K., "The Importance of Learning Style on End-User Training", MIS Quarterly, pp. 101-119, (1990).

[4] Compeau, D. R. & Higgins, C. A., "Application of Social Cognitive Theory to Training for Computer Skills", Information Systems Research, Vol. 6, No. 2, pp. 118-143, (1995).

[5] Dennis, A. R., Kinney, S. T., Hung, C., "Gender Differences in the Effects of Media Richness", Small Group Research, Vol. 30, No. 4, pp. 405-437, (1999).

[6] Deutsch, M., "Cooperation and Trust: Some Theoretical Notes", In M. R. Jones (ed.), Nebraska Symposium on Motivation, Lincoln: University of Nebraska Press, pp. 275-319, (1962).

[7] Johnson, D. W. & Johnson, R. T., "Cooperation and Competition: Theory and Research", Edina, MN: Interaction Book Company, (1989).

BEST COPY AVAILABLE

[8] Johnson, D. W. & Johnson, R. T., "Learning Together and Alone: Cooperative, Competitive and Individualistic Learning", 4th ed. Allyn and Bacon, (1994).

[9] Johnson, D. W. & Johnson, R. T., "Joining Together: Group Theory and Group Skills", 6th ed. Allyn and Bacon, (1996).

[10] Kolb, D. A., "The Learning Style Inventory Technical Manual", McBer and Company, Boston, MA, (1976).

[11] Leuthold, J. H., "Is Computer-based Learning Right for Everyone", Proceedings of the 32nd HICSS, pp. 1-8, (1999).

[12] Loke, E. A., Frederick, E., Lee, C. & Bobko, P., "Effect of Self-efficacy, Goals and Task Strategies on Task Performance", Journal of Applied Psychology, Vol. 69, No. 2, pp. 241-251, (1984).

The Project-based Cooperative Learning on Internet -- A Case Study on Geology Education

Jing-Yi Su*, Wei-Min Donald Chen*, Fetching Chen and Yi-Ben Tsai***
**Institute of Geophysics, National Central University, Chung-Li, Taiwan 320 ROC*
***Center for Teacher Education, National Central University, Chung-Li, Taiwan 320 ROC*

We have conducted an experiment on Internet learning in geology by high school students in Taiwan. A total of 74 students from 17 high schools enrolled in the beginning. 50 of them completed the 23-day program of learning activities. The experiment was designed on the concept of project-based cooperative learning on Internet. The overall topics for learning were the geologic landscapes of Taiwan. Four sub-topics were chosen to serve as the central themes for Topic Groups. Furthermore, the students were asked to enter on of the three Expert Groups. The sequence of learning activities was consisted of three stages: first stage in Topic Groups, second stage in Expert Groups, and third stage reassemble in Topic Groups. In contrast to traditional class learning mode, the Internet learning can leave complete records of the learning process of each student so that we can track their learning achievements. We found that the students liked the new Internet learning method because it gave freedom to exchange questions and answers among themselves without fears of embarrassment. We also found, by comparing the preconcept map and postconcept map, that the students have gained wider and more complete understanding of the overall geologic topic chosen for this experiment: The Geologic Landscapes of Taiwan.

Keyword: **Project-Based Cooperative Learning**, **Topic Group**, **Expert Group** and **High School Geology**.

1. Introduction

Internet is useful and getting more popular with the booming information technology. People can get any kind of information through Internet. If the benefits and convenience of Internet could be utilized in teaching, then students could go on learning by themselves when they feel free. It is likely that this learning method may become a main stream in the future. The present research project is designed based on this concept. Therefore, the emphasis is not only to evaluate student' s learning achievement but also to find out how much he/she learns geology through learning process.

Exploration is a core activity in science learning. Constructivists believe that learners can not get true understanding without going through stages of asking question – designing research collecting data-presenting the results (F.C. Chen and H.M. Jiang, 2000). Based on the above believes, we designed a project-based learning model of five steps for senior high school students. The students are enrolled in different senior high schools located in different parts of Taiwan. The separate locations minimized face-to-face communication. Learners were obliged to involve in Web-based learning. As a result, they left rich information and complete records documenting each student' s learning process through Internet.

2. Method

2.1 Participants

Seventy-four students from seventeen senior high schools in four regions (Taipei city, I-Lan county, Tao-Yuan county and Hsin-Chu county) participate in our experimental project. However, only 50 students from 13 senior high schools completed the entire experiment. Among these students, 47 are in the first-year class and 3 in the second-year class. Gender-wise 19 are boys and 31girls.

2.2 Procedures

The 50 high school students and one college graduate majored in geophysics serving as a mentor formed a network-based learning community. The students studied mainly on Web (http://glyedu.gep.ncu.edu.tw). There major tasks included browsing the Web pages, reading and writing articles in group discussions, finishing homework, talking to their classmates or teachers at school, and finding more information in library. But the student's major learning activity is to focus on group discussions (reading and writing articles) on Internet and collecting data. The purpose of collecting data is for group discussions. The students will find more information by going to library, asking their teachers and talking with their classmates to reinforce the data needs for group discussions. We saved all the articles in the hard disk of our server to keep complete records on the learning process. Those articles are the raw data for the following analyses and discussions.

The topics for group discussion in the project are assigned as "Geologic Landscapes of Taiwan". All learning activities are centered around these topics. This topics is further divided into four groups, namely, Rock's Story of Yeh-Liu, Coast Tourist Group, When Mountains Meet the Sea and Promise Taiwan A Future. These groups are called "Topic Group". At the beginning, 7 misconceptions related to the Topic Groups are given to the students to raise their interests in learning. Furthermore, the students are required to choose one of the "Expert Groups" that interested them. There are three Expert Groups designed in this experiment: Wind Effects, Water Effects and Geography & Human Effects. These Expert Groups will be elucidated in details in follow section.

The entire experiment lasted for 23 days in this project. At the first and last days of the experiment, the students are required to come to National Central University (Chung-Li, Taiwan, R.O.C.) and attend classes designed to entice their involvement in this project. For rest of the days during the experiment, the students learning by themselves through Internet at home or at school. The self-learning days are further divided into three stages; each stage lasted for seven days. First stage started with the "Topic Group". In the second stage, "Expert Group" is preceded. Then, the third and final stage returned to the "Topic Group" again. (Fig 1)

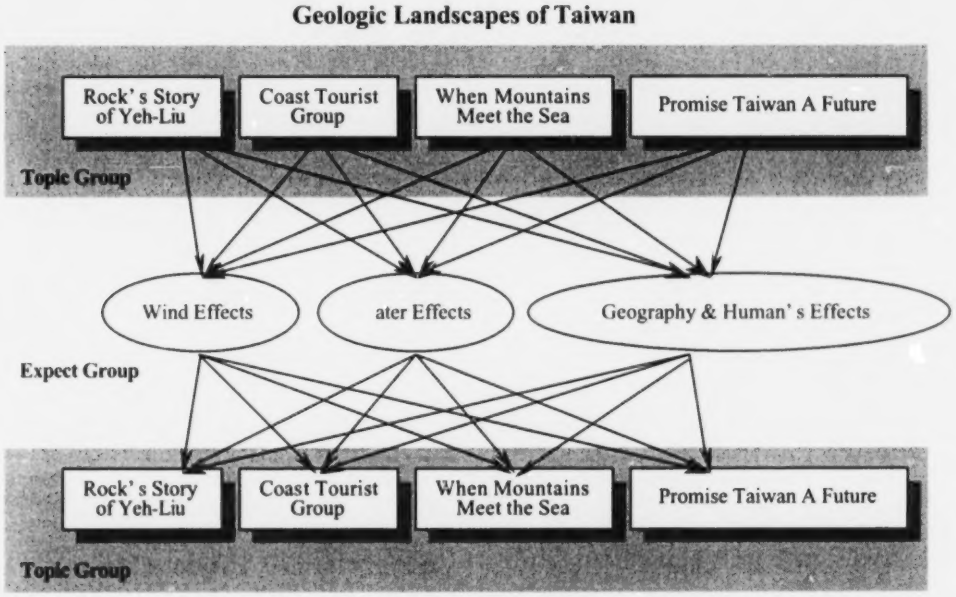


Fig1. Process of Cooperative Learning

During the first stage in Topic Groups, the same group's partners must help each other to set clearly several assumptions and to design research strategies. During the second stage, everybody needs to join one Expert Group and gathers enough knowledge and information for solving the problems met in the first stage. In the third stage, the students in Topic Group share what they learned in each Expert Group with their partners. Through this process, the members in the same group team up and solve the problems cooperatively just like putting together pieces in a puzzle. All discussions are posted in the Web site of this experiment through Internet. In

such circumstance, the students are compulsory to learn by asking and discussing with other participants in addition to the teacher.

2.3 Data collection

The data collected in this study include:

1. Results from the Multiple Factor Aptitude Test and Exploratory Test of Geology carried out before the experiment.
2. Students' homeworks including preconcept map, misconceptions, term paper, and postconcept map.
3. Discussion records on Internet: the students communication and learning through group discussion on the discussion board on Internet. The records are saved and used to analyze the gradual changes for each student.
4. Questionnaires: Every student is required to answer a questionnaire before the end of the project. There questionnaire provide the project more clues to understand how students record to this new leaning method.

2.4 Data analysis

In this study, the data collected from the open questions through the questionnaires and concept maps before and after the experiment have been used to study the merits of cooperative learning through Internet. With regard to the results from the tests of Multiple Factor Aptitude and geological background, they are treated as representatives of student's capability.

3. Results

Through analyses of the data collected so far, some preliminary results are present here.

3.1 Advantages of cooperative learning in science

From student's questionnaires we can find that, almost all students feel fresh, interesting, and useful about this learning experience. They can accept this learning mode. They have gained most achievements from group meetings, because

- *Through group discussion I cam understand partners' question, and I can review my own knowledge.* (No. S-18 of questionnaire)
- *I can ask any questions that I don't know.* (No. S-31 of questionnaire)
- *In discussion, my question can get the answer. Sometime I can get more information and knowledge, unexpectedly.* (No S-35 of questionnaire)

From their questionnaires we know that almost all the students interested in this learning mode that is very different from the regular classes. They consider this learning mode can trigger them to think about learning contents. Regarding traditional class learning, the students don't consider it will trigger them to think because "the knowledge is correct, certainly".

In fact, student is very enthusiastic in writing. The ask questions willingly. They can ask questions they don't understand, and answer that they understand. For answering partner's questions, they must search more information, and read more books. Through this cooperative learning mode, students can get more knowledge by themselves.

3.2 Advantages of studying science by cooperative learning on Internet

While students agree this new learning mode, it also means that they don't like traditional learning mode. We can find such answer from student's response to questionnaires:

- *Everybody can express their opinion on Internet eagerly, perhaps because the student doesn't have to be face to face with people.* (No. S-50 of questionnaire)
- *On face to face learning, it lets me fear and want to escape the teacher's eyes with care and upbraid. You can find your thinking has more free space on Internet Learning. You don't have any restrain and don't feel tense for talking face to face, because you only face a computer.* (No. S-31 of questionnaire)

- *This is the first time to try learning on Internet on my life. It was tensest moment in face-to-face learning, because talking face to face is always a barrier that I can't break up. I will be very tense, can't speck very well, and can't express my mind clearly. On the other hand, on Internet learning, I can talk with confidence and composure, don't have to care about their facial expressions.* (No. S-45 of questionnaire)
- *I will increase the interaction, especially, to us eastern Asians who are more reserved.* (No S-19 of questionnaire)

We can find a distinct characteristics of our students from above words. Most students are shy, tense, and conservative. They will need time to open their minds. They are not accustomed to express their opinions under other people's watching eyes. They worry about what can they do if their answers are wrong. These results can be referred to school teachers to improve traditional teaching mode. When the students don't answer teacher's question, it does not necessarily show they can't or don't understand, it maybe because they are just shy. Teacher can design a learning project knowing these characteristics of students to help them free from shyness and passiveness.

3.3 Evaluation of learning achievements

Before starting of the Internet learning, all students were required to finish a homework on "preconcept map". At the end of Internet learning, they were again required to finish on other homework on "postconcept map" (refer 2.3). We can find the following tendencies by comparing the preconcept map and postconcept map.

1. The most obvious difference is that student's concepts became more numerous. They used few concepts when doing the preconcept map. And they can use more concepts when doing the postconcept map.

2. The concept's range and level became wider and framework because more complete. The preconcept map maybe just focuses on narrow geological topics. In the postconcept map, the geological understanding became much wider.

3. Wrong concepts are corrected. There were some misconceptions in the preconcept map, For instance, they might use a wrong connective word with two concepts; it means the student doesn't know the relation between those concepts. In learning process, all mentors didn't talk to any student about his/ her mistakes. But eventually the mistakes become corrected in postconcept map. It means he/she has learned correct concepts and knows the relation between different concepts.

4. Conclusions

This experiment on Internet learning in geology by high school students in Taiwan has a total of 74 students from 17 high schools enrolled in the beginning. 50 of them completed the 23-day program activities. Based on analyses of the collected data so far, some preliminary results are presented here.

1. Almost all students were interested in the learning mode centering at Project-Based Cooperative Learning on Internet. They thought this learning mode could stimulate them to think about wider range of learning.

2. We found distinct characteristics of the participating students. Most students were shy, tense, and conservative. Teachers can design a learning project knowing these characteristics of students to help them free from shyness and passiveness in learning process.

3. Through this learning process, the students can get more knowledge. We can draw this conclusion from the following observations:

   i. The most obvious difference is that individual student's ideas become more numerous.
   ii. The range and level of student's ideas become wider and more complete.
   iii. Wrong concept are corrected, through group discussions.

References

[1] Chen, F. C. & Jiang, H. M., "Portfolio analysis of Project-based Cooperative Learning on Internet – A Case of Atmospheric Science Project", Global Chinese Conference on Computers in Education (GCCCE), (2000).

[2] Tasi, Y. B. & Chen F. C., "Research and Development of Earth Science Learning Environment of Senior High", National Science Council Monthly, Vol. 7, No. 9, pp. 1054-1065, (1999).

Tracking and Guiding Tools for Learning Groups in a Web Collaborative Learning System

Kuo-Liang Ou, Chen-Chung Liu, Jiun-Ren Huang, and Gwo-Dong Chen
Department of Computer Science and Information Engineering
National Central University
Chung-Li TAIWAN 32054
Tel.: +(886)3-4227151ext 4504 Fax.: +(886)3-422-2681
Email: klou@db.csie.ncu.edu.tw

Owing to prevent a learning group from failing, teachers need to observe the group learning situation, and discover its causal dependence in a web collaborative learning system. Therefore, teachers need to record the web logs and try to analyze these row data. However, the web logs amounts are often exceeding the teachers' readability and becomes to be meaningless. This work presents some assisting tools of Bayesian belief network supported another window to observe the leaning situation objectively, and predicts the probability of the learning situation before the end of semester. This work was experimented on managing a web collaborative learning with 706 students online. The results represents these tools relieved the teacher of tedious data collection and analysis, analyzed the causal dependence of each learning features, discovered the hidden learning features related with the social interdependence, and prevent the students learning from failed.

Keywords: **Bayesian Belief Network, Collaborative Learning, Learning Features, WWW**

1 Introduction

In existing web learning systems, students may feel lonely without learning companions. Many researches have indicatethat students will learn better when they learn in a group [1] [2] [3]. Thus, the group learning mechanism can be adopted into web learning to overcome the lonely study issue. A web collaborative learning system requires the teacher to put lots of efforts in tracking and guiding these groups on the web. It is difficult for teachers to capture the group learning status from the huge amount of unorganized web logs. The situation is even worse when hundreds of students are involved in collaborative learning, and it is difficult to get information from them [16]. Therefore, many assisting tools for analyzing the web logs were developed. [4]

However, most of these tools focused on providing summary of how the website is being accessed, for example, the statistics of access time, access frequencies, and the access location of web page. In fact, these numeral results and statistics are not enough for a teacher to obtain the status of learning groups in a collaborative learning system. Teachers ask for information to help them promote the collaborative learning performance. Example information includes whether a group leader success in fulfilling her/his role; whether there is distrust existing among group members, and low perceptions of help and assistance [5].

Moreover, a teacher needs information to track the social interdependence of a learning group. Johnson [1] identified that *social interdependence* is a key factor that affects the success of learning groups. The *social interdependence* includes the goal, reward, resource, role and task interdependence. The problem is these impact factors cannot be captured directly by analyzing access logs. Furthermore, the inter-group communication context is not apparent. Therefore, it is a challenge for a teacher to obtain the status of these impact factors immediately when tracking and guiding a web collaborative learning system.

Once the impact factors of a web collaborative learning is detected, the graphical model for representing the causal relationships is required for teachers to make a decision to teach strategies and intervene groups' learning online. In order to preventing a group from failing in the early semester, an appropriate invention is needed. After constructing such causal map for several times, teacher will accumulate some experiences of how to prevent groups from failing in time. However, this kind of individual experience is not reusable for other teachers or teaching assistants.

There we summarized two issues mentioned above when teachers try to manage the web collaborative learning.

- Discover the impact factors of learning situation:
  Since the social interdependence affects the collaborative learning deeply, teacher need some assisting tools to find out the impact factors hidden in web logs and group portfolios.
- Prevent groups to be failed by experience analysis:
  At the end of semester of a collaborative learning, the experience and logs could be an important reference for the next semester. If teacher could find out the impact reason of specific states, her/he could prompt the group to learn or prevent the group from failing.

To resolve the issues listed above, our research tried to employ some data mining techniques and supported some useful information for teachers to manage the web collaborative learning.

The participators in this research included 7 teachers, 5 teaching assistants and 706 students. All of these participators teaching and learning via video compacted disc (VCD), and collaborated the group works and discussed to members on web. Students were divided into 2 classes: Class-A and Class-B. Both classes were used the same teaching strategies and curriculums. In this research, the learning logs of Class-A were used for constructing the relational map between each learning feature. It was the simulated past-experience for predicting the learning states of Class-B. The result shows that with the assistance of these useful tools, teacher could track and guide the web collaborative learning with meaningful learning states, discover the impact factors associated with the social interdependence, and predict the learning state and make a teaching decision online.

2 The Bayesian Believe Network

This work employed the Bayesian belief network (BBN) [6] to model the learning situations and represented the causal relationship between these situations in a graphical map. The BBN is a directive map composed by some nodes and arcs, these nodes and arcs represent the joint probability distribution for a set of variables. In this research, the nodes represent the group's *Feature Space (FS)* [7], and the arcs represent the relationship and the joint probability of two FS. It is named as "FS-based Bayesian belief network (FSBBN)". In Figure 1, it is an example for illustrating the FSBBN of a web-based collaborative learning: the "Learning Failed" node represented the group grade less than 60 at the final of semester. The "Homework Late Submitting" node represented the group homework were submitted after the deadline. The "Less Discussing" node represented the discussion amount in discussion place were less than 3 post each day. The "Less Login" node represented the average login times of a group less than 1. The "Leader Failed" node represented the group leader were failed in his jobs. The arcs in BBN represented the causal relationships between each node, and were constructed by the Bayesian Classifier. The Bayesian Classifier figured out the probability of each node that was affected by the previous nodes.

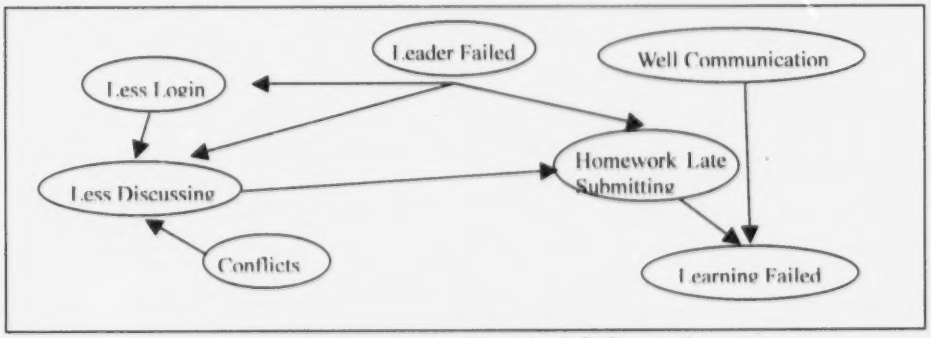


Figure 1: The example of Bayesian belief Network

Some probability tables deducted the directive arcs in FSBBN. Table 1 presents the probability of "Learning Failed" of a group, where "Learning Failed" is abbreviated to F, "Homework Late Submitting" is abbreviated to H, and "Well Communication" is abbreviated to W. The direct effects of "Learning Failed"included the probability of "Well Communication" and "Homework Late Submitting" both. Moreover, the direct effects of "Homework Late Submitting" included the probability of "Leader Failed" and "Less Discussion". In this way, the effects of "Learning Failed" included the probability of "Well Communication", "Homework Late Submitting", "Less Discussion", "Less Login", "Conflicts and Leader Failed".

	H,W	H,¬W	¬H,W	¬H, ¬W
F	0.35	0.93	0.02	0.54
¬F	0.65	0.07	0.98	0.56

Learning Failed

Table 1: The probability of Learning Failed

The FSBBN makes assistance for teachers finding out the relationships between each learning FS. It also supported the need for teaching decision in a web-based collaborative learning system, and will be illustrate in the following chapters.

3 Applying the Data Mining Tools in Learning Tracking and Teaching Guidance

To track students' learning status, teacher must to obtain the relationships between each impact factors of collaborative learning. In this chapter, several BBN tools support a directive map that illustrate these FS and help teachers to discover the objective causal relationships between these FS. These causal relationships support teachers to make a decision and promote the group to learn, prevent the group to be failed at the end of semester. This chapter will introduce some of free-wares and show how to apply these public tools in constructing a FSBBN and managing a web-based collaborative learning.

3.1 Observing the collaborative learning states and find out the impact factors

Bayesian Knowledge Discoverer (BKD) is noncommercial classification software for research, released by Knowledge Media Institute of Open University of UK. [8]. The aim of BKD is to provide a Knowledge Discovery tool able to extract reusable knowledge from databases, without expecting any particular methodological background from the user. To this aim, BKD uses BBN as a graphical representation of the dependent model in the database. Once the BBN generated from data, the network can be used as a self-contained reasoning system, able to provide observation, predictions and support decision making for a teacher.

The BKD needs a text file exported from database for constructing the BBN. The input data could be numeric or discrete data. To generated the complete causal network of a web collaborative learning, the input data of BKD should include the learning FS, personal profiles, online access statistics collaborative portfolios, and discussion situation. In Table 2, it illustrated that the teachers' interesting items about the learning situations. There are two groups of items: (1) learning FS (2) online statistic. All the values in this group were discrete Yes/NO or a label of level. The other items in second group were the online statistic from database, including the students' profiles, web accessing and discussion.
In Table 2, the "Conflict" means if the members have ever conflicted on the project goal with members, it represented the goal independence of a group. The "Lack Leadership" means the group leader failed in her/his role, it represented the leaders' role independence. The "Poor Comm" means the members made the communications with others rarely on the issues of project. The "Distrust" mean students have low trust with members about the discussion content and sharing resource, both of above FS represented the resource interdependence of a group. The "Poor Help" means if members did not like to help others in collaborative

project, it represented the reward independence of a group. The "Query Work" means the number that member query the current result of group project. It represents task interdependence of a group. Finally, the "Lower Grade" means the group failed in learning and got lower grades.

Group id	Conflict	Lack Leadership	Poor Comm	Distrust	Poor Help	Query Work	Disc Online	Email	Disc Lonely	Lower Grades	
1	N	N	Y	N	N	64	6	6	48	Y	
2	Y	N	Y	N	N	165	4	21	14	N	
3	Y	Y	N	N	Y	0	0	13	19	Y	
4	N	N	N	N	N	44	3	19	13	N	
5	Y	N	Y	N	N	196	4	26	25	N	
6	Y	N	N	N	N	198	57	6	170	N	
7	Y	N	Y	Y	N	91	4	27	33	N	
8	Y	N	Y	N	N	175	3	6	41	N	
9	Y	Y	Y	N	N	68	1	8	16	N	
10	N	N	Y	N	N	70	7	13	23	Y	
35	Y	N	Y	N	Y	12	2	3	15	Y	

Table 2: The input file for BKD (Class A)

After the input file import into the BKD, the system will construct a FSBBN for teachers to observe the relationships and the probability model for decision-making, like the example in Figure 1.

3.2 Experience reuse to prevent groups to be failed

To prevent groups to be failed early, the teacher would like to predict the group's learning state at the end of semester by the current states and her/his past teaching experience. The ideal to predict the learning states is to classify the new FS into the classes divided by the past FSBBN. In traditional classification tools, it contains two steps for prediction: first the system is trained by teacher's experience on a set of past data. The second, system will classify the cases by the trained set. The Robust Classifier (Roc) [8] is also noncommercial classification software for research, released by the Knowledge Media Institute of Open University of UK. It supports an efficient tool for teachers to classify the past FS into several classes, and predict the new FS into these classes.

There are four steps of Roc to predict a set of real-time FS illustrated as follows:

1. Define the Bayesian classifier from a database:
2. Class selection and discretization:
3. Learning the past learning FS:
4. Predictions the real-time FS:

There is an example how a teacher using the four steps to prevent the group learning failed:

Step1. Collecting the learning FS and online access data as the input file. Table 2 illustrated the teacher collected the input data of Class A for constructing the classifier. The input file has the same file format as the input file for BKD system.

Step2. Select one of the FS of input data as the class. For example, the teachers are interesting to obtain which group with the real-time FS will get lower grade at the end of semester.

Step3.After the Roc learning procedure proceed in this step, it generated the probability of each FS to the selected classes (Lower_Grades). In Table 3, two of FS: "Conflict" and "Leader_Failed" was listed and illustrate the probability of the group to be failed and get lower grades (Lower_Grades)

Step4. Predict the probability of learning failed via the online data of Class-B. Although Class-A and Class B were hold at the same semester, for prove the ability of prediction in this paper, the online FS of Class B were used as the test data. In case of the prediction were hold before the end of semester, some data were absent until the end of semester when predicting. In this research, several FS of Class-B were marked as '?' for simulating this situation.

Class Lower_Grade					
N Y					
(0.690) (0.310)					
	Attribute Conflict			Attribute Leader_Failed	
		Y	N		Y	N
	N	(0.621)	(0.379)	N	(0.172)	(0.828)
	Y	(0.385)	(0.615)	Y	(0.231)	(0.769)

Table 3: The results of Roc learning procedure

In Table 4, the coverage shows all the cases of Class B are predictable in RoC. The column "Lower Grades" is the original FS of Class B. It must be noted that in a real life case, this value of "Lower Grades" of Class B will not be known until the end of semester. The column "Predicted Result" is predicted by RoC with the input data in and the learning data. It is clearly that the system predicted group 1 would not get a Lower Grades at the end of semester. And the fact matched this prediction. However, the prediction of group 2 mismatched the fact. The column "Probability" represents the probability of such predictions of each group. In this experiment, the predicted result showed that the accuracy is 77.77% (28 correct, 8 incorrect). This credible result of RoC provides teachers not only predict the probability of each group to be Lower Grades, but also all other FS groups of social independence and will be discussed in next chapter.

Group id	Predicted Result	Lower Grades	Probability
1	N	N	0.561
2	N	Y	0.977
...	...	...	...
36	Y	Y	0.897
Correct:	28		
Incorrect:	8		
Accuracy:	77.77 %		
Coverage	100.0 %		

Table 4: The output file of predicted result (Class B)

4 Experience and Result

In this chapter, teachers exhibit a web-based collaborative learning on the "Introduction of Computer Network and Applications" course. The data mining tools such as BKD and Roc were employed and help teachers to observe the learning states, intervene the learning to promote collaborating and illustrated the ability to prevent the group to be fail before the end of semester.

4.1 The participants and the grouping on web

The participators included 7 teachers, 5 teaching assistants and 706 students in Taiwan. The 63% of students are teachers in high school, and all graduated form colleges or above. The 706 students were divided randomly into tow class named Class-A and Class-B. After the first month for students to be used to the environment, functions and operations, students were grouped into several heterogeneous groups by the grouping tools [9]. The grouping criterion included the personal profile and thinking style [10]. There were 35 groups in Class-A and 36 groups in Class-B, average 9.9 students in a group. The 63.5% of students are also the teachers in high school and all graduated from college or above. It represents most of the students did not have the difficult to get on-line. The students read the curriculums from video compacted disc (VCD). After the reading work, students must register in the NCUVC [11][12][15] collaborative learning system. The NCUVC support a web discussing space, collaborative project space and sharing resource in space, etc. The first group task is to elect the cadres, included the leader, co-leader and the clerk, and check-in the group private working space. The group private working space supported the online and offline discussion room, a resource sharing space, a portfolio space, a project scheduler, and a window for querying the member working states.

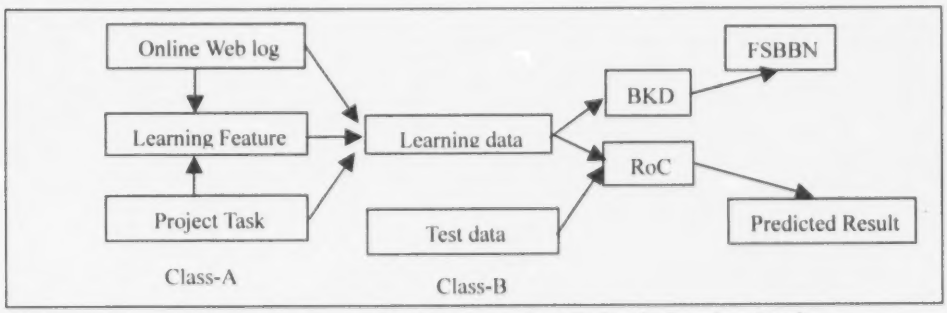


Figure 2: The process for observing and predicting the learning situation

Figure 2 illustrates the process for teachers to observe the learning FSBBN and predict the learning situation. For observing the learning states, teachers collected all the online/offline data to be the learning data and the input data for BKD system. The output of BKD is the form of graphical FSBBN. For predicting the learning situation of Class-B, teacher employed the training data to be the first input data of RoC system. The online data of Class-B is the test data and second input data of RoC. The result classified the cases of Class-B into the classes of Class-A, and support probability of each class for teachers.

4.2 Observe the learning states

After all the groups were ready to work together, teachers assigned the first project to each group. It is a collaborative project for constructing the web site for teaching the techniques of web programming. In the progress of project, teacher would like to observe the learning and working states of each group. There two type of observing method supported NCUVC. First, the subjective FS: teachers could construct the FS subjectively and focus on the specific group learning/working states, which are interesting for individual teacher. Because different teachers will define different FS for each group, it is the subjective observing tool dependent on teachers. Second, the objective FSBBN: it is a causal map based on the FS and all the accessing logs on web, the BKD system will construct the FSBBN for each group. Therefore, teachers could track the learning states and the causal relationships between each FS and access log. Because the causal map was constructed by the Bayesian method, it support the objective observing tool. The following figure is an example for observing the learning Class-A.

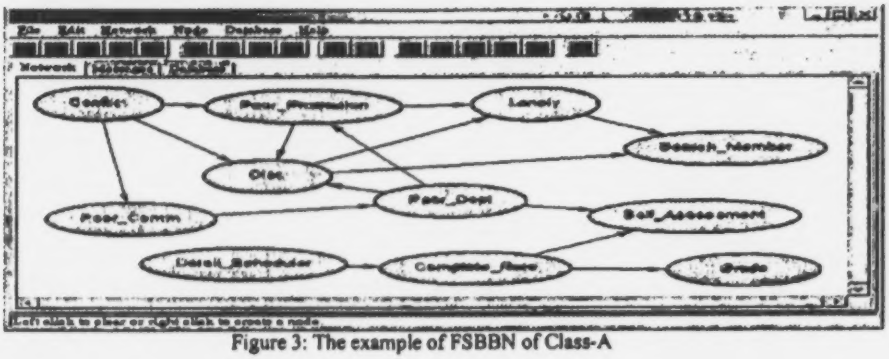


Figure 3: The example of FSBBN of Class-A

In Figure 3, teachers were interesting the causal relationships of homework grades (Hw_Grade) of each group. This FSBBN illustrated that the homework grades were influenced by the complete rate of homework (Complete_Rate). The BKD also figured out the probability of each level of Complete_Rate (high,mid,low) and the level of Hw_Grade(good,general,poor). It was illustrated in the following table.

Complete_Rate \ Grade	Good	General	Poor
High	0.956	0.022	0.022
Mid	0.006	0.990	0.004
Low	0.028	0.042	0.930

Table 5: The probability of Complete_Rate and Hw_Grade

It is clearly that the group with higher complete rate, it has higher probability (0.956) to get good grade at the end of semester. In contract, the lower complete rate has higher probability (0.930) to get poor grade. Thus, teachers could observe the causal relationships of each learning features with the help of FSBBN.

4.3 Discover the causal relationships between FS and social interdependence

The social interdependence exists when the outcomes of individual are affected by each other's action [1] [13]. It plays an important role for the success of a collaborative learning. However, teachers have difficult for observing the social interdependence without face-to-face interaction on web. In this chapter, all the social interdependence was transformed into the form of FS and the FSBBN, these representation could be a

BEST COPY AVAILABLE

window for observing and predicting the level of social interdependence. With the categories made by Johnson's *Interdependence Typology* [1] the five type of *positive interdependence* must be discussed first. The next table illustrated the web collaborative learning FS related to John's positive interdependence. Johnson's positive interdependence was not evident These FS were classify by teachers' subjectivity

Positive Interdependence	Feature Space
Goal interdependence	Goal_discuss, Query_group_portfolio, Query_members_work, ...
Reward interdependence	Grades, Help_members ,Answer_discussion,...
Resource interdependence	Discussing, Upload_resource, Query_resource, ...
Role interdependence	Allot_task, Leader_failed, Individual_responsibility, ...
Task interdependence	Portfolio, Query_scheduler, ...

Table 6: The associated feature space for observing the positive interdependence

However, some FS associated with these positive interdependence was hidden and not listed in the teachers' subjective FS. The Bayesian method could discover these *missing data* [14] and the causal relationships. In this experiment, teachers tried to collect all the web logs and the result of questionnaires, transformed these data into 70 FS as the input file of BKD. The BKD could discover the missing related FS associated with this social interdependence. First, teachers classified the groups into two classes: goal interdependence and poor goal interdependence. The new class was added into the system as the new FS and named as "Goal_Interdependence". Teachers could selected all the FS or a set of FS including the new FS as the input data of BKD. After the analysis of BKD, the new related FS associated with "Goal_Interdependence" could be discovered in the FSBBN.

4.4 Prevent the group to be failed

In chapter 4, the Roc system supported the credible prediction for the FS of Class B with the experience of Class A. In this experiment, the correct rate is 77.77% is good enough for a teacher to prevent the group to be failed. In fact, some irrelative learning data will reduced the correct rate. For saving time and increase the correct rate of prediction, teachers would like to migrate the redundant FS and remain the necessary FS. The issue is which FS should be migrated and which FS should be remained? The positive interdependence supported a good idea about this issue. In Table 7, teachers tried to predict the probability of learning failed (Low_Grades) with different FS associated with the positive interdependence.

Learning data	Correct Rate of Prediction
Goal interdependence FS	100%
Reward interdependence FS	88.89%
Resource interdependence FS	88.89%
Role interdependence FS	66.66%
Task interdependence FS	86.11%
All the FS	77.77%

Table 7: The correct rate of prediction with different type of FS learning data

The result illustrated that teachers selected different part of FS related with the social interdependence and improve the correctness of prediction. It is interesting that in this experiment, the FS related with goal interdependence has the most dependent relationship with the group grades. The FS related with role interdependence has the least dependent relationship with the group grades. Therefore, teachers could observe the goal interdependence FS at next semester to prevent the group from being failed. Teachers could not only predict the fail probability of a group, but also predict any FS with the subset of all the FS in this system.

5 Conclusion

To assist a teacher in tracking and guiding a web collaborative learning this work has presented the assisting tools for observing the group states, discovering the impact factors of learning situation, and reuse the experience to predict the learning state. The Bayesian method supports an efficient way to achieve these purposes. Without the proposed mechanisms, a teacher must spend considerable time in trying to analyze situation from huge amount of unorganized web logs. The causal relationships of learning situations were hard to track. To predict the learning situation depended on teacher's individual experience that is imprecise

BEST COPY AVAILABLE

and could not be reused for other teachers. This work (1) transformed the huge amount of meaningless web log into the form of readable and meaningful feature space, (2) supported the graphical FSBBN for observing the learning states and discovering the hidden impact factors of web collaborative learning, (3) predicted the learning situation successfully before the end of semester with the online learning situation and experience of past semester.

Observation and tracking the group's learning situation help teachers determine instructional strategies and group's learning performance. With the advantage of feature space and FSBBN, teachers can observe learning performance and analyze the influence of learning situations. The learning space is constructed as a hierarchical graph and teachers can define features for themselves via the instructional domain knowledge, doing to easily and meaningfully. The FSBBN illustrated the causal map of learning situations. With the past experience of tracking and guiding, teachers could predict the learning situation before the end of semester. Therefore, teachers could intervene the group learning to prevent the group from being failed.

Finally, the experiment result demonstrates that teachers' tracking and guiding a web collaborative learning with 706 students were successful and efficient.

Acknowledgement

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC88-2520-S-008-002.

Reference

[1] Johnson, D.W., and Johnson, R.T. "Learning together and alone" (33rd ed.). Egnlewood Cliffs, NJ: Prentice Hall

[2] Collis, B., Andernach, T., & Van Diepen, N. "Web Environments for Group-Based Project Work in Higher Education". International Journal of Educational Telecommunications. No.3 Vol.2 pp.109-130.

[3] Shotsberger, P.G., Smith, K.B., & Spell,C.G. "Collaborative Distance Education on the World Wide Web: What Would That Look Like?", Proceeding of CSCL, 1995. pp.312-316

[4] Zaïane O., Xin M., and Han J. "Discovering Web Access Patterns and Trends by Applying OLAP and Data Mining Technology on Web Logs". ADL 1998: 19-29

[5] Adams, D.M. and Hamm, M.E. "Cooperative Learning, Critical Thinking and Collaboration Across the Curriculum". Charles C Thomas Publisher, 1990

[6] Gertner, A.S., Conati, C., VanLehn. K. (1998). Procedural Help in Andes: Generating, Hints Using a Bayesian Network Student Model. AAAI/IAAI 1998: 106-111

[7] Ou, K.L. Chen, G.D., Liu, C.C., and Liu, B.J "Instructional Instruments for Web Group Learning Systems : The Grouping, Intervention, and Strategy" Proc. The 5th Annual Conference on Innovation and Technology in Computer Science Education, 2000

[8] Ramoni, M. and Sebastiani, P. "An introduction to the Robust Bayesian Classifier". KMI Technical Report Kmi-TR-79, Knowledge Mddia Institute, The Open University, Milton Keynes, 1999

[9] Chen, G.W., Ou, K.L., and Liu, C.C. "Instructional Instruments for Grouping, Intervention, and Strategy Analysis on Web Group Learning Systems". Proc. International Conference on Compters in Education 99, Chi-ba, Japan. (October, 1999)

[10] Sternberg, R. "Thinking Styles" ,Cambridge University Press.

Gertner, A.S., Conati, C., VanLehn. K. (1998). Procedural Help in Andes: Generating, Hints Using a Bayesian Network Student Model. AAAI/IAAI 1998: 106-111

[11] Ou, K.L., Chen G.W., and Liu,B.J. "A Group Learning Environment in a Virtual Classroom Built on WWW". Proc. 6th International Conference on Computer Assisted Instrution, 1997

[12] Liu, C.C., Chen, G.W., Ou, K.L., Liu, B.J., and Horng, J.T. "Managing Activity Dynamics of Web Based Collaborative Applications". International Journal of Artificial Intelligence Tools, Vol. 8, No. 2

[13] Webb, N.M. "Peer interaction and learning in small groups". International Journal of Educational Research, 13(1), pp. 21-29.

[14] Little, R.J.A. and Rubin, D.B. "Statistical Analysis with Missing Data". Wiley, New York.

[15]Ou, K.L., Chang, C.K., & Chen, G.D."Web-based Asynchronous Discussion System". Internatinoal Conference on Computers in Education 1998.

[16] Chang, C.K., Chen, G.D., Ou, K.L., & Liu, B.J. "Student Portfolio Analysis for Decision Support of Web-Based Classroom Teacher by Data Cube Technology". ED-MEDIA/ED-TELECOM 98

What kind of interaction and reflection emerged in a teachers' learning community?

Development and evaluation of computer supported collaborative learning (CSCL) software for teacher education

Jun NAKAHARA*, Toshihisa NISHIMORI, Yoshimasa SUGIMOTO***, Tatsuya HORITA**, Keizo NAGAOKA*****

** Communication & Media Lab. Dept. of Advanced Human Sciences, Graduate School of Human Sciences, Osaka University, 1-2, Yamadaoka, Suita, Osaka 565-0871 Japan*

***Faculty of Information, Shizuoka University, 3-5-1, Jyohoku, Hamamatsu, Shizuoka 432-0081 Japan*

**** National Institute of Multimedia Education, 2-12, Wakaba, Mihama-ku, Chiba, 261-0014 Japan*

n-jun@mbd.sphere.ne.jp**1*, nisimori@mmgate.hus.osaka-u.ac.jp**2*,
k-you@mmgate.hus.osaka-u.ac.jp**3*
*horita@horitan.net**, nagaoka@nime.ac.jp****

This study aimed at developing a CSCL software for a community of teachers and evaluating its effects. This CSCL software called Teacher Episode Tank has two interfaces called "Journal Window" and "Reflection Board". Through each interface, teachers can talk about their lessons and can reflect upon several aspects such as their lessons, their concepts of learning and teaching, and several educational points. Moreover, teachers are able to share ideas and benefit from interesting relationships among such ideas. In order to evaluate this software, twenty voluntary teachers participated in the research project along which two main points were analyzed: what kind of interaction and reflection emerged among teachers. The analysis led to two important conclusions. Firstly, in a virtual learning community on computer network, teachers could talk about teaching themes and share their views. Hence, the gradual increase of their interaction indicated the effectiveness of CSCL for teachers' education. Secondly, the software interface helped teachers to reflect upon three aspects: teaching methods, the concept of lesson and the concept of learning. Therefore, such reflections indicated that teachers were actively involved in the use of this software.

Keywords• **CSCL, Computer network, Learning community, Reflection**

1 Introduction

Some researchers have recently recognized the importance of Information Communication Technology for teacher education. The Computer Supported Collaborative Learning (CSCL) is one of the virtual learning environments for the school teachers. The purpose of this research is to develop and evaluate CSCL software as learning environment for teacher education. In this environment, teachers talked about their lessons, and also reflected upon them. In order to evaluate it, this research project was conducted by a voluntary teacher group. Two main aspects were analyzed: what kind of interaction and reflection emerged.

CSCL research is generated inside the field of cognitive science, which contains situated learning theory, and Information Technology. Situated learning theory suggests that learning is seen not as an individual's acquisition of Knowledge but as individual's participation in a learning community. Learners can learn in a community by means of practice, discourse, and activity. The importance of situated learning theory is that it generated an educational practice that is quite different from the traditional one which aimed at accumulating knowledge into individuals' heads. For example, Brown & Campione(1994) organized collaborative learning project to build a learning community in a classroom . In this project, learners were expected to inquire their topic of interest and exchange their expertise among them. Likewise, CSCL is designed to build a learning community through computer network.

Many CSCL research projects have been organized mainly in North America. In particular, Teaching TeleApprenticesships(Levin, Waught, Brown and Clift 1994) and TAPPED IN(Pea 1998) , are mentioning CSCL projects for teachers. Teaching TeleApprenticeships is the CSCL research project that supported the interaction among pre-service teachers, newly-appointed teachers and researchers who used e-mail and Bulletin Board System(BBS). As regards, TAPPED IN project, a virtual teachers' professional development center is built on the web site. In this case, many teachers can use BBS and chat system on this site to communicate with other teachers simultaneously. The design concept of both CSCL shares certain similarities, as the interaction among many teachers is the resource for teachers to enhance their professionalism.

However, there are two aspects related to prior CSCL research that have to be mentioned. Firstly, what kind of interaction emerged among teachers on CSCL project for teacher education? The interaction among teachers is not only emphasized but also required so as to clarify the quality of the interaction for further study. Recent teacher education research emphasized three point of teacher's activity to improve their teaching activity: externalization, sharing, and reflection. Teachers must externalize their everyday educational practice, share it with other teachers and reflect upon it so as to enhance their professionalism. Schön(1983) stated that the reflection upon their teaching is an indispensable element of their professionalism. For example, teachers write diaries everyday, and share this writing with other teachers to reflect upon their teaching (Conneley & Clandinin 1988). Secondly, previous CSCL research is not enough to characterize teacher's interaction on computer network and fails to consider the development of software interface to support it. In prior research, e-mail, BBS, and simple chat system were the channels used to support teachers' communication.

Murayama & Oshima(1999) stated that it is not enough to communicate by e-mail and BBS to discuss a topic about teaching, and concluded that it is necessary a specific interface which can display teachers' idea. Link or tag-attached as most of CSCL software's interface functions have contributed to establish the relations of the interaction among learners with visualization(for example, Scardamalia & Bereiter 1996), however, these interface functions in CSCL software are not developed yet for teacher education research.

Thus, we developed the CSCL software, which has the interface with visualized functions. This CSCL software was designed with the purpose that teachers could discuss their lessons with other teachers, and could also reflectupon several aspects such as their lessons, their concepts of learning and teaching and other educational matters.

2 Research Method

We developed a client-server shared database called Teacher Episode Tank (TET). TET client works on Windows 95/98/NT 4.0. TET server works on Window NT.

With regard to evaluation in educational technology, Bruce & Rubin (1993) concluded that we must inquire the realization process when the innovation leads to social practice. This kind of evaluation is called Situated Evaluation and aims to evaluate the effect of the new artifact in the real situation. This analysis requires collecting the data about behavior and practice of the when people are in the situation of using the new artifact. In order to evaluate this software, two main aspects were analyzed: what kind of interaction and reflection emerged. The subjects of evaluation were twenty teachers who were interested in collaborative learning by TV conference system. Those twenty volunteer teachers had been using TET everyday for three months. Not only teachers but also a faculty staff member of university and three graduate students participated in this project and properly joined teachers' discussion. Data for analysis were collected from learner's message on TET server; log data on TET client, and informal interview to teachers who participated in this project. The term of data collection was from September 1st. to November 28th. 1999.

3 Component of Teacher Episode Tank (TET)

3. 1. Journal Window

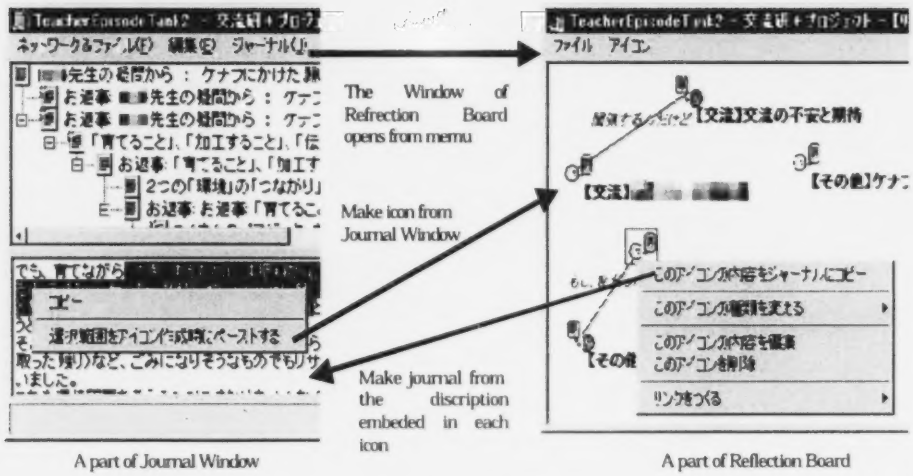


Fig. 1 Journal Window and Reflection Board

TET is composed of two interfaces called "Journal Window" and "Reflection Board". TET users can exchange messages with other users on "Journal Window "through network, and clarify the relations of interactions among users via "Journal Window "on "Reflection Board "so that TET users can reflect upon their teaching quite freely. TET users can change two interfaces alternately when using of this software.

Teachers can write their messages, specifically called "journal", about their teaching matters and comments regarding other teachers' journals on "Journal Window". Teachers who join this research project can look at and share their journals among each others on " Journal Window". The journals that teachers send are automatically categorized according to the topics of interest and categorized journals are displayed on "Journal Window" chronologically.

3. 2. Reflection Board

"Reflection Board" was implemented for teachers to clarify the relationship between journals by using some visual objects such as icon and link, and to put their comments about other journals. Teachers are expected to reflect upon their teaching methods and the concept of teaching on this interface. The characteristics of this TET software, a developed CSCL software, are that a teacher can privately use it for his reflection on this interface with visualization. It should be noted that this kind of interface function has not developed in TAPPED IN or Teaching TeleApprenticeships. As shown in Fig.1, each learner can extract from partially or completely other teacher's journal from "Journal Window" and paste it on "Reflection Board" as icon. The learner can also copy the content of icon on "Reflection Board" and move it to "Journal Window". Tags guiding teacher's interaction are attached to icon and link on Reflection Board. These tags are specific to the research project, and support teachers' relationships exteriorized in journals and ideas that can be concretely visualized. There are two main tags and five sub-categorical tags of icon. For example, two main tags are "My Idea" and "Your Idea", and sub-categorical tags are "Topic about Children", "Topic about Teacher", "Topic about TV Conference System", "Topic about Collaborative learning" and "others". According to the kind of these tags, the teacher can write the title and contents of icon when he makes icons. Besides, there are four kinds of links which are attached to tags. For example, four tags are "If I teach", "Relation", "Suggestion", "but". Learner can use this link to clarify the relations among icons and visualize the contents. The idea of the kinds of link derives from Engeströms' prior research. Engeström(1994) pointed out that one of the characteristics of communication among teachers was that they were fond of the subjunctive mood like "If I teach" rather than the formal constast like "However".

4 Evaluation of TET

TET was evaluated from two points of view: what kind of interaction emerged among teachers and what kind of reflection teachers exchanged on TET.

4. 1. What kinds of teachers' interaction were emerged on TET?

BEST COPY AVAILABLE

What kind of interaction emerged among teachers involved in learning community of TET? At first, let us begin to analyze the quantity of teachers' interaction on TET.

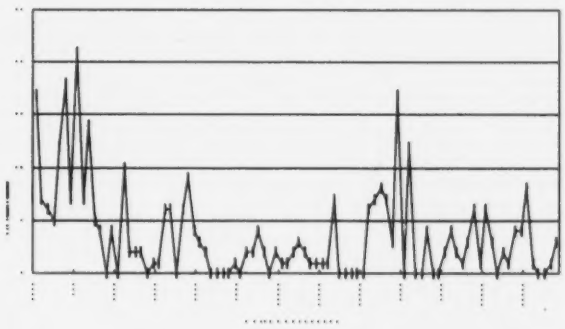


Fig. 2 The quantity of journal a day (N=330)

For the accomplishment of this research project, 25 professionals participated in and 330 journals were written. The daily average quantity of journals was 3.66 messages, the average quantity of journal per person was 13.2 messages. Fig. 2 showed the daily quantity of journal during our research project.

Category	The standard of classification
0. Project	Account of evaluation generally
1. Tool	The Topic of TET
2. How to use	The question on how to use TET
3. Formal report	Report of everyday practice in Japanese conventional format
4. Narrative	Teachers' reflection from everyday practice freely
5. Education	Topic of education
6. Material	Topic of learning material for example, TV conference system
7. Opinion	Opinion of education
8. Question	The question of other teachers' journal
9. Summary	The summary of other teachers' journal
10. Negotiation	The negotiation between two teachers about their lesson
11. Advice	Advice for other teacher
12. Note	The note of observation of other teachers' lesson
13. Others	Other content

By the following step, the analysis of journal contents was done by categorical classifications as shown in Table 1. Two researchers determined fourteen categories after reading the content of journals. For the sake of classification into categories, two researchers worked independently in the categorization of 330 journals. When those do not agree with the category classification, we discussed the content of journal so as to decide an appropriate category. The percentage of agreement was 74%.

Among 14 categories, "Formal report" and "Narrative" are the two most important ones. Here, " Formal report" represents the journal report about everyday practice in conventional format which consists of lesson title, lesson time, and lesson outcome. The characteristic of "Formal report" in the journal is that there is no emotional comment or reflection of the teacher in it. For example, the following journal fits into this category.

September 8th. , Wednesday
(Content) collaborative learning using TV conference system
(Time) AM 11:00 - 11:30
(Outcome)The purpose of my lesson today is have children get accustomed to TV conference system, Today, my students have experience of this system for the first time. In fact, students had no trouble in today's lesson, and enjoyed introducing and talking about insects and singing a school song all together
(99/09/08 Teacher Y's journal No. 98)

In this journal , teacher Y reported his lesson to other teachers ina conventional style, which is a popular style in Japan. In his writing, there is no emotional reflection and comment.

Regarding "Narrative" category, it is attached to the journal, and its content reveals teachers' reflection upon their teaching and lesson from their episode of everyday classroom activities. As described in the introduction, the purpose of TET is that teachers can talk about their lessons among each other and also reflect upon several aspects such as their lessons and their concepts of learning and teaching. The following journal is categorized into "Narrative".

Now, I divided my students into 4 groups and led them to plan independently projects of Kenaf (Kenaf is tropical tree and the most popular learning material of Problem-based learning in Japan). I think, it is desirable that each student communicates with students from other group about this Kenaf projects. However, I am beginning to question whether Kenaf as learning material is appropriate for this activity or not. You know, we can cook Kenaf and make papers from Kenaf, but each group is doing its activity independently, so it is difficult for students to collaborate with other groups. I wonder what makes each group collaborate with other.
(99/11/01 Teacher M's Journal No. 261)

A teacher's reflection on his practice was described on this journal. In a problem-based learning activity, the teacher had trouble related to integrate groups and how to have students communicate among them. So that way, "Narrative" journal contained teacher's reflection upon his classroom activity.

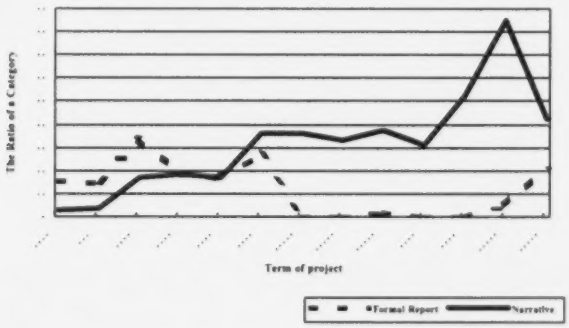


Fig. 3 showed that the quantity of "Narrative" was very low at the beginning of this research project, but gradually increased. On the contrary, the quantity of "formal report" was high at the beginning of this project, gradually decreased. Consequently, the tendency of the ratio "Narrative" to " Formal report" was low at the beginning, and the fact that it was high at the end of this research project showed that the teachers' learning community where many teachers talked about their teaching on CSCL was gradually formed.

4. 2. Teachers' Reflection

Here, the kind of reflection that emerged among teachers was examined by analyzing the data of "Journal Window " and "Reflection Board" on TET. Eleven teachers cooperated in the analysis. On Reflection Board, there are 23 icons (S.D.=11.3) and 18.7 links(S.D.=10.6) on average.

	Teaching Method	The concept of lesson	The concept of Learning	Others	Total
A	1	3	2	14	20
K	1	4	4	16	25
M	0	6	8	16	30
C	0	4	1	5	10
T	0	2	1	2	5
K	1	13	2	31	47
G	0	4	3	11	18
W	1	5	0	12	18
S	1	4	2	16	23
J	1	5	0	19	25
O	1	9	6	16	32
Total	7	59	29	158	253

Table. 2 Three kinds of reflection

There are many icons which teacher write about their reflections overall. Those icons were classified into three kinds of reflection as shown at Table. 2. First category was "Reflection upon Teaching Method". Second category was "Reflection upon the concept of lesson". Third category was "Reflection upon the Concept of Learning". The icon of "Others" category as shown at Table. 2 was added after discussion between two researchers. "Others" category was the icon that collected several comments, and was used as brief memo of teachers. In the paragraph, details about the three kinds of reflection about teaching methods, the concept of lessons, and the concept of learning are examined by quoting some cases.

4. 2. 1. Reflection upon Teaching Methods

"Reflection upon Teaching Methods" was observed on teacher's writing. "Reflection upon Teaching Methods" can be defined as the teacher's reconsideration of their teaching. By this stage, teachers consider whether teaching method has been effective and valuable or not. For example, Teacher W who conducted a presentation of children's scientific inquiry wrote the following journal.

> (Today, Children made a presentation of scientific inquiry.) But, their presentations were not interesting to me. Why? I considered this question.
>
> 1.Did I motivate them properly to make the presentation in front of classmates?
>
> 2.Did I pursue children to prepare their presentation?
>
> (99/09/03 a part of Teacher W's Journal No. 56)

Regarding this journal, two project members sent their replies. They gave Teacher W valuable advice and hints. The journal comments like as "Reflection upon Teaching Method" were more frequently observed on "Journal Window" than on "Reflection Board".

4. 2. 2. Reflection upon the concept of Lessons

"Reflection upon the concept of lesson" can be defined as teachers' reconsideration and question about the self-evident concept in everyday teaching. This kind of reflection was observed more often on Reflection Board than on Journal Window. For instance, Teacher G's journal was as follows.

> For example, well...everybody was writing about Social Studies on journal. But, by using "Reflection Board", I found that we did not discuss the essence of Social Studies. Teachers did not discuss what Social Studies is, and how it should be taught. After noticing that aspect, I realized that in fact, whenever I read others' journals, I found different meaning in them.
>
> (99/12/11 Teacher G's interview)

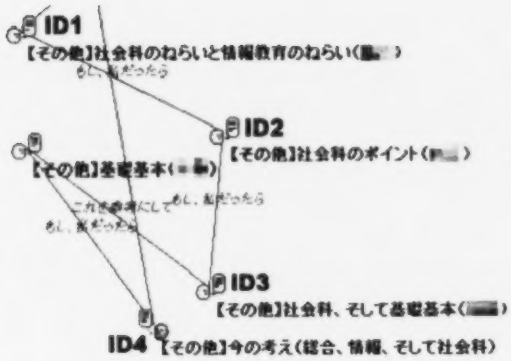


Fig. 4 A part of Teacher G's Reflection

In our research project, many teachers that major in Social Studies talked about their topic out of their own lessons. However, as Teacher G pointed out in his journal, although teachers using this CSCL software have interaction among them, no one was able toexplain what the essential core of Social Studies . Teacher G noticed it by using Reflection Board. Fig. 4 showed a part of Teacher G's Reflection Board.

On this board, Teacher G visualized other teachers' opinions (ID 1, ID 2, ID3, clarified the connections among such ideas and expressed his conclusions as icon (ID 4). In fact, we can conclude that "Reflection Board" supply teachers with effective support about questions regarding self-evident everyday practice.

4. 2. 3. Reflection upon the concept of learnin

"Reflection upon the concept of learning" can be defined as teacher's reconsideration of his own learning. In other words, teachers consider themselves as learners. This kind of reflection was more often observed on Reflection Board than on Journal Window. Teacher M's journal serve as an example of this reflection;

At first, Teacher M wrote about children's collaborative learning through TV conference system on some icons (ID1, ID2). Then, he wrote about the reflection upon his learning from other (ID 3, ID 4). Finally, he linked the icon of children's learning and those of teachers' learning. Hence, in some cases, the reflection upon teacher's learning derived from the reflection upon children's learning.

Fig. 5 A part ofeacher M's Reflection Board

BEST COPY AVAILABLE

5 Conclusion

Let us summarize the main point of our research. In this paper, we developed the CSCL software so that teachers can have online talk about their lesson and teaching, reflect upon their teaching and the concept of learning and teaching. To evaluate of this software, we adopted the evaluation method called Situated Evaluation, and analyzed what kind of the interaction and reflection emerged from teachers. From what has been discussed above. We can conclude as follows:
(1) In a virtual learning community on computer network, teachers can talk about their teaching and share their opinions among each other gradually. We can conclude from this fact that CSCL is an appropriate environment to facilitate teachers' learning.
(2) Therefore, it seems reasonable to express that as interfaces allow visualization, members of the learning community are effectively supported to interact and to clarify relations among ideas and comments.

References

[1]Brown, A. L. & Campione, J. C. "Guided discovery in a community of learners". McGilly, K.(ed.). Classroom lessons: Integrating cognitive theory and classroom practice. The MIT Press, MA. pp229 – 273 (1994)

[2]Bruce, B. C. & Rubin, A. . "Electronic quills: A situated evaluation of using computers for writing in classrooms" Erlbaum, NJ (1993)

[3]Clandinin, D. J. "Narrative and story in teacher education". Russell, T. & Munby, H.(eds.). Teachers and teaching: From classroom to reflection. Falmer, London pp 124 – 137 (1992)

[4]Conneley, F. M. & Clandinin, D. J.(eds.). "Teachers as curriculum planners : Narratives of experience". Teachers College Press, NY (1988)

[5]Engeström, Y. . "Teachers as collaborative thinkers: Active-theoretical study of an innovative teacher team." Carlgren I., Handal G. & Vaage S.(eds.). Teachers' minds and actions : Research on teachers' thinking and practice. Falmer, London. pp 43 - 60 (1994)

[6]Koschmann, T.(ed.). "CSCL: Theory and practice of emerging paradigm" . Erlbaum, NJ (1996)

[7]Levin, J., Waugh, M., Brown, D., & Clift, R. "Teaching TeleApprenticeships: A new organizational framework for improving teacher education using electronic networks" Machine-Mediated Learning. 4. pp 149-161. (1994).

[8]Murayama, I. Oshima, J. "The Characteristics of the communication between researchers and teachers on computer network.". Proceedings of 15th conference of Japanese society of educational technology. pp 619 – 620 (1999)

[9]Pea, R. "Distributed intelligence and the Internet as learning environment". Sayeki, Y., Yuasa, Y.(eds.). New direction of the use of computer in education. CIEC, Tokyo. pp 16 – 39 (1998)

[10]Scardamaria, M. & Bereiter, C. "Computer support for knowledge-building communities". Koschmann, T.(ed.). CSCL : Theory and practice of emerging paradigm. Erlbaum, NJ. pp 204 – 260 (1996)

[11]Schlager, M. S. & Schank, P. K. "TAPPED IN: A new on-line teacher community concept for the generation of Internet". Hall, R. , Miyake, N. & Enyedy, N.(eds.). Proceedings of CSCL'97. pp 231 – 240 (1997)

[12]Schön, D. A. "The reflective practitioner: How professionals think in action". Basic Books, NY (1983)

Proceedings

Content

▸Full & Short Papers (Computer-Assisted Language Learning)

A Computer-Assisted English Abstract Words Learning Environment on the Web
A new method for efficient study of kanji using mnemonics and software
A study of using Web articles to support college English students' ideas in writing
A Web-Based Model of Learning Java
AWETS: An Automatic Web-Based English Testing System
CALL with a Web-based Instructional System in Cooperative Learning Environments
CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL
Computer-Mediated Language Learning
Design for Interactivity
Developing a Web Concordancer for English as Foreign Language Learners
Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW
Development of Japanese-English,English-Japanese Conversation System with Voice Reading function and Machine translation
Development of the ELF in Taiwan Web site for English Learning and Teaching
Integrating Web-based Materials into Course Design
MyEnglishTeacher A WWW System for Academic English Teaching
Online ESL Learning: An Authentic Contact
Schema theory-based Instructional Design of Asynchronous Web-based Language Courses
The Design of a Synchronous Computer Aided English Writing Environment for the Internet
The Development of a Multimedia Program for Teachers to Integrate Computers into the English Curriculum
The effectiveness of integrating adaptive computer device and stimulus fading strategy on word-recognition for students with moderate mental retardation
Using electronic bulletin board as a virtual community to aid college English learning
Web Speaking: A Language Learning System in the Web

▲HOME

A Computer-Assisted English Abstract Words Learning Environment on the Web

Wenli Tsou*, Weichung Wang and Hungyi Li**
**Department of Languages & Literature Education*
***Department of Mathematics Education*
National Tainan Tainan Teachers College
E-mail: wtsou@ipx.ntntc.edu.tw

Vocabulary is the foundation of language learning. In review of the literature, the importance of vocabulary teaching has been emphasized again but the focus on vocabulary learning has been shifted to an individualized and self-paced learning process, rather than introducing frequency list. Learners need to interact with new knowledge they are going to learn with the existing knowledge or prior experience that they already have in their learning process. This corresponds to the idea of constructivism. Gearing to the same direction, we intend to design a system for abstract word learning. Since there is no concrete image for the abstract word, its learning is more difficult. We have developed an abstract word teaching-learning system which can facilitate teaching and also individual self-learning. Through multimedia and user friendly interaction techniques, student can assess the system anytime and receive different kinds of information on one spot. The learning material was conducted on a CAI system and would be carried out over the Internet. Students need only a web browser like Netscape navigator or Internet Explorer to access the system. A pilot testing was also conducted and promising results were yield. The result indicates that the abstract word learning system can successfully improve the quality of learning and teaching environment for the abstract words.

Keywords: **CALL, vacabulary learning, abstract word**

1 Introduction

Vocabulary is the foundation of language learning. In review of the literature, after 1970s, the importance of vocabulary teaching has been emphasized again in ELT (English Language Teaching)(4). ELT educators begin to review and reconstruct the importance of vocabulary learning and teaching. The focus on vocabulary learning has been shifted to an individualized and self-paced learning process, rather than introducing frequency list. Learners need to interact with new knowledge they are going to learn with the existing knowledge or prior experience that they already have in their learning process. As Gaims & Redman (3) emphasized in their discussion, new words' learning comes from learner himself. They advocated experiencing the lexical directly and extending vocabulary according to one's own need and purpose. This corresponds to the idea of constructivism, which asserts that learners participate in their own learning progress, and acquire the knowledge in context.

Furthermore, computer-aided research has giving us vast amounts of information about how words behave and the relationship they form in real-life communication. As a result, traditional ideas about what is involved in the teaching of lexis appeared to be no longer tenable. Many researchers have studied new thinking about vocabulary teaching. For example, the learner-based teaching proponents have prompted the idea of giving their students the tool and strategies to learn independently (6 & 7). In addition, the best way to learn new words is to consider it a "problem-solving exercise in which one attempts to find the best way of mapping new learning onto old (1). "Old-established words are part of a rich network of interwoven associations. As Schmitt & Schmitt (8) claimed "If new words can be integrated into this network, those associations can facilitate their recall".

Abstract words presents more difficulty in vocabulary teaching, and studies also show that compared with concrete words, abstract words are often perceived with lower accuracy in their meaning and language usage (5). Since there is no concrete image for the abstract word, its learning is more difficult for learners. Thus, the abstract word's teaching is often avoided from many vocabulary teaching and learning materials. However, when we review elementary English learning materials in Taiwan, we found that even with beginners, a lot of abstract words are already introduced in the context. Since it is not easy for teachers to teach or for learners to learn these abstract words, there is a need for a well-designed teaching or learning materials for abstract words.

Especially, vocabulary teaching has its priority in language learning at the elementary school level. English is going to be a required foreign language for most elementary schools in Taiwan. All kinds of English teaching and learning materials are thrown in the market. However, it is not easy to find appropriate teaching materials for elementary school level. Therefore, a good word teaching-learning system that can facilitate teaching and also individual self-learning is in urgent need.

Another reason for conducting this abstract vocabulary teaching and learning material is the massive application of computer in classrooms. The computer-assisted instruction (CAI) is now available for most teachers and students. CAI is going to become a new popular way of teaching and learning. Through multimedia and user friendly interaction techniques, students can access the system anytime and receive different kinds of information on one spot as well. With this abstract word learning material, other than controlling their own learning, students can also construct their own meaning for the learning material by selecting a suitable path out of all the various ways.

Thus, based on the points mentioned above, this study is intended to design an abstract-word learning system to facilitate teaching and self-learning. We planned to implement the learning material on a CAI system. While the CAI can be used as a standalone application, we would also carry out the CAI over the Internet. Students need only a web browser like Netscape navigator or Internet Explorer to access the system. Our implementation of CAI cannot only be used as a standalone application; we will carry it out over the Internet. Consequently, students may access the CAI anytime and anywhere by simply staying online and using a web browser, like Netscape Navigator or Internet Explorer. They do not need to install related software in advance. Course providers, like teachers, further enjoy the privilege of easy administration, real-time synchronization, and simple centralized contents updating.

If this abstract-word learning system can be implemented, pupils can use this system to learn abstract words through a more interesting way according to their own learning path. They can control their learning and retrieve their memory of the newly learnt vocabulary wherever they feel like to. In addition, this system is open for submission. Users or instructors can add to the system new words or modify the existing materials. In other words, the system can be updated and the database can also be enlarged. With this system, the researchers believe that this concept of vocabulary instruction and materials can open a new area to the English vocabulary teaching-learning field.

2 Methodology

FrontPage and Flash were applied in this study to design the abstract word learning system. The abstract word learning system includes the following areas; (1) text, (2) testing, (3) discussion, (4) related web sites, and (5) help, five different areas.

2.1. Text Area

This area is the main source of leaning materials. Based on the different characteristics of each abstract word, different means of presentations are selected, for example, pictures, movie, sound effect, games, etc. Through a variety of ways of presentation, we try to solidify and build up students' understanding of the abstract words.

The words selected on the word list are from Burkhard Leuschner's (2) " 2000 most frequent words" and the five recommended elementary English materials (Let's go、Gogo Loves English、Kids、Max &Mousy and YoYo & NaNa). We selected 295 abstract words from these two different resources. However, because of the limited budget and time, only 13 were included in this pilot system.

After the learner selected the word from the word list, s/he enters the definition area. When press the read icon, the pronunciation from a real person of that particular word or a sentence can be heard followed by related pictures. In general, the whole presentation is in English; however, the Chinese translation is also available. In order to get the Chinese translation, the user just needs to move the mouse over the designated English sentence.

The three icons on the upper right hand corner (Conversation, Practice and Songs) provide extra practices. Students can decide whether they want to study further about that selected word. The purpose is to provide the opportunity for students to control their own learning path. However, as aforementioned, since different word will have different ways of presentation, the icons for each word might differ. The display and explanation for each icon are as follows.

2.1.1 Conversation

Conversation provides context of the word for learners. In this area, motion pictures are used as a tool to elicit student's interests and concretize the impression or the meaning of each abstract word. Motion pictures can provide the setting and background information about the conversation. Students can actually experience the conversation and thus have better idea about the target word. In other words, through pictures and sounds, we hope the setting of the conversation can be provided and students' interests and understanding can be triggered.

2.1.2 Song

Songs and verses are very important for language learning, especially for young children. They are one of the best media to introduce language and culture. Therefore, in this section, we hope to introduce related songs or verses to reinforce the meaning and usage of the target word.

2.1.3 Practice

This part includes Plural practice, Comparison, Which is wrong? Choose the right one, Sentence completion, and Game.

- Plural
  Plural practice is specially designed for the vocabulary "this" and "that". Through the interaction with the computer software, we hope to reinforce the plural concept "these" and "those".
- Comparison
  Through comparison and contrast practices, students can relate these four words; this, that, these and those, easily and correctly with the existence of sounds, pictures and writing.
- Which is wrong?
  This activity emphasizes on mastering the relations of these four words (this, that. those & these) to the other words.
- Choose the right one
  In addition to sounds and writing, this section focuses on the usage of wh-words. Therefore, in this activity, individual words will be selected for each blank. By doing so , students have to understand when and how to use each of the target words correctly.
- Sentence completion
  In sentence completion, synonym, (e.g. mine, yours, his and hers) is presented as a different kind of input and output practices.

Game

Because of its unique characteristics, games can facilitate learning by providing a more interesting and relaxing environment. No actual scores will be calculated for the game; however, positive and negative sound effects will be provided alone with the results.

2.2 Testing

Testing area provides learners with on line self-evaluation opportunity. Learners can control their learning and retrieve their memory of the newly learnt vocabulary wherever they feel like to. The test itself also provides keys and the instant result for each question. In general, only the basic idea of the target word is tested, e.g. spelling and usage. Learners simply move the mouse to the desired alphabet then the result (or correct answer) will be shown immediately.

2.3 Discussion: E-mail and Chatting Room

This area provides contacts for students to the outside world. Learners can discuss or share their learning experiences with one another. Furthermore, they can cooperate and complete a group project with people in another learning environment or another country. This contrasts sharply with traditional learning in which the learning is independent and lonely. Through interaction or meaning negotiation, the understanding or the abstract word is deeply rooted and widely applied.

2.4 Related web sites

Through related web sites, knowledge can be cumulated quickly. Massive amount of information can be gathered by one click. The researchers have carefully selected these web sites; thus students can spend less time and energy to gather more related information for their learning.

2.5 Help Section

All the related information about this system is available for users in this section. The necessary knowledge for operating the system and prior knowledge about web application is all included here for any online service.

With this service, learners can access the whole system without any technical obstacles and obtain the greatest effects of applying this system.

3 Conclusion

The abstract word learning system was piloted to 60 sixth grade elementary school students. According to the literature, children at the age of 11 are believed to be ready for abstract thinking. Since the focus for this system is abstract words, sixth graders (around 12 year of age) are the best subjects for the study. The pilot study shows a better learning consquence of the abstract word learning system when compared with the instruction of the teacher. In other words, the abstract word learning system can successfully help students better learn abstract English words. In addition, the survey for the experimental group shows a great liking for the learning system from the students; around 80 percent of them enjoyed learning with this system and would like to learn with this kind of system again. This indicates that the system not only effective but also interesting which is a very important element for young children's learning. The above results have confirmed the significance and the advantage of this abstract word learning system. If this kind of abstract word learning system can be developed and used in schools, both the teaching and learning quality can be improved and students will have greater joy and success in language learning.

References

[1] Baddeley, A., Human Memory: Theory and Practice. Needham Heights, MA: Allyn and Bacon (1990).

[2] Burkhard, L., Wordlist: 2000 most frequent words [on-line]. Available: http://www.GMUEND.DE/PHG/PHONLINE/Englisch/Leuschne (1999).

[3] Gairns, R. & Redman, S., Working with words: a guide to teaching and learning vocabulary. NY: Cambridge (1986).

[4] McCarthy, M., "Recent directions in vocabulary teaching." The Language Teacher, Vol 65, No. 12, pp. 9-11, (1990)

[5] McFall, E. et al, Influence of Word Meaning on the Acquisition of a Reading Vocabulary in Second-grade Children. Reading and Writing: An Interdisciplinary Journal, Vol 8, No.3, pp. 235-50 (1996).

[6] O'Mally, J. M., Chamot, A.U., Learning Strategies in Second Language Acquisition. Cambridge: Cambridge University Press (1990).

[7] Oxford, R. L., Language Learning Strategies: What Every Teacher Should Know. NY: Newbury House (1990).

[8] Schmitt, N., Schimitt, D., Vocabulary Notebooks: Theoretical Underpinnings and Practical Suggestions. ELT Journal, Vol4, No. 9/2, pp. 133-143 (1995).

A new method for efficient study of *Kanji* using mnemonics and software

Chris Houser*, Shigeki Yokoi and Takami Yasuda****
**Kinjo Gakuin University, Omori 2-1723 Moriyama-ku Nagoya 463-8521 Japan,*
houser@kinjo-u.ac.jp
***Nagoya University, Furo-cho Chikusa-ku Nagoya 464-8601 Japan*

Japanese children spend hundreds of hours, over nine years, studying some 2000 written characters called *kanji*. Incredibly, most foreign adults attempt to study the *kanji* using the *same* method. But without these hundreds of hours, their efforts generally fail. In *Remembering the Kanji*, James Heisig presents a radical method for studying *kanji*. In only 200 hours, Heisig claims, adults can learn the *kanji*. A wonderful improvement! But few students follow his method; most complain that 200 hours is still too long. This paper introduces a refinement of Heisig's technique, a refinement combining modern memory theory with software, a refinement reducing the required time to 40 hours. The first author, a forgetful *kanji* neophyte, learned the *kanji* with this method, studying an hour a day, five days a week, for two months. His recall exceeds 95%, approximating native Japanese. This paper targets both teachers and students of Japanese as a foreign language, providing the knowledge and software required to rapidly learn the *kanji*, and inviting them to participate in a wider experiment using these new technologies.

Keywords: **CALL, Kanji, SuperMemo, Efficient study**

1 The *Kanji*

Perhaps the most difficult part of learning Japanese is memorizing its enormous character set: the 2000-odd *kanji*. These characters were imported from China into Japan. Because each character was imported several times over the centuries, while the Chinese and Japanese languages were evolving, each character now has multiple readings and meanings. As a result, the Japanese writing system is arguably the world's most complex.

Japanese children study these *kanji* for hundreds of hours over nine years of schooling. They start studying when six years old, before they have developed the ability to abstract, and hence can learn the characters only by *muscle memory:* They write the characters repeatedly, typically 20 times each. This method works, but imperfectly: Even after all this study, and the review that comes with daily use, adult Japanese forget some characters.

Most foreigners studying Japanese as a foreign language (JFL) try to learn the *kanji* using the same method: They write the characters repeatedly, perhaps while verbalizing the character's meanings and readings [7]. But since few adult JFL students have the hundreds of hours this method requires, most fail [4].

2 Heisig's method for studying the *kanji*

Heisig [4] offers an alternative study method.
Goal. Heisig's method allows adult JFL students to learn the *writing* and a *single meaning* of 2042 *kanji*. This is a narrow goal: Students concentrate on learning this writing and single meaning, and postpone learning other meanings, all readings, and the multiple character compounds.
Method. Since Heisig targets adults, he is able to use a sophisticated method, a method beyond the grasp of six year olds. He is able to use a *rational* method for learning *kanji*. Heisig prepared his method by

1. assigning each character a *keyword* (its single meaning),

2. splitting each character into a handful of *parts*,
3. ordering the characters so that parts precede their uses, and
4. inventing a mnemonic story to help recall each character's parts.

The keyword is usually the most common of the several Japanese meanings. The parts come from various sources: Some are simpler *kanji*; others are *primitives* – collections of commonly occurring strokes. Some of these primitives were identified centuries ago by Chinese and Japanese linguists (who call them "radicals"); other primitives were simply invented by Heisig. In all, Heisig uses a few hundred parts. The crux of his method:

Each character is learned, not as a mass of random strokes, but as a logical collection of parts.

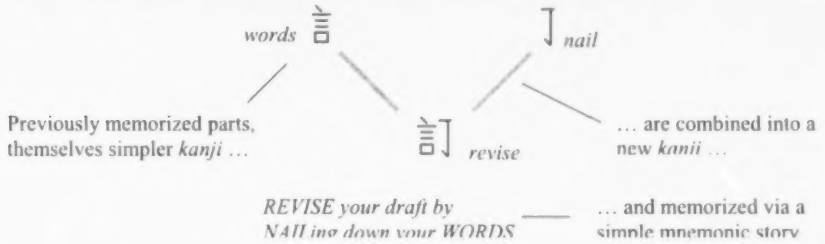
For example, consider the kanji with the keyword revise. This character has **nine meaningless strokes**, which prove quite a challenge to remember. But this same character has only **two parts** with the keywords *words* and *nail* – **meaningful** words which are much easier to remember. In effect, Heisig splits this character into these two parts, making a kind of equation: *revise* = *words* + *nail*. Most non-Japanese find this equation much simpler to recall than a meaningless jumble of nine strokes. When Heisig's students come to study *revise*, they have already learned the two parts – *word* and *nail* – since Heisig has sorted the *kanji* so that these parts precede their use in *revise*. By combining two previously learned parts, students easily remember this new character. But Heisig makes remembering even easier by providing a **mnemonic story**:

REVISE your draft by NAILing down your WORDS.

The image of "nailing down one's words" is so strong and logical that after students have read this mnemonic **once**, they will likely remember it for life.

This contrasts with Japanese students, who practice **writing** the character **repeatedly,** and may later forget it.

Heisig's main contribution is to **raise the level of abstraction** from strokes to parts. Rather than struggling to remember a large, sprawling jumble of meaningless jots and dashes, students effortlessly remember a simple story, calling to mind the few parts that compose a *kanji*:



Study. Heisig has done most of the work: He has assigned the keywords, identified the parts, invented the primitives, and sorted the *kanji*. Students need only read the keyword and story a few times to memorize each *kanji*. Heisig predicts study will require 200 hours – far less than Japanese children spend on rote repetition.

Analysis. Why is Heisig's method so effective? Here are three explanations.

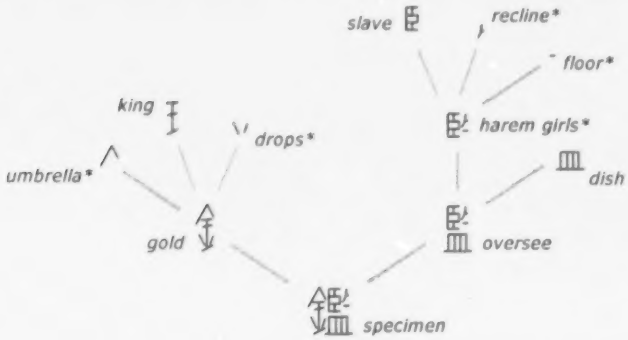
Simplicity. The stories are simpler than the *kanji*, simpler because they have fewer components. Each *kanji* consists of between 1 and 23 strokes; 75% of the *kanji* have more than seven strokes. But all have fewer than seven parts. Now human short-term memory can hold only about seven items [6]. Objects with more than seven known components cannot fit in short-term memory, and so cannot be remembered, or even recognized. This predicts that students learning strokes will remember 25% of the *kanji*, but students learning parts will remember 100%.

Abstraction. Practicing strokes engages only muscle memory: Most of the student's brain remains dormant. Heisig's stories engage the higher faculties of language, actions, settings, events, humor, and metaphor. Such meaningful symbolic processing engages more of the brain, and hence is more easily recalled, than mere orthographic syntax [8]. Humans recall abstract meanings and stories long after they forget specific examples and images [5].

Relations. When learned by rote, each *kanji*, indeed each stroke, must be learned anew: Nothing is connected to anything else. When learned by parts, each *kanji* is connected to previously learned *kanji*.

Heisig's method is rich in connections. When students learn a character, they are also reviewing its parts. In turn, most parts appear repeatedly, and hence are memorized easily.

As an illustration, consider the daunting 23 strokes of *specimen*. Stroke-by-stroke memorization is all but impossible. But *specimen* comprises only two parts: *gold* and *oversee*. It is easily recalled with a story such as *GOLD diggers OVERSEE their mineral SPECIMENS. Specimen* is studied after *gold* and *oversee* have been learned, from their own parts, with their own stories. So each step of study is small and simple, but the steps build on each other – primitives are woven into *kanji*, which are in turn used to build further *kanji* – until a vast web of rich connections is built up in the student's mind.



Parts are either simpler *kanji*, or *primitives* (marked with *)

Problem: Still too difficult! Heisig's method is a great improvement over the Japanese method, but it is not perfect. For Heisig provides stories for only the first 500 of his *kanji*, and asks readers to invent their own stories for the remaining 1542. Faced with this burden, many of Heisig's students stop studying after 500 characters. And those who do continue need unusual discipline, need to painstakingly construct and review flash cards, need a scheduling system to study, review, and test.

3 Kanji Can

Kanji Can [3, 1] is a database with a *complete* set of 2042 mnemonic stories. The stories are excellent, surpassing even Heisig's first 500:

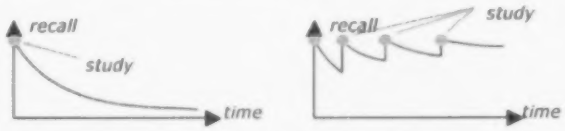
- Kanji Can's stories are shorter, and so easier to recall.
- Kanji Can's stories mention the parts in the order they are written.
  (Compare with Heisig's story for *revise* above, which reverses them.)

Kanji Can embraces Heisig's method, but extends his materials, and thus solves the problems mentioned above.

4 Flash Cards

The chief tool of most memorizers is the humble flash card. Flash cards are small paper cards with a *stimulus* written on the front side, and a *response* on the back. When studying foreign language vocabulary, the stimulus is typically a word in one's native language, and the response is the word in the foreign vocabulary. When studying *kanji* using Heisig's method, the stimulus is the keyword, and the response is the *kanji* itself.

Students read the stimulus and try to produce the response. They then check their response against the desired response on the back of the card. Cards that were correctly recalled are removed from the deck; cards not recalled are shuffled to the back of the deck, to be reviewed again. Used this way, flash cards combine self-testing with review. The cards catch mistakes and save them, allowing review until the student knows them all. Flash cards



Memory fades after Repeated study slows

are essential when following Heisig's method: Studying the stories is so easy that students will doubt they are really learning anything until they have been tested!

Problem: Inefficiency. Using flash cards takes a lot of time. Each card must be hand made. Then each card must be tested repeatedly, for only with repetition comes dependable memorization. Memory fades over time, but by reviewing partially forgotten material students extend their memories.

But how frequently should students review? Buzan [2] recommends review after ten minutes, a day, a week, a month, and then four months. But are these the best intervals for review? Testing too frequently wastes time reviewing material already well known. Testing too infrequently wastes time relearning forgotten material. The goal of flash cards is to "catch" learners just before they fall – to remind them just as they are about to forget. But the point of forgetting – and hence the optimal review interval – differs for each student, and even for each *kanji*: Some are easier to remember than others. How can we optimize study?

5 Super Memo

Super Memo is a general flash card program [9]. Like paper flash cards, these electronic cards can be used to review anything, including the *kanji*. Unlike paper cards, these electronic cards are neat and easily editable, but require a PC. Super Memo is better than paper flash cards because it contains a mathematical model of human forgetting: It can predict when a student will forget a *kanji*, and hence compute the best testing time. When testing with Super Memo, students tell the program how well they remember each *kanji*; the program uses this information to tune its model to each student, and to each *kanji*. The result closely approximates perfectly timed intervals, and hence maximum efficiency in studying.

Independent of the nature and amount of material they study, students using Super Memo all learn approximately 200 items/minute/year. This means that by studying one minute, every day, for a year, one can learn 200 items; or, by studying 10 minutes a day, 2000 items. This is much faster than many other study methods; in particular, Super Memo implies results in 1/5 of Heisig's time.

Super Memo's computerized scheduling provides more than optimal reviews. It also provides an incentive to study every day. A student using Super Memo runs the program every day and finds a list of items to review. If the student skips a day, the next day she will be confronted with twice as many items! This threat helps provide the discipline necessary in learning a large body of material, such as the *kanji*. (Unfortunately, this also means that if the student skips a week, she will be confronted with a mountain of review, and will likely quit altogether. Super Memo is not for the timid.)

6 New technology allows learning the *kanji* in only 40 hours!

This paper proposes a new method for learning the *kanji*, a method combining Heisig's novel ideas, Kanji Can's stories, and Super Memo's reviewing. Heisig provides the tractable goal and the idea of using mnemonic stories to recall the writing of *kanji* in terms of their parts. Kanji Can provides a complete set of these mnemonic stories. And Super Memo provides strict scheduling and efficient reviewing and testing. The combination of these three educational technologies provides a most efficient *kanji* learning method: the complete set of 2042 *kanji* can be learned in only 40 hours!

These 40 hours might be scheduled as 10 minutes a day, every day for a year, or an hour a day, five days a week, for two months. Memory manuals claim that an hour's study a day is optimal: Shorter study sessions waste time in frequent physical and mental preparation, longer study sessions induce fatigue, and both degrade efficiency [2, 5].

The first author learned the *kanji* in 40 hours by following this method.

Heisig has greatly accelerated *kanji* learning for adult JFL students. Kanji Can's complete set of stories enables students to concentrate on studying the *kanji*. Super Memo provides a well-documented speedup for any rote memorization. Combining these three technologies, we can learn the *kanji* in only 40 hours.

References

[1] Breen, J., *KanjiDic*, ftp://ftp.cc.monash.edu.au/pub/nihongo/00INDEX.html (2000).

[2] Buzan, T., *Make the most of your mind*, Pan, London (1977).

[3] Donaghue, M., *Kanji Can*, http://www.kanjisoft.com (2000).

[4] Heisig, J., *Remembering the Kanji I*, Japan Publications Trading Co., Tokyo (1977).

[5] Maddox, H., *How to study*, Ballantine, New York (1963).

[6] Miller, G., "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information", *The Psychological Review*, vol. 63, pp. 81-97, http://www.well.com/user/smalin/miller.html (1956).

[7] Sakade, F., Emori, K., Friedrich, R., Ohashi, S., *A guide to reading & writing Japanese*, Charles E Tuttle, Rutland, Vermont (1959).

[8] Schmidt, U. & Geyser, A., "How to study 2000 kanji in a few weeks", *Proceedings of ICCE 99*, pp. 595-598 (1999).

[9] Wczniak, P., *Super Memo*, http://www.supermemo.com (2000).

A study of Using Web Articles to Support College English Students' Ideas in Writing

Hsien-Chin Liou and Hsin-Yi Yeh
Dept. of Foreign Languages and Literature, National Tsing Hua University
101 Sec. 2, Kuang Fu Road, Hsinchu, Taiwan 300
Tel: +886-3-5742709
Fax: +886-3-5718977
Email: hcliu@mx.nthu.edu.tw

Among various Internet resources, the World Wide Web (the Web) becomes very popular recently and plays an influential role in English learning. This study aims to explore how college-level English learners in Taiwan cite reading materials on the Web to write their own compositions. Fifteen college sophomores were required to write a source-based paper using electronic resources on the Web. It was found that those who have higher reading proficiency and more previous Web experiences write better souce-based papers. Also, the subjects were able to obtain the gist of others' Web articles and organized it into their own compositions. The quality of citation was quite good, although the subjects relied on quotations from others' Web articles to support their own ideas.

Keywords: **Web-based learning, source-based papers, World Wide Web**

1 Introduction

In the Information age, college students and professionals have more and more opportunities to search for information on the Internet and the World Wide Web. Reading on the Internet is unlike traditional reading. Much has been claimed about the prevalence of hypertextual discourse and its possible impact on education. It is believed that reading on the Web, using the selected information, and making meaning on texts out of the synthesized results will become modern people's common ways of literacy practices—including communication, meaning-making, and knowledge production—in the near future. Moreover, in order to use the resources on the Web to aid their own language learning, learners have to identify their learning goals, search for information matching their goals, and discern relevant information in the vast amount of Web resources. Such a process is quite similar to the nature of source-based writing—integrating relevant information from other specialists' articles into one's own article to support one's own views. It is thus worthwhile to examine how college students go through the process and what the pedagogical implications such exploration may provide. However, there is not much done on source-based second language (L2) writing, based on our review of the literature. Also, hypertext reading and writing using electronic sources on the Web still remain unexplored in the foreign language (FL) learning/teaching areas, including Teaching-English-as-a-foreign-language (TEFL).

In view of lack of studies about the effects of using electronic sources on the Web to write source-based L2 writing, the study aims to explore the ways in which EFL learners integrate English reading materials on the Web into their own compositions via the two questions:

When FL learners use electronic sources on the Web to write source-based academic papers,
does their reading ability, previous Web experiences, and the amount of time they search and use sources on the Web have an impact on students' writing performance on such a task?
how well do learners in this study use citation strategies in source-based writing ?

2 A review of the literature

In this section, the literature on the relationship between reading and writing, source-based writing, and language learning on the Web are reviewed in order to provide a theoretical framework for this study.

2.1 The relationship between reading and writing

Based on Eisterhold's viewpoints [1], reading and writing have insepararable relationship and certain features transfer between these two domains. Studies on the reading-writing relationship in both native speakers of English and ESL students provide evidence that there is "reciprocal relationship between reading and writing" [2]. Correlational studies of reading and writing performance also confirm that " (1) better writers tend to be better readers; (2) better writers read more than poor writers; (3) better readers tend to produce more syntactically mature writing than poorer readers" [3]. To be more specific, Melanie [4] stated that reading and writing share common cognitive process, vocabulary and linguistic rules. In the process of reading and writing, learners have to deal with information encoded in the format of punctuation, spelling, and grammar. This kind of structural knowledge not only facilitates learners' reading comprehension but also aid them to organize their compositions logically and cohesively. Moreover, in order to use information from reading texts in their own compositions, they also have to undergo cognitive processes such as getting meaning, questioning ideas in texts, hypothesizing, organizing and evaluating the ideas, and clarifying their own thoughts in their final written product. Such a process enables learners to discover others' opinions and develop their own beliefs and thus enhances their own knowledge about writing and reading.

The benefit of reading to write can be discussed in two ways: the impact of reading models on writing and source-based writing. Reading articles written in specific genres gives readers opportunities to build on "schematic knowledge of genre" [5]. Being exposed to reading models, they also learn formats of the genres, know audience expectations, and discover opinions they can write about in their own papers. Spivey and King [6] reported the influence of reading models on writing by examining descriptive report written by 60 students from a public school in northern Texas. The subjects were categorized into more skilled and less skilled readers by their reading scores of the Comprehensive Test of Basic Skills. Over a three-day period in their language arts/English classes, the subjects were asked to write a report on the topic "rodeo"— the special activities held in Texas at that time. Three encyclopaedia articles on "rodeo" were given to students as reading models and their products about the report (including scratch paper, planning pages, drafts, and the final report) were analyzed to distinguish ideas they selected from the three source texts as well as content they added. Results showed that more skilled readers were more likely to include important ideas across the reading models into their compositions and made use of text structures to organize different ideas into the content of their compositions. Charney and Carlson [7] also investigated the usefulness of writing models on students' writing of research texts and the effects of models of different quality. The control group (subject number, N=22) saw no models whereas the models groups (N=73) were provided with either three good models (AAA) or one good, one intermediate, and one poor model (ABC). These models were experimental reports written by students in previous semesters of the same psychology course. Results showed that the models groups' texts were better organized than those of the control group. Moreover, there was no significant difference between subjects provided with three good models and those with models representing good, moderate, and poor quality. The authors concluded that models did have an impact on the content and organization of subjects' texts. That is, providing models of different quality (good, moderate, and poor) may help students identify the effective aspects of the good models and avoid making mistakes in their own compositions. Students may also infer from models if it is appropriate to include or exclude certain ideas in the texts.

2.2 Source-based writing

Based on the review of literature, there is no clear definition of source-based writing. The only synonym—discourse synthesis—has been defined by Sprivey as "a form of reading-to-write that involves readers (writers) in the process of creating new texts by organizing, selecting, and connecting content from more than a single source text" [8]. Studies which investigate the ways readers/writers compose new texts by selecting, organizing, and connecting ideas from source texts are discussed as follows.

First, Campbell [9] studied source-based writing for both native and non-native writers at college level. Based on their scores of SAT English Composition Achievement Test, twenty non-native speakers were further categorized into less proficient nonnative speakers and more proficient nonnative speakers. Thirty subjects in five composition classes were asked to write an essay in class within one hour on the topic "fraternities and/or sororities" by using concepts in a source text from an undergraduate anthropology

textbook. The resutls showed that patterns associated with student groups and sections of composition. In the first paragraphs of their compositions, non-native speakers used significantly more information from the source text than the native speakers did. In the body paragraphs, all the students used concepts from the background text as well as many of their own ideas. In the final paragraphs, both native and non-native speakers used significantly more information from the source than in their body paragraphs. The results showed that copying concepts from the source text was the primary method for the university students in the study to write their in-class compositions. Campbell suggested that a way to decrease the rate of copying is giving students ample opportunities to practice source-based writing, giving students writing assignments that use information from source material, and informing students of various methods of citing sources in their compositions. Besides, teaching source-based writing to non-native speakers should focus on the importance of using source materials to support their ideas rather than to govern the content of their compositions. In order to develop academic style in writing, it is important for students to read plenty of academic articles that have reference to other academic works as well as noticing how various concepts are integrated into such source-based articles.

Feng [10] investigated the writing process of two EFL graduate students when they used two reading texts to write academic papers in English. One of the two subjects was a more skillful writer and the other was less skillful. They were required to read two academic articles concerning the use of L1 and L2 in the foreign language classroom. Based on the two articles, they had to write an academic paper which discussed the use of L1 in EFL context such as Taiwan. Think-aloud was used to collect data when the two subjects read the two articles. Their writing process were videotaped. The results showed that during the composing process, the more skillful writer had more effective planning strategies and made more changes in meaning than the less skilled writer. The more skillful writer read the two sources more analytically and critically whereas the less skilled writer read in order to quote from the sources. Feng stressed the importance of "higher level reading skills" (p. 318) when students read academic source papers in order to write. She also suggested that the teacher should help students make more elaborate writing plans when composing from sources.

Based on the findings of the studies, we can conclude that more proficient readers and writers are able to extract ideas from sources in print to facilitate their language learning. However, there is not much known about how more proficient learners use sources on the Web to write academic papers.

2.3 Language learning on the Web

The educational use of the Web can be divided into three categories: studies on general learning on the Web, personal views of Web literacy, and studies which focus on English reading and writing on the Web. In the past ten years, the Web gains its popularity as a communication tool and as a media of general learning on the Internet. A brief survey of the literature shows that studies on learning in a hypertext environment can be summarized as following. Some studies [11, 12] focus on the design features for hypertext, such as what kinds of navigation aids prevent learners from getting lost in millions of Web sites. Other studies [13, 14] investigate the relationship between organization patterns of hypertext and learning styles of language learners. Still others [15, 16] aim to find out what kind of learning tasks are suitable for being carried out and what kind of learners are fit for learning in a hypertext environment.

Disadvantages of foreign language teaching/learning on the Web are mostly related to technical problems, such as technical interruptions, time delays in showing images, and constant changes of URLs of Web sites. Technical advantages of Web learning include global accessibility and twenty-four hour availability; pedagogic advantages include students' learning at their own pace and rapid retrieval of information. Also, reserachers [17, 18] emphasize that the most influential impact of the Web on language learning is the notion of self-directed-learning, which stresses a learner's individualized needs and learning at one's own pace.

If learners intend to use Web materials to fulfill their pedagogical needs, certain Web literacy is needed. Thomas [18] defines literacy on the Web as "the ability to find, evaluate, and use information." A number of researchers [19, 20] agree that the skills of information access, location, analysis, and evaluation are basic requirements in terms of efficient learning on the Web. In other words, locating and finding relevant Web resources for the task are related to Internet search skills (Web literacy). Organization and synthesis of relevant information belong to learners' writing ability. To what extent learners successfully define their tasks, determine the priorities of Internet resources available, and extract relevant information depends on their reading ability and higher order cognitive abilities. However, the entire complex process still remains unexplored in the foreign language teaching/learning field.

Besides studies prescribing users' literacy on the Web, Liou [21] investigated how the Web influences EFL college students in the aspects of writing, reading, vocabulary development, and understanding of global issues. Fifteen juniors in the experimental group were required to browse news on the Web sites given by the instructor, select a news article to read, and write a response journal based on the article. Eighteen juniors in the control group took regular writing course without reading news on the Web and writing response journals. The project lasted for a semester. It was found out that the experimental group outperformed the control group in writing. Also, students used Web resources held positive attitudes toward the Web and two-thirds of them kept using the Web after the project finished.

To sum up, using information on the Web has become quite popular for teaching and learning English in the ESL and EFL contexts. However, hypertext reading and writing using electronic sources on the Web still remain unexplored in the TEFL field. Due to the lack of empirical studies about using reading materieals on the Web to write academic papers, this project will be conducted to explore the relationship between readng proficiency, Web search, and writing performance. The study also aims to examine how college EFL learners in Taiwan use reading materials on the Web to do source-based writing.

3 Research method

The context for this study was a source-based writing project in Taiwan which involved reading and writing activities used by an intact group of college sophomore English composition course. The fifteen subjects, all female and English majors, received at least one year training on four skills in English in addition to six-year formal English instruction at high schools.

3.1 Research procedures

Before the project, a reading section of TOEFL were used to measure the subjects' reading proficiency; a questionnaire investigating their former Web experiences. As part of the course's syllabus design, students were required to write a source-based paper using electronic references on the Web based on their choice of topics of their own interests. Besides, the subjects were required to use search engines like *Yahoo* to search Web articles relevant to their topic. It took three weeks for the subjects to write and revise their source-based papers. The process involved identifying a topic, searching the useful Web sites and recording them on an off-line Web use log designed by the researcher, selecting relevant Web articles, selecting supporting ideas from the articles, and incorporating these ideas into students' own compositions. An end-semester questionnaire was used to obtain students' attitudes toward such a writing process. Students were required to turn in all documents in the process including Web articles they cited.

3.2 Data analysis

Data analysis involved quantification of variables, statistical analyses, and qualitative coding. For quantification of variables, see Table 1.

Table 1: Data Analysis

Variables	Detail	Instruments
Reading abilities		The reading comprehension section of the TOEFL test, 1998 [22] (Range: 0-100 points)
Web search	Previous Web experiences	Questionnaire of Web experiences (quantified based on a five-point scale)
	Amount of Web search	Two-week Web log—the amount of time a subject spends on searching and browsing the Web (Unit: minutes)
	Attitudes toward the Web	1. Questionnaire of Web experiences (quantified based on a five-point scale) 2. Questionnaire of attitudes (quantified based on a five-point scale)

Variables	Detail	Instruments
Writing performance	Source-based paper	1. Quantitative aspect—Overall writing ability which is measured using ESL Composition Profile [23] (Range: 0-100 points) 2. Qualitative aspect—Citation strategies (1) Types of citation—quotation, paraphrase, summary (Unit: frequency) (2) Relevance judgement (essential, relevant, and irrelevant) of the three citation types

For statistical analysis, Pearson product-moment correlation coefficient which was conducted to examine the correlation between students' TOEFL reading scores, previous Web experiences, Web search, and scores of the source-based paper. Qualitative coding of citation strategies in the subjects' source-based papers included citation types and relevance judgment of the citation types. First, citation types in Campbell's study [9] were simplified to three types: quotation, paraphrases, and summaries. Second, relevance judgments which were proposed Charney and Carlson [7] were simplified into a three-point scale (essential, relevant, and irrelevant) in this study and the scale was used to rate the appropriateness of three citation types (quotation, paraphrases, and summaries) in the subjects' composition. The results might shed light on citation strategies of EFL learners in Taiwan.

4 Results

4.1 Relationship between reading ability, Web experiences, Web search, and writing performance

In order to find out the relationships among the subjects' reading ability, previous Web experiences, Web search amount, and writing performance of citing Web sources in EFL context, Pearson Product-Moment Correlation Coefficient was conducted. The results are given in Table 2.

Table 2: Correlation among Reading Ability, Web Search Amount, Previous Web experiences, and Writing Performance

	Reading ability	Web search amount (mins)	Previous Web experiences	Writing performance
Reading ability	1			
Web search amount (mins)	0.06	1		
Previous Web experiences	0.60	-0.42	1	
Writing performance	*0.70	0.05	0.55	1

$p < .05$, N=15 (Two-tailed) *statistically significant

The correlation between the subjects' TOEFL scores and source-based papers was .70 ($p<0.05$). Because the subjects' reading abilities were positively correlated with their writing performance, the assumption that a more proficient reader is also a more proficient writer appears to be supported. Moreover, the correlation between the Web search and source-based paper was .05 ($p<0.05$). Since there was no significant relationship between their amount of Web search and writing ability, it indicated that the subjects' writing performance was not closely related to the amount of time they spent searching and using sources on the Web. Furthermore, the correlation between the Web experiences and source-based paper was .55. Perhaps Web experiences is a better indicator of students' writing performance in citing electronic sources to write formal papers than Web search does, but the coefficient is not significant. Also, the correlation between Web search and previous Web experiences was negatively correlated (-0.42), though not being high up to a significant level. It might indicate that the more experiences the subjects had in using hypertextual resources, the more familiar they were with the possible formats and contents on the Web, which might contribute to the less time and efforts they took searching information on the Web in order to finish the source-based papers.

4.2 Previous Web experiences and attitudes toward the Web-related writing tasks

The results of the two questionnaires are examined in order to probe students' previous Web experiences and their attitudes toward the Web-related writing tasks. It was found out that although most of the subjects

assumed positive attitudes toward the use of Web sites, their previous Web experiences was quite limited. 30% were newcomers to the Web, who have used the Web for no more than a year. 80% were not well-experienced users, whose Web experiences were below two years. Despite the fact that all of them have used search engines, 73% had difficulty locating information they need on Web sites in English. Only 33% agreed that they could find relevant information on English Web sites. Furthermore, although most of them deemed English Web sites as a tool to facilitate their English learning, few of the subjects (13%) browsed Web sites in English often enough and only one-third of the fifteen students liked to use English Web sites. To sum up, the subjects assumed bittersweet attitudes toward searching and browsing Web sites in English. There are two possible explanations of their behaviors: their browsing behaviors on the Internet and their language proficiency. One possibility is that they couldn't find what they need by using English search engines. Also, the less they browsed the Web sites, the less practice they would have finding and extracting information from the Web sites. The less they were familiar with the Web sites, the less information they would be able to find on the Web. This is so-called a vicious circle. The other possibility is that half of them didn't think their English was excellent enough to handle the contents of English Web sites. 53% said that browsing English Web sites made them nervous because their English ability was not good. 47% reported that they felt discouraged when there were too many words they didn't know in the Web texts.

When it comes to Web-based source writing, four-fifths of the subjects agreed that the availability of data on the Web was related to the types of topics they chose for source-based writing. That is, the more popular a topic is, the more people would like to discuss it on the Web and the easier to locate prevalent and general information about the topic. Moreover, two-thirds of the subjects agreed that browsing relevant articles on the Web did help them in writing source-based papers in comparison with materials in print. The benefits of using hypertextual articles to write source-based papers include giving students inspiration to organize their compositions, finding references in related articles, locating evidences to support their own ideas, reading data written in different formats, and practicing writing in a formal style.

4.3 Citation strategies in source-based papers

Three citation types were coded and counted in students' source-based papers: quotation, paraphrase, and summary. The results showed that the most frequently-used citation types in the subjects' source-based papers were quotation (43%), followed by paraphrase (32%), followed by summary (25%). According to Campbell (1990), quotation was the least integrated citation type in students' compositions whereas summary was the most integrated one. Compared with the percentage of the other two citation types (75%), summary—the type which requires students to obtain the gist of others' articles—occupied only 25% of citation types in students' compositions. Therefore, the results of the study seem to confirm that Chinese EFL learners rely on others' exact words to construct their own compositions.

Second, relevance judgements of the citation types are used to investigate how well the subjects incorporated ideas in others' articles into their own compositions. It was found that citations which were relevant to the students' compositions occupied the highest frequency (51%), followed by essential (40%), followed by irrelevant (9%). The distribution of the relevance judgment of each citation type was shown in Table 3.

Table 3: Quality of each citation type

	Essential	Relevant	Irrelevant	Total
Quotation	37%	53%	10%	100%
Paraphrase	17%	66%	17%	100%
Summary	74%	26%	0%	100%

The results indicated that summary was the best-used type because 74% of summary were incorporated into the subjects compositions as essential information and none of it was rated as irrelevant information in students' source-based papers. Quotation was used quite successful in the subjects' papers because 90% of the type was rated as essential and relevant. Paraphrase was the least successful citation type in students' source-based papers because only 17% of it was rated as essential and nearly one-fifth of it was regarded as irrelevant information.

The results also showed that although summary was not quite common in their papers (25%), once it was used in the subjects' papers, its quality was better than the other two citation types. The results also suggest that when citing others' concepts, some students had difficulty paraphrasing the most essential part in the

others' articles. They often spent a lot of space beating around the bush, repeating main plots in others' works without organizing them into their own papers. Furthermore, since 10% of the quotations in students' papers were irrelevant, it suggests that students should take more efforts to integrate the quotations into their own papers rather than put those quotations in their papers without justification.

5. Conclusion

Based on the results of this study, those who have higher reading proficiency and more previous Web experiences performed better when citing electronic sources on the Web to write source-based academic papers. It seems that more proficient readers are able to organize different ideas of Web sources into their own papers and that more experienced Web users had no difficulty locating and citing relevant source information in their papers. Moreover, the subjects were able to gain the gist of others' Web articles and organized the main ideas into their own compositions. Although the subjects in this study relied on quotations of others' texts to support their own ideas, the quality of quotation was as good as possible. In contrast, some of the subjects had greater difficulty paraphrasing others' concepts into their papers.

According to the fifteen subjects in this study, the advantages of using Web sources to write compositions were substantiating the content of their compositions. Its disadvantages included spending a lot of time without finding relevant articles on the Web and not knowing how to pick up the most appropriate text from the vast amount of sources on the Web. Therefore, if the teacher wants to use Web sources to aid students' ideas in writing, there are three things to which s/he should pay attention. First, students need guidance to learn how to use search engines well enough in order to locate relevant and in-depth Web sources. Second, the teachers should offer academic Web text models in class so that students can be more familiar with the organizing patterns of Web texts. Third, students should be taught how to differentiate good sources from bad ones as well as how to cite sources into their compositions. The teacher should emphasize that Web sources are used to support students' own ideas rather than governing the content of their own papers.

This study investigated how students' reading ability, previous Web experiences, and Web search amount influenced their source-based writing performance. The study also explored students' citation strategies in EFL context, including the format, types, and relevance of citation. Besides the pedagogical implications for integrating hypertextual sources into English writing instruction, the contribution of this study is that it was the only study in Taiwan that probed students' types of citation and relevance of citation when using English sources on the Web to write academic source-based papers. However, only fifteen subjects in an EFL context were involved in the study and it might be difficult for researchers in other contexts to draw inferences without further studies. Besides, the fifteen subjects in this study were allowed to choose three types of topics in writing source-based papers: a review of a book or a movie, a report of a well-known person, or a social issue. Although the freedom of topic selection reflected the notion of self-directed-learning—the most influential impact of the Web on language learning, it increased the difficulty of grading. The two raters had to discuss the grading criteria for each topic type. They also tried to be as fair as possible when grading fifteen pieces of papers with fifteen distinct titles. Future studies need to be aware of the issue of topic selection. Finally, the fifteen subjects' on-line activities on the Web were only reported by themselves in the Two-week Web Log. There is still room for qualitative studies which investigate students' on-line behaviors and their writing process when using hypertextual source sources to write academic papers.

References

[1] Eisterhold, J. C. (1990). Reading-writing connections: Toward a description for second language learners. In B. Kroll (Ed), Second language writing: Research insight for the classroom (pp.88-101). Cambridge: Cambridge University Press.

[2] Reid, J. M. (1993b). Teaching ESL writing. New Jersey, USA: Prentice-Hall.

[3] Carson, J. G. (1993). Reading for writing: Cognitive perspectives. In J. G. Carson & I. Leki (Eds.), Reading in the composition classroom: Second language perspectives (pp.85-104). Boston, MA: Heinle & Heinle Publishers.

[4] Melanie, F. (1998). Reading/writing connection. U.S., Florida (ERIC Document Reproduction Service No. ED 418391)

[5] Reid, J. (1993a). Historical perspective on writing and reading in the ESL classroom. In J. G. Carson & I. Leki (Eds.), Reading in the composition classroom: Second language perspectives (pp.33-60).

Boston, MA: Heinle & Heinle Publishers.

[6] Spivey, N. N., & King, J. R. (1989). Readers as writers composing from sources. (Technical Report No. 18). Berkeley, CA.: Center for the Study of Writing. (ERIC Document Reproduction Service No. ED 303785)

[7] Charney, D. H., & Carlson, R. A. (1995). Learning to write in a genre: What student writers take from model texts. Research in the teaching of English, 29(1), 88-125.

[8] McGinley, W. (1992). The role of reading and writing while composing from sources. Reading research quarterly, 27(3), 226-249.

[9] Campbell, C. (1990). Writing with others' words: Using background reading text in academic compositions. In B. Kroll (Ed.), Second language writing: Research insight for the classroom (pp.211-230). Cambridge: Cambridge University Press.

[10] Feng, H. P. (2000). Writing from sources in an EFL context: An exploratory study. In Proceedings of the Seventh Conference on English Teaching and Learning in the Republic of China (pp.310-321). Taipei: Crane.

[11] Dillon, A. (1991). Human factors issues in the design of hypermedia interfaces. In H. Brown (Ed), Hypermedia/hypertext and object-oriented databases (pp.91-106). London: Chapmean & Hall.

[12] Muter, P. (1996). Interface design and optimization of reading of continuous text. [On-line]. Available: http://psych.utoronto.ca/~muter/pmuterl.htm

[13] Leader, L. F., & Klein, J. D. (1996). The effects of search tool type and cognitive style on performance during hypermedia database searches. Educational technology research and development, 44(2), 5-15.

[14] Lin C. H., & Davidson-Shivers, G. V. (1996). Effects of linking structure and cognitive style on students' performance and attitude in a computer-based hypertext environment. Journal of educational computing research, 15(4), 317-329.

[15] Beishuizen, J., Stoutjesdijk, E, & Zanting, A. (1996). Using hypertext for studying and information search. Journal of educational computing research, 15(4), 289-316.

[16] Spiro, R. J., & Jehng, J. C. (1990). Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter. In N. Don & R. Spiro (Eds.), Cognition, education, and multimedia: Exploring ideas in high technology (pp.163-205). New Jersey: Lawrence Erlbaum Associates.

[17] Romiszowski, A. J. (1997). Web-based distance learning and teaching: Revolutionary invention or reaction to necessity? In B. H. Khan (Ed.), Web-based instruction (pp.25-37). New Jersey: Englewood Cliffs.

[18] Thomas, H. (1997). The new literacy: The challenges of hypertextual discourse. Computer assisted langauge learning, 10(5),479-489.

[19] Hill, J. R. (1999). A conceptual framework for understanding information seeking in open-ended information systems. Educational technology research and development, 47(1), 5-27.

[20] Uemura, T. (1999). EFL speakers and their use of the Internet. In The Twelfth World Congress of Applied Linguistics (pp.1-7). Tokyo: AILA.

[21] Liou, Hsien-Chin. (1997). The impact of WWW texts on EFL learning. Computer assisted langauge learning, 10(5), 455-478.

[22] Educational Testing Service. (1998). TOEFL test exercise book. United States: Educational Testing Service.

[23] Jacobs, H. L, Zinkgraf, S. A., Wormuth, D. R., Hartfiel, V. F., & Hughey, J. B. (1981). Testing ESL composition: A practical approach. Rowley, Mass.: Newbury House.

A Web-based Model of Learning Java

Chan Wai Nelson*, Andy Tsang**

**Department of Computing, Hong Kong Polytechnic University*
E-mail: csnchan@comp.polyu.edu.hk
***Department of Computing,Hong Kong Institute of Vocational Education (Kwai Chung)*
E-mail: cwtsang@vtc.edu.hk

This paper proposes the architecture of a VL model for computer-assisted-learning in Java. VL is an acronym that stands for Visual Learning. There are three important components in the VL model, namely Code Book, Dictionary and Play. In addition, a number of modules have also been built in order to provide better support to the VL model. These supporting modules are the Object-oriented Concept module, the Java Language Concept module, and the Problem Case module. All these components and modules are posted to a Web and made available for student access. A prototype has been developed for the purpose of studying the feasibility and operations of the VL model. The study and development of the prototype is a project funded by the teaching development grant of the University Grants Committee (Hong Kong).

Keywords: **Computer-assisted-learning, Code Book, Dictionary, Play.**

1 Introduction

Motivating students to learn is a difficult task since the dawn of civilization. It is even more difficult when the content involves a programming environment and a design methodology [Borne 1993]. However, with the aid of the modern computing technologies, the difficulties can be substantially reduced if a good design of visual programming environment [Zhang and Zhang 1998] can be implemented. Before we present how the computing technologies being incorporated into our model, it is worthwhile to investigate how motivation can be invoked from students' points of view. First of all, students are keen in

- What knowledge they will be learning?
- How to apply the knowledge in solving problem?
- How to apply the knowledge to an application?
- Is the knowledge easy to learn?

In the context of our Web-based model for learning the Java language, the first three concerns can be dealt with no difficulty. The first concern is easy to clarify. Most of the computing students know that the Java language is one of the state-of-the-arts of computing languages. For the second concern, we use the problem-base learning [Savery and Duffy 1995] as our teaching methodology in our Visual Learning model. Hence, students are able to apply the knowledge in solving problems. The third concern is quite critical. We intend to build the VL model using an application that most students are familiar with, for example, a cinema ticket booking system. After the students attended all the lessons, they should be able to build systems of similar application. The final concern is the most difficult to be realized by students. For this purpose, we have to rely on the modern computing technologies together with some design constraints. These design constraints are:

- Each lesson is consisted of a number of sessions.
- Each session is a stand-alone Java application.
- Each session is used as a building block for the next session.
- Information loading in each session must be minimized.
- Explanation facility for each session must be adequate and user-friendly

This paper intends to present the framework of the Visual Learning model. The VL model and its supporting modules are posted to a Web site. There are three supporting modules, namely the object-oriented concept module, the Java concept module and the problem case module.

2 Supporting Modules

The object-oriented concept module provides students a foundation on the features of object-oriented constructs. These include the concept of world, class, object, event, stored data, method, message, inheritance, information hiding and etc. The Java concept module provides students some language constructs corresponding to the concept mentioned in the object-oriented module. The problem case module is a set of Java problems that require students to work on either as a group or an independent project. To monitor the group work, chat rooms are available for each group of students to present or discuss their problems [Cleaver 1999].

3 Visual Learning for Java Module

The Visual Learning module is the core module of the VL model. It consists of a number of lessons, and each lesson is made up of a number of sessions. The Visual Learning model is constructed based on the consideration of the design constraints mentioned previously. The first page of the module is a table of contents that provides students an overall view of what they will learn. There are six lessons for this ticket booking system. Lesson 1 is an introduction that provides students a feel of how frame and widgets are being created. Figure 1 indicates that Session 1 of Lesson 1 has been selected. To avoid information loading, the screen is divided into three components, namely Code Book, Dictionary and Play.

Figure 1. Selection of Session 1 of Lesson 1

Lesson 2 is the continuation of Lesson 1 except that it provides students the concept of panel. Both Lesson 1 and Lesson 2 involve no interaction of widgets, such as radio buttons. Lesson 3 provides students a foundation of interaction technique using widgets. Lesson 4 involves text input and some basic control structures. Both Lesson 5 and Lesson 6 relate to information storing and information retrieving.

3.1 Code Book

The leftmost section is the Code Book component. It contains all the Java coding that is required to generate

BEST COPY AVAILABLE

the content as indicated by the title of the session. In this example, the coding is to generate a frame, as indicated by the title of Session 1. If the coding cannot be contained within the Code Book component, students are required to use the vertical scroll bar in order to see the hidden coding. To run the Java coding of this session, simply copy the contents into a text file followed by a compilation and execution.

3.2 Dictionary

The upper right hand section is the Dictionary section. Initially, this section is empty. A directive is displayed under the "Instructions:" text. It suggests to the students that a line of coding must be selected from the Code Book section. When a particular line from the Code Book section is selected, this line will then be appeared in the Dictionary section as depicted in Figure 2. All Java reserved words are expressed in black color, all user defined entities are expressed in red color. So far, the Dictionary facility has not been triggered. To invoke the Dictionary facility, the mouse pointer must point closely to the entity of interest. Therefore, students if so desire to use this facility, the mouse pointer must be pointed closely to the targeted entity. When the targeted entity turns its color to green, and at the same time, an explanation note will be displayed. If the mouse pointer moves away from the targeted entity, the note will be disappeared and the entity will restore its original color. Students may select another line from the Code Book to inquire the explanation of other entities in other lines.

Figure 2. After the line being selected from the Code Book, Dictionary echoes the line

Figure 3 shows the change of color of the selected entity together with the corresponding pop-up explanation note. Because the current session is built from the previous section(s), therefore those statements that appeared in the previous session(s) will not be equipped with the Dictionary facility. The reason behind this is that students should learn the previous session substantially before they attend the current session. In this connection, the Dictionary facility indirectly induces a side effect of enforcing students to understand the materials more wholeheartedly.

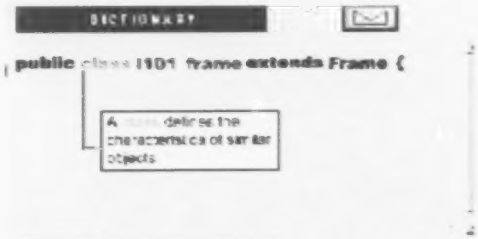


Figure 3. Explanation note being prompted when the "class" entity was selected

BEST COPY AVAILABLE

3.3 Play

Play is the lower-right-hand section. It is simply the implementation of the Java coding displayed on the Code Book section. The visualization schemes [Hirakawa, Yoshimi, Tanaka and Ichikawa 1989] between data of the Code Book and visual objects in the Play will not be built in this version.

4 Conclusions

The construction phase and the testing phase of the Web-based Model of Learning Java has been completed in January 2000. A group of 59 students from the Higher Diploma in Information Systems program of our University has participated in this project. Prior to joining the project, students had attended a programming course in C. The project commenced on February 2000 and will run for a period of nine weeks. For each week, there will be a two-hour lecture and one hour tutorial. The continuous assessment will consist of two group assignments and one independent project. A formal survey will be conducted at the end of the course. The number of access of the Web site by students has been recorded more than 1,300 for a period of six weeks. More complete findings will be reported later.

Acknowledgments

The development of the Web-based Model of Learning Java is a funded project supported by the University Grants Committee (Hong Kong). The authors would also like to express their sincere thanks to Mr. Julian Kwan for his kind support to the project.

References

[1] Borne, I., "A visual programming environment for Smalltalk", Proceedings of the IEEE Symposium on Visual Languages, pp. 214-218 (1993).

[2] Cleaver, T.G., "Interactive Web-based tutorials for engineering education", Proceedings of the IEEE Southeastcon '99, pp. 126-127 (1999).

[3] Hirakawa, M., Yoshimi, M., Tanaka, M.and Ichikawa, T., "A generic model for constructing visual programming systems", Proceedings of the IEEE Workshop on Visual Languages, pp. 124-129 (1989).

[4] Savery, J. and Duffy, J, "Problem-based Learning: An Instructional Model and *its* Constructivist Framework", Edu. Tech., 35: pp. 21-39 (1995).

[5] Zhang Da-Qian and Zhang Kang, "VisPro: a visual language generation toolset", Proceedings of the IEEE Symposium on Visual Languages, pp. 195-202 (1998)

AWETS: An Automatic Web-Based English Testing System

Zhao-Ming Gao
Department of Foreign Languages and Literatures
National Taiwan University
Taipei 106, TAIWAN
E-mail: zmgao@ccms.ntu.edu.tw

Test items are traditionally created by experts. While this approach has many advantages, it is laborious and time-consuming. Recent advance in corpus-based computational linguistics has shed new light on the feasibility of a computer-based language testing system capable of automatically generating items. This paper describes AWETS, an automatic web-based English testing system developed by the author's research team and used in his freshman English classes at National Taiwan University. AWETS automates test item generation, test delivery, scoring, and record keeping. It can generate random items for each testee in accordance with the input conditions of the test administrator. With AWETS, testers' jobs are reduced to inputting information such as a list of words and the time limit of each question. Besides being a useful tool for creating achievement tests in English vocabulary, AWETS can also generate proficiency tests based on a selected difficulty level without the need to input a word list. AWETS can be seen as a significant step toward future computer-based language testing system.

Keywords: **automatic generation of items, computer-based language testing, corpus-based computational linguistics, vocabulary testing**

1 Introduction

Test databank in current computer-based language testing systems is mostly created by human experts. This procedure is laborious and time-consuming. Moreover, since test databank is difficult to adapt, teachers using the systems have to spend a lot of time creating the tests for their own classes. To solve this problem, several researchers have suggested the feasibility of designing a tool to automatically generate items. For instance, [4] proposes creating a vocabulary test or exercise from a general corpus using a concordancer, and [5] suggests automatically generating CALL exercise from an electronic dictionary and a parsed corpus. Along the same line of research, we build AWETS, an automatic web-based English testing system that can greatly facilitate the creation of multiple choice vocabulary test. The system, designed with the central concern of adaptability, can generate multiple choice vocabulary test items in accordance with the conditions input by test administers. The system consists of three independent yet interrelated modules: the item generation module, the test delivery module, and the record keeping module.

2 The Item Generation Module

The system is developed based on a large collection of electronic texts and natural language processing tools such as a morphological analyzer and a part-of-speech tagger. The procedures of building the system are as follows.

1. Collection of a Text Database: We retrieve free electronic English texts from the internet primarily from Project Gutenburg and the Sinorama Magazine. Texts in Project Gutenburg are mainly literary works, while those in the Sinorama Magazine contain articles about the culture and events in Taiwan. To ensure that the retrieved texts are not too difficult for our learners, we only include works published after 1960.

The corpus size is about 0.2 million words.

2. Lemmatization: All the retrieved texts are processed by a morphological analyzer developed by University of Pennsylvania which changes regular and irregular inflections into their lemmas, i.e. basic forms (e.g. ran => run, happier => happy).
3. Frequency counts of lemmas: After lemmatization, frequency count of each lemma in the entire corpus is conducted.
4. Sorting of the frequency count of the lemmas in descending order:
5. Identification of the difficulty levels of each lemma: Three levels of difficulty are specified. They correspond to college entrance exams, TOEFL, and GRE. Each level has a range of adjustable values. At present, the range of these three values is stipulated as follows.

College Entrance Exam	Words which fall in the range of the most frequently occurring 3000 – 5000 lemmas
TOEFL	Words which fall in the range of the most frequently occurring 5001 – 7000 lemmas
GRE	Words which fall in the range of the most frequently occurring 7001 – 9000 lemmas

6. Tagging: Each text is processed by Eric Brill' s tagger which labels each word its part-of-speech information.
7. Indexing of each word: A database is created which records the documents and position in which a word occurs so that sentences containing a specified word can be retrieved in no time.

Test administrators can choose the level of difficulty, the part-o f-speech of words, as well as the number of questions to be tested. Once the choices are made, the system will randomly retrieve sentences which meet the input conditions via the index. A subroutine then converts the retrieved sentences into multiple choice questions. The distracters of the questions are chosen from words of the same difficulty level as the target word. Figure 1 is the user interface for inputting conditions. Figure 2 is the automatically generated test items.

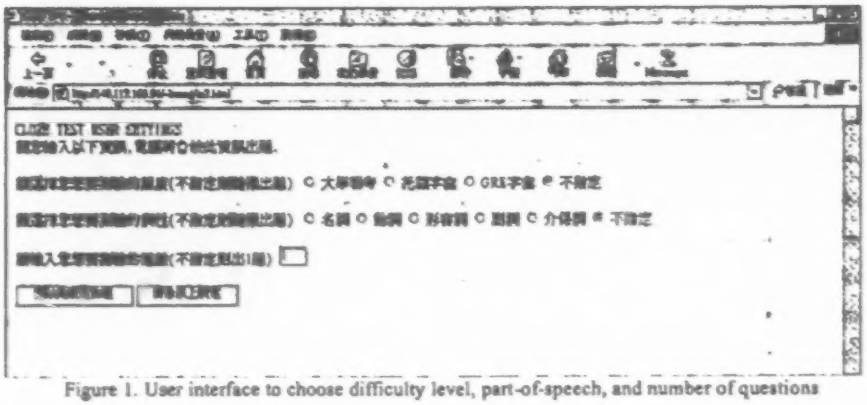


Figure 1. User interface to choose difficulty level, part-of-speech, and number of questions

BEST COPY AVAILABLE

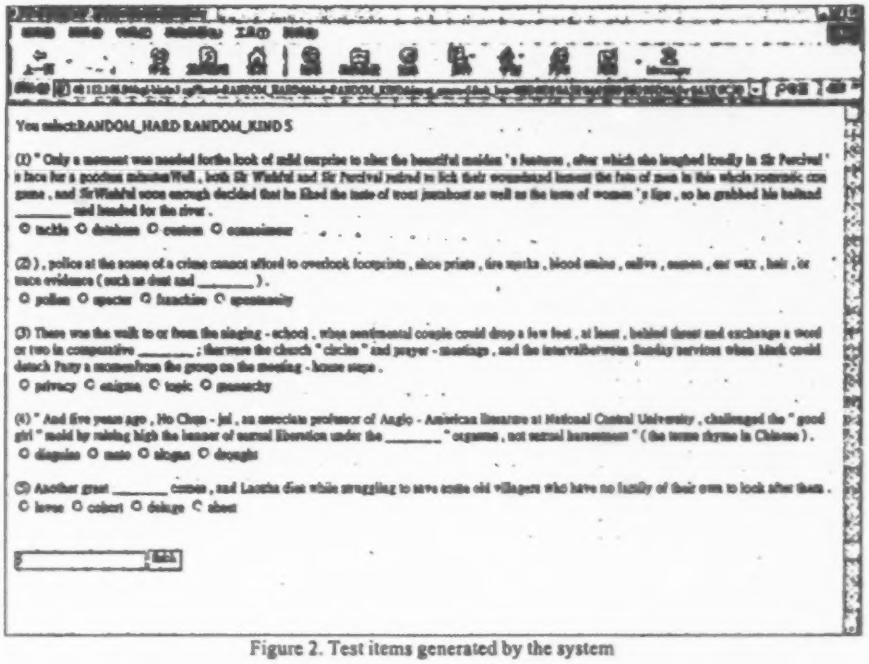


Figure 2. Test items generated by the system

As shown in Figure 2, the system is capable of generating individualized on-line vocabulary tests in the context of cloze tests based on the conditions input by a user. The system can thus be used as an excellent tool for self-paced vocabulary learning. If a learner wants to practice verbs at the TOEFL level, the system can create hundreds of such questions. As soon as he submits his answer, the system can check his answer and immediately present the correct answer to the user. Besides, if a test administer wants to change the difficulty level of the test, he can do it easily by changing the frequency range. To further facilitate the creation of vocabulary tests, the system also allows the test administer to decide which word should be tested. This is particularly useful for creating achievement tests. Once the tester inputs the words and the number of questions, the system can randomly generate multiple choice vocabulary tests in the context of cloze tests. Besides a corpus, AWETS also uses Wordnet, a lexical database developed at Princeton University, to generate items. It extracts the explanation of a lexical item and create multiple choice questions based on the item.

3 The Test Delivery Module

As described above, the item generation module can randomly create a specified number of questions in accordance with the input conditions by a test administer. To make test delivery more efficient, the test databank is created off-line. In other words, all the sentences meeting the input conditions are retrieved before the test starts. These sentences are converted into test items by a subroutine and then stored in the database. A subroutine then randomly retrieves a specified number of items from the databank and present them to the testees when the test starts. To ensure wide and unpredictable sampling, the subroutine is designed in such a way that no two tests are identical and no word will be tested twice in any test. The AWETS database also provides an interface (cf. Figure 3) for the test administer to input specification for the test. The interface allows the test administer to input the name of the test, the number of items, the time limit during which each question should be answered, and the number of times each testee can take the test. The test administer can further choose which classes and which words should be included in the test. After the test information is input by the test administer, testees proceed with the following procedures. They first input their user names and passwords. Before the real test begins, they are given 5 questions for practice. This procedure can help testees become familiar with the format of the questions. An interface and a test item such as Figure 4 is presented to the testees. As mentioned earlier, each question must be answered within a specified time limit. As soon as a question appears on the screen, the system begins to count down

BEST COPY AVAILABLE

the time left. The randomized questions and the time limit make cheating in the examinations much more difficult. Without these two functions, students might try to find answers from the person who sit next to them or from an on-line dictionary. The countdown device might also achieve a beneficial backwash, because testees need to speed up reading the question in order to finish the questions within the time limit.

Figure 3. The interface for the test administer to specify test information

Figure 4. The testees' interface and a generated test item

BEST COPY AVAILABLE

4 The Record Keeping Module

After each test, the system records the registration number, the name of the student, the test id number, the name of the test, as well as the student's score in each test. The database component allows teachers to query a student's record or the whole class's scores in an exam via the interface in figure 5.

57	hch	100.0000	2	
b85060030		57.5000	2	
b86302139		95.0000	2	
b86302135		80.0000	1	
b86303028		77.5000	2	
b86305125		72.5000	2	
b86305143		42.5000	2	
b86305213		80.0000	2	
b86501038		85.0000	2	
b86701131		77.5000	2	
b86701133		95.0000	2	
b86701137		90.0000	2	
b8870114		57.5000	2	
b86701152		80.0000	2	
b86701209		45.0000	2	
b86701211		95.0000	2	
b8870122		70.0000	2	
b86701224		75.0000	2	

Figure 5. The database interface for querying the whole class' s scores in a test

The database component greatly facilitates the calculation of validity and reliability. When testees are given more than one set of test items in a given test, the correlation of the scores can be easily computed. The system also records all the questions and testees' responses. These data can be used to analyze testees' test-taking strategies. With this function, item analysis is possible although no test candidates have identical tests.

BEST COPY AVAILABLE

Figure 6. A student's responses to the test items

5 Some Problems of AWETS

Although AWETS performs relatively well, there are some limitations which prevent it from being a completely reliable testing instrument. First, the basic assumption that difficulty of words can be determined by frequency is challenged by some scholars, since there are some words common in everyday life but much less common in texts. Moreover, a word might have several meanings some of which are much more difficult than the others. The approach proposed in this paper cannot distinguish the difficulty of the different meanings of a word. Another question is whether there might be more than correct answer in generated test items. When AWETS automatically creates multiple choice questions, it randomly chooses distracters from the dictionary. Although the distracters rarely fit the context, it might happen that some of them are acceptable. Note that choosing distracters with different parts-of-speech from the target word does not solve the problem, because a word might be used in different parts-of-speech. It should also be admitted that although AWETS can create individualized tests, it lacks a rigid method to ensure equal difficulty for all testees. Another technical problem involved is that the part-of-speech tagging program and the program which identifies sentence boundary is not one hundred percent correct. This might result in undesirable test items. Even when sentence boundary is correctly identified, some sentences might not be appropriate in testing a learner when taken out of context. This is particularly true of short sentences. Long sentences, however, are not always unproblematic. In a vocabulary test, all the words in the sentence are meant to give the contextual clues except the target word. In other words, the target word should ideally be the most difficult word in the sentence. Consequently, if there is a word in the same sentence more difficult than the target word, the test item might not be appropriate. Questions like these all require more rigid methods than those adopted in current implementation of AWETS.

6 Conclusion and Future Research

In this paper, we introduce AWETS, a web-based system that can automatically create vocabulary tests and

BEST COPY AVAILABLE

adapt items according to the conditions input by test administers. AWETS greatly facilitates the creation of vocabulary tests and has fully automated procedures for item generation, test delivery, scoring, and record keeping. At present, the validity and reliability of the automatically generated test items are being investigated. Future research will focus on solving the problems noted in section 5 by using sense-tagged texts and more rigid methods to identify difficulty of words.

Acknowledgements: The author wishes to thank Miss Lin Gui-Guang, Miss Liang Jing-Xiou, Mr. Zhao Zheng-Ming, and Mr. Lin Zheng-Ru for helping implement AWETS. AWETS is supported in part by a grant from the Computing and Information Network Center at National Taiwan University for the promotion of asynchronous learning.

References

[1] Bulter, Jonathan. Cloze procedures and concordances: The advantages of discourse level authenticity in testing expectancy grammar. System 19, 1/2, pp. 29-38, (1991).

[2] Hughes, Arthur. Testing for Language Teachers. Cambridge University Press, (1989).

[3] Stevens, Vance. Classroom concordancing: Vocabulary materials derived from relevant authentic text. English for Specific Purposes Journal 10: 35-46, (1991).

[4] Wilson, Eve. The Automatic Generation of CALL Exercises form General Corpora. In Wichmann et al. (eds.) Teaching and Lanuage Corpora. Longman, pp. 116 – 130, (1997).

CALL with a Web-based Instructional System in Cooperative Learning Environments

Miwha Lee
Pusan National University of Education
Pusan, Korea
E-mail: mlee@ns.pusan-e.ac.kr

This study developed a Web-based instructional system for computer-assisted language learning (CALL) and examined the effects of ability of the student and group composition on achievement in reading, writing, and listening comprehension in Web-based foreign language learning in a cooperative environment. Forty-four students were randomly assigned to heterogeneous and homogeneous groups. The results of the analysis showed that group composition as well as student ability significantly exerted differential effects on the learning outcomes. The implications of these results for CALL in a Web-based cooperative environment were discussed

Keywords: **Cooperative Learning, Computer-Assisted Language Learning, Web-based Learning**

1 Introduction

1.1 Background of the Study

In recent years, the Internet has been increasingly utilized as an effective instructional tool for language learning, since the Web can become a multimedia-based content provider for both verbal and non-verbal elements of communication with versatility and interconnectedness (Clinch, 1999; Harasim et al., 1996; Khan, 1997; McManus, 1995; Owston, 1997; Ritchie & Hoffman, 1996). Recent studies have shown that the computer as an instructional medium also has the potential for promoting interaction and collaboration among students (e.g., Cates & Goodling, 1997; Cavalier & Klein, 1998; Chen, 1995; Johnson & Johnson, 1996). Computer-assisted language learning (CALL) using a Web-based instructional system can, hence, provide a learning environment that facilitates positive interdependence and collaborative efforts among students. The students work together in small groups at the computer; their efforts are directed toward mutual, academically and socially beneficial, goals. In general, extensive research on cooperative learning has shown profound and positive effects on a wide range of students' cognitive and social-affective outcomes (e.g., Johnson & Johnson, 1999; Johnson et al., 1993; Sharan, 1990; 1994; Slavin, 1995; 1996).

One of the key features that characterize cooperative learning settings and distinguish them from other learning settings is the increased opportunity for interaction among students of diverse ability, beliefs, and value systems in the learning process. Researchers have explored interaction as one of the mediating variables . 'he relationship between cooperative learning and social and academic gains (Hettinger, 1995; Huang, 1995; Sharan, 1990; Webb, 1989). Hence, in a cooperative learning environment, students are typically grouped heterogeneously. The rationale for heterogeneous grouping is based on the assumption that students can encounter wider diversity in heterogeneous groups than in homogeneous groups. Of particular interest in this study are the ability of the student and group composition. Although research indicates that both high- and low-ability students gain social benefits by working in heterogeneous groups, the cognitive effects of ability grouping, heterogeneous or homogeneous, have been inconclusive (e.g., Cavalier & Klein, 1998; Huang, 1995; Mevarech et al., 1991; Webb, 1989; Webb & Lewis, 1988).

1.2 The Purpose of the Study

The purpose of this study was to examine the effects of student ability and the influence of heterogeneous and homogeneous group composition on achievement in reading, writing, and listening comprehension in computer-assisted foreign language learning with a Web-based instructional system in a cooperative learning environment. The achievement in reading, writing, and listening comprehension of high- and low-ability students were compared in heterogeneous and homogeneous groups featuring individual and group accountability.

2 Method

2.1 Subjects

The subjects were 44 undergraduate students enrolled in a required one-semester foreign language course at a university in a metropolitan city in Korea. All the subjects had some previous experience with computers (e.g., word processing, Internet, telecommunications, games, and/or programming). All students had taken English as a first foreign language and French, German, Chinese, or Japanese as a second foreign language in middle and high schools

2.2 A Web-based Instructional System

For the purpose of this study, a Web-based instructional system was designed and developed for French language learning. This instructional system appears to be one of the first Web-based instructional systems for computer-assisted French language learning in Korea. The instructional system was designed to be adaptive to individual learning situations on a non real-time basis. Students can navigate the hyperlinked multimedia contents without a pre-ordered learning schedule. Through their exploration and navigation, thus, they can design their own instruction. The contents of the instructional system are divided into two levels: beginning and advanced. Each level consists of 15 coherent but independent lessons. As shown in Figure 1, each lesson is composed of six sections: reading, writing, listening, speaking, grammar, and games.

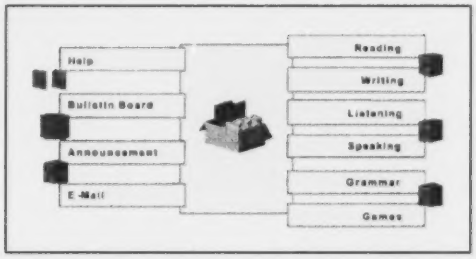


Figure1. Web-based instructional system for CALL

The reading section shows paragraphs in a variety of styles and includes interpretations and in-depth explanations regarding morphological, lexical, syntactical and semantic-pragmatic rules and expressions used in each sentence. The writing section enables students to gain pragmatic competence in their writing skills. It provides questions related to context-based composition. The listening section presents simple expressions with immediate text feedback to improve students' listening comprehension. The speaking section is designed with an emphasis on conversational practice, based on given situations presented as a picture. Concerning the grammatical rules of the previously presented sentences, the grammar section provides charts, pictures, and examples as well as explanations about those points. The game section is an additional unit designed to motivate students through games, songs, or puzzles, which may not deal with the lesson directly.

The instructional system also includes the interactive facilities: help, bulletin board, announcements, and e-mail. The help component includes general instructions regarding the system. The bulletin board deals with management-related interactions such as a school calender and logistics. The announcements show FAQ's (Frequently Asked Questions) on subject materials or technical problems. The e-mail allows for individual communications. These interaction facilities were designed to provide various types of asynchronous communications among three different user groups: teachers or tutors, students, and system administrators.

In designing and developing the user interface of the instructional system, a special emphasis was placed on user-friendliness and efficiency. A simple, intuitive design with a text -based menu, rather than a complicated design, was preferred. In addition, the instructional system utilizes well-designed TrueType fonts, which support Unicodes such as 'Lucida Sans Unicode,' 'Berdana,' and 'Times New Roman.' The basic color of the instructional system was carefully selected based on color-effectiveness studies (Moore, 1996; Pett & Wilson, 1996; Weinman & Heavin, 1996). Given current access speed to the Internet via modems or LANs (Local Area Networks) in schools, a minimum level of animation was used in order not to interfere with students' concentration level in the learning process (Jeong & Yoon, 1998). For consistent and systematic delivery of information, any subsequent hyperlinked information is presented on the same page. To this end, the interface was developed using Active Server Page (Hillier & Mezick, 1998) and Dynamic -HTML (HyperText Markup Language) (Homer, 1997).

2.3 Procedure

Before the study began, students were asked to complete a background survey, which was given in order to assess students' previous experience with computers and language learning and to provide a better description of the subjects. A pretest was administered to all students to identify those with high or low ability. Stratified random sampling was used to assign students to heterogeneous and homogeneous ability groups. Heterogeneous ability groups contained one high-ability student and one low-ability student. Homogeneous ability groups contained two high-ability students or two low-ability students. Students were unaware of the ability composition of the group. Students then received an overview of the Web-based instructional system and instruction for cooperative work. They were instructed to work cooperatively as a group on the task, to help each other learn, and to make group decisions on the course of their actions in the learning process. Students were not assigned specific roles within a group, nor were they allowed to divide the work. Students worked for 50 minutes each day, 2 days each week, for 15 weeks, a total of 30 instructional sessions for one semester.

2.4 Research Design and Data Analysis

The study employed a 2 x 2 factorial design. The between-subjects factors included Ability (high, low) and Group Composition (heterogeneous, homogeneous). The within-subjects factors included Achievement Scores of Reading, Writing, and Listening Comprehension. The analysis of variance (ANOVA) was performed to determine the interaction effects as well as the main effects of ability and group composition on achievement in reading, writing, and listening comprehension. The analysis of covariance (ANCOVA) was also conducted, with students' previous experience with computers and the pretest results serving as the covariates. The level of significance was set at .05 in this study.

3 Results

The means and standard deviations for achievement in reading, writing, and listening comprehension are presented in Table 1. The results of the analysis of variance for achievement scores by ability and group composition are shown in Table 2.[1]

[1] It should be noted that students' previous experience with computers and the pretest results did not significantly correlate with the achievement scores. The results of ANCOVA rarely differed. Hence, for the purpose of clarity, the results of ANOVA are presented in this section.

Table1. Means and Standard Deviations of the Achievement Scores by Ability and Group Composition

		Reading	Writing	Listening	Total
Ability					
High	M	8.39	8.22	5.43	22.04
	SD	1.23	2.13	2.43	4.76
Low	M	7.38	7.00	4.43	18.81
	SD	1.94	2.55	2.06	5.54
Group Composition					
Heterogeneous	M	8.64	8.27	5.18	22.09
	SD	1.33	2.19	2.42	5.26
Homogeneous	M	7.18	7.00	4.73	18.91
	SD	1.68	2.47	2.19	5.04
Total	M	7.91	7.64	4.95	20.50
	SD	1.67	2.39	2.29	5.34

3.1 Reading

Significant main effects were found for Ability, $F(1, 40) = 7.208, p < .05$, and for Group Composition, $F(1, 40) = 14.029, p < .05$, and significant interaction effects were also found for Ability and Group Composition, $F(1, 40) = 7.268, p < .05$. These results indicate that student ability and group composition exerted differential effects on achievement in the reading posttest, as shown in Tables 1 and 2. High- and low-ability students tended to achieve differentially across the groups of different composition on the reading posttest. The students in heterogeneous groups scored higher than did those in homogeneous groups. This pattern is more noticeable among low-ability students than high-ability students.

3.2 Writing

As shown in Table 2, there were significant main effects for Group Composition, $F(1, 40) = 4.401, p < .05$, and significant interaction effects for Ability and Group Composition, $F(1, 40) = 3.759, p < .05$. Yet, main effects for Ability were not statistically significant. Both high-ability and low-ability students working in heterogeneous groups tended to score higher on the writing posttest than did those working in homogeneous groups. These results indicate that the achievement of high-ability and low-ability students was dependent on the group composition in which they were working.

3.3 Listening Comprehension

No significant effects were found for Ability or Group Composition or for the interaction between Ability and Group Composition. The results indicate that the differences between the posttest means were not statistically significant, probably due to the relatively large standard deviations, as shown in Table 1.

Table 2. ANOVA Results for the Achievement Scores by Ability and Group Composition

	Source of Variation	Sum of Squares	DF	Mean Squares	F	*P*
Reading	Ability	12.750	1	12.750	7.208	.011
	Group Composition	24.817	1	24.817	14.029	.001
	Interactions	12.856	1	12.856	7.268	.010
Writing	Ability	17.892	1	17.892	3.719	.056
	Group Composition	19.442	1	19.442	4.401	.046
	Interactions	18.041	1	18.041	3.759	.050
Listening	Ability	11.600	1	11.600	2.316	.136
	Group Composition	2.759	1	2.759	0.551	.462
	Interactions	11.697	1	11.697	2.335	.134
Total	Ability	125.586	1	125.586	5.818	.021
	Group Composition	122.144	1	22.144	5.659	.022
	Interactions	126.632	1	26.632	5.867	.020

4 Conclusion

This study examined the effects of student ability and group composition on achievement in reading, writing, and listening comprehension in computer-assisted foreign language learning with a Web-based instructional system in a cooperative learning environment. The results of the analysis of variance indicate that group composition as well as student ability significantly exerted differential effects on the learning outcomes. Both high-ability and low-ability students working in heterogeneous groups showed higher achievement than did those working in homogeneous groups. These results corroborate and lend further support to the findings of the previous studies, that heterogeneous group composition benefits students of both high ability and low ability (Larson et al., 1984, Webb, 1982a; 1982b; Yager, 1986). The cooperative learning methods, in non-computer settings, often call for students to be grouped heterogeneously by ability (e.g., Sharan, 1994; Slavin, 1995). The findings of this study suggest that ability grouping can also be utilized as an effective and practical method in Web-based instructional settings

Suggestions for future research should be noted. First, a comparative study of group learning with individualized learning in Web-based instructional settings may be worth further investigation. Second, this study employed pairs; the findings may not apply to larger groups. Some research suggests the importance of group size as well as group composition in computer-based cooperative learning (Guntermann & Tovar, 1987). Finally, this study has focused on the product of group learning. Future research should also analyze the intra-group dynamics among students in the learning process.

References

[1] Cates, W. M. & Goodling, S. C. (1997). The relative effectiveness of learning options in multimedia computer-based fifth-grade spelling instruction. *Educational Technology Research and Development*, 45(2), 27-46.

[2] Cavalier, J. C. & Klein, J. D. (1998). Effects of cooperative versus individual learning and orienting activities during computer-based instruction. *Educational Technology Research and Development*, 46(1), 5-18.

[3] Chen, M. (1995). A methodology for characterizing comp uter-based learning environment. *Instructional Science*, 23, 183-220.

[4] Clinch, B. J. (1999). Web-assisted language learning. *Proceedings of Ed-Media 99*, Seattle, WA. 1334-1335.

[5] Guntermann, E. & Tovar, M. (1987). Collaborative problem solving with Logo: Effects of group size and group composition. *Journal of Educational Computing Research*, 3, 313-334.

[6] Harasim, L., Hiltz, S., Teles, L., & Turoff, M. (1996). *Learning networks*. Cambridge, MA: MIT Press.

[7] Hettinger, G. (1995). Raising the level of the debate: The effects of computer-mediated communication on group dynamics and critical thinking skills. *Proceedings of AECT*, 186-193.

[8] Hillier, S. & Mezick, D. (1998). *Inside programming Active Server Pages*. Redmond, WA: Microsoft Press.

[9] Homer, A. (1997). *Instant IE4 dynamic HTML: Programmer's reference*. Birmingham: Wrox Press.

[10] Huang, J. C. (1995). Effects of types of feedback on achievement and attitude during computer-based cooperative condition. *Proceedings of AECT*, 219-226.

[11] Jeong, H. & Yoon, A. (1998). Interface design of electronic -dictionary developing system: Considering end-user's knowledge. *Proceedings of '98 HCI*, 18-20.

[12] Johnson, D. W. & Johnson, R. T. (1996). Cooperation and the use of technology. In Jonassen, D. H. (Ed.). *Handbook of research for educational communications and technology*. New York: Simon & Schuster Macmillan.

[13] Johnson, D. W. & Johnson, R. T. (1999). *Learning together and alone: Cooperation, competition, and individualistic learning*. (5th Ed.). Needham Heights, MA: Allyn & Bacon.

[14] Johnson, D. W., Johnson, R. T., Holubec, E. J., & Roy, P. (1993). *Circles of learning: Cooperation in the classroom*. (4th Ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

[15] Khan, B. H. (Ed.). (1997). *Web-based instruction*. Englewood Cliffs. NJ: Educational Technology Publications.

[16] Larson, C. O., Dansereau, D. F., O Donnell, A., Hythecker, V., Lambiotte, F. G., & Rocklin, T. R. (1984). Verbal ability and cooperative learning: Transfer of effect. *Journal of Reading Behavior*, 16, 289-295.

[17] McManus, T. (1995). Special considerations for designing Internet-based education. In. D. Willis, B. Robin & J. Willis (Eds.). *Technology and Teacher Education Annual*. Charlottesville, VA: Association for Advancement of Computing in Education.

[18] Mevarech, Z. R., Silber, O., & Fine, D. (1991). Learning with computers in small groups: Cognitive and affective outcomes. *Journal of Educational Computing Research*, 7(2), 233-243.

[19] Moore, F. C. (1996). The do's & don'ts of web site design. [On-line]. http://www.webspertise.com/.

[20] Owston, R. D. (1997). The World Wide Web: A technology to enhance teaching and learning. *Educational Researcher, 26(2)*, 27-33.

[21] Pett, D. & Wilson, T. (1996). Color research and its application to the design of instructional materials. *Educational Technology Research and Development*, 44(3), 19-35.

[22] Ritchie, D.C. & Hoffman, B. (1996). Using instructional design principle to amplify learning on the World Wide Web. [On-line]. http://www.edweb.sdsu.edu/.

[23] Sharan, S. (1990). *Cooperative learning*. New York: Praeger.

[24] Sharan, S. (Ed.). (1994). *Handbook of cooperative learning methods*. New York: Greenwood Publishing.

[25] Slavin, R. E. (1995). *Cooperative learning: Theory, Research, and Practice*. (2nd Ed.). Englewood Cliffs, NJ: Prentice- Hall.

[26] Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, 21, 43-69.

[27] Webb, N. M. (1982a). Peer interaction and learning in small cooperative groups. *Journal of Educational Psychology*, 74, 642-655.

[28] Webb, N. M. (1982b). Group composition, group interaction, and achievement in cooperative small groups. *Journal of Educational Psychology*, 74, 475-484.

[29] Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, 13(1), 21-39.

[30] Webb, N. M. & Lewis, S. (1988). The social contex of learning computer programming. In R. E. Mayer (Ed.), *Teaching and learning computer programming*. Hillsdale, NJ: Lawrence Erlbaum.

[31] Weinman, L. & Heavin, B. (1996). *Coloring Web Graphics*. New York: New Riders.

[32] Yager, S., Johnson, D. W., Johnson, R. T., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *Journal of Social Psychology*, 126, 389-397.

CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL

Hiroaki Ogata, Yoshiaki Hada, Cheng Feng and Yoneo Yano
Dept. of Information Science and Intelligent Systems,
Faculty of Engineering, Tokushima University
2-1, Minamijosanjima, Tokushima 770-8506, Japan
Tel: +81-886-56-7498 Fax: +81-886-23-2761
E-mail: {ogata, hada, feng, yano}@is.tokushima-u.ac.jp
URL: http://www-yano.is.tokushima-u.ac.jp/ogata/

This paper describes an online markup-based composition learning environment system called **CoCoAJ** (Communicative Collection Assisting System for Java). It allows students and teachers to exchange marked-up documents via Internet, and its environment is very similar to a real world one in which people use pen and paper. In order to record and exchange corrected compositions with marks and comments, this paper proposes XCCML (eXtensible Communicative Correction Mark-up Language), that is based on XML (eXtensible Mark-up Language). XCCML facilitates teachers to analyze and reuse the marked-up documents for the instruction.

Keywords: **Computer assisted language learning, Collaborative writing, XML, Online document correction, Hypermedia.**

1 Introduction

Recently, teacher-centered instructional approaches in traditional writing classrooms are replaced with more active and learner-centered learning approaches with collaborative writing tools[2]. These tools can (1) change the way students and teachers interact; (2) enhance collaborative learning opportunities; (3) facilitate class discussion; and (4) move writing from solitary to more active and social learning. Writing compositions includes various sub-processes such as planning, transcribing, and revising, which do not need to occur in any fixed order [19]. In particular, the review process assisted with computer-based writing tools, has recently received much interest (see as examples [4, 9]).

Many researchers developed online markup systems employing some markup models. However, it is very difficult to analyze and reuse the marked documents that are collected through the writing classroom because the documents do not have a common structure. Therefore, it is necessary to define the generalized format for encoding and exchanging the marked-up documents in order that online markup systems are used easily and widely.

CoCoA (Communicative Correction Assistant system) has been developed for supporting foreigners and teachers to exchange marked-up documents by e-mail [14]. Its environment is very similar to a real one in which people use paper and pen. CoCoA allows teachers not only to correct the compositions sent from foreigners by E-mail, but also foreigners to see where and why the teacher had corrected them. CoCoA improves the opportunities that foreigners have for writing Japanese compositions and for receiving instructions from teachers. **CCML** (Communicative Correction Mark-up Language) [15] has also been proposed for the representation of marked-up documents, which is based on **SGML** (Standard Generalized Mark-up Language) [8]. With CCML, teachers and students can exchange marked-up documents via e-mail [16, 17]. In the experimental use of CoCoA, most of users commented that CoCoA was easy for them to understand the mistakes in documents because of the use of marks, and that the optional view of the original, marked or revised text was very useful. However, CoCoA cannot show users a hypermedia document including figures, tables, movies and links because it deals with only text.

This paper tackles how to correct hypermedia documents by the extension of CoCoA. This paper proposes **CoCoAJ** (CoCoA for Java) to do so. Also this paper describes **XCCML** (eXtensible CCML) for correcting

hypermedia documents, that are based on XML (eXtensible Markup Language). XCCML is combined CCML with HTML (Hyper Text Markup Language) that can represent hypermedia documents including pictures, movies, audios and so on.

We have been investigating technological support for Japanese language learning among overseas students. For example, CAI systems called Kanji Laboratory [7], JUGAME [23], GRACILE[23] and JULLIET[1] were developed to support Japanese language learning. However, an on-line mark-up supporting system for Japanese language learning has not yet been proposed. Usually, in a Japanese writing classroom, teachers have to individually review learners' documents using pen and paper[18]. It takes a lot of time for teachers to do this. Therefore, we have implemented CoCoA for writing Japanese composition.

2 Online markup models

There are some editing systems that support teachers to review and correct the students' drafts with online mark-up. Farkas & Poltrock [5] classified the mark-up models as followings:

(1) *Silent editing model*: This is the simplest model and it requires no special techniques. However, it is very difficult for the author to check the editor's work. This model is destructive because the editor cannot readily recover the original words once he/she has changed it.

(2) *Comment model*: This model employs pop-up notes, temporary footnotes, hidden text, and special symbols placed within the text. This model can work for special groups and ad-hoc situations. A system called XyWrite[10] was proposed with this model.

(3) *Edit trace model*: In this model, the editor works in the manner of an author, deleting, adding, and moving text as usual. The computer can compare the editor's new version with the original text, and allows the author to view the draft that contains the editor's changes. This model is apt to encourage heavier editing and less regard for the author's original text. Microsoft Word accepts this model.

(4) *Traditional mark-up model*: This adapts the traditional paper mark-up model to the computer screen. The symbols are both familiar and intuitive for editors and authors; for example, deletion, insertion, and move. For instance, Red Pencil allows the editor to apply a complete set of traditional editing symbols directly to a document. The editor uses "digital ink" to mark a traditional editing symbol along with the words. Moreover, MATE[6] allows the editors to use both digital ink and voice command toward pen and voice computing. In this model, authors and editors can interpret the editor's markings much more readily than in the edit trace model.

There are many systems that employ traditional mark-up which allows multiple users to mark-up an electronic document as if they were marking up a printed copy of the document. However, such systems do not globally come into practical and wide use in composition writing classes because of their special format. Moreover, it is very difficult to analyze and reuse the marked documents because the marked documents are unstructured. Therefore, the system should provide a generalized and structured format for encoding and interchanging marked-up documents via the Internet.

3 XCCML

Based on the experimental results, we propose XCCML for exchanging marked-up documents. XCCML is an application of XML, and it supplies a formal notation for the definition of generalized mark-up languages. XML is a device- and system-independent method of representing texts in electronic form. That is to say, XML is a set of mark-up conventions used together for encoding texts. A mark-up language must specify what mark-up is allowed, what mark-up is required, how mark-up is to be distinguished from text and what the mark-up means.

3.1 Features of XCCML

The main characteristics of XCCML are:

(1) Based on the experiment, XCCML presents six marks and annotation XCCML tags.

(2) The marks have three degrees of importance levels against respective corrections.

(3) The original text is generated through removing all the XCCML tags.

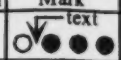
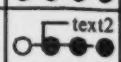
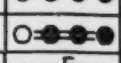
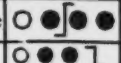
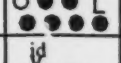
(4) The revised text is derived from the XCCML document.

(5) Because XCCML documents are text-formatted, it is easy to send them by e-mail.
(6) CCML documents easily make up full-text databases.
Needless to say, XCCML inherits its features from XML.

3.2 XCCML structure

As shown in table 1, XCCML documents consist of three parts: header, body and close. "Header" represents additional information about the document. For instance, "next" tag denotes the next version of the document. The marks for review are shown in the "Body" as XCCML tags. "Close" shows the editor's comments. In one sentence, "insert," "replace" and "delete" marks were used, while "join," "separate" and "move" marks were used over two sentences. The part between the start tag and the end tag denotes the learner's mistakes. The "string" attribute represents the revised part of the document.

Table 1: Marks and XCCML tags.

Correction	Mark	Tag
1. Insert		<Insert string="text"/>
2. Replace		<Replace string="text2"> text </Replace>
3. Delete		<Delete> text </Delete>
4. Separate		<Separate/>
5. Join		<Join/>
6. Move		<Movefrom refid="id"/> <Moveto id="id"> text </Moveto>

(1) Root tags

Tag name	Explanation	Attribute	Attribute's contents	End tag
XCCML	Beginning of XCCML tag	Version	Version number	</XCCML>
Head	Header information	None		</Head>
Body	Corrected document	None		</Body>
Close	Overall comments	None		</Close>

(2) Tags in header section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Title	Title of the document	String	Title name	None
Editor	People who corrected the document	Name	Name of the editor	None
		Email	Email address	
Author	People who write the original document	Name	Name of the author	None
		Email	Email address	

(3) Tags in body section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Insert	Insert words	String	Inserted words	</Insert>
		Level	Level of importance	
		Comment	Comment for the correction	
Replace	Change words	String	Corrected words	</Replace>
		Level	Level of importance	
		Comment	Comment for the correction	
Delete	Delete words	Level	Level of importance	None
		Comment	Comment for the correction	
Separate	Separate a paragraph	Level	Level of importance	None

		Comment	Comment for the correction	
Join	Join paragraphs	Level	Level of importance	None
		Comment	Comment for the correction	
Moveto	Moved position from the original spot	Fromid	ID	None
		Comment	Comment for the correction	
Movefrom	Original position of the words	Toid	ID	</Movefrom>
		Level	Level of importance	
Annotate	Comment for the correction	String	Annotation contents	None
		Level	Level of importance	

(4) Tags in close section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Comment	Overall comment	None	None	Necessary

3.3 Level of marks

We found that the marks do not have the same level of importance. We identify corrections on the following levels:

(1) Weak correction: The learner does not need to revise the document.
(2) Normal correction: The learner should correct the document.
(3) Strong correction: The learner must correct the document.

The strong corrections denote the important part of marks to be revised in the document. Using the importance level that the teacher had entered, the system provides the learner with the marks he/she wants to see. Therefore, the learner can avoid information overload from the reviewed documents. Every tag in table 1 has an attribute "level" that a teacher gives a number from one to three. Its default is two as normal correction.

3.4 Level of annotations

It is very important for a teacher to annotate the marked text for instruction in composition. For example, PREP Editor [12] is a word processor that allows writers and reviewers to create electronic margins, or columns, in which they can write and communicate through their annotations. We identify the following different kinds of annotations:

(1) Explanation: This is used for explaining the reason of a correction.
(2) Question: This is used for asking the learner a question; e.g., what do you want to write?
(3) Comment: This shows the educational view of the teacher with respect to the document.

4 CoCoAJ

CoCoAJ consists of CoCoAJ-Editor and CoCoAJ-Viewer. A teacher corrects the document of overseas students with CoCoAJ-Editor and the system saves the marked document in XCCML format. CoCoAJ-Viewer interprets the XCCML document, and shows the learner the marked document.

4.1 Learning processes using CoCoAJ

By using CoCoAJ, a learner receives instruction about a Japanese composition from a teacher with the following processes:

(1) The learner writes an original text with his/her familiar editor.
(2) The learner sends the document to his/her teacher with his/her own e-mail tool.
(3) CoCoAJ-Editor makes the document double-spaced. The teacher corrects the document with online marks and annotations. Then, the system allows the teacher to set the importance level to the marks in the document.
(4) After CoCoAJ-Editor saves the marked text as a XCCML document, the teacher sends it to the learner by e-mail.

(5) CoCoAJ-Viewer provides the learner with the marked text after interpreting the XCCML document. Then, the system allows the learner to select the importance level to see the important part of the marked text.
(6) CoCoAJ-Viewer automatically generates both the original text and the revised one from the XCCML document. After editing the revised text, the learner can send it again to the teacher and continue refining the text.
(7) CoCoAJ maintains the version of the document, if the learner wants to revise the same document.

4.2 System configuration

Figure 1 depicts the learning environment of CoCoAJ.

(1) XCCML parser: This module analyzes XCCML documents using the XCCML parser after reading them through the file management module. Then, it provides the results of correction according to the level of importance of marks.
(2) Correction module: This module inserts XCCML tags into the learner's document, according to the revision of the teacher. After saving the marked text, the teacher sends it by e-mail to the learner.
(3) Original text display module: This module generates the original text from the XCCML document by removing all the XCCML tags.
(4) Revised text display module: This module generates the revised text by applying XCCML tags.
(5) File management module: This module manages the versions of the documents. When the learner sends the teacher the revised document, the system creates a new XCCML document, inserts the "next" tag into the old XCCML document, and also enters the "previous" tag into the new XCCML document.

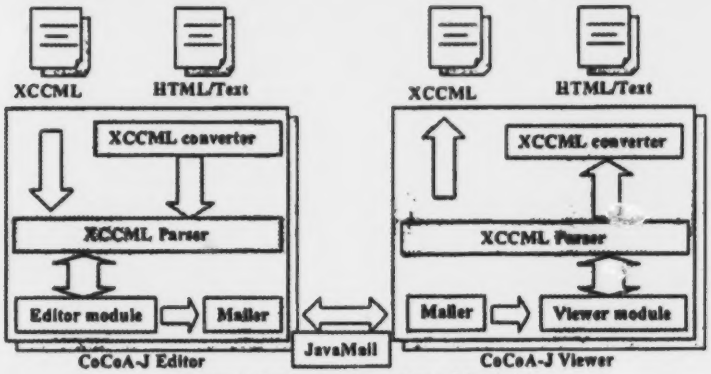


Figure 1: System configuration of CoCoAJ.

4.3 User interface

Figure 2 shows the screen snapshot of CoCoAJ-Editor. First, the learner writes a Japanese composition with a word processor and saves the document as HTML format. After that, the learner sends the document to the teacher by e-mail. By selecting a mark from the mark palette shown in the upper window, the teacher can revise the document. Moreover, the teacher can annotate the document using the annotation palette, and he/she can classify the marks according to the level of importance. The user can see the correcting document at the left side in the window and "*" means the user inserted the comment. The user can see the comments for the correction at the right side in the window. In this figure, the teacher substitutes "allow" with "allows" and gives a comment "*2". Also the teacher can see the original document and revised one by selecting window tag. After saving the marked document as a XCCML (see appendix A), the teacher can send it to the student by e-mail. Using CoCoAJ-Viewer, the learner obtains the same marked text that the teacher revised. By selecting the level of importance, CoCoAJ-Viewer provides only the marks over the level. The learner can reply to the teacher's comments and collaboratively write a composition with the teacher.

BEST COPY AVAILABLE

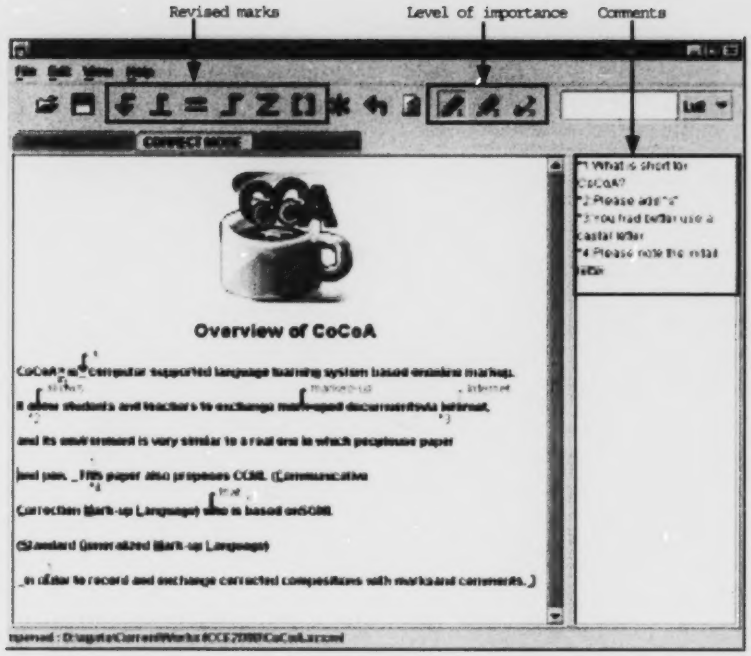


Figure 2: Screen snapshots of CoCoAJ-Editor.

5 Conclusions

This paper proposed a computer mediated language-learning system called CoCoAJ and XCCML for exchanging electronic marked-up documents. Now we are trying to propose XCCML to W3C (World Wide Web Consortium), and to show an XCCML document into Web browsers. After that, CoCoAJ will be able to be used for learning any language in an open-ended writing classroom. In our future research, we will investigate how to classify students' writing errors in their drafts, and how to assist a review process with AI technologies.

Acknowledgment

This research was supported in part by the Grant-in-Aid for Scientific Research (B) (2) No.09558017, No.09480036, and No.09230214 from the Ministry of Education, Science, Sports and Culture in Japan.

References

[1] Ayala, G. & Yano, Y. (1995). "GRACILE: A framework for collaborative intelligent learning environments", *Journal of the Japanese Society of Artificial Intelligence*, vol.10. no. 6. pp.156-170.

[2] Bonk, J. C. & King, S. K. (1995). "Computer conferencing and collaborative writing tools: Starting a dialogue about student dialogue," 1995 Proc. of Computer Supported Collaborative Learning.

[3] Brock, N. M. (1995). "Computerised text analysis: Roots and research," *Computer Assisted Language Learning*, vol.8, no.2-3, pp.227-258.

[4] Coniam, D. (1997) "A computerised English language proofing cloze program," *Computer Assisted Language Learning*, vol. 10, no. 1, pp.83-97.

[5] Farkas K. D., & Poltrock, E. S. (1995). "Online editing mark-up models, and the workspace lives of editors and writers," *IEEE Trans. in Professional Communication*, 38(2), pp.110-117.

[6] Hardock, G., Kurtecbach, G., & Buxton, W. (1993). "A marking based interface for collaborative writing," *Proc. of the ACM Symposium on User Interface Software Techonogy*, pp.259-266.

BEST COPY AVAILABLE

[7] Hayashi, T., & Yano, Y. (1994). "Kanji Laboratory: An environmental ICAI system for Kanji learning," *IEICE Trans. on Information and Systems*, E77-D(1), pp.80-88.

[8] Herwijnen, E. (1990). *Practical SGML*, Kluwer Academic Publishers.

[9] Kehagia, O. & Cox, M. (1997). "Revision changes when using word processors in an English as foreign languages context," *Computer Assisted Language Learning*, vol. 10, no. 3, pp.239-253.

[10] Kincade, D. & Oppenheim, L (1994) "Marking it up as we go along: Into editorial production's electronic future," *Journal of Scholarly Publishing*, Vol. 25, No. 3, pp.233-242.

[11] Matsumoto, Y, Kitauchi, A., Yamashita, T., Hirano, Y., Imaichi, O. & Imamura, T. (1997) "Japanese Morphological Analysis System ChaSen Manual," Nara Institute of Science and Technology Technical Report NAIST-IS-TR 97007. (in Japanese)

[12] Neuwirth, M. C., & Wojahn, G. P. (1996). "Learning to write: Computer support for a cooperative process," *CSCL: Theory and practice of an emerging paradigm*, Koshmann, T. (Ed.), Lawrence Erlbaum Associates, Publishers, pp.147-170.

[13] Ochi, Y., Yano, Y., & Hayashi, T. (1996). "JULLIET: Interactive learning environment for Kanji compounds learning," *Proc. of Educational Multimedia and Hypermedia 1996*, pp.539-544.

[14] Ogata, H. and Yano, Y. (1997). CoCoA: Communicative Correction Assisting System for Composition Studies, *Proc. of ICCE 97*, pp.461-468.

[15] Ogata, H., Yano, Y., and Wakita, R. (1998). CCML: Exchanging Marked-up Documents in a Networked Writing Classroom, *International Journal of Computer Assisted Language Learning*, Vol.11, No.2, pp.201-214.

[16] Ogata, H., Feng, C., Hada, Y., and Yano, Y. (1999). Computer Supported Proofreading Exercise in a Networked Writing Classroom, *Proc. of ICCE 99*, Vol.1, pp.414-417.

[17] Ogata, H., Feng, C., Hada, Y. and Yano, Y. (2000). Online Markup Based Language Learning Environment, *International Journal of Computers & Education*, Vol.34, No.1, pp.51-66.

[18] Sato, M., Kano, C., Tanabe, K., & Nishimura, Y. (1994). *Practical Japanese Compositions*, Bonjin-sya. (in Japanese)

[19] Scardamalia, M., & Bereiter, C. (1986). "Research on written composition," M. Wittrock (Ed.), *Handbook of research on teaching* (third ed.), Macmilian, pp.778-801.

[20] Schwind, B. C. (1995) "Error analysis and explanation in knowledge based language tutoring," *Computer Assisted Language Learning*, vol.8, no.4, pp.295-324.

[21] Shimano, H. (1986). *Handbook of proofreading*, Miki Publishers, Japan, in Japanese.

[22] Yano, Y., Miyoshi, K., & Hayashi, T. (1993). "Development of a game style environmental ICAI system for Kanji idiom learning," *Proc. of International Conference on Computers in Education '93*, pp.411-413.

[23] Yano, Y., Ogata, H., Sakakibara, R., & Wakita R. (1997). "CoCoA: Communicative correction assisting system for learning Japanese compositions", *Transactions of Japanese Society for Information and Systems in Education*, vol. 14, no.3, pp.21-28. (in Japanese)

Appendix A: **XCCML document in figure 4.**

```
<?xml version="1.0" encoding="Shift_JIS"?>
<!DOCTYPE XCCML SYSTEM "XCCML.dtd">
<XCCML>
<HEAD>
<Title string="Overview of CoCoA"/>
<Editor name="Hiroaki Ogata" email="ogata@is.tokushima-u.ac.jp"/>
<Author name="Yoshiaki Hada" email="hada@is.tokushima-u.ac.jp"/>
</HEAD>
<BODY>
<CENTER><IMG width="128" height="128"
src="image001.gif"/></CENTER><CENTER><H2>Overview of CoCoA</H2></CENTER> <H4>
CoCoA <Annotate level="3" comment="What is short for CoCoA?"/> is<Insert string="a" level="3"/>
computer supported language learning system based ononline markup.<BR/>
 It<Replace string="allows" level="3" comment="Please add &#34;s&#34;."> allow </Replace> students
and teachers to exchange <Replace string="marked-up" level="3"> mark-uped</Replace> document via
<Replace string="Internet" level="1" comment="You had better use a captal letter.">
internet</Replace>,<BR/> and its environment is very similar to a real one in which people use paper<BR/>
and pen. <MoveTo fromid="1" level="2" comment="Please note the initail letter."/>This paper also
proposes CCML (<U>C</U>ommunicative<BR/> <U>C</U>orrection <U>M</U>ark-up
<U>L</U>angua<Replace string="that" level="3">ge)</Replace> who is based on SGML<BR/>
 (<U>S</U>tandard <U>G</U>eneralized <U>M</U>ark-up <U>L</U>anguage)<BR/>
<MoveFrom toid="1" level="2">in order to record and exchange corrected compositions with marks and
comments.</MoveFrom></H4></BODY>
<CLOSE>
<Comment/></CLOSE>
</XCCML>
```

Computer-Mediated Language learning

Shu Ching Yang
Graduate Institute of Education, National Sun Yat-sen University
shyang@mail.nsysu.edu.tw

1 Introduction

The Web provides a new learning environment with a wealth of pedagogic possibilities. The colorful and visually engaging appearance, rich resources, online audio, video, and other interactive features, combine to make the Web an enormously valuable learning tool. Although it has been argued that web technology has the potential to provide a unique environment for teaching and learning, the psychological implications of its effects on learners' language learning has remained relatively unexplored. The current research does not present much empirical evidence to validate the instructional applications of web technology [1-6]. Furthermore, results of a meta-analytical study, Ayersman found that perceptions and attitudes toward technology are functionally important in promoting effective learning [7]. Therefore, more research needs to be conducted into learners' perceptions toward this new technology so specific guidelines for its successful implementation can be provided.

This study looked at learners' attitudes and perceptions as they conducted technology-augmented projects, and asked what were their affective attitudes and cognitive perceptions toward this tool. The study contributes to an understanding of language learning using the Web, and provides a basis for empirical studies of Taiwanese EFL learners performing real educational tasks with the Web. The insights gained in this small study will help EFL teachers design better learning environments with regard to classroom management, assessment and assignment.

2 Methodology

Participants

The 55 participants in this study were second year students, majoring in Applied English at a junior college. They had taken a 2-credit required course in Tourism English for two semesters.

Web-based Language Project

The goal of this project was to apply the language that the students had learned in an authentic context, to communicate, and to nurture students' global perspectives and information literacy. The project aimed to help students understand the Web with the ultimate goal of using it to create research projects about selected states in the U.S. Specifically, the objectives for the project were to: (1) provide students with background information about American culture, its separate states, cities, food, customs, people, history, travel information, etc. (2) provide students with an information-literate experience in web technology; (3) enhance students' discourse synthesis ability, namely, learning how to search, organize, and compose information for a research project. Students were asked to work on conducting a search of an assigned American state on the Web. Students could create their projects in whatever format they would like.

Instruments

A questionnaire was given to elicit relevant information on the participants' perception of, and attitudes towards, using the Web to complete their Web-based English projects. The first part of the survey pertained to background information. The second part consisted of 40 attitude and perception statements about learning experiences indicating levels of agreement or disagreement on a 5-point Likert-type scale with 5 standing for strong agreement. The Cronbach coefficient alpha of the survey was .87, suggesting the internal reliability to be quite acceptable. The third part included open-ended questions depicting their reflections about the project.

Data Collection and Analysis

After data collection, the quantitative and qualitative methods were performed. The qualitative analysis made from the student responses to the open-ended questions and the researcher' s observation, provided the opportunity to uncover deeper issues than might have been apparent in a quantitative study. Results from the factor analysis (principal axis factoring with varimax rotation) yielded six factors accounting for 64.11 percent of the variance. Following are the interpretations of each factor: cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web.

3 Discussion and Conclusion

The study investigated second-year junior college students' attitudes and perceptions towards the web as an educational resource. Six main factors concerning the learners' perceptions were identified, including cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web. The study showed that the reaction of students to technology-augmented assignments was mixed. Analysis of the survey revealed a generally positive attitude towards the project pertaining to the enhacement of cultural awarenss and overall language learning. A few negative responses were noted, as learners experienced varying degrees of disorientation and cognitive overload. In particular, those learners who do not adjust well to reading on the Web appear to have much learning anxiety and cognitive disorientation, and correspondingly, have a lower overall perception of language learning.

Some frustration with the challenges and difficulties in relation to computers and language were found. On the one hand, students' encountered technical difficulties in relation to the use of computers. The problems they encountered were; malfunctioning of the system, the periodic slowness of Internet connections, poor design of web documents, searching complications, time constraints and the inconvenience of being required to work on the project on campus. On the other hand, students commented on the challenges of reading, selecting, processing and evaluating information. For example, some learners had not developed effective searching strategies for locating appropriate information and, further made qualitative judgments as to the accuracy and reliability of specific information. Given the fact that interest is the impetus of learning, and method is the key to knowledge, teachers should inform learners of effective learning strategies and design diversified learning enviroments by providing intellectual, entertaining and interesting assignmets to enhance learners enjoyment. From this study, it could be concluded that computer-learning networks have the potential to empower students in well-designed learning environments. It is emphasized that the central computer-mediated learning experience in Language Studies can not be achieved by itself simply by the introduction of the learner to the web technology. Those learners who show reluctance towards technologically oriented projects need careful guidance and support from the pedagogical and technological applications of this self-directed curriculum. Therefore, providing scaffolding, both in using Internet applications and in orienting the learners to the task, is vital to the successful implementation and integration of technology into the curriculum.

It is undeniable that, being situated at the turn of 21 century as we are, developing the learner' s information literacy of the digital world is important. Learning to navigate and sift through huge amounts of information with speed and accuracy, as well as pursuing a critical level of understanding that goes well beyond literal or surface-level meaning, will prepare students for the challenges they will face as society delves deeper into the Information Age. The study calls for the learners' instrumental use of web technology to achieve language-specific goals. The project challenges learners to become both language and information literate in growing the following skills: awareness of global issues and concerns, the cross-cultural comparison, development of computer skills, enhancement of critical thinking and problem-solving skills, as well as specific communication skills such as arguing, persuading, or defending a particular point.

As the study shows, researching language instruction within a digital learning environment opens up a broader range of connections and meaning-making among learners. The present study is only a stepping stone on the way to examining learners' perceptions and attitudes toward the Web-based language project. Although this activity was conducted in a foreign language class, it could be adapted as an activity in a variety of disciplines to maximize the language dimension, such as social studies, global education, science, and cultural comparison [8]. The researcher believes that the possibilities for research in these powerful network environments will be conducive to broadening and refining language literacy.

References

[1] Bicknall, J., " Promoting writing and computer literacy skills through student-authored web Pages", TESOL Journal, Vol 8, No. 1, pp. 20-26, (1999).

[2] Green, A., "A beginner's guide to the internet in the foreign language classroom with a focus on the World Wide Web", Foreign Language Annals, Vol 30, No. 2, pp. 253-264, (1997).

[3] Garza, T., "The message is the medium: Using video materials to facilitate foreign language performance", Texas Papers in Foreign Language Education, Vol 2, No.2, pp.1-18, (1996)

[4] Lee, L., "Using internet tools as an enhancement of c2 teaching and learning", Foreign Language Annals, Vol 30, No. 3, pp. 410-27, (1997)

[5] Rankin, W., "Increasing the communicative competence of foreign language students through the FL chatroom", Foreign Language Annals, Vol 30, No. 4, pp. 542-546, (1997)

[6] Warschauer, M., "Computer-mediated collaborative learning", Modern Language Journal, Vol 81, No. 4, pp. 470-481, (1997)

[7] Ayersman, D., "Reviewing the research on hypermedia-based learning", Journal of Research on Computing in Education, Vol 28, No. 4, pp. 500-526, (1996)

[8] Moore, Z., " Technology and teaching culture in the L2 classroom: An introduction", Journal of Educational Computing Research, Vol 20, No., 1, pp. 1-9, (1999)

Designing for Interactivity

Johanna Klassen*, Douglas R. Vogel, and Emily Moody*****
**CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* pdklasse@cityu.edu.hk
***IS Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* isdoug@is.cityu.edu.hk
**** CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* Emily_Moody@hotmail.com

In education, 'interactivity' is the catalyst that has transformed the traditional classroom setting into an active media environment. Yet the standards for interactivity within education are by no means clear. Educators and multimedia designers are confronted with many questions concerning the effectiveness of interactive courseware as a learning tool. In this paper, the authors draw on their experience of producing the interactive courseware package *Virtual Language University*, an interactive multimedia package for language learning that has over 3,500 interactive tasks. Specific topics in the paper include screen design, navigation, effective task writing, choices in the type of user feedback, scoring and testing. Attention is given to decision-making procedures that deepen understanding, promote interactivity and encourage self-direction.

Keywords: **interactivity, multimedia, courseware design**

1 Introduction

In education, interactivity has transformed the traditional classroom setting into an active media environment. As Laurel indicates, interactivity is a necessary component for learning to take place. Learners only learn how to learn when they are actively and continually involved in the learning process [13]. Yet the standards for interactivity within education today are by no means clear. Educators and multimedia designers are confronted with questions concerning the effectiveness of interactive courseware as a learning tool, such as: how multimedia can be successfully integrated into the classroom, what level of interaction should be included, and which programs are most suitable. As this new area of learning evolves, those involved in interactive learning are discovering that developing material according to a multimedia interface is simply not enough [25]; [26]; [5]; [3]. Courseware designers are being challenged like never before to produce material that deepens understanding, promotes interactivity and encourages self-direction.

In this paper, the authors draw on their experience of producing an interactive courseware package to discuss the primary areas involved in designing a multimedia program in a Higher Education institution. A review of multimedia production discourse will be used to connect the discussion to broader issues within educational technology and interactive learning. Attention will be given to the decision-making procedures that add to an enhanced level of interactivity within computer-assisted learning.

2 Development Environment

2.1 Virtual Language University (VLU)

Virtual Language University (VLU) is an interactive learning program developed at the City University of Hong Kong. The courseware consists of four CD-ROMs and aims to provide a self-directed learning tool for students and academic staff interested in improving their English skills. The two-year long project was

funded by the Teaching Development Grant of the University Grants Committee. The development team that was responsible for creating the program was an eclectic international mix, consisting of a project manager, three computer programmers, a graphic artist, two scriptwriters and several student helpers. This team worked closely during every stage of the production, including the conceptual phase of brain-storming and scriptwriting, and the production phase of computer programming, video recording, and graphic design. The program was completed after an extensive review and piloting process that took several months.

Figure 1: VLU Campus Map

Figure 2: VLU Lobby

Upon entering VLU, users are introduced to four units: Listening, Writing, Vocabulary and Grammar, metaphorically represented as four separate buildings in a virtual university campus (See Figure 1). The animated host, a friendly Dr. Einstein, provides first time users with a tour of the campus and explains how the program works. Once the users have selected a building (or unit) to work in, they are given a test and provided with feedback on weaknesses before being directed to the appropriate level: 1, 2, or 3, with 1 being the easiest (See Figure 2). For example, the Listening Unit consists of five multimedia lectures from University professors, which include video, graphics, sound and about 40 tasks per lecture. Users can control the forward, back and replay buttons of the lecture, and in this way monitor their own pace and approach in a "learner controlled" environment [5]. Within the Writing Unit, a video tutorial by an actual English teacher guides the students through complex writing structures, pausing for interactive tasks along the way. The other sections, Grammar and Vocabulary, provide ample practice for users to improve their proficiency in grammar usage and to expand their vocabulary. In total, there are over 3,500 interactive tasks in the program, all of which are programmed to give immediate or delayed feedback and a percentage score after each task. Users can also access their last two scores, as this information is automatically stored in the computer.

2.2 Project Development

Developing a multimedia product calls for a collaborative effort from various team members drawing from different backgrounds. The team usually includes a project manager (who is often the instructional designer), a subject-matter expert, scriptwriters, computer programmers, graphic artists, a videographer, an audiographer and administrative support [2]; [15]. The success of an interactive learning product depends very much on the ability of the team to work together; "As multimedia development demands the cooperation of many highly skilled and talented individuals, division of responsibilities, smooth communication, and strong commitment to the objectives of the project are essential to make a project successful" [15]. Depending on the size of the team, one person may take on several roles throughout the course of a project, or roles may overlap - as was the case for the production of VLU.

The project manager addresses the conceptualization stage [[9] and plans the instructional design. This involves a critical look at the educational needs, the interface design and a proposal for the delivery

BEST COPY AVAILABLE

content. The project manager will identify the instructional goal of the program, which should define, in general, what the program intends to achieve [2]. At the same time, s/he will determine the learning characteristics important to the design, such as the level of instruction, language, age and culture of the end users. The project manager is also responsible for outlining the schedule for the project and may facilitate a liaison with external specialists. S/he coordinates the efforts of the team, encourages positive interpersonal communications, and ensures that team members stay on track and complete their part by specified deadlines [2]; [15].

The scriptwriter works with the project manager to develop the content and design of the final product. S/he is responsible for selecting appropriate media, writing tasks, creating storyboards as well as developing ideas for graphics. Together, the project manager and scriptwriter construct the skeleton for the project, which is then brought to life by the programmers and graphic artists. The early phase is probably the most important stage of the production - and, if done properly, can save hours of time in unnecessary programming and tedious revisions.

Once the programmers and graphic artists have the scripts in hand, they can proceed with the production phase. They may use a number of authoring programs, systems or languages to implement the suggestions of the scriptwriter and project manager [2]. The graphic artist designs the program's graphics and animation, working closely with the scriptwriter to ensure everyone is thinking in the same direction. The videographer collects and digitizes video and photo images and the audiographer records the necessary sound elements. In the case of VLU, university professors were videotaped professionally. Academic lectures were given on different topics, such as "Exploring the Internet", "Organizational Behavior" or the "Poetry of Cavafy". The scripts for the lectures were first written by the professors and then transformed into an interactive format by the scriptwriter and project manager. The professors also acted as the subject-experts of the team, providing specialized feedback during the piloting of the program.

2.3 Scriptwriting

The key to good interactive multi-media packages is the nature and level of interaction between the users and the application. The level of interactivity is directly related to the successful creation of appropriately placed tasks that range in nature and content. During the scriptwriting stage, decisions concerning the number and type of tasks, the style of feedback, the sequence of questions, the different levels of tasks and the type of scoring are made. The decisions should first be organized into an outline form to give a broader perspective and to ensure there is an appropriate distribution among all the categories. It is also important for scriptwriters to maintain consistency throughout the scripts with the use of identical terminology, predictable sequences and the same command language.

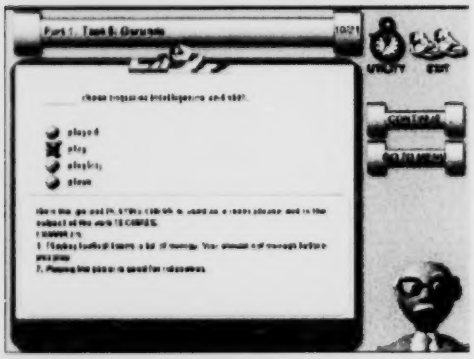


Figure 3: Grammar

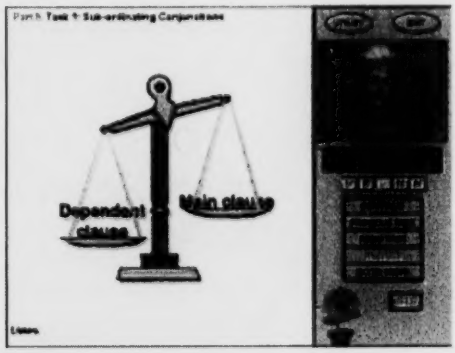


Figure 4: Writing

BEST COPY AVAILABLE

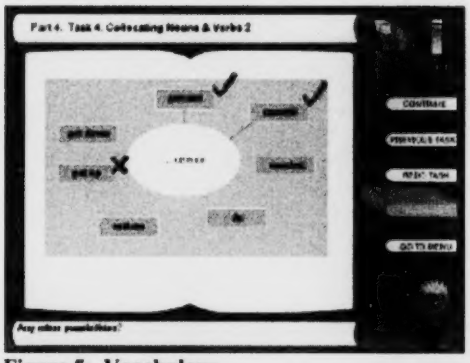


Figure 5: Vocabulary

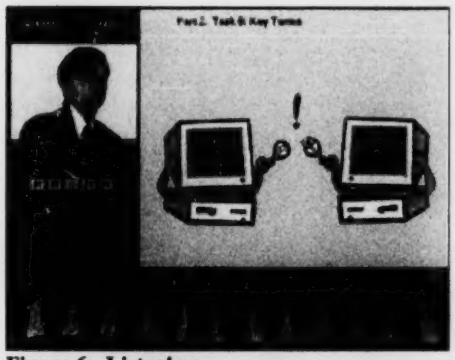


Figure 6: Listening

In VLU, tasks were written according to the instructional aim of each of the four units (See Figures 3-6). The main types of tasks that were used include click, drag, notepad writing and multiple choice. Multiple choice and click are the easiest to construct, both for the scriptwriter and programmer, but should be combined with other task types to ensure maximum interactivity. Each task is designed according to the learning objective of the unit. For example, in the Listening Unit, tasks are diagnosed as vocabulary, main ideas, key words, summary, predictions or inferences. When choosing the frequency and placement of tasks, Orr, Golas & Yao [17] advise including an option for an interactive task every three of four screens, or once every minute. Yet designers should avoid a strict adherence to any formula for interactivity, as it depends entirely on the content, style and complexity of the material being presented. "You cannot gauge the amount of active involvement in a technology product by the number of mouse clicks, and ... similarly, one cannot assess learning by overall level of activity" [26].

The binary structure of the computer makes the process of task-writing an interesting and difficult endeavor. The scriptwriter is faced with the challenge of creating insightful, thought provoking tasks that elicit predictable, quantifiable responses. Where a teacher may be able to judge the validity of a multiple range of answers, a computer cannot. It is therefore up to the scriptwriter to predict all of the potential responses, a challenge especially for tasks that allow users to type responses in an open-ended format. During the piloting of VLU, for instance, it was observed that certain open-ended questions caused frustration among students who believed their answer to be correct - and if judged by a real-life teacher, may well have been. It is for this reason that questions with vague, complex or multiple responses must be constructed with great care.

How, then, can multimedia tasks be written without oversimplifying multifaceted and in-depth subject matter? This has been one of the leading criticisms of multimedia development as it expands to cover the more concept-based material within higher education. Users may get an unwarranted sense of having mastered a complex subject after correctly answering a complete set of computerized quizzes and close-ended questions [14]. One method of avoiding such a compartmentalization of information is allowing students to write down their own opinions on a profound subject matter using a computerized notepad. In VLU, this non-graded task is used to elicit predictions of what the lecture could entail, or personal opinions that the student may have. In this way, students are encouraged to contribute their own ideas and thus are able to build confidence in their analytical skills. The producers of the interactive multimedia package *Investigating Lake Iluka* argue that the notepad facilitates cognitive self-management by allowing students "to collect and manage information from a variety of different sources" [6]. This is substantiated by Laurillard [14], whose case study found that students appreciated "being forced, or perhaps enabled, to consider and develop their own analysis first, before seeing what the expert has written".

BEST COPY AVAILABLE

3 Design Issues

3.1 Screen design

Interactive media places users in a one-on-one relationship with a program that can be as intimate, or more intimate than, a face-to-face exchange [22]. For that reason, it is the task of educational multimedia producers to transform that relationship into a successful learning experience. In a user-controlled environment that enables students to turn off the program whenever they want, screen design becomes essential to maintaining learner motivation. Effective screen design allows for maximum learning from the materials while providing the learner with appropriate control of the learning process [16]. This could be compared to the teacher's role at the beginning of a traditional classroom setting. An effective screen design sets the stage for meaningful 'deep learning' to take place and motivates the student to stay engaged. The signs of a poorly designed screen are cluttered displays, complex and tedious procedures, inadequate command languages, inconsistent sequences of action and insufficient informative feedback [20]. Such designs can lead to anxiety, poor performance and dissatisfaction with the program. Some researchers recommend limiting the amount of text on screen to three lines in order to prevent information overload [4]. Users are most effectively able to concentrate on the multimedia material when the screen is made user-friendly with consistent commands and positioning of buttons. The importance of the screen design is corroborated by a number of researchers [21], [1]; [23]; [8].

The choices for screen design are endless, but the two basic extremes are simple and complex. There are both advantages and disadvantages for either consideration. The primary advantage of keeping the screen 'simple and uncluttered' is that it is less likely that users will suffer from immediate sensory 'overload.' As Stemler points out, multimedia instruction packages can become "nightmares when designers try to dump anything and everything into a single program simply because the capability is there" [21]. Most researchers agree with this approach [17]; [18]; [19].

In many cases, a thoughtfully designed complex interface will hold the user's attention longer. The use of a metaphor is one way of integrating a number of complex features with a simple visual structure and provides users with a sense of place, familiarity and ease of use. Within VLU, the metaphor of campus buildings is employed to distinguish between the four sections of the program: Grammar, Listening, Vocabulary and Writing. This metaphor is also useful for selection of the three levels of difficulty within the program. After diagnosis, the users take an elevator to the appropriate level of the unit they are working in.

3.2 Navigation

Unlike passive approaches to education, in student-centered learning, users navigate the path of their own learning. Because of this, the navigation design of a program determines the level of interactivity users will experience. There is a delicate balance between giving enough sense of direction to avoid anxiety, without over-directing users. It is important for users to always know where they are going. Too much freedom may result in students reviewing material or completing tasks that are not relevant to their purpose. According to the findings of Laurillard, learners working on interactive media lacking a clear narrative structure will display learning behavior that is generally unfocused and inconclusive. Learner control, one of the key benefits of interactive media, thus becomes pedagogically disadvantageous if it results in mere absence of structure [14]. While the users should be provided with sufficient choice through hypermedia links, there needs to be a balance between jumping around and sticking to one task [5]. According to Wild and Quinn, the ideal combination is "scaffolded reflection", that is, navigation that encourages thinking without losing the focus of the instruction [24].

There are several possibilities for how users access materials: sequentially, semi-directed, free choice or through pathways. Each of these methods can be designed to have extreme linear order or extreme non-linear order where users have little or no chance of deviating from a predetermined sequence. Thus,

package possibilities can range from strict, prescribed, sequential learning to complete freedom of choice. An alternative is a semi-directed program, allowing for the possibility of choice within certain situations.

Users can be given the option of skipping ahead only when a task is finished or they can be allowed to skip ahead at any time. Common procedure is to have the exit function or menu function available to users at all times. This implies that the navigation has minimal travelling; that is, express pathways so users arrive at their desired destination as fast as possible with little or no redundancy. In contrast, users may not be given the option of skipping at all but can only exit when a particular task/topic/section/unit is finished. Kristof & Satran suggest that users should not have multiple paths to any particular location because this causes confusion [11].

In VLU, users can chose to skip ahead to sub-topics at any time, yet are required to select the Main Menu to do so. Thus, while students can jump around to any building or level, they automatically enter a linear sequence once they have chosen a particular lesson (unless they click on the Main Menu, which is available at all times). This is particularly true for the Grammar section, where skipping ahead may mean missing important grammatical rules and explanations. In this section, students choosing to skip ahead will hear a friendly reminder from the animated host: "You are not advised to go to this task at this stage". Users are then given the option of proceeding anyway, or returning to the previous section.

3.3 User Feedback

Within the interactive format, the educational value of a program is directly linked to the style and quality of user feedback. The users can receive either immediate or delayed feedback to responses or actions. Immediate feedback lets the users have only one attempt at providing correct information, or making a decision. Delayed feedback, in contrast, allows the users to have a longer learning experience, an experience which requires completion of one or more steps before the users receive any feedback.

Feedback can also range from: i) individualized feedback which is based upon individual choice and performance, ii) to a more general response which addresses content considerations, iii) to a type of scoring (percentage, grade, written comments). Personal feedback can be created to address users by name and either make suggestions or critique decisions made. In VLU, the computer greets users by name as they enter the program. Because most users tend to respond positively to being addressed individually, this is usually seen as a positive option [9].

3.4 Testing

Users can also be tested before, during, or after using a package. The test that precedes the work done in the package can be used as a diagnostic tool for the user. By diagnosing weaknesses or strengths, students can be directed to enter the program at an appropriate level of difficulty. Considerations on the nature of the test include whether or not the test should be timed, whether students should be able to choose the subject matter of the test and how long the test should be. The answer to these questions will depend upon the type of material being tested. Analytic material probably requires no time limit, whereas non-analytic material may need to be timed. A secondary consideration would be how many times a user can take a specific test. How often should tests in general be given? Once per unit? One test per section or per topic?

If testing is used, diagnosis will be more reliable if several tests have been taken; therefore, a bank of tests is useful. It follows then that each test must accurately assess the skills being tested and all tests must be equal in difficulty. The generation of tests can be accomplished by having a single bank of questions with the computer randomly selecting the questions. This will ensure that users do not duplicate test materials.

Testing within VLU is an option provided to users once they have entered one of the campus buildings. The test length varies according to each section, but averages about 15 minutes per unit. For example, upon entering the Listening Test area, users are presented with a pop-up menu that asks them to select a test in

their area of interest: Environment, English, Politics and Business or Social Issues. In this way, students are able to control their learning experience and are not penalized for a lack of knowledge in a particular area.

3.5 Scoring

Another question designers will need to address is what kind of report users will receive after completing a test or set of tasks. Does the program require written comments, percentage grades, or is a simple pass/fail more appropriate? Reporting can be automatic after each task, or the report can be accessed upon request. One extreme is for there to be no access to scores until the entire unit/section/package is completed; the other is for automatic reporting to occur whenever a task is completed. The feedback or report can be a numerical or graphic representation. There can be results posted on the screen, or they can be printed, or even saved to a disk. Another design possibility is to have a progress report after users have used the program for a specified period of time. The progress report can incorporate individual feedback or re-direction to an easier or more difficult level. Teachers may also want to have a network reporting option that automatically sends them the students' reports [9].

Within VLU, users are provided with a percentage grade for each task as well as an overall grade for the section completed. This provides users with a clear indication of their areas of weakness, whether it be in specific grammatical structures, writing topic sentences, listening for key words or creating compound nouns. A rating of "good", "average" or "poor" is also given, with 80 percent or higher being good, 79 to 50 as average and below 49 as poor. With this method of reporting, users are oriented within the tri-level system of the program and provided with goals for motivating improvement.

Conclusions

As multimedia producers, our goal is to harness the power of emerging technologies to achieve our educational objectives. With proper planning and design implementation, producers can not only simulate the classroom setting, but enhance it - and thus contribute to an overall rise in the level of educational standards. As Kozma points out, our ability to take full advantage of new technologies depends on the creativity of designers and our understanding of the relationship between these capabilities and learning [10]. This becomes especially important as computer-based multimedia becomes a ubiquitous aspect to learning at all levels [12]; [2]; [7].

This paper has discussed some of the issues involved in designing interactive courseware, with an emphasis on the Higher Education environment. The authors have attempted to use the experience of VLU to identify some of the key challenges involved in the various stages of multimedia design: development environment, design, user feedback and piloting. One of the greatest challenges involved in multimedia design is integrating the freedom-of-choice that makes interactivity what it is, without straying too far away from the sensible guidance necessary for any valuable educational endeavor. Designers are being challenged to create a learning environment that combines learner controlled browsing within a system-encouraged structure. As demonstrated in VLU, this bipolar dynamic is evident in almost every stage of the production process - from navigation to taskwriting to the integration of audio and visual effects. Every interactive learning production has its own set of problems and challenges, which is perhaps what makes multimedia design such an exciting and creative field to be working in. The lessons gained from VLU will continue to improve the program as it is exposed to more users and teachers, and as the development team generate new ideas for a revised version. It is hoped that these insights will contribute to the growing source of knowledge on multimedia design and ultimately lead to better products for students.

References

[1] Boyle, Tom. "*Design for multimedia learning*". London: Prentice Hall, (1997).

[2] Falk, D. & Carlson, H. "Multimedia in Higher Education: A practical guide to new tools for interactive teaching and learning", Medford, NJ: Learned Information, (1995).

[3] Gatlin-Watts, R., Arn, J. & Kordsmeier, W., "Multimedia as an instructional tool: Perceptions of college department chairs". Education Vol 120, No.1, pp. 190-196, (1999).

[4] Hannafin, M.J. & Rieber, L.P. "Psychological foundations of instructional design for emerging computer-based instructional technologies: Part II", Educational Technology Research and Development, Vol 37, *No.*2, pp. 102-114, (1989).

[5] Hanson-Smith, E., "Why multimedia?" CAELL Journal, Vol 7, No. 3, pp. 35-36, (1996-1997).

[6] Hedberg, J, Harper, B., Brown, C. & Corderoy, R., "Exploring user interfaces to improve learning outcome", In Beattie, K., McNaught, C., & Wills, S. (Editors) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 15-29, (1994).

[7] Heinich, R., Molenda, M., Russell, J., & Smaldino, S., "Instructional Media and Technologies for Learning", Englewood Cliff, NJ: Prentice Hall, 5th Edition, (1996).

[8] Ivers, K. & Barron, A. "Multimedia projects in education: designing, producing, and assessing", Englewood, CO: Libraries Unlimited, (1998).

[9] Klassen, J. and Milton, P., "Decision-Making in the Pre-production Stages of Developing an Interactive Multimedia Package", In Bradbeer, R. (Editor), Current Practice in Multimedia Education, Hong Kong: City University of Hong Kong Press, pp. 19-32, (1999).

[10] Kozma, R. "Learning with Media", Review of Educational Research, Vol 61, No. 2, pp. 179-211, (1991).

[11] Kristof, R., and Satran, A., "Interactivity by Design: Creating and Communicating with New Media", Mountain View, CA: Adobe Press, (1995).

[12] Lamb, A.C., "Multimedia and the teaching-learning process in higher education", In Albright, M.J. & Graf, D.L. (Editors) Teaching in the Information Age: The Role of Educational Technology, San Francisco: Jossey-Bass Publishers, pp. 33-42, (1992).

[13] Laurel, B. (Ed.) "The Art of Human-Computer Interface Design", Reading, MA: Addison-Wesley, (1990).

[14] Laurillard, D., "Multimedia and the learner's experience of narrative", Computers & Education, Vol 31, pp. 229-242, (1998).

[15] Liu, M, Jones, C. & Hemstreet, S., " Interactive multimedia design and production processes", Journal of Research on Computing in Education, Vol 30, No. 3, pp. 254-280, (1998).

[16] Milheim, C.L. & Lavix, C., "Screen Design for Computer-Based Training and Interactive Video: Practical Suggestions and Overall Guidelines", Performance and Instruction, Vol 31, No.5, pp. 13-21, (1992).

[17] Orr, K.L., Golas, K.C., & Yao, K., "Storyboard development for interactive multimedia training", Journal of Interactive Instruction Development, Winter, pp. 18-31, (1994).

[18] Overbaugh, R.C., "Research-based guidelines for computer-based instruction development" Journal of Research on Computing in Education, Vol 27, No. 1, pp. 29-47, (1994).

[19] Rambally, G.K. & Rambally, R.S., "Human factors in CAI design", Computers and Education, Vol 11, No. 2, pp. 149-153, (1987).

[20] Schneiderman, B. "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Reading, MA: Addison-Wesley, 2nd Edition, (1992).

[21] Stemler, L., "Educational Characteristics of Multimedia: A Literature Review", Journal of Educational Multimedia and Hypermedia, Vol 6, No. 3/4, pp. 339-359, (1997).

[22] Utvich, M., "Instructional Design: People and the Art of Interactive", Multimedia Producer, Vol 1, No. 9, pp. 1-5. www.kipinet.com. (1995).

[23] Vaughan, T., "Multimedia: making it work", Berkeley: Osborne McGraw-Hill, 4th Edition, (1998).

[24] Wild, M. & Quinn, C., "Implications of educational theory for the design of instructional multimedia", British Journal of Educational Technology, Vol 29, No. 1, 73-82, (1998)

[25] Wills, S. & Swart, R., "The book is dead, long live the book: Designing interactive publications", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 83-92, (1994).

[26] Woolsey, K. "Multimedia Opportunities", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 93 -98, (1994).

Developing a Web Concordancer for English as Foreign Language Learners

Howard Hao-Jan Chen
Division of Foreign Languages
National Taiwan Ocean University
2, Pei-Ning Road, Keelung, Taiwan 202.
E-mail: b0240@mail.ntou.edu.tw

Quite a few tools and techniques of corpus linguistics have been applied to foreign language teaching and learning. One of the most popular learning tools is the concordancer. It helps language learners to efficiently uncover hidden linguistic patterns in large amount of data and to answer their own questions about the target languages. This type of data-driven language learning has been highly recommended by second language teachers and researchers. However, good concordancing programs and suitable corpora in fact are not widely accessible for second language learners, so many learners cannot participate in data-driven learning. As Internet/World-Wide-Web has become the best platform for distributing educational resources, a web concordancer will provide a data-driven learning environment to students from anywhere at anytime. This paper first reviews several web-based concordancers for ESL/EFL learners (CobuildDirect Corpus Sampler, Hong-Kong Polytechnic Web Concordancer, and Web Concordancer for Gutenburg texts). Then the strengths and weakness of each of these web sites are identified and compared. The last section describes how language faculty at National Taiwan Ocean University (NTOU) develops a web concordancer for Taiwanese EFL learners. It is expected that this web concordancer will be able to provide Taiwanese EFL learners a fast, reliable, and user-friendly environment for data-driven learning.

Keywords: **Web-based English Learning, Data-Driven Learning, Concordancer**

1 Introduction

1.1 Corpus and Concordancer

Linguists working in the Chomskyian paradigm have been using native speakers' intuitions as the key data for linguistic research. More recently, some linguists no longer rely on their intuitions as the main data source, and they have also begun to analyze large amount of written and spoken texts (i.e., corpus) to uncover hidden linguistic generalizations. McArthur & McArthur [7] provided a very clear explanation regarding corpus and corpus linguistics.

> CORPUS [13c: from Latin corpus body. The plural is usually corpora]. (1) A collection of texts, especially if complete and self-contained: the corpus of Anglo-Saxon verse. (2) Plural also corpuses. In linguistics and lexicography, a body of texts, utterances, or other specimens considered more or less representative of a language, and usually stored as an electronic database. Currently, computer corpora may store many millions of running words, whose features can be analyzed by means of tagging (the addition of identifying and classifying tags to words and other formations) and the use of concordancing programs. Corpus linguistics studies data in any such corpus ...

In the past several years, since corpus linguistics has become a very exciting subfield of linguistics. Numerous electronic corpora were created, some of the most well known ones are the followings: Brown Corpus (text samples, American English), Lancaster-Oslo-Bergen Corpus (LOB; text samples, British

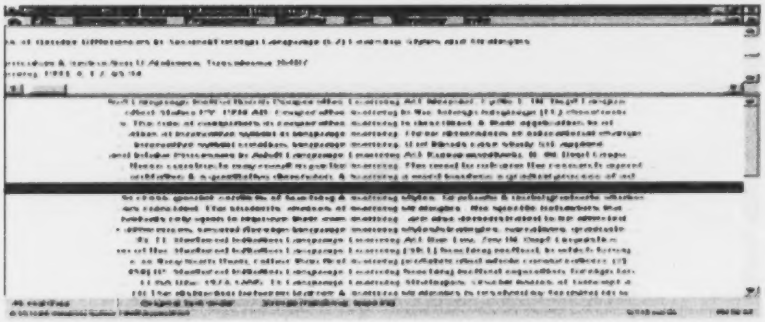
English), London-Lund Corpus (spoken British English), BNC (British National Corpus). Since a corpus often contains millions of words, corpus linguists need to use concordancing programs to uncover the patterns hidden in the huge amount of linguistic data. A concordance, in its simplest form, is an alphabetical listing of the words in a text, given together with the contexts in which they appear. The most common form of concordance today is the Keyword-in-Context (KWIC) index, in which each word is centered in a fixed-length field (e.g., 80 characters). Concordances of the word 'trust' are given below in Figure 1.

Figure 1. Concordances of the word Trust

[p] FOREIGN & Colonial Investment **Trust** has bowed to pressure from its 100,
being able to go one step further and **trust** in the love of another. [p] It took
for his friends, the House put its **trust** in him and together they faced the
all of his AIDS work. He cajoled the **Trust** into recognising its international
Status [/h] [p] T U European **Trust** is an Authorised Unit Trust Scheme
is that Sinclair, like most second **trust** lenders, doesn't want a 30-year
his grandfather was of Hitler. We **trust** many other Tory MPs will follow his
told him. I don't think he will ever **trust** me again but he had to admit he had
is a unit trust or investment **trust**-only PEP, as you can look up the trip. [p]
[p] Visit the National **Trust's** amazing Victorian folly garden at

More than a dozen of good concordancing programs are available, some well-known programs are the followings: MonoConc Pro, TACT, Word Cruncher, and WordSmith. One computer screen shot of MonoConc Pro is shown below in Figure 2. The lower window shows all the single-line concordances and the upper window shows the larger context of a certain selected concordance.

Figure 2. The Screen Shot of the MonoConc Pro Program.



The applications of corpus linguistics are numerous. According to Cathy Ball [1], these applications can be further divided into the following major domains.

1. Linguistics: to study linguistic competence or performance as revealed in naturally-occurring data. Most applications will require or lead to the creation of annotated text.
2. Diachronic linguistics: texts are all we have; introspection worthless; better to analyze a systematic collection of data than to reuse/reanalyze others' examples.
3. Computational linguistics: to train/test a natural language processing system on a representative sample of the kinds of texts the system is expected to process; to build large lexicons in a given domain ...
4. Applied linguistics: First/second language acquisition research: supplement/replace elicitation, as in 'Linguistics' above
5. Language teaching/learning: language for specific purposes (e.g. use newspaper corpora, corpora of scientific texts); to prepare vocabulary lists based on high-frequency lexical items; to prepare CLOZE tests; to answer ad hoc learner questions ('What's the difference between few and a few?'); to discover facts about language.

Geoffrey Leech [5], a prominent corpus researcher at Lancaster university, pointed out that "...while computers were limited to large mainframes available to the initiated few, computer corpora were largely restricted to research use. But as computers have grown smaller, cheaper, and massively more powerful, their use in teaching has grown immeasurably."

1.2 Data-Driven Learning and Classroom Concordancing

BEST COPY AVAILABLE

In recent years, the use of corpus in language teaching and language learning has grown steadily both in Europe and United States. One key approach to corpus in language teaching is the Data-Driven Learning (DDL) or Classroom Concordancing advocated by Tim Johns at Birmingham University. According to Odlin [8], Data-driven learning is an approach to language teaching that gives central importance to developing the learner's ability to "puzzle out" how the target language operates from examples of authentic usage. This approach is particularly associated with the use of computer concordances in the classroom but can be extended to other situations where the students has to work inductively from authentic data. According to Johns [3] data-driven allows language learners to explore a large amount of authentic target language texts by using the searching and indexing power of computer. This approach to second language learning is not only innovative but also powerful since it can help learners to resolve their own learning problems and help them to become independent second language learners.

Kettemann [4] and Stevens [9] suggested that there are several advantages of using data-driven learning. First, concordances give students easy and immediate access to authentic language production with many different styles and genres. Second, a concordancer is an extremely powerful hypothesis testing device on vast amount of data. It allows controlled speculation, makes hidden patterns of language use readily apparent, thus, enhances inductive thinking and exploratory leaning. Through using the concordancer on a regular basis, learners begin to develop strategies for dealing with a wide variety of texts. As a result of this kind of text analysis, learners are able to use concordance as a way of increasing their knowledge of English. Third, DDL allows students to interact with text actively and analytically and allow students to question, explore the word forms, usage, vocabulary, collocation, grammatical features, syntax, and stylistics. Learners assume control of the learning process.

2 The Underuse of Concordancing Tools

As mentioned above, the data-driven learning or classroom concordancing is such an empowering and innovative learning environment. It is an extremely useful tool for learning word usage and grammar of a foreign language. Leech [5] stated that "there is every reason to believe that language corpora will have a role of growing importance in language teaching." Researchers in different locations have been recommending it to language teachers and learners around the world. Nevertheless, classroom concordancing remains not as popular as it deserves to be. Why such a powerful learning tool and environment cannot be more popular?

John Flowerdew [2] pointed out several problems encountered when working with this new and exciting medium. First, many of the concordance lines will contain language which is beyond the proficiency level of the learners. Second, if single-line concordances are used, not all concordance lines may provide enough contexts to make the meaning clear. Third, depending on the size of the corpus and the frequency of the item chosen for concordancing, the concordancer may provide too few or too many examples of the particular usage to be illustrated. Moreover, Ma [6] also highlighted the importance of learner training. It is essential to familiarize learners with the new learning tool and environment before they can benefit from exploring the new environment.

In addition to the problems pointed out by Flowerdew, we believe that the accessibility to searching tools and corpora is another serious obstacle of making data-driven learning more popular. Both good concordancers and corpora mentioned above are not widely accessible to language learners. School or Institutes need to purchase and install good concordancing software on personal computers. Moreover, though there are many electronic texts available on the CD-ROMs and Internet, most texts are copyrighted and teachers cannot freely distribute them to second language learners. Furthermore, some hand-on training on the uses of the concordancing software is necessary since programs have rather different searching interface and functions. Even some educational institutes want to purchase the license of commercial concordancer and some electronic texts are available, students still need to go to the computer laboratory or computer center to use these precious learning resources. These difficulties and inconvenience in accessing concordancer and texts prevent second language learners from engaging in data-driven learning.

If language teachers and researchers can make a concordancing system easily and widely accessible to learners, it is more likely that second language learners will be more willing to explore the new learning environment. In the following sections, we will discuss how the Internet and web might be able to resolve some of the problems we outlined above.

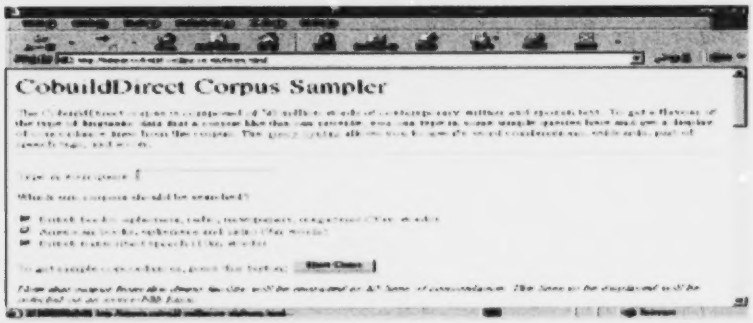
3 Web-based Concordancers

Internet and World-Wide-Web has been recommended as the most powerful platform for delivering/distributing learning materials to many learners. If a concordancing system can be made available via the Internet, second language learners can use any popular web browser to gain access to the web-based concordancing system at anytime from anywhere. They do not need to go the computer center and open the concordancer on a certain computer and load the corpus during the limited open hours.

The ideas of setting up an online concordancer loaded with text corpora have been implemented in several countries. One excellent web concordancer project is provided by Collins COBUILD project in Britain, the project generously provides a web concordancer- CobuildDirect Corpus Sampler, as an extra service for English language learners and teachers. The CobuildDirect corpus is composed of 50 million words of contemporary written and spoken text.

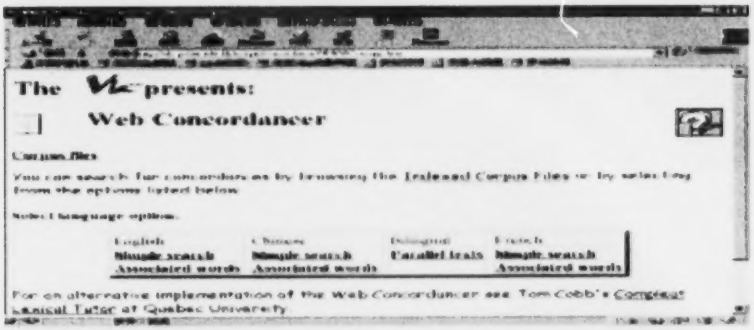
The interface of CobuildDirect Corpus Sampler is shown below in Figure 3. The user can type in some simple queries and get a display of concordance lines from the corpus. The query syntax allows users to specify word combinations, wildcards, part-of-speech tags, and so on. Because the corpus has been tagged automatically with a statistical tagger, we can specify a search on word/TAG combinations by appending an oblique stroke and a part-of-speech tag.

Figure 3. The Interface of CobuildDirect Corpus Sampler



Another interesting project is created and maintained by Chris Greaves and his associates at the virtual language center of Hong-Kong Polytechnic University. The interface of web concordancer is shown below in Figure 4.

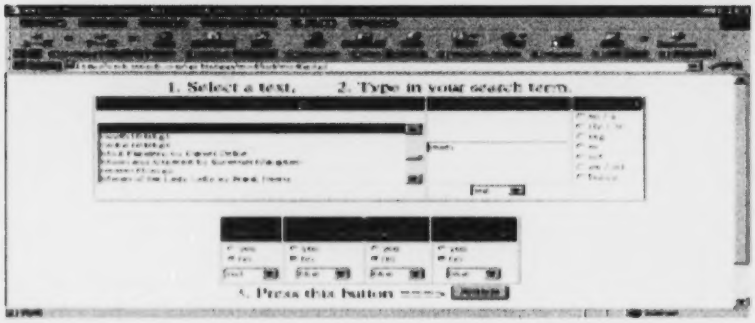
Figure 4. Web Concordancer at Hong-Kong Polytechnic University



One interesting web site in the U.S. which is completely based on the Gutenburg electronic texts offers a simple Web-based concordancer, as shown in Figure 5. Although the searching options of this site are not as comprehensive as those of the other two sites mentioned above, it offers an easy-to-use web system for language learners to explore.

BEST COPY AVAILABLE

Figure 5. The Interface of Gutenburg Concordancer



4 The Strengths and Weakness of the Existing Web-Based Concordancing Systems

All these web sites mentioned above are useful for ESL/EFL learners. However, each of these web sites has different strengths and weakness. In the following sections, we will examine the three web concordancers more closely and compare their strengths and weakness.

4.1 CobuildDirect Corpus Sampler

CobuildDirect Corpus Sampler is one of the most powerful web concordancer. Its strengths include the wider coverage of texts (50 millions words), tagged corpora which allow learners to specify words and their specific POS (part of speech) or a certain POS tag followed by a keyword. With this powerful search option, learners can specify the words with their part-of-speech. For instance, if they want to find the usage of trust as a verb, they can simply specify the query as trust/VERB.

Its weakness for ESL/EFL learners outside of Britain includes the slow connection speed, single-line concordance output without larger contextual information, and the limited numbers of concordance output. Many students in our writing classes complain that the connection to this site via TANET (Taiwan Academic Network) is fairly slow. They often lose their patience to search the words they want to know more about because of the poor Internet connection. Besides, the system only generates single-line concordance, so the contextual information is fairly limited. The users cannot look at the larger contexts to better understand the usage of the keyword. Last, since this is a sampler, the system at most can only supply about 40 examples for a particular query; this might not be enough for words with complicated meaning and usage.

4.2 Hong-Kong Polytechnic University

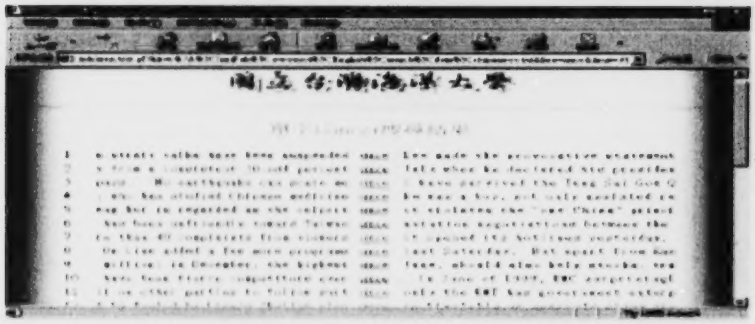
Compared with the CobuildDirect Sampler, the Hong-Kong Polytechnic University web concordancer has a faster connection. In addition, it also allows learners to click on the keyword to expand a single-line concordance to view its larger context, as shown in Figure one above. As for its weakness, the connection speed to this site is still not adequate but it is faster than the speed to COBUILD site. Besides, the corpora available online at Polytechnic University are not tagged with part-of-speech tags, so the Polytechnic web concordancer does not allow for words plus POS tags search. Students indicate that they sometimes need to search a word with a particular part-of-speech so that they can locate the specific information they need more efficiently.

4.3 The Gutenburg Concordancer in the U.S.

This site is not as popular as the two sites mentioned above. All of its corpora came from the well-known Gutenburg free electronic text project, and it contains about 80 million words. Gutenburg offers the electronic texts without copyright problem. However, based on our test, this site has the slowest connection from Taiwan. Moreover, the users can only search one text file at a time, so they often cannot find the words they want to know about. All the texts are also not tagged.

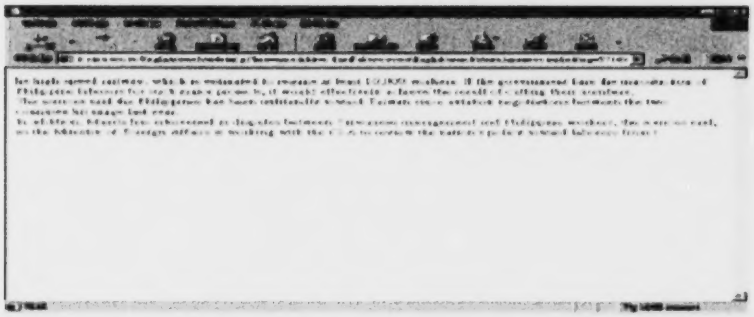
BEST COPY AVAILABLE

Figure 7. The Web Concordance Output



Third, since the display of larger linguistic contexts are fairly important when learners analyze the usage or the meaning of particular words or phrases. To make the data-analysis process more efficiently, NTOU web concordancer allows learners to have a convenient access to the larger context by clicking on any single-line concordance, as shown in Figure 7. An instance of the contextual information is shown below in Figure 8.

Figure 8. Larger Linguistic Context of a Concordance



Last, some learners indicated that they prefer to have the option of searching both words/phrases and POS tags when using web-based concordancers since a tagged corpus can help learners to filter out irrelevant information and help them locate the information they need more efficiently. Though the text tagging process could be time-consuming and difficult, we have adopted some tools to create tagged corpora. The tools and techniques used in our project are described below.

5.1 Tagged Corpora

Tagging a corpus with millions of words manually is not feasible. How can COBUILD project provide such a wonderful service? In fact, they use their automatic POS taggers to carry out the POS tagging. For our project, we also purchase a useful tagger to accomplish the daunting tagging tasks.

In fact, there are quite a few taggers available. We have compared various taggers and consider the limited resources we have in hand. We decided to adopt the inexpensive automatic POS (part-of-speech) taggers, the TOSCA tagger, to annotate the corpora. The TOSCA Research Group is a team of corpus linguists at the University of Nijmegen. One focus of their research is on the development of Tools for Syntactic Corpus Analysis (TOSCA). Its tag set consists of 17 major wordclasses. With features for subclasses and additional semantic, syntactic and morphological information, the total number of different tags is 220.

It is not possible for ESL teachers or learners to use the 220 tags. So we decide to keep the system simple by converting the detailed tagging system into to the major 17 word classes so users can use these tags more easily. For instance, if one needs to know the usage of 'issue' as a verb, then he/she can input a query, issue/VB, to the system. The outcome of word plus tag search is shown below in Figure 9. The POS tags would allow users to search the corpora more efficiently.

BEST COPY AVAILABLE

The following table summarize all the strengths and weakness of these three different web concordancers.

Table 1. The Comparison of Three Different Web Concordancers

	Hong-Kong PolyTechnic Web Concordancer	COBUILD Sampler	Gutenburg Web Concordancer
Connection Speed	Moderate speed	Slower	Slowest
Larger Contexts for Keywords	Available	Not available	Not available
Tagged Texts	Not tagged	Automatic tagged	Not tagged
Text Coverage	Several million-word text files	Several large corpora about 50 million words	About 80 million words
Learner Corpora	Available	Not available	Not available

5 National Taiwan Ocean University (NTOU) Web Concordancer

With a research grant from NSC (National Science Council) of Taiwan, a research team at National Taiwan Ocean University created a web concordancer. In this project we not only try to provide a faster and more reliable concordancing system open to all interested English teachers and users but also try to overcome some weakness of currently existing web-based concordancers.

Based on the comparison of the three major web concordancers. We would like to create a web concordancer with the following features and options for Taiwanese EFL learners and teachers.
1.Fast and reliable connection and quick response.
2.Large corpora for ESL/EFL learners and teachers (including both NS corpora and NNS learner corpora).
3.Larger contexts for any searched word.
4.Tagged corpora files that allow learners/teachers to search words with POS tags.

Since we have only limited funds, we do not expect to surpass the commercial web site such as Collins COBUILD or the well-funded project of Hong-Kong Polytechnic University. We aim at creating a fast, reliable, and friendly web concordancer for Taiwanese EFL learners and teachers. We will discuss the four goals outlined above in details in the following sections.

First, the connection to NTOU web concordancer can be faster since it is built on the TANET. For TANET user, our web concordancer will be able to respond to learner's queries within 15-20 seconds. Moreover, to increase the searching speed, we reduce each corpus size to around 10-15MB. This is a technique adopted at Hong-King Polytechnic University.

Second, we expect to have large corpora. Due to the copyright restrictions, we have to rely mainly on the free electronic texts from Gutenburg projects. We are also negotiating with several local English newspapers about putting their electronic texts online for educational purpose. In addition to the native speaker corpora, we also have a smaller learner corpus available. During the past three years, we have been collecting English writing samples of Taiwanese college students. Now we have a 200,000-word EFL learner corpus, and this corpus will be a very precious resource for language teachers or researchers to better understand Chinese EFL learners' interlanguage. The interface of NTOU web concordancer is shown below in Figure 6.

Figure 6. Interface of NTOU Web Concordancer

BEST COPY AVAILABLE

Figure 9. Search Outcomes of Word plus Tag

be so confident. The tribunal will **issue** indictments whether or not suspects
within seven days. [p] 3.4 We can **issue** instructions to you and Cardholders
be inflationary, the Fund would only **issue** notes when they were backed by its
KITCHEN Ideas [p] Welcome to **issue** number two of `Kitchen Ideas',
papers. `The 13th Air Force can't **issue** orders for you to travel to
on May 16 and September 14 to **issue** passenger service requirements in
but warranted clubs are entitled to **issue** permits to members' yachts as long
The Board has no immediate plans to **issue** preference shares. However, it
A limited company that does not **issue** shares for public subscription, and
Welna: The Swiss, in fact, do plan to **issue** statements similar to the EC's
complaints is that Greece will not **issue** visas at the border as Yugoslavia

6 Conclusion

Although NTOU web concordancer has been set up and running for a short period of time, students at NTOU show positive attitude toward this new learning tool. Some students suggest that the web site should be introduced to the whole university community since they found the searching tool to be useful for English learning. It is rather encouraging to receive students' positive feedback.

However, there are still difficulties in using web concordancers. According to Sun [10], the problems of using web concordancers can be divided into two categories: one related to computing resources, another related to the difficulties of using or interpreting the concordance output. For computing resources, NTOU web concordancer still has much room for improvement. For instance, we need put in more suitable text corpora and the search speed should be faster. Besides, the automatic tagging of texts still contains some serious errors.

As for the difficulties of using or interpreting the concordance output, Ma [6] and Sun [10] pointed out that learners need training on using concordancer. For learner training, we might create an online tutorial on the use of concordancer so learners can use the system more effectively. Sun [10] also indicated that it is rather time consuming to do data analysis. Sun pointed out that the concordance output seems too large to be manageable in some cases, and learners can be overloaded with information. In fact, a corpus contains either too much or too little information would cause troubles for language learners. Flowerdew [2] points out that we need to choose our corpora more carefully and make sure the corpora will meet the needs of learners. We will continue to collect users' feedback and further improve our concordancing system.

References

[1] Ball, C., "Tutorial notes: Concordances and corpora", http://www.georgetown.edu/cball/corpora/tutorial.html, (1996).

[2] Flowerdew, J., "Concordancing in language learning", The Power of CALL, Athelstan, pp. 97-113, (1996).

[3] Johns, T., "From printout to handout: Grammar and vocabulary teaching in the context of data-driven learning", Perspectives on Pedagogical Grammar, Cambridge University Press, 293-313, (1994).

[4] Kettemann, B., "On the use of concordancing in ELT", TELL&CALL, VOL 4, pp. 4-15, (1995).

[5] Leech, G., "Corpus linguistics and language teaching", Teaching and Language Corpora: a Convergence. Longman Press, pp.1-24, (1997).

[6] Ma, K. C., "Classroom concordancing: How and what students learn", Unpublished M.A. thesis, City Polytechnic of Hong-Kong, (1993).

[7] McArthur, T. & McArthur, R. "The Oxford companion to the English language", Oxford University Press, (1992).

[8] Odlin, T., "Perspectives on pedagogical grammar", Cambridge: Cambridge University Press, (1994).

[9] Stevens, V., "Concordancing with language learners: Why? When? What?", CAELL Journal, VOL 6, No 2, pp. 2-10, (1995).

[10] Sun, Y. Z., "Web-based concordancing: challenges and opportunities for English language teaching", The proceedings of the Eighth International Symposium on English Teaching, Taipei, Taiwan, pp. 517-526, (1999).

Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW

Jie Chi Yang* and Kanji Akahori**
**National Central University,*
38, Wu-Chuan Li, Chung-Li, Tao-Yuan, Taiwan 320
E-mail: yang@src.ncu.edu.tw
***Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan
E-mail: akahori@cradle.titech.ac.jp

This paper describes the development and evaluation of a Computer Assisted Language Learning (CALL) system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, cohesive expressions are used as cue words. The rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts is developed using Natural Language Processing (NLP) techniques. The main functions of the system are: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study. Furthermore, two evaluation experiments are conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the two experiments, respectively. The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning.

Keywords: **Computer Assisted Language Learning, Natural Language Processing, evaluation, technical Japanese texts**

1 Introduction

The aim of this research was to construct a Japanese learning environment for foreign students on the Internet. For students in science and technology universities, there is little time for enrolling in a regular Japanese language course, which involves spending a lot of time on experiments, studies and research, etc. The Internet environment is provided in almost all laboratories and can become an excellent virtual learning environment if there is a Japanese learning system which can be accessed on the Internet anytime and anywhere. The Internet has stimulated many new approaches to language instruction and learning, and it provides a great opportunity to learn one of the most important skills, writing. This is especially true for students in the science and engineering fields who need to write technical texts.

However, almost all CALL systems are concerned with learning how to improve one's reading and listening skills. Few systems are concerned with writing because of the difficulty of implementing an analysis of sentences typed by students who need to learn to phrase their own sentences freely without following any predefined rules. More and more researchers, therefore, use Natural Language Processing (NLP) techniques to analyze learners' typed sentence [9][16]. Recently, NLP techniques designed for use with CALL have attracted special attention (see, for example, [21][22], etc.), as this is expected to help improve writing skills.

Yang and Akahori [28][29] developed a Japanese writing CALL system using NLP techniques which can be used for learning and producing the Japanese passive voice on the WWW. Comparison of two Web-based CALL systems showed that the method of 'free input' and 'feedback corresponding to learners' typed sentence' is better than the method of 'multiple choice' and 'feedback that only displays the correct answer' [31]. Furthermore, an evaluation of the learning histories of the subjects who have actually used the system through the Internet shows that the system obtained a high degree of accuracy and instructional effectiveness [29]. These results demonstrate the effectiveness of the CALL system for writing using NLP techniques on the Internet.

Having sufficient vocabulary and grammatical knowledge is important when learning a foreign language. However, although vocabulary and grammatical rules are provided for correct sentence building in a foreign language, this knowledge alone is not enough. Being able to form correct sentences is by no means enough when it comes to expressing complex thoughts. The major problem for most foreigners learning Japanese is, apart from the writing system, the building of sentences: that is, knowing the corresponding words, the postfixes signaling the word's function (*de*, *ni*, etc.) and the position of the words (verbs final form). It is of paramount importance to learn how to structure one's thoughts: i.e., how to make an outline, how to signal the relative importance of a piece of information, and how it relates to the whole. Therefore, in order to write or to comprehend a structured sentence, it is necessary to learn how to associate sentences, in addition to having a good command of vocabulary and grammar. The connection between sentences can be described as conjunction of adjacent sentences, which is an important criterion for writing a good text as per research in *cohesion* or *discourse structure* [1][3][13][17][26]. Unfortunately, discourse structure is not amenable to single-sentence grammatical analysis, because there are no 'discourse grammars' [11].

Many methods concerning the analysis of discourse structure have been proposed in previous related works. Mann and Thompson's [18][19] rhetorical structure theory (RST) is an influential theory of text structure that is being extended to serve as a theoretical basis for computational text planning. RST postulates that a set of about 25 relations suffices to represent the relations that hold within normal English texts. Most relations have a cue word or phrase which informs the listener how to relate the adjacent clauses. RST can be applied to a computational model. There have been attempts at text generation using RST for the implementation of a prototype of the theory [10][20]. Cue words are also widely used in the identification of rhetorical relations among portions of a text [8][15][24]. Hobbs claims that coherence in conversations and in texts can be partially characterized by a set of coherence relations, which are classified into four categories. Hovy [10] collected and taxonomized the discourse segment relations; this set of relations contains three taxonomies of approximately 120 relations. Hirschberg and Litman [7] also summarize the proposed meanings of items classed as cue words in six computational and linguistic treatments.

In most of these earlier works, emphasis was put on the knowledge that is necessary for recognizing discourse structure. The problem of inference based on that knowledge was also emphasized. However, this does not mean that knowledge can be constructed easily from information available on computers. Constructing common knowledge to implement a practical system is often beyond the capabilities of current NLP techniques. Kurohashi and Nagao [14] proposed an automatic method for detecting discourse structure by checking surface information in text sentences. The information included 'clue expressions', 'occurrence of identical/synonymous words/phrases', and 'similarity between two sentences'. Their result indicates that, in the case of technical Japanese texts, considerable portions of discourse structure can be identified by incorporating the three types of surface information.

Since there are few practical CALL systems that use discourse analysis, the purpose of this study is to develop such a system for helping learners to write technical Japanese texts on the WWW. Section 2 describes the implementation of the system using NLP techniques. The authors took a similar approach to Kurohashi and Nagao [14], namely using surface information in texts. The rules for analyzing technical Japanese texts are based on micro-level (cohesive expressions) and macro-level (headlines) information. Section 3 describes the study that evaluates the effectiveness of the system in two experiments.

2 Implementation of the system

2.1 Method

The combination of cohesive expressions and headlines are employed in the implementation of the system. To examine discourse structure of technical Japanese texts, the classification of basic expressions by Yamazaki et al. [27] is adopted in this study. The reason for this is that their classification covers most of the

elements of technical Japanese texts. Based on their findings, the authors have classified cohesive expressions into 15 categories as follows: *comparison, contrast, analogy, cause and reason, basis, composition and enumeration, presentation, definition, classification, hypothesis and conditions, change of state, process of change, change with prerequisites, means and methods, selection*. The total number of expressions is 82. All of the expressions are converted into regular expressions to make the rules. In all, 654 distinctions in the regular expressions were extracted from the 15 categories of cohesive expressions. These formed 654 original rules, which are used in the process of analysis.

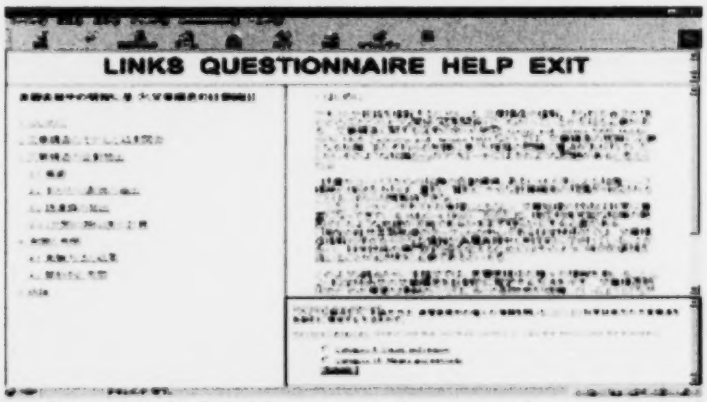
There are two patterns of rules: one is for 'simple pattern matching' and the other is for 'discourse analysis'. The former, called rule set A, is written as a regular expression form and the latter, called rule set B, is written as a regular expression combined with the result of morpheme analysis and syntax analysis. The rule in rule set B is written in a more restrictive form to improve the accuracy of discourse structure analysis. For example, if a sentence is applied to rule set A, it is then analyzed by the morpheme analysis and syntax analysis and the result will be matched to rule set B.

There are many text books on good writing, which nearly all contain a lot of material concerning the different kinds of categories or conceptual bricks at the discourse level out of which texts are built (see, for example, [4][5][6][12][25][26]. However, it is difficult to detect the text structure by just using their framework because it is too extensive and the varieties of different formats used by people for building technical texts too numerous. Instead of predefined framework, headline is used as macro-level information in this study. There are several reasons why the authors decided to use 'headline' instead. First, a well-chosen headline allows the reader to infer the text structure. Second, different formats of texts can be analyzed independently of the texts' style by using the headline. Third, it is easier to understand when the headline is displayed rather than a tree structure because the headline is a part of the original text.

2.2 The discourse structure analysis module

The discourse analysis module of the system contains 'simple pattern matching', 'morpheme analyzer', 'syntax analyzer', and 'discourse analyzer' components. First, the headlines are extracted and the Japanese texts are divided into sentences using several heuristic rules. Then all the sentences in all texts are matched with all the rules in the 'simple pattern matching' component. The 'rules for pattern matching' is used during the process of pattern matching. Because of the exclusive character of almost all of the rules, they are written in order of frequency to reduce the running time on the computer. The frequency of rules is made from the 'rules corpus'. The present system analyzes Japanese text sentences with the morpheme analyzer and syntax analyzer to check the dependency of sentences in the case grammar. Therefore, each cue word in the rules is not only matched against the word itself, but also against the 'parts-of-speech' of the cue word. Only sentences that match the rules written in restrictive form are needed for morpheme analysis and syntax analysis. This takes into consideration the problem of computer running time. The 'rules for discourse analysis' is matched again in restrictive form after the process of syntax analysis. The additional information (parts-of-speech, tense, etc.) is checked to identify the cohesive expressions, especially in the case where one sentence is matched with two or more rules.

Figure 1. One screen shot of discourse structure analysis



The learning page shows a list of technical Japanese texts. Learners can choose any one text by clicking the hyperlink on the list. When learners choose one of the texts from the list, headlines of the selected text are

BEST COPY AVAILABLE

analyzed and displayed first to help learners grasp the whole text structure. Secondly, learners can click on the headline of any part of the text that they want to read. Then the original sentences corresponding to the headline are displayed with the extracted cohesive expressions. The cue words in the cohesive expressions are displayed in color to enable learners to focus on it more easily. Learners can click on any cue words to further find out the cohesive expressions corresponding to the sentences. They can also refer to examples that correspond to the cohesive expressions from the 'examples corpus'. Figure 1 shows one screen shot of the system (text source: [14]). As shown in this figure, the headlines of the Japanese text are analyzed and displayed on the left side of the browser. The headlines show the structure of the text. On the right side, the original sentences corresponding to the selected headline are displayed on the upper part with the cohesive expressions extracted and a link made. When the cue word '*kotoniyori*' (in the first line of the third paragraph) is clicked, the matched cohesive expressions are displayed on the bottom right side of the browser.

2.3 System evaluation of the discourse structure analysis module

A system evaluation is conducted to evaluate the performance of the discourse structure analysis module on 24 technical Japanese texts. The system evaluation is designed for text analysis in two stages (pattern matching in Stage 1 and discourse analysis in Stage 2). The analysis consists of 3 items on both stages: *headline extraction*, *cohesive expression extraction* and *frequency of the rules*. The accuracy ratio of the headline extraction in Stage 1 is 95.22% on average. After a heuristic rule is added, the result of the headline extraction using the revised rules in Stage 2 gained an exceedingly high accuracy rate of 99.17%. The accuracy of the cohesive expression extraction in Stage 1 is 70.23% on average. On the other hand, the accuracy in Stage 2 improved to 92.70% on average. This result shows that using the rules combined with morpheme analysis and syntax analysis gained a higher degree of accuracy than only using the rules of simple pattern matching. After the cohesive expression extraction, the frequency of rules is calculated. The result of 'frequency of the rules' is saved to the 'rules corpus'. The order of frequency is taken as the order of the rules to reduce the running time on the computer.

2.4 The system for supporting technical Japanese texts writing

A CALL system is developed to help learners in the writing of technical Japanese texts. The system is implemented in terms of headlines and cohesive expressions, which is based on the method of the discourse structure analysis module. For headlines supporting, a connection between headline and texts corresponding to the headline is made automatically. Learners can click on any headline to immediately link to the content of texts corresponded to it. For cohesive expressions supporting, examples with the selected cohesive expressions are automatically extracted from the corpus of technical Japanese texts. Learners can refer to these examples to help them improve their writing skills.

The flow of the system is as follows:

(1) Learners register themselves to use the system. An ID number is given after registration. The ID number is used to identify the learner because a log of all learning histories is registered during the operation of the system.
(2) The page for headlines input is appeared. Learners can free input their headlines here. When learners completed their construction of headlines, each headline is automatically linked and displayed on the left side of the browser. The left side of Figure 2 shows an example of linked headlines.
(3) When learners choose one of the headlines, a text box is appeared on the top right side of the browser. Learners can compose their texts corresponded to the clicked headline in the text box. The top right side of Figure 2 shows an example of texts input.
(4) When learners click on the 'basic expressions' button on the bottom right side of the browser, the categories of cohesive expressions is appeared on a new page. Each category is classified further into sub-categories. When learners choose one of the sub-categories from the list, examples are automatically extracted from the corpus of technical Japanese texts and the result is displayed on the bottom of the browser. Figure 3 shows that examples are displayed corresponded to the selected sub-category of cohesive expressions.

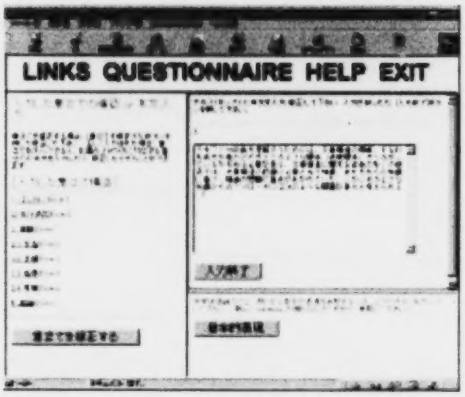


Figure 2. One screen shot of the linked headline and texts input

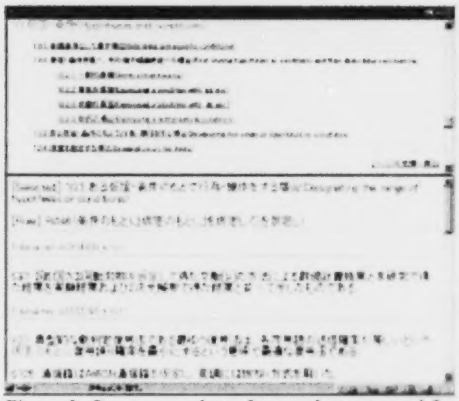


Figure 3. One screen shot of examples extracted from corpus

3 The study

Two evaluation experiments were conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the experiment 1 and the experiment 2, respectively. Thirty-three subjects participated in the experiment 1; the other seven subjects participated in the experiment 2. The subjects almost use the WWW and computer everyday.

3.1 Experiment 1

The purpose of the experiment 1 was to examine the functions of the system in terms of subjects' intuitive impression. Therefore, the experiment was designed to make a comparison between the system with the popular and well-known word processor: the MS-Word. During the experiment, the subjects were asked to look at the operation of the system and the MS-Word using video for duration of 10 minutes. The subjects were informed that they would be asked to fill in the questionnaire concerning the comparison of the two systems. The questionnaire consisted of 3 categories: *items of technical sentences writing*, *items of general sentences writing*, and *items of system operation*. The subjects were asked to rate 24 items on a 5-point scale. The subjects were also asked to make comments on the system.

Figure 4 shows the rating of the system and the MS-Word for each item with the 3 categories in experiment 1 and 2. The result of the experiment 1 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing. For those items of general sentences writing and system operation, the result shows that the MS-Word obtained a higher rating than the system or there was no significant difference on the two systems. However, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning').

Comments on the system are summarized as follows: Almost all of the subjects answered that it is necessary to involve the functions to access other objects, such as figures, tables and numerical expressions, etc. Since the system is emphasized on the discourse analysis of technical Japanese texts using NLP techniques, the target of the system is limited to 'texts'. However, figures, tables and numerical expressions are important components of technical texts. Therefore, development of such visual tools for supporting these objects is expected.

3.2 Experiment 2

The result of the experiment 1 suggests that the system is preferred to the MS-Word on technical texts writing. However, actual usage of the system is not evaluated. Therefore, in order to examine the effectiveness of the system in terms of actual usage of the system by foreign students, experiment 2 was conducted. During the experiment, the subjects were asked to compose a technical Japanese text using the system. The subjects were asked to write sentences concerning their specialization instead of a given task because a variety of subjects' different fields. After the composition is completed, the subjects were asked to fill in the questionnaire concerning the comparison of the system and the MS-Word. The questionnaire is identical to experiment 1, which is divided into 3 categories. Finally, the subjects were interviewed based on

BEST COPY AVAILABLE

their response to the questionnaires.

From Figure 4, the result of the experiment 2 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing, which is consistent with the result of experiment 1. For those items of general sentences writing and system operation, the result shows that the subjects preferred the system, or the MS-Word or there was no significant difference on the two systems. Comparing this result to experiment 1, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning'), which is consistent with the result of experiment 1. On the other hand, some items obtained different result between the two experiments. These items can be divided into 3 types: First, items 7 ('I want to recommend it to my friends') and 24 ('I want to use it more') are rated from 'no significant difference' to 'a higher rating to the system'. Second, item 2 ('It is friendly') is rated from 'a higher rating to the MS-Word' to 'no significant difference'. Third, item 11 ('It is easy to see') is rated from 'no significant difference' to 'a higher rating to the MS-Word'.

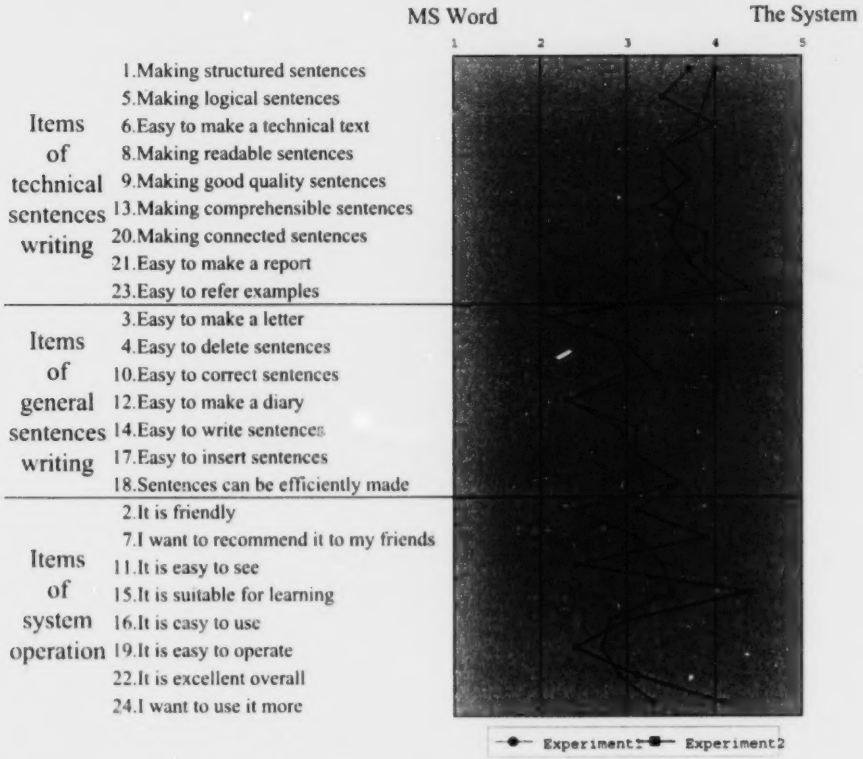


Figure 4. The rating for each item in Experiment 1 and 2

The subjects were asked to give reasons for their responses to the questionnaire items during the interview. The result of the interview concerning the functions of the system is divided into 4 types and summarized as follows: First, for automatically analyzing and displaying headlines, almost all of the subjects answered that it is very useful because they can click on any headline to immediately read the content of texts corresponded to it. The subjects also answered that headlines can be treated as an important role to help them to grasp the whole structure of the texts. Second, for automatically analyzing and displaying cohesive expressions, almost all of the subjects answered that it is very useful because they can find it is easier to convey their thoughts using explicit cohesive expressions. The subjects also answered that it is easy to find their errors because cohesive expressions in the texts are highlighted. Third, for referring to examples from corpus, almost all of the subjects answered that it is very efficient to writing because they can save a lot of time for finding examples from other references. The subjects also answered that they can imitate and learn more examples from the output of corpus. They can learn very much from the process of referring to examples in different texts, especially if there are many different usages in an expression. Fourth, for

Japanese language learning, almost all of the subjects answered that the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts. The subjects also answered that they can learn not only new cohesive expressions but also correct usages of cohesive expressions even they already know one of them.

Other comments on the system are summarized as follows: Almost all of the subjects answered that it is desired to improve the system to support the functions of electronic dictionary, thesaurus, grammar checking, etc. Therefore, construction of a good electronic dictionary for technical texts writing is considered as an important issue. Moreover, some subjects answered that it is better to extract examples form corpus according to learners' specialization than only random accessing to the corpus. From this result, constructing a corpus should not only consider the number of texts but also the balance of texts in each field.

4 Conclusion

In this paper, the authors describe the development and evaluation of a CALL system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, the rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts has been developed using NLP techniques. The system has the following functions: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study.

The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning. Based on the functions of the system, these results can be explained as follows: First, headlines can be treated as an important role to help learners to grasp the whole structure of the texts. Second, cohesive expressions often explicitly appear in the surface expressions of technical Japanese texts. Thus, it seems important and necessary to use these explicit cohesive expressions to structure one's thoughts in technical Japanese texts. Foreign learners especially may find it is easier to convey their thoughts using explicit cohesive expressions because these can be treated as an indicator of a discourse. Third, the corpus consists of the actual usage in technical Japanese texts from different fields. Instead of predefined examples, examples are automatically extracted from the corpus. Therefore, learners can learn very much from the process of referring to examples in different texts if there are many different usages in an expression. They can also save a lot of time for finding examples from other references.

In conclusion, the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts.

Acknowledgements

The authors would like to thank Dr. Kikuko Nishina (Professor in the International Student Center, Tokyo Institute of Technology) for her kind help during the analysis of technical Japanese texts. The authors would also like to thank Ms. Cheong Meng-Mei (Tokyo Institute of Technology) for her suggestions and comments on an earlier version of this paper. This study is funded by the Scientific Research Grant from the Ministry of Education of Japan (Subject No. B(2)10558019, Period: from 1 Apr 1998 to 31 Mar 2001).

References

[1]Chan, S.W.K. and T'sou, B.K. (1998). Analyzing Discourse Structure using Lexical Cohesion: A Connectionist Tool. In *Proceedings of the 1998 IEEE International Joint Conference on Neural Networks*, V1: 657-662.

[2]Hajicova, E. (1996). The information Structure of the Sentence and the Coherence of Discourse. In Hovy, E.H. and Scott, D.R. (Eds.), *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, 97-107. Berlin: Springer – Verlag.

[3]Halliday, M.A.K. and Hasan, R. (1976). *Cohesion in English*. London and New York: Longman.

[4]Hamada, M., Hirao, T. and Yui, K. (1997). *Paper Workbook for University/Foreign Student*. Tokyo: Kuroshio. [In Japanese.]

[5]Hayes, J.R. and Flower, L.S. (1980). Identifying the Organization of Writing Processes. In Gregg, L. and Steinberg, E. (Eds.), *Cognitive Processes in Writing: An Interdisciplinary Approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[6]Hayes, J.R. (1989). Writing as Problem Solving. In Hayes, J.R (Eds.), *The Complete Problem Solver*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[7]Hirschberg, J. and Litman, D. (1993). Empirical Studies on the Disambiguation of Cue Phrases. *Computational Linguistics*, 19(3), 501-530.

[8]Hobbs, J.R. (1979). Coherence and Coreference. *Cognitive Science*, 3: 67-90.

[9]Holland, V.M. and Kaplan, J.D. (1995). Natural Language Processing Techniques in Computer Assisted Language Learning: Status and Instructional Issues. *Instructional Science*, 23: 351-380.

[10]Hovy, E.H. (1993). Automated discourse generation using discourse structure relations. *Artificial Intelligence*, 63: 341-385.

[11]Hovy, E.H. and Scott, D.R. (Eds.) (1996). *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, Berlin: Springer – Verlag.

[12]Kinoshita, K. (1981). *The Techniques of Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[13]Kuno, S. (1978). *The Grammar of Discourse*. Tokyo: Daisyukan. [In Japanese.]

[14]Kurohashi, S. and Nagao, M. (1994). Automatic Detection of Discourse Structure by Checking Surface Information in Sentences. *Journal of Natural Language Processing*. 1(1): 3-20. [In Japanese.]

[15]Litman, D.J. (1994). Classifying Cue Phrases in Text and Speech Using Machine Learning. In *Proceedings of the Twelfth National Conference on Artificial Intelligence*, V1: 806-813.

[16]Loritz, D. (1992). Generalized Transition Network Parsing for Language Study: The GPARS System for English, Russian, Japanese and Chinese. *CALICO Journal*. 10(1): 5-22.

[17]Mann, W.C. (1984). Discourse Structures for Text Generation. In *Proceedings of the 10th COLING*. 367-375.

[18]Mann, W.C. and Thompson, S.A. (1987). Rhetorical Structure Theory: Description and Construction of Text Structures. In Kempen, G. (Eds.), *Natural Language Generation: New Results in Artificial Intelligence, Psychology and Linguistics*, 85-95. Dordrecht: Martinus Nijhoff Publishers.

[19]Mann, W.C. and Thompson, S.A. (1988). Rhetorical Structure Theory: Toward a Functional Theory of Text Organization, *Text*, 8(3): 243-281.

[20]Moore, J.D. and Paris, C. (1994). Planning Text for Advisory Dialogues: Capturing Intentional and Rhetorical Information. *Computational Linguistics*, 19(4), 651-694.

[21]Nagata, N. (1996). Computer vs. Workbook Instruction in Second Language Acquisition, *CALICO Journal*. 14(1): 53-75.

[22]Nerbonne, J., Dokter, D. and Smit, P. (1998). Morphological Processing and Computer-Assisted Language Learning, *CALL Journal*, 11(5): 543-559.

[23]Nishina, K. (1997). The Fundamental Research for the Development of Learning System of Technical Japanese. *Doctoral Dissertation*. Tokyo Institute of Technology, Tokyo. [In Japanese.]

[24]Reichman, R. (1985). *Getting Computers to Talk Like You and Me: Discourse Context, Focus, and Semantics*. The MIT press, Bradford Books.

[25]Shimizu, I. (1959). *The Manner of Japanese Writing*. Tokyo: Iwamani. [In Japanese.]

[26]Sugihara, K. (1994). *The Manner of English Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[27]Yamazaki, N., Tomita, Y., Hirabayashi, Y. and Hatano, Y. (1992). *Handbook of Technical Japanese*. Tokyo: Soutakusha. [In Japanese.]

[28]Yang, J.C. and Akahori, K. (1997). Development of Computer Assisted Language Learning System for Japanese Writing Using Natural Language Processing Techniques: A Study on Passive Voice, In *Proceedings of the 8th World Conference on Artificial Intelligence in Education (AI-ED97)*. 263-270.

[29]Yang, J.C. and Akahori, K. (1998a). Error Analysis in Japanese Writing and Its Implementation in a Computer Assisted Language Learning System on the World Wide Web. *CALICO Journal*, 15(1-3): 47-66.

[30]Yang, J.C. and Akahori, K. (1998b). A Discourse Structure Analysis of Technical Japanese Text. In *Proceedings of the Sixth International Conference on Computers in Education (ICCE98)*. Beijing, China. 643-650.

[31]Yang, J.C. and Akahori, K. (1999). An Evaluation of Japanese CALL Systems on the WWW Comparing a Freely Input Approach with Multiple Selection. *CALL Journal*, 12(1): 59-79.

[32]Yang, J.C. and Akahori, K. (2000). A Discourse Structure Analysis of Technical Japanese Texts and Its Implementation on the WWW. *CALL Journal*, 13(2): 119-141.

Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW

Jie Chi Yang* and Kanji Akahori**
**National Central University,*
38, Wu-Chuan Li, Chung-Li, Tao-Yuan, Taiwan 320
E-mail: yang@src.ncu.edu.tw
***Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan
E-mail: akahori@cradle.titech.ac.jp

This paper describes the development and evaluation of a Computer Assisted Language Learning (CALL) system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, cohesive expressions are used as cue words. The rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts is developed using Natural Language Processing (NLP) techniques. The main functions of the system are: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study. Furthermore, two evaluation experiments are conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the two experiments, respectively. The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning.

Keywords: **Computer Assisted Language Learning, Natural Language Processing, evaluation, technical Japanese texts**

1 Introduction

The aim of this research was to construct a Japanese learning environment for foreign students on the Internet. For students in science and technology universities, there is little time for enrolling in a regular Japanese language course, which involves spending a lot of time on experiments, studies and research, etc. The Internet environment is provided in almost all laboratories and can become an excellent virtual learning environment if there is a Japanese learning system which can be accessed on the Internet anytime and anywhere. The Internet has stimulated many new approaches to language instruction and learning, and it provides a great opportunity to learn one of the most important skills, writing. This is especially true for students in the science and engineering fields who need to write technical texts.

However, almost all CALL systems are concerned with learning how to improve one's reading and listening skills. Few systems are concerned with writing because of the difficulty of implementing an analysis of sentences typed by students who need to learn to phrase their own sentences freely without following any predefined rules. More and more researchers, therefore, use Natural Language Processing (NLP) techniques to analyze learners' typed sentence [9][16]. Recently, NLP techniques designed for use with CALL have attracted special attention (see, for example, [21][22], etc.), as this is expected to help improve writing skills.

Yang and Akahori [28][29] developed a Japanese writing CALL system using NLP techniques which can be used for learning and producing the Japanese passive voice on the WWW. Comparison of two Web-based CALL systems showed that the method of 'free input' and 'feedback corresponding to learners' typed sentence' is better than the method of 'multiple choice' and 'feedback that only displays the correct answer' [31]. Furthermore, an evaluation of the learning histories of the subjects who have actually used the system through the Internet shows that the system obtained a high degree of accuracy and instructional effectiveness [29]. These results demonstrate the effectiveness of the CALL system for writing using NLP techniques on the Internet.

Having sufficient vocabulary and grammatical knowledge is important when learning a foreign language. However, although vocabulary and grammatical rules are provided for correct sentence building in a foreign language, this knowledge alone is not enough. Being able to form correct sentences is by no means enough when it comes to expressing complex thoughts. The major problem for most foreigners learning Japanese is, apart from the writing system, the building of sentences: that is, knowing the corresponding words, the postfixes signaling the word's function (*de*, *ni*, etc.) and the position of the words (verbs final form). It is of paramount importance to learn how to structure one's thoughts: i.e., how to make an outline, how to signal the relative importance of a piece of information, and how it relates to the whole. Therefore, in order to write or to comprehend a structured sentence, it is necessary to learn how to associate sentences, in addition to having a good command of vocabulary and grammar. The connection between sentences can be described as conjunction of adjacent sentences, which is an important criterion for writing a good text as per research in *cohesion* or *discourse structure* [1][3][13][17][26]. Unfortunately, discourse structure is not amenable to single-sentence grammatical analysis, because there are no 'discourse grammars' [11].

Many methods concerning the analysis of discourse structure have been proposed in previous related works. Mann and Thompson's [18][19] rhetorical structure theory (RST) is an influential theory of text structure that is being extended to serve as a theoretical basis for computational text planning. RST postulates that a set of about 25 relations suffices to represent the relations that hold within normal English texts. Most relations have a cue word or phrase which informs the listener how to relate the adjacent clauses. RST can be applied to a computational model. There have been attempts at text generation using RST for the implementation of a prototype of the theory [10][20]. Cue words are also widely used in the identification of rhetorical relations among portions of a text [8][15][24]. Hobbs claims that coherence in conversations and in texts can be partially characterized by a set of coherence relations, which are classified into four categories. Hovy [10] collected and taxonomized the discourse segment relations; this set of relations contains three taxonomies of approximately 120 relations. Hirschberg and Litman [7] also summarize the proposed meanings of items classed as cue words in six computational and linguistic treatments.

In most of these earlier works, emphasis was put on the knowledge that is necessary for recognizing discourse structure. The problem of inference based on that knowledge was also emphasized. However, this does not mean that knowledge can be constructed easily from information available on computers. Constructing common knowledge to implement a practical system is often beyond the capabilities of current NLP techniques. Kurohashi and Nagao [14] proposed an automatic method for detecting discourse structure by checking surface information in text sentences. The information included 'clue expressions', 'occurrence of identical/synonymous words/phrases', and 'similarity between two sentences'. Their result indicates that, in the case of technical Japanese texts, considerable portions of discourse structure can be identified by incorporating the three types of surface information.

Since there are few practical CALL systems that use discourse analysis, the purpose of this study is to develop such a system for helping learners to write technical Japanese texts on the WWW. Section 2 describes the implementation of the system using NLP techniques. The authors took a similar approach to Kurohashi and Nagao [14], namely using surface information in texts. The rules for analyzing technical Japanese texts are based on micro-level (cohesive expressions) and macro-level (headlines) information. Section 3 describes the study that evaluates the effectiveness of the system in two experiments.

2 Implementation of the system

2.1 Method

The combination of cohesive expressions and headlines are employed in the implementation of the system. To examine discourse structure of technical Japanese texts, the classification of basic expressions by Yamazaki et al. [27] is adopted in this study. The reason for this is that their classification covers most of the

elements of technical Japanese texts. Based on their findings, the authors have classified cohesive expressions into 15 categories as follows: *comparison, contrast, analogy, cause and reason, basis, composition and enumeration, presentation, definition, classification, hypothesis and conditions, change of state, process of change, change with prerequisites, means and methods, selection*. The total number of expressions is 82. All of the expressions are converted into regular expressions to make the rules. In all, 654 distinctions in the regular expressions were extracted from the 15 categories of cohesive expressions. These formed 654 original rules, which are used in the process of analysis.

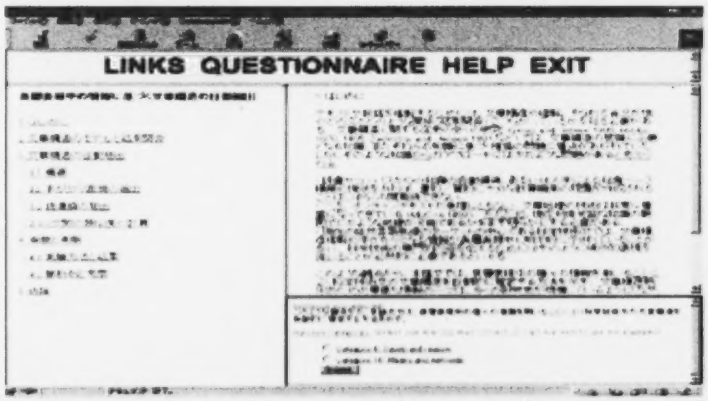
There are two patterns of rules: one is for 'simple pattern matching' and the other is for 'discourse analysis'. The former, called rule set A, is written as a regular expression form and the latter, called rule set B, is written as a regular expression combined with the result of morpheme analysis and syntax analysis. The rule in rule set B is written in a more restrictive form to improve the accuracy of discourse structure analysis. For example, if a sentence is applied to rule set A, it is then analyzed by the morpheme analysis and syntax analysis and the result will be matched to rule set B.

There are many text books on good writing, which nearly all contain a lot of material concerning the different kinds of categories or conceptual bricks at the discourse level out of which texts are built (see, for example, [4][5][6][12][25][26]. However, it is difficult to detect the text structure by just using their framework because it is too extensive and the varieties of different formats used by people for building technical texts too numerous. Instead of predefined framework, headline is used as macro-level information in this study. There are several reasons why the authors decided to use 'headline' instead. First, a well-chosen headline allows the reader to infer the text structure. Second, different formats of texts can be analyzed independently of the texts' style by using the headline. Third, it is easier to understand when the headline is displayed rather than a tree structure because the headline is a part of the original text.

2.2 The discourse structure analysis module

The discourse analysis module of the system contains 'simple pattern matching', 'morpheme analyzer', 'syntax analyzer', and 'discourse analyzer' components. First, the headlines are extracted and the Japanese texts are divided into sentences using several heuristic rules. Then all the sentences in all texts are matched with all the rules in the 'simple pattern matching' component. The 'rules for pattern matching' is used during the process of pattern matching. Because of the exclusive character of almost all of the rules, they are written in order of frequency to reduce the running time on the computer. The frequency of rules is made from the 'rules corpus'. The present system analyzes Japanese text sentences with the morpheme analyzer and syntax analyzer to check the dependency of sentences in the case grammar. Therefore, each cue word in the rules is not only matched against the word itself, but also against the 'parts-of-speech' of the cue word. Only sentences that match the rules written in restrictive form are needed for morpheme analysis and syntax analysis. This takes into consideration the problem of computer running time. The 'rules for discourse analysis' is matched again in restrictive form after the process of syntax analysis. The additional information (parts-of-speech, tense, etc.) is checked to identify the cohesive expressions, especially in the case where one sentence is matched with two or more rules.

Figure 1. One screen shot of discourse structure analysis



The learning page shows a list of technical Japanese texts. Learners can choose any one text by clicking the hyperlink on the list. When learners choose one of the texts from the list, headlines of the selected text are

BEST COPY AVAILABLE

analyzed and displayed first to help learners grasp the whole text structure. Secondly, learners can click on the headline of any part of the text that they want to read. Then the original sentences corresponding to the headline are displayed with the extracted cohesive expressions. The cue words in the cohesive expressions are displayed in color to enable learners to focus on it more easily. Learners can click on any cue words to further find out the cohesive expressions corresponding to the sentences. They can also refer to examples that correspond to the cohesive expressions from the 'examples corpus'. Figure 1 shows one screen shot of the system (text source: [14]). As shown in this figure, the headlines of the Japanese text are analyzed and displayed on the left side of the browser. The headlines show the structure of the text. On the right side, the original sentences corresponding to the selected headline are displayed on the upper part with the cohesive expressions extracted and a link made. When the cue word '*kotoniyori*' (in the first line of the third paragraph) is clicked, the matched cohesive expressions are displayed on the bottom right side of the browser.

2.3 System evaluation of the discourse structure analysis module

A system evaluation is conducted to evaluate the performance of the discourse structure analysis module on 24 technical Japanese texts. The system evaluation is designed for text analysis in two stages (pattern matching in Stage 1 and discourse analysis in Stage 2). The analysis consists of 3 items on both stages: *headline extraction*, *cohesive expression extraction* and *frequency of the rules*. The accuracy ratio of the headline extraction in Stage 1 is 95.22% on average. After a heuristic rule is added, the result of the headline extraction using the revised rules in Stage 2 gained an exceedingly high accuracy rate of 99.17%. The accuracy of the cohesive expression extraction in Stage 1 is 70.23% on average. On the other hand, the accuracy in Stage 2 improved to 92.70% on average. This result shows that using the rules combined with morpheme analysis and syntax analysis gained a higher degree of accuracy than only using the rules of simple pattern matching. After the cohesive expression extraction, the frequency of rules is calculated. The result of 'frequency of the rules' is saved to the 'rules corpus'. The order of frequency is taken as the order of the rules to reduce the running time on the computer.

2.4 The system for supporting technical Japanese texts writing

A CALL system is developed to help learners in the writing of technical Japanese texts. The system is implemented in terms of headlines and cohesive expressions, which is based on the method of the discourse structure analysis module. For headlines supporting, a connection between headline and texts corresponding to the headline is made automatically. Learners can click on any headline to immediately link to the content of texts corresponded to it. For cohesive expressions supporting, examples with the selected cohesive expressions are automatically extracted from the corpus of technical Japanese texts. Learners can refer to these examples to help them improve their writing skills.

The flow of the system is as follows:

(1) Learners register themselves to use the system. An ID number is given after registration. The ID number is used to identify the learner because a log of all learning histories is registered during the operation of the system.
(2) The page for headlines input is appeared. Learners can free input their headlines here. When learners completed their construction of headlines, each headline is automatically linked and displayed on the left side of the browser. The left side of Figure 2 shows an example of linked headlines.
(3) When learners choose one of the headlines, a text box is appeared on the top right side of the browser. Learners can compose their texts corresponded to the clicked headline in the text box. The top right side of Figure 2 shows an example of texts input.
(4) When learners click on the 'basic expressions' button on the bottom right side of the browser, the categories of cohesive expressions is appeared on a new page. Each category is classified further into sub-categories. When learners choose one of the sub-categories from the list, examples are automatically extracted from the corpus of technical Japanese texts and the result is displayed on the bottom of the browser. Figure 3 shows that examples are displayed corresponded to the selected sub-category of cohesive expressions.

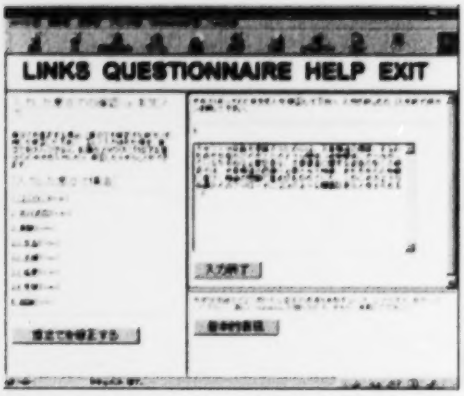


Figure 2. One screen shot of the linked headline and texts input

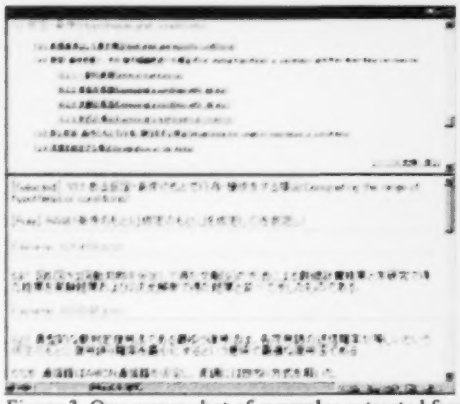


Figure 3. One screen shot of examples extracted from corpus

3 The study

Two evaluation experiments were conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the experiment 1 and the experiment 2, respectively. Thirty-three subjects participated in the experiment 1; the other seven subjects participated in the experiment 2. The subjects almost use the WWW and computer everyday.

3.1 Experiment 1

The purpose of the experiment 1 was to examine the functions of the system in terms of subjects' intuitive impression. Therefore, the experiment was designed to make a comparison between the system with the popular and well-known word processor: the MS-Word. During the experiment, the subjects were asked to look at the operation of the system and the MS-Word using video for duration of 10 minutes. The subjects were informed that they would be asked to fill in the questionnaire concerning the comparison of the two systems. The questionnaire consisted of 3 categories: *items of technical sentences writing*, *items of general sentences writing*, and *items of system operation*. The subjects were asked to rate 24 items on a 5-point scale. The subjects were also asked to make comments on the system.

Figure 4 shows the rating of the system and the MS-Word for each item with the 3 categories in experiment 1 and 2. The result of the experiment 1 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing. For those items of general sentences writing and system operation, the result shows that the MS-Word obtained a higher rating than the system or there was no significant difference on the two systems. However, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning').

Comments on the system are summarized as follows: Almost all of the subjects answered that it is necessary to involve the functions to access other objects, such as figures, tables and numerical expressions, etc. Since the system is emphasized on the discourse analysis of technical Japanese texts using NLP techniques, the target of the system is limited to 'texts'. However, figures, tables and numerical expressions are important components of technical texts. Therefore, development of such visual tools for supporting these objects is expected.

3.2 Experiment 2

The result of the experiment 1 suggests that the system is preferred to the MS-Word on technical texts writing. However, actual usage of the system is not evaluated. Therefore, in order to examine the effectiveness of the system in terms of actual usage of the system by foreign students, experiment 2 was conducted. During the experiment, the subjects were asked to compose a technical Japanese text using the system. The subjects were asked to write sentences concerning their specialization instead of a given task because a variety of subjects' different fields. After the composition is completed, the subjects were asked to fill in the questionnaire concerning the comparison of the system and the MS-Word. The questionnaire is identical to experiment 1, which is divided into 3 categories. Finally, the subjects were interviewed based on

their response to the questionnaires.

From Figure 4, the result of the experiment 2 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing, which is consistent with the result of experiment 1. For those items of general sentences writing and system operation, the result shows that the subjects preferred the system, or the MS-Word or there was no significant difference on the two systems. Comparing this result to experiment 1, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning'), which is consistent with the result of experiment 1. On the other hand, some items obtained different result between the two experiments. These items can be divided into 3 types: First, items 7 ('I want to recommend it to my friends') and 24 ('I want to use it more') are rated from 'no significant difference' to 'a higher rating to the system'. Second, item 2 ('It is friendly') is rated from 'a higher rating to the MS-Word' to 'no significant difference'. Third, item 11 ('It is easy to see') is rated from 'no significant difference' to 'a higher rating to the MS-Word'.

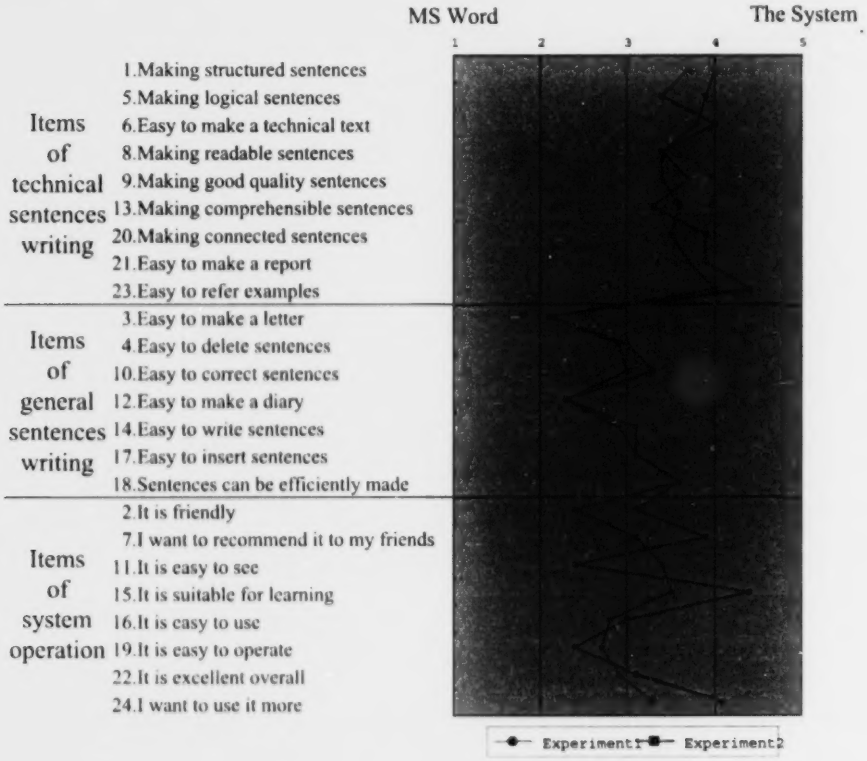


Figure 4. The rating for each item in Experiment 1 and 2

The subjects were asked to give reasons for their responses to the questionnaire items during the interview. The result of the interview concerning the functions of the system is divided into 4 types and summarized as follows: First, for automatically analyzing and displaying headlines, almost all of the subjects answered that it is very useful because they can click on any headline to immediately read the content of texts corresponded to it. The subjects also answered that headlines can be treated as an important role to help them to grasp the whole structure of the texts. Second, for automatically analyzing and displaying cohesive expressions, almost all of the subjects answered that it is very useful because they can find it is easier to convey their thoughts using explicit cohesive expressions. The subjects also answered that it is easy to find their errors because cohesive expressions in the texts are highlighted. Third, for referring to examples from corpus, almost all of the subjects answered that it is very efficient to writing because they can save a lot of time for finding examples from other references. The subjects also answered that they can imitate and learn more examples from the output of corpus. They can learn very much from the process of referring to examples in different texts, especially if there are many different usages in an expression. Fourth, for

Japanese language learning, almost all of the subjects answered that the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts. The subjects also answered that they can learn not only new cohesive expressions but also correct usages of cohesive expressions even they already know one of them.

Other comments on the system are summarized as follows: Almost all of the subjects answered that it is desired to improve the system to support the functions of electronic dictionary, thesaurus, grammar checking, etc. Therefore, construction of a good electronic dictionary for technical texts writing is considered as an important issue. Moreover, some subjects answered that it is better to extract examples form corpus according to learners' specialization than only random accessing to the corpus. From this result, constructing a corpus should not only consider the number of texts but also the balance of texts in each field.

4 Conclusion

In this paper, the authors describe the development and evaluation of a CALL system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, the rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts has been developed using NLP techniques. The system has the following functions: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study.

The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning. Based on the functions of the system, these results can be explained as follows: First, headlines can be treated as an important role to help learners to grasp the whole structure of the texts. Second, cohesive expressions often explicitly appear in the surface expressions of technical Japanese texts. Thus, it seems important and necessary to use these explicit cohesive expressions to structure one's thoughts in technical Japanese texts. Foreign learners especially may find it is easier to convey their thoughts using explicit cohesive expressions because these can be treated as an indicator of a discourse. Third, the corpus consists of the actual usage in technical Japanese texts from different fields. Instead of predefined examples, examples are automatically extracted from the corpus. Therefore, learners can learn very much from the process of referring to examples in different texts if there are many different usages in an expression. They can also save a lot of time for finding examples from other references.

In conclusion, the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts.

Acknowledgements

The authors would like to thank Dr. Kikuko Nishina (Professor in the International Student Center, Tokyo Institute of Technology) for her kind help during the analysis of technical Japanese texts. The authors would also like to thank Ms. Cheong Meng-Mei (Tokyo Institute of Technology) for her suggestions and comments on an earlier version of this paper. This study is funded by the Scientific Research Grant from the Ministry of Education of Japan (Subject No. B(2)10558019, Period: from 1 Apr 1998 to 31 Mar 2001).

References

[1]Chan, S.W.K. and T'sou, B.K. (1998). Analyzing Discourse Structure using Lexical Cohesion: A Connectionist Tool. In *Proceedings of the 1998 IEEE International Joint Conference on Neural Networks*, V1: 657-662.

[2]Hajicova, E. (1996). The information Structure of the Sentence and the Coherence of Discourse. In Hovy, E.H. and Scott, D.R. (Eds.), *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, 97-107. Berlin: Springer – Verlag.

[3]Halliday, M.A.K. and Hasan, R. (1976). *Cohesion in English*. London and New York: Longman.

[4]Hamada, M., Hirao, T. and Yui, K. (1997). *Paper Workbook for University/Foreign Student*. Tokyo: Kuroshio. [In Japanese.]

[5]Hayes, J.R. and Flower, L.S. (1980). Identifying the Organization of Writing Processes. In Gregg, L. and Steinberg, E. (Eds.), *Cognitive Processes in Writing: An Interdisciplinary Approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[6]Hayes, J.R. (1989). Writing as Problem Solving. In Hayes, J.R (Eds.), *The Complete Problem Solver*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[7]Hirschberg, J. and Litman, D. (1993). Empirical Studies on the Disambiguation of Cue Phrases. *Computational Linguistics*, 19(3), 501-530.

[8]Hobbs, J.R. (1979). Coherence and Coreference. *Cognitive Science*, 3: 67-90.

[9]Holland, V.M. and Kaplan, J.D. (1995). Natural Language Processing Techniques in Computer Assisted Language Learning: Status and Instructional Issues. *Instructional Science*, 23: 351-380.

[10]Hovy, E.H. (1993). Automated discourse generation using discourse structure relations. *Artificial Intelligence*, 63: 341-385.

[11]Hovy, E.H. and Scott, D.R. (Eds.) (1996). *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, Berlin: Springer – Verlag.

[12]Kinoshita, K. (1981). *The Techniques of Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[13]Kuno, S. (1978). *The Grammar of Discourse*. Tokyo: Daisyukan. [In Japanese.]

[14]Kurohashi, S. and Nagao, M. (1994). Automatic Detection of Discourse Structure by Checking Surface Information in Sentences. *Journal of Natural Language Processing*. 1(1): 3-20. [In Japanese.]

[15]Litman, D.J. (1994). Classifying Cue Phrases in Text and Speech Using Machine Learning. In *Proceedings of the Twelfth National Conference on Artificial Intelligence*, V1: 806-813.

[16]Loritz, D. (1992). Generalized Transition Network Parsing for Language Study: The GPARS System for English, Russian, Japanese and Chinese. *CALICO Journal*. 10(1): 5-22.

[17]Mann, W.C. (1984). Discourse Structures for Text Generation. In *Proceedings of the 10th COLING*. 367-375.

[18]Mann, W.C. and Thompson, S.A. (1987). Rhetorical Structure Theory: Description and Construction of Text Structures. In Kempen, G. (Eds.), *Natural Language Generation: New Results in Artificial Intelligence, Psychology and Linguistics*, 85-95. Dordrecht: Martinus Nijhoff Publishers.

[19]Mann, W.C. and Thompson, S.A. (1988). Rhetorical Structure Theory: Toward a Functional Theory of Text Organization, *Text*, 8(3): 243-281.

[20]Moore, J.D. and Paris, C. (1994). Planning Text for Advisory Dialogues: Capturing Intentional and Rhetorical Information. *Computational Linguistics*, 19(4), 651-694.

[21]Nagata, N. (1996). Computer vs. Workbook Instruction in Second Language Acquisition. *CALICO Journal*. 14(1): 53-75.

[22]Nerbonne, J., Dokter, D. and Smit, P. (1998). Morphological Processing and Computer-Assisted Language Learning, *CALL Journal*, 11(5): 543-559.

[23]Nishina, K. (1997). The Fundamental Research for the Development of Learning System of Technical Japanese. *Doctoral Dissertation*. Tokyo Institute of Technology, Tokyo. [In Japanese.]

[24]Reichman, R. (1985). *Getting Computers to Talk Like You and Me: Discourse Context, Focus, and Semantics*. The MIT press, Bradford Books.

[25]Shimizu, I. (1959). *The Manner of Japanese Writing*. Tokyo: Iwamani. [In Japanese.]

[26]Sugihara, K. (1994). *The Manner of English Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[27]Yamazaki, N., Tomita, Y., Hirabayashi, Y. and Hatano, Y. (1992). *Handbook of Technical Japanese*. Tokyo: Soutakusha. [In Japanese.]

[28]Yang, J.C. and Akahori, K. (1997). Development of Computer Assisted Language Learning System for Japanese Writing Using Natural Language Processing Techniques: A Study on Passive Voice, In *Proceedings of the 8th World Conference on Artificial Intelligence in Education (AI-ED97)*. 263-270.

[29]Yang, J.C. and Akahori, K. (1998a). Error Analysis in Japanese Writing and Its Implementation in a Computer Assisted Language Learning System on the World Wide Web. *CALICO Journal*, 15(1-3): 47-66.

[30]Yang, J.C. and Akahori, K. (1998b). A Discourse Structure Analysis of Technical Japanese Text. In *Proceedings of the Sixth International Conference on Computers in Education (ICCE98)*. Beijing, China. 643-650.

[31]Yang, J.C. and Akahori, K. (1999). An Evaluation of Japanese CALL Systems on the WWW Comparing a Freely Input Approach with Multiple Selection. *CALL Journal*, 12(1): 59-79.

[32]Yang, J.C. and Akahori, K. (2000). A Discourse Structure Analysis of Technical Japanese Texts and Its Implementation on the WWW. *CALL Journal*, 13(2): 119-141.

Development of Japanese-English, English-Japanese Conversation System with Voice Reading and Machine Translation

Yumemi MATSUZAKI* and Kanji AKAHORI**
**Graduate School of Decision Science and Technology, Human System Science, Tokyo Institute of Technology*
***The Center For Research and Development of Educational Technology, Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552,Japan
Tel: +81-3-5734-3233
Fax: +81-3-5734-2995
E-mail:{yumemi,kanji}@ak.cradle.titech.ac.jp

1 Research Background

In recent years, the internationalization of Japan has attracted many foreigners. But, in the present state we have seen mostly people are shy to speak to foreigners because they cannot speak foreign languages. Again, there are many attempts that enable one to communicate on the Internet. In a preceding research, there was an attempt to add word translation to word chatting function (refs.[1]). Besides in any communication plurality of media help in the understanding (refs.[2])(refs[3]). For examp le, there was another preceding research that showed that listening along with subtitling in the same language help understand the content in the foreign language education (refs.[4]).

2 Research Objectives

In this research, therefore, we have developed a conversation system, which uses machine translation and text reading in the networking environment. This system uses machine translation, which enable people to communicate between two different languages. And, it fulfills text-reading function of chatting to help understand conversation contents

3 Developmental Environment

This system is developed with "Microsoft VisualBasic 6.0". The Japanese-English translation engine of this system used "LogoVista E to J ver 5.0 "and the English-Japanese translation engine used "LogoVista J to E ver1.1". Japanese Voice synthesis engine is "IBM ProTalker 97", and English Voice synthesis engine is Microsoft Agent.

4 Outline of Developed System

In this system, when we input Japanese or English, we can get Japanese text or English one and its rendering text and voice synthesis of its rendering one.
The steps from the text input to the translation, and the voice output is shown as follows.
(1) Sentences, which the client inputs, are passed to the server.
(2) These sentences are then passed to the translation engine, and the server translates in English in case of

Japanese input and vice versa.

(3) The server sends translated sentences to both client and the other party.

(4) Translated sentences are indicated after input sentences on the receiver side, and translated sentences are displayed along with basic input on the other party side.

(5) If translated sentences are in Japanese, its voice output is given using "IBM ProTalker 97"(refs[5]) If it is English, then the output is given using "Microsoft Speech API"(refs[6])

5 Evaluation Experimentation

Three pairs consisting of one Japanese speaking person and one English speaking person were considered and experimented on the different setup. Type one is not using machine translation. Type two is using machine translation. We administered a free response type questionnaire for collecting data regarding the feeling of the participants during the different sessions. From the result the interest concerning learning of foreign language came up, and the participants' opinion of being able to take part in the conversation, not being aware of talking with foreigners using machine translation, were very positive. The pictures dawn by subjects with two different conditions are shown as the follwing.. The condition with word chatting not using the machine translation module. The left picture shows the picture which the sender want to send, and the left drawings shows the picture drawn by the receiver with the above condition.

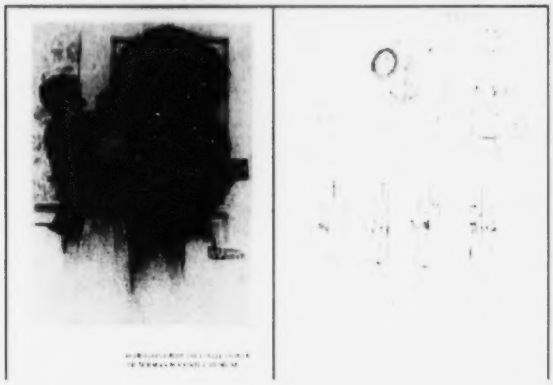


Fig.1

The condition with word chatting using the machine translation module. The left picture shows the picture which the sender want to send, and the left drawings shows the picture drawn by the receiver with the above condition. We can compare two pictures drawn by the receiver under the two conditions. As a result, we may roughly estimate that the picture using the machine translation module shows more precise information than the picture without the machine translation. As the above differences are based on a quite subjective judgment, it is not conclusive. Though the difference seems to be apparent from the view of quantities of sending information, we can't find the specific reasons caused the differences. The system developed with the chatting using the translation module will work effectively, especially to the persons who want to communicate each aother.

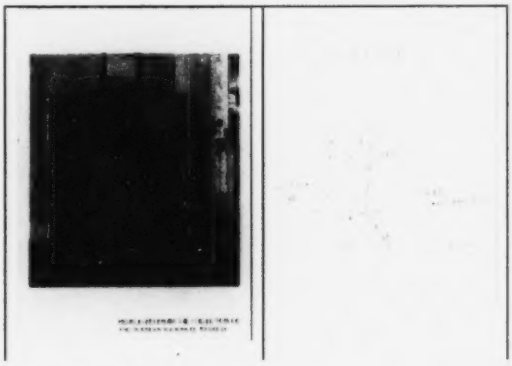


Fig.2

6 Future Works

We are now planning to expand the scope of speech recognition system as the future works. We have been introducing the speech recognition module to our system, and we are now evaluating the effectiveness of the speech recognition module to enhancing the communication.

Acknowledgement

The authors would like to thank Dr. Madhumita Bhattacharya in National Institute of Multimedia Education for her great assistance.

References

[1] Alexander BELOV, Masato HAYASAKA, Kanji AKAHORI, "Conversation learning by Japanese-Russian and Russian-Japanese chatting which uses machine translation." Japanese Journal of Information and System in Education. Vol.15. pp533-534. (1999)

[2] MARKHAM,P.L "The effects of captioned television videotapes on the listening comprehension of beginning, intermediate, and advanced ESL students." Educational Technology, 29(10). pp38-41. (1989)

[3] http://home.att.ne.jp/gold/PEROYON/Jikken1.htm

[4] Shiho YOSHINO, Kanji AKAHORI. "Effect of title addition in catching scene in English.", Japanese Journal of Educational Technology . Vo l.21. Suppl., pp29-32. (1997)

[5] http://www.jp.ibm.com/pspjinfo/pt20/intro.html

[6] http://www.microsoft.com/JAPAN/developer/library/techart/msdnnews/speak.htm

Development of the *ELT in Taiwan* Web Site for English Learning and Teaching

Hsien-Chin Liou
National Tsing Hua University, Department of Foreign Languages and Literature
101, Sec. 2, Kuang Fu Road, Hsinchu, Taiwan 300
Tel: +886-3-5742709
Fax: +886-3-578977
hcliu@mx.nthu.edu.tw

English learning involves both knowledge acquisition and skills automatization. On the other hand, the potential of Internet lies not only in a large quantity of information display, storage, and updating, but also in computer mediated communication (CMC). The two functions, knowledge base and electronic communication, match the dual processes of English learning: knowledge and use. The educational Web site, *ELT in Taiwan*, was constructed under such a theoretical view of English learning. Additionally, teacher professional development is another key consideration for the design of the Web site. With the new generation of Web objected oriented (WOO) software technology, synchronous CMC can be built with traditional Web sites together while keeping its feature of multimedia, text and graphics-based virtual reality for multi-users on-line synchronously. The knowledge-based Web site has a *Teacher Development* component, and a synchronous WOO, called *ForMOOsa*, implemented with a high school metaphor. *ELT in Taiwan* was also constructed to meet local needs of its target users, both teachers and students in Taiwan. The paper demonstrates how we incorporated the features mentioned above and what has been constructed so far.

Keywords: **MOO, Web, English learning and teaching, Teacher development**

1 Introduction

The number of the World Wide Web (the Web) sites increases exponentially nowadays. In additional to electronic commerce, electronic services, or electronic information, the Web is also a powerful educational medium or virtual space for e-learning. Universities start to deliver their courses via the Web because they save students' travel expense from afar, and allow much more students enrolling at the same time—because the Web course can be given in a classroom-less environment. Many well-designed Web sites with good-quality materials exist in English-speaking countries, and have been used for some time. The author [1] has asked college juniors in Taiwan to read the articles at the CNN site and write a response journal entries regularly. It was found that students improved in both English reading and writing performance via this activity. However, it was also found that American culture in the CNN news stories was not immediately comprehensible to college junior English majors. Guidance is needed when teachers try to use informational Web sites for English teaching. Even with English learning sites, the information there designed specifically for learners, not general users, still poses potential problems for learners in Taiwan, Republic of China (ROC)[2]. There is thus a need to design Web sites more appropriate for local needs. In Taiwan some Web sites have been developed. However, most of them are unsatisfactory from the English learning and teaching perspective. The paper describes the development process of a new Web-based English learning project that bridges English learning theories and practices.

2 Theoretical underpinnings

The most relevant theory to English teaching and learning seems to be second language acquisition (SLA) and Vygotsky's sociocultural theories. In this project, it is further believed that English teachers play a

crucial role in the advancement of English Learning and Teaching (ELT) in Taiwan and teacher education/development has not been systematically investigated in the past [3]; thus, a section on English teacher professional development is presented.

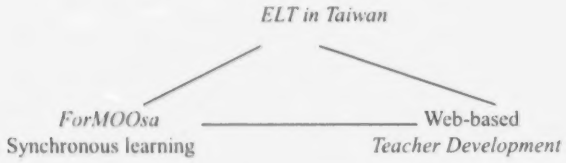
English learning involves both knowledge acquisition and skills automatization; its effectiveness requires improvement in terms of both competence and performance [4]. Skills automatization, related to notions such as control processing, accessibility, or performance, means to package bits of knowledge about English or a second language (L2), and to produce the entire package at a time without using extra cognitive resources to do psycholinguistic on-line compilation such as arrangement of word order. A learner may acquire a great amount of knowledge about English language and culture, and of the knowledge about the world. Still, he needs opportunities to use English in order to automatize the knowledge with adequate fluency, appropriateness, and appropriation. The more recent language learning theories emphasize the social construction of knowledge, notably Vygotsky's sociocultural theory [5]. Language learning is not only a cognitive task but more of a social activity where the process is participating in a knowledge-building community, a community of practice, or a community of second language learners.

Liou [6] addresses four types of myths existing in Taiwan concerning teacher education and points out that professional development using skills such as action research, or reflective practice [7,8] is a solution. New perspectives on English teaching or learning, theoretical development, or updated research findings are essential for a profession to advance. If teachers cannot become researchers themselves, do not conduct action research, care nothing but daily practice, everyone can teach. Often in Taiwan teaching is always one's last choice as soon as he or she retires from other professions. I think teaching is and should be regarded as a respected profession which requires education and cultivation and lifelong development to make teaching perfect. Teachers play the most important role in the ELT field and we need explicit teacher education discussion forum and research (investigating what teachers know, believe, value, and do) in Taiwan. The Web site, *ELT in Taiwan*, is a first step toward the goal.

3 Overall design

Although for advanced English learners, learning English and using it can mean the same thing. For beginners or intermediate learners, and for convenience of implementation, the design of the Web project, called *ELT in Taiwan (台灣英語教學園區)*, is divided into two components: a knowledge base for both English teachers and learners, and a dynamic synchronous CMC environment for English language use, namely, *Teacher development* (TE) and *ForMOOsa* as shown in Figure 1. The TE acts like a knowledge base of English teaching and learning where both teaches and students can visit to acquire updated knowledge about English to meet their own needs.

Figure 1. The framework of ELT in Taiwan



The current *TE* component has ten topics and 6 sub-topics:

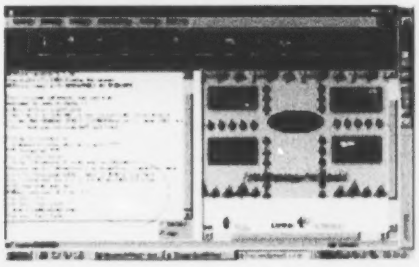
1. Instructed second language acquisition
   a. acquisition process and stages
   b. individual differences
   c. teacher education and professional development
2. New perspectives on English teaching and learning
   a. learner autonomy
   b. sociocultural theory
   c. critical pedagogy
3. Teaching of listening and speaking
4. Teaching of reading and writing
5. Teaching of vocabulary

6. Teaching of grammar
7. Teaching of culture
8. Teaching English in primary schools
9. English assessment
10. Computer assisted English teaching on the Internet

Most of the ten topics have (1) a brief introduction of the field, (2) an updated reference list, (3) examples of teaching materials, and (4) links to relevant sites. In the introduction, we provide brief but updated information about the field so that pre-service and in-service teachers can obtain an idea about the topic. In the reference list, we try to include seminal and updated sources for further reading. In some of the entries, we add an annotation so that readers can obtain a clearer picture of what the source contains. In the material example part, we show teachers what they can design to teach a specific area by providing ready-made on-line lesson. The lesson can be used by learners of different levels to acquire the knowledge about English on-line. The hyperlinks to relevant sites are selected based on our review with brief comments on the site itself. *ELT in Taiwan* so far uses mainly texts and graphics to present information; in the near future, we will incorporate audio and video as they are necessary.

Learners of English usually do not acquire English simply by obtaining the knowledge about the language; they need practice or opportunities to use the language in meaningful contexts for real purposes with genuine audience or interlocutors. This is where computer-mediated communication can play a crucial role. It is also this rationale of language for use and communication that we design the *ForMOOsa* synchronous environment based on graphics and text-oriented virtual reality. Some MOO (multi-user dimension/dungeon Object-Oriented) stations have been constructed in the North America, but none exists in Taiwan as far as we know. Often it takes great efforts and time to link to a site across the Pacific. Most of the time, the culture is alien to students in our country. It is practical and meaningful to construct a MOO of our own in Taiwan. In terms of computer technology, synchronous CMC has been implemented mostly at the telnet platform, instead of the Web's universal protocol. With the new generation Web-based MOOs (WOOs) software technology [9], synchronous CMC can be built with traditional Web sites together with the database such as enCore, an operating system-Red Hat Linux, and a server-LambdaMOO. The synchronous WOO, called *ForMOOsa*, is implemented with a high school metaphor which is simulated like text and graphics-based virtual reality. Its major architecture looks like Figure 2.

Figure 2. The architecture of *ForMOOsa*



It was constructed to address the local needs. The benefit for real audience is that the on-line learning environment will not be constructed with no specific users in mind. We plan to use *ForMOOsa* in a vocation high school in September as it will be incorporated in an "English teaching in the Internet" regular course. The targeted institution is a highly technology-enhanced school which is believed to become prevalent in our country soon. At its first stage of development, we built a virtual senior high school/vocational school on-line with classrooms, dormitory, exhibition hall, and a Cafe with a variety of objects appropriate in each area. Within the dormitory, we have a reading lounge with some legends of Taiwan, "Aunt Tigress", "Hsinchu Holy City Mayor Saved the Prince", and "The Legend of Hero Liaw Tien-Ting". MOOers can explore how the stories develop by reading the entire story, or choose to play interactive dialogues with parts in the stories such as Mandy, Liaw, or Holy City Mayor. The parts, bots or robots in the system, can pick up users' key words in questions and give corresponding responses. Another two bots, Jack and Lisa were created in the Café where they may talk to each other if MOOers activate them. The simulated dialogues are very useful for English learning as meaningful and communicative practices. By August 15 of 2000, we have completed three topic in the *teacher development* unit, "Teaching English in the Primary School," "English assessment", and "Teaching of grammar" (see http://TaiELT.fl.nthu.edu.tw/English/welcome.html);

BEST COPY AVAILABLE

and the prototypical framework of *ForMOOsa* (http://formoosa.fl.nthu.edu.tw:7000;) with some objects and bots. For the "Teaching English in the Primary School" unit, an updated English teaching view was adopted, namely, communicative language teaching, where use of English, instead of knowledge about English such as grammar and vocabulary, is emphasized. For instance, in the teaching mateiral section, *The Story of Santa Claus*, was designed with three types of Santa from different foreign countries. The aim is for learners to express some actions by Santa such as climbing in the chimney or giving presents, and to become aware of the fact that Santa is part of culture as Santa is different in different cultures.

4 Conclusion

As illustrated in this project, it is argued that the design of a Web site needs to address its audience needs by bridging theories and practices. Teacher professional development is as important as student learning of English. A local Web site should address its user needs. *ELT in Taiwan* has been devoted by a group of part-time members with limited time in five months. Given longer time, in the future, we plan to incorporate more advanced technologies and instructional design strategies so that we can contribute to the international academic forum.

Acknowledgement

The project is funded by the Ministry of Education in Taiwan under the 4-year project (January 2000, to December, 2003): Program for Promoting Academic Excellence of Universities. We would like to thank the grant of MOE and all the members involved.

References

[1] Liou, H. C. "The impact of WWW texts on EFL learning", Computer Assisted Language Learning, Vol. 10, No. 5, pp. 455-478 (1997)

[2] Yeh, H. Y. & Liou, H. C., "A study of using the Web articles to support college English students' ideas in writing," Proceedings of ICCE/ICCAI 2000, November 21-24. Taipei: Grand Hotel, Taiwan, (2000).

[3] Liou, H. C., "Reflective practice in a pre-service teacher education program for high school English teachers in Taiwan, ROC," System: An international journal of educational technology and applied linguistics, Vol. 29, No. 2, (2001).

[4] McLaughlin, B, "Theories of second language learning", Arnold, (1987).

[5] Vygotsky, L. S., "Mind in society: The development of higher psychological processes.", Cambridge: Harvard University Press, (1978).

[6] Liou, H. C, "English teacher education and professional development: Illustration of reflective practice," Vol. 8, No., 5, in press, (2000). (Chinese, Taipei: Taiwan Normal University)

[7] Freeman, D., & Johnson, K. E. "Reconceptualizing the knowledge-base of language teacher education" TESOL Quarterly, Vol. 32, No 3, pp. 397-418 (1998).

[8] Wallace, M. J., 1991. *Training foreign language teachers: A reflective approach.* Cambridge, Cambridge University Press.

[9] Looi, C. K., "WOOs: Multimedia collaborative learning environments that support different learning models," International Journal of Telecommunication, Vol. 5, No. 1, pp. 3-24, (1999).

Integrating Web-based Materials into Course Design

Lilly Lee Chen
Rice University
6100 Main Street, Houston, Texas, USA 77005-1892
Tel: 713-348-2820
Fax: 713-348-5846
E-mail: Lchen@ruf.rice.edu

1 Introduction

This paper is a report on a project in which Web pages were crucially incorporated in the design of a new college course titled anguage and Culture in Taiwan." There were two main reasons for making the Internet an integral part of the course: (1) the wide range of topics covered in this very general introductory course requiring the wealth of information sources easily accessible on the Internet and (2) necessity of frequent updates of information due to the fast and volatile nature of the political evolution in Taiwan, particularly during the presidential election year when this course was offered. The consideration of user factors was also important. The Internet responds well to today's college students who demand relevance (of issues that pertain to the here and now) and immediacy, and are as adept in clicking on the keyboard surfing the Internet as flipping the pages of a book.

More serious, though, in our course design is the educational philosophy that a college's mission is not so much to transfer knowledge as to create environments and experiences that bring students to discover and construct knowledge for themselves [1]. Exposure to the vast amount of knowledge on the Web necessitates focus and careful choice of relevant materials. As part of course assignments students were expected to present on topics of their choice. This ensured that they researched the subject matters in greater depth before presenting them in class, as they would be presenting to an audience of their peers.

2 Method and content

The ready accessibility of the Internet for both the students (practically all students have a PC) and instructor (to add to or update the course page), especially outside of class, altered in-class activities from those of traditional teacher-centered instruction to student-centered discussion and presentation. The utilization of e-mail also facilitated out-of-class preparation. Students were informed by e-mail to go to a certain new site or link for a new development of events. Similarly, the student e-mailed the instructor for information or help. The more out-of--class preparations the students have, the better the quality of in-class discussions the instructor can expect.

The syllabus was essentially a structure of links organized according to the class schedule of topics and activities. It is also a display of the scope and structure of the contents of the course. It changed dynamically as new links were discovered and added throughout the semester. The syllabus appears as a navigation bar. To facilitate learning we have minimized visual search by displaying this syllabus bar consistently on top of each page[2]. Students can easily navigate from site to site, not only to preview but also to review. Besides a general page of topics with their links to available Web sites, the page of each session further highlights some particular links to topics of the session, along with a list of references available on reserve in the library.

The contents of this course consist of two major areas: (1) culture and (2) language. The former includes a wide range of topics, such as a profile of Taiwan, history, political parties, customs, festivals, family relations, literature, world view of Taiwan, and the future of Taiwan. Generally each topic or a group of related topics was covered at a weekly session, which lasted two and a half hours, of which the first half was devoted to cultural discussions and the second half, instruction of language. The culture part of the course

was conducted in a seminar format along with presentations by students.

By dividing the content area into culture and language, we were not forgetting that language always operates in a culture [3]. Besides teaching phrases and sentences applicable in social situations, other aspects of the language, such as kinship terms, nursery rhymes, proverbs, songs, etc., abounding with traditions and cultural values, were also taught. The language part of the course contained sound files. Some had two types of reading, a slower one and a faster one, to facilitate learning. Taiwanese expressions in each language lesson generally contain both literal and free translations. This makes self-study very easy and convenient, as long as they could access the Web. Sound files were indispensable as Taiwanese is a tone language and furthermore has seven tones and possesses an elaborate tone sandhi system [4].

This Web program was produced entirely in the instructor's office by using Netscape Composer, SoundRecorder, and other freeware downloaded from the Internet [5]. The exercise part of the course, which features filling in of blanks, multiple choice, short answer, etc., was made possible by the ExTemplate program developed at Rice University Language Resource Center [6]. The ExTemplate application creates exercises that will be stored in a database for future retrieval [7]. It allows students to submit exercises via the Internet and be graded by the instructor also via the Internet. The language lesson sound files were integrated into ExTemplate. This feature was very useful particularly for tonal distinction exercises.

Our classroom was equipped with a multimedia Podium which allowed us to go on the Internet, show videos, movies, documents, play CD , etc. The Podium came in handy when a demonstration on the classroom screen was called for. Not only did the instructor use the Podium, students were encouraged to do their class presentations by using PowerPoint or by going to their own personal homepages where they collected Web links or images related to their topics for classroom presentation.

3 Conclusions

By incorporating the Internet into course design, we were able to create a more accommodating learning environment for the students and to give students more control over the learning process. As this was our fist attempt at teaching the course with Web-based materials, further refinements of many aspects of the course need to be made. For example, we can make pages less cluttered with text and add more digitized videos. Also researches can be conducted to determine students' reactions in terms of attitudinal factors and learning efficiency. Taiwanese on the Web is an on-going project. We solicit help and comments. This project attempts to raise awareness in the global community of the vitality of a culture less known and rarely covered in college courses. As universities generally suffer from budget constraints, by making this program available on the Web we hope to encourage teaching of this subject matter.

References

[1] Bar, Robert B., & Tagg, John, "From teaching to learning - a new paradigm for undergraduate education", Change 27-6 Nov./Dec., pp. 13-25, (1995).

[2] Aspillaga, M., "Screen design: Location of information and its effects on learning", Journal of Computer-based Instruction, 18(3), 89-92, (1991).

[3] Walker, G., & Noda, M., "Remembering the future: Compiling knowledge of another culture", Reflecting on the Past to Shape the Future, (eds.) Birckbichler & Terry, National Textbook Company, pp. 187-212, (2000).

[4] Chen, L., "Grammaticalization and Tone in Taiwanese", the 27th Forum of Linguistic Association of Canada and the United States (LACUS Forum 27), (2000).

[5] Chen, .L., Chang. J., Lai, S., & S. Yuen, S., "Web Based Instruction", Proceedings of the 8th International Conference of Chinese American Educational Research and Development Association (CAERDA2000), St. John's University, New York, September 16-17, (2000).

[6] Chen, L., Bartlett, C., & Verm, J., "ExTemplate: a tool for foreign language web editing", Proceedings of the South Central Association for Language Learning Technology (SOCALL 2000), Louisiana State University, Baton Rouge, Louisiana, April 7-8, (2000).

[7] ExTemplate Lesson Server: Online courseware authoring, http://lang.rice.edu/extemplate/, (accessed on August 1, 2000).

Agents in a WWW System for Academic English Teaching

Alexandra Cristea and Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621; Fax: +81-424-89-6070
E-mail:alex@ai.is.uec.ac.jp

This paper describes our research on building a free, evolutionary, Internet-based, agent-based, long-distance teaching environment for academic English. Here we will describe some of the design aspects of the system prototype, focusing especially on the adaptive features and the agents of the system.

Keywords: **Distance Education, CALL, Agent Technology**

1 Introduction

As distances constantly grow smaller and the Internet links more and more remote parts of the world, English gradually becomes the lingua franca for information exchange. In the academic field, in research and development, where international cooperation is a must, English is used frequently. Academic English is International English. Although accents are more or less variable, the spoken, but mostly, the written academic language has still its rules and etiquette. Academics usually know some English and have a more or less wide English vocabulary. However, especially in Japan, but in other non-English speaking countries as well, there exists the phenomenon that, although a person can read academic papers in English, when it comes to writing a paper by oneself, or to make an academic presentation in English, serious problems appear. Therefore, we embed these necessary rules and etiquette in our teaching environment. The main aim of our system is to help academics exchange meaningful information with their peers, through a variety of information exchange ways: academic homepages, academic papers, academic presentations, etc. As far as we know, this type of English teaching system is new. Some English teaching environments on the Web appeared, but, as in [1] or [11], they have two main defects: they are not free, and/or they are not automatic, but based on real human teachers at the end of the line. Good on-line dictionaries [12], [8] and several collections of English on-line books [2] exist, but those can only act as auxiliary helpers during the English learning process. Our aim is to have a system capable to function autonomously, without human interference, as a virtual, long-distance classroom, embedding the necessary tutoring functions within a set of collaborating agents that will serve the student. The course is called 'MyEnglishTeacher', because of its evolutionary nature, of adapting over time to the needs and preferences of individual users. These needs can be expressed explicitly, or can be implicitly deduced by the system, represented by its agents. We are currently in the process of adding more AI-based intelligent adaptation capabilities. Users can find in our virtual classroom situational examples of academic life, presented as Multimedia, with Audio and/or Video presentations, Text explanations and pointers to the main patterns introduced with each lesson, exercises to test the user's understanding, moreover, adaptive correction, explanation and guidance of the user's mistakes. The general guidelines for this system were proposed by our course design researcher in [3] and elaborated by us in [6].

2 Background

Virtual environments in education and distance-learning systems are the recent trends in education worldwide. This trend is determined by the current spread of the Internet, as well as by a real demand for better, easy-to-access, and cheaper educational facilities. Therefore, universities everywhere respond to the academic demand for technological and pedagogical support in course preparation, by developing specialized software environments [5]. As bandwidths grow, the traditional text environments gradually switch to multimedia and Video-on-Demand (VOD) systems ([17]). The problems in the current language

education systems, as well as the motivation of our research, as pointed out by our language specialist team member and [15], can be resumed as follows: the lack of learning activities for checking learners' constructive understanding (requiring the learner not only to memorize, but also to summarize, generate, differentiate, or predict); the lack of a variety of problem-solving tasks to motivate students to think about their reading; the learning process does not enable learners to become active participants; in the current Computer Aided Language Learning (CALL) systems, learners cannot key-in the target language's sentences freely; lack of explanatory feedback (telling the user why); lack of exercises related to the learner's individual characteristics; lack of considerations about the effectiveness of different physical attributes of the presentations, on the students' learning; lack of analysis of the interaction between learner and learning environment, with special focus on assimilation and accommodation. These problems could not be solved by traditional systems, mostly due to their lack of adaptability, or in other words, intelligence. In [19], it is stated: "there is the need to endow these systems with the ability to adapt and learn, that is, to self-improve their future performance". The objective of this research is to help learners achieve academic reading and writing ability. The course is intended for students whose starting English level is intermediate and upper-intermediate, who have some vocabulary of English, but not much practice in using it. The tutoring strategy used is to give the reader insight into his or her implicit or explicit learning strategies. The methodology applied is the communicative teaching approach, allowing communication and interaction between student and tutoring system, via agents. The interactive reading strategies applied and yet to apply include bottom-up theory, top-down theory, and schemata theory. The topics and stories used are mainly passages from textbooks, journals, reference works, conference proceedings, and academic papers, in other words, real-life academic products.

3 System features and modules

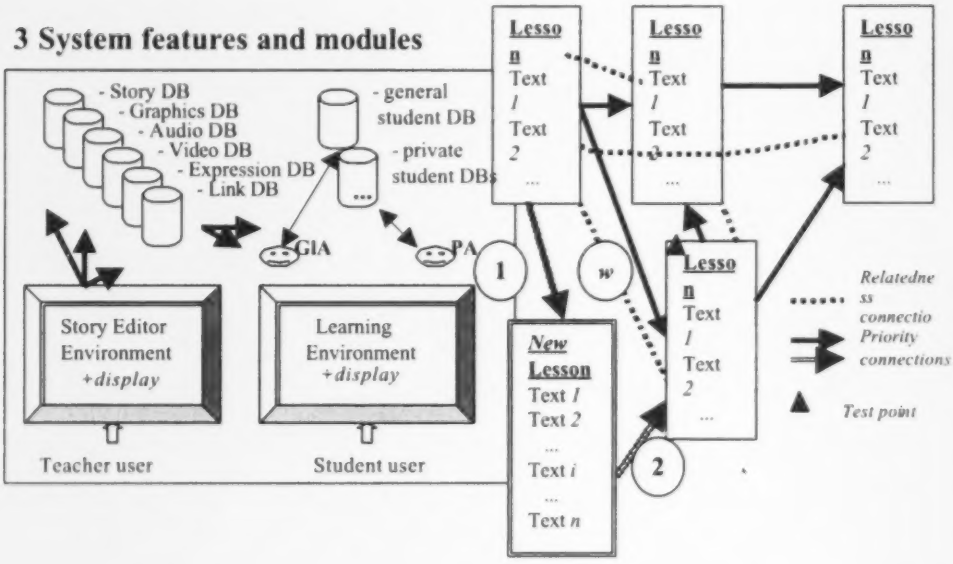


Fig. 1: The system modules and their interaction

Fig. 2: The subject link database

The system offers two interfaces, one for the teacher/tutor user, for course-authoring purposes, and the other one for the student user, who is supposed to learn. The information exchange from tutor to system contains input of lessons, texts, links between them, etc., but also asking for help in editing. The data from the tutor is stored in six different structured databases, including a library of expressions that appear in the text, a VOD database, a background image database, an audio database of listening examples, a full text database and a link database. The information exchange with the student is more complex. It contains usage of the presented materials, implicit or explicit advice, the student's advice requests, queries, searches, gathering of data on the student by the two agents, the Global Agent (GIA) and the Personal Agent (PA). Each of these agents has its own database on the student(s). The GIA stores general features on students, and the PA stores the private features of each student. User modeling follows many patterns, and has many applications. [7] proposes a fuzzy-based, stereotype collecting user model for hypermedia navigation. [18] elaborates on the Human Plausible Theory. ([4]) provides intelligent help for determining the cause of errors in software usage.

[14] has shown how prior belief (belief bias) can influence the correctness of judgment of the human (users). Other authors, like [10] have studied the relation between achievement goals, study strategies and exam performance. A realistic user model has to take into consideration the influences a system can achieve on the user, in order to allow an easy interpretation of the current state, as well as an easy and clear implementation of the user model.

4 The Authoring System Module (Story Editor)

Our most important goal is to design a meaningful, evolutionary feedback for the user. In order to build such a
system, an authoring tool is necessary for flexibility purposes: our colleagues researching the optimal material for academic English teaching should be able to add or delete freely the available resources. In a way, they are also clients/users, and should be restricted to build a courseware, which conforms to the capabilities of the system. In the following, these restrictions and their purposes are explained. These restrictions are necessary instruments for the two system agents to work with, as will be shown later in this paper.

Texts: Each video/audio recording has to have a corresponding TEXT (of dialog, etc.). For each text, it is analyzed if video is necessary, or if audio suffices, as audio requires less memory space and allows a more compact storage and a speedy retrieval. Each TEXT also has (beside of main text, etc.), the following attributes: a short title, keywords, explanation, patterns to learn, conclusion, and finally, exercises. Titles and keywords are naturally used for search and retrieval, but the explanation and conclusion files can be also used for the same purpose, as will be explained later on.

Lessons: One or more TEXTs (with video or not) make up a LESSON. Each LESSON also has (beside of texts, etc.) the following attributes: title, keywords, explanation, conclusion, combined exercises (generated automatically or not). Next, a text or a lesson will be referred as 'SUBJECT'.

Priority and Relatedness Connections: When introducing one or more subjects, the teacher has to specify the Priority Connections, i.e., to show the required learning order, with a directed graph (arrows). When there is no order, subjects will have the same priority, and build a set. The teacher (courseware author) should also add connections between related SUBJECTS, with indirect links. This means, the teacher has to add Relatedness Connections between subjects, for which no specific learning order is required, but which are related. These relations are useful, e.g., during tests: if one of the subjects is considered known, the other one should be also tested. The main differences between the priority connections and the relatedness connections is that the first ones are directional, weightless connections, whereas the latter are non-directional, weighted connections. After these priorities and links are set, the system will then automatically add more links via keyword matching, from explicit keyword files and keyword search within subjects. Priorities among the texts of a lesson are set implicitly according to the order of the texts, but can be modified, if necessary. The teacher / multimedia courseware author can decide if it is more meaningful to connect individual texts, or entire lessons, for each lesson. The way a new lesson is introduced, by asking the teacher to set at least the previous and the following lesson in the lesson priority flow, is shown in figure 2 (steps 1,2). As can be noticed from figure 2, priority connections, with no respective relatedness connection, can exist. This can happen when, e.g., common course design knowledge dictates that respective priority, but the learning contents of the lessons are quite different. These kinds of priorities are optimal student learning strategy related connections, not similar contents connections. These priorities help the system to place the current subject in the global subject map. Final priorities will be set by the system according to findings (teacher's input, keyword matching). This final result can be shown to the teacher or not, depending on the options under which the system is running. We are currently testing if it is wise to allow the teacher to have add/modify/delete rights. The final graph is used for the student, and it can be shown to the student upon request, serving as a map guide.

Numbering: SUBJECTS are numbered automatically in the order of their creation. Teachers are prohibited to use numbering. This is because otherwise, every time new material is brought, the numbering should be changed according to the new order of priorities. TEXTs are automatically numbered inside a lesson, and are referred from outside with two numbers: the LESSON number and the text number.

Test Points: The teacher should mark TEST POINTS (figure 2), at which it is necessary to pass a test in order to proceed (these tests can be at any SUBJECT level).

5 Student models and agents

The system gradually builds two evolutionary student models: a global student model (GS) and an individual student model (IS), managed by two intelligent agents: the personal agent (PA) and the global agent (GlA).

The reason for doing so is that some features, which are common to all students, can be captured in the GS. However, many studies have shown [17] that personalized environments and especially, personalized tutors, have a better chance of transferring the knowledge information from tutor to student. This is true even in the more general sense of a tutor and student, where the tutor can be man or machine, and the student likewise. In this work, we mean by agent a "computer system situated in some environment", "capable of autonomous action", "in the sense that the system should be able to act without the direct intervention of humans", "and should have control over its own actions and internal state" [13]. These agents' intelligence is expressed by the fact that each agent "is capable of flexible autonomous action in order to meet its design objectives", and that it is "responsive" (it perceives its environment), "proactive" (opportunistic, goal-directed), "social" (able to interact) [13], and of an "anticipatory" nature (having a model of itself and the environment, and the capability to pre-adapt itself according to these models) [9]. Next, the raw data stored for the two student models, the GS and IS, is presented.

The GS : The GS contains the global student features: the common mistakes; favorite pages, lessons, texts, videos, audios, grading of tests' difficulty (according to how many students do each test well or not); search patterns introduced, subjects accessed afterwards: if many IS use the same order, than they are recorded in the GS.

The IS : The IS contains the personal student features: the last page accessed; grades for all tests taken, mistakes and their frequency; if the student takes the test again and succeeds, his/her last grade is deleted, but his/her previous mistakes are collected for future tests; the order of access of texts inside each lesson; order of access of lessons (this can be guide to other students: "when another student was in your situation, he/she chose..."); frequency of accessing texts/ lessons/ videos/ audios, etc. - for guidance and current state check; search patterns introduced, subjects accessed afterwards (to link patterns with new subjects that the system didn't link before).

The PA: The role of the personal agent is to manage the information gathered on the user, and to extract from this information useful user guidance material. Each step taken by the user inside the environment is stored, and compared with both what was proposed to the user, as well as with what the user was expected to do (from the PA' s point of view). The differences between previous expectation and current state are exploited, in order to be used for new guidance generation. Beside of analyzing the own user and extracting knowledge from the data on him/her, the PA is able to request information from the GIA, about, for instance, what other users chose to do in a similar situation to the current one of the PA' s own user. Furthermore, the PA can contact other PA' s with similar profiles (after a matchmaking process), and obtain similar information as from the GIA, only with more specificity. The PA can decide to turn to another PA if the information from the GIA is insufficient for a decision about the current support method. The PA decides, every time a user enters the system, what material should be studied during that particular session, and generates a corresponding list. Therefore, the course index is dynamic, not static. To this material, the PA will add or subtract, according to the interaction with the user during the session. According to [16], the PA is therefore an interface agent ("a computer program to provide assistance to a user dealing with a particular computer application" – in this case, a learning environment). However, the PA' s job description is a little wider than this, as can be seen also in the following.

The GIA: The global agent averages information from several users, to obtain a general student model. The deductions of the global agent are bound to be non-specific. The GIA is necessary, because otherwise, the system will not profit from the fact that different users interacted with the system, and each new interaction can smoothen the path for following users. The GIA is to be referred before the PA starts looking for information from other PAs, process that can be more time-consuming. Therefore, the role of the GIA is to offer to the PAs condensed information, in an easily accessible, swiftly loadable form. From this description, it is clear that the GIA is subordinate to the PA (from the student user' s point of view). The GIA cannot directly contact the student user – unless the PA explicitly requests it. If the GIA considers that its intervention is required, it still has to ask for permission from the PA. In this way, the generation of confusing advice is avoided.

From the described interactions between agents and databases, and between the agents themselves, it is clear that the agents of the system work in two ways. The first way is based on the embedded rule/knowledge systems, which try to foresee, prevent and solve conflicting situations. The second way is as evolutionary, learning objects, which can adaptively change their representation of the subject space, by creating and deleting links and changing weights. A next step in the system' s agents design will be focused on adaptive problem, quiz and test generation. In short, this design is made necessary by the fact that a student, after failing to pass a test, has to be presented, after some more learning is done, with a new test, of similar difficulty and contents. As it is difficult for the teachers to generate as many tests as would be necessary for such repeated situations, this task is to be passed to the system' s agents. A very important task of each of the agents is also to keep the consistency of the subject link database. The agents inform the teacher(s) if some subjects form loops (determined by the priority connections set by the teacher(s)), if some subjects become inaccessible; if a teacher is not available, they make corrections by themselves, and decide from the student (s) feedback about the appropriateness of those changes.

6 Conclusions

We have proposed in this paper an Evolutionary, Web-based, Academic English Teaching Environment, called "MyEnglishTeacher". Moreover, we have described the rationale, the design and implementation and the modules of our system: an authoring environment for the teacher user(s), which is generating the lessons, and a learning environment for the student user(s). We have further on presented each of these modules in more details. The learning environment is based on two intelligent agents, interacting with each other and the student user, in order to guide the student through a new course for academic English, which is under development in our laboratory. We have also explained in which sense our agents evolve and present intelligence. Our agents build and modify student models with the help of a double graph: a non-weighted, directional priority graph, and a weighted, non-directional, relatedness graph. In addition, we have explained how, from the authoring system courseware design requirements, we enforce the generation of structured content databases, to serve as a basis to the rule/knowledge bases, which will be used and added to by the two agents. We believe that with our system we are addressing more than one current need: the need of an English tutor for academics, which should also be easily accessible – i.e., on-line –, free, adaptive and user-friendly.

References

[1] Aspera PrivaTeacher, http://www.privateacher.com/

[2] Bartleby.com, Great books on-line, http://www.bartleby.com/

[3] Cristea et al,. (1999) "The Theoretical Framework for CALL Courseware Development", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 723-726.

[4] Collins, A. and Michalski, R. (1989) "The logic of plausible reasoning: A core theory", Cognitive Science, Vol. 13, 1-49.

[5] Collis, B. (1999) 'Design, Development and Implementation of a WWW-Based Course-Support System", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 11-18.

[6] Cristea et al, (2000) "An Intelligent language teaching tool for the Web", Proc. of ISSEI 2000, Bergen, Norway.

[7] Di Lascio, L., Fischetti, E. and Gisolfi, A. (1999) "A Fuzzy-Based Approach to Stereotype Selection in Hypermedia", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 285-320.

[8] Dictionary, http://www.dictionary.com/

[9] Ekdahl, B., Astor, E. and Davidsson, P. (1995) "Towards Anticipatory Agents", Woolridge, M., Jennings, N.R. (Eds.), Theories, Architectures, and Languages, Lecture Notes in Artificial Intelligence, Springer Verlag, 191-202.

[10] Elliot, A.J., McGregor, H.A. and Gable, S. (1999) "Achievement Goals, Study Strategies, and Exam Performance: A Mediator Analysis", Journal of Educational Psychology, Vol. 91, No.3, 549-563.

[11] EnglishLearner, http://www.englishlearner.com

[12] Jeffrey' s Japanese-English ó English-Japanese on-line dictionary. http://enterprise.dsi.crc.ca/cgi-bin/j-e/jis/dict

[13] Jennings, N.R. and Wooldridge, M. (1998) "Applications of Intelligent Agents", Agent Technology Foundations, Applications, and Markets, Springer-Verlag.

[14] Sa, W.C., West, R.F. and Stanovich, K.E. (1999) "The Domain Specificity and Generality of Belief Bias; Searching for a Generalizable Critical Thinking Skill", Journal of Educational Psychology, Vol. 91, No.3, 497-510.

[15] Levy, M. (1997) "Computer-Assisted Language Learning", Oxford Claredon Press.

[16] Maes, P. et al. (1993) "Learning Interface Agents", Proc. of the 11th Nat. Conf. AAAI, MIT/AAAI Press.

[17] Tomek, I. (1999) "Virtual Environments in Education", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha. 3-10.

[18] Virvou, M., Du Boulay, B. (1999) "Human Plausible Reasoning for Intelligent Help", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 321-275.

[19] Weiss, G. And Sen, S. (Eds.) (1996) "Adaptation and Learning in Multi-Agent Systems", Springer Verlag, Lecture Notes in Artificial Intelligence, Vol. 1042.

Online ESL Learning: An Authentic Contact

Yu-Chih Doris Shih* and Lauren Cifuentes**
**Department of Educational Curriculum & Instruction, Texas A&M University*
4205 Boyett St., #C, College Station, TX 77801, USA
E-mail: dorisshih@hotmail.com
*** Department of Educational Psychology, Texas A&M University*
College Station, TX77843, USA
E-mail: laurenc@tamu.edu

As communication via telecommunications become easier, learning through online technologies is made possible. In a telecommunications project among US preservice teachers and Taiwanese English as a Second Language learners, Taiwanese students practiced English language and discussed cultural information with US partners who served as online tutors. Data revealed that Taiwanese ESL learners perceived online learning of English language and American culture to be valuable for its authenticity. Instructions on intercultural communication skills were found to be necessary prior to the connection in order to help eliminate misunderstandings between participants of two countries. The success of online learning depended on several factors such as participants' motivation, participants' attitudes, technology, preparation, and support services. Furthermore, Taiwanese learners who had successful experiences applied ten strategies to their ESL learning. These strategies were employed during a circular process of online learning.

Keywords: **ESL, Online Learning, Telecommunications, Intercultural Computer-Mediated Communications**

1 Introduction

The purpose of this research was to investigate a telecommunications project for Taiwanese students to learn the English language and acquire cultural information through online technologies. Preservice teachers (PSTs) at a state university in the United States worked with Taiwanese learners of English as a Second Language (ESL) at a Taiwanese university. The goal of the research was to study intercultural online learning.

In Taiwan, many scholars have been discussing the need for educational reform and change of instructional methods [7][36]. One change under consideration is increased use of online instruction. Taiwanese researchers suggested that the educational reform should include the adoption of methods proposed in the West (i.e., the United States, Great Britain, Australia, and other English-speaking countries), such as involving students in active learning, teaching critical thinking skills, and incorporating individualized instruction [4][25]. Harasim (1990) and Owston (1997) believed that instruction could be enhanced by online teaching. They have stated that online instruction allows for active learning, idea generating, idea linking, and idea structuring as well as helps the students to develop skills in critical thinking and problem solving. Individualized instruction is supported because both synchronous and asynchronous modes of instruction are workable through technologies.

When online teaching is used as a language instructional method, it remedies Taiwan's geographical isolation as an island and provides opportunities for ESL learners to communicate in an authentic English environment. Successful second language (L2) learning includes not only knowing the linguistic features of the language but also understanding the cultural concepts [14]. Sayers and Brown (1987) remarked, "foreign language students

need authentic contacts with native speakers and much practice in a range of language skills -- including reading and writing -- if they are to develop cultural awareness and communicative competence" (p. 23). L2 learners learn language and culture if instruction is facilitated by supportive individualized learning activities [13]. These activities must address the learner's current language level (Krashen's stage of i) and the level beyond the present language and literacy capacities (Krashen's stage of i + 1) [21]. Telecommunications can help overcome the limitations of Taiwanese isolation by providing for supportive and authentic language instruction.

2 Literature Review

Learning through telecommunications has evolved during the 1990s in the West and has proved to be successful [1][8]. To bring more applications into Taiwan, we need to first explore Taiwanese students' needs and attitudes in the use of such technology. Some scholars stated that Asian students employ different learning strategies than students in the West [17][32]. Cheng (1980) pointed out that the educational system in Taiwan has adopted many different educational methods developed in the West; however, utilization has been non-systematic and inappropriate for societal needs in Taiwan. Furthermore, Stewart (1985) and Dooley (1995) noted that the applications of educational technology in other countries besides the United States may be unsuitable because of cultural non-transferability. For instance, other cultures may value a different set of learning and teaching modes when compared to the United States, or they may have insufficient equipment for advanced technological applications. Taiwanese scholars have also urged that future investigations must be done specifically on distance-learning courses in Taiwan [6][37]. Therefore, close examination must be carried out prior to fully adopting new telecommunication technologies as learning tools in Taiwan.

As technology advances, communication over a distance and across cultures becomes easier and inevitable. However, very little can be found in the literature that addresses issues of online intercultural communication and the design considerations that would enhance such interaction. Lee (1999) urged designers and instructors of computer-based instruction to take cultural issues into consideration when developing learning environments and technology integration within curricula. Caution must be taken, especially when intercultural contacts occur in an online learning context, because communicators may not be who they seem to be online [28].

Collis and Remmers (1997) pointed out that to allow successful online cross-cultural contact, at least four issues have to be taken into consideration: communication and interaction, language, content, and representation form. First, communication and interaction are easily misinterpreted across cultures. According to the two researchers, more communication and interaction are not necessarily better than less, and well-structured communication may be preferable for wider audiences. Second, because language includes verbal and nonverbal cultural communication, those developing cross-cultural online instruction must be sensitive to cultural differences in communication styles. Third, designers must choose cross-cultural course content. Last, visuals can overcome problems associated with text-based language. However, one must be sensitive to cultural differences in the acceptability and interpretability of various aspects of visualization.

Research on online connections has been conducted in many areas during this decade. Projects connecting students with teachers or other students in multiple locations were implemented in many subject areas such as science [22], history [3], teaching [27], and language arts [35]. Similar projects in the area of foreign language learning are found in the teaching of Portuguese [20], Russian [30], Spanish [24], and ESL [19][33]. The results of these studies mainly stated how the participants at different sites benefited from the connection in increased technical competence, personal development, language improvement, and more meaningful cultural exchanges. No research has been found that explores the learning strategies used by students while learning a L2 online and the issues encountered during their online intercultural communications.

3 Purposes and Research Questions

There were three purposes of this study: first, understanding the Taiwanese ESL learners' perceptions of learning through distance technologies; second, exploring issues related to online intercultural communication; and third, identifying the learning strategies the Taiwanese learners employed during distance learning to accomplish the

acquisition of ESL and understanding of American culture. The three research questions guided the study were:

(1) How do ESL learners in Taiwan perceive language acquisition and cultural understanding via distance learning technologies after the experience?
(2) What intercultural phenomena can be observed in online learning for Taiwanese students?
(3) What online learning strategies do the Taiwanese use while learning the English language and learning about American culture?

4 Method

This study employed a qualitative research design. This design enabled the researcher to inquire, comprehend, and describe the experiencing world of the participants and the meaning of these experiences [2][26].

4.1 Participants

The project involved students in two different countries: US and Taiwan. There were 40 PSTs in the United States who took either *EDTC 305: Instructional Technology: Theory and Practice* or *INST 462: Language Acquisition and Development* at a state university. These were PSTs being prepared to teach English, ESL, political science, and history at the elementary or secondary level. The same number of participants in Taiwan were students who study in the Department of English Language and Literature at a university in Taipei, Taiwan. They were members of *English Composition and Conversation* classes at either sophomore or junior levels. The US and Taiwanese students participated in this research because their instructors included this online connection project as part of their course requirement. The participants in the United States ranged from the ages of 20 to 22, while the students in Taiwan ranged from the ages of 19 to 20.

In addition, the three professors in Taiwan whose students were project participants were also involved as research subjects. They were interviewed by the researcher in regard to their students' perceptions of online experiences, students' improvement in the English language as well as other types of knowledge through the connection.

4.2 Procedures

To carry out the study, US PSTs corresponded with Taiwanese university-level ESL learners for ten weeks. These PSTs served as tutors of the English language and American culture. The participants in both countries were matched one-on-one randomly prior to the connection. They were also given instructions and orientations on the utilization of e-mail systems and on online learning/teaching. The PSTs were provided with a lecture, discussion, supportive readings, example tutorial correspondences, and a web site of resources. The web site included a downloadable lecture about online learning, the expected online correspondence process guidelines, a midterm survey, sample correspondence, and previous participants' reflections (http://www.coe.tamu.edu/~lcifuent/classes/edtc305/online.htm). They also read on topics such as effective facilitation of computer conferencing [9], computer-mediated communication [18], interactivity in online environments [15], online teaching strategies [8], and cultural differences in teaching and learning [17].

Similarly, the students in Taiwan were supplied with an orientation where the project is introduced to them along with rules and regulations. Sample correspondence, results of previous connections, and suggestions for online learning and discussion topics were presented at their departmental website (http://www.eng.fju.edu.tw/cultural_connections.htm).

Every participant received a welcome letter to encourage them to open themselves up to this new experience. The PSTs were given a rubric with expected number grades to help them accomplish the requirements for their part of the connection. The Taiwanese students initiated the connection by sending out their first e-mail message to their US partners. The US PSTs analyzed their student's language level and started to instruct him or her according to that level through e-mail.

Mid-way during the ten-week connection, the PSTs were asked to fill out an online midterm survey. In Taiwan, the students submitted a brief report to their instructors every two weeks to keep track of their connection progresses.

At the end of the connection, the PSTs and their Taiwanese students filled out a post-connection survey. The PSTs also handed in all of their e-mail printouts and personal journals that reflected their online teaching and learning experiences. Similarly, the Taiwanese students handed in their final reports to their Taiwanese instructors. Two weeks after the end of the connection, the researcher traveled to Taiwan to conduct interviews with 12 Taiwanese students and the three Taiwanese professors. The interviews included open-ended questions.

4.3 Data Collection and Analysis

There were eight data sources: (a) printouts of correspondence; (b) the PSTs' midterm survey; (c) the PSTs' post-connection survey; (d) the Taiwanese students' post-connection survey; (e) the PSTs' reflective journal entries; (f) the Taiwanese students' final reports; (g) transcripts of the interview with the Taiwanese students; and (h) transcripts of the interview with the Taiwanese professors.

Data analysis in qualitative studies is an ongoing process during the research; it is best done simultaneously with the data collection [26]. Each time data are gathered, information was analyzed using procedures proposed by Emerson, Fretz, and Shaw (1995). The steps included close reading, open coding, writing memos, noting themes and patterns, and focused coding.

5 Results

Data analyses revealed remarkable information on the areas of (a) learner perception, (b) intercultural communication, (c) factors affecting online connection, (d) online learning strategies, and (e) online learning processes. First, this particular group of Taiwanese ESL learners was positive about L2 and cultural learning in an online setting. The results of a post-connection survey showed that participants more or less agreed that (a) E-mail connections have a positive place in ESL classrooms (mean of 3.71); (b) the Web-connection has a positive place in ESL classrooms (mean of 3.51); (c) they would participate in another online connection if given the opportunity (mean of 3.58); and (d) they would suggest their other friends or classmates participate in a similar project (mean of 3.85) (see Table 1). Even though the response to the question "Overall, my connection was successful" was not very high (mean of 3.26), learners who had an unsuccessful connection held positive attitudes toward the project. One student wrote in her final report, "My pal does not respond to me so often. I didn't learn much through this project this semester. But that doesn't mean this project is not good. I hope school brothers or sisters can still have the chance to get in this project."

Table 1. Taiwanese Students' Responses Toward the Online Connection

Questions	M	SD
The **E-mail connection** has a positive place in ESL classrooms.	3.71	0.67
The **Web-board connection** has a positive place in ESL classrooms.	3.51	1.50
I would participate in another online connection if given the opportunity.	3.58	1.13
I would suggest other friends or classmate participate in a similar project.	3.85	0.78
Overall, my connection was successful.	3.26	1.07

Note. Participants responded on a 5-point Likert scale (1= Strongly Disagree; 5 = Strongly Agree). The survey was complete by 37 participants.

Second, intercultural communication issues cannot be ignored. A lot of Taiwanese learners interpreted that their tutors were angry with them when they did not receive messages over a week. In addition, learners read what wasn't intended in the messages. They constantly apologized to the PSTs for being an inconvenience. Several learners ceased active interaction with the PSTs due to these personal interpretations. The Taiwanese professors suggested that acquainting learners with different thinking patterns and expression styles is necessary in future connections.

Third, factors that affected online connections included participants' motivation, attitudes toward each other, participants' fields of experience, frequency and quality of interactions, technology, preparation, and support

services (figure 1). Any missing component would hinder the success of the connection. Other resources such as teachers, peers, family members, libraries, and web resources provided extra assistance to the participants.
Fourth, during the correspondences, ten learning strategies were found to be used by the learners in their messages. These were paraphrasing, translation, Q&A from tutor to student, Q&A from student to tutor, explanation, elaboration, decision-making, self-reflection, metacognition, and transfer. The learners in the more successful pairs tended to use a variety of the ten strategies.

Finally, data indicated these ESL learners went through a series of processes for successful learning (figure 2). Motivated learners set learning goals for themselves with the PSTs' help. Those who prepared themselves well by finding topics of discussion or information in the libraries, the WWW, and traditional learning environment aimed for frequent and quality interactions via e-mail with the PSTs. After each interaction, a review period prompted learners for more interactions. Learners who went through these stages concluded that they had learnt new information and increased their confidence in using English reading and writing skills. Needless to say, this result increased their motivation to learn and thus encouraged the start of another learning cycle.

6 Discussions and Conclusion

This study is significant to both distance-learning educators and language-learning educators. There are at least three reasons for this significance. First, the study provides insights for distance educators, both for those in Taiwan and for those in other countries who have Taiwanese students enrolled in courses that are delivered via telecommunications. The results of the study help these instructors to further understand Taiwanese students' positive perceptions of L2 learning through online technologies, identify suitable conditions and environment for these learners, and decide the extent to which this mode of instruction is applicable to students from this cultural background.

Second, the online intercultural communications issues explored in this study assist telecommunications users with more effective communication. They help users become aware of and anticipate problems when coming into contact with people of other cultures via distance technologies. Even without using online technologies, intercultural communication is already complex. Therefore, interaction may be hindered further when technology is the transmission medium. Understanding the barriers and facilitators of online intercultural communication leads to better and more successful intercultural interactions.

Third, the identified ten online learning strategies and online learning processes will add to the literature on language learning and teaching. Such research is in demand because ESL programs in the United States are planning to deliver more ESL courses to foreign countries via distance learning technologies.

In summary, most Taiwanese ESL learners had a positive experience with the online connection. The few connections that failed were due to lack of participants' response, lack of participants' motivation, and technical failure. Nevertheless, providing L2 instruction to learners over cyberspace is a method that should not be ignored. Learners need to be prepared with adequate intercultural communication skills and online learning strategies.

Follow-up investigation of online ESL acquisition might include specific amount of improvement on learners' writings and learning via synchronous technologies such as chats, interactive videoconferences, and desktop videoconferences.

References

[1] Bates, A. W., "Technology, open learning and distance education", Routledge (1995)
[2] Bogdan, R. C., & Biklen, S. N., "Qualitative research in education: An introduction to theory and methods", Allyn & Bacon, 3rd ed (1998).
[3] Butler, W. M., "Writing to learn history on-line", The Clearing House, Vol. 69, No. 1, pp. 17-19 (1995)
[4] Chang, H-J., "Trends of instructional methods", Social Change and Educational Development, pp. 483-522, Taiwan Bookstore (1991)

[5] Cheng, S-H., "Chinese contemporary history of education", San-Ming bookstore (1980)
[6] Chou, C., Chou, J., & Tyan, N. N., "An exploratory study of Internet addiction, usage and communication pleasure - The Taiwan's case", International Journal of Educational Telecommunications, Vol. 5, No. 1, pp. 47-63 (1999)
[7] Chu, C-C., "Social change and current educational system", Social Change and Educational Development pp. 37-65, Taiwan Bookstore (1991)
[8] Cifuentes, L., & Shih, Y-C D., "Teaching and learning online: A collaboration between U.S. and Taiwanese students", Journal of Research on Computing in Education, Manuscript accepted for publication (2000)
[9] Cifuentes, L., Murphy, K.L., Segur, R., & Kodali, S., "Design considerations for computer conferences", Journal of Research on Computing in Education, Vol. 30, No. 2, pp.172-195 (1997)
[10] Collis, B. & Remmers, E., "The World Wide Web in education: Issues related to cross-cultural communication and interaction", Web-based instruction, pp. 85-92, Educational Technology Publications (1997)
[11] Dooley, L. M., "Problems and issues in distance learning using interactive video between the U.S. and selected African countries", International Journal of Educational Telecommunications, Vol. 1, No. 1, pp. 93-104 (1995)
[12] Emerson, R. M., Fretz, R. I., & Shaw, L. L., "Writing ethnographic fieldnotes", The University of Chicago Press (1995)
[13] Enright, D. S., "Supporting children's English language development in grade-level and language classrooms", Teaching English as a Second or Foreign Language, pp. 386-402, Heinle & Heinle (1991)
[14] Fantini, A. E., "Bilingualism: Exploring language and culture", Language, culture and cognition, pp. 110-119, Multilingual Matters (1981)
[15] Gunawardena, C. N., "Changing faculty roles for audiographics and on-line teaching", The American Journal of Distance Education, Vol. 6, No. 3, pp. 58-71 (1992)
[16] Harasim, L. M., "Online education: An environment for collaboration and intellectual amplification", On line Education Perspectives on a New Environment, pp. 39-64, Praeger (1990)
[17] Hofstede, G., "Cultural differences in teaching and learning", International Journal of Intercultural Relations, Vol. 10, pp. 301-320 (1986)
[18] Jonassen, D. H., Davidson, M., Collins, M., Campbell, J., & Haag, B. B., "Constructivism and computer-mediated communication in distance education", American Journal of Distance Education, Vol. 9, No. 2, pp. 7-25 (1995)
[19] Kamhi-Stein, L., "Promoting EFL teacher development through e-mail instruction", Computer-Assisted English Language Learning Journal, Vol 7, No. 4, pp. 14-19 (1997)
[20] Kelm, O. R., "The use of synchronous computer network in second language instruction: A preliminary report", Foreign Language Annals, Vol. 25, No. 5, pp. 441-454 (1992)
[21] Krashen, S. D., "The fundamental pedagogical principle in second language teaching", Studio Linguistica, Vol. 35, No. 1-2, pp. 51-70 (1981)
[22] LeBaron, J., & Teichmaun, V., "KITES: A middle school environmental science telelink to West Germany", Educational Technology, Vol. 29, No. 6, pp. 51-53 (1989)
[23] Lee, C. D., "Towards a framework for culturally responsive design in multimedia computer environments: Cultural modeling as a case", Paper presented at 1999 American Educational Research Association Convention at Montreal, Canada (1999)
[24] Leh, A. S., "Electronic mail in foreign language learning: Communication and culture", ERIC Document Reproduction Service No. ED409851, Association for Educational Communications and Technology (1997)
[25] Lin, S-C., "Current social change and instructional reformation in Taiwan", Social Change and Educational Development, pp. 459-482, Taiwan Bookstore (1991)
[26] Lincoln, Y. & Guba, E., "Naturalistic inquiry", Sage (1985)
[27] Lowry, M., Koneman, P., Osman-Jouchoux, R., & Wilson, B., "Electronic discussion groups: Using E-mail as an instructional strategy", Tech Trends, Vol. 39, No. 2, pp. 22-24 (1994)
[28] Newbold, W. W., "Transactional theory", http://www.bsu.edu/classes/newbold/htx/theory.htm (accessed on July 20, 1999).
[29] Owston, R. D., "The World Wide Web: A technology to enhance teaching and learning?" Educational Researcher, Vol. 26, No. 2, pp. 27-33 (1997)
[30] Samsonov, P., "Russian translation via e-mail", IALL Journal of Language Learning Technologies, Vol. 30, No. 3, pp. 39-42 (1998)

[31] Sayers, D., & Brown, K., "Bilingual education and telecommunications: A perfect fit", The Computing Teacher, Vol 15, No. 8, pp. 23-24 (1987)

[32] Smith, P. J. & Smith, S. N., "Differences between Chinese and Australian students: Some implications for distance educators", Distance Education, Vol. 20, No. 1, pp. 64-80 (1999)

[33] Soh, B-L, & Soon, Y-P., "English by e-mail: Creating a global classroom via the medium of computer technology", ELT Journal, Vol. 45, No. 4, pp. 187-292 (1991)

[34] Stewart, A., "Appropriate educational technology: Does 'appropriateness' have implications for the theoretical framework of educational technology?" Educational Communication and Technology, Vol. 33, No. 1, pp. 58-65 (1985)

[35] Traw, R., "School/university collaboration via e-mail: A unique approach to teaching reading and language arts", Tech Trends, Vol. 39, No. 2, pp. 28-31 (1994)

[36] Wang, C-Y., "Social science education in social change", Social Change and Educational Development, pp. 147-164, Taiwan Bookstore (1991)

[37] Young, S., "A field study of the implementation of a synchronous distance course with asynchronous Internet-supported telecommunications technologies in Taiwan, R. O. C.", International Journal of Educational Telecommunication, Vol. 5, No. 2, pp. 111-125 (1999)

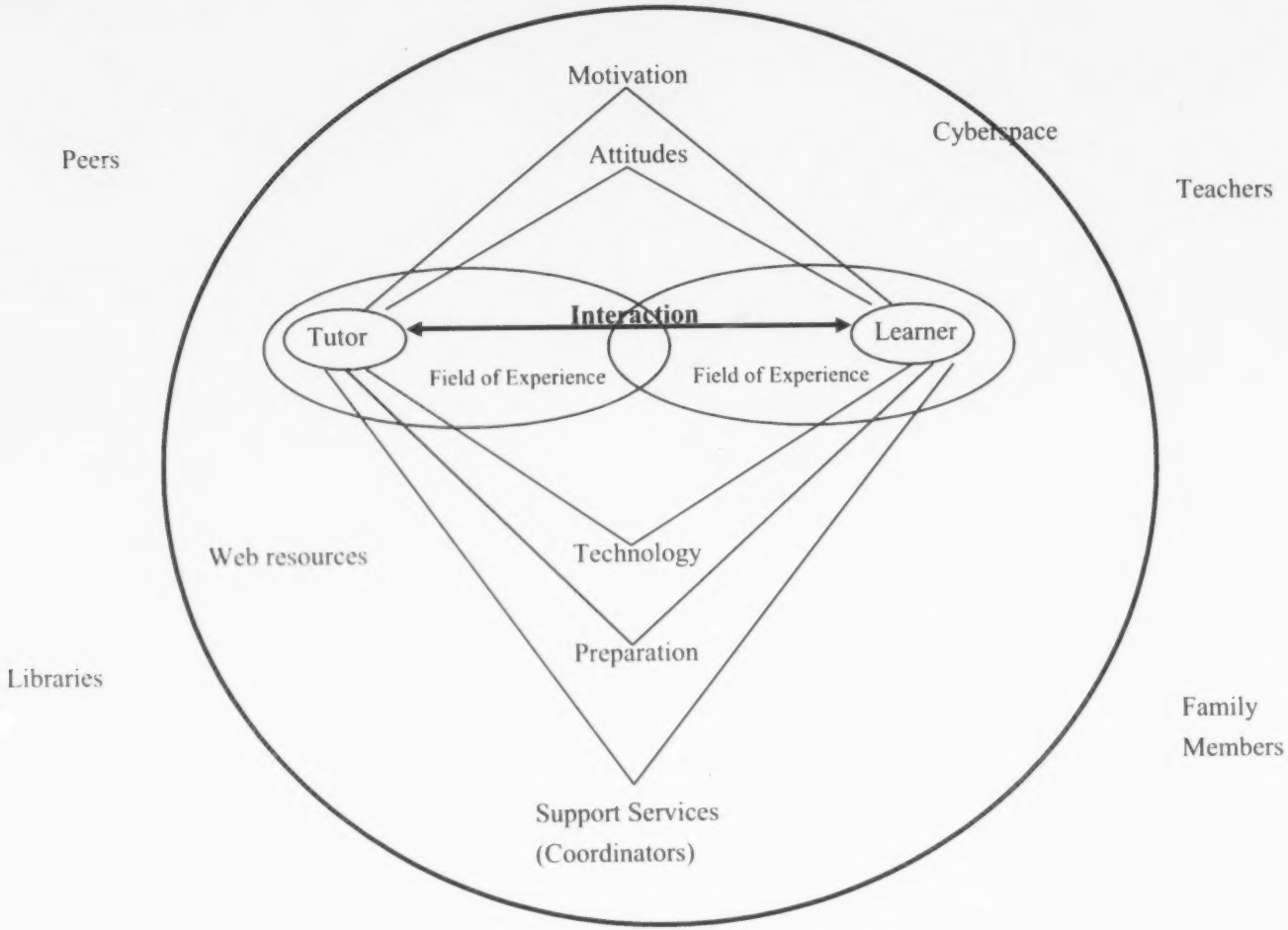


Figure 1. Factors Affecting Online Connections

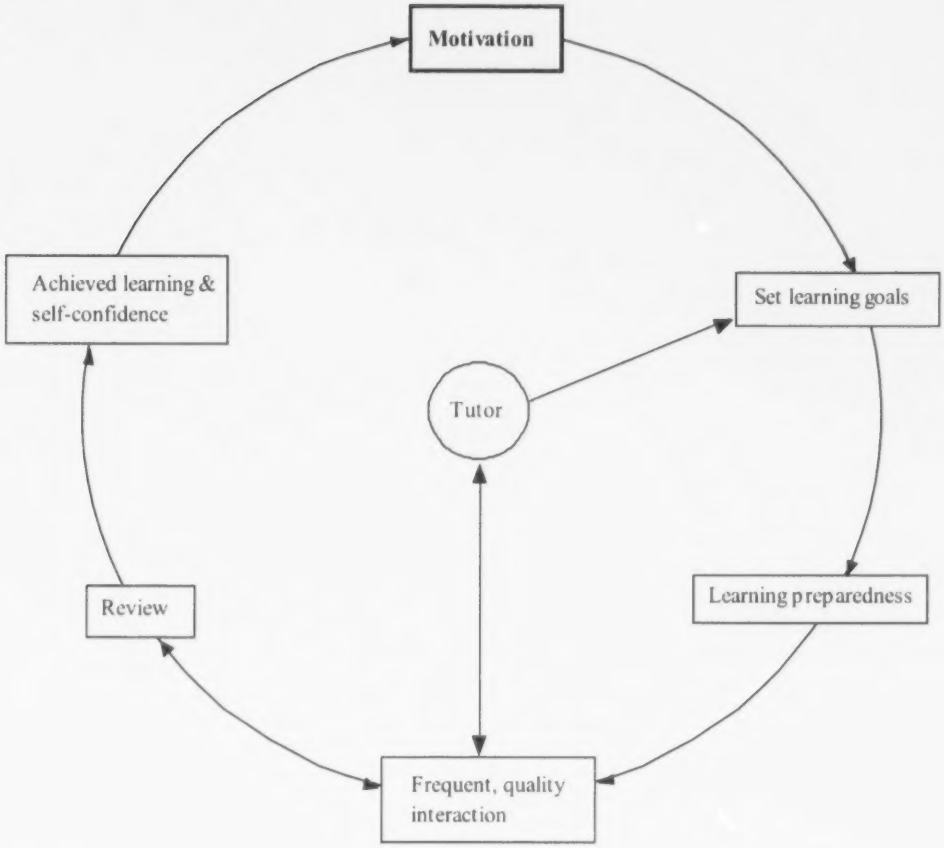


Figure 2. Online Learning Processes in the United States-Taiwan Connection.

Schema Theory-based Instructional Design of Asynchronous Web-based Language Courses

C. Candace Chou
Interdisciplinary PhD Program in Communication and Information Sciences
University of Hawaii
Email: chou@hawaii.edu

Instructional design (ID) provides a framework to facilitate both teaching and learning activities. ID also prescribes desirable learning outcomes. This paper introduces the implementation of an ID template in web-based language courses. The ID template incorporates several cognitive strategies based on schema theory. A schema-theory-based model provides a useful framework for knowledge organization and information processing. In a course that emphasizes reading comprehension, schema theory accounts for how learners construct meaning from texts based on the information they encounter, the prior knowledge they already have, and the way they interact with the new information. The ID template consists of four instructional sequences. The cognitive strategies, ID examples, and purposes for each sequence are illustrated. The sequences include warm-up activities, preparatory activities, core activities, and post activities. Each sequence is interconnected with the others and looped back to the beginning in each lesson unit. The preliminary evaluation results indicate the degree of student satisfaction for the ID template for various external and internal factors.

Keywords: **instructional design, schema theory, cognitive strategies, web-based foreign language instruction**

1 Introduction

Instructional design (ID) plays a critical role in the success of distance education. ID is an interdisciplinary science that provides a theoretical background for the design and implementation of instructional units to achieve desirable learning outcomes. ID principles encompass theories in both learning and instruction. Although the instructional design for web-based instruction does share some common principles with instructional design for traditional classroom teaching, the modes of instruction and learning are quite different from each other. The roles of learners and instructors continue to go through fundamental changes as well. What kind of instructional theories can be best applied to web-based education? There is no one single universal theory for all instructional design as the objectives, learning contexts, subject matters, and expected learning outcomes vary from one field to another. The development of ID also depends on the pedagogical principles that the instructors or instructional designers adapt to. The views on instructional design can be approached from different perspectives such as behavioral (Gropper, 1983); systematic (Gagne, Briggs, & Wager, 1992); structural (Scandura, 1983); motivational (Keller, 1983), transactional (Merrill, 1997); and cognitive (Tennyson, 1990; West et al., 1991). Cognitive schema theory especially receives prominent attention in the field of instructional design and language education for its emphasis on the use of aid for perception, learning, comprehension, and recall (Anderson, 1984; West et al., 1991). This paper focuses on the application of schema theory to the instructional design of language courses delivered through the World Wide Web. The preliminary evaluation results are summarized at the end.

2 Theoretical Framework

Why is ID important in web-based distance education? Reigeluth (1983) argued that ID is a linking science between theory and practice. This linking science was further elaborated by Tennyson and Schott (1997): "As a field of study, it provides a theoretical foundation to principles of instructional design, a research base confirming the theoretical foundations, and a direct involvement in the application of those principles" (p. 1). ID theories prescribe the variables and conditions required for certain learning outcomes. Furthermore, the practice of ID utilizes various methods and technologies to develop learning environments based on these theories (Tennyson & Schott, 1997). Many ID models have been developed and the theoretical bases vary greatly. A typical model includes the following five steps: "(1) setting the *objectives;* (2) *preassessment*, that is, determining whether the target students have the prerequisites to benefit from the instruction; (3) *planning the instruction*; (4) *trial*, that is, presenting the instruction for developmental purposes; and (5) *testing* and *evaluation*" (West et al., 1991). Each step can be further divided into more detailed instructional sequences. The focus of this paper is on planning the instruction based on cognitive learning theories. Schema theory is an especially appropriate cognitive learning theory because of its emphasis on knowledge organization and representation.

There is no one single theory called schema theory. It has evolved and become the basic component of many cognitive learning theories. According to cognitive theorists, schemas or schemata are mental data structures that represent our knowledge about objects, situations, events, self, sequences of actions and natural categories (Anderson, 1985; Rumelhart, 1981). Schemata are also like scripts of plays (Schank & Abelson, 1977). In other words, schemata are chunks of knowledge stored in the human mind by patterns, structures, and scaffolds (West et al., 1991). Based on Rumelhart's definition (1981), schemata serve the function of "scaffolding." Knowledge is perceived, encoded, stored, and retrieved according to the chunk of information stored in the memory. Schemata facilitate information processing. Schema can be "instantiated" by specific examples of concepts or events. For example, one's schema for "teaching" can be instantiated by viewing a scenario on the interaction between a teacher and students. As soon as schemata are instantiated, one can associate or recall more similar scenarios (Bruning et al, 1995). Schema theory is appropriate for language instruction due to its powerful explanation of memory and recall. In the case of reading comprehension, schema theory accounts how learners construct meaning from texts based on the information they encounter, the prior knowledge they already hold, and the way they interact with the new information (Bruning et al, 1995, p. 275). As summarized by Andre (1987), schemata serve the following important function in reading comprehension:

1. Providing the knowledge base for assimilating new text information
2. Guiding the ways readers allocate their attention to different parts of reading passages
3. Allowing readers to make inferences about text materials
4. Facilitating organized searches of memory
5. Enhancing editing and summarizing content
6. Permitting the reconstruction of content (Bruning et al., 1995, p. 275).

Schemata provide the backgrounds for learners to comprehend a text by inference. Schemata also make it possible to summarize a passage by selecting the parts that are important to them. These processes cannot be completed without the knowledge structures that schemata provide. Since one of the elements of schema theory is making predictions based on what learners already know, making the link between the old information and the new information has generated a great deal of research interest. Two areas of research in this direction are advance organizer and schema activation.

Advance organizers employ the structure of some materials that the learners are already familiar with as the framework of the new materials. In other words, advance organizers are designed to offer "ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows" (Ausubel, 1968, p. 148). Advance organizers are relevant introductory materials that are introduced in advance of the core texts. Recent studies have also shown that providing short and concrete examples for upcoming events are more useful to readers than abstract, general, and vague learner organizers (Corkill et al., 1988).

Schema activation refers to the design of activities for the purposes of activating learner's knowledge in

similar fields prior to learning new subject matters (Bruning et al., 1995). They are often in the forms of short questions. In a way, schema activation serves similar purposes of advanced organizers by linking new information with old information that the learners already know. However, schema activation relies more on the learners to generate information from their previous knowledge base. Schema activation works better if the schema activating activities are relevant to the to-be-learned information. A study on the reading comprehension of a group of fifth-graders showed that the group with relevant schema activation remembered the reading texts better than the groups with non-relevant schema activation (Peeck et al., 1982).

There are also many other cognitive strategies that help students with reading comprehension. These strategies are designed to help students in gaining control of their learning process for the purpose of comprehending reading texts. Bruning et al. (1995) summarized the following five strategies for reading comprehension:

1. *Determining importance:* Instructional activities can be designed to help learners locating the main ideas of the text. Without knowing the main ideas, readers would have a hard time understanding the text.
2. *Summarizing information:* Students should not only learn to summarize the main ideas in a passage but also generate a text that represents the original one. Students' reading skills improve when their summarization skills improve.
3. *Drawing inferences:* Studies have shown that the ability to make inferences is positively associate with reading skills (Dewitz et al., 1987; Raphael & McKinney, 1983). Good readers are usually good at guesswork.
4. *Generating questions:* Good readers ask questions frequently. Through self-questioning or peer-exchanged questions, learners will have a better understanding of texts.
5. *Monitoring comprehension:* Readers should have the ability of knowing when they understand the text and when they do not. A good reader also has the ability to detect errors and inconsistencies in the reading materials. When they become critical of the reading texts, they do a better job in detecting errors. Peer editing or peer-critiquing is a good way to monitor comprehension (Bruning et. al., 1995, p. 279-284).

The next section describes how some of the cognitive strategies can be employed in the instructional design of web-based language courses.

3 Instructional Design Template for Web-based Language Courses

The web course introduced in this paper is the first one in a series of Asian language courses using the same instructional design templates. There is a lack of higher-level language courses (3rd year and above) in Less Commonly Taught Languages (LCTLs) such as Asian languages and other non-Roman languages in American universities and colleges. Yet, the need for higher-level language courses does exist for students who would like to continue language studies. The objectives of the web courses are to provide opportunities for students whose institutes do not provide language courses in LCTLs and to disseminate information on the ID model of pedagogically sound language instruction. The first course that is currently offered through the University of Hawaii systems is a Chinese reading and writing course at the 3rd and 4th year level. A Chinese listening/reading/writing course and a Korean reading/writing course will be offered in fall 2000. More courses in Japanese and other LCTLs are in the planning stage at present. The instructional design template is summarized as follow:

Goal: To improve Chinese reading and writing skills.

Objectives:

1. Students will possess the skills to decipher reading materials through a series of cognitive strategies.
2. Students will improve writing skills through continuous revisions, peer-critique, and teacher feedback.
3. Students will have a good command of vocabulary in the subject matters covered in the course.
4. Students will co-construct knowledge together through collaborative tasks in building word bank, grammar clinic, and essay database.

Content: The content covers a wide variety of topics based on authentic teaching materials collected from China and Taiwan, including topics such as cuisine, travel, medicine, celebrities, university, and so on. These materials were developed into ten self-directed reading lessons on a CD-ROM. The web course uses the CD-ROM as the core reading materials. Each web lesson unit was designed to enhance the understanding of the equivalent core text in the CD-ROM.

Format of the Instruction: The World Wide Web and the CD-ROM were selected to deliver the instruction and course content. Asynchronous communication via email and web-forum are the means for student-student and student-teacher interactions.

Table 1 Instruction design template for web-based language courses

ID Sequence & Modules	Cognitive Strategies	ID Examples	Purposes
1. Warm-up activities	Schema activation	Word bank	Brainstorming on terminology Co-construction of knowledge base
2. Preparatory activities	Advance organizer	Picture matching	Preparation for forthcoming texts
3.1 Core activities	Determining importance Drawing inferences	Working on CD-ROM reading activities	Determining the importance of information
3.2 Core activities	Generating questions	Q&A	Self-questioning
3.3 Core activities	Scaffolding	Small Group Discussions	Debate/Discussion/Role Play Use input for other activities
3.4 Core activities	Monitoring comprehension	Grammar Clinic	Peer editing with teacher feedback
4.1 Post activities	Modeling	Sample essay	Teacher demonstration
4.2 Post activities	Recall	Language work	Monitoring comprehension
4.3 Post activities	Summarizing information	Composition & revision	Individual output with collective database on writing samples

Sequence of Instruction: The framework of the instruction sequence is adapted from Hiple and Fleming's (1996) work which is specifically designed for foreign language instruction. The ID examples are developed by the instructors Fleming & Lu (1999) for web-based language courses. There are eight units in each web course. Each unit employs the following four sequences of instruction.

1. *Warm-up activities:* These activities employ simple and short questions to activate learners' previous knowledge relevant to the subject matter. For example, on the unit for cuisine, students are asked to write down two or three things they know about Chinese cooking. Their responses are put into a database called the "word bank." By the end of each unit, students have accumulated an abundant collection of glossary under a specific language topic.
2. *Preparatory activities*: Students are asked to match some descriptions with pictures. These pictures provide a background information of the lesson and prepare the students for the forthcoming texts.
3. *Core Activities*: There are four components in Core Activities: working on the CD-ROM, Q & A forum, Small Group Discussions, and Grammar Clinic. Students first go through the reading activities in the CD-ROM. They then post questions about the content of the CD-ROM on the Q & A web forum. Following that, they are divided into three-member or two-member small groups to carry out a conversational task. Take the cuisine unit for example, they have to make up their minds on which restaurant to go to for dinner. One conversation example is provided so that students know in advance the scope and depth of the expected conversation. In Grammar Clinic, the instructors pick several erroneous sentences from the Small Group Discussions and post them

at the Grammar Clinic (a web forum) for peer editing and critiquing. All these sentences are posted anonymously.

4. *Post Activities*: In the final stage the learners model from teacher's examples and peers' writings before they work on their own essays independently. First, the teacher provides a sample essay and a language matching exercise to reinforce the key words in the essay. Gradually, teachers withdraw help and let the student compose their own essays. If they have a hard time starting, they can view other students' submissions of essays in the database to come up with more ideas.

Among the eight units, the last two units are designed for language exchange with native speakers from the country of the target language. For more details, please refer to the web site (http://www.lll.hawaii.edu/yuedu). The ID template can be modified for different language instruction. The Word Wide Web is an especially perfect media since all information is recorded and saved in the database. Students can always go back to review the collective database for their own review.

4 Evaluation of the web course

In the evaluation process, the instructional design team is interested in student feedback on the sequences of instruction. At the end of each unit, students are asked to fill out an anonymous feedback form that consists of 10 questions on a five-point Likert scale. Comment areas are provided for each question. Table 2 shows the preliminary partial results on the ID template evaluation.

Students had provided valuable feedback to the instructional design team. The team was able to use this feedback to adjust course content and activity design. Generally speaking, students agreed that most instructional design modules are useful for their learning. The degree of helpfulness varies from module to module. However, it seems that the students generally did not like the use of the CD-ROM. One reason is that the CD-ROM could only be used on a Macintosh while 95% of the students in the class used PC-compatible computers. PC users were restricted to use campus Macintosh computers to access the content in the CD-ROM. Furthermore, since the CD-ROM was developed for self-directed learning, there was also a lack of interaction between students and teachers. Finally, there were some bugs in the programming of the CD-ROM. Students were not enthusiastic about the programming bugs. The team is in the process of converting the CD-ROM into cross-platform media and fixing the bugs.

Table 2 Feedback on Instructional Design Lesson Template

1 = Strongly disagree; 2 = Disagree; 3 = Slightly Agree; 4 = Agree; and 5 = Strongly Agree		Unit 2 (mean)	Unit 4 (mean)	Unit5 (mean)	Unit7 (mean)
	Post Unit feedback questions	(n=11)	(n=9)	(n=11)	(n=9)
Q1	I have gained new knowledge from this unit.	4.09	3.78	3.73	3.56
Q2	When I ask for help, the instructors respond in a timely way.	4.45	4.33	4.09	3.33
Q3	When I ask questions, the instructors give me the answers I need.	4.36	4.33	4.09	3.67
Q4	The warm-up activities are useful. (i.e. contributing and sharing vocabulary)	3.73	3.78	3.73	3.44
Q5	The preparatory activities are useful. (i.e. matching pictures to text)	3.91	3.67	3.36	3.22
Q6	The content of the core lessons (CD-ROM) is well designed.	3.18	3.33	2.91	NA*
Q7	The forum discussions (i.e. Q&A, role-play, small group discussion) are useful.	4.09	3.78	3.73	3.33
Q8	The grammar clinic is helpful.	3.45	3.89	3.73	NA*
Q9	The language work is at the proper level of difficulty.	4	4.00	3.55	3.56
Q10	The essay writing is at the proper level of difficulty.	4.09	4.22	4.09	3.67
	Average	3.94	3.91	3.701	3.473

* Unit 7 is designed for language exchange. The questions on CD-ROM and Grammar Clinic are not applicable.

As for the web-based instructional modules, the warm-up activities were not deemed as useful as the instructional design team had expected them to be. When monitoring student online activities through the server-tracking program, it was found that most of them did not go back to use the database after submitting

the required entries. The instructor started requiring the students to incorporate the vocabulary into their essays towards the end of the semester. By then, it may have been too late to see how the change in instructional strategy would affect the way the students utilize the database. This is a good lesson for instructional designers. All instructional sequence should be interconnected and continuously looped back to the beginning. If the instructional modules are designed as stand-along units, students will not see the purpose of building on the knowledge based that they have co-constructed.

Finally, there seems to be a slight decline in the helpfulness of the ID modules when comparing the average in table 2. The perceived helpfulness declines especially in unit 7. The change in instructional format (i.e., language exchange) and the more specialized topic (i.e., movies) may have posed a greater challenge for less competent students. Interviews with the student may help to find out the real reasons. Nevertheless, the comments from students were overall positive. Here are a few comments from the students.

" The warm-up activities have been very helpful in preparing for the entire lesson."

"The preparatory activities makes one think harder about the subject material."

"Small group discussion wasn't as interesting as the previous units because there were a little interactions among students."

" I believe I would not have learned all of the new words from a textbook. Contributing and sharing vocabulary for this unit has really helped my ability to read the Chinese newspaper's entertainment section."

"The text for this section was presented in a way that forced me to focus and analyze more fully the meaning. A good challenge which I enjoyed."

" This unit helped me to learn unique vocabulary for discussions with almost any Chinese speaker. I am more confident that I can carry a conversation with a Chinese speaker about my favorite movie."

"While on occasion some vocabulary has been a little bit difficult, once I put the sentence or paragraph into context, the usage of the vocabulary became more clear."

5 Conclusions

ID sets up a framework for desirable learning outcomes. The incorporation of cognitive strategies helps students to efficiently achieve the learning objectives. It can be found from their comments that the students valued greatly the aspects of online interaction and co-construction of a knowledge database. It is through the collaborative tasks that they are able to interact for a purpose, i.e., for the completion of a task that has a real-world application. The overall ID objectives have been met through the instructional sequences. Nevertheless, there is not much evidence supporting the effectiveness of the ID modules other than students' own remarks. Further study on the comparison of the actual online activities (e.g. tracking the mouse clicks) with their perceptions on the usefulness of each ID module can provide more insight into the effectiveness of the instructional design. In addition, an objective panel of language experts to evaluate the performance of the students could also provide assessment to the final learning outcomes.

References

[1] Anderson, R. C. (1984). Role of reader's schema in comprehension, learning, and memory. In R. C.

[2] Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[3] Anderson, R. C. (1985). *Cognitive psychology and its implications*. New York, NY: Freeman.

[4] Andre, T. (1987). Questions and learning from reading. *Questioning Exchange, 1*, 47-86.

[5] Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart and Winston.

[6] Bourdeau, J., & Bates, A. (1997). Instructional design for distance learning. In S. Dijkstra, N. Seel, F. Schott, & R. Tennyson (Eds.), *Instructional design international perspective: Solving instructional design problems* (Vol. 2, pp. 369-397). Mahwah, NJ: Lawrence Erlbaum Associates.

[7] Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1995). *Cognitive psychology and instruction*. (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

[8] Corkill, A. J., Bruning, R. H., & Glover, J. A. (1988). Advance organizers: Concrete vs. abstract. *Journal of Educational Research, 82*, 76-81.

[9] Dewitz, R., Carr, E. M., & Patberg, J. P. (1987). Effects of inference training on comprehension and comprehension monitoring. *Reading Research Quarterly, 22*, 99-119.

[10] Fleming, S., & Lu, J.-Y. (1999). *CHN399a: Chinese Reading and Writing Course*. Available: http://www.lll.hawaii.edu/yuedu.

[11] Gagne, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of instructional design*. (4th ed.). Fort Worth: TX: Harcourt Brace.

[12] Gropper, G. L. (1983). A behavioral approach to instructional prescription. In C. M. Reigeluth (Ed.), *Instructional-design theories and models* (pp. 101-161). Hillsdale, NJ: Lawrence Erlbaum Associates.

[13] Hiple, D., & Fleming, S. (1996). *Stages of a receptive skill lesson development*. Available: http://www.lll.hawaii.edu/workshops/chinesenet/lessons/stages.html.

[14] Keller, J. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[15] Merrill, M. D. (1997). Instructional transaction theory: An instructional design model based on knowledge objects. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design international perspective: Theory, Research, and Models* (Vol. 1). Mahwah, NJ: Lawrence Erlbaum Associates.

[16] Peeck, J., Bosch, V. D., & Kruepeling, W. (1982). The effect of mobilizing prior knowledge on learning from text. *Journal of Educational Psychology, 74*, 771-777.

[17] Raphael, T. E., & McKinney, J. (1983). An examination of fifth- and eighth-grade children's question answering behavior: An instruction study in metacognition. *Journal of Reading Behavior, 15*, 67-86.

[18] Reigeluth, C. M. (1983). *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[19] Rumelhart, D. E. (1981). Schemata: The building blocks of cognition. In J. T. Guthrie (Ed.), *Comprehension and teaching: Research reviews* (pp. 3-26). Newark, DE: International Reading Association.

[20] Scandura, J. M. (1983). Instructional strategies based on the structural learning theory. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[21] Schank, R. C., & Abelson, R. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[22] Tennyson, R. D. (1990). Integrated instructional design theory: Advancements from cognitive science and instructional technology. *Educational Technology, 30*(8), 14-21.

[23] West, C., Farmer, j., & Wolff, P. (1991). *Instructional design: Implications from cognitive science*. Englewood Cliffs, NJ: Prentice Hall.

The Design of a Synchronous Computer Aided English Writing Environment for the Internet

Chin-Hwa Kuo*, David Wible, and Chia-Lin Chuo***
** Computers and Networking (CAN) Laboratory*
Department of Computer Science and Information Engineering
Tamkang University, Tamshui, Taiwan ROC
E-mail: chkuo@mail.tku.edu.tw
*** Department of English*
Tamkang University, Tamshui, Taiwan ROC
E-mail: dwible@mail.tku.edu.tw

The design of a synchronous computer aided English writing environment is described. Two novel mechanisms have been designed to provide the two fundamental capabilities on the Internet: (1) synchronous text co-editing, and (2) voice delivery. The system exploits the integration of computer and networking capabilities with linguistic and pedagogical principles crucial to distance language learning. In addition to the advanced capabilities of the synchronous writing environment, the system archives the learners' English writing production and content of learner-tutor interactions in a searchable database. The resulting archive offers a novel source of information that can radically extend the scope of research into second language acquisition and into the effectiveness of second language teaching. The data can also raise learners' self-awareness concerning their own language learning and provide teachers a window onto the recurrent needs of learners and the effectiveness of various responses to these needs.

Keywords: **Computer aided language learning (CALL), Distance learning, Learner corpus, Voice transmission, Co-editing**

1 Introduction

With the rise of the World Wide Web, there has been a corresponding resurgence in Computer Aided Language Learning (CALL). Currently, there are numerous commercially available packages ranging in format from CD-ROMs to web-based systems. While CD-ROMs are limited in the resources that can be included and in the level of interactivity and responsiveness to individual users, web-based systems have the advantage of transcending these limitations. More specifically, the Internet offers the potential of integrating content with computer and networking capabilities. Despite this potential, however, current web-based CALL systems are often limited to static systems which store content in relatively easily accessible formats. Among the limitations in these approaches, students are either constrained by restrictive sequencing of materials or fixed content; the learning behavior or performance of students is not recorded or exploited for insights into their needs or difficulties; the experience of previous users (whether students or teachers) is given no role in providing feedback or in evaluating the users or the system.

Among the distance learning systems on the Internet, a fundamental distinction can be drawn between two basic modes of interaction available: *asynchronous* and *synchronous*. In systems using the asynchronous mode, lecture content is provided, typically on web pages. Learners may pose their questions or opinions on discussion boards, and e-mail serves as the main communication channel. These systems lack capabilities for real-time communication between instructors and learners or among peers. In environments that use the synchronous mode, on the other hand, systems are required that support real-time communication modules and interactivity. Many currently available systems have text, audio, and video communication capability.

However, these systems do not take the specific needs of language learning and teaching into consideration.

In this paper, we propose a learning environment designed to overcome the above restrictions. Based on the proposed design philosophy, a synchronous English writing environment, WriteNow, has been designed and implemented on the Internet. The work reported here is the result of collaborative research between Computer and Networks (CAN) and Research in English Acquisition and Pedagogy (REAP) laboratories at Tamkang University.

The proposed system consists of two main components: (1) a synchronous English writing clinic and (2) an archived log of learner and learner-tutor output. In the first component, the synchronous writing clinic, we make use of a web-based user interface and provide the following functions: (1) an online essay display board with synchronous co-editing and dialog capabilities, (2) real-time voice communication, and (3) an online comment bank for tutors where frequently used comments can be easily stored, retrieved, and offered to students during the online tutorial sessions. The WriteNow system, then, differs from conventional CALL software packages in that it offers global access over the Internet, identifies the needs of learners and tutors, and provides online tools designed to meet these needs.

In the following sections, the description of the system is organized as follows. In section 2, an overview of the system is given. We illustrate the design philosophy and building blocks of the system. In Section 3, we describe in detail the technical mechanisms, such as session management, the co-editing mechanism, and voice transmission. The system implementation and user interface are described in Section 4. Directions for future work and a conclusion are given in Section 5.

2 System Overview

2.1 The Overall Online Language Learning Environment

WriteNow is one module in a larger web-based English learning environment designed to give learners and teachers access to each other and to online learning resources [11]. The larger system combines several components currently at various stages of development into an integrated online language learning environment weaving together the study and practice of English writing, reading, listening, and speaking skills. The environment has been designed based upon some basic premises concerning the domain of second language learning and teaching. First, language skills are best learned in a mutually reinforcing integrated environment that offers generous access to authentic English input as well as immediate feedback. Second, students learn best not simply by studying English but by using it in meaningful contexts as well. Finally, while the dearth of such idealistic conditions for English learning in non-English speaking settings is one of the most serious obstacles to EFL learners in those contexts, thoughtfully designed web-based systems can provide EFL learners with global access to these conditions. Crucially, however, such systems must be designed according to specifications provided by linguists and experienced language teachers.

The design schema of the overall system is represented in Fig. 1. Two sorts of language data are fundamental to this environment: English input offered to the learner and English output produced by the learner. With respect to input to the learner, the system's architecture enables content to be retrieved from a variety of sources in a range of media (text as well as multi-media). These can be edited or annotated for the learner by teachers or materials developers and then made available to the targeted learners. Learners access this English input through the learning environment at the center of the system. Here the learner's interface provides interactive access to content and to teachers and tutors. As far as output is concerned, learners are able to write essays and participate in online discussion boards with the help of online dictionaries and writing supports. Teachers, in turn, are provided interfaces through which they can comment on the learners' production. Crucially, these interactions are stored as annotated learner data, and learners, teachers, and researchers can access and analyze the relevant performance data and feedback. Researchers have authoring tools to create online help that addresses precisely the errors that they uncover in their investigation of the learner output. In this manner, the expertise of instructors and researchers and the learning experience of learners can be accumulated and shared with all users.

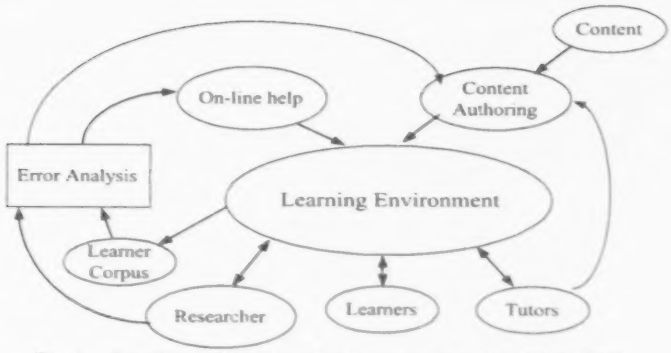


Fig. 1. Paradigm of the interactive language learning environment

2.2 The Synchronous Online Tutoring Environment

To simulate an on-site writing clinic on the Internet and to exploit the potential of the integration of computers, communication networks, linguistics, and language pedagogy, the proposed writing environment is equipped with the following special tools and functions.

(1) Co-editing: The essay under discussion is pasted by the learner onto the essay display frame and is displayed simultaneously on the tutor's and learner's computer screen. By using the mouse to select any portion of the displayed text, both learner and tutor are able to work on the same sentence and immediately identify the writing problem. Co-editing the same sentence, however, may result in conflicting data if a suitable co-editing mechanism is not available [1][4]. To satisfy this requirement, a textual co-editing mechanism has been developed.

(2) Online conversation: To enhance communication between the participants within this environment, a real-time voice conversation channel has been provided. Since most of the present Internet environments deliver only best effort service, we have developed a voice transmission scheme to overcome packet delay [6][7], jitter [12], and packet loss [10][8] in order to provide improved quality voice transmission for our purposes.

(3) Comment bank: The design of this environment provides users with the ability to mark a specific portion of an essay and immediately give comments concerning that portion of text. Giving comments is the basic tool that tutors have for conveying their specific suggestions to students about a piece of student writing. To reduce the tedious and repetitive aspects involved in giving this feedback, the tutors' interface includes a bank of easily retrieved frequently used comments. A standard set is provided, and, in addition, each tutor can edit these comments or create her own. The standard set consists of positive comments as well as corrective ones and simple but important session management comments (for example, 'has your teacher already given you any suggestions about this essay?' or 'Please paste your essay in the frame now.') As is well known, instructors' comments contain invaluable information for the learner. Fortunately, since the channels of communication for the WriteNow system are computer and networks, this data can be recorded, archived, and indexed to the specific portion of student text that each was aimed at. The data is retreivable by learners, teachers, and researchers, providing rare insights into the learners difficulties and the learning and teaching process.

(4) Online help: The WriteNow interface offers learners and teachers online access to learner dictionaries and other language resources that can be conveniently consulted during the tutorial session. This design feature is intended to meet the goal of providing students input and feedback at the moment of need. In addition, the overall online environment provides an authoring environment where domain administrators can create online help targeted specifically to the problems uncovered in research on the learners' English output. In the future, these helps will be made available in the WriteNow synchronous environment as well.

(5) Comment tabulations: A means of reflecting on the nature of students' writing difficulties and on the sorts of communication that tutors find useful in discussing the essays with students is provided in the

form of statistics on comments that have been used. A record is kept in each session of how frequently a comment has been given.

3 Design of Synchronous English Writing Clinic

Design of synchronous English writing clinic, WriteNow, is presented in this section. In the WriteNow module, we focus on designing the functions that provide real-time communication capability and *interactivity*. We describe the design of the system's special features: (1) the textual co-editing environment, (2) voice transmission on the Internet, and (3) the comment bank design.

3.1 Textual co-editing environment

The basic purpose of the co-editing environment is to allow two users who are separated by distance (for example a student and a tutor or two students) to discuss a piece of student writing and specifically to enable both parties to focus on the same portion of text at the same time and communicate clearly about that portion of text. In other words, the environment is intended to allow synchronous tutorial sessions for writing instruction.

This co-editing environment includes two modes, *control* mode and *free* mode. In the control mode, a priority scheme is set in place so that the tutor can overwrite the learner's output. In the free mode, the environment allows a two-way override in order to give the users a higher degree of flexibility in modifying the essay. In the free mode, however, data conflict can occur. With conventional, floor control mechanisms, such as token control, the data conflict problem is resolved at the cost of some degree of flexibility [3][5]. In the proposed approach, a co-editing mechanism, *Temporal And Spatial Data conflict detection* (TASD) [1], is developed which takes data consistency and user flexibility into account. The designed algorithm resolves the data conflict by using an *undo* process. Intuitively, data conflict arises when two events occur within the same markup area. By further analysis of the events into relationships such as temporal relations, spatial relations, and event attributes make it possible to avoid many *undo* processes. The version of the co-editing algorithm proposed here is an extension of our previous work [1].

3.2 Voice transmission on the Internet

As is well known, currently the Internet offers only a point-to-point *best-effort* service, which may present packet delay, delay variation, and packet loss. As a result, the voice quality is degraded. We have designed a voice tool to overcome this type of transmission difficulty [2][9]. We emphasize the design of redundant packet sending mechanism and QoS monitoring mechanism. The redundant packet sending mechanism evaluates the sending packet from a set of compression packet formats to compensate packet loss. The QoS monitoring mechanism serves the purpose of collecting the present network traffic conditions such as delay, delay jitter, and packet loss. The information is then used in playout time adjustment.

3.3 Comment Bank Design

The design of comment bank serves two purposes: (1) it reduces the tedious work of the tutor and (2) it permits the tabulation of online error statistics. To achieve these purposes, the comment bank has a standard set of comments as shown in Table 1 and an optional set of comments. There are three classes in the standard set of comments, namely, (1) starting comments, which help start the session with initial questions about the assignment, (2) comments about grammar, diction, and mechanics (such as punctuation), and (3) comments about rhetorical elements such as organization and unity. The most frequently used comments are collected in the comment bank so that tutors need not type them each time from scratch but can simply select them from the bank. The standard set of comments is shared among all tutors whereas each tutor has an optional set of comments which she or he can edit or modify according to individual preferences.

Table 1 The standard comments set

Class	Tag	Comment
	Welcome	Welcome online. What can I help you with?
	Draft of your essay	Do you have a draft of your essay to show me?
	Paste essays	Please paste your essays into the frame.

Starting comments	About this assignment	Tell me a little about this assignment.
	Audience	What audience you are to write this for?
	Teacher seen	Has your teacher seen this draft before?
	Teacher said	Tell me what your teacher said.
	What help	What would you like help with?
Comments about grammar and diction	Wrong word	I don't think this expression conveys what you are trying to say here.
	Fragment	This is a sentence fragment.
	Splice	This is a comma splice.
	Run-on	This is a run-on sentence.
	How to fix	What would be a way to fix the problem?
Comments about rhetorical elements	Unclear	I don't understand what this means here.
	Main idea?	I can't see the main idea of this part.
	Relevance	I don't see how this is related to the rest of the essay.
	Unity	It isn't clear how these ideas are related to each other.
	Give an example	You probably need an example to show what you mean.

4 Implementation and Results

The WruteNow system is implemented with MS Visual C++ 6.0. Currently, the system runs on a Windows 98, Windows 2000 or Windows NT platforms and is available for the students in the Department of English at Tamkang University.

The graphic user interface of WriteNow is shown in Fig. 2. After the initiation of the main page, a user can select the tutor from the online user list. When the connection is made between two users, learner and tutor make use of the co-editing area as editing ground. The markup area will also appear on the screen at the remote site, allowing both users to simultaneously focus on the same portion of text though they are at distant locations. The comment bank and online help also appear during a tutoring session—the comment bank for tutors only and online help for both tutor and learner. The content of comment bank is described in section 3.3. Currently, users can access an online electronic dictionary, a corpus of standard English which can be queried for examples of vocabulary in use, and so on. Both learner and tutor may select the corresponding tool from the main page. A voice control panel and text discussion board are provided as well. Thus, users may choose these communication channels for their convenience.

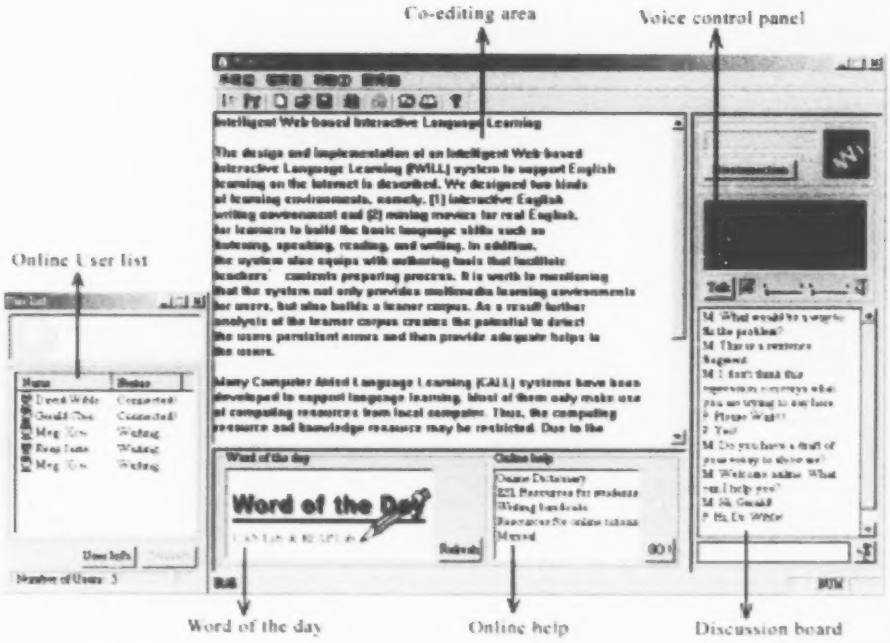


Fig. 2 The WriteNow synchronous virtual writing clinic GUI

5 Conclusions and Future Work

The advance of computer and Internet technology has resulted in dramatic changes in contemporary society. At this stage, one critical challenge brought by these changes is how to use these technologies in the development of novel and effective learning environments. In this paper, we illustrate our design philosophy, premised upon the integration of computer and networking technologies, linguistics, and language pedagogy in the construction of a synchronous virtual writing clinic, *WriteNow*, on the Internet. The proposed system not only breaks down temporal and spatial limitations, but also provides tools for detecting learning difficulties and addressing them in an online environment.

To achieve the design goals, the developed system consists of the following features which are distinct from usual networked writing environments. First, it provides *a co-editing* environment with voice communication support allows the users, to attend to a common focal point though separated by great distances. Thus, users may co-edit the same sentence and then identify relevant learning problems immediately. Second, a comment bank is provided which includes comments for encouragement and reinforcement, for correction, and for practical matters of session management. Through the tutor's use of the designed comment bank, a learner can be made aware of the nature of their problems and strengths and can be offered immediate resources that address these. Moreover, the data collected are recorded in learnerdata archive. Further data analysis can be applied offline to detect persistent learning difficulties. These data build the basis of inter-language research and the creation of online language help aimed specifically at empirically attested learner difficulties.

The developed system is currently being tested in the Department of English at Tamkang University. The corresponding software works on Windows 98/2000/NT and is available from our web site [13]. The synchronous writing clinic is currently integrated with a complementary *asynchronous* writing environment--an interactive English writing system in IWiLL used by over 200 English majors and six English professors at Tamkang University. The resulting system constitutes a novel multifaceted writing environment for second language learners and teachers.

BEST COPY AVAILABLE

References

[1] Chin-Hwa Kuo, Chia-Lin Chio, Chen-Hsiang Yu, and Wen-Yang Hsia, "In Supporting of Distributed Co-Editing Environment", in *Proc. ICS, Workshop on Computer Networks, Internet, and Multimedia*, pp17-24, 1998

[2] Chin-Hwa Kuo, Tsung-Chieh Hsu, and Wen-Ching Hsi, "Adaptive Scheme for Packet Audio over the Internet", in *Proc. SPIE*, Vol.3561,pp242-252, September 1998.

[3] Hans-Peter Dommel and J.J. Garcia-Luna-Aceves, "Floor Control for Multimedia Conferencing and Collaboration", *Multimedia System 5*, pp.23-38, 1997.

[4] M. Handley and J. Crowcroft, "Network Text Editor (NTE) – A scalable shared text editor for the MBone", *ACM Computer Communication Review*, Vol. 27, pp. 197-208, 1997.

[5] Mark O. Pendergast, " A Comparative Analysis of Groupware Application Protocols ", *ACM Computer Communication Review*, Vol. 28 , pp. 28-40 , 1998

[6] Tsung-Chieh Hsu, "Adaptive Synchronization Mechanism for Packet Audio Over the Internet", Master thesis, Tamkang University, Jun 1998

[7] Sue B. Moon, Jim Kurose, and Don Towsley, "Packet Audio Playout Delay Adjustment: Performance Bounds and Algorithms", *ACM Multimedia*, Jan 1998, pp17-28.

[8] Jean-Chrysostome Bolot, Sacha Fosse-Parisis, and Don Towsley, "Adaptive FEC-Based Error Control for Internet Telephony", *IEEE Infocom'99, New York, NY*, March 1999.

[9] Chin-Hwa Kuo, Chia-Lin Chio, Wei-Hao Chen, Tsung-Chieh Hsu, "Delivering Voice over the Internet", in *Proc. NCS, Workshop on Computer Network*, pp. 74-80, 1999

[10] M. Podolsky , C. Romer , and S. McCanne, "Simulation of FEC-Based Error Control for Packet Audio on the Internet", *Proc. IEEE Infocom'98*.

[11] David Wible, Chin-Hwa Kuo, Feng-yi Chien, Anne Liu, Nai-lung Tsao, and Hong-Sheng Chui, "A Web-based EFL Writing Environment: Integrating Information for Learners, Teachers, and Researchers,' submitted for publication to *Computers and Education*

[12] S. Jha and M. Fry, "Continuous Media Playback and Jitter Control", *Proc ICMCS'96*, pp.245-252.

[13] http://www.can.tku.edu.tw/IWiLL.htm.

The Development of a Multimedia Program for Teachers to Integrate Computers into the English Curriculum

Ya-Fung Chang
Center for Teacher Education, Tamkang University
151 Ying-Chuan Road, Tamsui, Taiwan 251
Tel: +886-2-26215656-2149
Fax:+886-2-26229751
Email: yfchang@mail.tku.edu.tw

A self-learning multimedia program was developed for English teachers' professional development in the integration of computers into the English curriculum. This program consists of four parts: (1) study guide (2) application cases (3) computer resources, and (4) related documents. In addition, a tool box is provided to gain access to a word processing system for taking notes, or to connect to a network discussion system for ideas exchange. This program was found satisfactory based on a preliminary evaluation. However, it will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use.

Keywords: **Multimedia, System development, ESL teaching, Teacher professional development**

1 Introduction

It is said that the use of computer technology can create authentic and rich learning environments where learners' communication skills in English may be enhanced greatly.[1][2] To have such benefits, it is important to integrate computers into the English curriculum. In so doing, many factors such as computer technology, subject matters, learners, and even the environments all need to be taken into consideration. Above all, the key factor to successful integration is the school teacher. Teachers eventually need to take the responsibility of determining when and how to use computers, and assessing the effectiveness of computer use with their students.[3] However, a survey report in 1999 by the National Center for Educational Statistics still indicated such problem since only less than 20% of current teachers in American reported feeling very well prepared for technology integration.[4] The teachers in Taiwan also have the same problems. Neither do they know what kind of computer resources available, nor do they know how to apply them to their classroom instruction. In view of this, a multimedia program was developed for middle school English teachers so as to increase their competence and confidence in the instructional use of computers, and consequently to help them integrate computers into their instruction.

In the age of information technology, teachers are required to learn about technology. On the other hand, technology can be used to promote teacher professional development. For example, Hawkes proposed the use of network-based communication for teachers to gain access to professionally relevant knowledge.[5] However, the network installation is more complicated compared to that of cd-rom. Furthermore, the quality of Internet transmission for large amount of data such as videos is still below our satisfaction. Therefore, this multimedia program for English teachers currently resides on a cd-rom instead of a web site. However, technical support is available via telephone calls or e-mails. In addition, teachers can share ideas with others by connecting to a network discussion system.

2 The Developing Process

The Systems approach to instructional design has been adopted to guide the production of this multimedia program and thus to ensure the quality of its end product. [6][7] On the whole, the process includes four phases, namely, analysis, design, development, and evaluation/revision.

2.1 Phase of Analysis

Based on the review of the literature, there is a need to enhance teachers' willingness, competence, and confidence in the use of computers in their English classrooms. Due to the advantages of convenience and flexibility, a self-learning multimedia program is proposed. Basically this program attempts to achieve the following goals: (1) to stimulate teachers to rethink the new roles of teachers in an information society, (2) to help teachers understand the principles and strategies of the classroom use of comoputers, and thus generate some possible ways of applications, and (3) to encourage teachers to follow the application cases and lesson plans provided by this program and actually apply computers to their classroom instruction

2.2 Phase of Design

After several discussions with English teachers, English teaching experts, and instructional designers, a framework of this program is finally settled as shown in figure 1. The "study guide" gives an overview of the program' s goals, operation procedures, and contents to help users get an overall view of this program in a short time. Thus the users are able to decide the best way to use the program to meet their own needs. The "application cases" provides several cases about teachers' classroom use of computers in English teaching. Since these cases are realistic, it is believed that they would give teachers strong inspirations and implications. Each case contains useful information including: (1) background of the school and the teacher, (2) lesson plan of using computers in his or her classroom, (3) "teaching on the spot" in the video format, (4) student reactions based on the questionnaire and interview data, (5) teacher reflections about this practice, and (6) related issues pointed out by the designer.

The "computer resources" lists the titles of cd-roms and web sites useful for English teaching. The publisher of each cd-rom and a short description of its content are provided. The address of each web site, a short description of its content, and the computer screen of its homepage are displayed. The "related documents" includes a set of helpful information regarding implementing computer technology. For example, the "future education" outlines schools, teachers, and English teaching in the future. The "use of computers" describes the strengths of computers, identifies types of applications, and presents samples of lesson plans. The "user guide" points out the issues of intelligence properties and computer ethics. It also includes software evaluation sheets. "The Implementation guide" reminds teachers of some factors that need to be taken into consideration in implementing computers in their classrooms. Finally, the "references" lists the titles of related articles and books so that teachers can get more detailed information if needed. In addition, a tool box is provided to gain access to the word processing system for teachers to take notes whenever they need, and to connect to a network discussion system for ideas exchange and sharing.

2.3 Phase of Development

The programming tool for this multimedia program is Authorware 5.0, and the program resides on a cd-rom to enable easy distribution. To collect the data for the "application cases", the whole teaching process of each case is video taped. Afterwards, the teaching process is divided into several steps. Accordingly, suitable video screens are selected for each step. These video screens are then transformed and stored in mpeg files. At the end of instruction, the student is asked to fill in an attitude questionnaire. Furthermore, the teacher and several students are interviewed. The whole questionnaires are then analyzed statistically, while the interview data are examined in depth.

2.4 Phase of Evaluation/Revision

English teachers, English teaching experts, and instructional designers are invited to participate in a preliminary evaluation of this program. The focus of this evaluation includes content, screen design, media effects, interface design, and system operations. This program will thus be revised and expanded according to their opinions and suggestions. In the future, a detailed study will be followed to investigate the effectiveness of its use.

3 Results and Discussion

Based on a preliminary evaluation reports by two English teachers and one instructional designer, it was found that the program's content is plentiful and practical on the whole. Moreover, the screen design is of high quality, the interface design is user friendly, and the program's operation is easy and consistent. However, some of the video screens in the "application cases" look gloomy. Sometimes, it takes efforts to identify the key plot of these screens. Finally, it is suggested to increase the quantity and variety of the cases in this program.

In regard to the quality problem of the video screens, it is because the teacher turned off all the lights in the classroom to make more readable the computer displays by a portable projector. Consequently the quality of video recording was affected. As to the small number of the cases, it is because few English teachers ever used computers in their classrooms. Most of them dare not try it. The availability of the computer hardware is another problem. At that time, there was no computer lab available for English teachers. Therefore, the three cases currently included in this program all occurred in the regular classrooms where cd-roms, a notebook computer, and a portable projector were used.

To increase the quantity and variety of the cases in this program, two cases are collected afterwards. The two cases all occurred in the computer labs. In addition, e-mails and Internet resources were used. The program will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use. Questionnaires on computer literacy, and attitudes toward this self-learning program, as well as the design of lesson plans will be used to collect the outcome data. The net discussion tracking system, and the journal writing will be used to collect the process data. In addition, relevant suggestions will be provided regarding optimal strategies and necessary supports which go well with the use of this self-learning multimedia program.

4 Conclusions

A self-learning multimedia program was developed for English teachers' professional development in the integration of computers into the English curriculum Based on a preliminary evaluation, the program was found satisfactory. However, it will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use.

References

[1] Kumar, V. S. ,Anjaneyulu, K.S.R.• Gupte, U. A., "VIDYA:A situated CALL environment", Computer Assisted Language Learning, Vol. 10, No. 2, pp149-172, (1997).

[2] Zhao, Y., "Language learning on the World Wide Web: Toward a framework of network based CALL", CALICO Journal, Vol. 14, No. 1, pp37-57, (1996).

[3] Keith, W.• Ines, C., "An evaluation of technology integration in teacher education for bilingual and English as a second language education majors", Journal of Research on Computing in Education, Vol. 30, No. 4, pp379-395, (1998).

[4] Schrum, L., "Technology professional development for teachers. Educational Technology", Research and Development, Vol. 47, No. 4, pp83-90, (1999).

[5] Hawkes, M., "Exploring network-based communication in teacher professional development", Educational Technology, Vol. 39, No. 4, pp45-52, (1999).

[6] Dick, W., & Carey, L., "The systematic design of instruction", Glenview, IL:Scott Foresman Company, (1985).

[7] Seels, B. & Glasow, Z., "Exercises in instructional design", Columbus: Merrill, (1990).

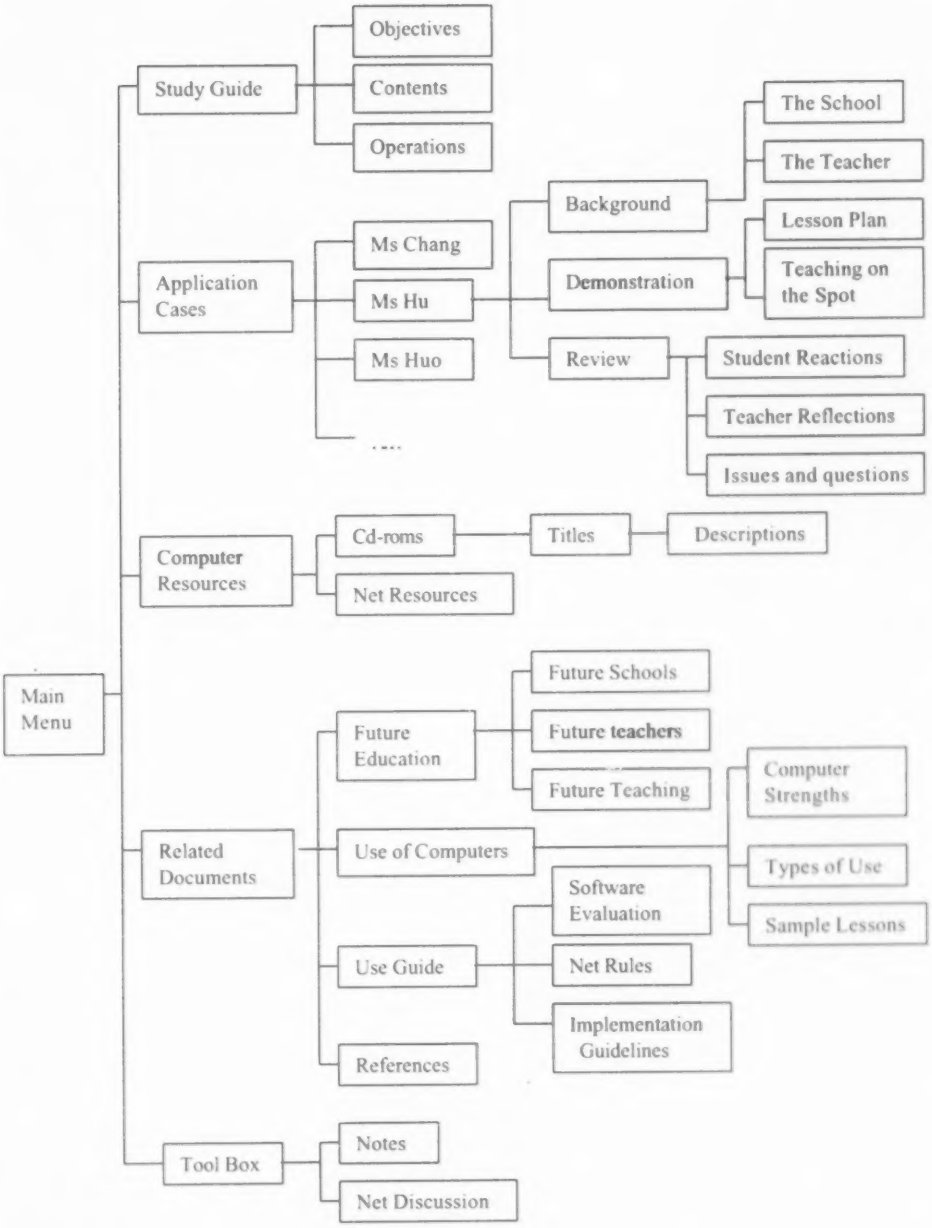


Figure 1 Framework of the multimedia program
Figure 1 Framework of the multimedia program

The effectiveness of integrating adaptive computer device and stimulus fading strategy on word-recognition for students with moderate mental retardation

Ming-Chung Chen*, Tien-Yu Li, Hwa-Pey Wang*** and Kou-Ping Yang******
**National Chiayi School for the Mentally Retarded*
123, Sec 2, Shi-Shian Rd. Chiayi city,Taiwan.
E-mail:mtchen@blue.com.url.com.tw
*** National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan
E-mail:tienyu@ice.ntnu.edu.tw.
****National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan.
E-mail: hpwang@icon.ntnu.edu.tw
*****Assistive Technology Foundation*
5F, 18-1, Sec 3, Ren-Ai Rd. Taipei

The purpose of the study is to examine the effectiveness of the instruction method involving computer device and stimulus fading strategy on word-recognition of two fourth grade students with moderate mental retardation enrolled in a special school. A single subject multiple probe baselines design across subjects is used. The students use the U1 system as the adaptive computer interface to learn word-recognition with the picture cue fading and the word enlarging. The result shows that both two students can identify the four print words correctly, even in different fonts and in different writing ways. The advantages of the adaptive computer interface and stimulus fading strategy are supported.

Keyword: **adaptive computer system, stimulus fading strategy, special education, mental retarded**

1 Introduction

It is getting more important to enhance everyone's reading ability in the information age, including individuals with mental retardation. Reading is a very complex process that involves at least two components, word recognition and comprehension. Word recognition is the base of comprehension [3]. To improve the ability of word recognition has been a hot topic in literature and research [5] [6] [8].

The goal of education for individuals with mental retardation is to help them to adapt to society. So the ability of word recognition is important for them too. In Taiwan, how to teach students with mental retardation to acquire reading skill was not noticed until recently, though the curriculum guide for students with mental retardation in Taiwan has emphasized that the practical language course should help students to learn functional Chinese. However, if we want the individuals with mental retardation to integrate into the mainstream society after they leave school, we should teach them to learn to identify the functional word as early as possible.

In practical, teachers usually use pictorial cues as reading instruction strategy to reduce task complexity, increase motivation, and lead to reading success [8]. The researcher in Taiwan also found that using pictorial cue could enhance the effects of word-recognition of the students with mental retardation [10]. But Pufpaff,

Blischak, & Lioyd indicated that some researchers found these methods were ineffective [8], the main problem is that students could not transfer their attention from pictorial cue to word when picture was absent [9].

Word-recognition is a sort of skills learned by way of stimulus discriminatory learning [1]. Sometimes, it needs to add some kind of stimulus (or control stimulus, prompt) that could assist the individuals to express expected response. Once the individual could respond correctly and stably under the prompt, the prompt should be moved gradually [1]. There are two types of instructional prompts, response prompts and stimulus prompts [1]. Using pictorial cues is one kind of stimulus prompts. That may be an effective strategy that we can use pictures as a prompt to teach individuals with mental retardation to learn to identify the target words, then move the pictorial cue systematically once the individuals could differentiate the target words correctly when the pictorial cue is existing. Sue concluded that stimulus prompts was an effective instruction method on word recognition for students with moderate mental retardation after she had analyzed a great deal of related research [9]. The result of Sue's research, using stimulus fading strategy to teach the three second grade students with moderate mental retarded to learn the specific functional Chinese words, showed that the students could learn effectively and efficiently.

In the past, including Sue's study, most of the special educators who use stimulus fading strategy to teach word-recognition create the cards which were composed of picture and word according to the principle of fading. The instructors should teach and provide the feedback by themselves, and the material couldn't be reorganized. As the computer has been more available in the classroom and the Department of Education in Taiwan has begun to purchase adaptive computer devices for students with disabilities, it facilitates students with mental retardation to study through computer and related adaptive devices. The multimedia could provide the feedback automatically and multi-sensory learning opportunity, and on other hand, the adaptive computer devices could help the students to overcome the interface barrier.

In fact, technology could assist the students with disabilities to learn literature effectively [4]. So could we design a computerized instruction program that embeds stimulus fading strategy and adaptive computer device to teach students with moderate mental retardation effective and efficiently?

2 Method

2.1 Participants and setting

Two students with moderate mental retardation on the fourth grade in the Chia-Yi special school participated in this research. The participants were selected on the basis of three criteria. First, they were capable to use verbal communication. Second, their emotions were stable. Third, they had a history of experiencing difficulties in recognizing words that were taught on their classes.

The IQs were obtained from WISC-Ⅲ, which were administered by the first researchers prior to the beginning of the study. In order to realize the participants' characteristics, the researchers reviewed their IEP files and interviewed with their teachers. A summary of the participant's characteristics appears in table 1.

Table 1
Participants Characteristics

Participant	Age	Gender	IQ(WISC-Ⅲ)	Performance of speech
A	10	Male	Full-Scale IQ 57 Verbal IQ 58 Performance IQ 64	Articulation disorder Received speech-language therapy About 4 words phrases
B	11	Male	Full-Scale IQ Verbal IQ Performance IQ	Articulation disorder received speech-language therapy About 2 words phrases

Both of the students had speech disorders and received speech therapy. Student A could answer to the

teacher's question in a short sentence, about four words. Student B was able to use 1-2 words to response teacher's questions. Although the two participants usually paid attention to the teachers on the class, and could do well on the task of picture matching, however, they could not recognize a word after the reading program.

Instruction was conducted by the researchers in the school's counseling room. A personal computer with an U1 computer interface system was placed on the table. The U1 system was designed by Assistive Technology Foundation. It is a kind of programmable keyboard that could be designed by the instructor [2]. The participant was sitting in front of the table and operating the U1 system when the instruction was proceeding.

2.2 Stimuli

Four functional Chinese characters were decided after the researchers discussed with the participant's teachers on the schedule of the reading program. The researchers used the editor of U1 system to create the layout of a printed page after the four target words were chosen. There were two frames on each page. All pictures and words were edited in the center of 11cm x 16cm frame. The word was printed vertically and located above the picture. According to the stimulus fading strategy, each target word was selected in 50-point, 100-point and 130-point Ming type, and the picture was set in 10cm x 10cm, 4.5cm x 4.5cm, 1cm x 1cm. Besides these three kinds of layout, there was another layout that was only 130-point words on it.

In order to avoid the participants to response to the stimuli on fixed location, each word was presented on both sides on different layout. So the researchers designed 10 pages for each fading step, 40 pages for the instruction. Additionally, the researchers designed the other 10 pages that presented the target word alone that were printed in 130-point Kai type to measure the generalization of different font, and 4 pages that was printed horizontally for testing the generalization of different printed direction.

For the purpose of multiple sensory learning, the researchers set up some functions for each frame. The computer would speak out the target word, show the picture of the target word, and then present the target word on the screen when the participant touched the frame on the layout on the U1 system during the instruction.

2.3 Definitions of independent and dependent variables

The independent variables were stimulus fading strategy and the using of U1 computer interface system.

The dependent variables were effectiveness (percentage of correctly identified target words) and efficiency (percentage of wrong response to mastery, and number of session to criterion).

2.4 Design

A multiple probe baseline across subjects was used to assess the effectiveness of integrating U1 system and stimulus fading strategy on word-recognition for the elementary students with moderated mental retardation. The particular strengths of the multiple probe baseline design were: (a) the treatment was not reversed, (b) prolonged baseline measures were unnecessary, and (c) the design permitted the evaluation of academic learning [1]. A constant time delay technique was selected for instruction in this study, and oral praising was used as the reinforcement.

2.5 Procedure

Each participant had two learning sessions (one was in the morning, the other was in the afternoon) each day from Monday to Thursday. In order to balance the effect sequence of instruction, researchers decided which participant would accept instruction randomly prior to the instruction, and decided the sequence of the instruction on each day after both participants attended the instruction.

2.5.1 Baseline

In the baseline period, the participants were tested about their familiarity with the target words. The students were asked to point out the word under researcher's order. During the baseline assessment, the researchers

did not give participants any feedback or promotion, but recorded their response. The percentage of correct response counted after testing each word five times was used as the participant's baseline performance.

2.5.2 Instruction sessions

Prior to instruction, researchers divided the four target words into two groups and decided which group would be taught at the beginning. 'Hospital '(醫院) and 'drugstore'(西藥房) were taught at first, then ' an internal medicine' (內服藥)and ' an external medicine'(外用藥).

Student A attended the step one instruction. Researchers put the 50-point layout on the U1, and read the target word, then ask students A to read the word and touch the target frame. If he could touch the frame correctly in 4 seconds delay period, the researchers said" you did a good job" as the reinforcement and go on the next target word. Others, the researchers would demonstrate the correct response and ask student to do it again. The correct response would be recorded when the student did it by himself. The percentage of correct response was counted after each word was tested five times. The student would not go to the step two instruction until he reached the master criteria, 80% correct response in the continued sessions. Then the instruction procedure would repeated till the participant could discriminate group one words with no pictorial cues. Then went on group two.

The student B would attend the instruction when student A could discriminate the words of group one stably and had the same procedure.

2.5.3 Maintenance and generalization

In order to examine whether the participants could maintain their word-recognition abilities, and generalize it to the different font and written direction. We continued to assess the participants' performance after the instruction sessions and presented the other layout with different font or written direction.

2.6 Reliability

In order to assess the participants' response accurately, we set up a function of the U1 editor to write the participant's answer into the *Microsoft EXCEL* automatically when they touch the frame of the layout on the U1.

3 Result

3.1 Instruction

The percentage of correctly identifying the four target words during the instruction sessions for each participant is presented in Figures 1 and 2. For these two participants, it is obvious that instruction integrating stimulus the fading strategy and the U1 computer interface system was a effective method to teach students with moderate mental retardation to identify these four target words. Both of them could reached criterion during in each session , excepted student B in learning 'drugstore' with no pictorial cues on step four on the first time .

The results for student A (see Figure 1) illustrate that he could identified each target word to 100% correctly in each fading step. It means that he did not have any difficulty in word-identification when the cues were faded. Contrarily, Student B encountered more problems in step 4, excepted ' an internal medicine'.

At the beginning of this study, we set up the criterion for fading the pictorial cue as participant could identify the target word correctly 80 % in 3 consecutive sessions. So there should be 12 sessions (4 steps and 3 sessions for each step) in need for the participant to reach the criterion that identifies the target word with no pictorial cue. The results in Figure 1 and 2 indicate that both of these two participants reached the criterion, excluded 'internal medicine ' for student B. It means that participants could learn efficiently.

3.2 Maintenance and generalization

Performance during the maintenance period shows that these two participants demonstrated great availability.

Both of them could identify the target words almost 100% correctly, excepted 'internal medicine' for student A and 'external medicine' for student B.

The outcome of the generalization is presented in table 2. two participants could identify the target word in Kia type in stead of Ming type in instruction, and recognize the word printed horizontally regardless of verticality at beginning of the instruction.

Table 2
Percentage of correct response of generalization

Participants	Target word	Printed in Kia type	Printed in horizontal direction
A	Hospital	100%	100%
	Drugstore	80%	100%
	Internal medicine	100%	80%
	External medicine	100%	80%
B	Hospital	80%	100%
	Drugstore	100%	80%
	Internal medicine	100%	100%
	External medicine	100%	100%

4 Conclusions

The purpose of this study was to examine the effects of integrating adaptive computer device and stimulus1 fading strategy on word-recognition for students with moderated mental retardation enrolled in 4th grade in a special school. The results indicated that both two participants could identify these four target words without pictorial cue. In other words , integrated adaptive computer input device and stimulus fading strategy could be an effective instruction method for the students with moderated mental retardation to recognize some functional Chinese characters. The results of this study is similar to Sue's study in 1992, she found stimulus fading was an effective strategy to teach students enrolled in the self-contained special class in elementary school to identify the functional Chinese characters.

According to the results of this study, special education educators can teach student to identify new Chinese characters by multi-media computerized instruction that use the adaptive computer input device, U1 system, as the interface and the stimulus fading as the instruction strategy.

Although this study indicates that participants could recognize the target words, it still could not offer enough evidences for us to realize if they could learn to identify each single word through this way. This is an issue worth exploring further.

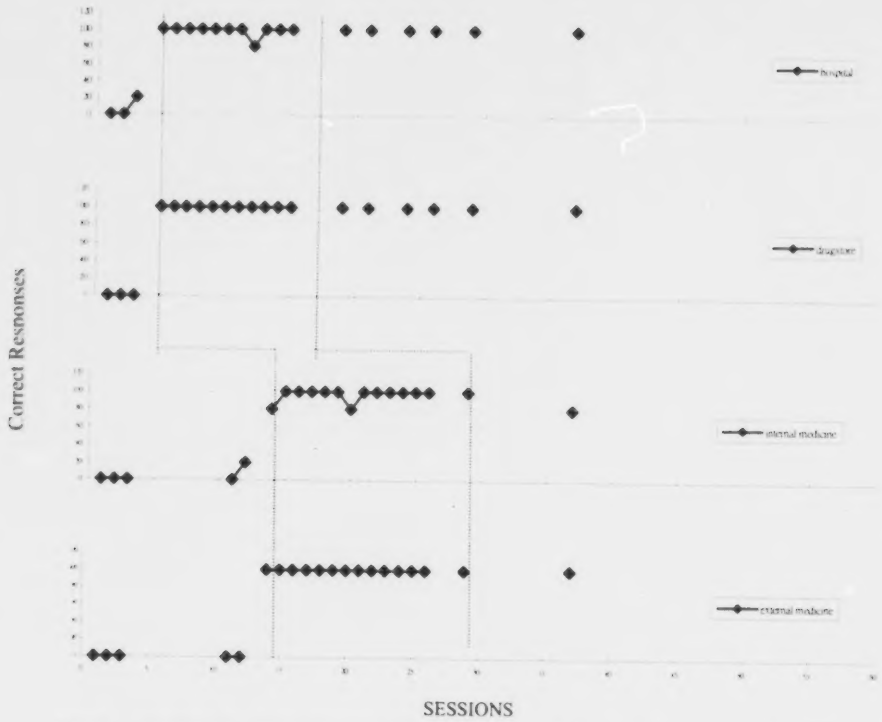


Figure 1. Percentage of correct responses during instruction period and maintenance period for student A

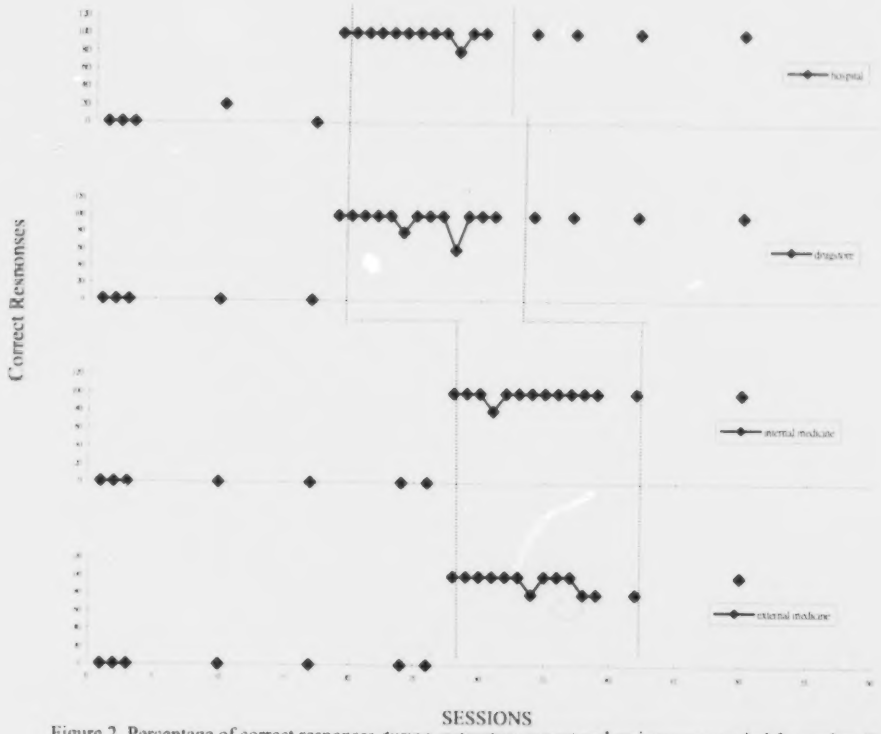


Figure 2. Percentage of correct responses during instruction period and maintenance period for student B

Reference

[1] Alberto, P. A. & Troutman, A. C., " Applied behavior analysis for teachers", Englewood Cliffs, New Jersey: Prentice-hall, Inc, 5th Edition, (1999).

[2] Assistive Technology Foundation, "The handbook of Unlimiter", Taipei: Assistive Technology Foundation, (1999).

[3] Bender, W. N., "Learning disabilities: Characteristics, identification, and teaching strategies", Boston, MA: Allyn and Bacon, (1995).

[4] Caver, J. M., & Burton-Radzely, L., "Technology links to literacy. A case book of special educator's use of technology to promote literacy", Calverton, MD: Macro International Inc, (1998).

[5] Chard, D. J., & Osborn, J., "Word recognition instruction: Paving the road to successful reading", Intervention in School and Clinic, Vol 34, No. 5, pp. 271-277, (1999).

[6] Chen, H. F., "The study of instruction of general orthographic knowledge of Chinese characters on elementary students with word-recognition difficulties", Bulletin of Special Education, No.17, pp. 225-252, (1999).

[7] Conners,F. A., "Reading instruction for students with moderate mental retardation: review and analysis of research", American Journal on Mental Retardation, No. 96, pp. 577-597, (1992).

[8] Pufpaff, L. A., Blischak, D. M., & Lloyd, L. L., "Effects of modified orthography on the identification of printed words", American Journal on Mental Retardation, No. 105, pp. 14-24, (2000).

[9] Sue, W. R., "A comparison of two stimulus fading procedures in teaching functional academic skills to students with moderate retardation", Master dissertation, National Changhua University of Education, (1992).

[10] Yang, U. S., "the diagnosis and instruction of Chinese performance for children with mental retarded", Taipei: National Taipei Teacher college, (1982).

Using electronic bulletin board as a virtual community to aid college English learning

Yu-Chuan Cheng* and Hsien-Chin Liou**
**mavis@mradio.url.com.tw*
***hcliu@mx.nthu.edu.tw*
Department Foreign Languages and Literature, National Tsing Hua University
101 Sec Kuang Fu Road, Hsinchu, Taiwan ROC 300
Telephone: 886-3-5742709
Fax: 886-3-5725742

With the rise of computer network, Computer-Mediated Communication (CMC) is now gaining more and more attention in the English-as-a-second language or English-as-a-foreign-language (ESL/EFL) field. It is claimed that CMC promotes learner empowerment and literacy on the basis of collaborative learning. Although some research has been conducted on the effect of synchronous conferencing on foreign language leaning, very few empirical studies have been conducted using asynchronous conferencing except the use of electronic mail in Taiwan. Bulletin Board System (BBS), among them, becomes a very prevalent CMC activity for college students in Taiwan. This present project aims to explore how BBS forms a virtual community to facilitate college English learning.This project was conducted in the fall semester of 1999 with 45 college freshman students in a general English class. An electronic bulletin board was built for this class only and activities on the board were integrated into the class learning. During the semester, free postings on this bulletin board outside of class time were encouraged, and two tasks serving as instructional interventions were required of all students to post to the board, followed by class debriefing. Additionally, two writing tasks with on-line pre-writing discussion on the board were interleaved with another two writing tasks without on-line discussion—serving as controlled tasks. The two sets were both followed by in-class pre-writing discussion before they actually wrote in class. The first set served as practice sessions. All the writings in the second set were holistically graded by two raters using the ESL Composition Profile. T-tests were used to compare the part scores (content, organization, language use, vocabulary, and mechanics) and total scores of the compositions between sessions. A Background and an Evaluation Questionnaire were used to obtain students' computer literacy and attitudes toward such use of the board. An interview was conducted with the class instructor to obtain data from her perspective. All the postings on the board were categorized according to topics and situations with frequency counts. How topics were elaborated and changed was documented. Detailed results and conclusions were reported and pedagogical implications were discussed.

Keywords: **asynchronous conferencing; Bulletin Board System; CMC; college English learning; virtual community**

1 Introduction

Since 1970s, computer network has become a new medium for communication. In view of significant communicative functions of computers, the educational fields, including the field of computer-assisted language learning (CALL), have paid more and more attention to computer-mediated communication (CMC)

on the belief about "language as communication" and the mediational function of computer network (Bruce & Levin, 1997; Cooper & Selfe, 1990; Zhao, 1996). The Bulletin Board System (BBS), one type of asynchronous conferencing, is now a significant CMC activity for college students in Taiwan, Republic of China. It provides an environment for users to exchange ideas, download files, chat, etc. to fulfill communications and social interaction functions. Moreover, from the perspective of computing cost, BBS is superior to other network facilities because it runs under the Unix and DOS environments and thus is faster than the operations under the Windows environments. Based on the merits mentioned above, BBS has become a prevalent electronic tool on college campus since the Taiwan Academic Network was established in 1992.

However, though BBS is a popular medium for communication among college students, it is usually negatively evaluated for some reasons. Due to the anonymity on BBS, conflicts, flames, imputations, etc. resulting from users' wordy warfare on the BBS are always the troubles during the process of communication. Besides, teachers in Taiwan always regard BBS as a time-wasting activity for students. They claim that many students are seriously addicted to BBS so that they neglect their schoolwork and fail courses. Nevertheless, because BBS possesses the characteristics of asynchronous conferencing via computers, it has the potentiality to be applied to the educational field. The pros and cons for using BBS for college teaching in Taiwan require empirical research to verify.

So far, there is not much done on BBS-assisted language learning and almost none in Taiwan, based on our review of the literature. In view of lack of studies about the effects of BBS on English learning in Taiwan and the popular of BBS on college campus in Taiwan, this study aims to explore how BBS forms a virtual community to facilitate college students' writing. There are three specific research questions to be explored in this study:

(1). How do college EFL learners take advantage of a class-based electronic bulletin board to aid their English writing? Would members in this class extend such a "learning community" beyond the classroom to learn English writing and other aspects?

(2). Does asynchronous on-line pre-writing discussion on BBS help college EFL learning?

(a). Does asynchronous on-line pre-writing discussion facilitate the in-class pre-writing discussion?

(b). Does asynchronous on-line pre-writing discussion improve EFL learners' writing quality? If it does, what aspects would it benefit?

2 Literature Review

2.1 CMC and Collaborative Learning

For the last several decades, collaborative learning has become the focal point in the English teaching field. Vygotsyky (1978) emphasizes that interacting with people of variant proficiency levels helps one make progress on his or her "zone of proximal development". Zhao (1996) reclaims the importance of apprenticeship learning for language learning. He mentions that "Learning a second language is thus a process in which the learner develop skills and knowledge necessary for becoming a full member through participating in the practice of the multilingual community" (p. 44). In other words, second language learners are supposed to become fully literate in a community by directly and peripherally participating in activities within a community in the target language. That is to say, language learning is not an isolated skill but a process of socialization.

With the mediational functions, CMC is of benefit to collaborative ESL/EFL learning. Because participants in CMC activities are linked together via the computer network, CMC helps create cyberspace in which network users may form members of a discourse community (Kollock & Smith, 1996; Korenman & Wyatt, 1996). Warschauer (1996) indicates that "sense of community" is beneficial for student empowerment, including student autonomy, equality, and learning skill. Therefore, exploring how CMC helps learner empowerment and literacy on the basis of collaborative learning is full of potential in the ESL/EFL field. Nevertheless, most previous research about CMC and language learning focuses on the effects of synchronous conferencing or e-mail. As for asynchronous conferencing via BBS, it still emains under-researched in CALL.

2.2 BBS for Foreign Language Learning

BBS, an essential service of CMC, provides an environment for people to exchange messages at their convenience. The most convenient about BBS is that it does not require participants to log on the network at the same time. Participants are allowed to read or send messages at any time they like because the posted messages would be stored for a certain period of time on the server or local mailbox. Generally, BBS provides at least four basic functions: files transmission, chatting, mail exchanging, and discussion. Among these functions, discussion is the major function of BBS. Each BBS has many bulletin boards, such as sports, music, food, computer games, etc., like the discussion groups on the Usenet. BBS users could connect to a specific BBS and find whatever bulletin board interests them. Then, they might read messages posted by other users, respond to posted articles, or cast personal questions.

Discussion on BBS acquires some features helpful for English learning and commonly found in other media for asynchronous conferencing. First, asynchronous conferencing is public exchanging, so messages and ideas transmitted via asynchronous conferencing are shared by a group of people. Once ESL/EFL learners are required to complete collaborative activities in the target language via asynchronous conferencing, they would acquire opportunities to communicate with real audience for authentic purposes. In this way, learners would become more motivated to learn English because they would realize that they learn English for authentic communication not for examinations. Second, like other tools for asynchronous conferencing, BBS may encourage equality of participation. Kroonenberg (1994/1995) find that students are more risk-taking when they discuss on BBS because they are allowed to hide behind the computer screen to express personal opinions. In this way, some social factors, such as gender, social status, personality, age, etc., would be reduced. Given chances to complete discussion on line, ESL/ EFL learning might turn into more student-centered.

Third, on-line discussion is beneficial for pre-writing activities. Warschauer (1996) indicates that "electronic discussion can be a good environment for fostering use of more formal and complex language, both lexically and syntactically" (p. 22). Language used in computer conferencing is more complex than the spoken text. For this reason, ESL/EFL learners would have chances to practice more formal language usage and language use on line than in face-to-face discussion. Fourth, asynchronous conferencing is free of time and space. It allows extending the "learning community" beyond ESL/EFL classrooms. Participants could retrieve or send messages whenever they are available. For this reason, learner autonomy would be enhanced; in addition to formal in-class instructions, learners are also permitted to learn English at their own pace off class. Fifth, the competition for turn-taking in traditional classrooms is reduced in asynchronous conferencing, so participants may get more time to think over their ideas and re-edit their messages. Once EFL learners have opportunities to discuss asynchronously, they are allowed to express ideas thoroughly without being interrupted during their turns. This characteristic would help those who are not orally fluent because they could eschew nervousness resulting from interruptions during the thinking flow. Last, BBS needs cheaper network connection, so BBS users could be free from the trouble caused by the traffic jam for real-time connection flow.

Although the BBS has characteristics of CMC which are helpful for foreign language learning, very few empirical studies about the effects of BBS on language learning have been conducted so far. Many studies all show positive values about discussion on BBS or on the mailing list for foreign language learning (Kroonenberg, 1995; Paramskas, 1995; Razika, 1995; Kroonenberg, 1997; Van Handle & Corl, 1998). Discussion on the BBS is reported to facilitate oral discussions in classrooms and empower some aspects of writing proficiency, such as language usage and creative thinking. However, most of the evidence come from personal observations of researchers and comments from students, there is no systematic and solid evidence showing to what extent discussion on BBS helps students make progress on their language proficiency, such as writing, reading, and thinking skills. Research that collects experimental comparison data to know about how asynchronous conferencing like the BBS facilitates learners' language skills or language proficiency is extremely needed and helpful to the profession.

In recent years, "discussion" is paid more and more attention to in ESL/EFL writing classrooms because it facilitates collaborative learning. Writing is regarded as not only an individual task but also a process of socialization. ESL/EFL learners are expected to become the competent writers who know how to write to learn and learn to write during the process of writing via discussion. With the rise of computer network, some researchers have applied synchronous on-line discussion to writing classrooms (Sullivan and Pratt, 1996; Warschauer, 1996; Huang, 1998). Huang (1998) further suggests pre-writing discussion be done on line besides being in class; thus, learners would gain more time to express ideas thoroughly. With the merits mentioned above, BBS is supposed to have the potential to provide English learners a suitable virtual

environment for discussion and serve as a beneficial aid for their learning of English writing. Due to the lack of systematic and empirical studies about using BBS for English learning in Taiwan, this present project will be conducted to explore how it will benefit college ESL/EFL learners' writing in Taiwan.

3 Methods

3.1 Participants

Participants involved in this project were 45 students in a Freshman English class, an instructor for the class, and an MA-TEFL graduate student. Over 60% of the students had the experience of using BBS for at least one year before this project was conducted. The students in this project were newly enrolled college freshmen of Computer Science in the fall of 1999. In this project, these students, who were from an intact group, took Freshman English as a required course in their college curriculum. This class met together once for two hours a week. Before these students entered college, they all had received formal English instruction for at least six years during their high school education. Most of them could read articles of complex syntactic structures and had had some practice on writing English articles of 120-150 words in their senior high.

3.2 The Learning Medium and Instruments

An electronic bulletin board was built as a supplementary learning medium for this Freshman English class. This bulletin board was built on the BBS of the Department of Materials Science & Engineering on campus. To get access to this bulletin board, it was necessary for participants in this project to find a computer which offered the service of network connection. Because the network facilities at the National Tsing-Hua University were adequately comprehensive, it was convenient for all the participants to gain access to the bulletin board on campus. Members in this class were allowed to take advantage of this bulletin board off class, so they might check entries or post messages at their convenience. The instructor announced messages for the whole class on this bulletin board. All the participants discussed whatever issue interested them on the board. Moreover, students wrote free journals, shared feelings, posted their works, or responded to others' ideas on this bulletin board. What important is that all the postings on this bulletin board were written mostly in English, sometimes in Chinese, to provide chances for this EFL class to make authentic communications in English.

Two questionnaires were designed to survey students' background and their attitudes toward using the class board. A Background questionnaire with 16 items was used in the beginning of the semester to gain some information about students' experience of English learning and using BBS. An Evaluation Questionnaire of 17 items was used at the end of the semester to evaluate whether this electronic bulletin board helped students' English learning: specifically, how they used this discussion forum and to what extent this discussion forum helped their English learning, especially English writing.

3.3 Instructional Design and Research Procedures

This project lasted for one semester--18 weeks. During the semester, in addition to free postings on this bulletin board, some activities were designed to encourage students to take advantage of this electronic bulletin board. The research procedures included three stages. At the first stage, i. e., the first week of the class, orientation activities were designed as warm-up of this BBS project. Students were asked to complete Background Questionnaire, request an individual account from the BBS administer, write a short self-introduction in English, and post the self-introduction to the bulletin board during the first week.

At the second stage, some English writing activities were designed to encourage students to utilize this discussion forum. Four writing activities were directly associated with evaluating effects of this class-based BBS on English writing. These four writing activities were divided into two sets: one for practice (P) and the other for formal evaluation (F). The P set aimed to help students become familiar with the process of writing; the F set was the source of data analysis for this project. Each set included two writing activities: besides in-class discussion and writing, one had on-line pre-writing discussion (OL) and the other had no on-line pre-writing discussion (NOL). The four writing activities in this project were referred to as PNOL, POL, FOL, and FNOL. During the writing activity, students got some guiding questions one week before in-class writing. They had to carefully think over those questions and prepare for the in-class discussion and writing

in the following week. In POL and FOL, students were additionally required to discuss guiding questions on the BBS during the week. When the day for writing came, students had to participate in the in-class pre-writing discussion for about 15 minutes first and then completed an in-class essay within 30 minutes. The topic for each writing task was assigned in class and related to the guiding questions students had discussed. All students' writings were graded and then returned with some marks for revision. As for the writing activities of the P set, they were quite similar to those of the F set. These four writing activities lasted for almost two months and the order of them were PNOL, POL, FOL, and FNOL.

In addition to these four writing activities, another two writing activities were taken as instructional interventions during the rest of the semester to promote participation on BBS. In the twelfth week, students were assigned to read an article off class and they had to connect to the BBS to answer two reading comprehension questions on the BBS. Two weeks later, the class appreciated a movie--*The Little Buddha*--in class. Students were required to write a short summary for this movie on the BBS off class. After students completed each of the two activities, the teaching assistant debriefed students' BBS postings in class in order to lead students to review some good ideas or excellent works. These instructional interventions aimed to encourage students to utilize the BBS more frequently and more interactively. At the third stage, i. e., the last week of the class, the Evaluation Questionnaire was employed to assess students' attitudes about the BBS on their EFL learning, particularly English writing.

3.4 Data Analysis

In order to evaluate how this class-based bulletin board aided students on their English writing, we conducted both quantitative and qualitative analyses. Firstly, we investigated how participants in this project extended a learning community beyond the classroom to learn English from the perspectives of the instructor, the researcher, and students. Students in this project completed the Evaluation Questionnaire at the end of the semester to help us understand how students evaluated the bulletin board as a learning aid. At the last week of the semester, the researcher also had an interview with the instructor in order to understand to what extent the instructor regarded BBS as a useful teaching aid. In addition, the researcher counted frequencies of posting, categorized postings, and traced the interaction of postings in order to know how participants utilized this discussion forum.

Secondly, by interviewing with the instructor, the researcher acquired the instructor's feedback towards students' in-class discussion in FOL and FNOL writing activities. Also, the researcher kept some diary about the classroom observation during the FOL and FNOL in-class discussion. Students responded in the Evaluation Questionnaire to show to what extent the pre-writing discussion helped their FOL in-class discussion.

Thirdly, students' in-class writings of FOL and FNOL were assessed using the ESL Composition Profile in *Testing ESL Writing: A Practical Approach* (Jacobs *et al.*, 1981) by two raters. The ESL Composition Profile is comprised of five scoring parts: content, organization, vocabulary, language use, and mechanics. For each part of the assessment, there are detailed criteria provided. The two raters are both graduate students: one is a TEFL major and the other is a linguistics major. Both of them were foreign languages majors in college. To make the grading as objective as possible, two raters practiced their grading for the writings in the practice session so that they could adjust the discrepancy in order to increase the reliability of the rating. Last, t-test was employed to compare total scores and the five part scores between papers with online pre-writing discussion and those without online pre-writing discussion.

4 Results and Discussion

4.1 BBS as a virtual English learning community

Totally, participants involved in this study posted 408 entries, including 353 postings required as assignments (86.5%) and 55 postings unrelated to assignment requirements (13.5%). During the semester, we expected students to post more self-initiated entries on this discussion forum. However, self-initiated postings were apparently fewer than assignment-directed postings. In some weeks, there was even no self-initiated posting found on this discussion forum. Nevertheless, after the 18th week—the last week of the semester—still four more self-initiated postings were found. It implies that although the majority of the students regarded this class-based bulletin board as assignment-oriented, this discussion forum did have an

impact on some of the students in the sense of being a member in a community.

Generally speaking, participants in this project did not utilize this class-based bulletin board frequently. Except for the researcher, who was required to check entries on BBS every 2 to 3 days in a week, the instructor used to browse postings every two weeks, and most of the students tended to visit this discussion forum only when they had to hand in homework on line. These could be confirmed by the Evaluation Questionnaire results. Around 60% of the students in this class regarded playing BBS as a necessity in their college life; however, on average, nearly 70% of the class browsed this specific class-based bulletin board only 0 to 3 times a week. About 20% of the students claimed that they did not browse this discussion forum carefully. Except handing in homework, they were not interested in utilizing this class-based board for any purpose; sometimes, they would even refuse to post homework on BBS. Besides, only 25% of the students would check almost every posting on BBS. The results above show that most of the participants in this class did not become voluntarily involved in this BBS-project yet; many of them merely regarded this discussion forum as a place for assignment display and they did not become used to share life experiences in English on BBS yet.

Originally, we expected that asking students to post an original message and respond to at least one classmate's message could stimulate more discussion on others' on-line essays or comments. During the semester, we found that around 80% of the students indeed had fulfilled the requirements of the writing project. However, almost none in this class attempts to post additional entries except for the required postings. The majority of the students tended to view replying to others' postings as merely an "assignment" or a "task". Once they completed the task, they did not attempt to give additional responses to others' message. Thus, there were few interactions among the assignment-directed postings; in contrast, more interactions emerged among self-initiated ones.

All the self-initiated postings are divided into two main categories: original postings, including postings related to assignments (feedback, announcement, and assignment reminding) and postings not related to assignments (classroom management, extracts[1], experiences, and blessings), and responses (postings replied to original postings). The majority of teacher's postings were associated with classroom management (42%) and responses (33%). The teaching assistant's postings focused on responses (38%) and extracts (31%). As for students' postings, a large proportion of them were responses (55%) and many of them were about student's personal experiences (26%). It indicates that participants in this class seemed to take advantage of this class-based BBS for different purposes. Being the conductor of the class, the teacher tended to pay more attention to issues related to classroom management in order to keep the class in order. The teaching assistant was inclined to post extracts or reply to students' postings in order to trigger students' motivation of using the BBS and promote interactions on BBS. Also, we learn that more than half of the students' postings were responses. Compared with students' performance on assignment postings, students' performance on self-initiated postings seemed more active because students were not required to respond to others' self-initiated postings but they did and responses were of more interactions.

Students' greater interaction on self-initiated postings could be supported by the comparison of responding patterns between assignment-directed postings and self-initiated postings. Restricted to the requirements of the assignments, many students' assignment-directed postings got no response from others, and some students' posting got only one response. When we examined self-initiated postings, greater interaction was found in the responding pattern of self-initiated postings. We found two examples that respectively got 6 and 7 responses involving negotiation among participants in self-initiated postings. Besides, the questions displayed in assignment-directed postings are rarely answered (18%); however, in self-initiated postings, approximately 60% of the questions were answered. Moreover, up to 66% of the questions raised by students in self-initiated postings gained responses from other participants of this project. Its percentage is higher than that of the teacher's and teaching assistant's answered questions (57.1%). It reveals that students in this class tended to answer questions raised by their peers rather than those raised by the teacher or the teaching assistant. These results not only indicate that self-initiated postings show more varieties in terms of its responding patterns but also imply that students behave more like a learning community and the teacher and the teaching assistant are outsiders of this community.

4.2 Effects of asynchronous discussion on college English learning

---

[1] extracts are messages transmitted from other boards within the BBS or some interesting poems or lyrics

Though this English discussion forum was not utilized widely and efficiently as we predicted, it did benefit the participants in this project to some extent. 26% of the class positively indicated in the Evaluation Questionnaire that they liked the implementation of BBS into the Freshman English course; around 67% of the class claimed that the idea of practicing English on BBS did trigger their motivation of learning English. When it comes to the effects of BBS on in-class discussion, the instructor and the teaching assistant pointed that there seemed no great differences between FOL and FNOL in-class discussion. During both FOL and FNOL discussion, there seemed no much interaction among the whole class. Whenever the leader of each group finished an oral report, no volunteer from other groups was willing to offer some comments or raise questions. Nevertheless, based on students' Evaluation Questionnaire responses, around 82% of the students asserted that if they had an on-line discussion before the day of in-class writing, they would know better how and what to express in English during the in-class discussion. About 9% of the class regarded asynchronous on-line discussion as an extremely beneficial aid on their in-class discussion. Compared with the effects of BBS discussion on in-class discussion, discussion on BBS seemed to be more helpful for in-class writing than for in-class discussion. Approximately 73% of the students indicated that on-line discussion helped them understand how and what to write for their in-class writing. Up to 22% of the class viewed the on-line discussion as a great supplementary for their in-class writing. Some students also claimed that they have learned some grammar knowledge and got opportunities to comment on others' ideas via on-line discussion.

Table 1 shows the comparison of FOL and FNOL writing performance. The FOL and FNOL papers from 44 students[2] were graded by two raters, whose inter-rater reliability reaches 0.7. Then, t-test was employed to compare FOL and FNOL writings. The results show that with on-line pre-writing discussion, students performed significantly better on the total score, organization, vocabulary, and language use, but not on content and mechanics. It indicates that asynchronous on-line pre-writing discussion led to better writing, particularly on organization, vocabulary, and language use. What interesting in Table 1 is the significant improvement of the language use and vocabulary in FOL writings. According to students' Background Questionnaire responses, they viewed grammar and vocabulary as the two parts that they had more difficulties in English writing. Based on the comparison of FOL and FNOL writing performance, asynchronous on-line pre-writing discussion seems to help students' language use and vocabulary in English writing.

Table 1
Comparison of FOL and FNOL Writing Performance

	FOL	(N=44)	FNOL	(N=44)			
	Mean	**SD**	**Mean**	**SD**	**df**	**t-value**	**p**
Total	69.98	20.77	67.54	21.86	43	3.621	*0.00077
Content	20.91	2.82	20.44	2.93	43	1.676	0.10098
Organization	15.52	0.999	14.88	1.188	43	3.789	*0.00047
Vocabulary	14.93	0.79	14.32	0.48	43	4.687	*2.8E-05
Language Use	15.57	2.02	14.94	1.84	43	3.345	*0.00172
Mechanics	3.03	0.05	2.94	0.096	43	1.48	0.14612

*$p<.05$ E-0.5 = 10^{-5}

5 Conclusion

From the results of this project, we find that the utilization of the BBS is not as efficient as we expected. According to students' Evaluation Questionnaire responses, we assume that the low utilization of this class-based bulletin board might result from three aspects: technical problems, the design of activities on BBS, language mode, and individual habits. Due to some inevitable factors, this class-based discussion forum was not allowed to be built on the most popular BBS on campus—The BBS of Computer Science (CS), and it was alternatively built on the BBS of Materials Science & Engineering (MSE). During the semester, we discovered that it was hard to trigger students' motivation to connect to the BBS of MSE because the BBS of MSE was lack of much merit that the BBS of CS has. Approximately 87% of the

[2] Of the 45 students in this class, one student's writing is excluded because he did not participate in FNOL in-class writing.

students in this project claimed that if the English discussion forum were built on the BBS of CS, maybe they would utilize it more frequently. Besides, students had to do some activities as the required assignments on BBS during the 18 weeks. The reading of a great amount of postings as requirements could be a problem that blocked students' use of BBS. It is possible that students had been exhausted in posting assignments, so not much energy left could be used to interact. Moreover, students' unwillingness to post in English and their individual habits of using BBS might be another two main obstacles. For most of the students, they did not get used to write English messages yet. They felt more comfortable while posting in their native language—Chinese. Some students further indicated that they did not like posting articles in Chinese on BBS not to mention posting English messages. They suggested that we pay some concern on this issue if there will be implementation of BBS in the future English course.

Though the utilization of this discussion forum is not as efficient as we predicted, the results do have some implications for the teaching and learning of college English writing. First, this project lends support for the hypothesis that asynchronous on-line pre-writing discussion leads to better English writing quality, particularly in organization, vocabulary and language usage. Therefore, English teachers may adequately integrate BBS discussion into writing classes in order to help students' quality of in-class writing or writing drafts. Second, once students are required to do some in-class oral discussion or oral presentation, they could be allowed to have asynchronous discussion first because on-line discussion helps learners' preparation for the in-class oral-discussion. Third, given an authentic environment for communication on BBS, English learners will be permitted to make communication for various purposes in the target language—English—beyond the classroom. Based on the benefits mentioned above, we suggest English teachers who are interested in the implementation of BBS be careful of the possible obstacles of blocking the utilization of BBS mentioned above and carefully design CMC activities on BBS to trigger students' motivation of English discussion on BBS. It might help lead the class to take advantage of BBS more efficiently and learn English more cooperatively.

Since little research is conducted on the effects of asynchronous conferencing on English learning, there is still a need for more explorations on this area. We would like to offer some suggestions to those who are interested in future research on how asynchronous conferencing, particularly BBS, aids English learning in the following. First, time limitation is a crucial factor that lowers the reliability if this project, so future researchers may design a more complete project that lasts more than one semester. Second, in order to increase the reliability and validity, future research needs to be replicated with more than one set of writings (e.g., two comparative pieces of writings). Third, future researchers might analyze interaction patterns of postings in a more systematic way, maybe some more interesting implications about how BBS helps form a virtual community for English learning will be found in future study. With the popularity of BBS among college students, BBS should have the potential to become a significant supplement in college English course. We also encourage those who are interested in this topic replicate this study in order to examine more effects of BBS on English learning.

References

[1] Educational technology: Media for inquiry, communication, construction, and expression, http://www.ed.uiuc.edu/facstaff.chip/taxonomy/

[2] Cooper, M. M., & Selfe, C. L., "Computer conferences and learning: Authority, resistance, and internally persuasive discourse", College English, Vol. 52, No. 8, pp. 847-869, (1990).

[3] Huang, S. Y., "Computer-mediated vs. face-to-face discussions: a comparison of their nature and effects on writing", National Science Council Final Report (NSC 86-2411-H-029-003), Taipei: National Science Council, (1998).

[4] Jacobs, H. L., Zinkgraf, S. A., Wormuth, D. R., Hartfiel, V. F., & Hughey, J. B., "Testing ESL composition: A practical approach", Rowley, MA: Newbury House. (1981).

[5] Kollock, P., & Smith, M., "Managing the virtual commons: Cooperation and conflict in computer communities", Computer-Mediated Communication: Linguistic, social and cross-cultural perspectives, Amsterdam/Philadelphia: John Benjamins publishing company, pp. 109-128, (1996).

[6] Korenman, J., & Wyatt, N., "Group dynamics in an e-mail forum", Computer-Mediated Communication: Linguistic, social and cross-cultural perspectives, Amsterdam/Philadelphia: John Benjamins publishing company. pp. 225-242, (1996).

[7] Kroonenberg, N., "Developing communicative and thinking skills via electronic mail", TESOL Journal, Vol. 4, No. 2, pp. 24-27, (1994/1995).

[8] Kroonenberg, N., "The French connection: Public journals for high school students", Virtual connections,

Honolulu, Hawai'i: University of Hawai'i, Second Language Teaching & Curriculum Center, (1997).
[9] Paramskas, D., "Computer conferencing as a tool for augmenting student interaction and collaboration", Virtual connections, Honolulu, Hawai'i: University of Hawai'i, Second Language Teaching & Curriculum Center, (1995).
[10] Razika, S., "A computer network for prospective teachers of French as a second language", Virtual connections, Honolulu, Hawai'i: University of Hawai'i, Second Language Teaching & Curriculum Center, (1995).
[11] Sullivan, N., & Pratt, E., "A comparative study of two ESL writing environments: A computer-assisted classroom and a traditional oral classroom", System, Vol. 29, No. 4, pp. 491-501, (1996).
[12] Van Handle, D. C., & Corl, K. A., "Extending the dialogue: Using electronic mail and the internet to promote conversation and writing in intermediate level German language", CALICO Journal, Vol. 15, No. 1-3, pp. 129-143, (1998).
[13] Vygotsky, L. S., "Mind and society", Cambridge, MA: Harvard University Press, (1978).
[14] Warschauer, M., "Comparing face-to-face and electronic discussion in the second language classroom", CALICO Journal, Vol. 13, No. 2 & 3, pp. 7-27, (1996).
[15] Zhao, Y., "Language learning on the world wide web: Toward a framework of network based CALL", CALICO Journal, Vol. 14, No. 1, pp. 37-51, (1996).

Web Speaking: A Language Learning System in the Web

David Lo, Wen-Tsai Liao and Ming-Syan Chen
Department of Electrical Engineering and Computer & Network Center
National Taiwan University
Tapei, Taiwan, ROC

Due to recent technology advances, an increasing number of applications are being ported to the Web at rapid pace. Such applications include Web Phone, Web Fax, Web BBCall, to name a few. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time. In this paper, we develop an interactive language learning system in the Web, called Web Speaking. By using Web Speaking, students are able to learn languages anywhere at any time as long as a Web interface is provided. Web Speaking is in essence a two-tier client-server architecture, and is divided into two components, namely (1) the language learning player at the client-side and (2) the course content provider at the server side. In this system, we put not only the course content but also the corresponding audio files in the server side in order to support a multimedia-teaching environment. The language-learning player runs at the client side and provides a user interface to access the course materials in the server. In addition, Web Speaking is able to improve the language speaking ability of the students with the display of the speech waveform which is generated by using the algorithms isolating the utterances of the speech. Students can capture the difference between the waveforms of their own speaking and the standard one provided by the instructor, and improve their speaking accordingly. By this language learning package, we can automate the procedures of preparing audio course materials, greatly facilitate the language learning by the students, and conduct data mining on student behavior. The teaching quality of language learning can thus be improved.

Keywords: **Distance learning, speech analysis, two-tier client-server architecture, World Wide Web**

1 Introduction

Recently, an increasing number of applications are being ported to the Web at rapid pace, including Web Phone, Web Fax, Web BBCall, and so forth. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time [1,2,3,5,6,7,8]. Traditionally, the students have to be present in the language-learning classrooms and use specific language learning mechanisms to improve their speaking ability. However, the major disadvantage of the traditional language learning is the limitation of time and space. For example, the students may have an English class in the Monday morning at the language-studio classroom and that class could be their sole opportunity to practice their language speaking, since the instructor is only present at that moment. Consequently, the effectiveness of the traditional language-learning systems is limited.

In this paper, we develop an interactive language learning system in the Web, called *Web Speaking*. The Web Speaking system we developed in the Computer and Network Center at National Taiwan University is in essence a two-tier client-server architecture. Through a Web interface, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space. In addition, using Web Speaking, students can communicate with the instructors interactively via the mechanism provided, and the teachers can timely edit the course materials

by writing the content of text and recording the audio files in response to the students' requests very easily. These are the very advantages of Web Speaking over some stand-alone commercial language-learning applications which are usually lack of interactive features.

In addition, the other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students to help the students to learn language speaking better. In Web Speaking, we implement the algorithms isolating the utterances of the speech [9,10] to improving the students' speaking ability. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. It is worth mentioning that Web Speaking system is meant to help the teachers to improve their teaching quality, and should be viewed as an auxiliary tool for teaching. By no means do we assert that Web Speaking is able to completely replace the role of an instructor or in any way to lessen the need for a teacher to personally interact with students. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

The paper is organized as follows. Section 2 depicts the whole system architecture. Section 3 presents the implementation and functionality of the Web Speaking. Section 4 concludes this paper.

2 The System Architecture of the Web Speaking

We use a two-tier client-server architecture for the Web Speaking system. The reason of using the two-tier client-server architecture is that it can provide our two key components, i.e., the language-learning interfaces at the client side and the course content provider at the server-side. This architecture can be easily extended to a three-tier one if an additional gateway is required in this application.

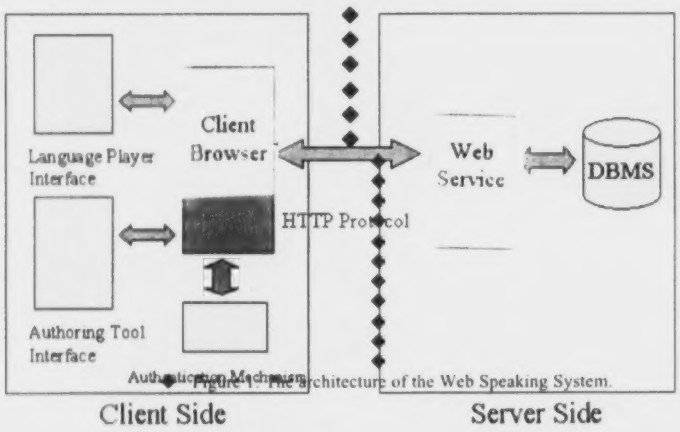


Figure 1. The architecture of the Web Speaking System.

Based on the two-tier client-server architecture, the Web Speaking System is designed as the Figure 1. At the client side, both the language player interface and the authoring tool interface use the DBMS (Database Manager System) to access the course materials in the server via the HTTP protocol in the Internet/Intranet. The program at the serve side then accepts the requests from the clients and returns the results of the requests to the clients. The DBMS at the server side saves not only the course materials but also the information of the users, including the students and the teachers. Using an authentication mechanism, the player is able to verify the user identification via the Web and to provide different user interfaces for students and teachers, as one form of personalized service. For instance, the students are only allowed to use the language player interface whereas the teachers can use both the language player interface and the authoring tool interface. The following subsections will introduce the operations of the Web Speaking System briefly.

2.1 The language learning player at the client side

To assist the students in language leaning on listening and speaking, the user interface (UI) of Web Speaking provides the functions of playing the audio files and those of recording the user's voice. Furthermore, the UI displays the wave shapes of the audio files and the user's voice for users to capture the differences and to improve their speaking. For example, once the user selects one topic of the course in upper-left area of the Figure 2, i.e., "There are always two sides to everything." In Figure 2, not only will the content be shown in the upper-right area but also the shape of this audio appears in the middle area. When the users are playing back the audio in the middle area, an indicator will run along the shape of the audio to indicate the exact timing of audio playing.

In addition to listening the audio and watching the shape of it, the users are also able to record their voice into the system, play it out, and compare its shape with the standard one in the course material. In order to prepare the course materials easily and automatically, Web Speaking provides an interface to authorize the use of course materials and to upload and download materials automatically from the course content provider. This is a very convenient feature for the teachers who are not familiar with the operations of the transmitting files in the Web. Furthermore, the teachers could edit the content of the course material and record the audio easily via this interface, such as adding a new topic of the course material or creating a new course in the upper-right area in the Figure 3. They can also playback and record the audio file of the course materials in the bottom area. As such, the language-learning player, including the language learning interface and the course material authoring tools interface, runs at the client side and provides a user interface to access the course materials in the server. In addition, we use the algorithms isolating the utterances of the speech to display the speech waveform in order to facilitate the language learning of students.

Note that the user needs to use the local resources, such as the I/O of the audio interfaces and the I/O of the storage interfaces at the client side. However, this I/O access is not allowable for the browsers, such as the Internet Explorer and the Netscape Navigator. Therefore, we implement a stand-alone language-learning program at the client side by using the Microsoft Visual Basic 6.0 programming tools.

2.2 The course content provider at the server- side

The major tasks of the server are to save and update the teaching materials and to query the databases when so necessary. These tasks are implemented by using the PHP script language and MySQL database at the server side. Since the PHP script language has been integrated with MySQL database, we use it to query the databases (MySQL). The client can then use the HTTP protocol to communicate with the server.

The course content provider is mainly a server combining the Web service and the database manager. It employs the PHP script language to access the MySQL database and to response the client's requests. As mentioned earlier, the server side of Web Speaking saves not only the contents of the courses but also the corresponding audio files in order to support a multimedia-teaching environment. Once the server gets a request, the content provider fetches the requested materials by the user from the database, and then, if the corresponding authentication succeeds, returns the result to the client.

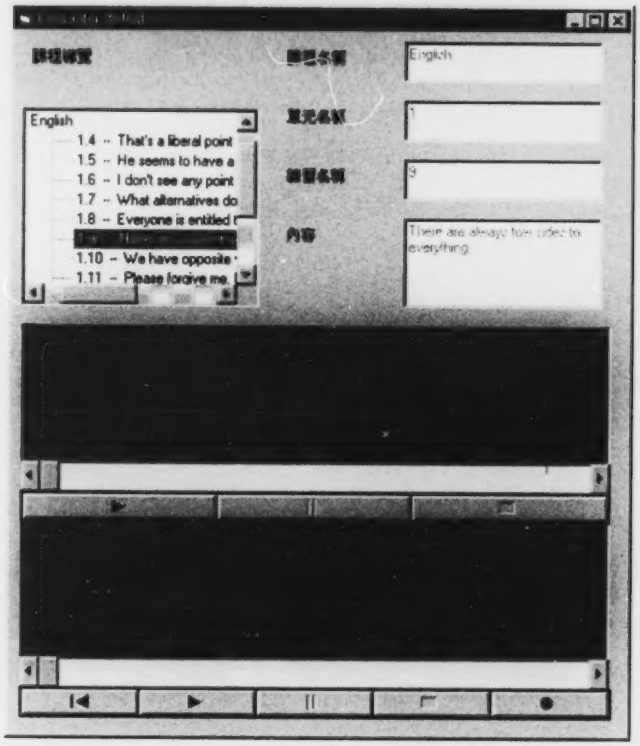


Figure 2: The language-learning player for the students

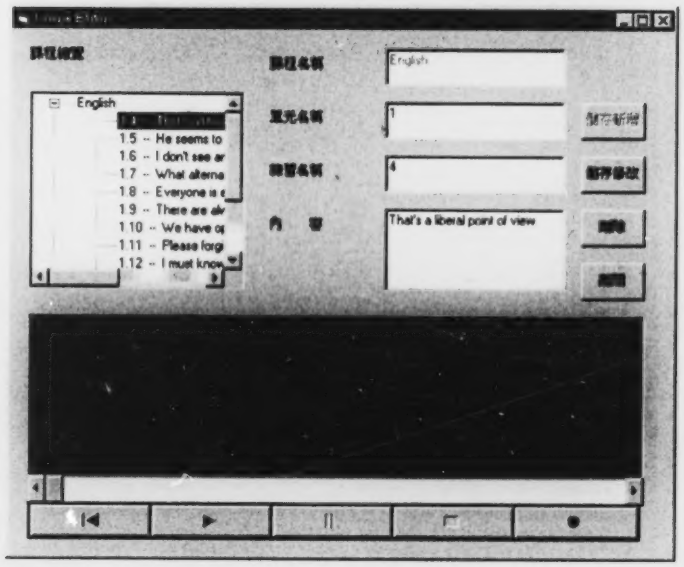


Figure 3: the authoring tools for the teachers

BEST COPY AVAILABLE

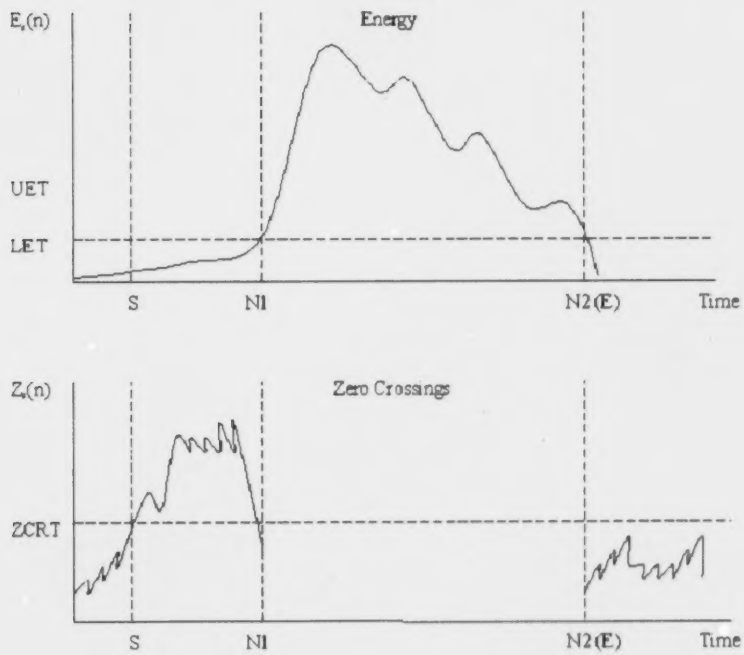
3 End Point Detection for Speech in Web Speaking

We introduce in this section the algorithm used to detect the endpoints of isolated utterances. To help the user learning the language speaking, we display both the waveforms of the speech produced by the user and the standard one prepared by the teacher. In addition, we isolate the utterances of the speech to help the user to understand how the speech looks like. This endpoint detection method [10] uses two parameters, i.e., the short-term energy ($E_s(m)$) and zero crossing rate ($Z_s(m)$), to detect the endpoints of an utterance. These two parameters are calculated as follows, where s(n) means the speech signal, w(n) means the window function, and N means the length of the window.

$$E_s(m) = \sum_{n=m-N+1}^{m} s^2(n)$$

$$Z_s(m) = \frac{1}{N} \sum_{n=m-N+1}^{m} \frac{\left|\operatorname{sgn}\{s(n)\} - \operatorname{sgn}\{s(n-1)\}\right|}{2} w(m-n)$$

$$where \quad \operatorname{sgn}\{s(n)\} = \begin{cases} +1, & s(n) \geq 0 \\ -1 & s(n) < 0 \end{cases}$$



◆ Figure 4: Illustration of the endpoint detection algorithm.

The endpoint detection algorithm is depicted in Figure 4 and described below.

Step 1. Assume that the window function *w(n)* is a rectangular function with the window size *N* being 10 ms, and the first 100 ms of the speech signal is background noise. Then, use this signal segment to calculate the mean and variance of $E_s(m)$ and $Z_s(m)$.

Step 2. Using the statistics derived from Step 1, determine three thresholds, i.e., the upper energy threshold (UET), the lower energy threshold (LET), and the zero crossing rate threshold (ZCRT).

Step 3. Search from the beginning until the energy $E_s(m)$ exceeds the threshold UET. Then, run backward until the energy $E_s(m)$ falls below the threshold LET. We call this point the tentative beginning point N1. The tentative ending point N2 is calculated in a similar way.

Step 4. From the tentative beginning point N1, we examine the zero crossing rate for the previous 250 ms

signal segment. If there are more than three occurrences of counts above the threshold ZCRT, we select the first point backward from N1 whose zero crossing rate is higher than ZCRT as the beginning point (S) of the word. If there are no more than three occurrences of counts above the threshold ZCRT, the tentative beginning point N1 is directly selected as the beginning point of the word. The ending point (E) is decided in a similar way with exception that the forward searching direction replaces the backward one.

By using the above algorithm we can partition the waveforms of the speech. Furthermore, the language-learning player displays the shapes in the screen and also indicates the timing when the waveform of the speech plays. Thus, this functionality of the language-learning player offers not only the playout of the audio but also the display of the waveform shapes at the same time. This is a very helpful feature for students to learn language speaking.

Note that we can collect students' practicing records in the Web Speaking system. Through some data mining techniques, we can find useful information about the student behaviors, e.g., the common mistakes made by the students. Clearly, using such information discovered, the instructor is able to improve their language teaching by reminding the students of how to speak better when the students encounter common problems.

4 Conclusions

In this paper, we developed a Web Speaking system to improve the language learning and teaching for the students and the teachers. By using Web Speaking, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space in traditional teaching environments. The advantage of Web Speaking over some stand-alone commercial language-learning applications lies in the full interactivity Web Speaking provides. The other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students in order to help the students to learn language speaking better. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

Acknowledgement

The authors are supported in part by the Ministry of Education Project No. 89-E-FA06-2-4-7 and the National Science Council, Project No. NSC 89-2219-E-002-007 and NSC 89-2213-E-002-032, Taiwan, Republic of China.

References

[1] E. Bilotta, M. Fiorito, D. Iovane and P. Pantano, "An Educational Environment Using WWW", Computer Networks and ISDN Systems, 27, pp. 905-909, 1995.

[2] "CEIBA," High Performance Computing Lab of Department of Electrical Engineering of National Taiwan University, ftp://www.cc.ntu.edu.tw/pub/Webcourse/.

[3] J. Chang, M. S. Chen and I. P. Lin, "Design and Implementation of a Software Package for Network Education", Proc. of the 2000 International Conference on Engineering Education, August 14-16, 2000.

[4] M. S. Chen, J. Han and P. S. Yu, "Data Mining: An Overview from Database Perspective", IEEE Trans. on Knowledge and Data Engineering, Vol. 8, No. 6, pp. 866-883, December 1996.

[5] "Distance Learning in National Taiwan University", National Taiwan University, http://www.cc.ntu.edu.tw/~ccdl.

[6] D. Dwyer, K. Barbieri and H. M. Doerr, "Creating a Virtual Classroom for Interactive Educations on the Web", Computer Networks and ISDN Systems, 27, pp. 897-904, 1995.

[7] B. Ibrahim and S. D. Franklin, "Advanced educational uses on the World Wide Web", Computer

Networks and ISDN Systems, Vol. 27, No.6, Apr. 1995.
[8] J. C. Jehng, Y.F. Shih, S. Liang and T. W. Chan, "TurtleGraph: a computer supported cooperative learning environment", The Proceedings of the World Conference on Educational Multimedia and Hypermedia, Vancouver, Canada, AACE, pp.293-298, 1994.
[9] M. C. Lai, B. H. Chen and S. M. Yuan, "Toward a new educational environment", World Wide Web Journal, Issue One: Conference Proceedings, Fourth International World Wide Web Conference, O' Reilly & Associates, Inc., pp. 221-230, Nov. 1995.
[10] L.R. Rabiner and M.R. Sambur, "An Algorithm for Determining the Endpoints of Isolated Utterances", The Bell System Technical Journal, Vol. 54, No. 2, February 1975, pp. 297-315.

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

Proceedings

Content

▸ Full & Short Papers (Creative Learning)

A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents
A Java-based Interactive Learning System of Junior High School Level Geometry
A study of collaborative teaching for creative learning in an engineering class
An approach to modeling an educational domain
An Interactive Game System to Stimulate Word Associations
DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment
The Artistic Interface - A Transition from Perception to Screen
Using Virtual Environments for Studying Water Phases and Phase Transitions

▲ HOME

A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents

Takashi OHNO* Kenji SAITO* Hajime SAITOH and Takashi MAEDA***
**Graduate School of Hokkaido Information University*
Ebetsu 069-8585, JAPAN
Tel: +81-11-385-4416 Fax: +81-11-384-0134
***Graduate School of Engineering, Hokkaido University*
Sapporo 060-8628, JAPAN
Tel: +81-11-716-2111(ext.6498)
E-mail: {t-ohno, maeda, ksaito }@do-johodai.ac.jp, hajime@complex.eng.hokudai.ac.jp

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing a collaborative learning support system being developed on VESMA(Virtual Environment Server for Multiple Agents) system.

Keywords: **Collaborative Learning, Intelligent Agent, Virtual Environment**

1 Introduction

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. In other words, it is possible that the learner's interest and concern will be attracted if there is an intermediary who supports the learner with the idea of using the teaching/learning materials function as a learning object between the learner (user) and the learning object. And, it is very important to grasp the learner's mental state in collaboration with plural learners in a virtual environment like a computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing such a learning support system as a part of our Virtual University project being built up on VESMA(Virtual Environment Server for Multiple Agents) system.

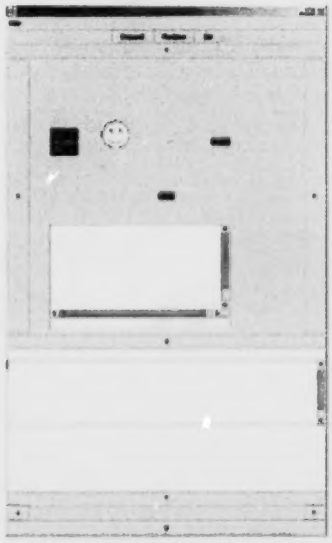


Fig. 1 Client of VESMA System

In the rest of the paper, we describe a general mechanism of VESMA system and its features in section 2. In section 3, we discuss on collaborative learning in such a virtual environment including some intelligent agents who support such learning. In section 4 and 5, we will discuss the supporting function of effective collaborative learning and the learning process in the collaborative learning support system. Concluding remarks and some future works are briefly described, in the last section,.

2 VESMA System

In this paper, we have been constructing a virtual environment using the VESMA system developed in the

BEST COPY AVAILABLE

Java language. This VESMA system provides the programming environment to simulate the virtual space which a lot of elements exchange the message and affect each other. This system has been used for an agent programming, the simulation of a physical/social phenomenon and a probabilistic network etc. by present.

2.1 Server-Client System The VESMA system is a system which consists of the server and the client, and contains user's avatar, the object and the agent that is in virtual environment in the server. The client displays an environment surrounding user(s), and interprets the inputs of the user, and let the avatar execute it. This system can be executable in all platforms, and translate an arbitrary object between server-client or server-server through a computer network, because this system uses the Java language.

The objects corresponding to the entrance can exist in a virtual space of the VESMA system, these objects are connected with another place of this server or other servers, and the user can move between the servers freely by accessing this entrance object.

2.2 Layered Structure A virtual space of the VESMA system can take the layered structure, as can be seen in the last paragraph of section 2.1. When a complex virtual space and a lot of rooms are made, it is very convenient to be able to make the layered structure for representing a spatial metaphor. For instance, layered structures such as the city, university, faculties, and laboratories can be represented.

2.3 Autonomous Object The object is static or passive in a usual educational virtual environment system, so it can answer to a user's request or reply to a messages, but it is difficult to realize an object which behaves actively. The object in VESMA system can behave with own thread by programming the object to send oneself the message. In other words, VESMA system supports making of an autonomous agent.

2.4 Simulation of Various Phenomenon The VESMA system is not only suitable as the educational virtual environment programming environment, but also suitable for the simulation of a physical phenomenon. Our collaborative learning support system on VESMA system can simulate a physical phenomenon as well. It is also possible that the user can experiment by operating the experiment tool in the virtual environment, and change the parameter and setting the experiment, and repeat the experiment trying and erring. These experiments are useful for voluntary environments.

Moreover, our system can simulate not only physical phenomenons but also social phenomenons or probabilistic process, and can display the results of the simulations by various graphical expressions such as a density graph or digraph.

3 Collaborative Learning in Virtual Environment

3.1 Virtual Environment and Learning Style

The virtual environment in this paper means a "communication environment in computer networks". Usually, a user can take only the service that he had already known the existence in the usual network. Though such information is useful, sometimes people get information that is of significant value by chance discovery. We think that positively building up and providing such an environment to increase the chance of this happening are important. The virtual environment in made by various information can be considered for the typical example. In this paper, we use VESMA system to realize the collaborative learning support system. Because of server-client architecture supported by VESMA system, our collaborative learning support system can be "distributed" in space and "synchronized or non-synchronized" in time. Generally, learning styles can be divided into the following three types : 1. *Individual learning*, 2. *group learning*, 3. ***Collaborative learning***.

(1)*Individual learning* : the problem solving whereby a learner does by himself. (2)*Group Learning* : the problem solving via task sharing. (3) *Collaborative learning* : the problem solving by use of result sharing. In other words, Each learner solves his own problem based on the information and data given to him by other learners. Thus Collaborative learning is group learning with more goal oriented communications. In the field of the education, it is considered that the latter learning style is especially effective because the quality of the answer improves on the whole by having learners with differing knowledge do an information exchange.

3.2 Collaborative Learning

The following are the strong points of collaborative learning in a virtual environment[2] : (1)There is no restriction of time and geographical space. (2)It can lead to solving problems by doing opinion exchange with other people. (3)It can obtain objective awareness of problems. On the other hand, it has several weak points : (1)Learners get behind if they don't participate voluntarily. (2)There is the possibility that learning may progress in different directions. (3)Differing abilities of learners (members) may be a problem for the progress of their learning. We think about the method of the learner support which a weak point 3 is changed to the strong point.

Good ideas in subject preparation, group formation support, communication support, and ideas such as an interface become necessary to get over these problems. We examine the interface using intelligent agents in consideration of such characteristics in this paper.

4 Supporting Collaborative Learning

4.1 Grasp of the learner's state

It is important to grasp learner's state in the learning system. When learning in a virtual environment on the computer network, it is especially important. Because, people's communications become indirect in a virtual environment.

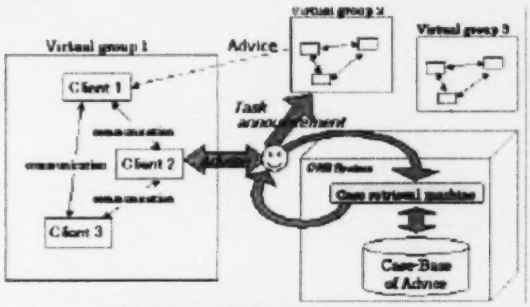


Fig. 3 **Architecture of Collaborative Learning Support System**

Generally, when students learn about certain topic, offering materials suitable to the learner's level of understanding is necessary. This research aims to check the learner's mental state, in broad sense, using agents to grasp it automatically. It is also important to promote collaborative learning smoothly by giving a kind of "role" to each learner in the group in consideration of the learner's personality. For example, the learner who is good at teaching others might become a leader, and give support to other learners in the group. The control that gives hints to make it refer to an exercise is necessary for cases when learners come to a deadlock in their learning.

4.2 Learner Modeling

Then, the following is necessary for the learner modeling from the viewpoint of collaborative learning,
The individual model : It has proper knowledge, the mistaken knowledge, the knowledge that it hasn't been studied, the interest or concerns, information such as a role, personal manipulation history.

$D_l = \{(T_1, U_1) \ldots\ldots (T_n, U_n)\}$ D_l : learner model, T_i : learning topic, U_i : understanding of topic

4.3 Intelligent Agents

An agent works like a human beings, and supports teachers and learners. An agent communicates other agents or avatars, and behaves actively in various situation. Making a graphical representation of these agents, users can come in contact with an agent familiarity. In this paper, we will discuss the intelligent agents ("*learner modeling agent*", "*group agent*", "*advisor agent*", "*evaluation agent*") who support collaborative learning in virtual environment.

The *learner modeling agent* grasps the learner's degree of progress and the degree of his understanding. The *group agent* controls the information that a *learner modeling agent* has, and monitors the relationships of each learner in the group. An *advisor agent* carries out various supports directly for the learner. An *evaluation agent* judges whether or not the knowledge that a learner got by working at collaborative learning is useful. **Fig. 2** illustrates the architecture of collaborative learning in virtual environment including *advisor agent*. These agents do various support while the learner advances collaborative learning.

As different autonomous object, some characteristic mascots may be included in our Virtual University based on a feature described in 2.3.

BEST COPY AVAILABLE

5 The method of some supporting in Collaborative Learning

5.1 Collaborative Learning Support

As an example of collaborative learning support, *pattern1* • •When you come to a deadlock. *pattern2* • • When you mistake the solution. *pattern. 3* • •When you can not understand what to do next.

How to solve the problem of the pattern 2 : First is support by the learner in the group(using *Contract Net*). Next is support by the learner in other group(using *Contract Net*). Finally is Support by the *CBR* system. *Contract Net* achieves the allocation of the task by the negotiation between the processing nodes. In this paper, the selection of the advisor was attempted by contract net. We think it might be easier to understand "By getting advice from the learner who is close to one's understanding degree".

5.2 CBR and Calculation of Similarity Degree

CBR(Case-Based Reasoning) is a kind of reasoning which solve the new problem by a case similar to current problem. A case is expressed as follows.

$$D_c = \{(T_1, U_1, W_1) \ldots\ldots (T_n, U_n, W_n)\}$$

D_c : case, T_i : learning topic, U_i : understanding of topic, W_i : importance degree of topic

The advisor agent selects a case that current condition and a case are the most similar.

$$Sim_{ch} = \sqrt{\sum_{i=1}^{n} W_i (U_{ci} - U_{li})^2}$$

Sim :similarity degree, U_{ci} :understanding degree of topic of case base, U_{li} : understanding degree of topic of learner model, W_i : importance degree of the topic

•

6 Concluding Remarks and Future Works

We have constructed a virtual environment on a VESMA system, and examined communication processes on it. And, we have examined the function of the intelligent agents in the collaborative learning support system and the validity and support for the learning process.

In this paper, we have discussed that learners can obtain better methods for voluntary learning by the appropriate support of the intelligent agents. And various intelligent agents provide environments for the group learning which enables learners to do active collaborative learning.

And we have realized practical collaborative learning support system in which the following advantages are provided using VESMA system. The learners communicate each other and share the teaching/learning materials in the virtual environment by not only a text-based interface but also a graphical interface. A user of VESMA system can move among two or more servers which is distributed in the Internet. We can make a small creature, or can make physical experiments because of the function of VESMA which realize autonomous objects. And VESMA system has the layered structure of virtual environment, so many places can be constructed in one server corresponding to user's spatial metaphor, and the learner can easily access a place he/she wish.

References

[1] Hajime Saitoh, Azuma Ohuchi, Noriko Tanaka and Takashi Maeda, "On the Application of The Participants Assistance System in Collaborative Communication Environments to a Collaborative Learning", Communications and Networking in Education, Learning in a Networked Society, (June 13-18, 1999).

[2] Takashi Ohno, Noriko Tanaka, Hajime Saitoh and Takashi Maeda, "A study on Collaborative Learning Support System using Interface Agent" (in Japanese), THE INSTITUTE OF ELECTRONICS, INFORMATION AND COMMUNICATION ENGINEERS, TECHNICAL REPORT OF IEICE, OFS99-26, AI99-38 (1999).

[3] I. Tomek, "Virtual Environments in Education", Advanced Research in Computers and Communications in Education, (Eds. G. Cummings *et al*), IOS Press, (1999).

A Java-based Interactive Learning System of Junior High School Level Geometry

Yu-Ru Chen*, Tzyy-Leng Allen Horng, and Don-lin Yang***
**Department of Information Engineering*
***Department of Applied Mathematics*
Feng Chia University
100, WenHwa Rd, Seatwen, Taichung, Taiwan407
**Tel: +886-4-4517250 ext. 3743*
***Tel: +886-4-4517250 ext. 5126*
**Fax: +886-4-4516101*
***Fax: +886-4-4510801*
**E-mail:dlyang@fcu.edu..tw*
***E-mail:tlhorng@math.fcu.edu.tw*

In this paper we propose a Java-based CAI system that provides a learning-by-doing environment with hands-on exercise and instant interaction capabilities on the World Wide Web. Our current topics of interest is the Euclidean geometry for junior high school students. To design the system, we adopt the theory of concept map to construct teaching and learning materials. We are currently testing the system and has observed that it does significantly help students in learning geometry.

Keywords: **CAI, concept map, Euclidean geometry, Java applet**

1 Introduction

As computer science and Internet technology make speedy progress at every moment, computer aided instruction (CAI) plays an important role in our life, especially in future education for global citizens at every corner of the world. Many researches focus on the web-CAI, but there are some drawbacks in these systems:

(1) Some of these systems simply use graphs or animations and text to describe the meanings of the teaching materials. Although this way of displaying is more lively than the traditional textbooks, the learners still need to stare at the screen uncomfortably to read the text thoroughly to understand its meanings. Besides, some subjects such as mathematics need to be learned by practicing with examples.
Plain text reading is just not enough.

(2) Most multimedia web-CAI systems requires high bandwidth, which is still a problem for the current internet infrastructure. Long waiting time for response will definitely degrade the effect of learning no matter how well designed the web-CAI system is.

To demonstrate our ability of conquering the above problems, we have developed a web-CAI system in Chinese (http://www.math.fcu.edu.tw/~tlhorng/geometry) for teaching and learning junior-high-school Euclidean geometry (named just geometry in the following context). Students can have great fun in learning on our system owing to its highly interactive and experiment-oriented features. Besides, the system is designed all using small-size Java applets, and is therefore robust enough to tolerate the usual congestion on the internet.

The rest of the paper is organized as follows: Section 2 introduces our design theories such as the concept maptheory and dynamic geometry method; Section 3 shows the implementation and Section 4 summarizes the whole work and some future enhancement.

2 Theories behind our design

First we employ the concept map theory to plan the curriculum and then apply dynamic geometry method to design the curriculum to be highly interactive, problem-oriented and, most importantly, interesting. In this way, the learners are encouraged to learn by playing with those Java applets, and to construct their knowledge system by concept map theory.

2.1 Concept map theory

In order for learners to make a meaningful learning, Ausubel present a meaningful learning theory [1]. The idea in this theory is that whenever to learn a new concept or a new knowledge it must base on the prior experience. Ausubel's theory considers that the relation between the new concept and learner's prior knowledge plays an important role in the meaningful learning. Whenever the new knowledge, learners' prior concept, and proposition framework are successfully joined, learning is created. In other words, learners can make a meaningful learning by utilizing learners' prior concept to link the new concept to organize the whole knowledge. Novak further presents a concept mapping method for the purpose of verifying Ausubel's theory [1]. Concept map is composed of propositions. Every proposition contains two concept nodes and a relation link between them. In a concept map, concepts are represented in a hierarchical way. A general or summarized concept is put in an upper hierarchy, and a specific or particular concept is put in a lower one. A graph describing the integration of concepts from the lower levels to higher ones and the relation linking among them is called concept map that can represent a knowledge structure effectively.

2.2 Dynamic geometry method

To teach or learn geometry effectively, we usually have the following two aspects in mind [2]: knowledge developing (the deductive method), and knowledge acquiring (the generalizing method).

Both are equally important. However, most of the current geometry curriculum in junior high school has been emphasizing on how to prove a geometric problem by the deductive way, and frequently ignoring how to the generalize a geometry concept by experiments and observation. Our web-CAI system present the curriculum in both ways and particularly emphasizes the latter one.

3 Implementation

In our web-CAI system, the whole curriculum is problem-oriented, and each geometric problem, besides its proof, is designed to be explored by experimentation which is implemented by Java applets. Java applet is selected owing to its full-featured library for designing internet applications and its platform-independent portability [3-5]. The code was written by JDK 1.1 and is entirely in Pure Java™.

3.1 Drawing the concept map

There are four steps to draw the concept map: 1. concept seeking, 2. concept categorization, 3. concept hierarchy, 4. concept relation.

Concept seeking: First list all important concepts to be taught. A concept is the foundation unit stored in the human brain, although everyone may store a same thing by concepts in his own different way. That is why everyone may response differently when seeing or hearing an identical event at the same time. This individual opinion of everybody is called the concept.

Concept categorization: After seeking for concepts, this step is to divide concepts into two parts: event and target. Taking circle as an example in our geometry curriculum, we can list twelve relevant important concepts as categorized in table 3.1

Concept hierarchy: After categorizing the concepts, we further place them into a hierarchy. As mentioned above, a more general concept will be put in a upper level, while a more specific one in a lower level. Figure 3.1 is the hierarchy chart of Table 3.1.

Concept relation: After putting all concepts in a hierarchy, we further denotes those relations among concepts to form a complete concept map. Following the above, the circle's concept map is shown in Figure 3.1.

Event	Target
line	relationship between a circle and a line
chord	relationship between a chord and the diameter
chord and center	relationships between a chord and its distance to center
central angle	relationship between a central angle and a chord
arc	relationship between a chord and a arc
circumferential angle	relationship between a arc and a circumferential angle
tangent	two tangents from an external point to a circle are equal in length
quadrilateral	the opposing angles of a quadrilateral inscribed in a circle is complementary
triangle	three bisectors are concurrent in a triangle
incenter	Distances of the incenter to the three sides of a triangle are equal
two circles	relationship between two circles
two circles and tangent	tow circle' s common tangent

Table 3.1. Concept categorization

3.2 Composing the plan for teaching materials

By the concept map, we can further propose the teaching materials and write down these ideas into a table called the plan of teaching materials. Following the above, Table 3.2 shows a small part of the plan: the relative locations of two circles and their common tangent.

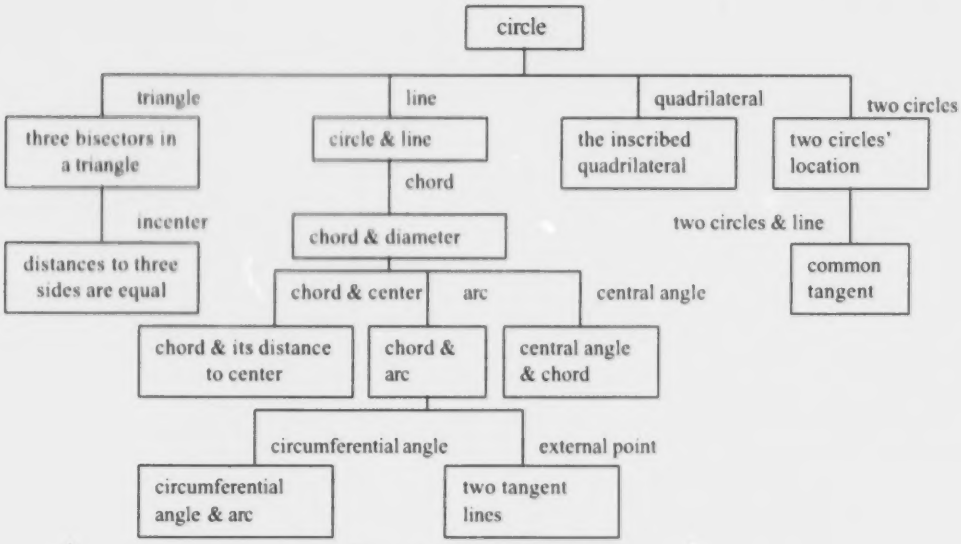


Figure 3.1 Circle' s concept map.

Page	Consist Concept
Circles' locations	There are six kinds of relations for two circles judging from their locations: separated internally, separated externally, tangential internally, tangential externally, intersecting and coincident.
Common tangent	Two circles on a plane can have the following common tangents according to their relative locations: When the two circles are separated externally, there are two external common tangents and two internal ones. When the two circles are tangential externally, there are two external common tangents but one internal one. When the two circles intersect at two points, there are two external common tangents and no internal one. When the two circles are tangential internally, there is only one external common tangents and no internal one. When the two circles are separated internally, there is neither an external common tangent nor an internal one.

Table 3.2 A part of the plan of teaching materials

3.3 Displaying the teaching materials by Java applet

Taking the common tangent of two circles as an example, we display this part of teaching materials by the

BEST COPY AVAILABLE

Java applet shown in Figure 3.2 (a)-(c). This Java applet is designed that the learner can play around by dragging any center (shown as red dots) of the two circles which will change the distance between these two centers. From the movement, the learner can observe various kinds of common tangents happening for the two circles. If we show it alternatively by some static graph or animation, the learner would have problem catching its meaning effectively.

3.4 The examination module

Besides those Java applets for displaying teaching materials, our web-CAI system also provides an examination module for on-line testing. Through this module, teachers can edit test problems and grade students' answers, and students can take tests and look up for their grades all on our web-CAI system. Four individual applets, in charge of problem editing, examination, grading, and grade looking-up, consist of this examination module. Figure 3.3 particularly shows the problem-editing part, in which teachers can edit a test problem and draw the illustration related to it. Also, all the test problems can be saved in a database server driven by JDBC• Java Database Connectivity. JDBC is a Java-standard SQL database access interface [6]. It provides access to varieties of databases. After teacher edit the examination questions, the students can take the exam on our web-CAI system. On that, students can write down the answers and draw some auxiliary lines on the illustration which may be required for proving a geometric theory or just to help them solve the problem. Teachers can then grade and comment the students' answers, and the students can look up for the grades and teacher's comment later all on our web-CAI system.

4 Conclusions and future work

We have developed a web-CAI system that provides an interactive learning and testing environment on Web. In this way, the learner can learn more effectively than other multimedia-CAI systems. Currently we have chosen Euclidean geometry in junior high school as an example, and plan to extend to other science subjects, the physics and chemistry in the future. Besides, we keep modifying the GUI in our system to be more friendly and interesting. We also plan to choose a junior high school to test our system and evaluate its performance.

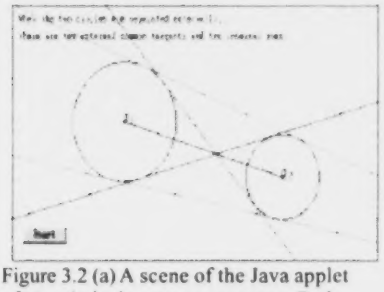


Figure 3.2 (a) A scene of the Java applet of two circles' common tangents. Red points are subject to dragging.

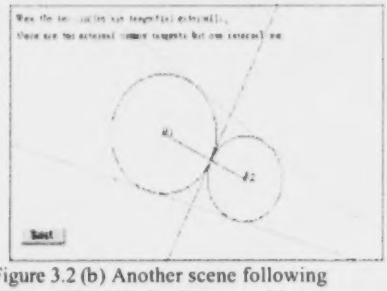


Figure 3.2 (b) Another scene following Figure 3.2 (a). Red points are subject to dragging.

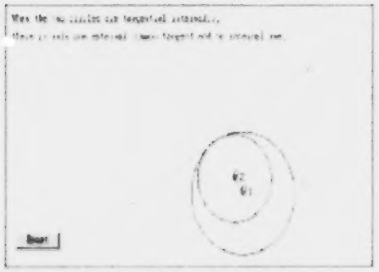


Figure 3.2 (c) Another scene following Figure 3.2 (b). Red points are subject to dragging.

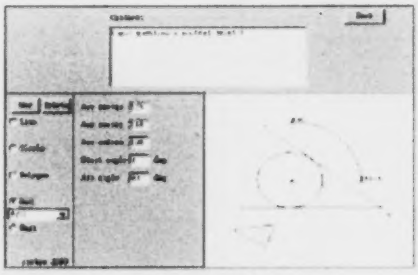


Figure 3.3 Test problem editing part of the examination module.

BEST COPY AVAILABLE

References

[1] The concept mapping homepage, http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm.
[2] Mathematics resources center, National Normal Taiwan University, http://mathsup.math.ntnu.edu.tw/.
[3] Knudsen, "Java 2D Graphics' ', O' Reilly, Cambridge, Massachusetts, (1999).
[4] Arnold and Gosling, "The Java programming language' ', Addison-Wesley, Reading, Massachusetts, (1998).
[5] Deitel and Deitel, "Java : how to program' ', Prentice Hall, Upper Saddle River, New Jersey, (1997).
[6] Reese, "Database Programming With JDBC and Java' ', O' Reilly, Cambridge, Massachusetts, (1997).

A study of collaborative teaching for creative learning in an engineering class

Jiunn-Chi Wu*, Pei-Fen Chang, Shu-San Hsiau*** and Tse-Liang Yeh******

Dept. of Mechanical Eng., National Central University, Chung-Li, Taiwan

**Tel: +886-3-4267335, junwu@cc.ncu.edu.tw*

****Tel: +886-3-4267341, sshsiau@cc.ncu.edu.tw*

*****Tel: +886-3-4267339, tlyeh@cc.ncu.edu.tw*

***Center for Teacher Education Program, National Central University, Chung-Li, Taiwan*

***Tel: +886-3-4227151~3853, pfchang@cc.ncu.edu.tw*

We synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of creativity knowledge and skill via web courseware. This paper discusses three main themes of creative learning: 1) the effectiveness of collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via creativity contest and design project. Several findings were observed based on qualitative evaluation of this class. First, the most rewarding course topics identified by the students is the creativity contest and design project because it provides ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, adapting dissimilar teaching style of our collaborative teaching generated anxiety to a number of students, which suggest the structure and sequence of the course development are need to be modified in order to fit students' level of capacity and readiness. Finally, we have demonstrated how problem solving and engineering design procedures can be closely integrated and taught, and what are the necessary knowledge and skills to enhance students' ability to become creative as well as effective problem solvers.

Keywords: **Collaborative teaching, Creative learning, Web-based learning**

1 Introduction

Creativity is inherent and a native intelligence. Many studies, show that the creative cognition can be trained and learned [1, 2]. Therefore, proper education and nourishing environment can foster creativity. *Creative problem solving* (CPS) is referring to use creativity or creative thinking for problem solving, which is a learning model being actively studied [3, 4]. It helps student use systematic method to solve a complex and realistic problem, possibly with multiple solutions. Students brainstorm to generate all possible solutions, categorize and evaluate solutions, develop implementation plan, and finally execute the plan [3]. CPS emphasizes the practice of creative thinking, implementation of creativity, and stresses on the creative leaning process. It can be regarded as a learning model for knowledge synthesis.

It is our responsibility and challenge as teachers to educate student who will be able to succeed in the high-tech environment. To educate students to cope with the rapidly changing world, they must not only to actively acquiring new knowledge, but also to have the skill of creative problem solving. In reflecting such responsibility and challenge, the course of "*Open-ended Creative Mechanical Engineering Design*" was offered in Department of Mechanical Engineering, National Central University for the last three years. The spirit of this course is asking students use their creativity to work as industrial engineers, form several mission-oriented teams, communicate and cooperate with other people, and deal with real industrial open-ended problems.

We wish to demonstrate how problem solving and engineering design procedures can be closely integrated and taught and what are the necessary knowledge and skills to enhance students' ability to become creative

as well as effective problem solvers. Hence, we synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of CPS knowledge and skill via web-based courseware. An integrated web-courseware [5] is constructed for above purposes. In the following sections, four main themes in our study will be introduced: 1) the collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via contest and design project.

2 Collaborative teaching and course modules

2.1 Collaborative teaching

Based on the experiences for the past three years, we perceive the need for professionals from other disciplines to stress the importance of communication as well as teamwork skills for engineering students. More importantly, a scientific evaluation of the course and its effects on the students' learning of creativity must be done in cooperating pedagogical experts with engineering ones. The analysis of student outcomes can give information about the success of the innovative course in achieving our objectives.

But the question is: how can professors with engineering background to integrate their technical knowledge with an educational-oriented perspective? Engineering faculties may understand the cognitive and emotional conflict that students encounter, but couldn't verify their teaching approaches in order to take into account students' different learning styles. Besides, an engineering course taught by faculty of non-engineering background face a challenge of given students the new perspectives without accommodating the technology orientation of engineering students.

With above forethought, we propose and implement the collaborative teaching from four professors of interdisciplinary backgrounds: thermal/fluid sciences, mechatronics, education, and network-based learning. Collaborative teaching is a novel teaching approach, it allow teacher deliver lecture in a more efficient way and share mutual teaching experience, improve teaching deficiency, and understand learning difficulty of students. In devising the design-oriented courseware, besides compose the materials for hands-on creativity project, we also strengthen educational idea of cognitive psychology, learning strategy and learning evaluation. Such collaborative teaching team up with the expertise of education and engineering is hoping to build a nourishing environment for rising student's learning motivation, encouraging student to develop mature, diversified cognition and thinking, and then be able to perform higher level of creative thinking.

2.2 Course modules

The contents and modules (see Table 1) are designed to develop competence in mechanical engineering, creativity, and teamwork. Five major units are emphasized: 1) Introduction of creativity, 2) Basic principles of CPS process, 3) Hands-on learning activities to inspire creativity, 4) Engineering design process, 5) Creativity contest and design project. In the first one-third activities is centred on the development and inspiration of creativity and creativity education, and the next one-third of the units enable students to practice the creative mechanical engineering design. The last one-third of the activities finishes the implementation of creativity phase so as to show off student's imagination with the creativity contest and design project.

We use creativity contest and design project as a tool to enhance creative learning of students. One creativity contest is hold in every semester in order to incubate students' learning interest. It is all up to students to decide the material, procedures, requirements, and rules for the creativity contest with teacher's facilitation in order to develop the environment of freedom.

The design project could relate basic principles and concepts to real problems and to improve students' understanding, motivation and creativity [6]. Implementing a project is a way to encourage students to look deeply and laterally at individual topics and consider how they can be applied to real situation. They motivate students to confront both familiar and unfamiliar situations with confidence, providing a sense of achievement and satisfaction. Each team member is expected to be aware of the specific skills of others in order to achieve effective and collaborative working relationships. More importantly, each member needs to take other people's views into account.

3 Tools for fostering creative learning

We construct three tools to assist the creative learning process: 1) the creative activity board, 2) the search engine, 3) the engineering courseware of domain knowledge.

The creative activity board, which is a web-BBS, is employed as the main interface for creative activity. Students are encouraged to actively utilize their own web-BBS for discussing their design projects with teachers and with classmates. They can announce important messages (e.g., resource acquiring) and post their current executing status of their project. More importantly, this board can be used to share their ideas and problem-solving approaches at any times with anyone who is interested in the topic. For convenient discussion of the creative ideas via network, particularly in the format hand-made sketches or the design charts, a FTP (download/upload) function is added in this board. Every user can participate the creative activity through web. The evolution and implementation of creativity can be recorded and exhibited. Properly application of this board can encourage students' morale for continually performing their design projects.

Students may encounter many problems when they execute the design project. The related information may be found in the courseware of domain knowledge or discussed in the creative activity board. Through the search engine, students can find useful knowledge and retrieve information from the integrated courseware more effectively by using appropriate keywords.

The creative activity cannot be successful without domain knowledge as its foundation [7]. When students are working on their team design projects, they need to integrate their domain knowledge based on the previous courses. There are four course modules materials are integrated: 1) Machine Design Course, 2) Electric Circuits and Electronics with Laboratory, 3) Innovative Application of Engineering Software, 4) Creative Mechanical Design. See [8] for detail description of content of these course modules.

4 Results: interaction on the web-environment

In the beginning whether students invest themselves in the class or not, depends on the development of the feedback from teachers. We use the web-BBS as the interaction interface with the students. After each team reported their project status, we will comment their idea and improvement of design prototype. Next, their status report will be upload in the creative activity board, and allow peers to review and comment. Encourage and endorsement from peers and teachers goes to those active teams. All interactions on the web are transparent and will inspire student if teachers can give feedback just-in-time, and guide each team to post their suggestion. In this way, both students and teachers will not be trapped in the classroom, and once the obstacle is encountered, it can be posted in the web and then exchange message. The more people to view these obstacles, the more possibility for the problem can be solved. Since not only teachers can help, peers can assist too. This is what we observed in this class when student performing their design projects Positively and timely feedback from teacher and classmates enrich the value of the board.

We made surveys based on interviews, questionnaires, and articles of creative activity board. The most rewarding course content identified by the students is the creativity contest and design project because they provide ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, others are disturbed by the open-ended nature of the course materials. They claim that it is tiresome to cope with various teaching styles of four individual teachers. The evidence from our research also suggests that students' problem solving processes were affected by their understanding of the rationale of interdisciplinary course development. Therefore, teachers need to assist students to make their own links with the material they are engaging with in order to eliminate the negative impacts of the course content. For instance, increase the teaching topics involving mechanical hands-on activities might provide students more practice and appreciate the CPS process.

The issues of students' learning difficulties are complex and dependent on several factors, including course organization and development, the subject or topic being taught, teaching style, and students' expectations [9]. Although students see the new learning experience as an opportunity to broaden their scope, some others claim that the challenge of finding a design topic themselves was beyond their ability to manage. In order to set the stage for project design, our data showed that it is crucial that team members to accommodate each other and to devote their personal commitment. It is clear from our interview that failure to do so did

influence the students' motivation to finish the project.

5 Conclusions

We have created a learning environment that facilitates students' development of problem solving abilities, enhances their confidence for cooperative creativity, and finally, provides students knowledge and skills for mechanical engineering design. The collaborative teaching is a novel experience to both of teacher and our student. Each member contributes their expertise and become the tutor to the other members. More importantly, the effort of compromising one another on the process serves as a role model for their students to work cooperatively.

The results of this study suggested significant concern for the students' anxiety created by the need to meet the special requirements of four individual teachers. It leads us to speculate whether the structure and sequence of the course development are appropriate to the students' level of capacities and readiness. Rather than viewing these problems as collection of obstacles and difficulties, we believe that we can make a difference in the learning of our students and chose to conceptualize those dilemmas and challenges in a constructive guide. Hence, we are currently adopting a new teaching approach by dividing the class into expert versus observer groups. The emphasis of the approach is to take responsibility as a learner and to develop the ability to ask questions about the projects done by other groups. We also conduct a peer-evaluation to encourage student to evaluate each other's projects critically and objectively. We wish students to believe, as we did, that creative learning is within reach of anyone who is willing to exert himself and take responsibility.

Acknowledgement

This research work is supported by the Ministry of Education of the Republic of China in Taiwan under grant: Grand Project for Excellence, 89-H-FA07-1-4.

References

[1] Bransford, J. D. and Stein, B. S., *The ideal problem solver: A guide for improving thinking, learning, and creativity* (2nd ed.), New York: W. H. Freeman and Company (1993).
[2] Chance, P., *Thinking in the classroom: A survey of programs*, New York: Teachers College Press (1986).
[3] Sternberg, R. J., & Lubart, T. I., *Defying the crowd: Cultivating creativity in a culture of conformity*, New York: Free Press (1995).
[4] Lumbsdaine, E.& Lumbsdaine, M., *Creative Problem Solving*, McGraw-Hill (1995).
[5] CEdesign, http://lisant.src.ncu.edu.tw/cedesign/ (in Chinese).
[6] Blicblau, A. S. and Steiner, J. M., "Fostering creativity through engineering projects," European Journal of Engineering Education, vol. 23, pp. 55-65 (1998).
[7] Jonassen, D. H., "Instructional design models for well-structured and ill- structured problem solving learning outcomes," Educational Technology Research & Development, vol. 45, pp. 45-94 (1997).
[8] Hsiau, S. S., Wu, J. C., Yeh, T. L. and Tsai, S J., "The web-based learning environment for creative design course," Proceeding of 2000 Internatinal Conference on Engineering Education, Taipei, Taiwan, Aug .(2000).
[9] Pirrie, A., Hamilton, S. and Wilson, A., "Multidisciplinary education: some issues and concerns," Educational Research, vol. 41, pp. 301-314 (1999).

Content Outline	Learning Activities
Orientation to creativity	1. Introduce the importance of creativity to learning
Cognitive process of creative problem solving	2. Illustrate four stages of CPS skills
Thinking styles and contexts for developing creativity	3. Demonstrate pros and cons of various thinking style
Creative personality and teamwork experience	4. Film-viewing to illustrate the characteristics of creative people 5. Interview team members and identify their personality

Principles and strategies of lateral thinking	6. Analogy 7. Simulation activities
Conventional engineering design process	8. Discuss basic rules for invention 9. Apply rules to improve the design of commercial product 10. Brainstorm potential ideas for creativity contest via web
Problem solving in electric circuits and electronics (E&E)	11. Problem solving a case to illustrate the E&E concepts relate to project design
The creativity contest (by individual)	12. Peer-evaluate and select the top three most creative rubberband-powered vehicles
Research for proposal (RFP) of creative design project (by group)	13. Develop a RFP based on all information gathered 14. Oral presentation to class

Table 1 The course modules of the *CEdesign* web-class.

An approach to modeling an educational domain

Gennadiy ATANOV
Donetsk Institute of Social Education; DISO, Donetsk, 83000, Ukraine
E-mail: atanov@dongu.donetsk.ua

The paper develops a topic of construction of the normative student model. The subject student model is a part of it representing a sum of demands to the curriculum of the subject, to students' knowledge and skills, and a semantic model of the domain. The subject student models pick out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain. Examples in physics are given.

Keywords: **student modeling, domain modeling, knowledge, skills, semantics**

1 Introduction

A fundamental concept of modern didactics and pedagogical psychology is the student (learner) model. It arose within computer technologies of education and was provoked by the necessity to formalize our representation about students. Of course such representations had been worked out long before any appearance of computers, and definite formalization of them began together with didactics. But it is computer technologies that gave a new impulse to development of these representations, transformed them into an object of deep investigations, transferred to a qualitatively new level [8,9].

In the widest sense, the student model is our knowledge about a student. There are two sides here: (1) knowledge about how the student is, and (2) knowledge about how we want to see him/her. The first knowledge is determined by the way of analyses of student's behavior, and it is natural to call it a behavioral student model. It is changing together with the student's change therefore it is also called dynamic, or current, one. Mechanism of construction of this model is the cognitive diagnostics [9].

Knowledge about how we want to see students, that is, demands to their final state is a normative student model. As a rule, this knowledge is various. It consists of demands to personal qualities of future specialists, their professional qualities and skills, their knowledge and skills in different subjects, characteristics of their physical and psychological state, and so on. The final aim of teaching is achievement of such a state when the behavioral student model concurs with the normative one.

2 The subject student model

A part of the normative student model determining domain knowledge is a subject student model [3]. In knowledge engineering, it is called expert knowledge, or domain model [5,6]. The subject student model picks out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain, or a model of a subject. Let us note that if the dynamic modeling is quite a developed branch of Artificial Intelligence, the domain modeling is developed to a lesser degree. It is clear, as specialists in Artificial Intelligence, as a rule, are not the ones in any other domain.

Under knowledge they understand the main conformities to natural laws helping us to solve particular problems (production, scientific, economic, and others) [5]. Facts, concepts, algorithms, intercommunications, rules, strategies of making decisions, and so on make up knowledge. The pithy sense of the concept «knowledge» is that knowledge reflects our imagination about domains and expresses a system of concepts, as well as relationships and dependencies between them.

According to the classification, there is a division of domain knowledge into declarative and procedural ones.

The first is statements about properties of the subjects of a domain and relationships between them. The declarative knowledge is often called a factual one, and this reflects its essence very well. The procedural knowledge describes the order and character of the transformation of the domain objects. Its another appellation is rules. In our opinion, it is not quite right, as the declarative knowledge, giving relationships between the objects, is also rules. Thus the procedural knowledge is not simply rules but rules of transformation.

The final aim of instruction is formation of way of acting. The way of acting is realized via skills in the practical activity [7]. The mechanism of this is operation with knowledge (both the declarative and procedural) being displayed in the behavior of a person. Therefore, in a wide sense, skills are attributed to knowledge, namely behavioral one [9]. The procedural knowledge is realized in skills. And sometimes, skills are called the procedural knowledge but, as we could see, the term "procedural knowledge" has been already occupied. Definition "operation knowledge" reflects the essence of the things clearly and in the most unambiguous manner. Thus, the subject student model has to contain skills that are to be formed in the process of instruction. Let us call a list of such skills the operational subject student model.

The declarative component of the domain knowledge makes up a semantic part of it, namely the semantic student model.

One of the distinctive properties of knowledge is that it has a certain structure. It is very important, especially for the instructional material, to define its structure. It is well known that to master a portion of the instructional knowledge is to determine its place in the structure of the instructional material. Therefore, one of the problems while constructing the subject student model must be determination of the subject knowledge structure. Studying the structure of the instructional material is a theme of an independent important and deep investigation. The subject student model must give more or less extended ideas about what the subject knowledge is. Such ideas are an essential part of any curriculum. A usual way here is a thematic approach when themes are enumerated. Let us call a list of themes liable to studying the thematic subject student model.

In teaching, it is very important methodologically to determine which role either knowledge plays and which functions it carries. In other words, it is necessary to fulfil a functional structuring of the instructional knowledge. It can be done with the help of a list of functional rubrics. The functional knowledge will be determined in such a way. Within it, there is knowledge performing both nontransforming functions (for example, facts, conclusions) and transforming ones (algorithms, methods, instructions). The functional knowledge makes up the functional subject student model.

In such a way, we suggest a four component subject student model consisting of thematic, functional, operational, and semantic parts. Such a subject student model in physics is carried out at the physics and didactics of physics department of the Donetsk State University [1-3].

3 The thematic subject student model

The thematic subject student model has been well known for a long time. In essence, it is a usual curriculum of the course, its program. It is built just according to the thematic principle, sections and themes liable to studying are enumerated in it. The model reflects the structure of the course. The program can be worked out in detail to different degree but it is always neither knowledge itself, nor its content but its names. In fact, this is a define characteristic of the subject knowledge, some knowledge about the subject knowledge. Knowledge about knowledge is called metaknowledge. Thus, the thematic subject student model is a metaknowledge.

It is a natural and convenient model for planning and organizing the instructional process. The more, it is an obligatory normative document. Preparation of any course begins with its creation (that is, creation of the course curriculum). Nevertheless, it is excessively general to use it for diagnostics.

As a rule, knowledge in many computer tutoring systems is structured according to the thematic student model.

4 The functional subject student model

The functional subject student model shows which role either knowledge plays; and it is also metaknowledge. It has a define structure in the horizontal direction, which may be given with the help of some rubrics. The role of knowledge and its functions depend on a particular subject. For example, we picked out the following rubrics for physics courses: *concepts, wordings, laws, properties, consequences, conclusions, reasons, formulas, equations, models, methods, and algorithms* [3]. The rubrics have a filling that, nevertheless, also does not reflect semantic of the subject and is metaknowledge.

It is the subject student model that allows working out in details what students must know. Let us give an example from the molecular physics. Students have to know: definitions of the concepts: *mole, thermodynamic system, pressure, temperature, density, concentration, ideal gas, equation of state*, and so on; wording and consequences of: *Pascal's law, Maxwell's and Bolzmann's distributions, Kirchhoff's law*, and so on; deductions of: *the mine equation of kinetic theory, equation of the adiabatic process, law of atmospheres*, and so on.

5 The operation subject student model

As it was noted, the operation subject student model is a list of skills liable to mastering by students. Let us note that skills in education make up a hierarchical system [2]. It consists of five groups of skills: fundamental, methodological, general, inter-subject, subject. Subject skills take the highest position in the hierarchy of skills.

We pick out three classes of the subject physical skills: general, particular, and experimental. The general skills are, on the first hand, methodological ones. Spectrum of the particular skills is far wider, for example, there are more than 200 them in the list in physics. According to the contents of the instructional material, the following skills are picked out: *to find, to determine, to fix, to build, to obtain, to calculate, to compute, to estimate, to distinguish, to pick out, to sort, to take into account, to represent, to traverse, to decompose, to compose, to generalize, to put in practice, to use, to formulate.*

There is a fragment of the list of the skills below:

3.1. General skills

To analyze physical processes and phenomena, to estimate orders of physics magnitudes and determine essential factors, to build physical models, to build mathematical models of particular physical processes and phenomena, to determine boundaries of applicability of the models, and so on.

3.2. Particular skills

3.2.2. Molecular Physics and Thermodynamics

To estimate quantity of particles and their mass in particular conditions, to determine parameters of state of gas, to determine number of degrees of freedom and molecular mass of a gas and mixture of gases, to determine possibility of the use of the model of an ideal gas, to make use functions of distribution to find average values of physics magnitudes, and so on.

Experimental skills are divided into three groups: *to measure physical magnitudes; to reproduce independently physical phenomena and processes; experimental particular skills.*

There is a hierarchical structure of the subject skills corresponding to the development of the subject in instruction. Besides that all of them also have a definite structure in the horizontal dimension because they are complicated, or composed, skills. In order to master them, a wide spectrum of skills both of the lower levels and subject is necessary. For example, skill *to solve physical problems* is composed of ten simpler skills: *to pick out the necessary information from the condition of a problem to solve it, to code the condition of the problem in a word form, to draw a picture to the problem, to choice a rational method of solving*, and so on.

6 The semantic subject student model

Semantic knowledge in different subjects is contained in textbooks, other training literature. There are two parts in the content of any textbook: CON-1 and CON-2 [7]. CON-1 is knowledge making up the content of

a domain directly, CON-2 is knowledge attending the CON-1 (for example, knowledge from other subjects, interpretations, explanations, examples from life). In fact, it is the CON-1 that is the semantic knowledge of a domain. Nevertheless, this knowledge is not picked out especially, it is distributed all around the textbook, interacts with another knowledge, and is not formalized.

Semantic knowledge represents the declarative component of the subject knowledge as the procedural knowledge is realized in skills (operational knowledge). Thus to construct a semantic student model on the basis of a textbook, it is necessary to pick out domain facts from it and group them in a definite order. According to their structure, facts may be of a great variety. As a rule, they are compound ones. Nevertheless, elementary facts may be picked out that, appearing in different relationships, form the compound facts. General questions of representation of facts in instruction are considered in works [4]. For example, expression "*Translational motion is the motion that all the point of a solid body have identical trajectory*" is a compound fact as it can be represented as a set of the following elementary facts: (1) *a solid body moves; (2) all the point of the body have identical trajectory; some motion is called the translational one.*

One can easily see that the elementary facts do not carry any semantic loading of the domain although they contain domain terms. Only on gathering together in a compound fact they acquire some doma in sense. Such compound facts are finished thoughts and they are represented by finished sentences, or expressions. Let us call them the *semantic* facts. As a matter of fact, the semantic facts are a unit of the domain knowledge as smaller portions of it have no domain sense. The objects of the expression are concepts, phenomena, processes, laws, principles, theorems, conclusions, consequences, reasons, properties, rules, and so on.

It is the full set of the semantic facts that is the semantic subject student model. The order of their disposition is subordinated to the logic of the development of the course.

Such a semantic subject student model was firstly constructed in Gas Dynamics and than in Physics [1]. Those were very small brochures because there were no calculations, proofs, and explanation in them. Nevertheless, they contained all the statements of the courses. These brochures received the title *semantic synopsis*. As an example, there is a fragment from a physics semantic synopsis below:

3.1. The elementary work of a force is defined as the scalar product of the elementary displacement of the point of the force application.

3.2. The work of a force is defined as a line integral from the elementary work along the trajectory of the point of the force application.

3.3. The unit of the work is one joule that is equal to a work done by a force of one newton on a displacement of one meter.

In the opinion of instructors and students, the synopsis turned out an effective means while consolidating the instructional material, preparing to seminars. It helps to size up the structure of the instructional material, pick out and easily memorize the most essential its moments. It is very important that student remember them for a longer time.

The synopsis allows carrying out fast and regular control students' knowledge during a lecture. In this case, the expressions serve as a base for the open type test tasks being created by missing some keywords in the expressions. Students note a great value of the synopsis while preparing to the examinations when there is a danger do not pick out and master the main statements of the course.

Let us note that the semantic facts are distinctive rules as they define character of relationships between the elementary facts. In other words, they are rules according to which the elementary facts are connected between themselves. This circumstance stipulates possibility to represent the semantic knowledge by means of the production method. It is done with the help of rules of a kind "if A than B" where A and B are some facts. An example of such a representation of the above mentioned definition of the translation motion is given below:

If <*a solid body moves*> and
<*all the point of the body have identical trajectory*>
than <*such a motion is called the translational one*>.

Each of the expressions may be represented in such a way. Thus the production knowledge base of the subject will be constructed. Its constructing is considered in details in work [4]. As our practice shows, constructing production knowledge bases by students while learning is an effective kind of learning activity.

7 Conclusion

An approach to construction of the subject student model as a part of the normative one is described. The model consists of four components: thematic, functional, operation, and semantic. The thematic model gives ideas about the structure of the subject, the semantic one reflects its content, functional one determine what students have to know, and operation one does what students have to be able. The approach allows constructing more detailed current student models and reaching the main aim of teaching, namely forming the way of acting, more successfully.

References

[1] Atanov, G.A., Belaya, T.D., Beshevly, B.I., etc. "The base synopsis in physics". Kyiv, NMK VO, (1993) (in Russian).

[2] Atanov, G.A., Efros, T.I. "System of skills in instruction as a part of the learner model". Proc. of the Intern. Conf. on Computer Assistant Learning CAL-97. Exeter, UK, pp. 369-372, (1997).

[3] Atanov, G.A., Martynovitch, N.N., Tokiy, V.V. "Curriculum of Physics Course as a Student Model". Proc. of the Intern. Conf. on Computer Technologies in Education ICCTE'93. Kyiv, Ukraine, p. 138 (1993).

[4] Atanov, G. A., Pustynnikova, I. N. "Representation and Structuring of Domain Knowledge by the Semantic Networks and Productions Methods". Proc. of the 8th Intern. PEG Conf.: Meeting the Challenge of the New Technologies. Sozopol, Bulgaria,, pp. 392 - 393 (1997).

[5] Brachman, J., Levesque, H.J., Reiter, R. "Knowledge representation". MIT Press, (1992).

[6] Dean, T.L., Allen, J., Aloimonous, J. "Artificial intelligence: Theory and practice". Benjamin/Cummings (1994).

[7] Mashbits, E.I. "Psychological and pedagogical problems of computer assistant learning". Pedagogika, Moscow (1988) (in Russian).

[8] Self, J. "Dynamics of Learner Models. Artificial Intelligence and Education". IOS Press, Amsterdam (1994).

[9] Wenger, Å "Artificial intelligence and tutoring systems. Computational approaches to the communication of knowledge". Morgan Kaufmann, Los Altos (1987).

An Interactive Game System to Stimulate Word Associations

Naoko Niitsu*, Takeyuki Kojima, Bipin Indurkhya, Yoshiyuki Kotani
Tokyo University of Agriculture and Technology
Department of Computer Science, Tokyo, Japan
**E-mail : naoko@fairy.ei.tuat.ac.jp*

We present here an interactive game system designed to stimulate user's knowledge associations between words. The system is based on a word-association television game called "Himitsu no Tsunagari". This game uses two different words and an association word. Each player is given a word, and must guess the other word and the association word to win the game. Our system allows person-to-person matches and person-to-computer matches. We believe that our system stimulates the users' creativity and their ability to form associations. Our system also acquires knowledge of word associations from game records. As more and more games are played, the system's knowledge of associations grows, and so does its ability to compete with the user.

Keywords: **Educational game, Interactive learning, Knowledge acquisition, Word association.**

1 Introduction

Many games have been designed to enhance various human abilities. Saeki [8] has pointed out that educational software needs to motivate learners in order to attract and retain their attention. If only its appearance is attractive, learners tire of the software soon. One approach developed in our lab to motivate children is the "Instruction Assisted Computer" (IAC) paradigm [4]. In this paradigm, the system is given a passive role and the children are put in the driver's seat. The result is that the familiar roles of teacher and pupil are reversed, and it is the children who end up 'teaching' the computer. To date we have successfully developed and studied several different systems using this paradigm [3][6][8].

Associations between words and concepts form a major dimension of human knowledge. Stimulating these associations can greatly influence concept formation and increase one's problem-solving skill [1][9]. Models based on association networks have been used for vocabulary acquisition [5] [7], and many association word-games have been developed [2].

In this paper, we describe a system to play an association game called 'Himitsu no tsunagari'. This game requires the player to think of several concepts at once and look for associations between them. We believe that this stimulates various associations inherent in the user's knowledge. Our system allows a user to play with another user (on the web, so that two users do not have to be in the same place), or with the computer. It also has a knowledge acquisition module, which analyzes the associations created in each game. These associations are added to the system's knowledge base, and result in a gradual improvement in the system's performance. In the rest of this paper we describe our system and the results of our initial experiments.

2 A Brief Introduction to Himitsu no Tsunagari

Himitsu no Tsunagari is a television game show in Japan. It is an association game using two different words (called 'keys') and another word that is associated with both keys (called a 'link'). There are two teams and a judge. Behind each team, a key is hidden (see Figure 1), so that each team can see the opponents' key, but not their own. Neither team can see the link. The goal of the game is to find their own key and the link. Each team takes turn guessing answers based on the visible key and the past guesses of the other team. The judge provides an evaluation of each guess ('correct', 'close', etc.). For example, in the second row in Table

1, Team B can infer that their key is something "yellow" from Team A's previous answer

The associations between the keys and the link are not limited to those semantic or conceptual, but can be of any kind. For example, in Japanese "Niji" serves as a link between the keys "14 o' clock" and "rainbow" because both keys are homonyms of "Niji".

3 Design and Implementation of the system

Here we describe the interactive system for the Himitsu no Tsunagari game. We first describe the goals of our system. Then we explain the rules of the computer game, which are a little different from those of the TV game. Thirdly we present an outline of our system and discuss the relations among various modules. Fourthly, we describe the reasoning and knowledge acquisition modules in more detail. Finally, we describe the interface of our system.

Table 1. Flow of a game (Topic : keys - banana and strawberry, association - fruit)

Team	Visible key	Answer (Key)	Answer (Association)
A	Banana	Sunflower	Yellow
B	Strawberry	Lemon	Sour
A	Banana	Grapefruit	Fruit
B	Strawberry	Pineapple	Fruit
A	Banana	Raspberry	Fruit
B	Strawberry	Banana	Fruit

3.1 Design goals of the System

In order to allow many people to play and enjoy our system, we set the following design goals:

- The game can be played on the Web.
- The computer can be one of the players.
- The system has an easy-to-use interface.

3.2 The rules of the computer game

We clarified and added some rules to the TV game rules, as explained below.

- The game is played with two players and one judge
- At the beginning of a game, each player is given a key and the judge is given both keys and the link.
- The judge evaluates each guess as 'correct', 'near miss,' incorrect', or 'strange'.*
- Each player is allowed 90 seconds for making a guess.
- The game is finished when the judge declares the guesses of the key and the link as correct.

3.3 Overview of the system

The structure of our system is shown in Figure 1. There are five modules in it: game server, user interface, knowledge acquisition, reasoning module (making guesses), and knowledge database. The game server is responsible for sending the keys and the link to the players and the judge, and for passing messages (guesses and evaluations) between the players and the judge. The words used in the game and their associations are saved in the knowledge

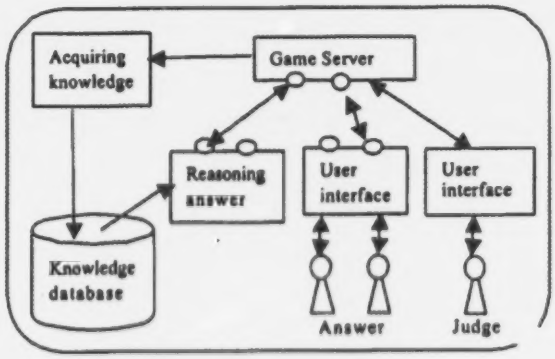


Figure 1. Structure of the system

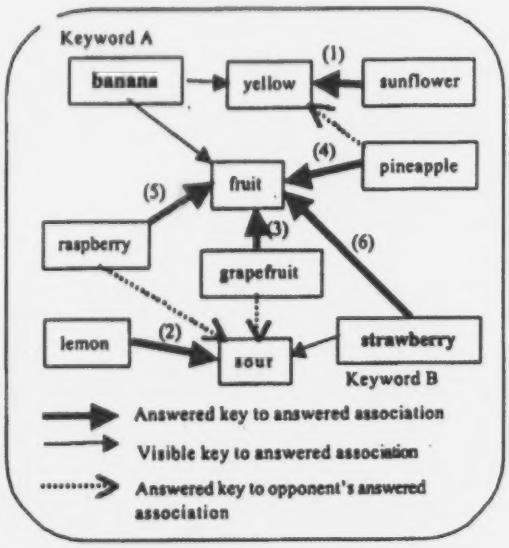


Figure 2. Association network from a game.

BEST COPY AVAILABLE

database. This knowledge is used to make guesses when the computer is one of the players.

3.4 Acquiring and Reusing Knowledge

We describe here our approach to acquiring knowledge about word associations from past games, and using this knowledge to make guesses in subsequent games.

3.4.1 Knowledge acquisition from past games

From the record of a game we can make an association network (Figure 2). It is difficult to say from the record which guesses of the opponent were useful for a player in making his or her own guesses. For example, when the opponent's guess seems quite unrelated to the visible key, a player may just disregard it. However, we assume that the link and the key in each player's guess are associated. We also assume that the link in each player's guess is associated with the key visible to that player. So we add <guessed-key, guessed-link> (➡) and <visible-key, guessed-link> (⟶) to our set of associations in the knowledge base. We call each of these pairs an "association pair", and the network created by all the association pairs an "association net".

3.4.2 Reasoning Module: Guessing the key and the link

As mentioned above, we assume that the link guessed by a player is associated with the visible key and the guessed key. For this guess we make two assumptions: the guessed link is correct or incorrect, and the guessed link has something to do with the hidden key. For example, if the opponent guessed "the key is 'apple' and the link is 'red'", and it was judged incorrect, a player can infer that the opponent's visible key (and the player's hidden key) is associated with red and the correct link is not "red". From these two pieces of information we can search for plausible answers in the association net (Figure 3). Every time the opponent makes a guess, the computer searches the association net and adds a certain weight to each plausible association pair. When it is the computer's turn to make a guess, it selects the association pair with the highest weight.

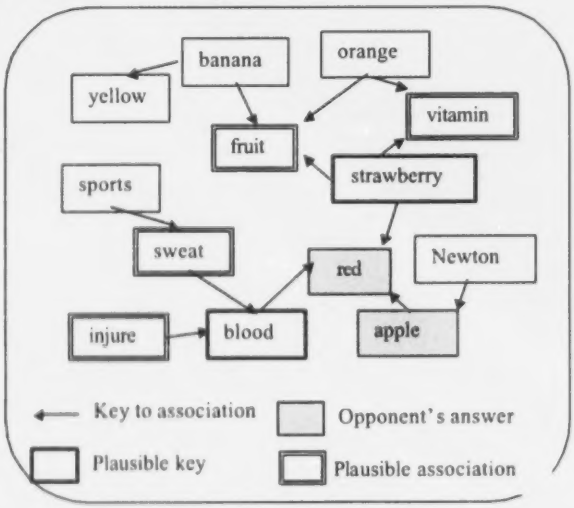


Figure 3. How to search for plausible answers

3.5 Interface

There are two displays, one for the judge and one for the players. They differ only in the input area. The player-interface displays the visible key and the history of the game (the player's guesses, the opponent's guesses, and the judge's evaluations), and has areas for entering the guessed link and key. The judge-interface is similar except for the input area. Instead, it has eight buttons (four each for the key and the link) at the bottom of the screen to evaluate the players' guesses. There is a time limit of 90 seconds, after which an answer is sent automatically.

4 Experiment

We tested our system with 10 undergraduate students in the Computer Science Department. In the beginning, we explained how to play the game with various topics and a sample game. Then subjects were matched to a computer to play the game using ten topics for two hours. Assistants judged the games. Subjects sometimes thought deeply and sometimes seemed to hit upon an idea quickly. We acquired about 1,400 answers. Here is a result of one game (see Table 2).

BEST COPY AVAILABLE

After playing the system, we let the subjects explain from which words they guessed the answers. We used their explanations to determine from how many words an answer was guessed • we call this the 'base-words number'. For example, "wiener" was guessed from "coffee" and "hotdog", so the base-words number is 2. The average base-words number was 1.4. This result shows that users try to consider more than one word in playing this game.

Table 2. An example, "Wiener & Twins". Both concepts also called "sohseiji" in Japanese

Turn	visible key	Key	Association
Computer	Wiener	American	Coffee
Suiject	Twins	Haliwood	Shuwalzneger
Computer	Wiener	Ketchup	Hotdog
Suiject	Twins	No	No
Computer	Wiener	Salami	Sausage
Suiject	Twins	Wiener	Sausage

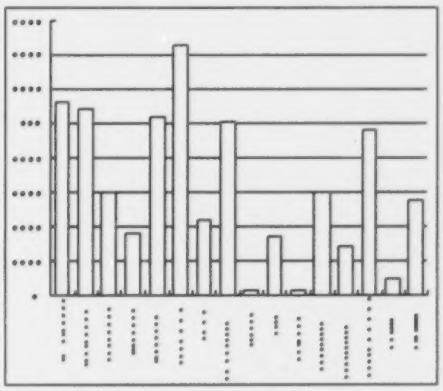
Some subjects tended not to answer within 90 seconds. Such subjects were found to have a higher base-words number than those who answered in time.

We categorized the associations into 16 groups (Graph 2), most of them from Togawa's classification. Superior, inferior, instance, synonym, same, emotion (<magic, muse>), character (<apple, red>), character2 (<Wright, airplane>), component (<sausage, pork>), inclusion (<apple, pineapple>), junction (<sun, flower>), place/time, phonic, verb, target (<knife, apple>), ellipsis (<wolf, liar>wolf boy lies a lot). Synonym was the most frequently guessed category. Ellipsis association represented 5% of the guesses. We think that playing with the system stimulates many kinds of associations.

We also gave a questionnaire after playing the game. In spite of its free answer form, most players answered that they enjoyed thinking and the moment of hitting upon an idea.

5 Conclusion

We described an interactive system using the Himitsu no Tsunagari game. In this game a user can play against either other users or a computer player. The computer uses the knowledge acquired from past games. It improved itself by acquiring knowledge from game records. Users tried to answer using associations to 1.4 words on average and in various categories. In addition, they said they enjoyed thinking about the answers in the experiment. We believe our system stimulates users' ability of associating words. Since many games were played, the computer acquired sufficient knowledge to compete well against users.



Graph 2 Categories of associations

References

[1] Entwisle, D.R., "Word associations of young children", John Hopkins Press, Baltimore, 1966.

[2] Kanasugi, T., & Matsuzawa, K., "The world of word-play", SIG-LSE-9903-S-4, 1999. (Special Interest Group on Language Sense processing Engineering of Japanese Society for Artificial Intelligence.)

[3] Kitajima, K., Nakagane, H., Inui, N., Kotani, Y., & Nishimura, H., "Knowledge acquisition oriented education system using a crossword puzzle", Proceedings of 54th National Conference of IPSJ, Vol. 4, pp. 299-300, 1997.

[4] Kotani, Y., "IAC – An education tool based on the paradigm 'the user is the teacher'", Proceedings of 'New Methods of Computer Usage in Education' Symposium, pp. 49-53, 1989.

[5] Meara, P.M., "Network structures and vocabulary acquisition in a foreign language", in P. Arnaud & H. Bejoint (eds.) "Vocabulary and applied linguistics", Macmillan, London, 1992.

[6] Otomo, A., Inui, N., Nose, T., Indurkhya, B., & Kotani, Y. "A building-block playing system using circles and squares to promote creativity in children", Proceedings of ICCE' 99, pp. 542-549, 1999.

[7] Rapaport, W.J., & Ehrlich, K., "A computational theory of vocabulary acquisition," in L. Iwanska & S.C. Shapiro (eds.) "Natural language processing and knowledge representation: Language for knowledge and knowledge for language", AAAI Press, Menlo Park (CA), pp. 347-375, 2000.

[8] Saeki, A. "The new computer and education", Iwanami books, Tokyo, 1997.

[9] Schwartz F., & Rouse R.O., "The activation and recovery of associations", International Universities Press, New York, 1961.

DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment

Ying-Dar Lin, Wen-Chun Sun, Chien Chou, Huan-Yun Wei
Department of Computer and Information Science
National Chiao Tung University
Hsinchu, Taiwan
Tel: +886-3-5712121-56667
Fax: +886-3-5712121-59263
E-mail: ydlin@cis.nctu.edu.tw

With the rapid growth of both computer technology and the Internet, conventional models of testing are gradually being replaced by CAT (Computer Assisted Testing) systems. However, the major problem in most CAT systems is the difficulty in refreshing and supplying test items. This paper presents a novel network CAT system, DIYexamer (Do-It-Yourself Examer). It has three features that differentiate it from existing CAT systems: student DIY items, item-bank sharing, and automatic assessment of item discriminability. DIYexamer accepts test items contributed form teachers as well as students, and allows limited item sharing between item-banks possibly maintained by different organizations. An algorithm is applied dynamically to assess the discriminability of items in item-banks in order to filter out less qualified contributions, hereby assuring the quality of stored items while scaling up the size of item-banks.

Keywords: **computer assisted testing, test evaluation, test acquisition, discriminability, distant learning**

1 Intorduction

With the continuing development of computer technology and the Internet, educators now have new alternatives for creating, storing, accessing, distributing and sharing learning as well as testing materials. Should testing be performed on or learned from computers, and then a computer can best assess the work, Bugbee (1996)[1]. Hence, assessing the learning achievements and attitudes of students via computers or networks becomes a challenging task for many educators and researchers.

A. Computer-assisted Testing Categories

Computer-assisted Testing (CAT) or Computer-based Testing (CBT), the use of computers for testing purposes, has a history spanning more than twenty years. The documented advantages of computer administered testing include reductions of testing time, an increase in test security, provision of instant scoring, and an individualized adaptive testing environment [2][3][4][5]. As listed in Table 1, three categories of CAT are currently employed: standalone packages, test centers and networked systems.

TABLE 1: Categories of CAT

	Network support	Item generator	Random item selection	Item source	Item quality assessment	Item-bank sharing	Test result analysis
Standalone package	No	Built in item-bank	Yes	Fixed	No	No	Yes
Test center	Yes	Expert	Yes	Limited	Yes	No	Yes
Networked system	Yes	Built in item-bank	Yes	Fixed	No	No	Yes

1) Standalone package: This type of computer software package is typically stored on disks or CD-ROMs. Some packages have built-in item-banks, while others require teachers to input test items. These CAT packages generally do not have network capabilities.
2) Test center: The test centers or lab services require dedicated computer terminals for testing purposes. Students are required to complete the computer-based tests at the centers. Well-known applications of this type of service are Graduate Record Examinations (GRE) and Graduate Management Admission Test (GMAT), as provided by Educational Testing Services (ETS) [6].
3) Networked system: This enables students to perform an examination through an Internet connection. Concurrent testing of multiple users, automatic score calculation, and automatic test result analysis are supported by a networked system. The major advantages of networked systems are the convenience of examinations and test result calculation. However, the major flaws are the limitation of the amount of items and no item discriminability assessment.

B. Problem Statement

Regardless of which CAT system is employed, a critical issue in developing CAT is the construction of a test item-bank. Traditionally, asking teachers and content experts to submit items generates the item-bank. Three major drawbacks of the traditional method can be observed:
1) Limitation of item amount: Teachers and content experts tend to have similar views on the test subject. That is, in a given field vital subject matter might be confined. Therefore, although more teachers and content experts are invited to contribute test items, the total number of distinct items remains low.
2) Passive learning attitude: Students are conventionally excluded from the creation of tests. In a typical computer-assisted testing system, teachers generate tests, the system presents test sheets and students then complete the tests. That is, within the system of testing, they play a passive role, and are not afforded the opportunity to conduct "meta-learning" or "meta-analysis."
3) No guarantee on item quality: Permitting students to generate tests may be a possible solution to the aforementioned problems. However, this raises a new problem: quality assurance and ensuring that the tests are worth storing and used for further tests. Even when the whole item-bank is contributed by teachers and content experts, ways to dynamically assess and filter test items are needed.

The rest of this paper is organized as follows. The three distinct features of DIYexamer are introduced in section 2. Section 3 describes how the DIYexamer was implemented and its functionalities for administrators, teachers, and students. The discriminability calculation formula is then presented in section 4. Finally, the accuracy of discriminability discretion of DIYexamer and conventional methodology are compared through a real-life test in section 5.

2 The Diyexamer Solution

The DIYexamer[7] is a Web-based multi-server system that allows students to contribute test items, and provides an effective means of verifying the discriminability of these items. Three main ideas are as below:

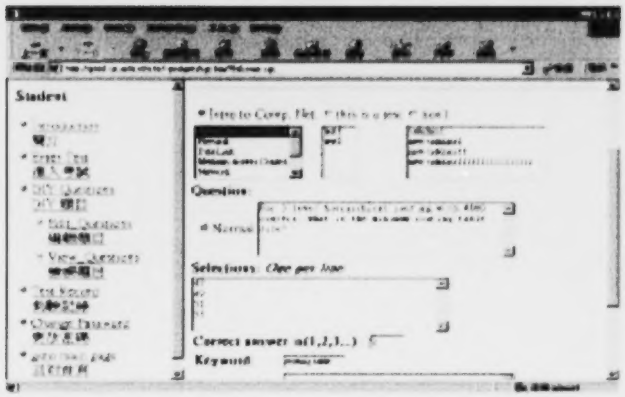


Fig 1: Students generate items into the item-bank

1) Item DIY by students: DIYexamer allows students to generate test items into the item-banks online as Fig 1. Teachers can query these items generated by students as Fig 2. In addition to rapidly increasing the total number of items in an item-bank, this feature also encourages students to develop *meta-learning*, i.e. *creative learning*. In order to submit tests, students must thoroughly study the learning materials, develop higher-level overviews of the materials, and practice cognitive and creative thinking.

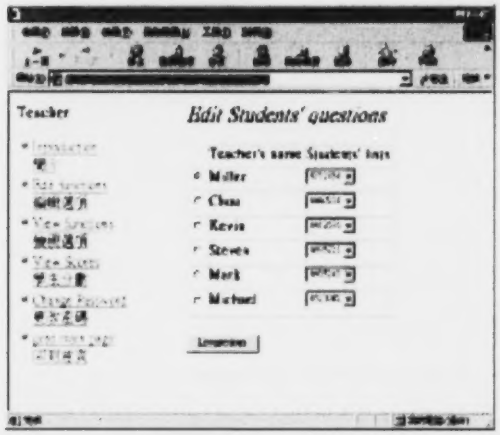


Fig 2: Student DIY items as queried by teachers

Fig 3: Average item discriminabilities of item-banks

2) Assessment of item discriminability: DIYexamer provides an item-discriminability assessment method to ensure the quality of the stored items. In addition to ensuring the internal consistency of existing test items, this method also continuously and dynamically screens additional new items in the item-bank. Fig 3 shows the average item discriminabilities of several item-banks.
3) Item-bank sharing: DIYexamer, a scalable multi-server system, connects many item-banks stored in different servers. Therefore, via the Internet, more items can be accessed and shared. The sharing is limited and controlled in a sense that a server issues a request, describing the criteria of a test item it requests, to another server. A server does not open up its item-bank for unlimited access.

Additional advantages have been identified and include the facts that since DIYexamer provides a real-time on-demand generation of test-sheet function, cheating is avoided. Also, DIYexamer provides an item cross-analysis function to which the degree of difficulty for each test as well as the entire test base can be accurately measured.

BEST COPY AVAILABLE

3 Diyexamer System Implementation

A. DIYexamer Network Architecture

DIYexamer is a WBT (WWW-Based Testing) system. An important feature is the sharing of item-bank via network connections. According to Fig 4, several DIYexamer servers form a *scalable test union*. Therefore, each server can access other servers and thus achieve item-bank sharing. A remote server can also join the test union to share additional test-bank resources, and leave the test union without affecting other servers.

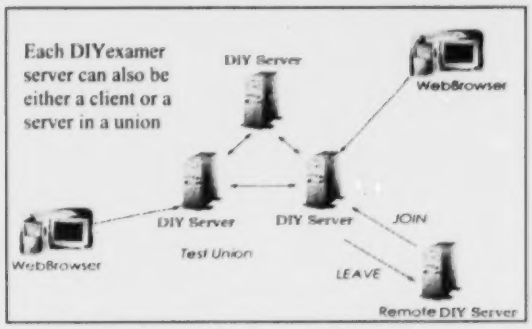


Fig 4: Network Structure of DIYexamer

B. Internal System Model

The internal architecture of DIYexamer (Fig 5) is divided into three layers. Interface layer is responsible for providing web interface for users. Test Profile Layer (TPL) selects items to form a test sheet, computes scores, and calculates the discriminability of selected test items. Test base Sharing Layer (TSL) accesses both local and remote databases via a network. Three functions of TSL are listed in Table 2:

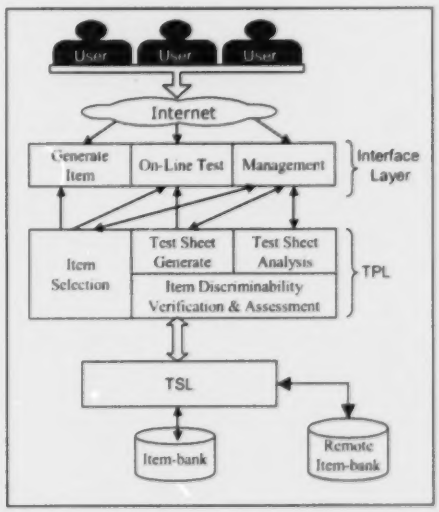


Fig 5: Structure of DIYexamer

TABLE 2: Functions of TSL

Function	Description
Add new items	New items and corresponding answers are categorized to specific chapters and stored in the local item-bank.
Access local item-bank	Accessing local while generating test sheets and calculating discriminability.
Connect to remote item-bank	Item-bank sharing through a connection to a remote item-bank.

Environments and development tools used to construct DIYexamer are listed in Table 3. Perl is used to write CGI programs to create user interface as homepage. Apache, an open source web server software, is responsible for front-end. The back-end, item-bank, is handled by Postgres.

TABLE 3: Environments and development tools

Function	Tools
HTTP Server	Apache 1.3.3 [8]
Programming Tools	Perl 5.003 [9] · CGI.pm-2.56 [10] · Gd.pn-1.14[11]
DBMS	Postgresql 6.5.3 [12]
O.S.	Red Hat Linux release 6.1[13]

C. Functionalities for administrators, teachers and students

DIYexamer provides a web interface for users to remotely control and operate the system. Three types of users are supported: administrators, teachers, and students. Corresponding functionalities are listed in Table 4.

TABLE 4: Functionalities for different users

	Administrator	Teacher	Student
System and Database	• Examine system status • Join a test union • Leave a test union • Create personal accounts • Create group accounts • Modify accounts • Modify item-bank • Redact course division • Backup database	• React course division	
Item production		• Create tests sheet • Select test items • Edit test items • Read test items	• Edit test items • Read test items
Test	• Network Invigilate	• Input scores of homework	• On-line test
Analysis	• Analyze tests • Analyze test items	• Analyze tests • Analyze test items • Analyze subjects and divisions	• Analyze tests
Inquiry		• Inquire tests • Inquire test items generated by students • Inquire students scores	• Inquire personal scores

4 Discriminability Assessment Of Diyexamer

A. Method of Traditional Discriminability Assessment

A criterion against which the quality of test items is judged is the assessment of discriminability. An item is regarded as with high discriminability when competent students correctly answered it, while less competent students incorrectly answered it, and vice versa. When computing item discriminability, those students with relatively high and relatively low scores are taken as samples. Those students whose scores fall in middle range not

considered. Next, item discriminability is computed according to the performance of these sampled students when answering each item.

In the traditional discriminability assessment method[14], those in the top 30% and the bottom 30% rank groups are chosen as samples. The top 30% scorers are defined as "high-rank group (H)", while the bottom 30% scorers are defined as "low-rank group (L)". The formula for calculating the discriminability of an item is as follows:

$$\text{Discriminability} = \frac{\text{The number of students in H that answered correctly}}{\text{The number of students in H}} - \frac{\text{The number of students in L that answered correctly}}{\text{The number of students in L}}$$

In the traditional method, two major drawbacks can be observed. The first one has something to do with whether the 30% is in terms of *count of students* or *range of scores*. The sampled students fall in the top 30% and the bottom 30% rank groups, i.e. in terms of *counts*. However, it is possible that these scores differ only slightly from the average score especially when scores are not wide-spread distributed, where many scorers should not be considered in computing the discriminability. Second, the effect on discriminability assessment by each student in either group is assumed to be the same. However, those students that received different scores have different degrees of tendency to correctly or incorrectly answer an item. For example, a sampled student who received 97 points should have higher referential value than a sampled student who received 80 points.

B. Method for DIYexamer's Discriminability Assessment

When selecting sample students, only those whose scores have large gap with the average score should be considered. Accordingly, those with the top 30%, in terms of range, scores are defined as "high-score group (H')", while those with the bottom 30% scores are defined as "low-score group (L')".

To show the different criteria and effects of choosing samples in the traditional method and DIYexamer method, Fig.6 depicts the score distribution in a test. In this example, the highest score is 92, the lowest score is 34, and the average score is 69. The "high rank score group" and the "low rank score group" are chosen according to these two methods. Take student X as an example, the score of X is 66, which differs only 3 points from the average score. The associated information of X should have little, if not none, referential value in computing item discriminability. However, X is chosen as a sample in the high rank group in the traditional method. This fallacy results from using rank group, in terms of count, as the criterion of choosing samples. In DIYexamer, X is not chosen since score group, in terms of range, rather than rank group is used. Only those with large gap with the average score are chosen as samples.

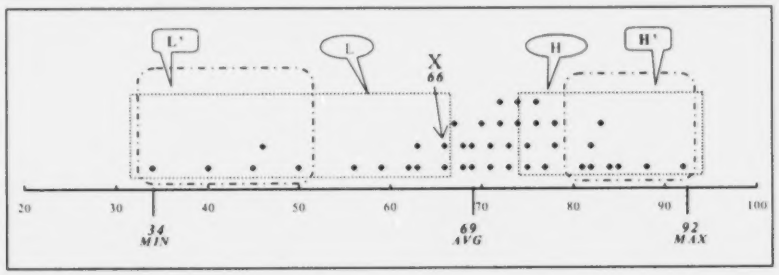


Fig 6: Comparison of samples taken in the traditional method and DIYexamer method

For different samples to have different impacts on discriminability, a referential value with respect to an item is generated for each student selected as a sample. We first define the item discriminability as the average of all associated referential values, as shown below:

$$\text{Discriminability} = \frac{\text{Sum of the referential values of sampled students}}{\text{Number of sampled students}}$$

Since the referential values depend on students' scores, the referential values are computed according to the ratio of correct and incorrect answers of the sampled students. The ratios of correct and incorrect answers are defined as follows:

$$\text{Ratio of correct answer} = \frac{\text{Number of items answered correctly}}{\text{Number of items on the test}}$$

$$\text{Ratio of incorrect answer} = \frac{\text{Number of items answered incorrectly}}{\text{Number of items on the test}}$$

TABLE 5: Principle to compute the referential value of a student with respect to an item

Student	Answer	Item discriminability	Referential value to compute discriminability
Competent (With high ratio of correct answer)	Correct	High	Ratio of correct answer
	Incorrect	Low	Ratio of incorrect answer
Less competent (With low ratio of correct answer)	Correct	Low	Ratio of correct answer
	Incorrect	High	Ratio of incorrect answer

According to Table 5, the referential value of a student correctly answered an item is the ratio of correct answer of the student. Alternately, the referential value of a student incorrectly answered an item is the ratio of incorrect answer of the student. This policy comes from the fact that an item should have increased discriminability if correctly answered by a competent student, while rendering decreased discriminability if correctly answered by a less competent student. In this way, a competent student contributes large referential value to a correctly answered item and small referential value to an incorrectly answered item, and vice versa.

C. Algorithm for DIYexamer's Discriminability Assessment

The test result of a student is used if the score falls in either the high or the low score group. A referential value is computed for each item the student answered. The discriminability of an item is the average of all of the associated referential values.

To calculate for each item, information must be recorded in the database. First, the highest and the lowest scores (i.e. Gmax and Gmin) of all students who answered the question item are recorded to calculate Gh and Gl. Gh and Gl are used as thresholds to determine whether a student is eligible to affect the rating of an item. Second, the number of students with referential values (i.e. n) and the sum of referential values (i.e. Accumulator) are recorded. The calculation formula and the corresponding definition of used parameters are listed below. Algorithm of DIYexamer's discriminability assessment summarized in Fig 7.

Accumulator: sum of referential values
n: number of students with referential value
T: number of correctly answered questions in this test
F: number of incorrectly answered questions in this test
Gmax: highest score of all students answered this question
Gmin: lowest score of all students answered this question
Gh: high threshold for ratio of correct answer
Gl: low threshold for ratio of incorrect answer
Ans: A Boolean variable indicates whether a student correctly or incorrectly answered the question

```
if((T/(T+F)>Gh) or (T/(T+F)<Gl))
{
 if (T/(T+F)>Gmax)
   Gmax = T/(T+F)
 else(T/(T+F)<Gmin)
   Gmin = T/(T+F)
 Gh = Gmax-(Gmax-Gmin)*30%;
 Gl = Gmin+(Gmax-Gmin)*30%;
 n = n+1;
 if (Ans==Correct)
   Accumulator = Accumulator + T/(T+F);
 else (Ans==Wrong)
   Accumulator = Accumulator + F/(T+F);
 Discrimination = Accumulator /n;
}
```

Fig 7: Discriminability assessment algorithm

5 Evaluation Of The Discriminability Assessment In Diyexamer

The fairness and performance of DIYexamer was evaluated. We conducted an experiment where 10 students took the test on-line using DIYexamer with 10 items. Table 6 summarizes the test results. Fig 8 shows the score distribution of the experiment. Discriminability for each item is computed using both the traditional method and the DIYexamer method. However, the discriminability originally falls between -1 to 1 using the traditional method, while falling between 0 to 1 using the DIYexamer method. To compare these two methods, both two ranges of discriminability are then normalized to 0 to 10, as shown in Fig 9.

According to Fig 9, the item discriminability differs in these two methods because the samples taken are different. The low-score group consists of student 1, 2, and 3 by the traditional method, while only 1 and 2 by the DIYexamer method. In this case, student 3 got 4 points, which differs from the average score (i.e. 5.2 points) by only 1.2 points. Since student 3 should have little, if not none, impact on the assessment of discriminability, student 3 is in fact not a proper sample.

Observe that, in Table 6, student 1 who is a less competent student and has incorrectly answered all items except item 1, and student 10 who is a very competent student and has incorrectly answered item 1. Thus, item 1 can be concluded as of low discriminability. Comparing the assessment results in these two methods, the computed item discriminability of item 1 is very low in the DIYexamer method but not as low in the traditional method.

Comparing item 3 and item 1 in Table 6, item 3 should have higher discriminability than item 1 because competent students tend to answer item 3 correctly and less competent students tend to answer item 3 incorrectly, which is not true for item 1. However, item 3 and item 1 have the same discriminability, i.e. 5, by the traditional method. In this case, the actual discriminability is more accurately reflected in the DIYexamer method than in the traditional method.

TABLE 6: Result of the test experiment

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Number of correct answers(score)
student1	1 (correct)	0 (incorrect)	0	0	0	0	0	0	0	0	1
student2	1	0	0	1	0	0	0	0	0	0	2
student3	0	1	1	0	1	0	0	1	0	0	4
student4	1	1	0	1	0	0	0	1	0	1	5
student5	0	1	0	1	0	0	1	1	0	1	5
student6	1	1	1	0	0	1	0	1	1	0	6
student7	0	1	1	1	1	0	0	1	1	0	6

student8	1	0	0	1	1	1	1	0	1	1	7
student9	1	0	0	0	1	1	1	1	1	1	7
student10	0	1	1	1	1	1	1	1	1	1	9

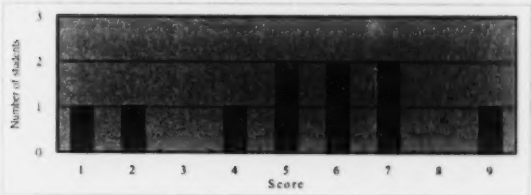


Fig 8: Score distribution of the test experiment

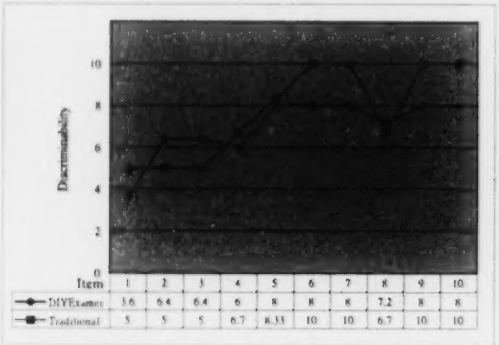


Fig 9: Comparison of item discriminability

6 Conclustion

This paper has presented a novel architecture for a networked CAT system, DIYexamer. It supports item DIY by students, item-bank sharing, and item discriminability assessment.

For discriminability assessment, new calculation formula were proposed. When compared with the traditional assessment scheme, the main difference is that the top and the bottom 30% of the *score* group, in terms of *range of scores* were selected rather than the *rank* group, in terms of *count of students*. Thus, item discriminability is more accurately reflected particularly when the tested students have close scores.

Item-bank sharing and item DIY by students has increased both the *amount* and the *variety* of questions in item-banks. Item DIY by students promotes *creative learning* within students, while automatic discriminability assessment assures better quality than traditional CAT systems.

A questionnaire was used to survey subjective attitudes of students about DIYexamer. As shown in Table 7, the outcome revealed that most students were interested in item DIY.

TABLE 7: DIYexamer questionnaire results: percentage and the number of students in parentheses of each question

Question	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Item DIY is interesting.	12.3 (7)	43.9 (25)	21.1 (12)	15.8 (9)	7.0 (4)
Item DIY is fanciful.	19.5 (10)	49.1 (28)	21.1 (12)	10.5 (6)	1.8 (1)
I am curious about the testing result of my DIY item.	26.3 (15)	59.6 (34)	10.5 (6)	3.5 (2)	0.0 (0)
I learned a lot when creating items.	12.3 (7)	47.4 (27)	22.8 (13)	17.5 (10)	0.0 (0)
I am curious about the teacher's opinion about my DIY item.	22.8 (13)	50.9 (29)	22.8 (13)	1.8 (1)	1.8 (1)
I am curious about other students' opinions about my DIY item.	15.8 (9)	56.1 (32)	21.1 (12)	7.0 (4)	0.0 (0)
I studied harder to prepare item DIY.	10.5 (6)	54.4 (31)	21.1 (12)	14.0 (8)	0.0 (0)
Judging the difficulties of my DIY items is easy.	40.4 (23)	38.6 (22)	14.0 (8)	7.0 (4)	0.0 (0)
Judging the fitness of my DIY items is difficult.	36.8 (21)	49.1 (28)	8.8 (5)	5.3 (3)	0.0 (0)
Item DIY by students comes from the laziness of teachers.	7.0 (4)	12.3 (7)	43.9 (25)	33.3 (19)	3.5 (2)
If possible, I hope such item DIY mode through the whole course can replace conventional testing.	1.8 (1)	10.5 (6)	35.1 (20)	38.6 (22)	14.0 (8)

BEST COPY AVAILABLE

Items generated by students are easier than by the teacher.	7.0 (4)	36.8 (21)	28.1 (16)	24.6 (14)	3.5 (2)
I knew more about the testing material after item DIY procedure.	8.8 (5)	50.9 (29)	22.8 (13)	15.8 (9)	1.8 (1)

The technique proposed herein is useful in general tuition not only to improve the quality of test items and fairness; but also to save time from generating questions and computing scores. We recommend that DIYexamer be popularized to schools.

ACKNOWLEDGEMENT

The authors would like to thank Tsung-shun Wu, Yi-Neng Lin, Chih-Hsuan Tseng, and Ding-Li Wang for the prototyping works of DIYexamer.

REFERENCE

[1] C. Bugbee, "The equivalence of paper-and-pencil and computer-based testing," J. of Research on Computing in Education, vol. 28, no. 3, pp. 282-299, (1996).
[2] C. V. Bunderson, D. K. Inouye, and J. B. Olsen, "The four generations of computerized educational measurement," in Educational measurement (3rd ed.), R. L. Linn, Ed. New York: American Council on Education—Macmillan, pp 367-407, (1989).
[3] S. L.Wise and B. S. Plake, "Research on the effects of administering tests via computers," Educational Measurement: Issues and Practice, vol. 8, no. 3, pp. 5-10, (1989).
[4] A. C. Bugbee, Examination on Demand: Findings in Ten Years of Testing by Computers 1982-1991. Edina, MN: TRO Learning, (1992).
[5] Load, F. M., Applications of Item Response Theory to Practical Testing Problems. Erlbaum, Hillsdale, NJ ,(1980).
[6] "Educational Testing Services Network", http://www.ets.org (accessed on Augest 22, 2000).
[7] "DIYexamer system", http://speed.cis.nctu.edu.tw/~diy (accessed on Augest 22, 2000).
[8] "Apache HTTP Server Project", http://www.apache.org/apache/ (accessed on Augest 22, 2000).
[9] "The Perl Language homepage", http://perl.com/ (accessed on Augest 22, 2000).
[10] L. Stein, "CGI.pm-a Perl5 CGI Library", Version 2.31, 2/8/1997, http://www-genome.wi.mit.edu/ftp/pub/software/WWW/cgi_docs.html (accessed on Augest 22, 2000).
[11] "GD.pm-Interface to Gd Graphics Library", Version 1.14, http:// www-genome.wi.mit.edu/ftp/pub/software/WWW/GD.html (accessed on Augest 22, 2000).
[12] "The Postgres95 homepage", http://s2k-ftp.cs.berkeley.edu:8000/postgres/ (accessed on Augest 22, 2000).
[13] "Red Hat Inc.,", http://www.redhat.com/ (accessed on Augest 22, 2000).
[14] Jacobs. L. C. and Chase, C. I., Developing and Using Tests Effectively: A Guide for Faculty. Jossey-Bass, San Francisco, CA ,(1992).

The Artistic Interface - A Transition from Perception to Screen

Peter D Duffy
Queensland University of Technology
66 Harts Rd, Indooroopilly, Brisbane, Qld 4068
p.duffy@kormilda.qld.edu.au

1 Introduction

At present a dichotomy of computer art instruction exists, where the computer as an art medium, presents the learner with almost limitless possibilities of image manipulation; yet instructional methodology and current art curriculum provide no coherent framework through which the learner can effectively access this information.

2 Research

Throughout the last five years the researcher has taught numerous art concepts and involved students in art tasks using the computer. The reality of the researcher's teaching situation is that the use of the computer within an art context is not debated, but accepted as a part of the everyday teaching process. After several years and testing different ways of approaching the teaching of computer programs several issues emerged which warranted further consideration:

1. Frustration exists due to the limited time that students had available to use the computer and the amount of information students were expected to utilize.
2. Many computer graphic programs are structured in similar ways (display a similar interface) and use similar symbols (icons) to represent functions within the program
3. Students seem unaware of these similarities and unable to transfer an understanding of one programs GUI (Graphic User Interface) to another computer graphic program.
4. Students appeared to have no mental map or problem solving strategies with regard to searching for answers to problems within a computer art environment.

These thoughts led to the intention within this research study which is to document the qualitatively different ways that students interact with the graphic user interface of computer graphic software in an art education context in order to create art.

It is hypothesized that students need to build some form of mental model regarding the software program they are interacting with in order to understand its application domain. That by examining the influence of different types of interface cues regarding navigation within a computer art context a greater understanding of students' conceptions regarding utilizing the computer as an artistic medium could be facilitated. Interface cues in this regard pertaining to the icons, layout and menus presented to the user. This is defined by the researcher as the Artistic Interface. This Artistic Interface is the interaction that occurs between the student's artistic intent and the graphic user interface of the computer.

The underlying art educational assumption here is that the clearer the mental model the student has, the more capable the student will be at understanding the program, at locating a specific function and achieving the desired artistic result. Within the context of this study it is postulated that students with a clearer mental model of the graphic user interface (GUI) will have a more effective art educational experience (a more effective Artistic Interface) when utilizing the computer as an artistic medium.

In order to develop this 'mental model' a phenomenographical mode of inquiry will be used. Roth and Anderson (1988) stated that they consider learning to be a change in one's view of some phenomenon. Also Marton (1992) suggested that: "In order to develop teaching methods that help students arrive at new understandings of a given phenomenon, we must first discover the finite ways individuals may understand that phenomenon. Then, through experimentation, we may discover the most effective ways to bring

students from a given conception to another, more advanced one, that is, from 'misunderstanding' to understanding." (p.253) Thus if students' conceptions of how they interact with the computer in an art educational context can be documented, then a learning framework could be developed which could enhance their understanding of the GUI of a particular program, and maybe other computer graphic programs.

3 Educational Considerations

Within a consideration of the influences of the GUI this study situates itself into the line of those devoted to the analysis of a possible correlation between the user's cognitive skills and his / her navigation abilities in an interactive, iconic, multimedia environment. This has been supported and further documented by Castelli, Colazzo, and Molinari, 1994; Elm and Woods, 1985; Osborne, 1990; Thuring, Hannemann, and Haake, 1995.

An effective analysis of students utilizing the computer in art education must begin with 'what is the student trying to do? Previous studies (Elm and Woods, 1985; Osborne, 1990) have demonstrated that getting lost is a consequence of the lack of a clear conception of the relationships within the system. In relation to this study this statement seems to imply that an effective use of the computer as an artistic medium depends upon the ability of the user to abstract from the system display discrete understandings relevant to the desired artistic result and that this may involve building a conceptual representation of a particular software programs GUI. It is further postulated within this study that if a learner can construct an effective mental map, or conceptual representation of a particular software programs GUI then this mental map maybe facilitate an easier and more effective understanding of another program due to the similarities in their GUI.

4 Conclusions

There is ongoing educational debate about the nature of the information society and the range of 'literacy's' needed to handle, understand, and communicate information in a variety of forms (Baker, Clay and Fox, 1996). The researcher has suggested that literacy in the information age requires not only the skills to operate the technology, but also the ability to identify and structure a line of inquiry in order to solve a particular problem. In this instance what is being analyzed is the range of 'literacy's' needed to form a line of inquiry into a computer art domain.

This research into the Artistic Interface is an attempt to document students' understanding of differing computer graphic arbitrary symbols (a software programs vocabulary) placed according to a systematic formula (a software programs grammar) to produce an understanding of various icons (pictograms used to represent a function of the computer). The researcher will seek to examine the qualitatively different ways that students understand the GUI in a particular computer graphic program and within a particular art educational context. This will involve a phenomenographical study that will lead to further understandings regarding students' perceptions of the Artistic Interface.

References

[1]. Baker, D.A., Clay, J., and Fox, C. (1996). "Challenging ways of knowing in English, maths and science". London: Falmer Press

[2]. Castelli, C., Colazzo, L., and Molinari, A. (1994). "Ht-Dedalus: Analysis of some models of hypertext performance". EC Newsletter, 6(1), 15 - 27.

[3]. Elm, W.C., and Woods, D.D. (1985). "Getting lost: A case study in interface design". Human Factor Society, 927 - 931.

[4]. Marton, F. (1992). "Phenomenography and "the art of teaching all things to all men"" Qualitative Studies in Education, 5(3), 253-267.

[5]. Osborne, D.J. (1990). "Browsing and navigation through hypertext documents: A review of the human-computer interface issues". Interactive Multimedia, 1, 3-32.

[6]. Roth, J.J., and Anderson C.W. (1988). "Promoting conceptual change and learning from science textbooks". In P.Ramsden (ed.) Improving learning: new perspectives. London: Kogan Page.

[7]. Thüring, M., Hannemann, J., and Haake, J. (1995). "Hypermedia and cognition: Designing for comprehension". Communications of the ACM, 38(8), 57-66.

Using Virtual Environments for Studying Water Phases and Phase Transitions

Jorge F. Trindade* and Carlos Fiolhais **
**Physics Department and High Education School for Technology and Management, Polytechnic Institute of Guarda, 6300 Guarda, Portugal*
E-mail: jtrindade@ipg.pt
*** Physics Department and Center for Computational Physics, University of Coimbra, 3000 Coimbra, Portugal*
E-mail: tcarlos@hydra.ci.uc.pt

In recent years, many studies have dealt with students' reasoning in science. Those studies suggested that pupils, in different degrees, have difficulties in understanding matter phases and phase transitions. To increase pupils understanding of phases and phase transitions, we are developing the "Virtual Water" project, a virtual environment centered on the learning of the structure and properties of water in its different phases. Within this environment, the molecular dynamics in the solid, liquid and gaseous phases of water and the corresponding phase transitions take place in three-dimensional space, with the possibility of haptic interaction with the molecules.

Keywords: **Virtual reality, virtual environment, water, phases and phase transitions**

1 Introduction

All substances undergo dramatic changes in their qualitative properties when certain parameters pass through particular values. Matter phases and phase transitions have received considerable attention in the framework of research on children's understandings in different ages and development stages [1-4], [10], [15].

Ice melting is an everyday example of a phase transition. When the temperature increases, keeping the pressure constant, the molecular vibrations become gradually more violent and thermal expansion occurs. Since this increase of vibration amplitude is gradual, one might expect that the macroscopic properties of water would also undergo a smooth change. While this is true for most temperatures, there is a well-defined temperature for which something dramatic happens: a sudden change in the properties of the substance and the appearance of a liquid. The liquid, in its turn and at a higher temperature, undergoes another phase transition going into a gas.

Few pupils use the corpuscular theoretical model taught in school to explain these processes. Indeed, their knowledge and understanding of the corpuscular theory of matter is sometimes very fragmentary. They apply it in some situations but not in others. For example, they may apply the corpuscular theory to explain gases but not to explain solids and liquids. There are also cases where pupils say that the shape and size of molecules changes when the state of matter changes: the shape of molecules depends on the shape of the vessel, molecules of solids are the biggest while gas molecules are the smallest for Portuguese children (13-15 years) [9], etc.

Other studies of students' conceptualization of phase transition from liquid or solid to gas have indicated that some children have difficulties conceiving gas as a substance [6] [12]. As students do not develop the general idea of gas prior to formal learning, the perceptual clues for detecting and identifying gases are weaker than for liquids and solids. Although pupils know some properties of air, they do not compare air with other gases, claiming that other gases do not have the same properties as air. A frequent explanation is that air is a big bulk system [11]. Gases are frequently linked by some invisible entity, something immaterial, for example energy in various forms. Kircher [5] also reports that high school pupils understand gases as a

continuous substance with no empty space between particles.

Since the use of images is a powerful tool for understanding complex and/or abstract information and since immersion in virtual environments is a recent technique which needs to be explored and evaluated, a virtual environment for studying phases and phases transitions is being developed by the Physics and Mathematics Departments of the University of Coimbra, Portugal, the Exploratory "Henry the Navigator", in Coimbra, and the High School for Technology and Management of the Polytechnic Institute of Guarda. We have named it "Virtual Water".

2 Overview of the Molecular Dynamics Virtual Environment

"Virtual Water" (VW) is a set of virtual environments designed to help in the instruction of high school students of Physics and Chemistry (it might also be useful for freshman university students). The main goals of this virtual reality application are:

a) To provide an educational environment for students to explore some microscopic concepts which they are taught in class.

b) To develop a practical knowledge concerning the application of virtual reality techniques to education, contributing with data on the usefulness of virtual reality [13-14].

The molecular dynamics component of VW is devoted to understanding some water properties and studying its phases and phase transitions by computer simulation. These simulations are based on the corpuscular theory of matter and use the equations of Newtonian Mechanics. We assume that the dynamics can be treated classically because more realistic simulations (incorporating quantum effects) are cumbersome and more computationally demanding. We also assume that the force between any pair of molecules depends only on the distance between them.

The interactions using *dataglove* allow the user to act and change the environment in order to distinguish the properties of solids, liquids and gases. The *cybertouch* system associated to the dataglove enables the user to experience some molecular behaviors that are impossible to feel in real world. For example, in the solid phase the user may fly through the ice structure and learn about it (Figure 1). Using the *dataglove* the user is able to break the ice and with the *cybertouch* system he can feel the increase of molecular vibrations with the temperature. While breaking ice may be a common macroscopic experience, watching the network of hydrogen bond and feeling molecular vibrations, for example, are quite uncommon experiences. On the other hand, in the liquid and gas phases, it is possible see and try to grab a molecule, understanding by direct experience that its speed is bigger than in the solid phase.

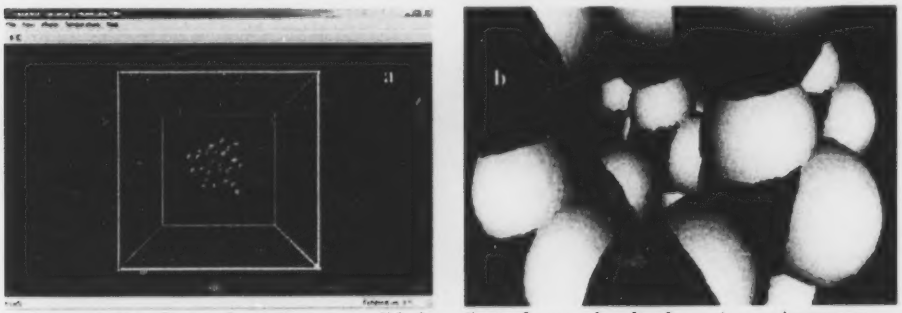


Figure 1: Two frames fro m the water solid phase (ice) of our molecular dynamics environment: a) balls model of a group of molecules; b) flying through the ice structure.

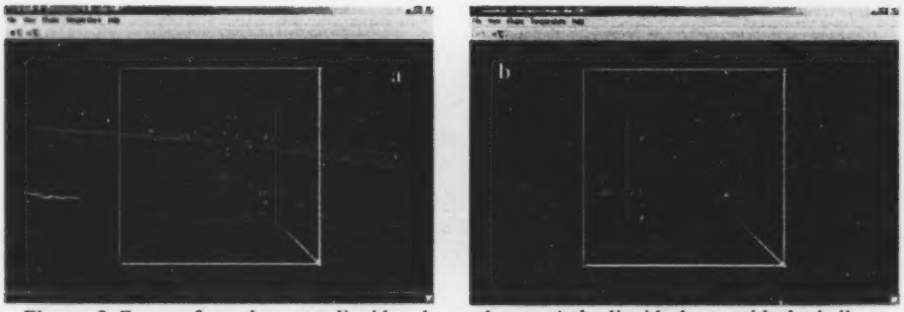


Figure 2: Frames from the water liquid and gas phases: a) the liquid phase, with the balls model of twelve molecules; b) The gas phase, showing the same molecules. These pictures, as well as those of Figure 1, were created with *PC Gamess*, *Molden*, *3D Studio Max*, being the dynamics implemented in *Visual C*$^{++}$on *WorldToolkit*.

Using balls models of water molecules the user may interiorize the corpuscular theory of matter. Since the molecular dynamics simulation takes place in a box (closed system) it is easy to understand that the molecules are the same in solid, liquid or gas phases. It is clear from our virtual environment that, in any phase of water, empty intermolecular spaces are present, these being smaller in the solid and liquid phases than in the gas phase (Figure 2). The density is different in the three phases.

For designing the VW models we used the free software *PC Gamess* [8], that performs the calculations on the water molecule, and *Molden* [7], for the molecular representations. For model development and optimization we used commercial software packages (*Mathcad* and *3D Studio Max*) and *Visual C*$^{++}$ for implementing the molecular dynamics algorithm. Concerning the definition and creation of the virtual scenarios we used *WorldToolkit* (from Sense8). For navigating in the virtual environment and interacting with our models we use a *dataglove* with *cybertouch* system (for haptic information) from Virtual Technologies.

3 Conclusions

Important strategies in teaching Physics and Chemistry are based on central the idea that matter consists of particles but the fact that these are invisible hinders sometimes the development by students of the right scientific concepts. However, the analysis and comparison of various results in the pedagogic literature show that some incorrect concepts and their relationships are simply transferred from the macroworld to the micro world. In fact, there is a firm link between the concepts on matter structure and empirical knowledge of macroscopic phenomena.

If students accept the corpuscular theory mainly for gases and not for solids and liquids, it is advisable to confront them with this contradiction and to treat specifically the processes of phase changes from gas to liquid, and *vice versa*, in terms of identity of substance, identity of particles and conservation of the number of particles. Similar procedure applies to students who accept better the corpuscular theory for solids.

The use of immersive virtual environments and haptic information, although recent, seems to be a powerful means for visualizing and understanding complex and/or abstract information. Actions like grabbing a molecule, breaking hydrogen bonds networks, feeling molecular vibrations, flying through channels in ice and through the empty spaces of molecules in liquid and gas phases (as in George Gamow's book "Adventures of Mr. Tompkins"), etc. are impossible in real world but possible in computer simulations.

"Virtual Water", our virtual environment for studying phases and phase transitions based on corpuscular theory of matter is promising to make progresses along the indicated directions. We are acquiring new means in learning and teaching the Physics and Chemistry of water and building knowledge on virtual reality techniques and tools, which can later be applied to other problems. In particular, our experiment with virtual reality should point out what are the most effective educational benefits and also to indicate the weaknesses of this new technology in an educational setting.

Feedback from pupils is being collected and analyzed in order to quantify the pedagogical usefulness of our

virtual environment. Of course, if these techniques prove to be successful, teacher's strategies should incorporate them. We hope that, with tools like the one we are developing, intangible experiments become more and more concrete and that this fact may facilitate the development of scientific models among science students.

Acknowledgements

The authors thank Prof. Dr. Victor Gil, from the Chemistry Department of the University of Coimbra, for his precious suggestions, and Prof. Dr. José Carlos Teixeira, from the Computer Graphics Center of the same University, for his technical advice. We also wish to acknowledge the assistance of the students Nuno Pereira and Eduardo Coutinho, who have developed the molecular dynamics component of "Virtual Water". This research was supported in part by the Portuguese Foundation for Science and Technology (project PRAXIS/FIS/14188/1998).

References

[1] Andersson, *B.*, "Pupils' conceptions of matter and its transformations (age 12-16)", Studies in Science Education, *18*, pp. 53-85 (1990).

[2] Driver, R. Squires, A., Rushworth, P. & Wood-Robinson, V., "Making Sense of Secondary Science - Research into Children's Ideas" (London: Routledge) (1994).

[3] Driver, R., Goesne, E. & Tiberghien, A. (ed.), "Children's Ideas in Science" (Milton Keynes: Open Universitv Press) (1985).

[4] Garnett, P., & Hackling, M., "Student's alternative conceptions in chemistry: a review of research and implications for teaching and learning", Studies in Science Education, 25, pp. 69-95 (1995).

[5] Kircher, E., "Research in the classroom about the particle nature of matter" in W. Jung, H. Pfundt and C. Rhoneck (ed.), in *Proceedings of the International Workshop on Problems Concerning Students' Representation of Physics and Chemistry Knowledge* (Ludwigsburg: Pedagogische Hochschule), 342-359 (1981).

[6] Lee, O., Eichinger, D. C., Andersson, C. W., Berkheimer, G. D. & Blakresle, T. D., "Changing middle school students' conceptions of matter and molecules", Journal of Research in Science Teaching, 30 (3), pp.249-270 (1993).

[7] Molden, a package for displaying MOLecular DENsity, written by G. Schaftenaar, CAOS/CAM Center Nijmegen, Toernooiveld, Nijmegen, The Netherlands.

[8] PC Gamess, a program for ab initio quantum chemistry, written by Alex. A. Granovski, Moscow State University.

[9] Pereira, M. P. & Pestana, M. E., "Pupils' representations of models of water", International Journal of Science Education, 13(3), pp.313-319 (1991).

[10] Pfundt, H. & Duit, R., "Bibliography: Student's Alternative Frameworks and Science Education", 4th ed. (Keil, Germany: Institute for Science Education) (1984).

[11] Sere, M. G., "Children's conceptions of the gaseous state prior to teaching", European Journal of Science Education, 8(4), pp.413-425 (1988).

[12] Stavy, R., "Children's conceptions of gases", International Journal of Science Education, 10(5), pp.553-560 (1988).

[13] Trindade, J., Fiolhais, C. & Gil, V., "Virtual Water, an application of virtual environments as an education tool for physics and chemistry". In *Advanced Research in Computers and Communication in Education*, Proceedings of ICCE'99 – 7th International Conference on Computers in Education, Chiba, Japan, ed. G. Cumming, T. Okamoto, and L. Gomez, vol. 2, pg. 655-658, (IOS Press, Amsterdam) (1999).

[14] Trindade, J., Fiolhais, C., Gil, V. & Teixeira, J. C., "Virtual environment of water molecules for learning and teaching science", Computer Graphics Topics, 5 (11), pp.12-15 (1999).

[15] Wandersee, J. H., Mintzes, J. J. & Novak, J. D., "Research on alternative conceptions in science". In D. Gabel (ed.), *Handbook of Research on Science Teaching and Learning* (New York: Macmillan), pp.177-210 (1994).

Proceedings

Content

▸Full & Short Papers (Educational Agent)

Agent-oriented Support Environment in Web-based Collaborative Learning
An Agent-Based Intelligent Tutoring System
Design of Systematic Concept Learning Model Using Computer Education Search Engine
Educational Agents and the Social Construction of Knowledge: Some Issues and Implications
Real-Time Handwriting Communication Systems for Distance Education and Collaborative Learning
Strange Creatures in Virtual Inhabited 3D Worlds

▲HOME

Agent-oriented Support Environment in Web-based Collaborative Learning

Tomoko Kojiri and Toyohide Watanabe

Department of Information Engineering,
Graduate School of Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8603, JAPAN

Phone: +81-52-789-2764, Fax: +81-52-789-3808
E-mail: {kojiri,watanabe}@watanabe.nuie.nagoya-u.ac.jp

Currently, the web-based learning support systems are one of interesting and hot topics in points of the utilization of Internet and the application of computers to education. In particular, the web-based collaboration is very applicable means to make unfamiliar students, who are unknown with each other, discuss together in the same virtual interaction space. However, there are some problems derived from the gap between the real world and virtual environment: coordination for discussions, cooperative reactions, comprehension of learning progress, etc. These problems may be dependent on the fact that the actions of students cannot be influenced from the behaviors of others directly.

In this paper, we address a coordination mechanism to promote cooperative actions/reactions for progressive discussions. Our idea is to apply an agent-oriented framework to this coordination mechanism and introduce two different types of agents. One is a coordinator and the other is a learner. The coordinator monitors the learning progress of group and promotes the discussion, if necessary, so as to reach their common goal successfully. The learners are assigned to individual students, and act as interaction mediators among students in place of the corresponding students. Of course, the coordinator is a passive entity and learners are active entities in our collaborative learning space.

Keywords: **Collaborative learning environment, coordinator, learning situation, learner, personal learning history**

1 Introduction

The fast and world-wide enlargement of Internet/Intranet has made it possible that every person can interact instantly without depending on their physical locations. Also, various applications, which are available on the web environment, have been developed with respect to the content-based resource sharing, in addition to the traditional message exchanges. The web-based collaborative learning is one of applications, based on such a hot topic, and has been applied as computer-support for virtual learning space. If their computers were connected mutually through the web-based learning environment, students can discuss their common solving process successively and exchange various solving methods/ideas cooperatively. However, there are some problems to encourage activated discussions among students and make it possible that individual students should understand the correct answer and solving process effectively:

1) students may not participate into the discussion interactively because of their hesitation, derived from the fact that they are unknown with each other;

2) students cannot grasp the behaviors of others directly or indirectly because only the direct actions and reactions are observable through the interactive interface.

These problems are radical drawbacks for collaborative learning.

In order to solve these drawbacks effectively, we propose an agent-oriented support environment for collaborative learning. Of course, the agent-oriented frameworks for the construction of collaborative

learning mechanism/environment have been already investigated until today. Florea[1] proposed a multi-agent collaborative learning environment in the web world. In this environment, three kinds of agents were introduced: personal agent which gets the information according to the requests of each student, tutor agent which generates advices when personal agents asked for the help, and information agent which acquires more information from Internet. Agents are activated by students' requests so that this system environment does not benefit passive students. Ogata, et al.[2] proposed mediator agents in the collaborative learning environment which assist students to find suitable collaborators. The mediator agent for each student holds the corresponding students' profile which indicates the understanding and interesting degrees about knowledge. When a student has problems, his/her mediator agent asks other mediator agents for the learning situations of their corresponding students and specifies appropriate students who may be able to help solving the problems. This research copes with the above problem 1) indirectly because this functionality supports to arrange appropriate learning group, but does not manage the progress of collaborative learning. Nakamura, et al.[3] and Liming, et al.[4] introduced respectively pseudo students which correspond to individual human students. These pseudo students have the same knowledge as the corresponding students and participate in the discussion in their ways if the corresponding students do not join in the discussion positively or cannot understand the discussion stage. These research viewpoints focus on passive students such as problem 1), but do not solve the problem 2). So, in spite of these various agent-based investigations, the previous drawbacks are not always overtaken.

In this paper, we address a collaboration learning environment, organized systematically under two different types of agents: coordinator and learner. The coordinator takes roles to monitor the discussion situation among students, grasp the learning progress and guide the learning process if necessary. The learners are virtual students corresponded possibly to individual students in our web-based collaborative learning environment. The coordinator and learner are complementary entities in the learning environment: the coordinator is a passive entity; and the learner is an active entity as the autonomy for practically participated student. In our investigation, we expect the collaborative learning of high school students who study mathematical exercises together, especially computation for the roots of equations. First of all, we show an overall framework of our collaborative learning environment in the web-world in Section 2. The functionalities about two different types of agents are stated in Sections 3 and 4, and then our prototype system is shown in Section 5. Finally, we conclude our paper in Section 6.

2 Collaborative Learning Environment

In the web-based collaboration learning environment, the actions/reactions of participated students are inherently different from their behaviors to be performed in the real world. Students in the physically constrained learning space can speak with each other by means of face-to-face, feel/recognize activities, occurred from the discussions of students, directly by various sensitive receptors and find out some new events/facts indirectly. Although these are not always implemented adaptively in the web-based virtual learning space, it is necessary to organize a collaborative learning environment in which the logical activities for support of interaction, discussion and comprehension can be implemented successfully and effectively.

Figure 1 shows our collaborative learning environment conceptually, which is characterized by two different types of agents: coordinator and learner. The coordinator places on the center of our virtual classroom (as a network server), monitors the interaction among students and generates advices if necessary according to the learning situation. This interaction is supported on the conversation means through the public communication line. The learner is a pseudo student in our virtual classroom and is assigned to the corresponding student one by one. The learner takes roles of the personal management of interaction interface for the corresponding student, the handshaking control of public communication line, the management of its own private learning history, and so on. In addition, the learner can communicate with other learners directly through the private talking line in order to exchange their personal learning histories.

Since students are studying with limited learning tools in the virtual web-based learning space, they sometimes do not able to communicate naturally. Furthermore, various students participate in the learning group and the learning process is not always completed successfully: i.e. some students are not able to solve the problem, some students are not able to understand the derived answering process after all, and so on. The coordinator solves such drawbacks in the virtual web-based learning space by managing the learning situation globally: the coordinator takes a place of teacher in our classroom activity. For the purpose of resolving inappropriate learning situation stepwisely and guiding

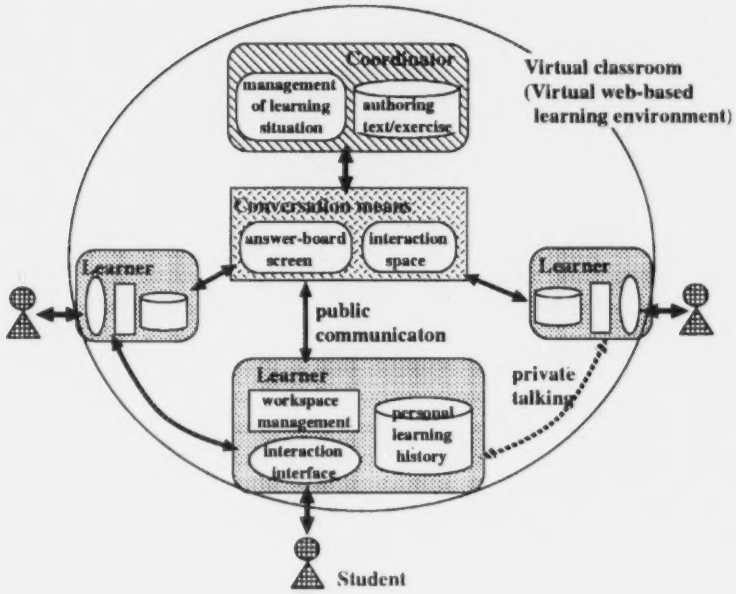


Figure 1: Collaborative learning environment

the learning group effectively, how to model and control learning situation is an important subject. If the coordinator grasps the learning situation appropriately, the advices which were generated from it may give appropriate hints in order for the learning group to proceed to the next phase of learning process. However, it is not always necessary to model the learning situation in detail precisely. This is, we think, because among the learning group students are able to help each other by discussion, so that the coordinator only has to detect the situation which the learning group cannot proceed the learning by itself.

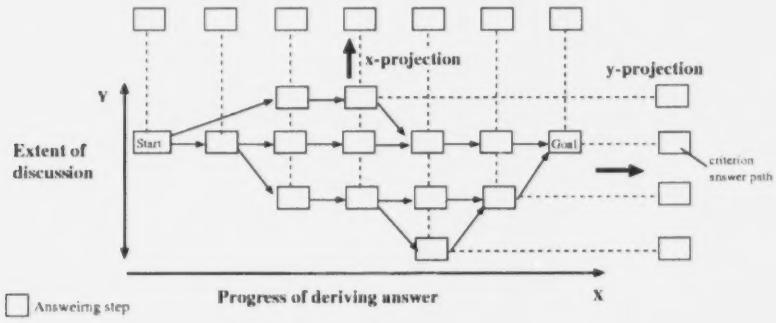


Figure 2: Answer space

The coordinator holds the right answer and the answering paths for an exercise as a knowledge to grasp the current learning situation. When the exercise has several answering paths for the goal, the answer space of exercise is expanded as 2-dimensional network structure, in Figure 2. In this figure, the learning progress along x-axis means the stepwise progress of deriving answer, whereas that along y-axis shows the extent of discussion. If the coordinator grasps the learning situation on the basis of the answering process of network structure as it were, it is very troublesome to manage the eventually

BEST COPY AVAILABLE

changeable conversation stages successively. Therefore, our coordinator manages the learning situation with respect to the following two viewpoints separately: ratio of derived step for a whole answering process and extent of discussion. By monitoring the learning situation under these points of view, the coordinator is able to grasp the learning situation easier and generate advices timely. In particular, it is necessary and sufficient to manage the learning situation of group globally, but not individually do that of each student.

The learner acts as a network client in place of the corresponding human student in the virtual web-based learning space. This provides not only the interaction interface for virtual learning space attached to the corresponding student, but also the function of indirect interaction among students, so as to judge the understanding levels or personalities of them, which we call the focus function. According to the focus function, students select the opinions of particular students whom they evaluate as key students. In order to realize the focus function, the learner needs to have the knowledge about the corresponding student and exchange it with other learners. Therefore, the personal learning history is prepared for learner, which represents understanding level and personality of corresponding student. The learner constructs and maintains the personal learning history according to the current situation. Exchange of personal learning history is one-to-one interaction so that public communication is not necessary for the focus function. Therefore, we introduce mobile agents called mediators as children of the learner, that take responsibilities for the exchange of personal learning histories among learners. The mediator moves among learners by requesting/carrying the personal learning history on the private talking line.

3 Coordinator

The coordinator grasps the learning situation from two viewpoints: ratio of derived step for a whole answering process and extent of discussion. For the ratio of derived step, which corresponds to the x-axis of answer space in Figure 2, we have already proposed the resolution derivation scenario which represents the phases of deriving answer stepwisely [5, 6, 7]. The scenario is generated by means of projecting the answer space onto x-axis and consists of ordered states which correspond to individual phases of deriving answer. Grasping an approximate learning situation makes it possible that the coordinator generates advices timely and effectively because each state corresponds to the individual ratio of derived step. On our scenario structure, the current learning state is pointed by the indicator *current*, which points out the currently discussing stage. The coordinator infers the current state from student inputs and moves the indicator to the corresponding state. However, the utilization of only one current discussion indicator is not enough to manage the learning state of group sufficiently. In addition to *current*, indicators *upper* and *lower* are prepared for the representation of current understanding levels of learning group. *Upper* points out the state of understanding level which is estimated that best understanding student reached to and *lower* points out the state of worst understanding student did. The coordinator is able to grasp the learning situation on the basis of the relationship among these 3 indicators (Figure 3).

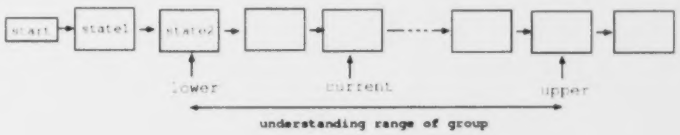


Figure 3: Resolution derivation scenario and indicators

On the other hand, the extent of discussion is estimated by the number of derived answering paths with different discussion viewpoints. The difference of discussion viewpoints among answering paths is defined as the ratio between common and uncommon answering steps. That is, if two answering paths contain large number of answering steps as common part, they are regarded as more similar paths; but if they have many different answering steps, they are judged as different paths. Common answering steps means that the answering methods which are used to derive those steps are the same. Once two answering paths were diverged, the following answering steps may be derived based on different answering methods so that they are regarded to be uncommon. From such viewpoint, the coordinator holds an answer tree which was transformed from whole answering paths as a tree structure. Figure 4

shows the construction of answer tree, derived from the answer space in Figure 2. The answering steps after the divergence are regarded as uncommon steps so that they are copied as different objects(Figure 4a). Then, the answer tree is transformed by means of collecting common answering steps for the purpose of grasping the difference among answering paths. The nodes in the tree are generated as a collection of answering steps that are common to particular answering paths and the path from root node to particular leaf node corresponds to each answering path. When the answer has been derived, the coordinator specifies derived/underived answering paths, calculates the differences between the derived answering path and other answering paths based on the answer tree, and estimates the extent of discussion.

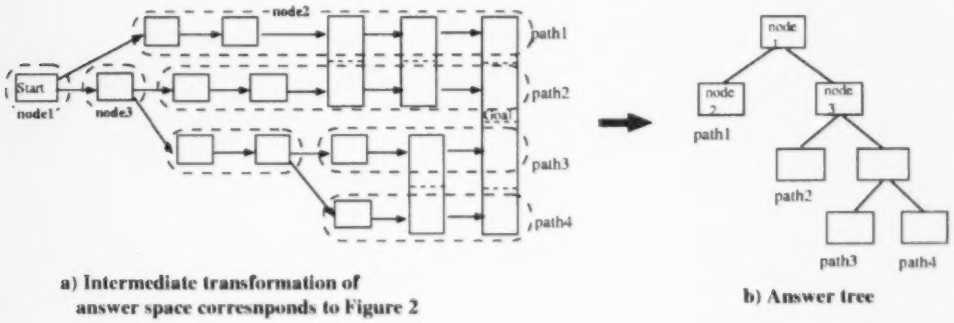


Figure 4: Construction of answer tree

By grasping the learning situation from these aspects, the coordinator is able to handle the changeable learning situation and generate appropriate advices at the right time.

4 Learner

The learner is situated on each student's computer and acts as a pseudo student in the virtual web-based learning environment. The learner provides the interface to the human student and controls the private talking among students such as focus function. Since the learner connects the private talking line according to only corresponding student's request, it behaves independently with the coordinator that manages the public communication.

A personal learning history is the model of corresponding student which is held by the learner. The personal learning history represents the understanding level and the characteristic of corresponding student. Some data of personal learning history are prepared by the human student beforehand and others are gathered by the learner occasionally through the learning. Currently, the picture and utterances of students are collected as a personal learning history. The feature of student does not change through the learning, so the picture is set by each student before the learning starts. Utterances indicate the understanding level of student and also attitude toward the learning; i.e. active or passive, understanding or not-understanding, and so on. They are gathered and added to the personal learning history by the learner when corresponding student send their opinions to the public communication line.

In order to exchange the personal learning history through private talking line, the learner generates mediators for each communication. The mediator is constructed as a mobile agent which processes its tasks while moving through the network autonomously[8]. Figure 5 shows the movement of mediator for acquiring the personal learning history of other students. When the corresponding student requests to get the personal learning history of particular students, the mediators are generated by the learner respectively. Once generated, the mediators move to the target learners through the network and ask for the personal learning history, attended inherently to the target learners. After the acquisition of personal learning history of target learner, the mediators move back to their original learner and disappear autonomously, since their roles are to acquire the personal learning history from target learners. Under such mechanism, students are able to know other students' characteristics even in our virtual web-based learning environment without any direct interaction.

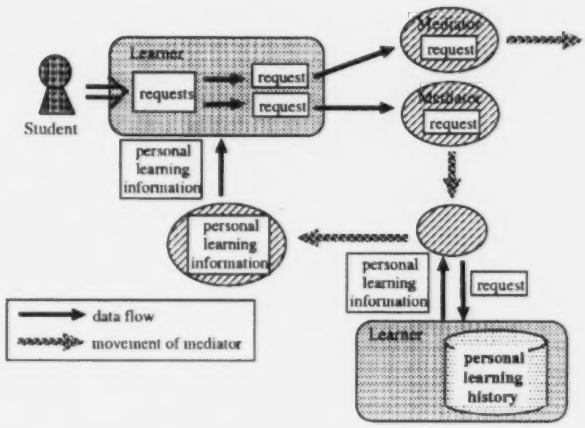


Figure 5: Mechanism for acquiring personal learning information

5 Implementation

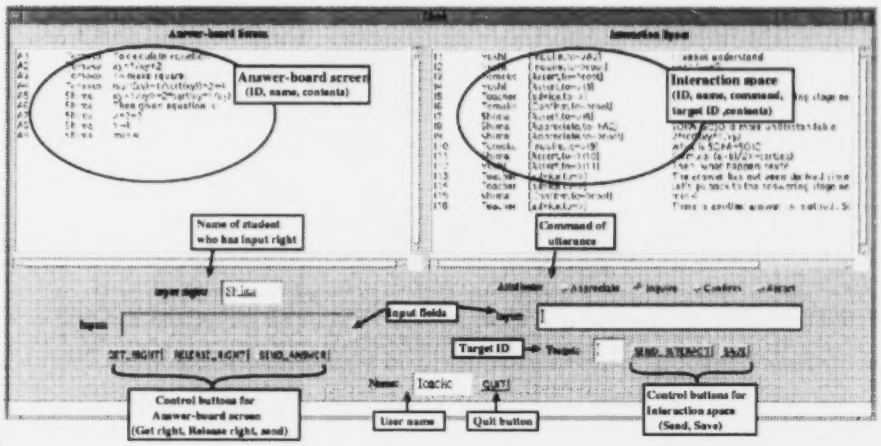


Figure 6: Interaction interface on student operation

We have implemented our prototype system on Internet using UDP protocol, since UDP protocol is suitable to control the frequent interaction of short messages. Figure 6 shows the interaction interface in our system. Two communication tools are prepared: answer-board screen and interaction space. The answer-board screen is a public communication tool which is used to arrange the group's answering process. Only one student is permitted to input on the answer-board screen at a time so that the input right is set. On the answer-board screen, ID, student' name, and contents of input is shown. The answer-board screen functions as a blackboard in our real world. On the other hand, the interaction space is prepared for free conversation so that all students are able to input freely. In order for the coordinator of our system to grasp the learning situation easily, commands that classify the opinions are introduced: Appreciate, Inquire, Confirm, and Assert. Students choose the commands when they input their opinions. In addition to the commands, students specify the target inputs which trigger off their opinions for the purpose of grasping the flow of conversation smoothly. Thus, in addition to the ID, student's name, and contents of input, command and ID of target input are also displayed on

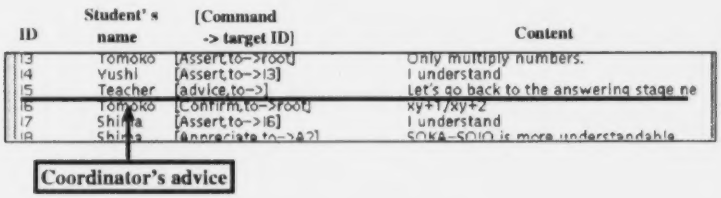
BEST COPY AVAILABLE

interaction space.

As for the coordinator, we prepared several advices which indicate the states of learning situation when the learning is proceeded inappropriately. Currently, the coordinator generates advices when it detects the following learning situation:

- learning situation has not been changed for a long time,
- some students cannot understand currently discussing stage, and
- students have not derived all viewpoints of solving the exercise.

The coordinator's objective is to activate the discussion, so the advices are generated on the interaction space as the same style as all other students' utterances. Figure 7 shows an example of advices generated by the coordinator. As for the advice, the speaker name is set as "Teacher", the command of advice is "advice", and the ID of target input is nothing because the advice is generated for the learning group but not for individual students.



ID	Student' s name	[Command -> target ID]	Content
I3	Tomoko	[Assert,to->root]	Only multiply numbers.
I4	Yushi	[Assert,to->I3]	I understand
I5	Teacher	[advice,to->]	Let's go back to the answering stage ne
I6	Tomoko	[Confirm,to->root]	xy+1/xy+2
I7	Shinya	[Assert,to->I6]	I understand
I8	Shinya	[Appreciate,to->A2]	SOKA-SOUO is more understandable

Figure 7: Advice example of coordinator on interaction space

The learners was implemented using AgentSpace[9] as a middle-ware to control the behavior of mediator. Figure 8(a) is an interface for generating requests. On the upper window, the causality of utterances on interaction space is arranged based on corresponding student's utterances. The arrangement of utterances on the upper window helps to decide the focusing students for generating requests. Once a student decides focusing students, he/she inputs IP addresses of focusing students, because mediators need IP addresses where they will work on beforehand in our current version. Then, he/she specifies the file name of focusing student's personal learning history. If a student wants to know only the particular utterances of focusing students, he/she sets the ID's of corresponding utterances shown on the upper window. Figure 8(b) is the result windows of requests for personal learning history. When requests have been completed successfully, the result windows are generated and the personal learning histories of focusing students are shown individually. Currently, the picture of focusing student is shown on the upper window and his/her utterances are shown on the lower window.

6 Conclusion

In this paper, we proposed a collaborative learning environment which contains two different agents: the coordinator and the learner. The coordinator monitors the public communication among learning group and generates advices so as to lead them to their learning goal. For this purpose, the coordinator grasps the learning situation globally from two viewpoints: the ratio of derived step for a whole answering process and the extent of discussion. Although the management structure of learning situation is simple, the coordinator may be able to find the most cases that students are not able to cope with inappropriate learning situation by themselves. On the other hand, the learner controls the private talking such as focus function. The learner holds the personal learning history of corresponding student as his/her characteristics and acquires other students' personal learning histories by generating the mobile agents called mediators. Currently, these agents function independently. However, for our future work, the interactions among coordinator and learners are necessary for the coordinator to generate more effective advices. In addition, the evaluation for the interaction interface of our prototype system and the preparation of more factors for personal learning history based on the result of the evaluation are also our future works.

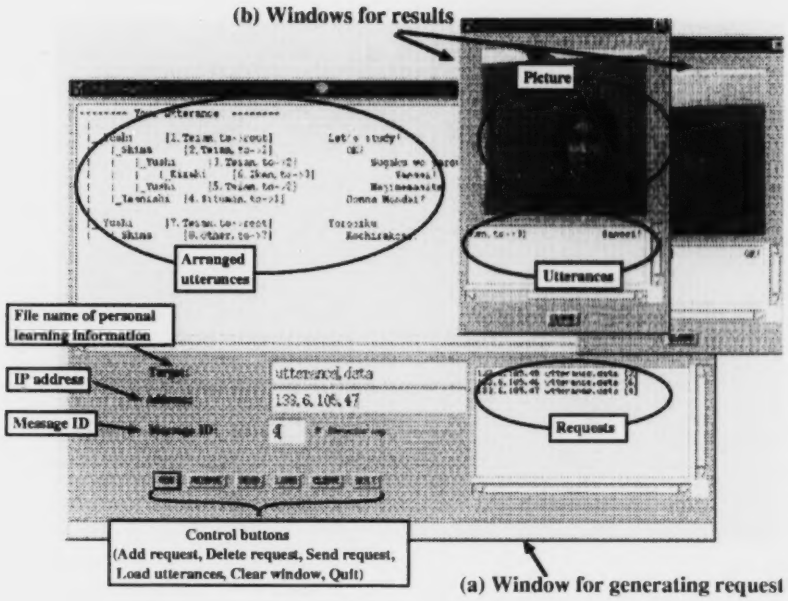


Figure 8: Interface for handling requests

Acknowledgments

The authors are very grateful to Prof.T.Fukumura of Chukyo University, and Prof.Y.Inagaki and Prof.J.Toriwaki of Nagoya University for their perspective remarks, and also wish to thank our research members for their many discussions and cooperations.

References

[1] A. M. Florea: "An Agent-based Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 161–164 (1999).

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano: "Knowledge Awareness Map for Open-ended and Collaborative Learning on World Wide Web", *Proc. of ICCE'99*, Vol. 1, pp. 319–326 (1999).

[3] M. Nakamura and S. Otsuki: "Group Learning Environment Based on Hypothesis Generation and Inference Externalization", *Proc. of ICCE'98*, Vol. 2, pp. 535–538 (1998).

[4] G. Liming, H. Minghua and Q. Yuhui: "A Web-based Multi-Agent Collaboration Learning System", *Proc. of ICCE'98*, Vol. 1, pp. 205–210 (1998).

[5] T. Kojiri and T. Watanabe: "Cooperative Learning Support Mechanism, Based on Scenario of Specifying Solving Process", *Proc. of ICCE'98*, Vol. 2, pp. 532–534 (1998).

[6] T. Kojiri and T. Watanabe: "Adaptable Learning Environment for Supporting a Group of Unspecified Participants in Web", *Proc. of SITE'99*, pp. 1937–1942 (1999).

[7] T. Kojiri and T. Watanabe: "A Management Method of Leaning Situation in Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 386–393 (1999).

[8] J. E. White: "Telescript Technology: Mobile Agents", *Software Agents (J. Bradshaw (ed.)), MIT Press*, pp. 437–472 (1997).

[9] I. Sato: "AgentSpace", *http://islab.is.ocha.ac.jp/agent/* (1999).

An Agent-Based Intelligent Tutoring System

C.M. Bruff and M-A. Williams
University of Newcastle,
NSW 2308, Australia
Email: cgcmb@cc.newcastle.edu.au *and* maryanne@eBusiness.newcastle.edu.au

In this paper we describe the architecture of an agent-based intelligent tutoring system. The agent architecture is based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using an agent oriented programming language called JACK [1]. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to embed previously developed Java modules in an agent environment. In essence our intelligent tutoring system builds and maintains a student model in a dynamic learning environment where new, possibly inconsistent or uncertain, information is obtained through interactions with the student, and where the system may not have complete knowledge when deciding on the next instructional step. Our architecture supports the development of highly individualised student models using techniques in belief revision, nonmonotonic reasoning and possibility theory.

Keywords: **Educational Agent, Intelligent Tutoring Systems, Artificial Intelligence in Education, Belief Revision**

1 Introduction

In this paper we describe the architecture of an agent-based intelligent tutoring system. The agent architecture is based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using in an agent-oriented programming language called JACK. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to embed previously developed Java modules in an agent environment. In essence our intelligent tutoring system builds and maintains a student model in a dynamic learning environment where new, possibly inconsistent or uncertain, information is obtained through interactions with the student, and where the system may not have complete knowledge when deciding on the next instructional step. Our architecture supports the development of highly individualised student models using techniques in belief revision, nonmonotonic reasoning and possibility theory. This architecture was described in a previous paper [5].

2 Using Intelligent Agents

Agents vary in capability from procedural wizards to information agents which are used for information filtering and retrieval. Herein the term agent is taken to mean: *an encapsulated computer system that is situated in some environment and that is capable of flexible, autonomous action in that environment in order to meet its design objectives,* as suggested by Wooldridge [29]. By autonomous we mean agents have control over both their internal state and their behaviour, in other words they can make choices regarding their actions depending on their internal state and the goal they seek to achieve. Objects in the object-

[1] JACK was developed at Agent-Oriented Software (http://agent-oriented.com)

oriented paradigm do not have this capability. Agents can be both reactive or proactive, in other words, they can react to external events and they can pursue goals. Agents can make run-time decisions that were not foreseen at design time.

It has been consistently argued, for example by Wooldridge [29], that an agent-oriented approach to problem solving and software engineering offers substantial benefits for complex systems. In particular, Jennings [14] has argued that the usual tools identified by Booch [4] of problem decomposition, abstraction and organisation acquire more power if an agent-oriented approach is adopted, because the agent-oriented approach supports distributed processing and at the same time reduces the system's control complexity. Decisions about the next action to be performed are devolved to the agents, and this obviates the need for a global controlling module and as a consequence gives rise to more flexibility and better performance.

3 Implementing Intelligent Agents in JACK

JACK is an agent programming language, which in essence provides agent infrastructure to the Java programming language. Agents are designed in JACK and compiled into standard Java code before being executed. Agent-oriented programming is a highly sophisticated paradigm which is highly suited to intelligent tutoring in a real-time environment.

JACK agents are based on the BDI Framework of Rao and Georgeff [20]. They are autonomous software components that execute plans (intentions) to achieve their goals (desires). The plan chosen at any given time depends on the current set of beliefs. JACK agents can also respond to events as well as striving for goals, in other words they exhibit both proactive (goal-driven) and reactive (event-driven) behaviour. Each agent possesses: (i) a **database** (set of beliefs), (ii) a set of **events** it will respond to, (iii) a set of **goals** that it wishes to achieve, and (iv) a set of **plans** that describe the appropriate responses to events or ways to achieve goals.

A JACK agent remains idle until it is given a goal to pursue, or until it is has to respond to an event. The agents are autonomous and they must determine the appropriate response to goals and events, i.e. the appropriate plan to be executed. A JACK Agent is able to exhibit the following behaviours [JACK Manual]:

- A goal-directed focus. The agent focuses on the objective and not the method chosen to achieve it.
- Real-time context sensitivity. The agent will keep track of which options are applicable at each given moment, and makes decisions about what to try and retry based on the present conditions.
- Real-time validation of approach. The agent will ensure that a chosen course of action is pursued only for as long as certain maintenance conditions continue to be true.
- Concurrency. The agent system is multithreaded. If new goals and events arise, the agent will be able to prioritise.

The JACK Agent Language extends Java in the following ways:

- It defines new base classes, interfaces and methods.
- It provides extensions to the Java syntax to support new agent-oriented classes, definitions and statements.
- It provides semantic extensions (runtime differences) to support the execution model required by an agent-oriented software system.

The JACK Agent Language provides the following five main class-level constructs:

- **Agent**: The agent construct is used to define the behaviour of an intelligent software agent. This includes capabilities an agent has, what type of messages and events it responds to and which plans it will use to achieve its goals.
- **Capability**: The capability construct allows the functional components that make up an agent to be aggregated and reused. A capability can be made up of plans, events, databases and other capabilities.

- **Database**: The database construct provides a generic relational database. It has been designed specifically so that it can be queried using logical members. Logical members are like normal data members, except that they follow the rules of logic programming. Agents can also use regular Java data structures for storing information, but the built -in database can generate events when particular changes occur.
- **Event**: The event construct describes an occurrence that the agent must take an action in response to.
- **Plan**: An agent's plans are analogous to functions. They are the instructions the agent follows to try to achieve its goals and handle its designated events.

4 Agent Communication

Our system is a multi-agent system. Agents need to interact to build and manage the student model. As a consequence our agents require the ability to communicate to one another. JACK provides the infrastructure of the communication but does not specify a particular language or protocols, hence designers can choose the most appropriate for their application. We have chosen KQML as our protocol for exchanging information and knowledge. It is based on speech acts theory as described by Searle [23]. One of the main reasons for our choice is that all the information for understanding the content of the message is included in the communication itself. It is defined by the following protocol structure, as outlined by Huhns and Stephens [13]:

```
(KQML-performative
        :sender        <word>
        :receiver      <word>
        :language      <word>
        :ontology      <word>
        :content       <expression>
        ...)
```

The performatives in our systems are: evaluate, achieve, monitor, revise, extract, tell, and ask. In JACK the agents must know one another's name, and when agents that are communicating are running in separate processes, then the JACK network communications layer needs to be used to allow these processes to communicate. KQML-speaking agents behave as clients and servers, and communication can be synchronous or asynchronous.

5 The Architecture

The ability of an Intelligent Tutoring System to deliver appropriate individualised instruction to a student depends heavily on the type and calibre of the information held about the student in the student model. This in turn depends on the type and level of sophistication of the knowledge representation used in the system and on the effectiveness of the methods used to elicit new information about the student and to incorporate the new information into the student model. Problems arise when new information conflicts with information already in the student model; when the student model contains insufficient information for the tutor to decide on the next instructional step; or when there is uncertainty associated with some of the information about the student - for example, there may be more than one way of interpreting an error made by a student in terms of what the student knows or does not know. There have been many approaches to dealing with these problems.

A number of studies (e.g. Mizoguchi et al [19], Kono et al [17], Giangrandi and Tasso [9]) have applied Truth (or Reason) Maintenance Systems (Doyle [7], DeKleer [6]) to overcome the problem of new information conflicting with old. The TMS identifies the conflicts, which must then be resolved by some domain specific reasoning system. A TMS must maintain not only the beliefs of the student, but also the justifications for them, and therefore use of a TMS is computationally very intensive. Huang and McCalla [12], and Huang [11] have developed a "Logic of Attention", a modification of the TMS which overcomes the problem of efficiency by focusing only on the parts of the student model and instructional planner that are relevant to the current sub-goals. Jones and Poole [15] examined how Reiter's default logic [21] could be

used to build expert diagnostic systems.

One general approach to coping with uncertain or incomplete information is to assume that student models do not need to be completely accurate and absolutely precise to be successful. In granularity-based recognition of students' problem solving strategies the philosophy is that student behaviour can be recognised at some level of detail, even if this is very coarse (McCalla and Greer [18]). In the "fuzzy" student model approach (eg Hawkes et al [10] and Katz et al [16]), which is grounded in fuzzy set theory, a student might have partial membership in the set of students who are expert in a particular skill, and partial membership in the set of students who are less expert in that skill. Alternatively, application of Bayesian belief networks (e.g. Villano [25], Shute [24], and Reye [22]) deals with the problem of uncertain information and also facilitates prediction of student knowledge and performance, but most likely at the cost of extensive knowledge engineering and programming.

Intelligent tutoring systems will, in general, have to provide mechanisms to deal with four interrelated information modeling problems:

- Uncertainty of information,
- Incompleteness of information, ie all relevant information may not be known.
- Fusion of information, where information is merged from different sources, and
- Revision of an existing knowledge base when new information is obtained. This new information may be inconsistent with the knowledge base.

Information that is uncertain or incomplete may need to be revised as it is refined over time. Hence, revision of a knowledge base is closely related to modelling both the uncertainty and the incompleteness of information.

In a previous paper [5] we proposed an architecture in which the problem of conflicting information is resolved using methods recently developed by Williams [26, 27, 28] based on the AGM paradigm for belief revision (Alchourron et al [1]). We used possibility theory (see Dubois and Prade [8]) to take care of uncertain information, nonmonotonic reasoning, in particular Reiter's default logic [21] and the formalism of Antoniou and Williams [2], to deal with missing information, and Theory Extraction for fusion.

Our new proposed system architecture is illustrated in Figure 1 below. It has been modified to take advantage of the agent-based architecture, and consists of the three component agents: the knowledge management agent, the student agent, and the inference agent.

6 The Agents

The **Knowledge Management Agent**: This agent mainly responds to events which take the form of requests from other agents. Agents request information regarding such things as domain knowledge, typical errors and misconceptions, suggestions for the next task to present the student. The domain knowledge is structured to suit the application at hand and managed by an agent. We are currently exploring two applications; one based on a mathematical dictionary for schools, The MathProbe[2], and a second focusing on database design for our own courses at the University of Newcastle. An agent that knows about common student errors and misconceptions has a better chance of diagnosing problems than a system without this knowledge. The quality of this knowledge is often what sets a good teacher apart. In both the domains that we have selected this knowledge is well known and widely accepted. For example, *students who consistently place foreign keys in the wrong database table normally do not understand the concept of cardinality of relationships between entities.*

The notion of knowledge granularity has been widely used in the literature (eg. McCalla and Greer [18]). In our architecture granularity is used in both the domain knowledge and in the set of common errors and misconceptions. Levels of granularity fit naturally into the agent architecture and can be used to help the agent choose an appropriate plan.

The **Student Agent**: Each student is assigned an individual agent instantiation. The main objective of this agent is to manage the evolution of the student model, i.e. a representation of the student's knowledge about

[2] See http://mathresources.com/mathbrow.html

the domain knowledge and the student' s personal goals and preferences. This model is described using the following components:

- The Student' s Goals using JACK Goals
- The Student' s Preferences using the JACK Database,
- Explicit Knowledge about the Student based on their performance so far using the JACK Database.

The student agent is autonomous and responds to input from the student.
The **Inference Agent**: The inference agent manages a team of agents that provide several forms of useful inference mechanisms and sophisticated reasoning operators. It is not necessary for the agents requesting knowledge to know how the Inference Agent generates that knowledge. The Inference agent uses slave agents for deduction[3], abduction and induction. The belief revision agent[4], possibilistic reasoning agent[4], nonmonotonic reasoning agent[4] and theory extraction agent[4] rely exclusively on the slave agents.

The student agent' s goals will typically vary from student session to student session, and can be customised by a third party such as a human tutor. These goals determine the learning strategies and tasks to be used during a given learning session. The learning strategies together with the database describing the current state of the agent and its knowledge about the student' s capabilities will largely control the agent' s behaviour. These strategies are ultimately implemented via an agent that constructs a learning task hierarchy. This learning task hierarchy is constructed at run time. It can be viewed as a sub-hierarchy of the global task hierarchy customised using the current student profile. This sub-hierarchy is designed to provide feedback about the student that can be used to build and manage the student model during a learning session. In addition, it is used to diagnose student problems and subsequently offer remedial action.

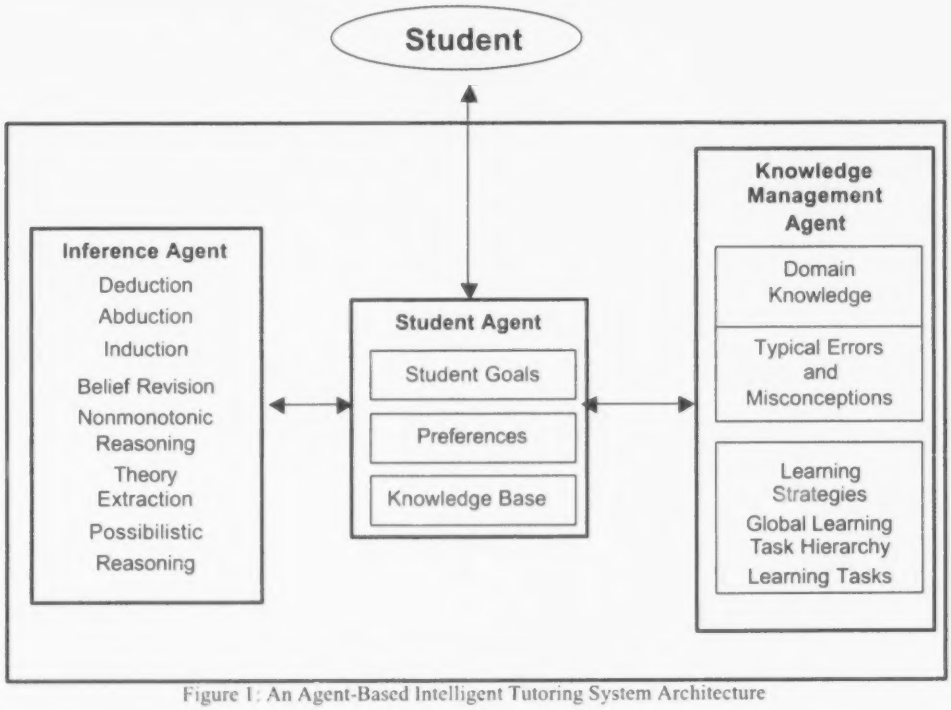


Figure 1: An Agent-Based Intelligent Tutoring System Architecture

[3] See http://ebusiness.newcastle.edu.au/vader
[4] See http://ebusiness.newcastle.edu.au/saten

7 Conclusions

In a previous work we identified several information modeling problems that arise in Intelligent Tutoring Systems: change, incompleteness, information integration, and uncertainty. We described an architecture for an intelligent tutoring system that addressed these problems based on recent developments in knowledge representation and reasoning in the areas of belief revision, possibilistic reasoning, nonmonotonic reasoning and theory extraction.

In this paper we described an agent-based design of the architecture based on the BDI framework. The BDI framework is based on the use of Beliefs, Desires and Intentions. Our architecture is under construction using an agent oriented programming language called JACK. JACK provides an agent-oriented development environment. It supports the BDI framework and is built on top of the Java development environment. It not only provides all the necessary agent infrastructure for our architecture, but it also allows us to use previously developed Java modules in an agent environment.

The main advantage of using an agent-based approach is that the control module has been eliminated. Control has successfully been devolved to the agents, i.e. there is no need for a superagent to oversee the communication and interaction. This leads to better performance and a more customised student learning session.

References

[1] Alchourrón, C., Makinson, D. and Gärdenfors, P. (1985), On the Logic of Theory Change: Partial Meet Functions for Contraction and Revision, *Journal of Symbolic Logic* **50**: 510 - 530.

[2] Antoniou, G. and Williams, M-A., Reasoning with Incomplete and Changing Information, *Journal of Information Science*, 99, **1 & 2**: 83 – 99, (1996).

[3] Antoniou, G. and Williams, M-A., Teaching Intelligent Information Management, in the *Proceedings of the First International Conference on Computational Intelligence and Multimedia Applications*, 380 – 384, (1997).

[4] Booch, G., Object-oriented Analysis and Design with Applications, Addison-Wesley, Reading, MA, 1994.

[5] Bruff, C.M. and Williams, M-A, An Intelligent Tutoring System Architecture based on Knowledge Representation and Reasoning, in *Proceedings of the 7th International Conference on Computers in Education*, IOS Press, 736-743, 1999.

[6] De Kleer, J., An Assumption-based TMS, *Artificial Intelligence*, **28**, 127 – 162 (1986)

[7] Doyle, J., A Truth Maintenance System, *Artificial Intelligence*, **12**, 231 – 272 (1979)

[8] Dubois, D. and Prade, H., Epistemic Entrenchment and Possibilistic Logic, *Artificial Intelligence*, **50**, 223–239, (1992).

[9] Giangrandi, P. and Tasso, C., Truth Maintenance Techniques for Modelling Students' Behaviour, *J. Artificial Intelligence in Education*, **6**, 153 – 202, (1995).

[10] Hawkes, L.W., Derry, S.J. and Rudensteiner, E.A., Individualized Tutoring using an Intelligent Fuzzy Temporal Relational Database, *International Journal of Man-Machine Studies*, **33**, 409 – 429, (1990).

[11] Huang, X., Modelling a Student's Inconsistent Beliefs and Attention, *Student Modelling: the Key to Individualized Knowledge-Based Instruction*, eds. J.E. Greer and G.I. McCalla, 267 – 280, (1994).

[12] Huang, X. and McCalla, G., Instructional Planning using Focus of Attention, *2nd International Conference on Intelligent Tutoring Systems* eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 443 – 450, (1992).

[13] Huhns, M.N. and Stephens, L.M., Multiagent systems and societies of agents, in *Multiagent Systems: a Modern Approach to Distributed Artificial Intelligence*, ed. G. Weiss, MIT, 79 – 120 (1999).

[14] Jennings, N.R., On agent-based software engineering, Artificial Intelligence **117**, 277 – 296, (2000).

[15] Jones, M. and Poole, D., An Expert System for Educational Diagnosis based on Default Logic, *Proceedings of the 5th International Workshop on Expert Systems and their Applications*, Vol. **2**, 673 – 683, (1985).

[16] Katz, S., Lesgold, A., Eggan, G. and Gordin, M., Modelling the Student in Sherlock II, *J. Artificial Intelligence in Education*, **3**, p. 495, (1993).

[17] Kono, Y., Ikeda, M., Mizoguchi, R., To Contradict is Human - Student Modelling of Inconsistency, *2nd International Conference on Intelligent Tutoring Systems*, eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 451 – 458, (1992).

[18] McCalla, G.I. and Greer, J.E., Granularity Based Reasoning and Belief Revision in Student Models, *Student Modelling: the Key to Individualized Knowledge-Based Instruction*, eds. J.E. Greer and G.I. McCalla, 39–62, (1994).

[19] Mizoguchi, R., Ikeda, M. and Kakusho, O., An Innovative Framework for Intelligent Tutoring Systems, *Artificial Intelligence Tools in Education*, eds P. Ercoli and R. Lewis, 105 – 120, (1988).

[20] Rao,A. and Georgeff, M., Modeling rational agents within a BDI-architecture, in the Proceedings of the International Conference on Principles of Knowledge Representation and Reasoning, (1991).

[21] Reiter, R., A Logic for Default Reasoning, *Artificial Intelligence*, **13**, 81 – 132, (1980).

[22] Reye, J., A Belief Net Backbone for Student Modelling, *3rd International Conference on Intelligent Tutoring Systems*, Montreal, 596 – 604, (1996).

[23] Searle, J.R., Speech Acts: An essay in the philosophy of language, Cambridge University Press, 1970.

[24] Shute, V., SMART evaluation: Cognitive Diagnosis, Mastery Learning and Remediation, *Proc. Artificial Intelligence in Education*, 123 – 130, (1995).

[25] Villano, M., Probabilistic Student Models: Bayesian Belief Networks and Knowledge Space Theory, *2nd International Conference on Intelligent Tutoring Systems* eds Frasson, C., Gauthier, G. and McCalla, G., Montreal, 491 – 498, (1992).

[26] Williams, M-A., Iterated Belief Revision: A Computational Model, in *the Proceedings of the Fourteenth International Joint Conference on Artificial Intelligence*, Morgan Kaufmann Publishers, San Francisco, 1541 – 1550, (1995).

[27] Williams, M-A., Towards a Practical Approach to Belief Revision: Reason-Based Change, Luigia Carlucci Aiello and Stuart C. Shapiro (eds), *Proceedings of the Fifth International Joint Conference on Principles of Knowledge Representation and Reasoning*, Morgan Kaufmann Publishers, 412 – 421, (1996).

[28] Williams, M-A. Anytime Belief Revision, in the *Proceedings of the Fifteenth International Conference on Artificial Intelligence*, Morgan Kaufmann Publishers, San Francisco, 74 - 80, (1997).

[29] Wooldridge, M., Agent-based software engineering, IEEE Proceedings Software Engineering **144 (1)** 26 – 37, (1997).

Design of Systematic Concept Learning Model Using Computer Education Search Engine

Seong-Guk Kang*, Young-Houn Lee and Seong-Sik Kim*****
Dept. of Computer Education in Korea National University of Education
Tel: +82-043-2303786
Fax: +82-043-2314790
*E-mail: *lovena@comedu.knue.ac.kr, ** lyh@blue.knue.ac.kr,*
****seongkim@cc.knue.ac.kr*

The requirement of education site to apply IT(Information Technology) to class is increasing day by day from development of computer and internet. But, present web-based coursewares are most individual teaching types centered on learners, and each kind of learning theories and models consisting of a main axis of WBI are emphasized on courseware or general, so they cannot be directly applied in education site actually. In this aspect, educationally designed search engine may provide quality information to teachers and be used as good educational tool in class using internet by supporting teaching and learning actively. In this study, we designed computer education search engine and a new learning model introducing it, and we examined that this model may have a positive effect in systematic concept forming process of learners for curriculum concerned.

Keywords: **Computer Education, Search Engine, WBI**

1 Introduction

The requirement of education site to apply IT(Information Technology) to class is increasing day by day from development of computer and internet. But, present web-based coursewares are most individual teaching types centered on learners, and each kind of learning theories and models consisting of a main axis of WBI are emphasized on courseware or general, so they cannot be directly applied in education site actually. The education pattern using internet, which is suggested in • 1nternet and Education• (Baek, Young-gyun, 1997), got close to school site well relatively, but it will be meaningless if quality sites are not continuously supported. Therefore, plan and learning model to suggest useful site suitable for learning contents to teachers and help them to easily find related information and construct teaching design with those, and to make learners reduce problems of loss of direction and attend class with active attitude. In this aspect, learning model through special search engine may suggest a solution. In the aspect that meaning of knowledge and learning in cognitive constructivism is considered as acquirement process with systematic concept formed on the basis of situation and learner's knowledge, active search process through search engine is very similar to it, and special search engine constructed suitable for curriculum may properly control problems of web-based learning which may occur in learning process.

In this study, we designed computer education search engine and a new learning model introducing it, and we examined that this model may have a positive effect in systematic concept forming process of learners for curriculum concerned. Also, we suggested a design plan of special search engine to support it and were to prepare a base to broaden research range of WBI in school education and to make many people meet with educational information further easily..

2 Systematic Concept Learning Model

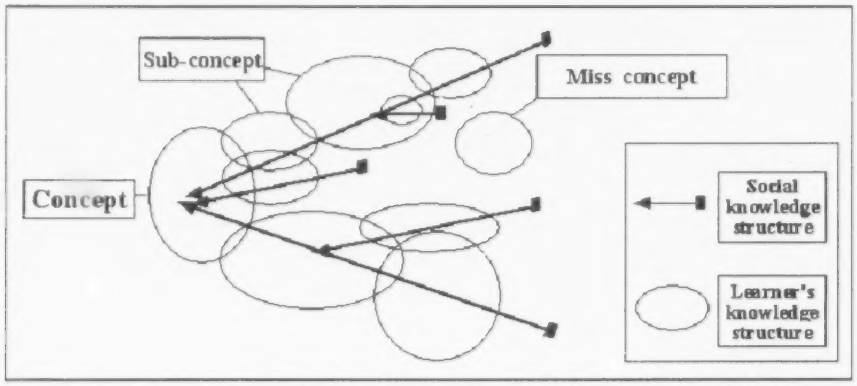
2.1 Meaning of Systematic Concept

Since development of cognitive psychology in 1980s, development of high-technology by pedagogical engineering access and new development of high cognitive ability by development of cognitive psychology have created new-type teaching design concept of constructivism. And, concept of the subject of learning has been changed from intentional concept which focuses on static side and behavioral change to concept of construction of active learner and knowledge to pursue information of volunteer experience and problem solving and reorganize existing knowledge for getting new insight(Mayer, 1992).

The systematic concept is based on concept of knowledge and learning by constructivism, and means complete concept which combines divergent knowledge including originality, creative problem solving and creative transfer of learning and structured knowledge which means partial concept naturally organized in the whole system to which one concept belongs. It accepts basic viewpoints of constructivism - knowledge is structured by the subject of recognition(Duffy; Jonassen, 1991), logically connected(Brown; Duguid, 1989) and formed through social negotiation(ConGlasersfeld, 1989)- in the macroscopic aspect, but it shows the following difference in the aspect that it emphasizes system and transfer of knowledge.

First, semi-fixed opinion of a change in knowledge structure. A change in knowledge structure suggested in constructivism and a viewpoint that it is constructed according to social conditions are right in changes over may centuries. In changes of past education, the structure of knowledge has been changed according to the periodic conditions and change in vision on human, and actually social demands also have been changed. But, structure of changing knowledge is limited if it is premised on a life cycle in which knowledge is constructed, utilized and transferred in human. Furthermore, weight given with meaningful learning activities is not large in a life cycle.

In case of individual knowledge structure constructed intrinsically, the range of individual change may be broad, but generally individual knowledge structure in education is less rational and universal than social knowledge structure. And individual knowledge structure which is far out of social knowledge structure is difficult to be recognized. Therefore, it is assumed that knowledge according to systematic concept follows semi-fixed structure which recognizes partial construct according to individual in socially formed universal structure.



(Figure 1) Structured Concept : Correlation of social knowledge structure and learner's knowledge structure

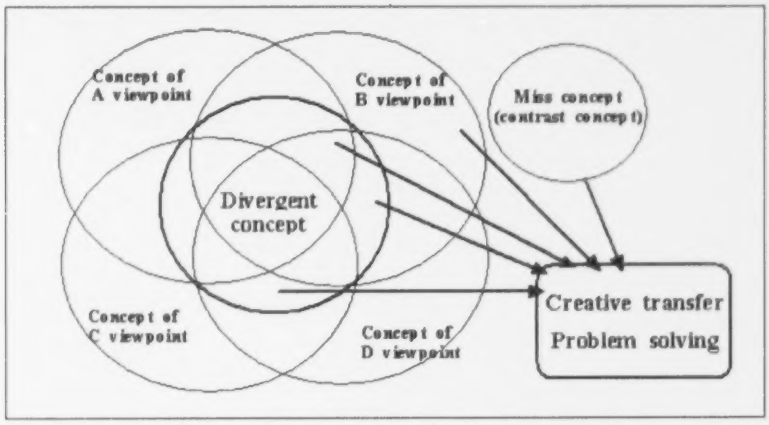
In (Figure 1), concepts formed in socially standardized knowledge structure and floating knowledge structure formed in learners are diagrammed. The social knowledge structure has a possibility of gradual change according to social conditions, and learner's knowledge structure corrects miss-concept, complements the system and forms complete concept on the basis of social knowledge structure; It is structured concept.

Second, knowledge according to systematic concept does not limited to construction of knowledge, and on the basis of this, it emphasizes that creatively transferable knowledge is complete knowledge. Creative transfer means rapid development into valuable and new knowledge is realized on the basis of existing knowledge. To get a new creature, two processes - building of a knowledge base as a prepared source of creation and transfer of knowledge to problem solving - are required(Kim, Seong-sik, 1999). The base of

knowledge may be completed through structured concept and in this process also miss-concept performs accessory role.

Supposing that you perform concept learning of CPU in the concept forming process of computer structure. Concept of CPU in learner is formed rather through CPU position and various visions of CPU - viewpoint of HW developer, computer seller and computer scholar - in computer structure than through direct definition of terms and suggestion of its role. And it forms complete concept corrected and complemented to concept corresponding to miss-concept - CPU in sewage disposal plant. The concept formed as this realizes a source of power for learner to have an ability to cope with various conditions which occur in relation to CPU and to solve a problem creatively and transfer on the basis of the concept of CPU.

As this, concept to make learner oneself construct creative transfer and solutions for various problems is divergent concept. The divergent concept makes concept to be learned be complete in various concepts and systems under social structure, has a synergic effect on obtaining other concerned concepts, and further may be a help to formation of non-concerned concept and improvement of creative thinking power.



(Figure 2) Creative transfer of divergent concept

In (Figure 2), it is diagrammed that divergent concept of learner which is formed through various viewpoints has an effect on creative transfer, problem solving and learning of other concepts. This figure shows that various concepts in learning process and even miss-concept as well as concept formed through learning play an important role in creative transfer.

2.2 Components of Systematic Concept Learning

Components of systematic concept learning are composed of active learner, problem conditions for learning target, learning contents of systematic structure, peripheral concept including miss-concept, teacher as active assistant, media for learning process control and assessment for creative transfer. Roles and contents of these are as [Table 1].

[Table 1] Components and roles of systematic concept learning

Components	Roles and contents
Learner	Learner solves problem conditions as the subject of learning, constructs system of learning contents, and obtains systematic concept.
Problem condition	It is regarded same with learning target and is a final target for acquiring concept. The problem conditions are suggested including a key of problem solving and a motive of learning.
Learning contents	Learning contents are constructed according to social knowledge structure and education course and are constructed structured concept with general nature.
Peripheral concept	It is constructed including miss-concept contrasted with concept of various viewpoints and is suggested in a category which includes learning contents.

Teacher	Teacher prevents breakaway of learner and induces access to structured concept as active sympathizer for problem solving rather than one of knowledge sources. Also teacher constructs peripheral concept connected with learning contents and records it, and assesses the process.
Media	It includes document, video data, web document and clue information connected with these as suggestion form of peripheral concept. And it means virtual space in which learning may be realized.
Assessment	The process to solve problem conditions is recorded and assessed through media. Another problem conditions about which systematically formed concept may generate creative transfer are suggested, and the problem solving process is assessed.

2.3 Basic Premise of Systematic Concept Learning

The systematic concept learning is based on the followings:
First, learner should be prepared well for learning and be motivated properly.

Second, the subject of learning is a community of learners, learners and learners, and learners and teachers.

Third, the structure of concept is semi-fixed, and should be general and proper on the basis of social knowledge structure.

Fourth, problem conditions should include learning process of the target concept, and in consideration of connection between precedent knowledge and transfer, should be set before learning.

Fifth, teacher should select peripheral concept, control learner properly and be responsible for assessment as community which participates in learning actively.

Sixth. learner and teacher should exist in a same learning space. Learning space includes virtual space.

Seventh, tools to suggest and select peripheral concept effectively and control learning process are required.

Eighth, it should focus on concept acquirement and transfer, and in case of learning accompanied with behavior such as practice, special learning procedure should be accompanied.

Ninth, peripheral concept necessary to solve problem conditions and the related information should be fully built.

Finally, systematic concept learning is a guided learning type, is based on learning subject of secondary school or higher, and is not suitable for infant and the lower classes of elementary school relatively.

2.4 Promotive Elements of Systematic Concept Learning

Motivation is an element to promote effective process of systematic concept learning. The promotive element as intrinsic motivation depends on problem conditions and the related interest. Setting of problem conditions similar to real situation induces learner to have an interest on learning itself and maximizes concept acquirement.

And, planning for problem solving, concentration on object, high cognitive recognition of contents to be learned and how to learn it, positive research of new information, clear perception of feedback, self-confidence and satisfaction from achievement, and no anxiety on failure act as elements of learning motivation(Johnson & Johnson, 1985).

The promotive element as extrinsic motivation depends on suggestion method of peripheral concept and compensation for assessment. If it constructs learning process as detective praying which applies search and a motive element reflected in assessment is added to the whole process, extrinsic motivation is formed in learner and natural concept learning may be expected.

2.5 Obstructive Element of Systematic Concept Learning

(1) Uncontrolled Concept
The uncontrolled concepts are never-related concept to obstruct systematic concept formation, incorrect concept, example of too many concepts, and example of too few concepts. The never-related concept in computer education learning process confuses concept structure which is totally different from the existing knowledge structure for the proper part, so it confuses learner. The incorrect concept may break down or damage a well formed concept system in knowledge structure, and too many or too few peripheral concept makes concept system be imperfect.

(2) Non-structured Concept Structure
The social knowledge structure constructed with unsafe structure may have a bad effect on setting direction of concept formation. But, if education course according to educational policy of a nation is reorganized as social knowledge structure, it may not be a significant problem.

(3) Instability of Media
If a form in wh ich peripheral concept is suggested and a space in which learning is performed are unstable, it may decrease learner's motivation and interfere systematic concept formation. Especially, if learning is performed on web, special caution on system stability is required.

(4) Formation of Motivation Contrary to Learning Process
The unexpected motivation according to media or learning method suggested in learning process makes control of learning be difficult. Induction of interest from magnificence and peculiarity of media itself or formation of provocative motivation may act as obstructive factor of learning.

2.6 Web-based Systematic Concept Learning Model

The systematic concept learning theory may have a complete system under the condition that learner and teacher use special search engine and perform class in a same place. Existing web-based learning just depends on web courseware or uses it accessorily, but a characteristic of web-based systematic concept learning model is that web-based learning using traditional class pattern and special search engine is constructed with the same weight.

In this section, components of class design and additional components according to the above are shown. The main design bases are class design theory and problem solving scenario in home and suggestive issues of web-based learning models are referred to. The general model of web-based learning design is inclusively designed, and according to the contents, it is considered that media and construction of learning method may be varied, and selection procedure of these is included in the model itself. But, in case of this web-based concept learning design model, the structure is organized close to concrete class design from several previously selected components such as selection of tool - search engine - and form of learning method. It has the following 8 steps;

2.6.1 Selection of Learning Contents

For class design, first, teacher analyzes what contents should he or she teach with curriculum, related teaching materials, guidebook and reference data. Especially, for computer education, the learning contents are changed very fast, so teacher's role is very important. For example, if operating system is learning content, although learning content in curriculum and teaching materials is Window 95, it is required to be reanalyzed as Window 98 according to learner's level and social conditions. The proper learning target should be set by analyzing characteristics of selected learning contents.

2.6.2 Setting of Learning Target

The learning target should be set on the basis of selected learning contents. Settings - 'classification and definition of concept, and suggestion of base', 'use of effective method for concept acquirement', 'search of concept and application of related technology', and 'understanding of organization and construction of concept and taking an interest' - are possible.

2.6.3 Organization of Learning Concept

This step organizes concepts connected with learning target concretely, analyzes concept structure which has already been organized in learner, and defines position and peripheral concepts in the structure of concept to

be learned, and also defines positive miss-concept and negative miss-concept for expectable miss-concept. Teacher uses special search engine as tool in this process, and terms dictionary and related information suggest peripheral concept and miss-concept. And it may be used to find the position in classification system. Uncontrolled concept and non-structured concept which act as obstructive factor of systematic concept learning in organization of concept should be prevented.

2.6.4 Construction of Problem Conditions

Teacher should establish concrete problem conditions to acquire concept to be formed in learner. Problem conditions should be constructed to be able to induce motivation and interest from learner, and it should be constructed as form to purse achievement of learning target and to be far apart from statement of learning target. From this, it may be difficult for learner to recognize a fact that he or she learns. Here, promotive factor of systematic concept should be applied. And, problem conditions to promote creative transfer of concept formed in learner at the final step should be considered.

2.6.5 Construction of Learning Process

Construction of learning process designs the whole structure to be performed in real class. Concentration of learner is induced, and learning target is suggested, and initiative factor is learned, and factors necessary for the whole parts such as stimulation search, learning guide, performance inducement, feedback are designed.

2.6.6 Selection of Learning Method

This step constructs organization and role of learner. This step has two types; first, teacher prepares organization and role previously according to contents, and second, teacher prepares organization and role in the course of class. This step constructs groups to be able to perform cooperative learning and give competitive factors between groups. This process suggests problem conditions designed by teacher or reorganizes it through interaction with learner, and designs concept searching method to solve problem conditions in learner groups.

2.6.7 Teaching and Learning

In this step, teaching and learning are realized. Teacher may suggest prepared document or other learning data, and learner systemizes and acquires concept through concept search process. The special search engine searching process constructed by teacher in the learning process construction step makes learner go through systematic concept search process in partially controlled search structure and record this process, so it is used in learning assessment. Learner acquires systematic concept and peripheral concept and positive miss-concept in search process. This forms formation of extrinsic concept to generate creative transfer. Teacher participates in problem solving process of learner as positive search assistant and performs minimal controlling role.

2.6.8 Control and Assessment of Learning

This step assesses whether concept formation of learner agrees with learning target, suggests problem conditions for promotion and confirmation of creative transfer and solves them. Also, this step assesses concept formation and establishes the complemental policy on the basis of learning process of learner recorded in search engine.

3 Design Plan of Special Search Engine

In this study, we performed required analysis and inhouse study for groups of teachers, students, and specialists in education to develop computer education special search engine as space in which systematic concept learning will be realized. In this, key points are as follows;

First, detail information of site and the reliability aspect. By detail information of site including characteristics of site, key data, subject of use, and speed, learner may greatly decrease access time to necessary educational information. Also, functions to increase reliability are required such as link keeping function to remove non-serviced site and operation of professional surfer by directories.

Second, systematic user-centered classification type. Educational information should be specialized and subdivided into classification by learning ranges and systems, by education courses, and by general ranges. Also, functions that information is sorted and suggested by user classes are required.

Third, provision of terms dictionary. Terms dictionary to be able to correctly suggest concepts that learner requires should be suggested as hypertext or hypermedia type.

Fourth, formation of community. Realtime and non-realtime community tool is needed so that formation of community between learner and learner, learner and teacher be possible in special search engine.

Fifth, design and assessment of learning process. Functions that teacher supports each kind of design necessary for learning process such as motivation factors, key information, expectable learning process, and functions to record and assess search process of learner are required.

4 Conclusion

Recent WBI studies have been centered on web courseware and remote education site based on it, and with this trend, web browser based newest technologies are being developed and applied. It is very positive in remote education and will meet various demands of learners. With this, also we should consider it in school education site. This study suggested an education model which is further closer to demand of the site in computer education, and designed design plans of special search engine necessary for it. We are designing and implementing further concrete real class model and detail functions and DB of search engine, and through this, will examine systematic concept forming process of learner. We hope this study will be a turning-point at which computer education may be activated in curriculum education.

References

[1] Anderson, E. S., K. V. Grude, T. Haug and J. R., "Turner. Goal Directed Project Management", London : Kogan Page, (1987)

[2] Anita E. Woolfolk (1998). "Educational Psycology" , Hakmoon Publisher

[3] Denis dion Jr. antonie Escobar etc, "Develpment of Educational Tools : a Web-Oriented Approach", (http://www.gel.ulaval.ca/~ift19965) (1996)

[4] Glaser, R., "Components of Psychology of Instruction : Toward a Science of Design", Review of Educational Research, (1997)

[5] Harasim, L. Foreword., "In From Bulletin Boards to Electornic Universities : Distance Education", Computer-Mediated Communication, and Online Education : The American Center for the Study fo Distance Education, (1987)

[6] H.A. Latchman etc, "Information technology enhanced learning in distance and convertional education". IEEE trasactions on education, (1999)

[7] James E. Baker etc, "A New Model for Algorithm Animation Over the WWW", (1999)

[8] Jenkins, Charlotte, Mike Jackson, Peter Burden, and Jon Wallis, "Searching the world wide web : an evaluation of available tools and methodologies", Information and Software Technology, pp. 985-994, (1998)

[9] Miller, T., E., and P. C. Clemente. "The 1997 American Internet User Survey : Realities Beyond the Hypertext", GVU's 8th WWW Survey Result, (1997)

[10] R. S. Peters . "Anthropology and Education" , Pedagogical Science Publisher, (1980)

[11] R. S. Peters . "Pedagogical Philosopher Criticism Theory", Seogwang Publisher, (1989)

[12] TaeWook Lee etc, "Computer Curriculum Pedagogy" , Hyongsol Publisher, (1998)

[13] Baek, Young-gyun . "Design of Web-based Learning" , Yangsowon, (1999)

[14] Gang, Mi-ryang, "Effect of Constructivism Teaching-Learning on Social Morality of Children" , master's degree paper of graduate school of education, Kyung Hee Univ., (1999)

[15] SeongSik Kim, "The Computer Education for Creative Transfer" , paper of the Computer Education Society, (1997)

[16] YoungHoun Lee, "Design and Implementation of Search Engine with Web and DB linkage", master's degree paper of Korea National University of Education, (1998)

Educational Agents and the Social Construction of Knowledge: some issues and implications

Carolyn Dowling
Australian Catholic University
115 Victoria Parade, Fitzroy, Victoria 3065, AUSTRALIA
Phone: (61 + 3) 9241 4456
Fax: (61 + 3) 9241 4546
Email: c.dowling@patrick.acu.edu.au

The use of intelligent software agents within computer mediated learning environments is currently an important focus of research and development in both AI and educational contexts. Roles envisaged and implemented include those of tutor, of 'manager', of information seeker and of fellow learner. Each of these raises its own special challenges in relation both to the capabilities of the software and to our understandings in regard to the nature of the learning process. High on the list of factors currently believed to contribute to effective learning is social interaction in the service of knowledge construction. Within many electronic learning environments we are currently witnessing the emergence of a new participant in the social interactions that mediate learning. The substitution of computer programs possessed of varying degrees of intelligence, autonomy and 'personality', for certain dimensions of human presence within the computer based classroom raises a number of questions related to the processes through which knowledge is socially constructed, and to the qualities which are necessary to ensure successful participation in those processes. Through discussion of both theoretical perspectives and practical examples, this paper explores some of these issues.

Keywords: **AI in Education, Educational Agents, Intelligent Tutoring Systems, Interactive Learning Environments, Networked Social Learning, Teaching and Learning Process**

1 Introduction

Developments in computing and information technology in recent years have rapidly propelled the notion of intelligent software agents from concept to implementation. Today, whether or not we are always aware of them, they are an integral part of a growing number of computing environments. From the invisible armies of knowbots and related entities scurrying around the Net in the service of increasingly sophisticated search engines to the cheery little characters who pop up on our screens offering assistance with anything from formatting a date to constructing a complex multimedia presentation, or the 'personalities' with whom we interact in chat rooms in happy ignorance of their purely digital nature, intelligent agents are alive and well and are multiplying rapidly.

An early but still useful conception of a software agent is, "A character, enacted by the computer, who acts on behalf of the user in a virtual environment", useful in mediating " ... a relationship between the labyrinthine precision of computers and the fuzzy complexity of man [10, p. 355]. Later definitions tend to be expressed in more functional terms, such as, "An agent can be viewed as an object which has a goal and autonomously solves problems through interaction, such as collaboration, competition, negotiation and so on" [9]. This definition has some similarities with that offered by Maes [12] who defines an agent as:

"A computational system which:

- is long lived;

- has goals, sensors and effectors;
- decides autonomously which actions to take in the current situation to maximize progress towards its (time-varying) goals" [12, slide 5].

Summarising the writings of a number of researchers, Aroyo and Kommers [1, p. 237] identify four major characteristics of agents as being autonomy, responsiveness or reactiveness, pro-activeness and social ability. Other qualities frequently proposed, but not supported by all researchers or indeed by all users, include the ability to learn from experience and consequently to respond in flexible and possibly unforeseen ways to particular situations, and the possession of a believable 'character' or personality as a basis for social interaction.

It appears that a combination of factors has contributed to the current proliferation of software agents. Apart from the technical developments which have opened up the possibility of implementing what were previously largely theoretical conceptions, there is our very real need for assistance as we operate within computing environments characterised by rapid change, large quantities of extraordinarily complex information, and a lack of common organisational structures through which information may be accessed and managed. As Laurel predicted, there are now many situations in which, in the interests of efficiency, some form of 'intelligent' mediation is required between computer systems and the needs of users.

There are, of course, different forms that this mediation could have taken. The strong propensity for most users to accept assistance in the form of a more or less personified entity as largely unproblematic undoubtedly derives at least in part from the anthropomorphic elements implicit in most computer interfaces from the earliest days of computing. It can be strongly argued that a degree of personification has always been automatically and inevitably conferred as much by a program's use of language as a component of the interface as by our everyday understandings of the 'intelligence', albeit artificial, of computers. Intelligence and language use are, after all, key defining attributes of human beings.

Not only are we accustomed to interacting with computers as though they share with us a degree of 'humanity', but in a number of areas of activity we have been persuaded to value 'social' interaction particularly highly. Education is a good example, given the extent to which our current understandings of learning depend upon an acceptance of the belief that knowledge is to a large extent socially constructed. In the current drive to move teaching and learning online, the notion of agency in computing has found a strong ally and a vehicle for expansion. Unless the social interactions that mediate learning in face to face environments can be shown to have a digital equivalent, proponents of online courses will be forever 'on the back foot', with their products being regarded by most educators as second best. While courses incorporating the communications facilities of the Internet certainly go a considerable way in promoting interactions of various types between teacher and student and also between student and student, the possibility of using software agents to create an illusion of interpersonal interaction so convincing as to achieve pedagogical outcomes equivalent to those deriving from a relationship with another human being is extremely enticing to the designers of electronic learning environments.

2 Some examples of socially interactive pedagogical agents

Johnson [7] has proposed the following definition the role of a pedagogical agent as distinct from those designed for other purposes:

> "Pedagogical agents are autonomous agents that support human learning, by interacting with students in the context of interactive learning environments. They extend and improve upon previous work on intelligent tutoring systems in a number of ways. They adapt their behaviour to the dynamic state of the learning environment, taking advantage of learning opportunities as they arise. They can support collaborative learning as well as individualized learning, because multiple students and agents can interact in a shared environment. Given a suitably rich user interface, pedagogical agents are capable of a wide spectrum of instructionally effective interactions with students, including multimodal dialog. Animated pedagogical agents can promote student motivation and engagement, and engender affective as well as cognitive responses" [7, p. 13].

This is a comprehensive and optimistic vision, incorporating a number of possible roles for software agents within educational environments. Types of agents currently implemented in projects around the world include record keepers, information seekers, testers, facilitators of collaboration, tutors or instructors, fellow learners, and tutees. Of special interest in regard to this paper are those that contribute to the overtly social

dimensions of the learning environment. The last three listed most clearly fulfil this criterion.

2.1 Agents as instructors

There is a sense in which perceptions of the role of computers in the learning process have come full circle. Early models of the role of 'computer as tutor' in the form of drill and practice style of instructional software, generally based on Skinnerian principles and incorporating very limited interaction between user and computer, have long been rejected by most educators in favour of a range of other more acceptable guises including that of a learning tool, an information source, and a learning 'space'. With the development of agent technologies, as Johnson suggests, new possibilities now exist for incorporating computers within the learning environment in a range of socially interactive roles, including that of 'tutor', through modes of interaction more in keeping with current pedagogical theory.

It is commonly asserted that the presence of computers in classrooms has itself played a part in modifying the image of the teacher as the 'sage on the stage' in favour of a more collaborative model. Not surprisingly, these changing concepts are well reflected in many implementations of 'agent as teacher'. As Solomos and Avouris [18] write, for instance:

> "The user mental model of the system should be based on the metaphor of the "invited professor" rather than the "knowing everything own tutor". ... Our first findings confirm the observation that today's users, accustomed to hypertext-like interaction, are more likely to accept this collaborative teaching metaphor, according to which their tutoring system is viewed as an intelligent hypertext browser, offering links to other tutoring systems with the right content and at the right time" [18, p. 259].

The increasingly popular concept of the teacher as a facilitator of learning is also reflected in such statements as: "Each student working on the project will have an agent, operating in the background, watching progress, measuring it against the plan, and taking remedial action when necessary" [19, p. 362].

2.2 Agents as fellow learners

A style of agent of special significance in the context of socially constructivist theories of learning is the 'fellow learner', which to differing degrees might be presumed to include all participants within the learning environment. If agents are to gain widespread acceptance in the field of education, this is an important area for research and development. Since the 1980s Chan [2, 3] and colleagues have been working on a range of models of socially interactive agents for learning environments, perhaps the best known being the 'learning companion' – a software entity having limited knowledge of the domain in question, conceptualised as a fellow learner with whom the student may collaborate and even disagree. As in real life, some of these learning companions may be better informed than the student in the relevant domain of knowledge, while others may know less. Perhaps not surprisingly, in learning environments for younger students, animals are a popular choice of persona for such agents, as in this example of a networked learning environment for Taiwanese high school students, as described by Chan:

> "The Dalmation is having the same performance as the student. ... Another animal companion is Dragon, like one of those animal companions in Mulan, a Disney cartoon of this summer. This dragon will "learn" (mainly rote learning) from the student and also from other students on the Net and so may know more than the student. At certain point it'll stop learning and come back to teach the student. In a way, Dragon is protecting the student" [3].

An interesting development of this concept is presented by Sheremetov and Nunez [16, p. 310], who describe the function of a 'monitor agent' as being to modify the role, behaviour or expertise of learning companions from that of strong group leader to a weaker companion or even a passive observer, depending on its interpretation of the degree of guidance required by the learner.

2.3 Agents as pupils

We are all familiar with the common wisdom that we learn through teaching others. At the school level, many educators have long been familiar with the concept of the computer as 'tutee' through the use of the Logo programming language, in which 'teaching the turtle' was a familiar metaphor for the activity of programming. More recently, a number of researchers have explored the translation of this concept into electronic learning contexts where agents exist to be 'taught' by the student user, as in the example from Chan quoted above. A further example is described by Ju [8] who writes of a computer based peer tutoring

system employing two categories of agent – an 'expert', and a 'learner':

> "... students become active learners who are guided to learn by teaching a computer. After the students watch how the computer expert solves a set of linear equations [the program] helps the human student act as a teacher in order to learn more about the subject matter. At this time, the computer plays the role of a student ..." [8, p. 559].

3 Some issues for consideration

3.1 Multiple agents

Most agent based systems utilise a number of agents, many of them capable of a complex range of interactions with the student, with one another, and increasingly with agents associated with other programs. Their individual purposes derive from theoretical analyses of the component tasks and activities that are included in the larger scale pedagogical interactions of human beings. As educators, and indeed as students, we may simultaneously enact a range of roles within the educational environment. The apparently unitary activity of 'teaching' involves such elements as demonstrating, guiding, telling, questioning, explaining, testing, motivating, criticising – even learning! Many researchers consider that the electronic medium makes it feasible to identify and separate out these diverse functions. These can then be enacted through different configurations of agents working in relationships which ranging from collaboration to competition.

An example is the Multiple Agent Tutoring System (MATS) described by Solomos and Avouris:

> " MATS is a prototype that models a "one student-many teachers" learning situation. Each MATS agent represents a tutor, capable of teaching a distinct subject. All MATS tutors are also capable of collaborating with each other for solving learning difficulties that their students may have" [18, p. 243].

Strategies for most efficaciously combining the activities of multiple agents such as these necessitate a complex agent architecture, and understandably occupy a great deal of the research agenda in this area. Of interest in relation to their participation in the social construction of knowledge is the fact that one of the most common metaphors employed by a number of researchers and courseware designers is that of a 'society' of agents, a conception reminiscent of Minsky's *The Society of Mind* [14], Gardner's multiple intelligences [6] and other related theories of cognition and behaviour. In describing the different aspects of the design of their "multi-agent, computer-based interactive environment", for example, Costa and Perkusich [4, p. 196], drawing on the work of Franklin and Graesser [5] refer to their aggregation of agents quite specifically as a 'society'.

> "The society [of artificial tutoring agents] is an open multi-agent system made up of a collection of tutoring agents that co-operate among themselves to promote the learning of a certain human learner. This society is designed to be open and dynamic in the sense that it allows maintenance operations such as the entry and the exit of agents, besides eventual modifications in the knowledge and in the inference mechanisms of an agent. Each agent defines an expert tutor in some domain, having the necessary knowledge to solve problems in this domain. These agents are cognitive and possess properties like autonomy, goal-oriented, social ability" [4, pp. 197-198].

While on the one hand, the variety of functions of agents within a multi-agent environment must also be appreciated as an attempt to realise the type of rich user interface which Johnson suggests is necessary if the pedagogical interactions within electronic learning environments are to approximate to any degree to the face to face educational experience, some educators have concerns in regard to the assumptions underlying these practices. They argue that such developments are underpinned by a reductionist rather than a holistic understanding of the processes and relationships involved in teaching and learning. In separating out the different components of pedagogical interactions, are we enabling each part to be realised more effectively, or are we failing to acknowledge that the global act of human teaching may in fact be more than the sum of its component parts? It seems reasonable to suggest that firm judgments on issues such as this must await greater experience of the roles of agents within these learning contexts.

3.2 Personification

Another focus of debate concerns the degree to which personification is helpful in fostering fruitful pedagogical interaction between the human learner and software agents. This question clearly relates more

to the 'socially interactive' agents than to those fulfilling more tool-like functions, which arguably require far less in the way of 'personality'. As noted earlier in this paper, there are clear arguments for accepting that a degree of personification of computer interfaces is inevitable. As Shirk puts it:

> "Although there is some dispute among software critics concerning the advisability of having 'personalities' in computer programs, their presence seems unavoidable. Any time there is communication between a computer and a human, the information presented by the computer has a certain style, diction, and tone of voice which impact upon the human's attitude and response toward the software" [17, p. 320].

However the extent to which this should be deliberately fostered is less clear, although many feel intuitively that it should be an important element in the creation of an electronic learning environment characterised by interactions which can reasonably be described as 'social'.

An important aspect of the representation of 'character' or personality is visual appearance. Interestingly, both research and experience suggest that the relationship in the case of software agents is far from straightforward, and that a mismatch between realism in appearance and the apparent knowledge level of the agent can have a deleterious effect on credibility. The more visually realistic the representation, the higher the expectations of the user in relation to the appropriateness and 'intelligence' of utterances and actions. Agents that 'look' smart and 'act' or 'talk' dumb are poorly received by many users, who express a higher tolerance for the limitations of a 'character' more sketchily represented, for instance through cartoon-like graphics. As Masterton, writes, for instance, "A common problem with AI programs that interact with humans is that they must present themselves in a way that reflects their ability. Where there is a conflict between the ability of the system and the users' perception of that ability a breakdown occurs and users may either fail to exploit its full potential or become frustrated with its shortcomings" [13, p. 215]. He goes on to suggest the implementation of a degree of anthropomorphism intended to convey qualities such as friendliness and usefulness, without the implication of possession of full human capabilities [13, p. 211]. He describes the development and role of such an entity in the form of a VTA (Virtual Teaching Assistant) which is able to introduce topics and answer simple questions, the more complex types of exposition and interaction being left to the human teacher. In terms of a traditional scenario at university level, the VTA functions somewhat like a tutor or demonstrator as distinct from a lecturer. "In this way faculty is left free of the guiding and assisting issues of the course and is able to concentrate on more complex questions and higher level issues generated during the course" [13, p. 211].

Further instances of this principle are the examples of agents presented as animals discussed earlier in this paper. Our expectations in regard the cognitive skills of animals may well be more appropriate to the capabilities of software agents than are our experiences of human-to-human interactions.

3.3 Autonomy

Closely related to the 'intelligence' of software agents is the issue of autonomy, in particular the degree to which an agent should be furnished with pre-existing goals which might lead it to take particular action without instruction from the user, and even contrary to what the user might perceive as his or her interests and wishes. Exploring the implications of such entities existing and interacting within virtual reality environments, Loeffler [11], for instance, notes that the unpredictability resulting from significant autonomy might well result in agents who are less 'helpful' to us than we might hope or indeed expect. It is easy to slip from such considerations into the need for a contemporary version of Asimov's laws of robotics as conceived in fictional terms more than 30 years ago!

In educational contexts, the implications of autonomy, particularly in terms of control of and responsibility towards the learner, are potentially extremely complex and difficult to address without more exposure to these types of software, and indeed it is quite likely that such experience may cause community understandings in regard to appropriate relationships between the 'human' and the 'not human' in electronic contexts to develop and change over time. In the short term, current trends in educational thinking which favour giving more control and autonomy to the learner would appear to be more in line with the thinking of researchers such as Schneiderman who favour 'direct manipulation' over the development of interactive agents with a significant degree of independence of action. Where agents are involved, they may be programmed so as to exercise control over the learner on behalf of the creator of the learning environment, or they may be configured so as to be more sensitive to a user model, and more responsive to instruction from the user/student. In the latter instance, the agent would have a greater degree of responsibility to the needs and wishes of the learner, but this may not be in keeping with the pedagogical goals of the teacher.

Trust is another aspect of the teacher/learner relationship that is complicated by the degree of autonomy with which a pedagogical agent is endowed. To the extent that the programmer chooses to delegate certain functions and responsibilities to the agent, it is their problem, but it may also be an issue for students, particularly those with more insight into the nature of the agents with which they are interacting.

A further concern in regard to the autonomy of pedagogical agents relates to the issue of intervention in the learning process. Despite the finding of Aroyo and Commers [1] that pro-activity is a quality frequently sought after in agents, there is an important issue of balance to be addressed in relation to the educational process. It is well accepted that a high degree of unsought assistance whether from a human teacher or an excessively diligent and proactive agent can be quite detrimental, in particular to the metacognitive aspects of learning. Of course this is also an issue for teachers and learners in face to face educational contexts!

3.4 Level of participation in the social construction of knowledge

The belief that it is possible for agents to participate effectively in the social aspects of knowledge construction is central to the work of many theorists and researchers. Sheremetov and Nunez [16], for example, whose works derives overtly from the theoretical frameworks of Piaget and Vygotsky, argue that:
"The design of learning environments, virtual or not, aims to promote productive interactions. In this type of learning a student changes from being a passive information receiver to an active collaborator, interacting with the tutors and colleagues in the learning process. Learning does not only result from acquiring knowledge, solving problems or using tools, but also from interacting about these on-going activities with persons and agents"[16, p.305 – 306].

In relation to their specific project they write: "Our emphasis lies in the role of interactions in an artificial learning community as a group of real and artificial learners, tutors, and facilitators, working, supporting and learning from each other [16, p. 306]. But however personified and autonomous the software agent, can it really be said to participate fully in the social construction of knowledge? It has been argued quite extensively that even the most heavily personified of computer programs suffer from an intrinsic lack of ability to participate in the metacognitive aspects of learning. Pufall [15], for instance, expresses a strong belief that a computer program is unable at any level commensurate with human capacities to modify its own knowledge structures or cognitive processes, and so cannot be regarded as a co-constructor of knowledge in a meaningful sense. While this might well have been the case in relation to earlier computer based learning environments, can we continue to make the same claims with confidence today or in the future? The capacity of software to 'learn' and adapt to experience through the incorporation of new information, the appropriate modification of its representation of the context in which it functions (its 'world') and of its inference mechanisms, is undoubtedly increasing. One way of considering this question might be to look at it in terms of the type of distinction sometimes made between 'hard' and 'soft' notions of artificial intelligence. If our test of full participation depends on an understanding that the agent has 'learnt' in precisely the same way that the human has learnt, then we will have difficulty accepting the electronic entity as genuine co-constructor of knowledge. If, however, we make our claim on the grounds that it appears to the human learner that the agent has participated in the learning that has taken place, then perhaps we can at least tentatively admit such a piece of software to membership of the social milieu which has mediated the educational experience.

Conclusions

It is clear that developments in agent technology have created a range of new possibilities in terms of aligning computers more strongly with prevailing educational theories and philosophies. In considering the many issues which might be raised in relation to the nature and roles of pedagogical agents, there are three overarching questions. Firstly, do agents have the potential to enhance learning, or do they threaten to undermine those aspects of the educational enterprise that we most value? Secondly, to what extent might they assist in the replication of the social dimensions of face to face learning within online environments? Thirdly, do they go further than this, and create new possibilities in regard to the social mediation of learning? To the extent that visions such as those of Johnson [7] are able to be realised, we may be faced one day with the need to re-evaluate our attitudes regarding the relative merits of a human teacher and an electronic entity designed specifically for educational purposes. But while the rhetoric of developers often suggests an ideal surpassing the sometimes imperfect realities of human-to-human pedagogical interactions, the 'jury' of online learners and of educators is still out.

References

[1] Aroyo, L & Kommers, P., "Preface – Intelligent Agents for Educational Computer-Aided Systems", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[2] Chan, T.-W., "Learning companion systems, social learning systems, and the global social learning club", Journal of AI in Education 7 (2) (1996).

[3] Chan, T.-W. (1998), "The past, present, and future of educational agents", http://www.apc.src.ncu.edu.tw/apc/ppt_chan.html (accessed on February 3, 2000).

[4] Costa, E.deB. & Perkusich, A., "Designing a Multi-Agent Interactive Learning Environment", in Proceedings of International Conference on Computers in Education (ICCE '97), Kuching, Sarawak, Malaysia, December 2 – 6, pp. 196 – 203, (1997).

[5] Franklin, S. & Graesser, A., "Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents", Proceedings of the Third International Workshop on Agent Theories, Architectures and Languages, Berlin: Springer-Verlag (1996).

[6] Gardner, H., "Frames of mind: the theory of multiple intelligences", New York: Basic Books (1983).

[7] Johnson, W.L., "Pedagogical Agents", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp.13 – 22, (1998).

[8] Ju, Y. (1998), 'Development and formative evaluation of a computer-based peer tutoring system', Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 559 – 566, (1998).

[9] Kinoshita, T. & Sugawara, K., "Agent oriented computing", Tokyo: Soft Research Center (1995).

[10] Laurel, B., "Interface agents: metaphors with character", in Laurel, B. (ed.) The Art of Human-Computer Interface Design, Reading, Massachusetts: Addison-Wesley (1990).

[11] Loeffler, C.E., "Artificial Life of Agents", Proceedings of the IFIP World Conference on IT Tools, Canberra, Australia, September 2 – 6, pp. 48 – 55, (1996).

[12] Maes, P., "Software Agents Tutorial", http://www.media.mit.edu/people/pattie/CHI97 (1997), (accessed on March 18, 2000).

[13] Masterton, S., "Computer support for learners using intelligent educational agents: the way forward", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 211 - 219, (1998).

[14] Minsky, M., "The Society of Mind", London: Picador/Heinemann, (1985).

[15] Pufall, P., "Function in Piaget's system: some notes for constructors of microworlds", in Forman, G. & Pufall, P. (eds) (1988), "Constructivism in the Computer Age", Hillsdale, New Jersey: Lawrence Erlbaum Associates, (1988).

[16] Sheremetov, L. & Nunez, G., "Multi-Agent Framework for Virtual Learning Spaces", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[17] Shirk, H.N., "Technical writers as computer scientists: the challenges of online documentation", in Barrett, E. (ed.), "Text, Context and Hypertext: writing with and for the computer", Cambridge, Massachusetts: MIT Press (1988).

[18] Solomos, K & Avouris, N. (1999), "Learning from Multiple Collaborating Intelligent Tutors: An Agent-Based Approach", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[19] Whatley, J., Staniford, G, Beer, M. &Scown, P. (1999), "Intelligent Agents to Support Students Working in Groups Online", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

A Real-time Handwriting Communication System for Distance Education+

Hsin-Chu Chen* Jho-Ju Tu and Jianping Zhang*****

Department of Computer and Information Sciences, Clark Atlanta University , 223 J.P.Brawley Dr., SW, Atlanta, GA 30314. hchen@star.cau.edu.

*** Instructional Technology Center and School of Education, Georgia Southwestern State University, 800 Wheatley St., Americus, GA 31709. tu@canes.gsw.edu*

**** Department of Computer Science, Utah State University, Logan, Utah 84322. jianping@zhang.cs.usu.edu*

1 Introduction

In this paper we present the design and implementation of a handwriting communication system for real-time graphical information exchange. This system provides an environment for a user to write and erase messages on a computer screen using a light pen or a mouse and to transmit the handwriting message to another user on the Internet in real time. The communication techniques employed for the system include the basic client-server model and peer-to-peer model. The client-server model is mainly for sending handwriting information using the world wide web. The peer-to-peer model, however, is aimed at real-time communications between two end users on the network to conduct instant dialogues. The system is implemented using Java . It can be integrated into many different applications such as collaborative learning, on-line discussions, and distance education.

2 Communication Models

A handwriting communication system may be implemented using a client-server or a peer-to-peer model. Each model has its cons and pros. The client-server model, in which the client sends requests to the server and the server responds to the request [3], works well in situations when immediate responses are not necessary. For a real-time instant dialogue or information exchange, however, the client-server model alone is somewhat restrictive due to its limited degree of interactivity. To achieve a full degree of interactivity for this type of applications, a peer-to-peer model that allows for full duplex real-time communications is more appropriate, since the two end users of the system may send and receive information at the same time, roughly speaking.

In addition to communication models, we must also take into account the nature of the communication protocols and decide which to use. Information exchange carried over the Internet normally requires support from either TCP or UDP, which are the two protocols operated at the transport layer in the TCP/IP protocol suite [1]. When TCP is employed, the information is sent as a data stream, similar to a telephone conversation. Since TCP requires a connection setup prior to transferring data, it incurs an initial time delay. UDP, on the other hand, does not require such a connection setup. However, the delivery of datagram packets, which are independent data units sent individually from the source to the destination, is not guaranteed. Datagram packets may arrive out of order too. For textual information, UDP may not be a bad choice because the user normally can tolerate, to certain degree, occasional loss of packets or misplaced textual data. In our handwriting system, the handwritten information is represented as numerical data which are sensitive to the loss of any single bit of information, therefore, TCP is our natural choice.

+ This work was supported in part by the Army Research Laboratory under grant DAAL01-98-2-D065.

3 System Design

Our design philosophy for the development of the handwriting portion centers around the following principles: interactivity, functionality, reliability, user-friendliness, and portability. A handwriting communication system must possess two important capabilities. The first is the ability to support the writing by a light pen, or a mouse if such a pen is unavailable, and the display of the handwritten data. The second capability should allow users to transmit and receive handwritten data from the network. To achieve these goals, a friendly graphical user interface, which requires the use of abstract windowing toolkit and event handling, is a necessity. In order to make the system a useful communication tool on the Internet, it must support both textual and graphical information exchanges. The system must also provide functions for users to overwrite or modify handwritten message received over the network. In addition, the programming language used for implementation must be platform independent so that the system can be easily ported to other machines with different operating systems.

4 Description of the System and its Applications to Distance Education

As mentioned earlier, we use Java [2, 4] as the programming language and TCP as the transport protocol for transferring handwritten data in our current client-server communication system. A graphical user interface consisting of buttons, radio check boxes, and a handwriting area, as well as the operations associated with the interface have been developed using the abstract windowing toolkit. All main tasks of the system are invoked from within the event handling functions. Our system currently allows users on the Internet to exercise handwriting from within a web page that contains the client code and send the information to the server that accepts the handwritten data. It can also be used to enhance online presentations over the Internet. This is due to the fact that the system allows users to perform handwriting directly on the specified writing area in a web page. By putting the presentation material inside the handwriting area, it is possible to add notes, make corrections, highlight important subjects on the spot during the course of the presentation.

The handwriting communication system has many applications in distance education and on-line collaborative learning. It can be used by an instructor to deliver on-line lectures via the web; the instructor may use one part of the screen to present prepared presentations and another part to highlight the important points of his/her presentation using a light pen. It can be used by fellow students in different locations to solve problems collaboratively and work on team projects. In addition, the instructor and students can use it to conduct on-line class discussions and answer student's questions by employing the communication capability.

5 Conclusions

In this article, we have presented the basic approaches, design considerations, and implementation of a real-time handwriting communication system on the Internet as well as its applications to on-line education. Our design philosophy centers around functionality, interactivity, portability, and user friendliness.

References

1. Andrew S. Tanenbaum, "Computer Networks", NJ: Prentice Hall, 3rd Edition , (1996).
2. David Flaganan, "Java in a Nutshell, Sebastopol", CA: O' Reilly & Associates, (1996).
3. David Gunter, et al., "Client/Server Programming with RPC and DCE", IN: Que, (1995).
4. Patrick Naughton and Herbert Schildt, "JAVA: The Complete Reference", CA: McGraw-Hill, (1997).

Strange Creatures in Virtual Inhabited 3D Worlds

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jerners Vej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +4598156279 Fax: +4598142444
E-mail: jensf@hum.auc.dk

This paper discusses the strange creatures that currently populate 3D cyberspace and3D Internet. First, the concept of Virtual Inhabited 3D worlds are discussed and defined. Next, some of the key elements or basic entities that can be found within the horizon of Virtual, Inhabited 3D Worlds are identified and denned. Among these basic elements are objects and agents, differentiated by whether or not their primary function is to carry out an action. Agents (denned as entities, which primary function is to carry out actions) have two main forms, which have been described as relatively sharply differentiable polar opposites. This is done based on questions such as: who is controlling the agents? ' who is doing the driving?' On the one hand there are agents that react independently of the user, but which are controlled by software or AL, the so-called ' autonomous agents' or ' bots' . On the other hand, there are agents, which directly represent and are controlled by users, the so-called ' avatars. Although there is then, in principle, a differentiation, in terms of definition, between bots and avatars, the paper argues that both concepts cover a relatively wide spectrum of very different types of phenomena with differing degrees of control. There also seems to be a tendency toward the appearance of more and more hybrids- in the present context termed ' cyber-hybrids' - combining avatars and bots. Furthermore, these hybrid forms are in many ways the most interesting and most promising in the virtual worlds at the moment. Rather than considering avatars and bots as polar opposites, it may therefore be more productive to consider them as the outer points along a continuum, between which can be found all sorts of combinations or hybrids. Following this line of argument, the paper outlines a new typology of hybrid creatures, which currently populate the continuum between (objects) bots and avatars in Virtual worlds.

*The paper was not available by the date of printing.

Proceedings

Content

▸Full & Short Papers (Evaluation of Learning and Systems)

A new method for efficient study of kanji using mnemonics and software
A Study on the Relation between Touch-typing Skill and Thinking-typing
An experiment of situated learning on college students
An approach to modeling an educational domain
An Assessment Framework for Information Technology Integrated Instruction
An Effectiveness Study of Web-based Application for Mailing List Summary and Review
An Empirical Study of Design and Use of a Multimedia Composition-Making System for Children
Applicability of an Educational System Assisting Teachers of Novice Programming to Actual Education
Defining Educational R&D: A Content Analysis of Journal Articles and Implications for Instructional Technology
Design and Evaluation of Constructivist Web-based Instructional Systems
Design and Implementation of Cooperative Monitoring Agent using Mobile Agent
Development and evaluation of web-based in-service training system for improving the ICT leadership of schoolteachers
Development of a LAN-based Formative Evaluation Module as an Instructional Management System
Development of a Web System to Support Computer Exercises and its Operation
EDASEQ - A log-file analysis program for assessing navigation processes
Evaluating educational multimedia: a case study
Evaluation of class organization in the computer literacy education
Evaluation of the Web-Based Learning System
Everything in Moderation? Developing successful collaborative projects between European initial teacher education students.
Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers
Implementation of an Internal Execution Simulator and its Application to Computer Literacy Education
The Criteria and Evaluation of Metadata/Keywords in Image Retrieval
The research on difficulty of asynchronous learning materials based on time distribution
The usability aspects of an universal brockerage and delivery system for the Pan-European higher education
Which Chinese input method is more suitable for sixth-grade pupils?keyboarding or non-keyboarding
Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

▲ HOME

A new method for efficient study of *Kanji* using mnemonics and software

Chris Houser*, Shigeki Yokoi and Takami Yasuda****
**Kinjo Gakuin University, Omori 2-1723 Moriyama-ku Nagoya 463-8521 Japan,*
houser@kinjo-u.ac.jp
***Nagoya University, Furo-cho Chikusa-ku Nagoya 464-8601 Japan*

Japanese children spend hundreds of hours, over nine years, studying some 2000 written characters called *kanji*. Incredibly, most foreign adults attempt to study the *kanji* using the *same* method. But without these hundreds of hours, their efforts generally fail. In *Remembering the Kanji*, James Heisig presents a radical method for studying *kanji*. In only 200 hours, Heisig claims, adults can learn the *kanji*. A wonderful improvement! But few students follow his method; most complain that 200 hours is still too long. This paper introduces a refinement of Heisig's technique, a refinement combining modern memory theory with software, a refinement reducing the required time to 40 hours. The first author, a forgetful *kanji* neophyte, learned the *kanji* with this method, studying an hour a day, five days a week, for two months. His recall exceeds 95%, approximating native Japanese. This paper targets both teachers and students of Japanese as a foreign language, providing the knowledge and software required to rapidly learn the *kanji*, and inviting them to participate in a wider experiment using these new technologies.

Keywords: **CALL, Kanji, SuperMemo, Efficient study**

1 The *Kanji*

Perhaps the most difficult part of learning Japanese is memorizing its enormous character set: the 2000-odd *kanji*. These characters were imported from China into Japan. Because each character was imported several times over the centuries, while the Chinese and Japanese languages were evolving, each character now has multiple readings and meanings. As a result, the Japanese writing system is arguably the world's most complex.

Japanese children study these *kanji* for hundreds of hours over nine years of schooling. They start studying when six years old, before they have developed the ability to abstract, and hence can learn the characters only by *muscle memory*: They write the characters repeatedly, typically 20 times each. This method works, but imperfectly: Even after all this study, and the review that comes with daily use, adult Japanese forget some characters.

Most foreigners studying Japanese as a foreign language (JFL) try to learn the *kanji* using the same method: They write the characters repeatedly, perhaps while verbalizing the character's meanings and readings [7]. But since few adult JFL students have the hundreds of hours this method requires, most fail [4].

2 Heisig's method for studying the *kanji*

Heisig [4] offers an alternative study method.
Goal. Heisig's method allows adult JFL students to learn the *writing* and a *single meaning* of 2042 *kanji*. This is a narrow goal: Students concentrate on learning this writing and single meaning, and postpone learning other meanings, all readings, and the multiple character compounds.
Method. Since Heisig targets adults, he is able to use a sophisticated method, a method beyond the grasp of six year olds. He is able to use a *rational* method for learning *kanji*. Heisig prepared his method by

1. assigning each character a *keyword* (its single meaning),

2. splitting each character into a handful of *parts*,
3. ordering the characters so that parts precede their uses, and
4. inventing a mnemonic story to help recall each character's parts.

The keyword is usually the most common of the several Japanese meanings. The parts come from various sources: Some are simpler *kanji*; others are *primitives* – collections of commonly occurring strokes. Some of these primitives were identified centuries ago by Chinese and Japanese linguists (who call them "radicals"); other primitives were simply invented by Heisig. In all, Heisig uses a few hundred parts. The crux of his method:

Each character is learned, not as a mass of random strokes, but as a logical collection of parts.

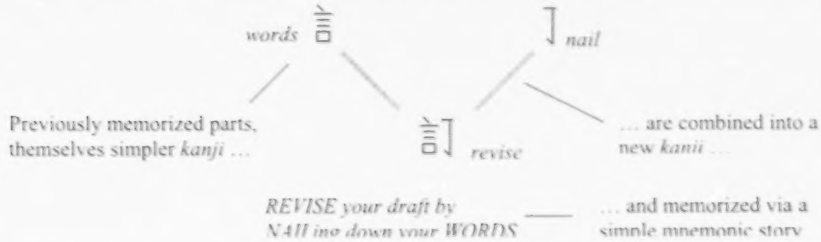
For example, consider the kanji with the keyword revise. This character has **nine meaningless strokes**, which prove quite a challenge to remember. But this same character has only **two parts** with the keywords *words* and *nail* – **meaningful** words which are much easier to remember. In effect, Heisig splits this character into these two parts, making a kind of equation: *revise* = *words* + *nail*. Most non-Japanese find this equation much simpler to recall than a meaningless jumble of nine strokes. When Heisig's students come to study *revise*, they have already learned the two parts – *word* and *nail* – since Heisig has sorted the *kanji* so that these parts precede their use in *revise*. By combining two previously learned parts, students easily remember this new character. But Heisig makes remembering even easier by providing a **mnemonic story**:

REVISE your draft by NAILing down your WORDS.

The image of "nailing down one's words" is so strong and logical that after students have read this mnemonic **once**, they will likely remember it for life.

This contrasts with Japanese students, who practice **writing** the character **repeatedly,** and may later forget it.

Heisig's main contribution is to **raise the level of abstraction** from strokes to parts. Rather than struggling to remember a large, sprawling jumble of meaningless jots and dashes, students effortlessly remember a simple story, calling to mind the few parts that compose a *kanji*:



Study. Heisig has done most of the work: He has assigned the keywords, identified the parts, invented the primitives, and sorted the *kanji*. Students need only read the keyword and story a few times to memorize each *kanji*. Heisig predicts study will require 200 hours – far less than Japanese children spend on rote repetition.

Analysis. Why is Heisig's method so effective? Here are three explanations.

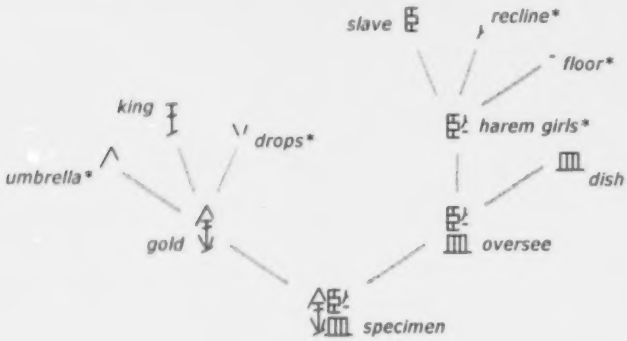
Simplicity. The stories are simpler than the *kanji*, simpler because they have fewer components. Each *kanji* consists of between 1 and 23 strokes; 75% of the *kanji* have more than seven strokes. But all have fewer than seven parts. Now human short-term memory can hold only about seven items [6]. Objects with more than seven known components cannot fit in short-term memory, and so cannot be remembered, or even recognized. This predicts that students learning strokes will remember 25% of the *kanji*, but students learning parts will remember 100%.

Abstraction. Practicing strokes engages only muscle memory: Most of the student's brain remains dormant. Heisig's stories engage the higher faculties of language, actions, settings, events, humor, and metaphor. Such meaningful symbolic processing engages more of the brain, and hence is more easily recalled, than mere orthographic syntax [8]. Humans recall abstract meanings and stories long after they forget specific examples and images [5].

Relations. When learned by rote, each *kanji*, indeed each stroke, must be learned anew: Nothing is connected to anything else. When learned by parts, each *kanji* is connected to previously learned *kanji*.

Heisig's method is rich in connections. When students learn a character, they are also reviewing its parts. In turn, most parts appear repeatedly, and hence are memorized easily.

As an illustration, consider the daunting 23 strokes of *specimen*. Stroke-by-stroke memorization is all but impossible. But *specimen* comprises only two parts: *gold* and *oversee*. It is easily recalled with a story such as *GOLD diggers OVERSEE their mineral SPECIMENS. Specimen* is studied after *gold* and *oversee* have been learned, from their own parts, with their own stories. So each step of study is small and simple, but the steps build on each other – primitives are woven into *kanji*, which are in turn used to build further *kanji* – until a vast web of rich connections is built up in the student's mind.



Parts are either simpler *kanji*, or *primitives* (marked with *)

Problem: Still too difficult! Heisig's method is a great improvement over the Japanese method, but it is not perfect. For Heisig provides stories for only the first 500 of his *kanji*, and asks readers to invent their own stories for the remaining 1542. Faced with this burden, many of Heisig's students stop studying after 500 characters. And those who do continue need unusual discipline, need to painstakingly construct and review flash cards, need a scheduling system to study, review, and test.

3 Kanji Can

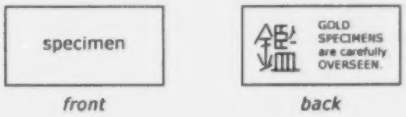
Kanji Can [3, 1] is a database with a *complete* set of 2042 mnemonic stories. The stories are excellent, surpassing even Heisig's first 500:

- Kanji Can's stories are shorter, and so easier to recall.
- Kanji Can's stories mention the parts in the order they are written.
  (Compare with Heisig's story for *revise* above, which reverses them.)

Kanji Can embraces Heisig's method, but extends his materials, and thus solves the problems mentioned above.

4 Flash Cards

The chief tool of most memorizers is the humble flash card. Flash cards are small paper cards with a *stimulus* written on the front side, and a *response* on the back. When studying foreign language vocabulary, the stimulus is typically a word in one's native language, and the response is the word in the foreign vocabulary. When studying *kanji* using Heisig's method, the stimulus is the keyword, and the response is the *kanji* itself.



Students read the stimulus and try to produce the response. They then check their response against the desired response on the back of the card. Cards that were correctly recalled are removed from the deck; cards not recalled are shuffled to the back of the deck, to be reviewed again. Used this way, flash cards combine self-testing with review. The cards catch mistakes and save them, allowing review until the student knows them all. Flash cards

Memory fades after Repeated study slows

are essential when following Heisig's method: Studying the stories is so easy that students will doubt they are really learning anything until they have been tested!

Problem: Inefficiency. Using flash cards takes a lot of time. Each card must be hand made. Then each card must be tested repeatedly, for only with repetition comes dependable memorization. Memory fades over time, but by reviewing partially forgotten material students extend their memories.

But how frequently should students review? Buzan [2] recommends review after ten minutes, a day, a week, a month, and then four months. But are these the best intervals for review? Testing too frequently wastes time reviewing material already well known. Testing too infrequently wastes time relearning forgotten material. The goal of flash cards is to "catch" learners just before they fall – to remind them just as they are about to forget. But the point of forgetting – and hence the optimal review interval – differs for each student, and even for each *kanji*: Some are easier to remember than others. How can we optimize study?

5 Super Memo

Super Memo is a general flash card program [9]. Like paper flash cards, these electronic cards can be used to review anything, including the *kanji*. Unlike paper cards, these electronic cards are neat and easily editable, but require a PC. Super Memo is better than paper flash cards because it contains a mathematical model of human forgetting: It can predict when a student will forget a *kanji*, and hence compute the best testing time. When testing with Super Memo, students tell the program how well they remember each *kanji*; the program uses this information to tune its model to each student, and to each *kanji*. The result closely approximates perfectly timed intervals, and hence maximum efficiency in studying.

Independent of the nature and amount of material they study, students using Super Memo all learn approximately 200 items/minute/year. This means that by studying one minute, every day, for a year, one can learn 200 items; or, by studying 10 minutes a day, 2000 items. This is much faster than many other study methods; in particular, Super Memo implies results in 1/5 of Heisig's time.

Super Memo's computerized scheduling provides more than optimal reviews. It also provides an incentive to study every day. A student using Super Memo runs the program every day and finds a list of items to review. If the student skips a day, the next day she will be confronted with twice as many items! This threat helps provide the discipline necessary in learning a large body of material, such as the *kanji*. (Unfortunately, this also means that if the student skips a week, she will be confronted with a mountain of review, and will likely quit altogether. Super Memo is not for the timid.)

6 New technology allows learning the *kanji* in only 40 hours!

This paper proposes a new method for learning the *kanji*, a method combining Heisig's novel ideas, Kanji Can's stories, and Super Memo's reviewing. Heisig provides the tractable goal and the idea of using mnemonic stories to recall the writing of *kanji* in terms of their parts. Kanji Can provides a complete set of these mnemonic stories. And Super Memo provides strict scheduling and efficient reviewing and testing. The combination of these three educational technologies provides a most efficient *kanji* learning method: the complete set of 2042 *kanji* can be learned in only 40 hours!

These 40 hours might be scheduled as 10 minutes a day, every day for a year, or an hour a day, five days a week, for two months. Memory manuals claim that an hour's study a day is optimal: Shorter study sessions waste time in frequent physical and mental preparation, longer study sessions induce fatigue, and both degrade efficiency [2, 5].

The first author learned the *kanji* in 40 hours by following this method.

Heisig has greatly accelerated *kanji* learning for adult JFL students. Kanji Can's complete set of stories enables students to concentrate on studying the *kanji*. Super Memo provides a well-documented speedup for any rote memorization. Combining these three technologies, we can learn the *kanji* in only 40 hours.

References

[1] Breen, J., *KanjiDic*, ftp://ftp.cc.monash.edu.au/pub/nihongo/00INDEX.html (2000).

[2] Buzan, T., *Make the most of your mind*, Pan, London (1977).

[3] Donaghue, M., *Kanji Can*, http://www.kanjisoft.com (2000).

[4] Heisig, J., *Remembering the Kanji I*, Japan Publications Trading Co., Tokyo (1977).

[5] Maddox, H., *How to study*, Ballantine, New York (1963).

[6] Miller, G., "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information", *The Psychological Review*, vol. 63, pp. 81-97, http://www.well.com/user/smalin/miller.html (1956).

[7] Sakade, F., Emori, K., Friedrich, R., Ohashi, S., *A guide to reading & writing Japanese*, Charles E Tuttle, Rutland, Vermont (1959).

[8] Schmidt, U. & Geyser, A., "How to study 2000 kanji in a few weeks", *Proceedings of ICCE 99*, pp. 595-598 (1999).

[9] Wozniak, P., *Super Memo*, http://www.supermemo.com (2000).

A Study on the Relation between Touch-typing Skill and Thinking-typing

Yuji YOHINAGA* and Hiroaki KAWABATA**
The Graduate School of System Engineering, Okayama Prefectural University
111 Kuboki, Soja, Okayama, 719-1197, Japan
*E-mail: *yoshinaga@mx3.tiki.ne.jp **kawabata@cse.oka-pu.ac.jp*

Word processor is more and more widely used as a tool of externalization and reflection of thinking in recent years in Japan. In that case, it will be necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). The experiments were made to study the relation between touch-typing skill and thinking-typing. The examinees were 46 non-computer majors of the university. The students were asked to type words or sentences appearing in their heads on 3 subjects. The touch-typing skill of the students was measured by touch-typing exercise software. The results suggested that a touch-typing speed of 2 strokes/second is necessary, at least, to type smoothly words or sentences appearing in the head. What's more, the results of the experiments suggested that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Key words **Thinking-typing, Touch-typing, Externalization, Self-evaluation, Analysis of variance**

1 Introduction

The methods for human beings to externalize their thinking are language expression, diagram expression, letter expression and so on [1]. Among these expressions, letters are widely expressed by word processors in recent years in Japan. The method of word processor's usage has been changed by the popularization of them. In other words, the method that uses a word processor to transcribe a manuscript written by handwriting, has been changed to the method that uses a word processor in the process of externalization and reflection of thinking. With the latter method, it is necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). Thinking-typing needs a certain level of typing skill. Although a number of studies have been made on typing [1][2], there are few studies on thinking-typing.

In the lesson of computer exercise at the university, the first author is raising the level of students' typing skill through touch-typing education and, at the same time, is raising the ability of the students' utilizing a word processor as a tool of externalization and reflection of thinking [3]. In the lesson, the experiments of thinking-typing by touch-typing were made to study the relation between touch-typing skill and thinking-typing. Touch-typing speed and self-evaluation of thinking-typing were adopted as the scale of thinking-typing level. The first experiment (Experiment 1) was made in July, 1999, and the second experiment (Experiment 2) was made in February, 2000. In this paper, results regarding Experiment 2, and comparison between Experiment 1 and Experiment 2 are reported, because results regarding Experiment 1 had been reported already [1][4].

2 Method

The experiments of thinking-typing by touch-typing were made in the lesson of the computer exercise for the first-year students at the university. In this study, the data of 46 students, whose data of Experiment 1 and Experiment 2 were complete, were analyzed. In the experiments, the students typed the following subjects by touch-typing.

One-way analysis of variance was used to test for significant differences in thinking-typing speed among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the 3 subjects(*Shiritori* $F=12.46$, $df=3$, $p<.01$ Imagination $F=11.31$, $df=3$, $p<.01$ Impression $F=23.55$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in thinking-typing speed among the 4 touch-typing levels or not. The results are shown in **Table 2**. Homogeneity subgroup is a group of similar levels whose difference is not significant. In the 3 subjects, there were significant differences of thinking-typing speed between the level under 2 minutes and the level over 2 minutes. These results show that reaching touch-typing level under 2 minutes in Experiment 2 was one of the conditions to type smoothly words or sentences appearing in the head.

Tabel 2. Tukey's multiple comparison of thinking-typing speed

	Touch-typing skill	Number of persons	Homogeneity subgroup		
			Gr1	Gr2	Gr3
Shiritori	Level under 1 minute	6	1.13		
	Level of 1 minute	23		0.84	
	Level of 2 minutes	12		0.59	0.59
	Level of 3 minutes	5			0.51
Imagination	Level under 1 minute	6	0.65		
	Level of 1 minute	23	0.52	0.52	
	Level of 2 minutes	12		0.35	0.35
	Level of 3 minutes	5			0.28
Impression	Level under 1 minute	6	1.08		
	Level of 1 minute	23		0.72	
	Level of 2 minutes	12			0.47
	Level of 3 minutes	5			0.42

p .05 *f*

3.2 Relation between Touch-typing Skill and Self-evaluation of Thinking-typing

Self-evaluation of Experiment 2 was divided into positive self-evaluation and negative self-evaluation to study the relation between self-evaluation and touch-typing skill. Positive self-evaluation is "very good", "good" and "a little good". Negative self-evaluation is "a little bad", "bad" and "very bad". As for self-evaluation point, positive self-evaluation is 1 point, and negative self-evaluation is 0 point. The mean of self-evaluation point of each touch-typing level is shown in **Table 3**.

Table 3. Touch-typing skill and self-evaluation

Touch-typing skill	Number of persons	Self-evaluation point					
		Shiritori		Imagination		Impression	
		Thinking	Typing	Thinking	Typing	Thinking	Typing
Level under 1 minute	6	0.50	1.00	0.17	1.00	1.00	1.00
Level of 1 minute	23	0.61	0.96	0.52	0.96	0.74	0.96
Level of 2 minutes	12	0.67	0.75	0.42	0.83	0.83	0.75
Level of 3 minutes	5	0.40	0.60	0.40	0.40	0.80	0.40
All the examinees	46	0.59	0.87	0.43	0.87	0.80	0.85

One-way analysis of variance was used to test for significant differences in self-evaluation point among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the typing evaluation of imagination and in the typing evaluation of impression (typing evaluation of imagination $F=5.11$, $df=3$, $p<.01$ typing evaluation of impression $F=4.86$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences about the typing evaluation of imagination and the typing evaluation of impression among the 4 touch-typing levels or not. The results are shown in **Table 4**. Typing evaluation of Level of 3 minutes in imagination was significantly lower than other touch-typing levels, and typing evaluation of Level of 3 minutes in impression was significantly lower than Level under 1 minute and Level of 1 minute. These results show that the students of Level of 3 minutes could not type smoothly imagination or impression, comparing with the students of other touch-typing levels.

【Subjects of Experiment 1】

Subject 1 Type words that you think with *shiritori* (a Japanese word chain game). Type them by *hiragana* (Japanese alphabet). The time limit is 3 minutes.

Subject 2 Type words that you image with "university". Type them by *hiragana-kanji* (Japanese alphabet – Chinese characters) translation. The time limit is 5 minutes.

Subject 3 Type sentences of your self-introduction. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

【Subjects of Experiment 2】

Subject 1 Same as Subject 1 of Experiment 1.

Subject 2 Type words that you image with "student life". Type them by *hiragana-kanji* translation. The time limit is 5 minutes.

Subject 3 Type sentences of your impression about the lesson of the computer exercise. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

After the experiment, the students evaluated themselves on the 3 subjects. In Experiment 2, the students evaluated themselves on whether they could think out words and sentences or not (thinking evaluation), whether they could type words and sentences by touch-typing or not (typing evaluation). The evaluation standard was divided into 6 levels "very good", "good", "a little good", "a little bad", "bad" and "very bad".

The touch-typing skill of the students was measured in the lessons before and after the lesson of the experiments. The measurement content is testing typing time of entering Japanese sentences of *hiragana* (about 240 strokes) that were displayed in a monitor at random, by *romaji* (Japanese Roman characters) input and touch-typing.

3 Results and Discussion

3.1 Relation between Touch-typing Skill and Thinking-typing Speed

Touch-typing skill in Experiment 2 was divided into 4 levels under 1 minute (Level under 1 minute), between 1 minute and 2 minutes (Level of 1 minute), between 2 minutes and 3 minutes (Level of 2 minutes), between 3 minutes and 4 minutes (Level of 3 minutes). The mean and the standard deviation of thinking-typing speed in each touch-typing level are shown in **Table 1**. Thinking-typing speed in each subject was calculated by the next equation.

$$s = \frac{L}{T}$$

s Thinking-typing speed in each subject

L Typing linage in each subject*

T Time limit in each subject (minute)

*Number of letters per line, after *hiragana-kanji* translation, is 40.

Table 1. Touch-typing skill and thinking-typing speed

Touch-typing skill	Number of persons	Thinking-typing speed (linage/minute)					
		Shiritori		Imagination		Impression	
		M	*SD*	*M*	*SD*	*M*	*SD*
Level under 1 minute	6	1.13	0.25	0.65	0.16	1.07	0.14
Level of 1 minute	23	0.84	0.23	0.52	0.14	0.72	0.19
Level of 2 minutes	12	0.59	0.11	0.35	0.06	0.47	0.11
Level of 3 minutes	5	0.51	0.13	0.28	0.09	0.42	0.10
All the examinees	46	0.77	0.27	0.47	0.17	0.67	0.25

Table 4. Tukey's multiple comparison of self-evaluation

	Touch-typing skill	Number of persons	Homogeneity subgroup	
			Gr1	Gr2
Typing evaluation of imagination	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.83	
	Level of 3 minutes	5		0.40
Typing evaluation of impression	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.75	0.75
	Level of 3 minutes	5		0.40
	p .05		f	

3.3 Relation between Learning of Touch-typing Skill and Change of Thinking-typing Speed

The mean of learning ratio of touch-typing skill and the mean of change ratio of thinking-typing speed in each touch-typing level of Experiment 2 are shown in **Table 5**. Learning ratio and change ratio were calculated by the next equation.

$$\alpha = \frac{T1}{T2} \qquad \beta? \frac{s1}{s2}$$

α Learning ratio of touch-typing skill
$T1$ Touch-typing time of Experiment 1 (minute)
$T2$ Touch-typing time of Experiment 2 (minute)
β Change ratio of thinking-typing speed
$s1$ Thinking-typing speed of Experiment 1 (linage/minute)
$s2$ Thinking-typing speed of Experiment 2 (linage/minute)

Two-way analysis of variance was used to test for significant differences in the 4 touch-typing levels and the 3 subjects about change ratio of thinking-typing speed in Table 5. As a result, main effect of the 3 subjects was significant($F=4.14$, $df=2$, $p<.05$). Main effect of the 4 touch-typing levels and interaction were not significant. What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in change ratio of thinking-typing speed among the 3 subjects or not. As a result, there were significant differences of change ratio of thinking-typing speed between Subject 3 and other subjects. Next, correlation between learning ratio of touch-typing skill and charge ratio of thinking-typing speed is shown in Table 6. A moderate significant positive correlation was observed between learning ratio of touch-typing skill and change ratio of thinking-typing speed in Subject 3. So it can be said that learning of touch-typing skill is very effective on the increase of thinking-typing speed of Subject 3. What is the qualitative difference between Subject 3 and other subjects? It is the easiness of thinking. Thinking evaluation point in Table 3 expresses the easiness of thinking in each subject. Thinking evaluation point of impression (Subject 3) is higher than other subjects. So it is considered that words of impression (Subject 3) was easier to be thought out than other subjects. Therefore, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Table 5. Learning ratio of touch-typing skill and change ratio of thinking-typing speed

Touch-typing skill	Number of persons	Learning ratio of touch-typing	Change ratio of thinking-typing speed		
			Subject	Subject 2	Subject 3
Level under 1 minute	6	1.69	1.35	1.61	2.03
Level of 1 minute	23	1.58	1.24	1.47	1.93
Level of 2 minutes	12	1.57	1.18	1.57	1.61
Level of 3 minutes	5	1.50	1.89	1.47	1.80
All the examinees	46	1.58	1.31	1.51	1.84

Table 6. Correlation between learning ratio of touch-typing skill and change ratio of thinking-typing speed

	Change ratio of thinking-typing speed		
	Subject	Subject 2	Subject 3
Learning ratio of touch-typing	0.245	0.089	0.565**

**p .01 f

4 Conclusion

From what has been discussed about the relation between touch-typing skill and thinking-typing speed, and relation between touch-typing skill and self-evaluation of thinking-typing, it can be concluded that a touch-typing level under 2 minutes is necessary, at least, to type smoothly words or sentences appearing in the head. The speed of 240 strokes in 2 minutes equals 2 strokes/second. 2 strokes are needed to input a *hiragana*. So the speed of 120 *hiragana* in 2 minutes equals 1 *hiragana*/second. The aim of touch-typing education for thinking-typing should be set at 2 strokes/second (1 *hiragana*/second). What's more, from what has been discussed about the relation between learning of touch-typing skill and change of thinking-typing speed, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

References

[1] Y. Saeki, "New Computer and Education", Iwanami Sinsyo, pp.104-105 (1997).

[2] T. Ohno, "The Effect of the Typing Skill for the Typing Process", Research Report of Information Processing Society of Japan(Human Interface), 63-6, pp.31-36 (1995).

[3] C. Kogo, "Use of electronic mail in assignments, term paper and final examination in college courses, and relationships between grades of them and typing skill", Research Report of Japan Society for Educational Technology Conferences, 96-4, pp.1-4 (1996).

[4] Y. Yoshinaga and H. Kawabata, "Touch-typing education in considering of self-evaluation", Proceedings of the 2000 IEICE General Conference(Information and System 1), p219(2000).

[5]Y. Yoshinaga and H. Kawabata, "A Experiment Report about Thinking-Typing by Touch-Typing", Proceedings of the Federation of Cyugoku Branch Electronics and Information 1999, pp.366-367(1999).

[6]Y. Yoshinaga and H. Kawabata, "A Study on the Effect of Touch-Typing Skill for Thinking-Typing", Advanced Research in Computers and Communications in Education(2), pp.833-834(1999).

An experiment of situated learning on college students

Fonchu Kuo*, Hin-chung Wong, Gin-Fon N. Ju***, P.M. Chen*, T.W. Lin*, Shu-Hui Liu** and Hsiao-Chiao Hung****

**Department of Computer Science, Soochow University, Taipei, Taiwan, R.O.C., P. O. Box 14-135, Taipei, Taiwan*

E-mail: kfc@cis.scu.edu.tw

***Department of Microbiology, Soochow University, Taipei, Taiwan, R.O.C. No. 70, Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

wonghc@mail.scu.edu.tw

****Department of Psychology, Soochow University, Taipei, Taiwan, R.O.C., No. 70,Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

gju@cis.scu.edu.tw

Several experiments of situated instruction have been done in elementary school. We conduct the inaugural experiment on college students. A group of 44 students who are taking food microbiology course involved in this experiment. We designed a science fiction named "Save the Taiwan", which is a story regarding a Microbiology technician handles a disease crisis. A student can learn how to deal with the crisis and solve the problem of an infectious disease when he uses this CAI software. The evaluation practice consists of four dimensions, subject domain demands, instructional demand, user interface demand, and pragmatic demands. The result of evaluation shows notable effect on college students.

Keywords: **situated learning, evaluation of CAI, Microbiology**

1 Introduction

The advantage of traditional instruction is that the knowledge that students learned can be "stiff knowledge". The stiff knowledge can not be smoothly applied to solve the actual problem in a real environment (Brown, 1989). Situated cognition bases on the theory that the learning should be constructed at real situation. Only when the learner derive the knowledge from the real situation then he realizes the real meaning of the learned knowledge and cherish the value of knowledge and take it as the tool for solving the problem. (Cognition and Technology Group at Vanderbilt, 1990)

There was experiment on elementary school student (Tsu, 1997). The experiment was focus on learning simple mathematics calculating. We conduct the experiment on college student, trying to find out if situated learning can be succeed on the domain of higher education. The students of Department of Microbiology have to take laboratory classes during the period of 4 years college. They always have the problem of how and where to apply what they have learned in the class. The instructive goals of laboratory class are diverse. Lazarowitz & Tamir (1992) believe that learning is a process of construction. Despite of learning the laboratory skill, oral discussion between instructor and students should be part of the learning process. In addition, a more inexpensive and more efficient instruction method, such as computer aided instruction or simulations, should be adapted in the class. Anchored situated instruction adapts computer technology to implement situated cognition theory. (Cognition and Technology Group at Vanderbilt,1990) In our software, we develop a pseudo but can be real situation, embedded the learning materials in the circumstances. Through the interaction between user and CAI software, learner can then practice the process of collecting and filtering information as well as the methods to solve the problem.

2 Design features of our approach

The script was written and designed by a professor of Department of Microbiology. We adopt several principles in our design.

1. Provide vivid circumstance. Multimedia allows us to design a vivid environment, so that the situation can avoid over-simplified and lack of context. (Yang, 1995). Multimedia also provides plentiful visual symbols, e.g. video images, graphic charts, sound as well as text to make the play more fun and close to real environment.

2. To hide useful information in the story, a learner may have trouble to transfer what he has learned to different situation if he was teaching in a simplified or provided obvious cue environment. Whereas, a learner can learn to justify what information can be useful and what information is not useful for solving the problem in a simulated situation.

3. To randomize the plot of the story, the learner can memorialize the plot if he has experienced in using this CAI software. This can then cause the learning process in vain. We use Random function in our design; one of the bacteria was picked randomly and then, in turn, develop different story.

4. To have productive result, there may be only one answer or solution in a traditional instruction. However, in a real environment, there may be more than one solution to solve the problem. They may be pros and cons from one to one, but they may all workable. We do not provide firm answer to user instead, we provide an open-ended environment for user to construct his own path and solution.

3 The story

3.1 Outline of the story

There is a food mediated infectious disease occurs in a small town that locates at the seashore of Taiwan island. Within a few days, this infectious disease has spread to nearby counties and caused many cases of death. Tai-shang (see photo 1), the leading actor, a technician of the local public health administration office, is responsible for finding out the etiologic agent of the disease. In the story, Tai-shang is facing many challenges like the ones in real life. His girl friend, professor and colleagues are all in the plot and interactive with him. After the accident happened, he had faced the pressure from his superior, public media, even from a local councilor. He must acts like a detective who searches the cue and a scientist who seeks for the truth of problem. Finally, with the encouragement of his college instructor, Ta-shang successfully finishes his task.

Photo 1. A clip photo from video " To save Taiwan".

3.2 Goal of learning

a. Cognitive aspect

a. Assessment of identifying the virus, fatal virus can not be classified from appearance. Thus, the learner

BEST COPY AVAILABLE

has to make a judgement base on the information gathered from the plot and then decide how to proceed the process of bacteria identification.

- b• Learning of the skills of bacteria identification, there are skills, e.g. Stain, biochemical test, can be practiced.
- c• Usage of bacteria identification index table, after the preliminary result of biochemical test, the learner needs to learn to use bacteria identification index table for final judgement.

b• Attitude • •

- a• Right attitude of science work, through playing the role in the game, the learner can identify the spirit of scientific work, diligence and concentration, as the attitude of being a scientist.
- b• Social caring, since the story has a local background, we hope the learner can improve the caring of local society by solving the problem for local society.

4 Evaluation of our experiment

There are four criteria of the evaluation of the designated software. The criteria is based on the character the teaching subject, human learning theories, and research on user interfaces• Kuittinen, 1998• • The criteria consist of four types of requirements: subject domain, instructional, user interface design and pragmatic matters. We invited two batches of domain experts, the faculties of Department of Microbiology and industry professionals to evaluate subject domain. They focused on examining if the concept and methods of this domain are generally applied in our software, which means they checked the relevancy to instructional aims. The group of 20 experts showed their positive opinion at the following chart.• Table 1 •The instructional demand is a student-centered approach. We divide a group of 44 college students who are taking food microbiology into two groups. The 22 randomly selected members of test team used our software for average 6 hours in a period of a week. A cognitive examination was taken after one week. The result shows that the test team has better performance in cognitive aspect. Table2• The interactivity, display elements and connections between them are examined as the criteria of user interface. We use questionnaire to test team and found out that the team members show satisfaction of the user interface.• Table 3• As the pragmatic criteria, the hardware and software requirements are evaluated to see if a specific and /or expensive equipment or environment is required to use the software. Our software can be used in a common Microsoft Windows environment plus Pentium compatible personal computer. A learner can run our software either at computer room in campus or at his own PC.

Table 1. The result of experts poll

	number	Min	Max	Average	standard deviation	variance
Can the instructional goal of " assessment of identifying pathogenic bacteria " be reached?	12	3	4	3.67	0.49	0.242
Can the instructional goal of " learning the identification methods " be reached?	12	2	5	4.00	0.74	0.545
Can the instructional goal of " usage of diagnostic table for the identification bacteria " be reached?	12	2	5	4.08	0.79	0.629
Can the instructional goal of " influence on right scientific attitude " be reached?	12	2	4	3.58	0.79	0.629
Can the instructional goal of " influence on social caring" be reached?	12	2	4	3.25	0.87	0.750
Does the content of software cover" common foodborne pathogenic bacteria and their characteristics"?	12	2	5	3.92	0.79	0.629
Does the content of software cover" procedures of identification of pathogenic bacteria"	12	4	5	4.33	0.49	0.242
Does the content of software cover" knowledge for assessment of methods used in bacterial identification"	12	2	5	4.17	0.83	0.697

Table 2. Evaluation on the cognitive improvement of the software

Item		n	Average	SD	F-value	df	t-value
Score of Midterm examination	Control group	23	61.96	6.92	2.54	42	-0.34
	Exp. group	21	62.90	11.03			
Semester score	Control group	23	80.09	9.66	1.00	42	1.59
	Exp. group	21	75.48	9.65			
Cognitive Examination	Control group	23	29.74	6.11	1.09	42	-3.14**
	Exp. group	21	41.29	6.98			
Situated Questions	Control group	23	3.57	2.64	1.04	42	-3.73**
	Exp. group	21	6.57	2.69			
Questions on Microbiological Skill	Control group	23	26.17	5.07	1.08	42	-5.47**
	Exp. group	21	34.71	5.28			

Table 3. Evaluation of user interface of the software

	number	Min	Max	average	standard deviation	variance
I do not need tutoring before I use this software	21	2	5	3.95	0.92	0.848
I can easily know how to jump to next screen	21	1	5	3.76	1.18	1.390
I can exit the software anytime, anywhere.	21	2	5	4.52	0.93	0.862
I do not have the situation that I can not proceed because that I did not memorize the previous information while I use this software.	21	2	5	4.19	0.87	0.762
It's easy to modify my answer before I press the "confirm" bottom	21	2	5	4.10	0.94	0.890
I can receive the system feedback anytime when I use the software.	21	2	5	3.90	0.77	0.590
The system feedback is clear enough and no need to be explained.	21	2	5	3.81	0.81	0.662
I can use the software without reading the user's manual in ahead	21	2	5	4.19	0.87	0.762
I think the execution speed is proper to me.	21	2	5	3.95	0.80	0.648
I can handle the execution speed of my own.	21	2	5	3.81	0.75	0.562
I am satisfied the quality of the video.	21	1	5	3.29	1.01	1.014
I can use the software without knowing how to operate Window NT	20	3	5	4.55	0.60	0.366
Total score	21	39	55	47.81	4.12	16.962

5 Conclusions

We completed situated learning software "To save Taiwan" which attract the user to learn the microbiology knowledge and skills. This interactive software provides multimedia and random plots, which enable user to play the role in the story. It can also served as the tool to convey the right scientific attitude and social caring to learners.

The evaluation of this study showed promising results. It is possible and valuable to adapt situated learning to other disciplines in higher education. A disciplinary can construct the learning process on a situated

environment. By using the multimedia software, a learner can learn knowledge as well as the attitude in a near true story. He can then realize the meaning of the knowledge and identify himself with what he has learned and then applied to real environment.

References

- 1. Hsu, H.Y. "Design of anchored instruction" Audio-Visual Instruction bimonthly. 37(1), page14-24, (1995)
- 2. Yang, C. H. "The situated instruction theory and hypermedia learning environment". Instruction technology and media. August, 1995. page41-48. (1995)
- 3. Brown, J. S.Collins, A., & Duguid, P., " Situated cognition and the culture of learning", Educational Researcher, 18,32-41. (1989)
- 4. Cognition and Technology Group at Vanderbilt., "Anchored instruction and its relationship to situated cognition ", Educational Researcher, 19,P2-10, (1990)
- 5. Lazarowitz, R., and P. Tamir.. "Research on using laboratory instruction in science. In: Handbook of research on science teaching and learning". Ed. By D.L. Gabel. P. 94-127. MacMillan Publishing Company, New York., (1992)
- 6. Kuittinen, M. "Criteria for evaluating CAI applications", Computer & Education 31, 1-16, (1998)
- 7. Winn, William,"Instructional design and situated learning: Paradox or partnership?" Educational Technology 33(3), page 16-21,(1993)

An approach to modeling an educational domain

Gennadiy ATANOV
Donetsk Institute of Social Education; DISO, Donetsk, 83000, Ukraine
E-mail: atanov@dongu.donetsk.ua

The paper develops a topic of construction of the normative student model. The subject student model is a part of it representing a sum of demands to the curriculum of the subject, to students' knowledge and skills, and a semantic model of the domain. The subject student models pick out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain. Examples in physics are given.

Keywords: **student modeling, domain modeling, knowledge, skills, semantics**

1 Introduction

A fundamental concept of modern didactics and pedagogical psychology is the student (learner) model. It arose within computer technologies of education and was provoked by the necessity to formalize our representation about students. Of course such representations had been worked out long before any appearance of computers, and definite formalization of them began together with didactics. But it is computer technologies that gave a new impulse to development of these representations, transformed them into an object of deep investigations, transferred to a qualitatively new level [8,9].

In the widest sense, the student model is our knowledge about a student. There are two sides here: (1) knowledge about how the student is, and (2) knowledge about how we want to see him/her. The first knowledge is determined by the way of analyses of student's behavior, and it is natural to call it a behavioral student model. It is changing together with the student's change therefore it is also called dynamic, or current, one. Mechanism of construction of this model is the cognitive diagnostics [9].

Knowledge about how we want to see students, that is, demands to their final state is a normative student model. As a rule, this knowledge is various. It consists of demands to personal qualities of future specialists, their professional qualities and skills, their knowledge and skills in different subjects, characteristics of their physical and psychological state, and so on. The final aim of teaching is achievement of such a state when the behavioral student model concurs with the normative one.

2 The subject student model

A part of the normative student model determining domain knowledge is a subject student model [3]. In knowledge engineering, it is called expert knowledge, or domain model [5,6]. The subject student model picks out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain, or a model of a subject. Let us note that if the dynamic modeling is quite a developed branch of Artificial Intelligence, the domain modeling is developed to a lesser degree. It is clear, as specialists in Artificial Intelligence, as a rule, are not the ones in any other domain.

Under knowledge they understand the main conformities to natural laws helping us to solve particular problems (production, scientific, economic, and others) [5]. Facts, concepts, algorithms, intercommunications, rules, strategies of making decisions, and so on make up knowledge. The pithy sense of the concept «knowledge» is that knowledge reflects our imagination about domains and expresses a system of concepts, as well as relationships and dependencies between them.

According to the classification, there is a division of domain knowledge into declarative and procedural ones.

The first is statements about properties of the subjects of a domain and relationships between them. The declarative knowledge is often called a factual one, and this reflects its essence very well. The procedural knowledge describes the order and character of the transformation of the domain objects. Its another appellation is rules. In our opinion, it is not quite right, as the declarative knowledge, giving relationships between the objects, is also rules. Thus the procedural knowledge is not simply rules but rules of transformation.

The final aim of instruction is formation of way of acting. The way of acting is realized via skills in the practical activity [7]. The mechanism of this is operation with knowledge (both the declarative and procedural) being displayed in the behavior of a person. Therefore, in a wide sense, skills are attributed to knowledge, namely behavioral one [9]. The procedural knowledge is realized in skills. And sometimes, skills are called the procedural knowledge but, as we could see, the term "procedural knowledge" has been already occupied. Definition "operation knowledge" reflects the essence of the things clearly and in the most unambiguous manner. Thus, the subject student model has to contain skills that are to be formed in the process of instruction. Let us call a list of such skills the operational subject student model.

The declarative component of the domain knowledge makes up a semantic part of it, namely the semantic student model.

One of the distinctive properties of knowledge is that it has a certain structure. It is very important, especially for the instructional material, to define its structure. It is well known that to master a portion of the instructional knowledge is to determine its place in the structure of the instructional material. Therefore, one of the problems while constructing the subject student model must be determination of the subject knowledge structure. Studying the structure of the instructional material is a theme of an independent important and deep investigation. The subject student model must give more or less extended ideas about what the subject knowledge is. Such ideas are an essential part of any curriculum. A usual way here is a thematic approach when themes are enumerated. Let us call a list of themes liable to studying the thematic subject student model.

In teaching, it is very important methodologically to determine which role either knowledge plays and which functions it carries. In other words, it is necessary to fulfil a functional structuring of the instructional knowledge. It can be done with the help of a list of functional rubrics. The functional knowledge will be determined in such a way. Within it, there is knowledge performing both nontransforming functions (for example, facts, conclusions) and transforming ones (algorithms, methods, instructions). The functional knowledge makes up the functional subject student model.

In such a way, we suggest a four component subject student model consisting of thematic, functional, operational, and semantic parts. Such a subject student model in physics is carried out at the physics and didactics of physics department of the Donetsk State University [1-3].

3 The thematic subject student model

The thematic subject student model has been well known for a long time. In essence, it is a usual curriculum of the course, its program. It is built just according to the thematic principle, sections and themes liable to studying are enumerated in it. The model reflects the structure of the course. The program can be worked out in detail to different degree but it is always neither knowledge itself, nor its content but its names. In fact, this is a define characteristic of the subject knowledge, some knowledge about the subject knowledge. Knowledge about knowledge is called metaknowledge. Thus, the thematic subject student model is a metaknowledge.

It is a natural and convenient model for planning and organizing the instructional process. The more, it is an obligatory normative document. Preparation of any course begins with its creation (that is, creation of the course curriculum). Nevertheless, it is excessively general to use it for diagnostics.

As a rule, knowledge in many computer tutoring systems is structured according to the thematic student model.

4 The functional subject student model

The functional subject student model shows which role either knowledge plays; and it is also metaknowledge. It has a define structure in the horizontal direction, which may be given with the help of some rubrics. The role of knowledge and its functions depend on a particular subject. For example, we picked out the following rubrics for physics courses: *concepts, wordings, laws, properties, consequences, conclusions, reasons, formulas, equations, models, methods, and algorithms* [3]. The rubrics have a filling that, nevertheless, also does not reflect semantic of the subject and is metaknowledge.

It is the subject student model that allows working out in details what students must know. Let us give an example from the molecular physics. Students have to know: definitions of the concepts: *mole, thermodynamic system, pressure, temperature, density, concentration, ideal gas, equation of state*, and so on; wording and consequences of: *Pascal's law, Maxwell's and Bolzmann's distributions, Kirchhoff's law*, and so on; deductions of: *the mine equation of kinetic theory, equation of the adiabatic process, law of atmospheres*, and so on.

5 The operation subject student model

As it was noted, the operation subject student model is a list of skills liable to mastering by students. Let us note that skills in education make up a hierarchical system [2]. It consists of five groups of skills: fundamental, methodological, general, inter-subject, subject. Subject skills take the highest position in the hierarchy of skills.

We pick out three classes of the subject physical skills: general, particular, and experimental. The general skills are, on the first hand, methodological ones. Spectrum of the particular skills is far wider, for example, there are more than 200 them in the list in physics. According to the contents of the instructional material, the following skills are picked out: *to find, to determine, to fix, to build, to obtain, to calculate, to compute, to estimate, to distinguish, to pick out, to sort, to take into account, to represent, to traverse, to decompose, to compose, to generalize, to put in practice, to use, to formulate.*

There is a fragment of the list of the skills below:

3.1. General skills

To analyze physical processes and phenomena, to estimate orders of physics magnitudes and determine essential factors, to build physical models, to build mathematical models of particular physical processes and phenomena, to determine boundaries of applicability of the models, and so on.

3.2. Particular skills

3.2.2. Molecular Physics and Thermodynamics

To estimate quantity of particles and their mass in particular conditions, to determine parameters of state of gas, to determine number of degrees of freedom and molecular mass of a gas and mixture of gases, to determine possibility of the use of the model of an ideal gas, to make use functions of distribution to find average values of physics magnitudes, and so on.

Experimental skills are divided into three groups: *to measure physical magnitudes; to reproduce independently physical phenomena and processes; experimental particular skills.*

There is a hierarchical structure of the subject skills corresponding to the development of the subject in instruction. Besides that all of them also have a definite structure in the horizontal dimension because they are complicated, or composed, skills. In order to master them, a wide spectrum of skills both of the lower levels and subject is necessary. For example, skill *to solve physical problems* is composed of ten simpler skills: *to pick out the necessary information from the condition of a problem to solve it, to code the condition of the problem in a word form, to draw a picture to the problem, to choice a rational method of solving*, and so on.

6 The semantic subject student model

Semantic knowledge in different subjects is contained in textbooks, other training literature. There are two parts in the content of any textbook: CON-1 and CON-2 [7]. CON-1 is knowledge making up the content of

a domain directly, CON-2 is knowledge attending the CON-1 (for example, knowledge from other subjects, interpretations, explanations, examples from life). In fact, it is the CON-1 that is the semantic knowledge of a domain. Nevertheless, this knowledge is not picked out especially, it is distributed all around the textbook, interacts with another knowledge, and is not formalized.

Semantic knowledge represents the declarative component of the subject knowledge as the procedural knowledge is realized in skills (operational knowledge). Thus to construct a semantic student model on the basis of a textbook, it is necessary to pick out domain facts from it and group them in a definite order. According to their structure, facts may be of a great variety. As a rule, they are compound ones. Nevertheless, elementary facts may be picked out that, appearing in different relationships, form the compound facts. General questions of representation of facts in instruction are considered in works [4]. For example, expression "*Translational motion is the motion that all the point of a solid body have identical trajectory*" is a compound fact as it can be represented as a set of the following elementary facts: (1) *a solid body moves; (2) all the point of the body have identical trajectory; some motion is called the translational one.*

One can easily see that the elementary facts do not carry any semantic loading of the domain although they contain domain terms. Only on gathering together in a compound fact they acquire some doma in sense. Such compound facts are finished thoughts and they are represented by finished sentences, or expressions. Let us call them the *semantic* facts. As a matter of fact, the semantic facts are a unit of the domain knowledge, as smaller portions of it have no domain sense. The objects of the expression are concepts, phenomena, processes, laws, principles, theorems, conclusions, consequences, reasons, properties, rules, and so on.

It is the full set of the semantic facts that is the semantic subject student model. The order of their disposition is subordinated to the logic of the development of the course.

Such a semantic subject student model was firstly constructed in Gas Dynamics and than in Physics [1]. Those were very small brochures because there were no calculations, proofs, and explanation in them. Nevertheless, they contained all the statements of the courses. These brochures received the title *semantic synopsis*. As an example, there is a fragment from a physics semantic synopsis below:

3.1. The elementary work of a force is defined as the scalar product of the elementary displacement of the point of the force application.

3.2. The work of a force is defined as a line integral from the elementary work along the trajectory of the point of the force application.

3.3. The unit of the work is one joule that is equal to a work done by a force of one newton on a displacement of one meter.

In the opinion of instructors and students, the synopsis turned out an effective means while consolidating the instructional material, preparing to seminars. It helps to size up the structure of the instructional material, pick out and easily memorize the most essential its moments. It is very important that student remember them for a longer time.

The synopsis allows carrying out fast and regular control students' knowledge during a lecture. In this case, the expressions serve as a base for the open type test tasks being created by missing some keywords in the expressions. Students note a great value of the synopsis while preparing to the examinations when there is a danger do not pick out and master the main statements of the course.

Let us note that the semantic facts are distinctive rules as they define character of relationships between the elementary facts. In other words, they are rules according to which the elementary facts are connected between themselves. This circumstance stipulates possibility to represent the semantic knowledge by means of the production method. It is done with the help of rules of a kind "if A than B" where A and B are some facts. An example of such a representation of the above mentioned definition of the translation motion is given below:

If *< a solid body moves>* and
< all the point of the body have identical trajectory>
than *<such a motion is called the translational one>*.

Each of the expressions may be represented in such a way. Thus the production knowledge base of the subject will be constructed. Its constructing is considered in details in work [4]. As our practice shows, constructing production knowledge bases by students while learning is an effective kind of learning activity.

7 Conclusion

An approach to construction of the subject student model as a part of the normative one is described. The model consists of four components: thematic, functional, operation, and semantic. The thematic model gives ideas about the structure of the subject, the semantic one reflects its content, functional one determine what students have to know, and operation one does what students have to be able. The approach allows constructing more detailed current student models and reaching the main aim of teaching, namely forming the way of acting, more successfully.

References

[1] Atanov, G.A., Belaya, T.D., Beshevly, B.I., etc. "The base synopsis in physics". Kyiv, NMK VO, (1993) (in Russian).

[2] Atanov, G.A., Efros, T.I. "System of skills in instruction as a part of the learner model". Proc. of the Intern. Conf. on Computer Assistant Learning CAL-97. Exeter, UK, pp. 369-372, (1997).

[3] Atanov, G.A., Martynovitch, N.N., Tokiy, V.V. "Curriculum of Physics Course as a Student Model". Proc. of the Intern. Conf. on Computer Technologies in Education ICCTE'93. Kyiv, Ukraine, p. 138 (1993).

[4] Atanov, G. A., Pustynnikova, I. N. "Representation and Structuring of Domain Knowledge by the Semantic Networks and Productions Methods". Proc. of the 8th Intern. PEG Conf.: Meeting the Challenge of the New Technologies. Sozopol, Bulgaria,, pp. 392 - 393 (1997).

[5] Brachman, J., Levesque, H.J., Reiter, R. "Knowledge representation". MIT Press, (1992).

[6] Dean, T.L., Allen, J., Aloimonous, J. "Artificial intelligence: Theory and practice". Benjamin/Cummings (1994).

[7] Mashbits, E.I. "Psychological and pedagogical problems of computer assistant learning". Pedagogika, Moscow (1988) (in Russian).

[8] Self, J. "Dynamics of Learner Models. Artificial Intelligence and Education". IOS Press, Amsterdam (1994).

[9] Wenger, Å "Artificial intelligence and tutoring systems. Computational approaches to the communication of knowledge". Morgan Kaufmann, Los Altos (1987).

An Assessment Framework for Information Technology Integrated Instruction

Chuan-Shih Wang* and Chia-Chin Li**
The Institute of Information and Computer Education, National Kaohsiung Normal University
116, Heping 1st Rd., Kaohsiung, Taiwan, R.O.C.
** jason@icemail.nknu.edu.tw **april@ icemail.nknu.edu.tw*

Information technology integrated instruction is the education tendency in the future, and it is also an important issue in the development of education in Taiwan. An assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference. This article proposes an framework for assessing information technology integrated instruction. The framework includes kernel and periphery parts. Kernel part refers to the whole teaching process, including information technology, curricula, learning materials, instructional strategies, learning activities, and evaluation. Periphery part refers to the surroundings situation, including teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

Keywords: **information technology integrated instruction, technology integration, educational technology, evaluation**

1 Introduction

The rapid development of information technology (IT) has not only brought about major effect on economy and industry but also made a great impact on society and education. In particular, the prevalent use of computers and the rapid development of the Internet have gradually changed our life style and pattern, with their impact on education being unprecedented. Many educators and policy makers believe that technology can be a catalyst for educational reform [3,4,10]. They suggest that the use of technology in classrooms will shift the roles of teachers and students. Teachers will act more like facilitators by helping students access information, process it, and communicate their understanding [4].

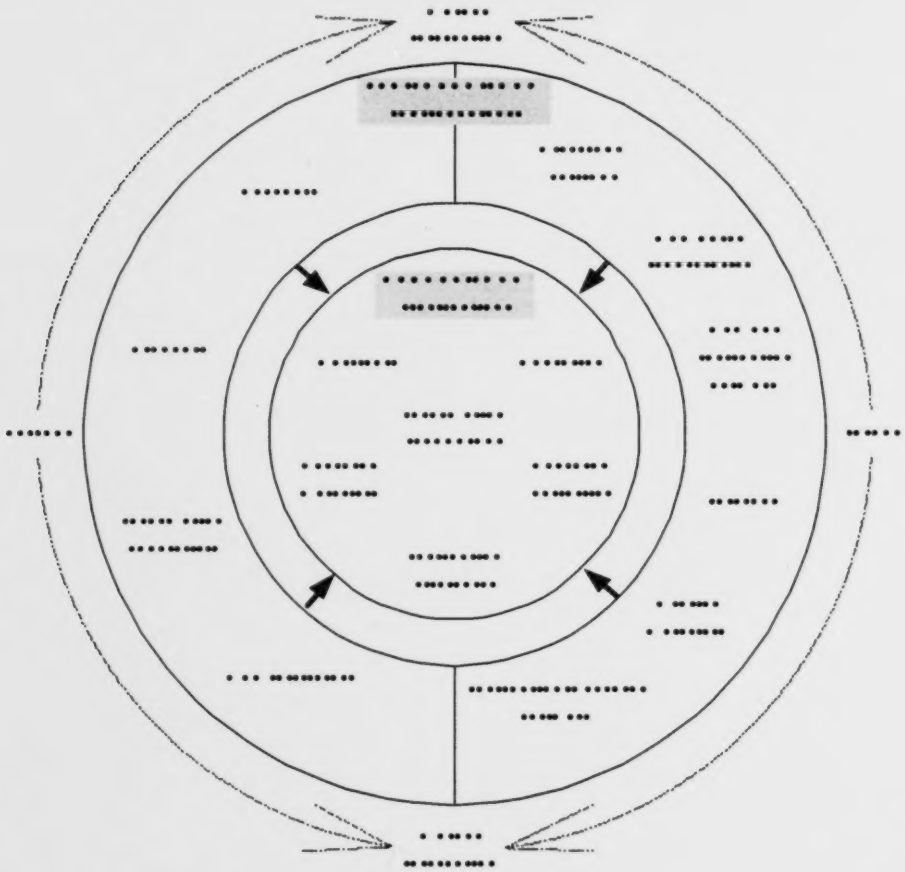
Beginning the 2001 academic year, Taiwan will implement phase-by-phase the nine-year integrated curriculum for its elementary and junior high schools [11]. To cultivate students' basic ability to "apply technology and information", the new curriculum will have to emphasize integrating IT into the teaching of various courses. Amid this major reform of curriculum, the Computer Center of the Ministry of Education has planned for the integration of information curriculum with other areas of learning [7]. At the same time, it has selected 18 elementary and junior high schools in which teaching experimentations will be carried out [1]. Therefore, an assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference.

2 The essence of information technology integrated instruction

The United States has implemented IT integrated instruction for years. Many educators are now actively using technology along with effective teaching strategies to integrate technology into their curriculum [9]. In contrast, IT integrated instruction is still a newly heard noun in Taiwan. Many teachers are unfamiliar with it, and some think of it as another name for computer-assisted instruction (CAI). Information technology has

developed rapidly, and the role of IT in education has changed over these years, from being an auxiliary to teaching to being an indispensable tool of education. Therefore, IT integrated instruction is distinguished from CAI.

In IT integrated instruction, information technology is an indispensable tool in the teaching environment because it is integrated into the curriculum, learning materials, teaching and learning [2]. Moreover, the traditional curriculum, materials, and teaching are transformed through the characteristics of information technology: the subject-based curriculum and materials become student-based; the teacher-driven teaching activities become student-centered. Information technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. It is not something one does separately; it is part of the daily activities taking place in the classroom [3].



F

igure 1. The assessment framework for information technology integrated instruction

Figure 1 depicts the assessment framework of IT integrated instruction. The assessment framework consists of two major parts: Kernel Part and Periphery Part. The kernel part primarily assesses the whole teaching process. Because the implementation of IT integrated instruction will bring about changes to teaching, the aspects to be assessed in this part should include not only the use of IT in teaching but also other perspectives of teaching: curricula, learning materials, instruction strategies, learning activities, and evaluation. The periphery part primarily assesses the teaching environment, learning resources, information equipment, personnel qualities, and administrative as well as professional support. All these factors will influence the outcome of teaching. In particular, IT integrated instruction is in need of supportive and coordinated environmental conditions. There are many perspectives of the periphery part that are related

with IT integrated instruction, and ten of them are carefully identified and included for assessment: teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

3 Assessing the kernel part

The kernel part refers to the whole teaching process, and Table 1 shows the perspectives and emphases to be assessed. The aspects of the kernel part are illustrated in the following paragraph.

Table 1. Emphases of the kernel part to be assessed

Perspective	Emphasis
Information technology	The use and role in instruction
Curricula	Subject-based separate curricula or Student-centered integrated curricula
Learning materials	Sequential or problem-based
Instructional strategies	Traditional expository approach or constructivist approach
Learning activities	Teacher-driven or student-centered
Evaluation	Traditional paper-and-pencil testing or multiple assessment

3.1 Information Technology

Information technology may refer to equipment or products, such as computers, network, peripherals, etc. It may also refer to the methods or processes in which the equipment of IT is used to help with the solution of problems. It is the purpose of implementing IT integrated instruction not only to enable students to use the equipment or products of IT but also to use the IT equipment to solve practical problems in learning and life.

In this perspective, we care about how IT is used in teaching and what role IT plays in teaching. The level of the use and role in instruction is developed:

- Nil (level 0): IT is not used and plays no part in teaching.
- Isolation (level 1): IT is used to teach students how to use IT (e.g. keyboarding, drill-and-practice, word-processing activities). There is no or little connection between IT and instruction content.
- Supplement (level 2): Teachers use IT to assist instruction and students use IT to aid learning occasionally. IT is viewed as a supplement to existing instructional program.
- Support (level 3): IT is needed to complete most learning activities. IT serves as a support to instruction.
- Integration (level 4): Students and teachers can use IT in every-day learning/teaching naturally, confidently, and actively. IT is expansively viewed as tool, process, method to find solutions to authentic problems in any time anywhere.

3.2 Curricula

For elementary and junior high schools, the curricular idea should be life-centered and be in compatible with the development process of students' physical and mental abilities; respect character development, inspire individual potential; cultivate civic qualities, respect the value diversified culture system; enhance science knowledge and skill, meet the requirements of modern life. The design of curriculum should be based on students, on practical experience, and devoted to cultivating the basic abilities required of modern citizens [11]. Therefore, the curriculum should be designed as student-centered integrated or interdisciplinary curriculum, not subject-centered separate curriculum.

IT is used as a tool to help students solve the problem. IT literacy should not be taught as an isolated subject, nor should activities with IT be isolated from other activities in the classroom [12]. Therefore, Taking the students to the computer lab once a week for 40 minutes is not necessarily integration [3]. The teachers should commit to designing student-centered integrated curriculum and integrate IT into the curriculum.

3.3 Learning Materials

Textbooks are the main materials for elementary and junior high schools and the primary learning materials of students. In traditional education, textbooks were unified, having only one version. They were based on subject systems and separate from students' living experience. Besides, it was difficult to innovate them,

they could not meet society's requirements for rapid transformation. In 1996 Taiwan implemented a policy which would partially allow publishers to edit and provide textbooks for elementary and junior high school so long as they are approved by the Ministry of Education. On February 3, 1999, VIII (2) of National Education Act was empowered, which unequivocally directs the full use of ministry-approved textbooks for elementary and junior high schools. A new epoch for textbooks was thus heralded in. Teachers should be able to exert their professional autonomy, and students should be allowed a flexible, autonomous learning leeway.

The presentation of learning materials should not be limited to static traditional books, but the characteristics of computer multi-media should be used to present these materials. Static words and pictures, animated pictures and films, voice, acoustic effect and music in combination would make teaching materials lively and motivate students to learn. Besides, they can help students to understand abstract concepts or knowledge and enhance learning effectiveness. If hyperlink technology is used, nonlinear learning materials can be designed so that what students see can be highly individual and not the same. As such, the content of learning materials is flexible, adaptive to individual difference, and compatible with the spirit of individualized learning.

In addition to textbooks, there are many resources on the Internet that can be used as learning materials. These resources can provide "instant", "living" information [8]. Teachers not only can search for information to be included in teaching materials but also can use the real-time information on the Internet to conduct teaching. Students not only can search for information on the Internet but also can conduct independent learning any time, any place by using the learning materials on the Internet.

The use of information technology can make learning materials diversified and lively, make their content flexible and integrated with life. Not only can teachers easily motivate students to learn, but students also can learn happily in a rich teaching situation.

3.4 Instruction Strategies

The teaching strategy of the traditional expository approach is teacher-centered. Students learn what is taught by the teacher, but are given a limited room for thinking, discussion, presentation and exploration. The teaching effectiveness is ostensibly good, and students' performance on examination seems impressive. Yet this approach contradicts the essence of education. In a series of meaningless learning process, what students learn is segmented memory that is extraneous to their experience and cannot be applied in practical situations of their daily life. Nor can they enjoy learning.

Constructive teaching strategy is student-centered. The teacher would first arrange a teaching situation to arouse students' motivation for learning and then would conduce students to explore and think. Through the interaction with peers, the students can gradually integrate the new knowledge into their own system of knowledge and make it an essential part of this system. By this constructive teaching, students must actively learn, while the teacher can only play the role of facilitator, auxiliary, and consultant.

When students use teaching software and browse for Internet resources, they must explore and think actively and construct their own knowledge through the interaction between machine and person and through social interaction. Therefore, the teacher is a "coach" for the student rather than a provider of knowledge. Self-directed learning is an attainable goal for both the student and teacher when IT is integrated in the various content areas [6]. That is, IT integration is most likely to occur in learner-centered classrooms in which the teacher acts as a facilitator [3].

3.5 Learning Activities

Traditional lecture-based and teacher-driven activities can no longer satisfy the needs of modern education. It is not only monotone, also lacks interaction between peers. Learning activities should be student-centered so that the learner can actively work to explore knowledge, clarify concepts, and gradually construct his/her system of knowledge. In addition, project-based and cooperative learning activities should be adopted to allow the learner the opportunity to produce high-level interaction with his/her peers. These activities not only can cultivate a respectful, responsible, and confident attitude and the abilities to express, communicate, coordinate, think, and create but also can increase learning effectiveness.

In cooperative learning activities, students can use computer to communicate and discuss, or use a certain

support cooperative work software to facilitate collaboration. Finally, multi-media would be used to present the learning effectiveness of students. Cooperative learning is not limited in local class. It can also be applied across schools, countries, and culture. Therefore, IT enriches the learning activity.

3.6 Evaluation

The traditional evaluation approach primarily depends on paper examinations and determines learning outcome by the scores on the test sheets. This type of evaluation measures only a dimension of knowledge, unable to reflect the wide spectrum of learning process. Future evaluation will become diversified; performance evaluation may be conducted along with paper evaluation; students' self-evaluation, peer evaluation and juried evaluation may be conducted along with teacher's evaluation; in addition to evaluating learning outcome, the learning process should be evaluated; in addition to quantitative evaluation, qualitative evaluation should be adopted; in addition to evaluating cognitive domain, the evaluation of affective and skill areas should be included. Only such a comprehensive evaluation can reflect the learning process, not only be able to understand what the student has learned but also be able to understand how the learning has occurred.

IT integrated instruction is helpful to the implementation of diversified evaluation. For example, the electronic portfolio is an ideal means of integrating IT into the instruction. It gives the student and teacher an alternative form of assessment. Furthermore, electronic portfolios motivate students to produce quality work, and they also increase students' self-esteem by showcasing their best work [6].

4 Assessing the periphery part

The periphery part primarily refers to the surrounding situations. Table 2 shows the perspectives and emphases to be assessed. The following illustration is based on perspectives.

4.1 Teachers

The teacher is vital in leading teaching activities. Without sufficient information literacy and professional ability, he or she cannot apply information technology on teaching, let alone implement IT integrated instruction. Regarding professional ability, the teacher should be able to integrate IT, in addition to assessing software and digital materials. The attitude is another emphasis of assessment. If the teacher has a positive attitude toward computer, he/she can readily introduce and apply computer on teaching; if the teacher can accept the change in teaching status and role, the implementation of IT integrated instruction would not cause a great impact.

4.2 Students

Students are the chief character in education. In teaching, students should take the initiative to construct their own knowledge. In implementing IT integrated instruction, students can obtain from the process related knowledge and skill and steadily strengthen their information disposition. Gradually students should be able to use, naturally and confidently, computer equipment in active learning and to construct their system of knowledge.

4.3 Information specialists

Teachers are not information specialists. In extensive application of IT to teaching, they will definitely encounter many technical problems that can not be solved by them. In this case, information specialists can support teachers in solving such problems. It is much easier for information specialists with education background to integrate IT with education and guide classroom teachers to implement IT integrated instruction.

4.4 Administrators

Whether administrators feel important about IT integrated instruction is intimately related with the implementation of IT integrated instruction. In addition, if the classroom teacher can gain sufficient administrative support, he or she will be more willing to implement IT integrated instruction.

4.5 Classroom Settings

Generally speaking, teaching activities are conducted indoors. Therefore, the IT equipment in classroom is indispensable to the integration of IT into teaching [14]. The computer and peripherals should not be outdated. The operation system and application software installed in the computer should be appropriate for the use by students and suit the needs of teaching. Moreover, for a class of more than 10 students, a large display device or broadcasting teaching equipment is needed. Finally, it matters whether they are managed properly or whether the fair use by students is ensured.

Table 2. Emphases of the periphery part to be assessed

Perspective	Emphasis
Teachers	Information literacy and professional competency Attitude toward information technology and instructional change
Students	Information literacy Attitude toward information technology
Information Specialists	Professional competency Support for teacher
Administrators	Attitude toward information technology integrated instruction Support for teacher
Classroom Settings	Number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripherals (e.g. printer, scanner, digital camera) Broadcasting teaching facilities Management
Computer Laboratories	Number of computer labs, number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripheral (e.g. printer, scanner, digital camera) Broadcasting teaching system Management
Campus Instruction Network	Structure of campus network and network type Domain account File server and database server CD cabinet (perhaps made possible through software simulation)
Internet	Method and speed of Internet connection Actual connection speed Internet server (e.g. web server, proxy server, DNS server, mail server) The mechanism to filter out inappropriate information.
Digital Materials	Digital materials that can be used on the Internet Digital materials created by the teacher
Instruction/Learning Software	Quantity Adaptation

4.6 Computer Laboratories

In a situation in which IT is integrated into teaching, sometimes it is required that one person have one machine. Computer laboratories can justly meet this requirement. Therefore, the management of computer laboratories is an important assessment item and can decide whether the computer equipment can sufficiently support classroom teachers [14]. Moreover, computer laboratories can also provide the most appropriate places for teachers' advancement and students' training of information skill. The equipment in the computer laboratories should not be outdated. Furthermore, there must be a broadcasting system, enabling students to know the whole content of teacher' s lecture in a ready manner.

4.7 Campus Instruction Network

The planning and erection of campus instruction network aims not only to construct an instruction network on campus but also to enable every classroom on campus to connect to the Internet through the campus

network. After the campus network is erected, File Server and CD cabinet (perhaps made possible through software simulation) should be erected, in which the teaching software owned by the school is stored so that all the teachers of the school can access to it readily and can apply it to teaching. In addition, the establishment and management of network account is equally important, ensuring the safety of information [14].

4.8 Internet

There are unlimited, un-exhaustive teaching resources on the Internet. If computers can not be connected to the Internet, the application of IT to teaching is compromised. Therefore, it is very important to provide information settings of the Internet. In addition, it is needed to erect Internet-related Server, in particular, Web Server must be erected so that teachers' teaching information and the learning outcome of students can be stored on it to facilitate examination and simulation by teachers and students. Besides, Internet is full of erotic and violent information which is unsuitable to students. It is extremely important to build a mechanism to prevent students from seeing those inappropriate content [14].

4.9 Digital Materials

Digital materials may be presented through information equipment and be used in teaching activities. Therefore, plentiful digital materials should be able to help integrate IT into teaching of various subjects. Therefore many on-line materials on the Internet can be used for teaching purpose. To decrease the amount of time required for browsing and facilitate the use of the materials by teachers and students, on-line index and search systems are also required. In addition, if on-line materials are not appropriate for teaching needs, classroom teachers may create their own materials to be presented on information equipment or use materials created by colleague teachers with the approval from the original designer [14].

4.10 Instruction/Learning Software

Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) software is a help to teaching and learning. With more software, teachers are better equipped to apply IT to teaching. This software should be stored on the CD cabinet or File server on the campus network so that teachers can readily use it whenever needed. In addition, if existing teaching software available on campus is evaluated, further information can be provided to teachers [14].

5 Conclusions

That teachers and students can extensively use computers for teaching or learning purpose to heighten teaching qualities and learning effectiveness is the ultimate goal of the infrastructure construction of information education [5]. In other words, integrating computer into teaching of various subjects is the ultimate goal of the Ministry of Education in promoting information teaching [13]. What IT integrated instruction means is not merely to assist teaching by computer but work to integrate IT into curriculum, learning material and learning activities. At this point, the role of teachers begins to transform, from that of a main character to that of a support character. Therefore, the implementation of IT integrated instruction not only harmonizes with the ultimate goal of information education but also prompt the reform of education so that learning becomes more effective, efficient, and meaningful.

IT cannot be successfully integrated overnight. It needs to take years to complete the process. The process should be carried out in order, stage by stage. Taiwan's IT integrated instruction is germinating. The assessment framework set forth in this article can be used not only to carry out practical evaluation but also serve as reference for development. Teachers' in-service education, pre-service training, administrative support, enriching IT equipment, developing appropriate digital materials and teaching software should be taken to strengthen the perspectives of the periphery part and to diversify the surroundings so that teachers can realize the benefits brought about by IT on education, Accordingly, teachers can apply IT to teaching, gradually infuse IT into learning activities, curricula, learning materials, and adopt student-centered teaching strategies and multi-facet evaluation. All this can lead to the fulfillment of the meanings of IT integrated instruction.

References

[1] Chang, H. Y., "1999 review of implementation of infrastructure construction plan for information education by the Ministry of Education", Ministry of Education Computer Center newsletter, No. 8810, pp. 1-8, (1999).

[2] Chiu, K. H., "Concepts and methods of computer-integrated instruction", Taiwan Education Review, No. 479, pp. 1-8, (1990).

[3] Dias, L. B., " Integrating technology: Some things you should know", Learning & Leading with Technology, Vol. 27, No. 3, pp. 10-13, 21, (1999)

[4] Dexter, S. L., Anderson, R. E., & Becker, H. J., "Teachers' views of computers as catalysts for changes in their teaching practice", "Journal of Research on Computing in Education", Vol. 31, No. 3, pp. 221-239, (1999).

[5] Han, S. M., "Infrastructure construction of information education – acceleration", Information and Education, No. 68, pp. 14-16, (1998).

[6] Hanfland, P., "Electronic portfolios: Students documenting their best work", Learning & Leading with Technology, Vol. 26, No. 6, pp. 54-57, (1999).

[7] Her, J. K., "Viewing the prospects of information education in elementary and junior high schools from the promoting strategy of information education of the Ministry of Education", Information and Education, No. 68, pp. 2-13, (1988).

[8] Lee, C. M., Wu, C. J., & Lin, M. C., "Erection of information education software and material resources center", Information and Education, No. 68, pp. 21-28, (1998).

[9] Levine, J., "Planning strategically for technology integration", Proceedings of Technology and Teacher Education Annual 1998 (SITE '98), Charlottesville, VA, pp. 293-295, (1998).

[10] Mehlinger, H., "School reform in the information age", Phi Delta Kappan, No. 77, pp. 400-407, (1996).

[11] Ministry of Education, "Tentative Guideline for Nine-year Integrated Curriculum for Elementary and Junior High Schools (first learning stage)", http://teach.eje.edu.tw (accessed on April 13, 2000).

[12] Sprague, D. & Dede, C., "If I teach this way, am I doing my job: Constructivism in the classroom", Learning & Leading with Technology, Vol. 27, No. 1, pp. 6-9, 16-17, (1999).

[13] Tu, A. P. & Lin, H. H., "Accelerating the infrastructure construction of Taiwan's information education: Alternative for expanding internal demand – special interview of Chen Li-hsiang, director of computer center of the Ministry of Education", Information and Education, No. 68, pp. 29-32, (1998).

[14] Wang, C. S., "Criteria for assessing information situation of information technology integrated instruction", Information and Education, No. 77, pp. 36-47, (2000).

An Effectiveness Study of Web-based Application for Mailing List Summary and Review

Satoru FUJITANI* and Kanji AKAHORI**
**Mejiro University College.*
4-31-1, Naka-ochiai, Shinjuku, Tokyo 161-8539 Japan
Tel: +81-3-5996-3127 Fax: +81-3-5996-3125
E-mail: fujitani@mejiro.ac.jp
***The Center for Research and Development of Educational Technology, Tokyo Institute of Technology.*
2-12-1, O-okayama, Meguro, Tokyo 152-8552 Japan
Tel: +81-3-5734-3233 Fax: +81-3-5734-2995
E-mail: akahori@ak.cradle.titech.ac.jp

This paper reports an effectiveness research of e-mail discussion review support system with summary extraction method. The support system we have developed can automatically extract summary sentences from the normal conversational style language in e-mail messages using reference relationship of e-mails that participants have discussed. One could use the summary sentences for looking back on discussion, and use them as an idea database at a glance. Japanese natural language processing technology has been applied in the proposed method. In order to evaluate the effectiveness of the system, we conducted experiments using a questionnaire and protocol analysis. We compared the two system; the system with and without summary sentences in the table of e-mail content. As a result, following fact-findings were obtained. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader pay attention to the detail information such as name of discussing member.
Finally, we concluded that the system with summary sentence is effective for understanding of relationship among various e-mail messages.

Keywords: **Mailing lists, Natural language processing, Distance learning, Learning environment, Summary sentence extraction, Collaborative learning, Factor analysis, Reading strategies**

1 Introduction

Collaborative learning support environments for network-based discussion appear to be investigated quite often [1][2]. For instance, e-mail is extensively used in the classes for learners' communication.

The research topic we reported here is collaboration support tools that intended for e-mail discussion. For the purpose of sharing of participants' activities on computer networks, we have proposed a summary extraction method along the development of mailing list discussions and an outline presentation tool for mailing list [3][4][7][9]. Japanese morphemes analysis system [8] is applied in our researches. This web-based tool supports reviewing the past discussion on the mailing list. As for results of the summary extraction method, we conducted comparative evaluation between the result of human summarization and of the method. The result suggests that the proposed method can detect major sentences in e-mail articles properly [4].

There is a number of preceding researches on the keyword and summary sentences extraction methods of documents [5][6][15]. But the most of extraction methods in preceding researches applied to well-

documented text, like the newspaper manuscript or research paper. On the other hand, this research targets on the conversational style language in text form. For identifying the outline of e-mail discussion, there are many difficult problems in e-mail messages. These are:

- E-mail messages are conversational style language and many summary extraction methods using syntactic information could be not applied.
- The title of e-mail might not be changed as the discussion continues, if so, the title is not meaningful as the summary of documents.
- The method should identify the flow of discussion corresponding with e-mails in order to grasp the topic.

Besides, most of evaluation experiments in summary extraction method with natural language processing technology focus on the validity of algorithm, like adaptability or reproducibility. About analysis of reading comprehension when additional information, e.g. summary, is given, we could refer Ausubel's research on the advanced organizer model [10]. The paucity of reports on sentence comprehension process encouraged us to investigate it.

The purpose of the present paper is to analyze how the summary sentences accomplishes to an actual comprehension process. In this paper we describe an experimental study of e-mail message reading process with or without the extracted summary sentences.

In the first experiment, we investigated e-mail message reading strategies using responses of questionnaire. We conducted comprehension test and reading process analysis. In the reading process analysis, the result was divided into seven factors using factor analysis. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader give attention to the detail information such as names of participating members.

In the second experiment, we analyzed peer discussion processes while reading e-mails on the World Wide Web (WWW) interface. We conducted the comprehension test of the e-mail messages. We also conducted protocol analysis of e-mail reading comprehension. Also hereupon, we compared the results with two conditions, one is a group to which the summary sentence of the e-mail messages was given, and the other is a group without summary sentence of e-mail messages. The results of protocol analysis show some difference in the number of utterance collected during the experiment.

2 Summary extraction method along development of discussion

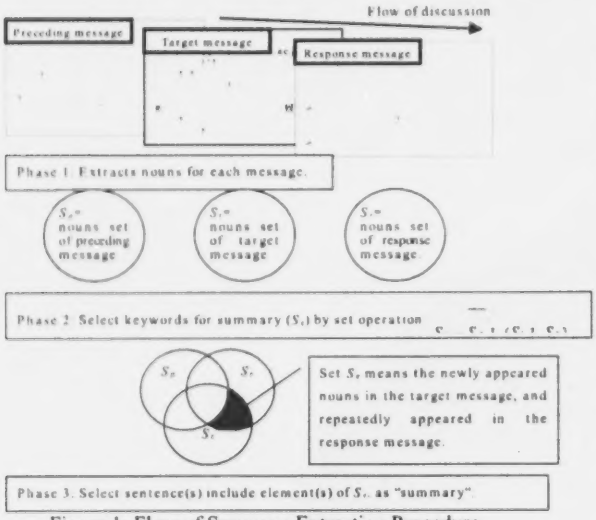


Figure 1: Flow of Summary Extraction Procedure from the target message.

The summary extraction method was discussed in our preceding research [3][4]. In this paper, we de-scribe the outline of the extraction method for better understanding by the readers.

2.1 Idea of the extraction method

We tried the extraction of keywords and summary sentences of the discussion from the document in the mailing list based on the preceding research [11] intended for the discussion such as Netnews. This key-word extraction method can be used in the discussion environment with the following features; (1) The change in the topic does not take place easily in a row. (2) There is a habitual practice that the participants do repeated revisions during the discussion, and

uses the quotation appropriately. But although it is limited in our case, e-mail discussion might develop in many ways, and the topic is changeable. The relationship of e-mail message for the keyword extraction between the target message and the past messages is little in e-mail discussion.

Then, in this paper, we set up a hypothesis: Although there was a dependency on the topic, e-mail messages with new information are tempted to encourage responses later. That is, we can treat them as topic making messages in the mailing list. We proposed a summary extraction method that enables pick up those new information as keywords and summary sentences in the messages [3][4]. Figure 1 shows flow of keyword and summary extraction by this method from the content of the message of the mailing list.

However, this summary extraction method supposes both preceding and response messages must be consecutive in the thread. Therefore, we set some assumptions for these exceptions. When the target message is the beginning message in the thread, the title of the message is also used and extracts common nouns among the title of the target message and the body of related messages. On the other hand, when the target message is the last message in the thread, we choose keywords only from the preceding and the target message, and common nouns in both messages is treated as keywords for the target message. Moreover, summary sentences are regenerated when there is a new message in the mailing list.

2.2 Summary generation and WWW display tool

We implemented summary generation and display tool using the proposed summary extraction method. This can be operated on the World Wide Web (WWW) to refer to past messages of mailing list [7]. Fig-ure 2 shows the display of Web page with and without summary sentences. These Web pages fulfill the role of table of contents (TOC) of mailing list. Readers look for contents from the list view with tree structure along continuity of e-mails. They can trace the body of each message from Web link. TOC shows serial number, writer, date of issue, and the title of the e-mail. In Figure 2(b), under the link to the body, summary sentence obtained by the noun set is displayed. When more than one sentence is extracted by the method, it becomes so complicated that the implication of TOC is diminished. So we referred to the procedure widely used in full-text search system [6], the number of displayed sentence is trimmed off to only one sentence that include maximum different number of chosen keywords. We treat that sentence as important sentence for TOC.

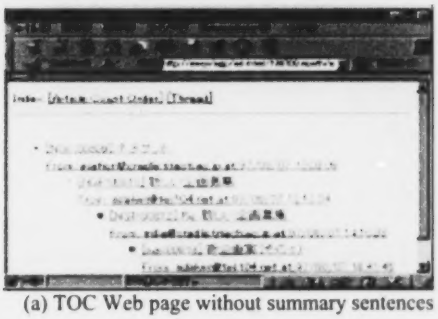
3 Evaluation experiment in the e-mail message comprehension

In this research, we carried out the evaluation experiment on effects of summary presentation while reading past e-mails on the mailing list. We conducted reading comprehension test and factor analysis of reading strategies.

3.1 Methods

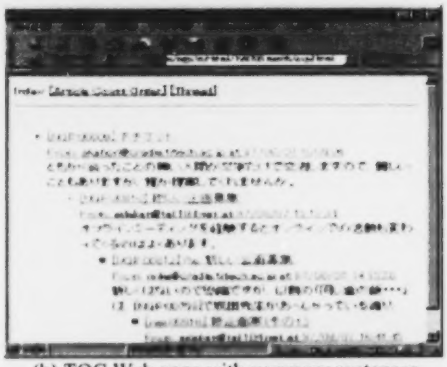
3.1.1 Subsubsections

In the experiment, we made the settings resembling the actual Web-based environment of the mailing list.



(a) TOC Web page without summary sentences

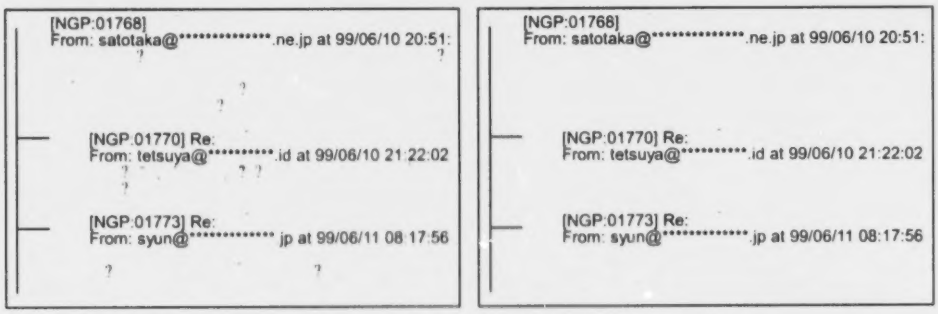
Figure 2: "Table of contents" Web pages for review.



(b) TOC Web page with summary sentences.

BEST COPY AVAILABLE

We printed out the several e-mail messages in a row, referred to as "thread", and the table of contents (TOC) for the e-mail messages in addition. Figure 3 shows the part of the experimental materials. To the semblance



(a) Printed TOC with summary sentences. (b) Printed TOC without summary sentences.

Figure 3: The part of the printed experimental materials

of Figure 2, the summary is generated from the proposed summary extraction method. It appeared in parallel beneath each entry in the TOC, or not appeared. E-mail messages for the summary extraction method consist of nine messages of mailing lists. The topic in the mailing list is the educational use of the Internet for foreign Japanese schools and domestic schools.

3.1.2 Procedures

Subjects of the experiment are 56 undergraduate students. None of the subjects know about the mailing list. The printed TOC as described above is affixed in front of the e-mail messages. The printed experi-mental materials were distributed to the subjects, and the researcher explained the experimental setting: "We are going to try to read past e-mails, and catch up with the exchange of the e-mail discussion." In addition, the participants were asked to use TOC positively.

The subjects read these documents for eight minutes. After the eight minutes, the researcher confirmed all the subjects had read the documents once. After that, the subjects were not allowed to read the docu-ments again, and they did the e-mail comprehension test. They had answered the following questions:
1. Write down the name of places which had appeared on the first e-mail as much as you remember.
2. Write down the episode of the first e-mail as much as you remember.
Later, they answered a questionnaire, which was consisting of 28 items with five-point rating scale and space for writing comments. The items were concerning the e-mail reading strategies. In order to make questionnaire, we referred the preceding research about sentence intelligibility [12] and our preceding researches.

3.1.3 Experimental Design

The factor of the experiment materials is presence of summary sentences in the TOC. We can divide the subjects into two levels. 56 subjects were randomly assigned to both two experimental settings of the materials, and were divided into the two groups of 28. Therefore, it is a between-subject experimental design with one factor.

3.2 Results

3.2.1 The comprehension test

In the question 1: "the name of places which had appeared in first e-mail", we compared the numbers of correct answers between two groups. We leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the number of correct answers

Table 1: Extracted factors and results of ANOVA

Name	Ratio	
1. Read the content in detail and memorize	21.5%	**p<.01
2. Use Table of Contents	10.5%	*p<.05
3. Think about the development of discussion	8.7%	
4. Combine their knowledge	7.1%	
5. Think about the theme of discussion	5.1%	
6. Read back and force	4.3%	
7. Write down a memo	3.9%	
Accumulated Explanation Ratio	61.1%	

(F(1,48)=1.065, p>.10).

In the question 2: "the episode of the first e-mail", we have chosen eight words from the message as answer words of the question beforehand. We compared the numbers of appeared answer words between two groups. We also leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the average number of the answer words (F(1,48)=.415, p>.10).

Table 2: ANOVA for Factor Scores

(a) ANOVA for Factor Score of factor 1.

Source	SS	df	MS	F	R^2
Factor	5.61	1	5.61	7.21	0.0098**
Error	38.11	49	0.78		
Total	43.72	50			

**p<.0

(b) ANOVA for Factor Score of factor 2.

Source	SS	df	MS	F	R^2
Factor	4.62	1	4.62	5.99	0.0180*
Error	37.78	49	0.77		
Total	42.39	50			

*p<.0

3.2.2 E-mail reading strategies

The factor analysis with major factor method and varimax rotation method was applied to the 28 questionnaire items concerning strategies of the comprehension for e-mail messages.

As we shown in Table 1, we sequentially named the seven factors. We extracted these factors from the change in the eigenvalue. The accumulated factor explanation ratio was 61.1%. Next, factor score of seven factors was calculated par subjects.
Table 2 shows results of ANOVA. As a result of ANOVA for seven factors, a significant difference was found in the first factor "Read the content in detail and memorize" (F(1,50) =7.212, p<.01) and the second factor "Use Table of Contents" (F(1,50)=5.988, p<.05).

In addition, we compare the score for each item in two groups.

As a result, the group with summary sentences could promote reading strategies such as "Usefully reading TOC help me to know the content of sentences" (t(51)=3.58, p<.01), and "Refer TOC to read the content in the messages" (t(52)=2.76, p<.01). Those who use summary sentences would have tendency that they try to know the relation between the content and the whole structure of the thread.

On the other hand, the group without summary sentences would take reading strategies such as "Pay attention to the participant's name or the name of places appeared on the e-mail while reading" (t(50)=2.34,p<.05), "Read the content carefully and memorize in detail" (t(51)=1.94, p<.10). Thus, they attempted to give attention to the detail information such as names of discussing members.

3.3 Summary of the experiment

In the experiment, there was a significant difference in the e-mail reading strategies while there was no significant difference in the recognition of e-mail contents. Our proposed method is a kind of new information presentation method for the support of e-mail reference. We might say our summary extraction method and display tool for mailing list could help readers to suppress consideration of detail information in the documents. On the other hand, these supports help to maintain the particular contents easier.

4 Protocol analysis of e-mail reading process

From the suggestion in the preceding section, adding summary sentences possibly provide a hint on the e-mail reading strategies. In this section, we examined changes of e-mail reading strategies when having the benefit of summary sentences using protocol analysis. To put it concretely, the subjects answer questions after reading the content of e-mail messages that is displayed on the WWW pages. We have observed the e-mail reading strategies while participants were reading e-mail messages.

4.1. Methods

4.1.1 Experimental materials

We have used 43 e-mail messages of the mailing list for the summary extraction method. Educational use of the Internet in foreign Japanese schools and domestic schools was focused in this mailing list.

Each e-mail message can be traced back and forth from TOC WWW page shown in Figure 2. We have set two conditions; one was in which summary sentences were given, and the other was in which it was not given.

4.1.2 Subjects

Subjects were 20 undergraduate students forming ten pairs. The reason for making group of two is that the subjects could discuss naturally with each other, and therefore, we could collect natural speech proto-cols easily from the conversation [13][14]. They were randomly assigned to two different experimental settings as described previously in this paper.

4.1.3 Procedure of the experiment

The two subjects were seated in front of the computer and were given an instruction for the present ex-periment by researcher. After the e-mail reading, the subjects were asked to answer some questions on reading comprehension. The subjects were allowed to start reading e-mail messages from anywhere. Then, they read e-mail messages through WWW pages for 20 minutes. After that, they were asked to answer some questions regarding particular content in the e-mail messages within 15 minutes. Finally, they were interviewed about the provision of advance information of the mailing list and the interest on the topic of discussion. None of the subjects know about this mailing list.

4.2. Analysis and Results

In this experiment, we recorded peer protocol with a digital video (DV). Then, we played the recordings and type in the conversation by listening the recordings. During the analysis of utterance, we identify sev-eral reading strategies or procedure for sentence comprehension. For each unit of procedure and strategy, the protocol was classified into the protocol categories [13]. For the classification, we have used the result of the factor analysis as we seen in Table 1. The categories "Read the content in detail and memorize" and "Use Table of Contents" were found to be significantly different on factor analysis. In the first cate-gory, we have considered utterances if the subjects read particular personal name and place name aloud. In the second category, we have considered utterances if the subjects read aloud the summary sentences or pursue continuity of the mailing list by pointing to the TOC. Some subjects pointed using mouse cur-sor's move or their fingers.

Table 3: Frequency of strategies appearance between two categories

Protocol category	With summary	Without summary
1. Read the content in detail and memorize	128	103
2. Use Table of Contents	35	22

Table 3 shows the comparative result with two protocol categories. As the number of subje.ts is very less, a clear conclusion could not be drawn. But as in Table 3, the frequency of category 1 wa, relatively higher than that of category 2. As a the result, by means of summary display tool with e-mail messages has been suggested as a method to manage a lot of reading strategies easily. However, though the differ-ence of the frequency does not contradict the results of ANOVA in the previous section, it does not show a significant difference in the comparison of ratios ($\chi^2(1) = 0.67, p > .10$).

In this experiment, a significant difference was not seen in the frequency of the e-mail reading strate-gies. We need to add the number of experiments as well as study the influence of experimental design in peer conversation.

5 Conclusions

The results of this research may be summarized as follows:

1. We applied the summary extraction method for mailing list, and analyzed e-mail reading comprehen-sion and reading strategies for reference. Although the result is limited to the e-mail messages we used, the display of e-mail summary sentences affects experimental subjects' reading strategies. On the other hand,

the result of comprehension test does not show significant differences. We may con-clude at this point that the method of summary sentence extraction is effective in understandings of relationship of e-mail messages.

2. The influence of summary display on the e-mail reading strategies was examined from the analysis of utterance protocol. The use of Table of Contents WWW page along with e-mail summary sentences does not make a difference in the frequency of utterances, but preferential trend for the use of e-mail summary sentences was observed.

As a problem yet to be solved in the future, we are interested in examining the effectiveness of reading strategies when e-mail messages are posted and read in real time.

Acknowledgement

Our special thanks are due to Madhumita Bhattacharya, Ph.D., the National Institute of Education, Singapore, for reading the manuscript and making a number of helpful suggestions.

References

[1] Kusunoki, F. & Sayeki, Y., "We can learn because of the opinions different each other", Journal of Information Processing Society of Japan, Vol. 40, No. 6, pp. 564-568, (1999).

[2] Inaba, A. & Okamoto, T., "The Network Discussion Supporting System Embedded Computer Coordinator at the Distributed Places", Educational Technology Research, Vol. 18, Nos. 1-2, pp. 17-24, (1995).

[3] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method for Web-based Mailing List Review Application and Its Effectiveness Study", Advanced Research in Computers and Communications in Education (ICCE99), G. Cumming et al. (Eds.), IOS Press, Vol. 1, pp. 327-334, (1999).

[4] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method of E-mail Discussion and Its Web-based Application to Mailing List Review", Educational Technology Research, Vol.23, Nos. 1-2, *In printing*, (2000).

[5] Sasaki, I., Masuyama, S. & Naito, S., "Proposal on sentence extract method which pays attention to vocabulary coherency", Technical Report of Information Processing Society of Japan, 93-NL-98, pp. 65-72, (1993).

[6] Sumita, K., Tomono, T., Ono, K. & Miike, S., "Generation of Automatic abstract with document structural analysis, evaluations as retrieval presentation function", Journal of The Institute of Electronics, Information and Communication Engineers, D-II, Vol. 78-J, No. 3, pp. 511-519, (1995).

[7] Fujitani, S. & Akahori, K., "Improvement of content summary extraction method along with development of discussion about document of mailing list summary system", Proceedings of 14th annual conference of Japan Society of Educational Technology, 2pB02-3, pp. 691-692, (1998).

[8] Kurohashi, S. & Nagao, M., "Japanese morpheme analysis system "JUMAN" version 3.61", Graduate school of information science, Kyoto University, (1999).

[9] Ken'ichi Fukamachi, "fml" Mailing List Server Package, http://www.sapporo.iij.ad.jp/staff/fukachan/fml/index-e.html (accessed on August 1, 2000).

[10] Ikeda, S. & Tanaka, S., "improvements of experiment diagram in preceding organizer research", Reading sciences, Vol. 29, No. 2, pp. 41-55, (1985).

[11] Ishihara, M. & Akahori, K., "Developments of discussion summary system for discussion support with problem", Journal of Japan Society of Educational Technology, Vol. 22, No. 1, pp. 1-12, (1998).

[12] Uchida, N., "Is the sentence understanding process "top down" or "bottom up?" ": In Shun-ichi Maruno, some controversies in cognitive psychology, Kyoto: Nakanishiya publication, pp. 165-188, (1998).

[13] Kaiho, H. & Harada, E., "Introduction of protocol analysis", Tokyo: Shin-yo-sha, pp. 118-134, (1993).

[14] Madhumita, & Akahori, K., "An Evaluation Method for Audiovisual Software Based on Protocol Analysis", Media and Education, Vol. 1, pp. 19-27, (1998).

[15] Firmin, T. & Chrzanowski, M. J., "An Evaluation of Automatic Text Summarization Systems, Advances in Automatic Text Summarization", The MIT Press, pp. 325-336, (1999).

An Empirical Study of the Design and Use of a Multimedia Composition-Making System for Children

Kaori Iwashita*, Shinya Kawakami and Bipin Indurkhya**
Department of Computer Science, Tokyo University of Agriculture and Technology, Koganei City, Tokyo, Japan, tel: 81-42-364-3311
**e-mail: kaorii@ma.neweb.ne.jp, **e-mail: kawakami@fairy.ei.tuat.ac.jp*

In this paper, we describe our experiences in designing and using a multimedia composition-making system for children. The system allows children to make compositions using pictures, sounds and text. Moreover, it also allows pictures in the composition to be animated. We experimented with children using this system in three different settings. In the first setting, no topic was assigned to the children. In the second and third experiments, children were given a topic (different for each experiment) for composition related to their activity. We present here the results of our experiments and comment on how the constraints imposed by the topic affect children's expressive abilities.

Keywords: **animation, children's expressive abilities, constraints and creativity, multimedia composition.**

1 Introduction

In recent years, many researchers have studied multimedia techniques and have incorporated them into various educational systems. For example, Silva [5] described a multimedia soundscape system, "They Are Catching Sounds in the Park!", for environmental education. In this system, children search for sounds by clicking anywhere in the picture. When they click an appropriate object, its associated sound and information are presented to the children. Brna [1] proposed a system for composing and writing stories via cartoons. Harviainen [2] presented a co-authoring system in which many users work together to compose a story. Ishii [3] and Kawakami [4] have developed other systems for making stories with multimedia. All this research demonstrates that multimedia has much potential for stimulating the ability of children to express themselves. In particular, we find that children can express their creative and imagined ideas much better with pictures and words than with words alone. Moreover, if we add an ability to attach sounds to pictures, and allow pictures to be animated, then this expressive power increases considerably.

Motivated by these factors, we have developed a system to help children write multimedia compositions, and have tested it with children in three different settings. In this paper, we describe our system and report on our experiences with children using the system.

2 Prototype of the System

We developed a prototype of a multimedia composition-making system. Using our prototype,

- Children can express their thoughts and ideas via pictures, sounds, text, and animation sequences. In our system, children must first choose a background scene, in which they can then insert picture objects, sounds, and text.
- Except for the background, children can attach sounds and text to picture objects, and can animate them to make a multimedia composition.

This system has two modes: a 'Set up' mode for the teacher or supervisor to allow them to determine which background scenes, picture objects, sounds, etc. are made available to the children for writing a composition,

and a ' User' mode for children to write compositions.

The ' Set up' mode has the following two functions:

1) Select situation: Set the context or theme for the composition.
2) Edit situation: Set the categories of background scenes, picture objects and sounds corresponding to a theme.

The ' User' mode has the following seven functions:

1) Select background scenes.
2) Select picture objects.
3) Select sounds.
4) Write text.
5) Animate composition.
6) Save composition.
7) Load composition.

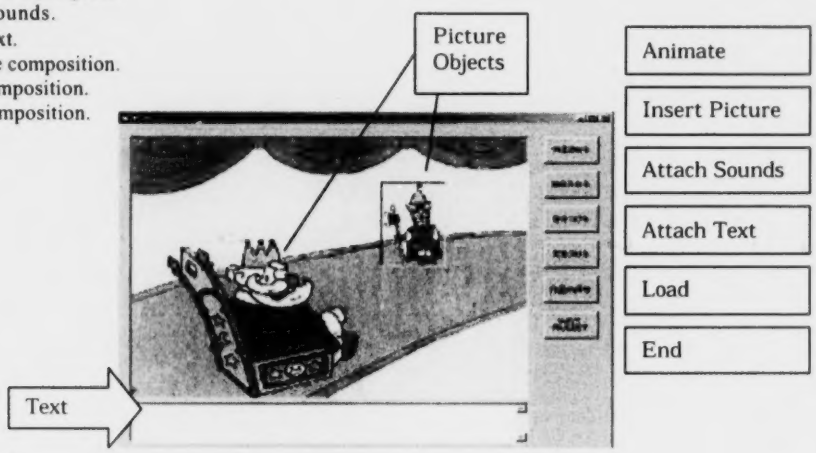


Figure 1. An example of the main window

By double clicking on a picture in the main window, the sound attached to that object (if any) can be heard. Also, when the picture of an object is selected in the main window, the text attached to it is displayed in the text box.

The animation module has five functions: show picture, hide picture, output sound, show text, and move picture.

To replay animation, children click the 'start' button in the animation window. When the button is clicked, the system starts the animation sequence as previously specified. It replays each action one by one, but it pauses when the action is ' show text ' . To continue from there, the user needs to click the ' start ' button again.

3 Experiments with the system

We did three different experiments in which children used our system. In each experiment, the setting and the tasks given to children were different, as described below.

3.1 Experiment I

In this experiment, we studied a constraint-free use of the composition system. The children were not given any specific topic of composition, and they could use the system any way they like to create any composition freely. We prepared 54 background scenes, 185 pictures and 68 sounds. Because no topic was given, children chose a variety of themes.

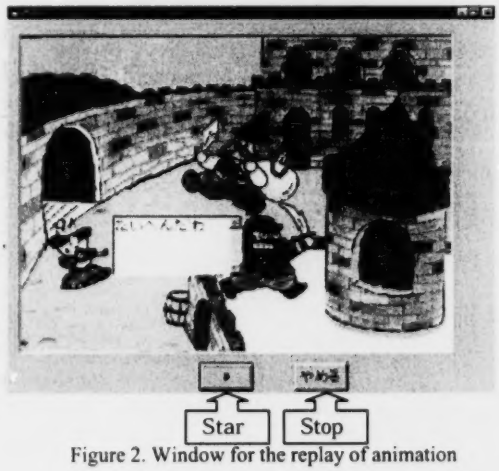


Figure 2. Window for the replay of animation

BEST COPY AVAILABLE

3.2 Experiment II

In this experiment, we introduced a constraint by giving a topic of composition to the children, and analyzed the generated compositions. The experiment was done at an activity center for children. At this center, children of each grade come periodically, and play or make some handicraft. One of the handicraft projects for third-grade children was making kites. So, the following week, we asked the children to make a composition about kite making. For the experiment, we prepared a version of the system with six backgrounds scenes of craft rooms. Three of these were scenes with kites in them, and the others were scenes with only a room and tables without kites. We also prepared 68 pictures and 35 sounds appropriate for kite-making activity.

3.3 Experiment III

In this experiment, we introduced a tighter constraint by giving a more specific topic of composition to children, and studied its effect.. We asked the children to make a composition for the story "The coward king and robber" (original title in Japanese). The original story is written in Japanese. At the same activity center for children used in Experiment II, the children made an extended version of this story, made a picture book to illustrate various scenes in the story, and then told the story using these pictures at their Christmas party. The week following the party, we asked the children to make a composition for this story using our system.

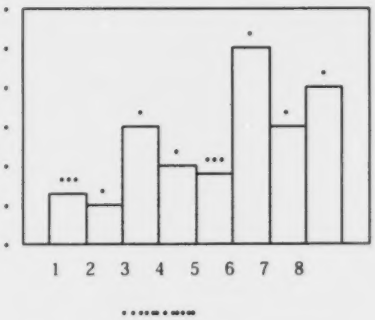


Figure 3. Differences between the composition picture and the original picture from the picture book (for each background scene)

For this experiment, we prepared a version of the system with eight background picture scenes related to the story. We also prepared 66 picture objects and 33 sounds appropriate to the story.

In this experiment, we were interested in analyzing the differences between compositions made using our system and the corresponding pictures in the picture book for this story that the children had made earlier. We used the following method for computing the difference. The picture objects were grouped into ten categories, and the difference between two pictures (with the same background scene) was calculated as follows:

> For each picture object category: if there is an object of that category in both the pictures, we say that the difference between the two pictures with respect to that category is zero. If one picture has an object from that category, and the other has none, we say that the difference with respect to that category is one. The difference between two pictures is the sum of the differences over all ten categories.

Figure 3 shows the result of applying this procedure.

We see that the differences for the climactic scenes (scenes 6• 7) are higher than the other scenes.

3.4 Discussion

An analysis of the compositions produced in the three experiments is shown in Tables 1, 2 and 3. Table 1 shows the average number of compositions produced by a participant in each experiment. We see from it that the children were most expressive when the topic was most constrained (Experiment III).

Table 1. Number of compositions per participant

	Experiment I	Experiment II	Experiment III
Number of participants	11	7	5
Number of compositions per participant	1.3	1.4	4.6

Table 2 shows a more detailed analysis of compositions with respect to how multimedia features of the system were used.

Table 2. Number of multimedia features per composition

Multimedia feature	Experiment I	Experiment II	Experiment III
Picture objects	3.6	11.2	6.9
Sound attachments	1.1	2.4	1.6
Text attachments	-	1.1	1.6
Animation	1.0	2.8	9.9

Here we see that picture and sound attachments are used most in Experiment II. This may be because in this setting children were describing a situation using generally one page (screen). For this, they used many objects and sound attachments to provide information about the depicted situation. We also see that text attachments and replay actions were used most in Experiment III. It might be because in this setting they were describing a story, for which text attachment is a useful way to express characters' utterances, and animation is useful to express characters' movement. We also would like to point out that in Experiment III there were fewer picture objects and sound attachments per composition. This is because to show the flow of events in the story, children made many compositions (Table 1).

Table 3. Analysis of animation operations per composition (in percent)

Animation operation	Experiment I	Experiment II	Experiment III
Show picture	0	0	53
Hide picture	0	0	4
Output Sound	13	0	10
Show text	-	0	15
Move picture	87	100	18

In this table we see that in Experiments I and II, mostly the 'move picture' operation was used. In composing a story, however (Experiment III), the 'show picture' was used most. We also found that the 'hide picture' operation was rarely used.

4 Conclusions

From our experiments, we see that the multimedia features of the composition-making system are most useful in illustrating a story or a narrative. Sound and text attachments and animation operations can be very helpful in expressing movement of characters and the progression of events in a narrative. We also found that many children are most expressive when they are given a focus of composition.

From these results, we propose that a system such as ours can be used in the classroom for children to make compositions about field trips and class excursions For each trip or excursion, the teacher can set up the system appropriately by choosing relevant picture and sound libraries before children use the system. In this way, we feel that our system can provide a step forward from Silva [5]. Children are more actively involved in making compositions with our system than in exploring with 'They are catching sounds in the park!"

Acknowledgements

We would like to thank all the children who participated in the experiments, and the staff at the children's center for their cooperation. We thank Professor Yoshiyuki Kotani, and members of the Kotani-lab for their help and cooperation during this research. Some pictures used in the background of Experiment III were taken from [6].

References

[1] Brna, P., Martins A., & Cooper B., "My First Story: Support for Learning to Write Stories", Advanced Research in Computers and Communications in Education, pp. 335-341, 1999.

[2] Harviainen, T., Hassinen, M., Kommers P., & Sutinen, E., "Woven Stories: Co-authoring over the Internet", Advanced Research in Computers and Communications in Education, pp. 285-292, 1999.

[3] Ishii, Y., Indurkhya, B., Inui, N., Nose, T., Kotani, Y., & Nishimura., H., "A System Based on Rodari's 'Estrangement' Principle to Promote Creative Writing in Children", ED-MEDIA & ED-TELECOM 98,

Vol. 2, 1685-1686, 1998.
[4] Kawakami, S., Indurkhya B., Inui, N., & Kotani, Y., "A Story Making System for children", Advanced Research in Computers and Communications in Education, 359-360 1999.
[5] Silva, M.J., Silva, J.P., & Hipolito, J., ""They Are Catching Sounds in the Park!" Exploring Multimedia Soundscapes in Environmental Education", ED-MEDIA & ED-TELECOM 98, Vol. 2, 1274-1279, 1998.
[6] Yamawaki, K., & Miyamoto, E., "Yowamushi o-sama to to-zoku", Kyoiku Gageki, 1989.

Applicability of an Educational System Assisting Teachers of Novice Programming to Actual Education

Hiroyuki Suzuki*, Tatsuhiro Konishi and Yukihiro Itoh****
* *Graduate School of Science and Engineering, Shizuoka University*
** *Faculty of Information, Shizuoka University*
Johoku 3-5-1, Hamamatsu, Shizuoka, Japan 432-8011
Tel: +81-53-478-1474 Fax: +81-53-478-1499
E-mail: {h-suzuki, konishi, itoh}@cs.inf.shizuoka.ac.jp

In this paper, we propose a technique for reducing processing time during program evaluation, and examine processing time of evaluating programs of which sizes are relatively large in novice programming courses. We proposed a method of constructing an automated evaluation system assisting teachers teaching novice programming. Our system evaluates learners' programs by comparing them with a standard algorithm representing teacher's intentions. By using our system, teachers can easily pick up learners' defective programs. We constructed a prototype system, and examined whether the system can evaluate programs actually submitted by learners. We confirmed that it could evaluate the programs validly. However we found that we should improve the processing time after evaluating various programs. In order to reduce processing time, we extend the matching algorithm using two ways. As a result, processing time is improved without spoiling the accuracy of matching. After that, we design a model course of novice programming based on actual courses in our university. And we examine the relation among program size, arbitrariness of teacher's intention and processing time. Then we confirm that the processing speed of our system is fast enough to be used in actual education environment.

Keywords: **educational system assisting teachers, automated evaluation system, program diagnosis, experimental evaluation**.

1. Introduction

By using program diagnosis technique, many programming education systems have been developed[1][2]. Most of them are designed to help learners, not the teachers. We think it is necessary to help teachers in order to give learners better advice. It needs much effort for teachers to evaluate many programs. So we constructed a prototype system assisting teachers teaching novice programming[4]. We have designed a model course on the basis of actual novice programming education course. Then, we have examined whether the system can evaluate programs written by learners. We confirmed that it could evaluate the programs validly[5]. However we found that we should improve the processing time after evaluating various programs. In this paper, we propose a technique for reducing the processing time (section 3), and examine processing time of evaluating programs of which sizes are relatively large in novice programming courses, then confirm that the processing speed of our system is fast enough to be used in actual education environment (section 4).

2. Our previous work

Generally, teachers teaching novice programming arrange goals for their exercises, and set exercises related to the goals. We call these goals "*teacher's intentions*". They evaluate whether each program submitted by a learner achieves the goals or not, and advise the learners according to the result of the evaluation. However, it needs much effort for them to evaluate many programs with various bugs. So we support them by developing an automated evaluation system classifying programs which perfectly satisfy *their intentions*, which partially satisfy *their intentions* or do extra work, and which don't satisfy *their intentions*. Therefore they only have to check the

unsatisfied programs carefully.

We found that most of *teacher's intentions* can be represented with standard algorithms to solve exercises. So we use the standard algorithms for inputting *teacher's intentions*. We designed an algorithm representation based on PAD expression. We call the representation "Extended PAD". By using the Extended PAD, teachers are allowed to use the following structures in order to represent arbitrariness included in *their intentions*.

Non-ordering structure: It represents arbitrariness on the order among tasks,
Alternative structure: It represents arbitrariness on method to achieve a goal.

The Extended PAD consists of two types of elements: elements which correspond to a Pascal operation or control structure, and which correspond to a sequence of Pascal operations. We call the previous elements "primitive operations", and the other "macro operations".

We developed a method matching learners' programs with a standard algorithm. According to this method, the system tries to check correspondence of every combination of statements in a learner's program with the statements in a standard algorithm. If it judges that a statement in a learner's program matches with a statement in a standard algorithm, it makes a hypothesis on a correspondence of these statements and correspondences of variables referred by the statements. Then it continues matching the other statements on the basis of the hypothesis. As the matching process succeeds, the hypothesis grows up. Generally, possible correspondence of variables is not unique. So the other hypotheses containing the other correspondences of variables are set up at the same time. According to the result of matching, it outputs its judgement, "perfect match", "partial match" or "no match" based on the most plausible hypothesis. "Partial match" means that a learner's program doesn't match with a standard algorithm perfectly, but both the ratio of matched statements to the whole in the learner's program and the ratio of matched statements to the whole in the standard algorithm are higher than each threshold we defined.

3. Improvement of processing time

In order to reduce processing time, we should re-consider a method of matching programs. The system outputs the result of judgement on the basis of the most plausible hypothesis. The others are rejected. So if the system has an ability to find useless hypotheses on the way during matching process and avoid checking the correspondence of statements on the basis of the useless hypotheses, processing time must decrease.

So we extend the matching method as follows:

1) When the system intends to make new hypothesis containing correspondence of a new combination of statements in a learner's program and a standard algorithm, it calculates the ratio of matched statements to the whole under the assumption that all of the following statements will be matched perfectly. If the ratio cannot reach the threshold, the system doesn't make the hypothesis and omits the process of matching the following statements based on the hypothesis.

2) After the system has matched whole statements on the basis of a certain hypothesis, it tries to match statements on the basis of another hypothesis. In such a case, when the system finds that the ratio of matched statements to the whole cannot reach the ratio of previous trial, under the similar assumption to 1), it stops matching the following statements.

As a result, processing time is improved without spoiling the accuracy of matching. We confirm that evaluation of programs is not changed by the extension. Table 1 shows improvement of processing time necessary to judge the programs. Exercise (1), (2) and (3) are illustrated in Table 2. The computer system used for both experiments before and after the extension is an Engineering Workstation JU2/2300 (CPU: Ultra SPARC-II (300MHz) * 2, SPECint95: 12.3, SPECfp95: 20.2, Operating System: SunOS5.6, Made by: Japan Computer Corp.).

Table 1: Improvement of processing time.

	Number of programs	Average time of processing [sec/program]	
		Before extension	After extension
Exercise(1)	42	184.98	1.57
Exercise(2)	56	1.43	0.13
Exercise(3)	49	109.06	1.10

4. Applicability of our system to actual education environment

In order to discuss applicability of our system to actual scene in education, we design a model novice programming course based on actual courses in our university[5]. The exercises in the course are seen in Table 2. We use programs submitted by learners in the actual courses of our university.

We write each standard algorithm of exercise within the following restriction: the number of steps of

Extended PAD must be less than twice the number of steps of a standard program for corresponding exercise. The reason is that teachers don't prefer writing more detailed standard algorithms because of their costs.

The computer system used for this experiment is also the Engineering Workstation JU2/2300.

Table 2: The exercises in the model course.

Exercise(1)	There are several birds and tortoises. Find the number of them when the following conditions are given: (1) Sum of the heads of birds and tortoises. (2) Sum of the legs of birds and tortoises.
Exercise(2)	A character datum that is an uppercase character will be input by user. Convert it to lowercase.
Exercise(3)	A hexadecimal number will be input by user as two digits of character datum "0-9" or "A-F". Convert it to a decimal number.
Exercise(4)	Solve an equation "ax^3+bx^2+cx+d=0" by using the Newton method.
Exercise(5)	Sort integer data in an array by using the straight selection sort algorithm.
Exercise(6)	Solve simultaneous equations by using the Gaussian elimination.

4.1 Result of experiment

In order to evaluate processing time, we must consider the following factors: program size of standard algorithms and one of learners' programs, arbitrariness of *teacher's intentions*, judgement of learners' programs. Therefore we examine the relation among these factors and processing time. Table 3 shows:

- Program size of a standard algorithm and arbitrariness of *teacher's intention*.
- The number of learners' programs and average of their program size.
- Judgement of learners' programs, and the average processing time.

We measure the program size by the number of statements, blocks and variables, and the arbitrariness by the number of alternative structures and non-ordering structures including a standard algorithm. The judgement means the number of learners' programs that are judged "perfect match", "partial match" and "no match" by our system.

As program size increases, the number of combination of statements in a learner's program with the statements in a standard algorithm also increases. At the worst case, the number of the combination increases proportionally to factorial of number of the statements. However Table 3 shows gentler increasing. From the result, we think our extended matching method works well. Exercise (4) needs rather long processing time. We think that the number of statement per block is larger than the other exercises, and most of statements in the block have dependencies, i.e. a variable assigned some value by an assignment statement is often referred in the following statements in the same block. In such a case, the system must compound formulas and the process of compound needs rather long time. However, we check how often such an exercise appears in actual textbook[3] for novice programming and find that only one exercise.

Table 3: Relation among program size, arbitrariness of standard algorithm and processing time.

	Standard algorithm					Learners' programs				Judgement of Learners' programs			Processing time [sec/program]	
	Number of:					Average of:				Number of:				
	Statements	Blocks	Variables	Alternative	Non-ordering	Programs	Statements	Blocks	Variables	Perfect match	Partial match	No match		
(1)	5	1	4	0	0	42	9.2	9.1	1.4	0	4	38	0.96	
(2)	4	1	2	0	0	56	9.3	2.1	3.1	3	17	36	0.30	
(3)	11	5	4	0	0	49	19.7	7.7	5.9	0	0	49	1.50	
(4)	9	4	5	0	0	14	9.9	2.0	6.6	7	1	6	6.23	
(5)	10	4	5	0	0	14	9.8	4.0	5.1	1	10	3	0.30	(*)(#)
	10	4	5	1	0	14	9.8	4.0	5.1	1	10	3	0.31	(*)
	10	4	5	2	0	14	9.8	4.0	5.1	1	10	3	0.43	(*)
	10	4	5	3	0	14	9.8	4.0	5.1	1	10	3	0.44	(*)
	10	4	5	0	1	14	9.8	4.0	5.1	1	10	3	0.35	(#)
	10	4	5	0	2	14	9.8	4.0	5.1	2	9	3	0.52	(#)
(6)	28	12	11	0	0	24	27.3	11.8	11.0	1	11	12	9.87	(*)
	28	12	11	11	0	24	27.3	11.8	11.0	1	11	12	31.00	(*)

We evaluate our system on another standpoint. As arbitrariness of *teacher's intention* increases, possible combinations of statements in a learner's program with the statements in a standard algorithm also increase. We prepare some standard algorithms for the exercise (5) and (6), and process actual programs of learners. The result is seen in the lines with (*) and (#) in Table 3.

We prepare a standard algorithm including three alternative structures representing two methods to achieve a goal. At the worst case, the number of combination of statements in a learner's program with the statements in the standard algorithm increases 8 (=2^3) times. However Table 3 shows 1.5 times increasing. We also measure processing time by using a standard algorithm of exercise (6) including 11 alternative structures representing two methods. Although it seems that processing time increases 2048 (=2^11) times, Table 3 shows only 3 times increasing. Similarly, on exercise (5), we prepare a sample of Extended PAD including 2 non-ordering structures

representing arbitrariness on the order between two tasks. In this case, it seems that processing time increases 4 (=(2!)^2) times. However Table 3 shows 1.8 times increasing. We think that the reason why the processing time isn't so increased is that our extended matching method works well. When our system evaluates using standard algorithms that include alternative structures or non-ordering structures, useless hypotheses are rejected at earlier stage of matching process.

In the next section, considering the result shown in Table 3, we discuss applicability of our matching method to actual education.

4.2 Estimation of processing time for actual exercises in novice programming

We survey model programs in a textbook[3], and write standard algorithms considering alternative coding methods or alternative order of statements. Then we investigate the program size, numbers of alternative structures and numbers of non-ordering structures. The result is seen in Table 4.

We can regard that our matching algorithm processes even programs belonging to the most complicated class in actual education within practical processing time. The reasons are as follows:

- The number of statement in programs of high level is less than the exercise (6) on average. And the largest number of statement is equivalent to the exercise (6).
- The number of alternative structure is almost 4 for programs of middle or high level.
- The number of non-ordering structure is less than 2.
- Therefore we think that our system can evaluate the most complicated program in the textbook with processing time similar to exercise (6) (31.00s/program).
- In fact, if a teacher takes care of 100 students in a class, the time necessary to evaluate their programs by our system is only 50 minutes or so. We think this is practical enough.

Table 4: Program size of exercises in a standard textbook of novice programming.

Exercise		Number of programs	Number of statements	Alternative structures		Non-ordering structures
				Iteration	Others	
Basic level	(the four rules of arithmetic, etc.)	19	8.5	1.1	0.2	1.2
Middle level	(sorting, etc.)	34	17.9	4.0	0.5	1.1
High level	(searching trees, etc.)	14	20.9	3.5	0.3	1.1

5. Conclusions

In this paper, we extend our matching algorithm to improve the processing time. Through the examinations and the discussion about processing time, we confirm that our system can evaluate actual programs in novice programming in practical time. Now, we are constructing a graphical user interface for describing standard algorithm. We will evaluate usability of our system after constructing it.

Acknowledgements

This research was supported in part by Grant-in-Aid for Scientific Research (c)(11680216) from Japan Society for the Promotion of Science.

References

[1] Anne Adam & Jean-Pierre Laurent, "LAURA, A System to Debug Student Programs", Artificial Intelligence, Vol.15, pp.75-122, (1980).

[2] Haruki Ueno, "Integrated Intelligent Programming Environment for Learning Programming", IEICE Transactions on Information and Systems, Vol.E77-D, No.1, pp.68-79, (1994).

[3] Nobuo Yoneda, Teruo Hikita & Takafumi Sakurai, "Pascal Programming"(in Japanese), SAIENSU-SHA Co.,Ltd., (1991).

[4] Tatsuhiro Konishi, Akihiro Suyama & Yukihiro Itoh, "Evaluation of Novice Programs Based on Teacher's Intention", Proceedings of ICCE'95, Singapore, Dec. 5-8, pp.557-566, (1995).

[5] Yukihiro Itoh, Tatsuhiro Konishi & Hiroyuki Suzuki, "On Experimental Evaluation of an Educational System that Supports Teachers of Novice Programming", Proceedings of ICCE'98, Beijing, China, Oct. 14-17, Vol.2, pp.234-238, (1998).

From Research to Development: A Content Analysis of Journal Articles

Alex Rath* and Shihkuan Hsu**

** Shih Hsin University, Language Center,1 , Alley 17, Sec. 1, Mucha Rd., Taipei, Taiwan 110*
Tel: +886-2-22368225 x316, E-mail: rattle@cc.shu.edu.tw
*** National Taiwan University, CTE, 1, Sec. 4, Roosevelt Rd., Taipei, Taiwan 106*
Tel: +886-2-23692364 x214, E-mail: skhsu@ccms.ntu.edu.tw

While the goal of educational research is to improve the field of education, most of the material used in the field is not necessarily developed from research. While most of the researchers in the university study the theory and practice, it is the textbook publishers and computer companies that make the tools available for schools and teachers. The disconnected and fragmented process between research, dissemination, development, and production not only wastes the effort and resources put forth in research and practice, but also hampers the development of the field of education. Using the method of content analysis, the authors examine the connectivity of educational research and development reported in a highly regarded professional journal over the past two decades. The results found that over 80% of the research studies presented only parts of a full-fledged R&D process: Theory, research, development, funding, and dissemination. Among them, about 40% of the articles addressed both research and development. It is argued that although the full-fledged R&D is a crucial process to enable the transformation of good research into quality practice, it has not received enough attention in the field of education. Implications for educational technology are particularly discussed.

Key words: **Educational Research, Research and Development, Content Analysis, Instructional Technology, Information Dissemination**

1 Introduction

The separation of research and development has long haunted the field of education. The professional approach to creating new instructional tools in the academic realm starts with educational research. The corporate instructional tool developers reiterate that the process starts with research. Theoretically, the process includes three stages: (1) research and development (also called R&D), (2) product development, and (3) production Dumbleton [1]. In actual practice, very little of the research makes it out of the lab and becomes widely used in practice. At the same time, corporate developers of instructional technology or curriculum material invest little in educational research. To go beyond personal observations and anecdotal evidence, a method is invented to examine the level of full-fledged R&D available in professional journals that are widely circulated in educational circles. The research question was: What amount of full-fledged R&D that includes theory, research, development, funding and dissemination was published in the *American Educational Research Journal*?

2 Method

In this study, the method of content analysis is used to evaluate the level of educational R&D reported in journals. Content analysis, or bibliometric analysis, includes evaluation of macro-trends such as dissemination as well as microanalysis such as the nuance of a single line of text. Ample precedent exists to use content analysis to evaluate the state of educational R&D. Articles in *AERJ* and other journals have been analyzed in order to understand R&D productivity, university productivity, faculty productivity, program quality, methodological quality, journal content, and journal rhetoric. Therefore, analysis of articles in *AERJ* provides a measurable indication of the extent that full-fledged educational R&D is published.

Random selection produced a dataset of *AERJ* articles (N=278). About 40% (n=116) of the papers directly

and indirectly related to instruction. Of the articles, 74 indirectly related to instruction and were eliminated. Excluding all articles unless they were directly related to instruction produced a small subset, comprising about 15% (n=42) of the sample, which were analyzed in this study. Articles were coded according to five components: Theory, research, development, funding, and dissemination. The range is 1-5, where 1 indicates only one part of the R&D process was included and 5 indicates that all five parts were found in the article. The mean number of R&D components reported in the instruction articles (n=42) was 3.36 and the standard deviation was 0.98.

3 Results

Content analysis was used to determine the extent to which theory, research, development, funding, and dissemination appeared in the selected articles. Evaluating the elements separately showed the frequency of R&D components. All 42 articles (100%) presented research. Thirty-one articles (74%) achieved dissemination. Twenty-nine articles (69%) reported funding. Twenty-one articles (50%) discussed theory. Of all the parts of R&D, development was the lowest frequency. Only 18 articles (43%) presented educational development. This was not surprising. Many articles were efforts to see that was happening in classrooms and with individuals, and there were many tests of theory.

The next step in describing the articles on instruction is to determine how many R&D articles combined all five parts. Of the 42 articles on instruction, the complete R&D process was clearly observable in only five (12%) papers. These papers were published in 1964, 1971, 1990, 1996, and 1997, suggesting that the more recent papers have slightly better coverage of the R&D process. Fourteen (33%) of the articles contained four components of R&D. Fifteen (33%) of the articles contained three components. Seven (17%) of the articles contained two components. One article (2%) had just one component.

By combining the two top categories, a new way to interpret the data emerges. The articles in the top two categories, articles with five and four parts of the R&D process, 45% (n=19) can be described as more developed studies than the articles with one, two, or three parts. It is interesting to note which component was missing in the articles which reported four parts. The missing component was theory, 42% (n=6), development, 42% (n=6), funding, 8% (n=1), and dissemination, 8% (n=1), respectively. There is a pattern emerging: research, funding, and dissemination.

A characteristic paper format emerges which has theory, research, and dissemination. Researchers are testing theories. Combining the three part and four part papers, which includes 69% of the articles (n=29), demonstrates the emphasis on educational theory and educational research. The pattern of what is included and what is missing appears when ranked in order of frequency. The four part studies present, in order of frequency, the following components: research, dissemination, funding, theory, and development. The three part studies present, in order of frequency, the following components: research, dissemination, funding, theory, and development. In other words, both three and four parts studies have the same pattern. They are most likely to do research, achieve dissemination, get funding, use theory, and complete educational development. Educational development is last on the list of R&D components presented in nearly seven out of ten *AERJ* articles. When funding and dissemination are dropped, the following pattern emerges: theory and research.

4 Conclusions

The incomplete R&D program is an unfulfilled opportunity. When numerous programs are unfinished, and the results are not fully disseminated, the investment is marginalized. When the knowledge from the incomplete program is not added to the knowledge base, overlap will occur and resources will not be put too good use. Teachers and administrators need choices, and only full-fledged R&D will give them a selection of programs for their schools. Corporate developers, like schools, need educational R&D. With such a limited number of full-fledged R&D articles in *AERJ*, it is possible that education professionals are missing an important opportunity.

References

[1] Dumbleton, J. H., "Management of high-technology research and development", Amsterdam, The Netherlands: Elsevier Science Publishers, 2nd Edition, (1989).

Cooperative Monitoring System using Mobile Agent

Young-Gi Kim, Sun-Gwan Han, Jae-Bok Park
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1283
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
young7@compedu.inue.ac.kr {fish,jbpark}@eslab.inha.ac.kr

This paper is a study on the design and implementation of the cooperative monitoring system using a mobile agent for an educational portal site. Generally educational portal sites have many addresses of teacher's homepage related education. Therefore, portal site has a very difficult task with maintaining a consistent address of site as well as it is impossible that administration of portal examines all dead sites in searching education site and DB. In order to solve this problem, we designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. This monitoring system applies to the Korean educational portal site (KEPS) for elementary students and teachers. For efficiency this system, we made an experiment that compared a cooperative monitoring agent system with a stationary monitoring agent system.

Keyword: **Education Portal Site, Cooperative Monitoring System, And Mobile Agent**

1 Introduction

Today, the advent of the web that can easily be connected through the "Internet" is known to be an easy and popular method for teaching and learning. Web-based educational homepages are used in many computer assistance medias and also the numbers of educational sites are on the increase extremely.

An extremely increase in number of homepage raises a question whether a student can search appropriate homepage for learning. In case of finding educational contents using a general searching engines, the searched site can exist an irrelevant contents against a student's request. Moreover the result of searching content fell into learning confusion, because the contents are difficult to apply at learning intact.

In order to overcome this problem, an educational portal site was constructed to gather only educational homepages that had been made several times before. An advantage of educational portal site is that content is used correctly and rapidly in learning because searching site is well constructed. In addition student can easily get suitable contents. For gathering of an educational homepage, an educational portal system, called KEPS, was constructed by the EDUNET and Inchon National University of Education.

While walking past a type of the gathered homepage in KEPS, it can be seen as to make not by an expert institution or a special company but by a teacher and a private person. As a result, characteristic of the homepages have to be petty and is frequently updated. Because the educational homepage can disappear easily, portal site faces difficulty to maintain consistency of the site address. If a hyperlinked address of a portal site is not connected or the retrieval site is disappeared to user, then this portal site may bring discredit to student. In order to maintain consistency of portal, the administrator of portal site must validate all addresses of site. But this examination is impossible work that man completely manages and finds. Consequently, a monitoring of a site address for finding the dead site can be process by an intelligent agent instead of human.

A single agent needs comprehensive amount of time required for the monitoring of a portal site. If a single agent examines extremely a many site addresses, the monitoring work may be inefficient. Because a mobile agent is possible with decentralization and a parallel processing, the monitoring works using a mobile agent

can be process effectively [5].

Accordingly, this study designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. In the following section, the mobile agent and monitoring scheme will be surveyed and the overview of the structure of monitoring agent will be designed. And the next section will be focused on implementation and experimentation of monitoring agent system. Finally the conclusion and future works will be described.

2 Mobile Agent and Cooperative Monitoring

The agent is a program with intelligent characteristics to help the users with the use of computers and take the user's place. The intelligent agent perceives any dynamic stimulation or condition and interprets the data collected for a solution to the problem and exercises reasoning for a final decision. It also acts to change the conditions within its environment in order to perform assigned duties. It has autonomy, social ability, reactivity, pro-activeness and a cooperative relationship, learning, mobility, and so on [9].

Generally an agent divides a kind of two by the mobility, a stationary agent to be executed roles in single system, while the mobile agent is executed at various systems after moving through the networks. An execution example of the mobile agent is shown in figure 1 and the mobile agent based environment is viewed figure 2. The mobile agent server must be installed to act a mobile agent as figure 2.

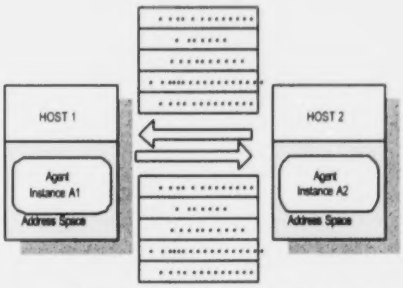


Figure 1. Execution of mobile agent

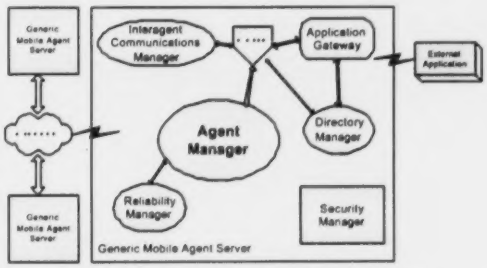


Figure 2. Mobile agent based environment

The mobile agent has a specific characters listed below compared with a stationary agent [5][6].

- The mobile agent reduces the network load.
- The mobile agent overcomes network latency.
- The mobile agent encapsulates protocols.
- The mobile agent executes asynchronously and autonomously.
- The mobile agent adapts dynamically.
- The mobile agent is naturally heterogeneous.
- The mobile agent is robust and fault-tolerant.

In the information retrieval, a monitoring work ascertains a state of gathering sites for the maintenance of data consistency. Generally, because the information of the web is changed frequently, a monitoring job by human is an impossible or inefficient work. This monitoring job can be processed by intelligent a computer program instead of a human. Such a program is called the web robot or an intelligent agent system [10][11].

In case of examining many sites in the monitoring work, if a single agent of the only server processes monitoring work, then the monitoring work may be needed long time and overloading of a monitoring server. The mobile agent has made possible cooperative and speedy monitoring job from distribution and parallel processing [8][11].

3 Cooperative Monitoring System

3.1 Overview of System

BEST COPY AVAILABLE

Overview of the KEPS system, including the temporary monitoring agent system is shown figure 3.

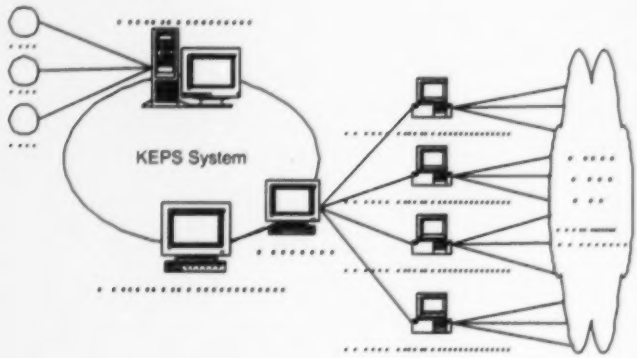


Figure 3. Overview of system

The portal system is consisted of four parts. There are the portal web server (PWS) and the monitoring agent server (MAS), the temporary monitoring server (TMS), a mediator. For using educational portal service, user must be connected with the Portal web server. Gathered address of an educational homepage is supported searching service of an education contents to user through the Portal web server. The Portal web server has searching engine, site DB and a query processor. The monitoring agent server has a stationary monitoring agent and a cooperative mobile agent, error DB, a mobile agent server. Also the monitoring agent server performs works as a creation and an allocation, a control, a gathering of the monitoring mobile agent. For the mobile agent perform it's task fully, each server is installed the mobile agent server necessarily.

The temporary monitoring servers are in existence out the KEPS system. In order to process a fast monitoring work, the TMS have function of distributed and parallel processing. The number of TMS is not fixed but dynamic by amount of monitoring job. Furthermore the TMS is used in temporary palace which mobile agent examines each a state of the registered site. At ordinary times, the TMS is not used usually for examining a state of the registered site. However the TMS can be only used when is requested by the mediator agent server.

The mediator is situated between the monitoring agent server and TMS, and acts as the role of mediation with the mobile agent and servers. All agents and agent servers must be registered in the mediator.

3.2 Design of KEPS System and Cooperative Work

The structure of the KEPS System is detail shown figure 4. The portal web server is consisted of searching engine and query processor, is shared the gathering DB of portal site. The searching engine provides searching service about education content and the query processor is shown the result searching at DB. The monitoring agent server is consisted of inference engine and agent manager, error DB. The monitoring system in monitoring agent server has a stationary agent and a mobile agent for distribution and parallel working. A stationary agent examines the state of gathering site and the confirmation of HTML documents through HTTP connection. After a failure sites are saved at temporary error DB, these will be deleted from site DB of portal web server. A permanent deletion of fail sites is executed by inference engine of the monitoring agent server.

When a monitoring agent server is overloaded or the stationary monitoring agent has difficulty processed by examination with many site, the monitoring agent server requests to the mediator about information of the registered TMS. If the number of the TMS is lacking, the monitoring agent server waits until the TMS becomes sufficient. Having sufficient number of the TMS, the mobile agent is created to divide as a suitable size of address by inference engine. And then the mobile agent has been created by a monitoring agent server, will be cloned with suitable number. Each mobile agent is allocated a monitoring work and will be dispatched to the TMS through ATP connection. The mediator agent can grasp each work states of an agent by using the agent finder.

Each agent is moved to temporary monitoring server and examines the allocated addresses of sites through HTTP. When a mobile agent is finished all checking of sites, it sends to the monitoring agent server with the result of observation. If the job of the mobile agent is occurred some problem, monitoring agent server creates a new mobile agent and re-dispatches to the TMS. All results gathers, result of examination saves at site DB and error DB. Finally, dispatching the agents retracted by the monitoring agent.

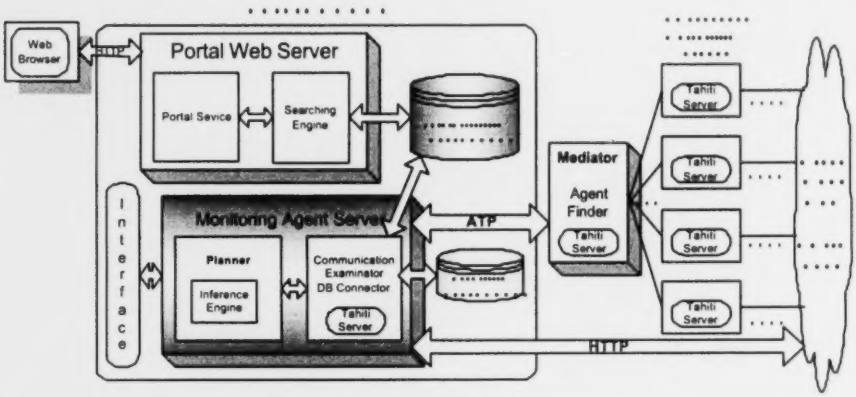


Figure 4. Structure of the KEPS system

The processing algorithm of execution about monitoring working is shown figure 5. The job of monitoring using the mobile agent has advantages that prevent an overloading of a single server and lessen monitoring time by distribution and parallel processing. Because agents are not used stationary server but are dynamically used in other servers, all servers performed share resources of monitoring system. Accordingly, each agent can do cooperative parallel processing using autonomous and society properties of agent.

4 Implementation and Experiment

4.1 Implementation and Application of System

The monitoring agent system proposed in this study was implemented two types. The stationary monitoring agent was implemented by using VC++ and CLIPS. Also the mobile monitoring agent system proposed in this study was implemented using JAVA based Aglet API and JESS. Aglet is the java class library for that can easily design and implement all the properties of the mobile agent. Moreover the Aglet provides with the Tahiti server and Agent finder for helping research of users.

The stationary monitoring agent interacts with the mobile agent of Tahiti server based environment. Inference engine of the stationary monitoring agent was used the CLIPS dynamic linked library and the mobile monitoring agent system was used the JESS class library. The CLIPS and JESS are rule based inference engine and was used to infer planning and allocation of the mobile agent. SQL was used for the gathering DB of portal site. ODBC and JDBC were used to connect the monitoring agent system and the gathering DB of site.

BEST COPY AVAILABLE

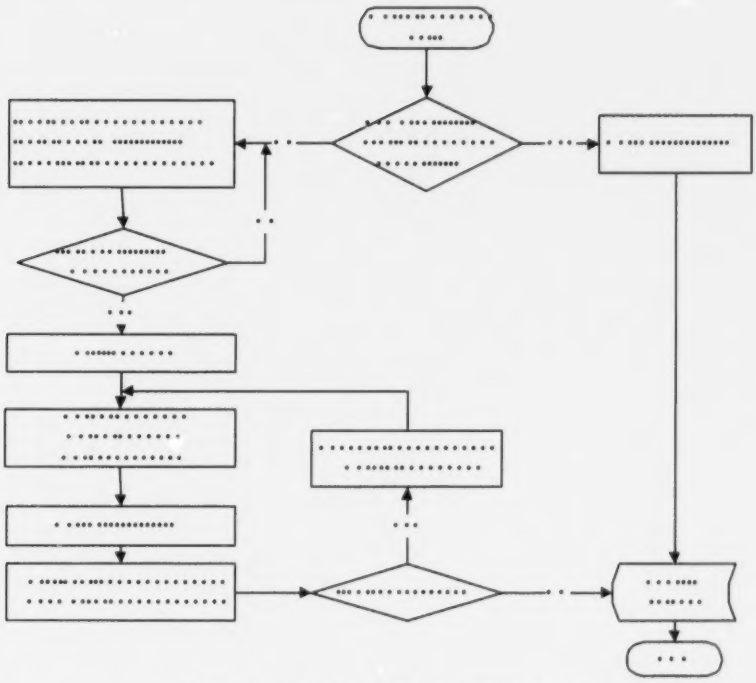


Figure 5. Algorithm of monitoring procedure

Figure 6 below is image of the interface of the stationary monitoring agent by making VC++. Figure is shown that the single monitoring agent is examining each site. The stationary monitoring agent was consisted of three parts mainly. The left screen of figure is represented list that the agent will examine site of DB. Also the center of screen is viewed results of a successful site and the right screen is represented results of a failure site.

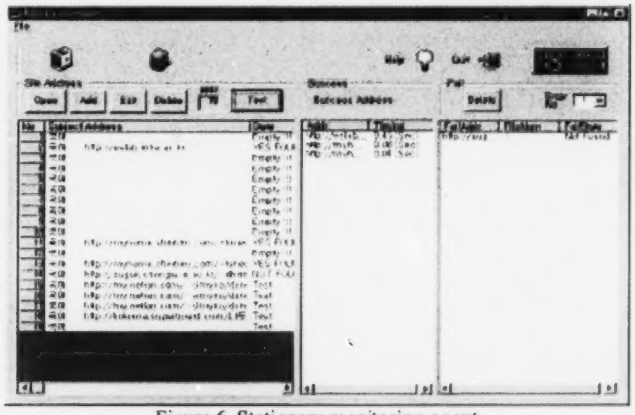


Figure 6. Stationary monitoring agent

Figure 7 is shown screen that the mobile monitoring agent is examining each site with distribution and parallel processing. If the numbers of sites are many in existence, the stationary monitoring agent executes the mobile agents to interact with the Tahiti server as followed image. Above window of figure is represented the stationary monitoring agent. Black screen below is viewed that mobile agent sever is executed by the stationary monitoring agent. Small screen below is shown the Aglet viewer. The Aglet viewer perform an important role as a creation, dialog, dispose, cloning, dispatching, retracting of a mobile agent.

BEST COPY AVAILABLE

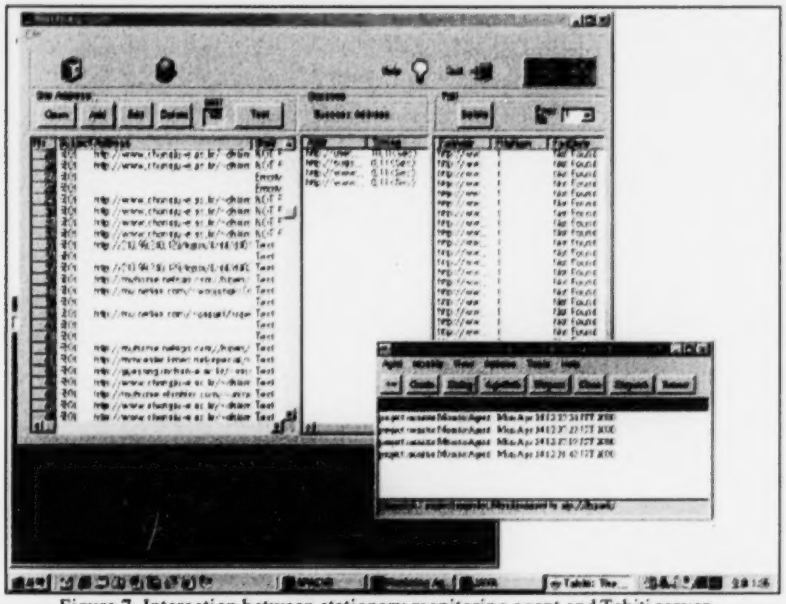


Figure 7. Interaction between stationary monitoring agent and Tahiti server

In order to use the implemented monitoring system in this study, we applied at the educational portal system and the KEPS system in the EDUNET server. Figure 8 is shown the searching screen of the web browser using KEPS system. This portal site in the EDUNET was constructed for the Korean elementary student and teacher. Also this site contains all contents about the curriculum of the Korean elementary school.

Figure 8. Searching of KEPS system

4.2 Experimental Results

For examining the efficiency of the cooperative monitoring system using the mobile agent, we compared and evaluated a monitoring time of each agent system. A comparative and estimative items listed below are as followed.

- Comparative item
  - *The single stationary monitoring agent vs. the cooperative monitoring agents.*
- Estimative items
  - *The monitoring time of the single monitoring agent*
  - *The monitoring time of the cooperative monitoring agents(3)*
  - *The monitoring time of the cooperative monitoring agents(7)*
  - *The number of sites: 10,30,50,70,90,110,130,150,170,190 ..etc.*

BEST COPY AVAILABLE

The experiment measures examination time of sites using a comparative and estimative items above. The estimative result is shown Table 1 and is represented figure 9 with form of graph. The horizontal axis of graph is represented the number of site and the vertical axis of graph is represented monitoring time of each agent.

In case of the number of an examine site is small, the result of experiment is viewed that the single stationary agent is faster speed of examination than the mobile monitoring agent. Also, when mobile agent is dispatched to three servers, speed of examination is faster than is dispatched to seven servers. The reason is caused by overtime occurred because the many mobile agents are created, allocated, gathered.

However, the more the number of site increases, the faster the mobile monitoring agent gets speed of checking than the single stationary agent. In particular, when the cooperative monitoring system using many agents, experimental result is shown that a speed of examination is very fast. If a single stationary agent processes very many sites, the result of execution can be useless though the result is very accurate.

Consequently, the cooperative monitoring agent can become higher execution speed by distributed and parallel processing and an overload of network by using a mobile agent can be decreased. If a server has an active environment of the mobile agent, the servers can be used with an active space of a searching agent and a monitoring agent.

Table 1. Result of monitoring time

Agent Type \ Number of Agent	10	30	50	70	90	110	130	150	170	190
Stationary Monitoring Agent	42	137	201	261	374	412	518	592	645	743
Mobile Monitoring Agent(3 Servers)	120	132	143	165	221	253	262	282	316	335
Mobile Monitoring Agent(7 Servers)	130	121	124	122	148	143	147	183	186	182

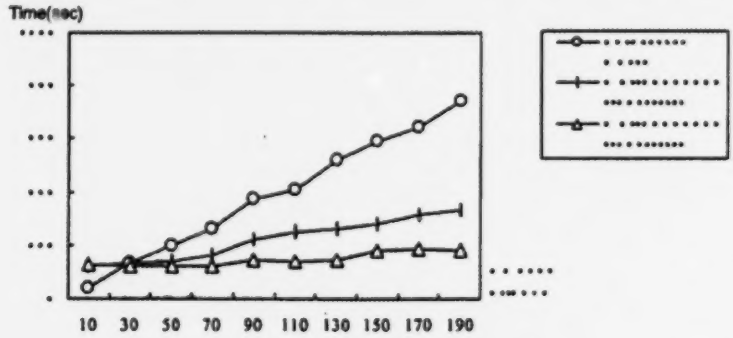


Figure 9. Graph of monitoring result

5 Conclusion and Future works

This study is on the efficiency of cooperative monitoring agent using mobile agent for educational portal site. The monitoring job has been getting difficulty processed by human. Thus, an intelligent agent can process the monitoring of the portal site instead of human. A monitoring work by using a single stationary agent needs long time for checking of many sites.

In order to overcome the problem in this study, the mobile agent is used in monitoring job. The monitoring job of educational portal site can be processed by collaborative method of decentralization and parallel using the mobile agent. The monitoring system was implemented by using the Aglet and Tahiti server. This system could execute cooperative monitoring job through an intelligent interaction between the stationary agent and a mobile agent. Also the KEPS system is possible with the mediation and the registration of agents by using the mediator agent between the monitoring server and the temporary agent sever.

The temporary agent sever is not fixed with the number but can be dynamically changed. Therefore all servers are by resources of monitoring job and each server can exe cute its role by inference.

More studies are required on research that constructs knowledge base for inference engine of the mobile agent. For effective portal site constructed, future work needs researches about not only intelligent monitoring but also intelligent searching and gathering of educational information. In order to interact between the mobile agents, we require research about KQML, language for sharing and exchange of knowledge between agent and agent.

References

[1] Akhil Sahai, Christine Morin INRIA-IRISA, • Mobile Agents for Enabling Mobile User Aware Applications• ; Just Research, 1998.

[2] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol 72, pp.329-365, 1995.

[3] Bryce L. Allen, Information Tasks: Toward a User-Centered Approach to Information Systems:, Academic Press, San Diego, CA, 1996.

[4] B.Venners,"Solve Real Problems with Aglets, a Type of Mobile Agent", Java World, www.javaworld.com/javaworld/jw-05-1997/jw-05-hood.html.

[5] Chang, D., Lange, D. "Mobile Agent: A new paradigm for distributed object compuing on the WWW. In Proceedings of the OOPSLA96 Workshop: Toward the Integration of WWW and Distributed Object Technology, ACM Press, N.Y., pp 25-32, 1996.

[6] Danny Lange and Mitsuru Oshima "Programming and Deploying Java Mobile Agents with Aglets", Addison-Wesley Longman, Mass., 1998.

[7] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[8] J.White, "Mobile Agents," in Software Agents, J. Bradshaw, ed., MIT Press, Cambridge, MA,1997.

[9] M. Wooldridge, M., Jennings, N. R., "Intelligent Agents: Theory and practice. The Knowledge Engineering Review, 10(2)", Springer-Verlag, pp 115-152, 1995.

[10] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[11] R. Tolksdorf, "Intelligent Information Agent: On Coordinating Information Agents and Mobility", Springer-Verlag, pp 396-411,1998.

Development and Evaluation of Web-based In-Service Training System for Improving the ICT Leadership of Schoolteachers

Kanji AKAHORI*, Hidetsugu HORIGUCHI, Katsuaki SUZUKI*** and Masatoshi NAMBU******

**Tokyo Institute of Technology*

Graduate School of Decision Science and Technology, Dept. of Human System Science.

2-12-1, Ookayama, Meguro-ku, 152-8552, Tokyo,

Tel.+81-3-5734-3233, Fax +81-3-5734-2995, akahori@ak.cradle.titech.ac.jp

***National Institute of Educational Research,*

****Iwate Prefectures University, ****Jyoetu University of Education*

This paper describes an analysis of the effectiveness of an in-service training system developed by a project sponsored by the foundation of the Information-technology Promotion Agency, Japan (IPA). We developed and carried out a 10 days training course for 65 teachers in three different locations. The three main elements of this course were (1) training curriculum, (2) CD-ROM materials, and (3) Web-based support system. The participants of this course were hoping to become Information Technology (IT) leaders in their schools. An analysis was conducted to investigate the factors influencing the effectiveness of the training. Based on our analysis, we were able to draw the following conclusions: (1) Web-based training support system and CD-ROM materials were very effective to improve teachers' knowledge and skills, regardless of prior knowledge and skills (2) Traditional instructional style (i.e. one-way instructor-centered style) was generally an ineffective training method.(3) CD-ROM materials significantly enhanced the effectiveness of teachers' creating materials (such as a Web page), especially when the CD-ROM was used for self-study. These findings will be useful for educators and educational designers who plan and conduct in-service training programs.

Keywords: **Distance Education, Teacher Training System, Web-based Learning, Teacher Education, Training Program Assessment**

1 Introduction

The Japanese Ministry of Education decided to introduce the Internet to all Japanese schools (i.e. elementary to high schools) by 2001 to promote students' Information Communication Technology (ICT) literacy and the effective utilization of information tools to enhance subject-area learning. It has been reported that in order to realize information technology education, three major factors are crucial: Preparing sufficient hardware, providing excellent software, and promoting teacher's ICT literacy (refs. [1]). Several papers describe certain barriers for integrating ICT into curricula (ref. [9], [5]). The Ministry of Education in Japan introduced several projects aimed at promoting teacher training by removing these barriers. One of these projects was named "Project for development and evaluation of in-service training system for improving the ICT literacy of schoolteachers" sponsored by the Information-technology Promotion Agency foundation (IPA). This project was divided into two sub-projects, one to develop ICT leadership of schoolteachers, and another promote the training of ICT coordinators. This article examines the development of ICT leadership of schoolteachers, especially focusing on the evaluation of in-service training system.

The project consists of about forty members, joined by a variety of experts including engineers from

computer software companies, ICT-experienced teachers, and university researchers. The project has conducted over one year starting in 1998, and included the following elements:
(1) Development of training curriculum and support system
(2) Implementation of the training according to the curriculum using the support system
(3) Analysis of effectiveness of the training system

2 Outline of in-service training system

The training system consists of major three components: (1) training curriculum, (2) CD-ROM materials and (3) Web-based support system.

2.1 Training curriculum

The guiding concept of the training curriculum is based on a constructivist approach (refs. [11]), and computer-mediated, problem-based training such as the learning from doing complex, challenging, and authentic problem through collaboration and communication (refs. [8]). The curriculum was designed to achieve the following goals:
(1) To train ICT leaders to play the central role in promoting classroom teachers' ICT literacy in each school.
(2) To attach greater importance to practical skills (rather than computer operation skills) by using ICT tools in actual classes (refs. [5], [14]).
(3) To improve basic skills of networking such as connecting to the Internet and configuring the school's LAN.
(4) To develop consultation skills for the leader to provide advise classroom teachers.
(5) To provide a computer-mediated learning-support system for sharing knowledge dynamically.

2.2 Development of CD-ROM materials

CD-ROM materials were developed in cooperation with a computer software engineer, an expert teacher, and university researchers according to the training curriculum. Many resources related to the training course, including teachers' case studies and video of actual classes using ICT tools which were recorded onto CD-ROM and used for instructor's presentation and participant's self-learning (refs. [6]). Figure 1 shows an example of an interview scene of expert teachers on CD-ROM materials, five disks in total.

2.3 Web-based support system

Fig.2 shows the configuration of a web-based support system for training. This support system consists of many modules such as database references, collaboration support, registration, and management of bulletin boards, checking items and participant's response in order to realize sharing discussion, collaborative group-based works and participants' reflection on each other's work (refs. [3], [12]). Fig.3 shows an example of a bulletin board in the system where participants can submit and share their opinions.

3 Design of system evaluation

The training program was conducted in three different locations. Each program ran for a period of 10 days, and a total of 65 teachers participated. These participants were identified as candidates to become school ICT leaders. The program for the training course, which consists of 12 topics, is shown in table.1.

Evaluation plays a critical role in the improvement of a training system. Despite the importance of evaluation, little research exists to analyze the factors contributing to the effectiveness of the training system (refs. [7], [10], [13]). In order to obtain findings helpful to the design the training program, we carried out an evaluation according to the following scheme. Checking was done at pre- and post- training, and all training scenes (such as participants' talk, activities, collaborative work and instructors' presentations) were videotaped for measuring activities' time and conducting qualitative analysis.

We introduced a total 106 items organized into 12 topic areas. Participants were required to respond to these 106 items before taking the course (pre-check), again just after taking the course (post-check), and one last time after the training was finished (after check). We compared differences among scores of pre-, post-, and

after check scores in the course. In order to analyze the factors influencing differences of pre- and post-scores, we carried out the regression analysis shown in a later section.

Figure 1. An example of motion picture of CD-ROM material: Interview Scene of expert teachers

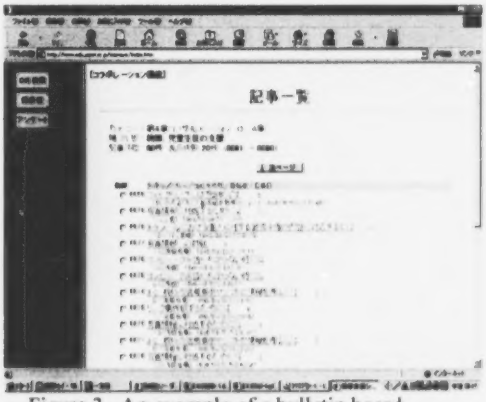


Figure 3. An example of a bulletin board in web-based support system

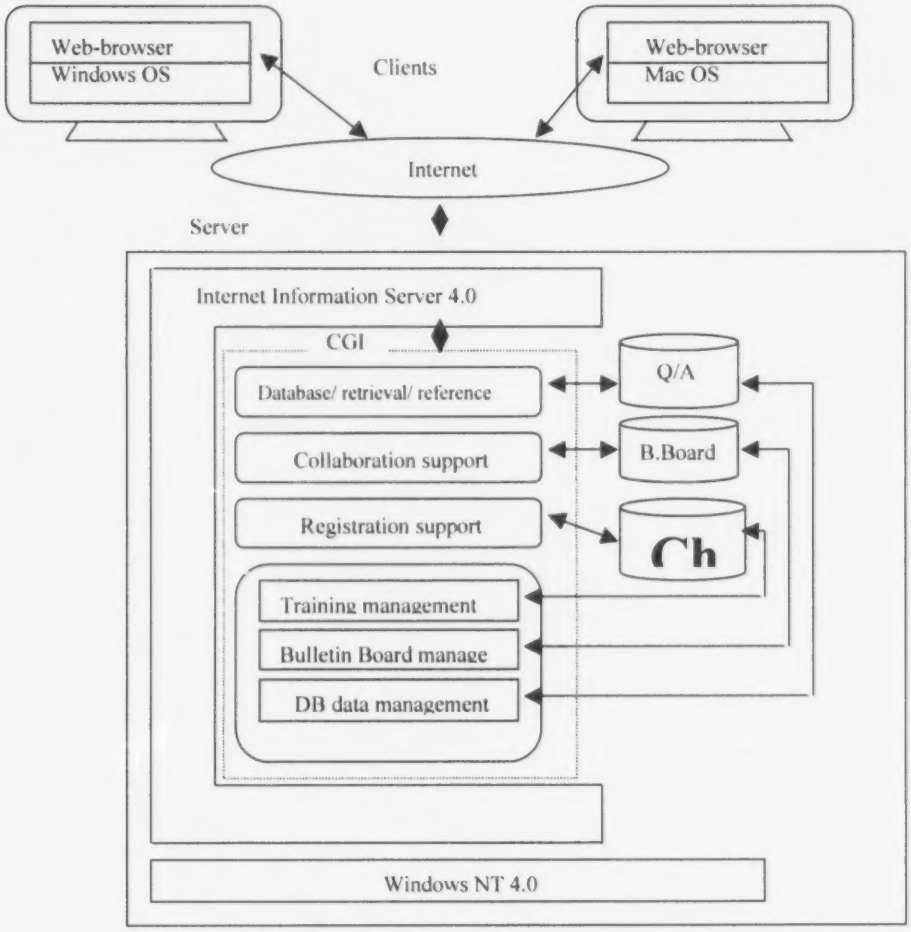


Figure.2. Configuration of web-based support system

BEST COPY AVAILABLE

Date	In the morning 9:00 10:30 10:40 12:00		After noon 13:10 14:40 14:50 16:20		Assignment 16:30 17:30
1st	Orientation Opening ceremony	Present situation and some problems in ICT education Ministry of Education Lecture	Direction of information society Lecture/Discussion	Fundamental technology supporting ICT education Lecture& discussion	
2nd	Contents and methods on ICT education Lecture and discussion		Curriculum development of ICT education Presentation and group work		Homework to develop school curriculum
3rd	To continue developing curriculum for each school	Participants' Presentation of each curriculum Discussion	Technical Foundation on OS, Multimedia and network Demonstration and lecture		Homework for topics
4th	Foundation of network focusing on LAN in campus, design of configuration of LAN, and management of network system Demonstration and lecture		Information ethics and privacy protection Lecture and discussion	Producing homepage Demonstration and individual work	Homework as homepage producing
5th	Presentation of produced homepage Discussion How to make materials		ICT utilization to subject learning and the role of computer and the Internet Lecture and discussion		Homework for topics
6th	How to develop a lesson plan and how to make materials using computer, hypertext and internet Presentation and group work				Homework for materials production
7th	Continuing to materials production Group work		Presentation of produced materials Discussion	Collaborative learning Lecture/discussion	Homework for checking consultation
8th	How to develop consultation skills concerning to ICT education Discussion and group work		Practice of consultation Discussion and group work		Homework for practice
9th	How to promote and manage in-service training at each school Presentation and discussion		Practice to make training plan at each school Group work and discussion		
10th	Presentation of training plan Discussion	Issues on management of training in a school Discussion	Closing ceremony		

Table 1. The training program for a 10 days training course

4 Results of differences among pre, post and after taking the course

The rating system consisted of four levels: 4 (good understanding), 3 (some understanding), 2 (little understanding), and 1 (no understanding at all). The maximum score is 424 (calculated by 4 times 106), and the minimum score is 106. Figure 4 shows the change of total scores with post- and after check sorted on pre-check scores. This figure shows that the scores with post- and after check are almost independent on pre-check scores, which means the training program was effective regardless of participants' prior knowledge and skills.

The figure also shows three regions which are the pre-achieved region before training, the achieved region

by the training. and the unachieved region in spite of the training. Therefore, we can evaluate the area size of the achieved region by the training as the training effectiveness. In roughly estimation, it was as desirable as expected.

4.1. Analysis of factors affecting the training effectiveness

In order to pick up the factors affecting the training effectiveness, we made the following assumptions.

Assumption 1. The in-service training system will be effective to all participants with various prior ICT knowledge and skills, as anticipated from the previous section. .

Assumption 2. The Web-based training support system and CD-ROM materials will work well with comparison to the traditional training system such as lecture-based instructional style.

The model for testing these assumptions is as following.

Post-check score ← pre-check score + Web-based support system
+ CD-ROM materials + instructional style

Where, pre-check score represents participants' prior knowledge and skills, post-check score represents participants' knowledge and skills achieved by the training, and instructional style shows instructor's presentation, participants' individual learning, group works and so on. This model is based on the relation that the post-check score, it is called as a dependent variable, is influenced by other independent variables such as pre-check score, Web-based support system, CD-ROM materials and instructional style. Here, we call the above independent variables as factors affecting the training effectiveness

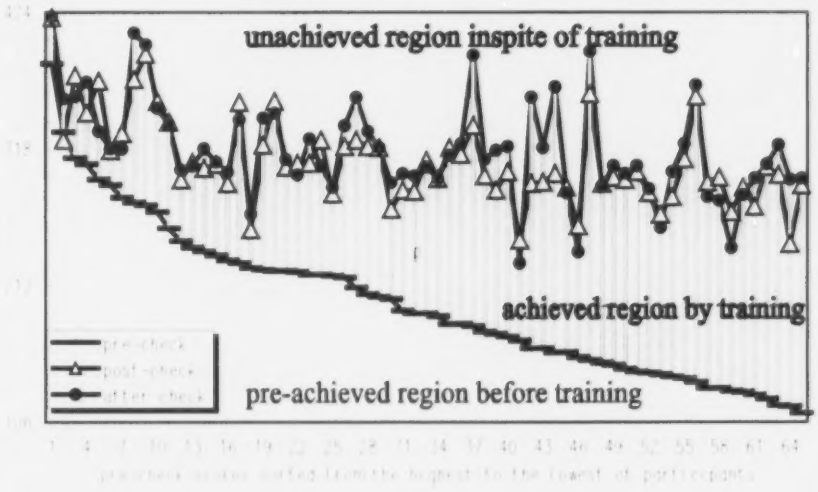


Figure 4. Dependence of post- and after check scores sorted by pre-check scores

The regression analysis should be suitable for evaluating the factor's size. The factor's size can be obtained by calculating the regression coefficients of each independent variable in the above regression equation. Here, we will adopt the time spent during the training course as a value of independent variables except pre-check score. This means that the factor with more spent time contributes to the training effectiveness more than the less spent time. We can estimate the size of regression coefficients as the affecting size of factors. Time spent in each factor was measured using videotapes recording all training course. A part of data is shown in table 2. In the table, topics number shows topics in the training course, 12 in total, factors show lecture, presentation, group work Web-based support, CD-ROM for use and so on, and numerical data in the cell show the spent time in each factor and each topics with the unit minutes except scores.

Table 3 summarized the result, data of the regression coefficients' size, calculated by regression analysis and

the result is shown in figure 5 as a visual graph

Topics No.	1	2	3	4	5	6	7	8	9	10	11	12	Total
Check items counts	10	5	4	15	18	8	8	5	4	9	12	8	106
Lecture	58	76	73	58	163	30	87	28	38	72	13	22	718
Presentation	80	0	62	22	40	10	55	83	0	159	112	35	658
Group work	0	0	91	93	93	0	55	0	0	0	173	0	505
Individual learning	0	25	0	32	73	0	60	80	0	35	0	0	305
Web-based support	10	25	22	9	10	18	10	9	43	43	10	5	214
CD-ROM for individual	32	30	15	0	0	0	12	30	10	0	0	93	222
CD-ROM for group work	0	0	14	0	0	0	0	0	0	55	0	0	69
CD-ROM for presentation	8	13	3	119	5	74	41	12	27	9	28	0	339
Pre-check score	1.84	2.21	1.80	1.69	1.81	1.42	1.81	1.63	1.43	2.24	1.89	2.19	
Post-check score	2.69	3.01	2.79	2.79	2.94	2.91	2.85	3.03	3.16	2.89	3.02	2.91	

Table 2. A part of data table showing the spent time for elementary teachers
Time unit: minutes, pre- and post- scores: average score

N (total counts of items)=36 (=12 factors times 3 locations)

□(decision coefficient)□ **0.713 * (p<0.05)**

Dependent variable□scores of post-check

Factors (Independent variables)□

	factors	sub factors	regression coefficient
(1)	pre-skills of teachers	pre-check score	**0.010**
(2)	training style	lecture	**0.332 + (p<0.10)**
		presentation	**□0.220**
		group work	**0.180**
		individual work	**0.364 + (p<0.10)**
(3)	supporting system	web-based system	**0.589 ** (p<0.01)**
(4)	CD-ROM materials	for self learning	**0.310**
		for group work	**0.068**
		for presentation	**0.010**
(5)	school class	elementary	**0.360 + (p<0.10)**
		junior high school	**0.065**

Table 3. Result of regression analysis: coefficient's size of each variable

From table 3 and figure 5, we could find the following results.

(1) The biggest influencing factor was the Web-based support system, which was statistically significant within 1 percent level.

(2) More spent time using CD-ROM for self-learning contributed to higher scores in the post-check. This means that the CD-ROM is more effective when used for self-study than other uses such as group work and instructor's presentation.

(3) More spent time in instructor's presentation was less effective to the scores of post-check, which was statistically significant. This means that a traditional teaching style, such as one way directed lecture-based style, is ineffective to the training.

(4) Differences were found between teachers of elementary and junior high schools.

(5) Scores of post-check were almost independent to scores of pre-check. This means that the training system will work effectively regardless of quantity or quality of a teacher's prior knowledge and skills as expected in the previous section.

From the above results, we can conclude that the first and second assumptions substantiated.

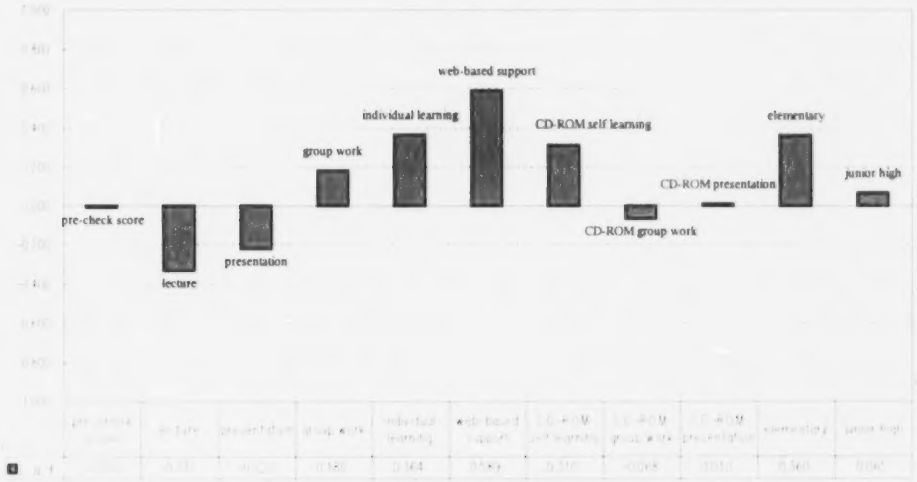


Figure 5. Comparison of each factor's size

4.2. Analysis of factors affecting on the works produced by participants

In the training course, participants were assigned to produce works such as homepage, a lesson plan using CD-ROM, and so on. Instructors rate the produced works with four grades from the points of check items' view. The regression analysis was done using the similar method as the previous section. The result is shown in table 4,

---

N (total counts of items)=21 (=7 produced works times 3 locations)

□(decision coefficient)□**0.764 ** (p<0.01)**

Dependent variable□scores of produced works rated by instructors

Independent variable□

	factors	sub factors	regression coefficient
(4)	CD-ROM materials	for self learning	**0.522 ** (p<0.01)**
		for presentation	**□0.574 ** (p<0.01)**

Table 4. Result of regression analysis on produced works

We could find only the factor of CD-ROM materials as statistically significant, shown in table 4. From this result, we could find that only using CD-ROM materials for self-learning works effectively. In contract, the use of CD-ROM materials for instructor's presentation was relatively ineffective. It can be interpreted that one way directed instructional style was also ineffective to work-production, which was the same finding as shown in the previous section.

5 Conclusions

The conclusion is summarized as the following:

(1) Web-based training support system and CR-ROM materials were effective to improvement of teacher's knowledge and skills, regardless of quantities and qualities of prior knowledge and skills.

(2) Traditional training style, one-way directed and instructor-centered style, was ineffective to in-service training.

(3) Using CD-ROM materials for self-learning enhanced the quality of teachers productions.

From the above conclusions, we can give some useful suggestions to educators and administrators who plan to conduct in-service training courses. The important points are:

BEST COPY AVAILABLE

(1) Modify the training approach from a traditional teacher-centered to a participant-centered style (refs. [2]),
(2) To introduce rich materials for self-learning or group works (refs [4]),
(3) To introduce Web-based support system,
(4) To promote opportunities for exchanging teachers' knowledge and skills, especially rich-experienced practical know-how.

Suggestions (3) and (4) are very important because teachers can share their know-how with others, which works well when conducting real lessons in schools (refs. [9]). Web-based support system enables teachers to share their know-how and knowledge anytime, anywhere, and with anyone. Moreover, CD-ROM materials also can be used at anytime, anywhere, and by anyone. Therefore, it is important to provide rich self-learning resources that contain expert teachers' case studies and a support system that enables the sharing of dynamic, experience-based knowledge, and communication. Such resources can truly be called integrated training environments.

Acknowledgements

The authors would like to thank Ms. M. Suzuki, Fujitsu Learning Media Co., for her great assistance, and also Dr. D. J. Scott and Dr. M. Yanagisawa for their cooperation. We would also like to express our appreciation to the following people who assisted with this project: Mr. T. Maesako, Mr. K. Hatano, Mr. T. Horita, Mr. T. Nakagawa, Mr. T. Sanada, Mr. K. Nagashima, Mr. M. Suzuki, Mr. J. Tamura, Mr. K. Nakagawa, Mr. K. Tanaka, Mr. Y. Mohri, Mr. M. Maeda, Mr. M. Ichikawa, and Mr. M, Itoh.

References

[1] Akahori K., "Effectiveness and some problems of the Internet: Utilization to education from overview of school practice research in Japan", proc. of SITE (Society fro Information Technology & Teacher Education), 98 International Conf. in Washington, DC, 1157-1156,1998
[2] Collins M., "Comparing Web, Correspondence and Lecture versions of a second-year non-major Biology course", British J. of Educ. Technol. Vol.31, No.1, 21-27, 2000
[3] Collis B., "Designing for differences: cultural issues in the design of WWW-based course-support sites", British J. of Educ. Technol. Vol.30, No.3, 201-215, 1999
[4] Dillon P., Tearle P., Hudson A., "The Images for Teaching Education Project: developing multimedia resources within an integrative framework", British J. of Educ. Technol. Vol.30, No.4, 359-367, 1999
[5] Ertmer P. A., "Addressing First- and Second-Order Barriers to Change; Strategies for Technology Integration", Educational R & D, Vol.47, No.4, pp.47-61, 1999
[6] Jonassen, D., Rohrer-Murphy, L., "Activity Theory as a Framework for Designing Constructivist Learning Environments", Educational R & D, Vol.47, No.1, pp.61-79, 1999
[7] Kumar K.L., "Assessment of the Effectiveness of a Short Course via Internet", Educational Technology Research (in Japan), Vol.22, pp.27-33, 1999
[8] Laffey J., Tupper T., Musser D., Wedman J., "A Computer-Mediated Support System for Project-Based Learning", Educational R & D, Vol.46, No.1, pp.73-86, 1998
[9] Lawson T., Comber C., "Superhighways Technology: personnel factors leading to successful integration of information and communications technology in schools and colleges", J. of Information Technol. for Teacher Educ. Vol.8, No.1, 41-53,1999
[10] Ravitz J., " Evaluating Learning Networks: A Special Challenge for Web-based Instruction", in "Web-based Instruction" (Editor Khan B.H.) Educational Technology Publications, New Jersey, 361-368, 1997
[11] Reeves, T.C., Reeves, P.M. " Effective Dimensions of Interactive Learning on the World Wide Web", in "Web-based Instruction" (Editor Khan B.H.) Educational Technology Publications, New Jersey, 59-66, 1997
[12] Sannomiya, M., Kawaguchi A., "Cognitive Characteristics of Face to Face and Computer Mediated Communication in group Discussion: An Examination from Three Dimensions", Educational Technology Research (in Japan), Vol.22, pp.19-25, 1999
[13] Tessmer M., McCann D., Ludvigsen M., "Reassessing Training Programs: A Model for Identifying Training Excesses and Deficiencies", Educational R & D, Vol.47, No.2, pp.86-99, 1999
[14] Willis J., Thompson A., Sadera W., "Research on Technology and Teacher Education: Current Status and Future Directions", Educational R & D, Vol.47, No.4, pp.29-45, 1999

Development of a LAN-based Formative Evaluation Module as an Instructional Management System

Youngcook Jun and Wangryang We
Sunchon National University, Department of Computer Education
315 Maegok-dong Sunchon city, Chonnam, Korea, 540-742
{ycjun, wrwe}@rise.sunchon.ac.kr
Ph) +82-61-750-3341

This paper describes a LAN-based module program for formative evaluation during classroom teaching. Within one-hour classroom instruction, teachers can hardly assess what students significantly understand during history instruction. With this system, teachers are apt to create, modify, retrieve and manage formative evaluation processes based on a database. In addition, the teachers organize test items and other instructional materials in elaborated sequences relevant to their teaching plans. Our system consists of an instructional management tool and a module-based formative evaluation system. Our system is implemented with Visual Basic 6.0, Access DB and Crystal Reports 5.0. The final part of this paper presents how to enhance system based on the Bayesian inference system.

Keywords: **formative evaluation, knowledge diagnosis, instructional management.**

1 Introduction

School teachers are either implicitly or explicitly affected by the use of computer in classrooms. They tend to consider utilizing the computing power for their instructional improvement. One of the most prominent purposes for teachers to adopt the computer is regarded as Computer-Managed Instruction (CMI). How to manage instruction and learning in real classrooms turns out to be a very practical problem for teachers [2].

The survey result conducted by Lee, et al. [4] indicates that over 60% of the participants responded that they prefer using one computer per each person when software is applied to classroom instruction. Even though web technology has been dominated under the name of WBI (Web-based Instruction), our system is designed on the LAN environment due to heavy network traffic and rather a weak requirement for multimedia. We only focus how to enhance the teachers' capability to manage their instruction by adding formative evaluation module into the existing instructional sequences similar to a web-based formative assessment program [1].

This paper describes LAN-based VisEval which is a module-based formative evaluation system. The VisEval was originally designed as a quiz-like testing tool that makes Korean teachers avoid difficulties in assessing teaching materials to students. With this system, teachers are apt to evaluate the students' understandings as a part of performance evaluation that is encouraged among most of the Korean teachers by the Ministry of Education. In addition, the VisEval helps teachers elaborate teaching sequences relevant to their teaching plans by simply adopting other teaching resources due to modularized design of VisEval.

2 Design and implementation of VisEval 1.0

The VisEval 1.0 is a prototype system that helps teachers easily check students' learning progresses. This prototype is aimed at playing the role of an evaluation aid for teachers who usually skip the evaluation procedure during classroom teaching. The teachers thus take advantages of using the VisEval by creating, classifying, retrieving and managing test items before instruction. The overall framework was implemented in Visual Basic 6.0 with Access DB for Windows environment.

Within the limited time for instruction, teachers are expected to motivate students' learning and control the overall pace of instruction. Without any tool, teachers can hardly try to evaluate quiz-like tests at the end of instruction with further statistical analysis as a part of performance evaluation. With VisEval, teachers can set up the test duration so that the main classroom teaching cannot be overloaded for both teacher and students.

Our system is based on Module program which means that the whole teaching sequence are divided into small parts so that the teacher can organize the necessary parts for lesson plans. The traditional CAI program, on the other hand, is regarded as system-driven program, which means that the whole instructional program consists of one system containing domain knowledge and control structures. Our system is thus treated as a component-like module-driven program.

2.1 Module for teachers

A module for teachers is designed in the following ways: it is easy for teachers to reorganize test items and to manage evaluation procedures. The other important factor is associated with the way feedback is provided. Our system only provides immediate feedback only when the active engagement of the user is assured. Once the feedback is issued, the user is not allowed to solve similar problems but to receive guided instruction from the system with the treatment of the whole test items again. The user is only allowed to solve multiple choice items at a time. According to the result, the user is expected to repeat the test items in a linear fashion since the teacher only provides 10 minutes or so for students to transfer acquired knowledge items. The table 1 shows the main functions of instructional module of VisEval.

Table 1. Functions implemented in the module for teachers

Function name	Content
Item manger	Generation, modification, deletion of item DB, conversion of DB items into texts
Responses analyzer	Item response analyzer, Scoring functions
Simulation for students	Student' s trial for simulating
Other tools	Distribution of test files on LAN, collection of the test results, sharing of test files in different formats

2.2 Module for students

Once the module for teachers is ready to go students are expected to login the system. The immediate transaction of the test items enables the students to assess their own understandings of the learning materials. Without the corrective feedback, each student is allowed to follow his/her own guided instructional module provided by the system. Different formats of the test items are available with special characters such as mathematical symbols implemented by RTF (Rich Text Format). After the evaluation procedure, the transaction of the test results to the teacher' s computer is finished via LAN. The sample result of the students' assessment for one class is shown in figure 1, being created from Crystal Reports for Visual Basic. The analysis of each test item for each class is processed from the module for teachers as depicted in figure 2.

As the module for students is designed to provide supplementary learning according to test results, the control flow for guided learning is implemented. This mechanism is up to present indexed by the teacher' s setting with a predetermined threshold. We are currently investigating much fine-grained knowledge diagnosis method such as knowledge-state inference system based on Bayesian inference network. The flow control for guided learning to date is coded using item-binary matrix relying on the teachers' previous teaching experiences. The future modification plan of our system is explained in the following section.

학급별 개인별 채점 결과

작성일자: 2000-03-22
문제번호 1_2_3_4_5_
정 답 /4/신석기혁명/2/2/중석기시대_중석기

학급	번호	성 명	점수	응답 결과	채점 결과	점수이력	답 안 내 용
11	11	11	20	5 • 3 2•	XXX OX	/20	5***32***
11			20.00				
총계			20.00				

페이지번호 1

Figure 1. Test results taken by individual student in each class

문항별 학급별 응답 결과

작업일자 00-02-01
정 답 /2,3/2/4/3/물정,불교_물영,불교
정답기호 2개정답 : a=1,2 b=1,3 c=1,4 d=1,5 e=2,3 f=2,4 g=2,5 h=3,4 i=3,5 j=4,5

문제번호	답지	학급 01	02	04	05	06	07	총계
1-1	1	0	0	0	1	0	0	1
	2	2	3	1	0	0	0	6
	3	0	0	1	0	0	1	2
	5	0	0	0	0	1	0	1
	총계	2	3	2	1	1	1	10

Figure 2. Item responses for students in each class

3 Conclusion

The features of the VisEval are, up to present, suited for Korean teachers' needs of easily evaluating high school history instruction in the computer rooms. Even though there are some limitations as being an automated instructional system, the VisEval will be enhanced further as the system evolves. One of the drawbacks in our system is the lack of guides and suggestions on how to accurately diagnose the students' knowledge states. The following future plan dictates possible enhancement of our system with two extra modules based on the previous research [3].

The first part is a module that draws knowledge inferences for a given student's problem states based on pre-built test item attributes. The second part decides which abilities of the student need complementary practices according to the diagnosis done by the inference system. This second module also provides students with adaptive ways of taking relevant problem items mapped from item-attribute matrix in the domain of middle school mathematics. As shown in Jun's research [2], all of these mechanisms are operated on the WWW environment via Common Gateway Interface (CGI).

We begin with carefully examining test items in terms of content domains and student abilities. By constructing an incidence matrix with content domains and student abilities, each test item can be mapped into a content-ability matrix. With this test item matrix, we proceed to building knowledge-state inference system based on Bayesian Inference Network algorithm[5].

For example, Certain contents and abilities can be pre-requisites of other concept, say node N1, which means students first need to understand the pre-requisites of the concept (N1). Priors of network nodes are empirically assigned according to teachers' teaching experiences. This big graph is then fed for computer programs that calculate Bayesian inference [4]. We tested Ergo [7] and Netica (http://www.norsys.com/home.html) for WWW environment. The result of processing such a Bayesian

program updates probability distribution among nodes. Such posterior probabilities are discretely scaled so that VisEval can provide fine-grained guided learning materials to students.

In short, VisEval has several possibilities for future enhancement on WWW environment as an instructional management system for distance education as similarly reported in [1]. We furthermore pursue a fine-grained knowledge diagnosis capability with which the system intelligently guides students on their own paces outside classrooms. The use of Bayesian network algorithm seems promising for our future project. Error diagnosis system such as Rule Space model is another reference to encode test item attributes and projection space of multi-facets of knowledge items [9]. Even though the scope of our system is mainly focused on teachers' side in classroom teaching, the future version of VisEval can extend its capability of guiding students as an individualized learning management system.

References

[1] Han, B-R., Hong, J-Y., & Song, K-S. *Design and implementation of formative assessment program for distance computer education*. Journal of Korean Association of Computer Education, (2000).

[2] Jun, Y. *Web-based Computer-Managed Instruction for high school mathematics*. Paper presented at the ICMI-EAST Asia regional conference on mathematics education, Chungbuk, Korea., (1998).

[3] Jun, Y. & Kim, S-H. *Development of a Web-based Knowledge-State Inference System for Guiding Middle School Mathematics Learning*. Proceedings of ATCM ' 99, Guangjou, China, Dec., (1999).

[4] Lee, C-H., Shin, S-B., Yoo, I-H., & Lee, T-W. *Analysis of applications with educational software in Korea*. Proceedings of Korean Association of Computer Education, Jan., (2000).

[5] Mislevy, R. J. Probability-based inference in cognitive diagnosis. In P. Nichols, S. Chipman, & R. Brennan (Eds.), *Cognitively Diagnostic Assessment*. Hillsdale, NJ: Lawrence Erlbaum, (1995).

[6] Nichols, P. D., Chipman, S. F., & Brennan, R. L. *Cognitively diagnostic assessment*. Hillsdale, NJ: Erlbaum, (1995).

[7] Noetic Systems, Inc. ERGO [computer program]. Baltimore, MD: Author, (1991).

[8] Ritter, S. & Koedinger, K. An architecture for plug-in tutor agents. *Journal of Artificial Intelligence in Education, 7*(3/4), 315-34, (1996).

[9] Tatsuoka, K. K. Rule space: An approach for dealing with misconceptions based on item response theory. *Journal of Educational Measurement, 20*(4), 345-354, (1983).

Development of a Web System to Support Computer Exercises and its Operation

Hajime Kitakami, Sueda Takashi, Yasuma Mori and Susumu Kuroki
Faculty of Information Sciences Research, Hiroshima City University
3-4-1 Ozuka-Higashi, Asa-Minami-Ku, Hiroshima 731-3194, JAPAN
Tel: +81-(0)82-830-1587
Fax: +81-(0)82-830-1587
E-mail: kitakami@its.hiroshima-cu.ac.jp

This paper describes the development and operation of a Web-based system to support computer exercises used in a course on data structures and algorithms. To develop such a system, this paper proposes using the functions of a Web-based system to deal with a learner's state transition model based on computer exercises. The Web system developed by us has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participant and teacher, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of this system resulted in students' heightened motivation to work, good communication between participants and teachers, and a reduced workload for teachers.

Keywords: **Web, Database, Exercise, Autonomous Learning, Domain Model, Communication, Questionnaire, Data Mining, Operation, Evaluation**

1 Introduction

The new curriculum of the Department of Intelligent Systems at Hiroshima City University has added computer exercises to subjects related to algorithms and programming, thus encouraging students, from freshmen to sophomores, to make the most of their ability for practical programming with representative algorithms. The curriculum offers two ongoing three-hour courses that include theory and practice.

This paper focuses on computer exercises for the course "Data Structures and Algorithms," which is a part of the core curriculum for sophomore students. The general objective of the course [1, 2] is to facilitate the transition from computer literacy to a professional level of information processing. Even though students have considerable knowledge of computer operations, they do not have perfect command of them Moreover, they do not have enough experience in basic programming techniques. In order for them to have command of the theory and the practice, we have developed many exercises to improve the management of participant registration and learner's goals, information about the exercises, mutual interaction between participants and teachers, management of report submissions, and collection of questionnaires, among others. However, a problem arises because the workload for both teacher and students increases in the process. To solve this problem, we have developed the necessary support Web system dealing with a learner's state transition model based on computer exercises. Moreover, we report the operational results obtained from real exercises.

2 Assessment of learners' situation before the training

The contents of the courses "Data Structures and Algorithms I" and "Data Structures and Algorithms II" were divided into two courses, each including both theory and practice, using C in the new curriculum The former includes major elements such as stack, queue, list, naive sort, recursive function, quick sort, tree structure, and binary sort in the second semester of the first year. The latter includes major elements [3, 4] such as complexity, file processing, linear search, binary search, hash, B-tree, pattern matching, graphical

searches, Kruskal, and Dijkstra in the first semester of the second year. Since students can easily understand the content of many classes if they have attended C in an earlier semester, "Structured Programming" was also organized into two courses including both theory and practice using C in the first semester of the first year. This course includes major expressions such as if-, while-, and for-statements, array, data types, pointer, function, and structure in C. Moreover, the teaching of computer literacy includes major elements such as word processors (e.g., LaTex), programming tools (e.g., mule, e-macs), drawing tools (e.g., TGIF), the input tool for Japanese characters, electronic mail, X-window, and the shell command on UNIX, among others, in the same semester.

An evaluation of the learners' situation before starting the course "Data Structures and Algorithms II" that is the focus of this paper provided the following results:

(1) Students did not have much knowledge about algorithms and data structures with practical usage. They had learned simple and short programs but did not have much experience with longer programs. For example, they did not have experience in how to update longer programs by themselves.

(2) They did not have enough motivation for autonomous learning. They were less eager to learn than freshmen. For example, they did not consult textbooks or dictionaries on their own when they had trouble understanding an exercise.

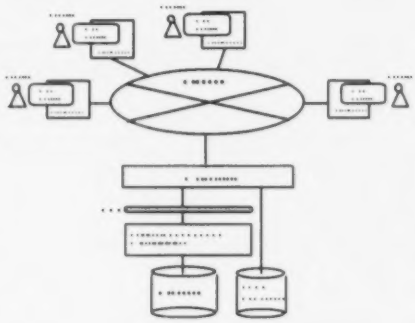


Figure 1. System Configuration

(3) Twenty-five percent of the students did not understand the C language. Seventy-five percent of the students tended to forget the C language, since they had not had a chance to practice it for more than 2 months after the second semester of the first year.

(4) Many students did not have sufficient skills to attain perfect command of software tools such as TGIF or LaTex.

3 Conceptual view of the computer exercise

Figure 1 shows the system configuration to support the exercise. Since each learner does his exercises at a workstation connected to the Internet, he can access information managed by the Web server. The Web server stores the exercises as HTML documents. The application program located in the CGI (Common Gateway Interface) manages information related to his registration, personal goals, and questionnaires. The application program is implemented in Parl, Shell, and SQL. The information inputted by the Web browsers is stored in the database and used by the learners.

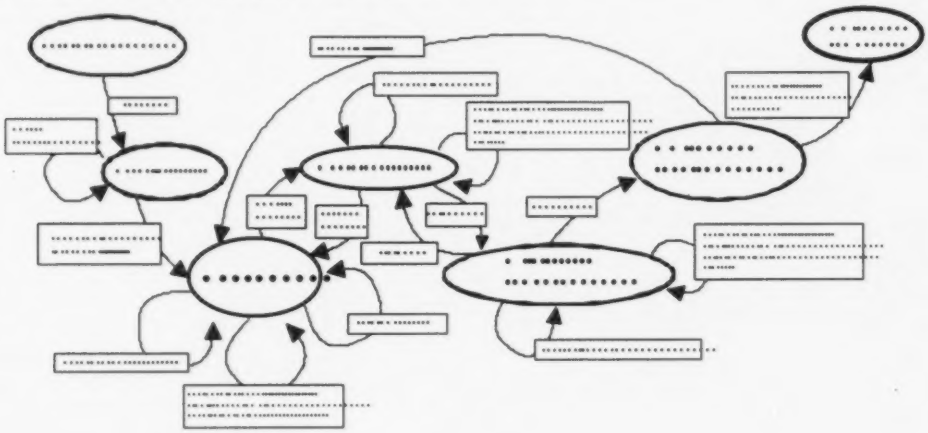


Figure 2. Computer Exercise Model

We tried to computerize human work as much as possible in the existing computer exercise. Notice of all 15 exercises included in the course was given on the Web page. We connected both basic programs and measurement data to the Web page for each exercise. Using a Web browser, both could be downloaded from the Web server to a student's site. Before starting on the first exercise, students had to fill out an electronic registration form for the class using the Web browser. When a student inputted his school number, name, password, and e-mail (electronic mail) address in the registration form, the system issued him a registration number using e-mail and the Web page. If the student needed any information about the exercises after that, he could get it by inputting his registration number and password using the Web browser.

Figure 2 represents the state transition for the computer exercise model. "Starting the Course," located at the left side of Figure 2, represents the state before starting the class. The student moves to the state of "Completing the Course" if he finishes all exercises successfully. If the student inputs personal data in the class registration form, the student moves to the state of "Class Participant." If the participant replies to the first questionnaire and inputs his personal goals for the exercise using the Web browser, he moves on to the state of "Exercising." At this stage, the learner is allowed to solve the exercise. If the learner inputs a question to the teacher on the Web page, he receives a reply from the teacher on the Web page. After finishing the exercise, the learner moves on to the state of "Making the Report" and can answer our questionnaire for the exercise as he finishes the exercise. If the learner submits his report to the teacher, he moves on to the state of "Waiting for the Evaluation." If the evaluation is poor, the teacher contacts the student, helps him, and asks him to re-submit the exercise. The Web system does not support their interaction in the situation, since we believe that face-to-face communication is preferable. This situation is different form Fujimoto's Classroom Management System [5]. After the learner reaches the state of "Completing the Submission," he will input his personal goals for the next exercise. After that, he will move to the state of " Exercising."

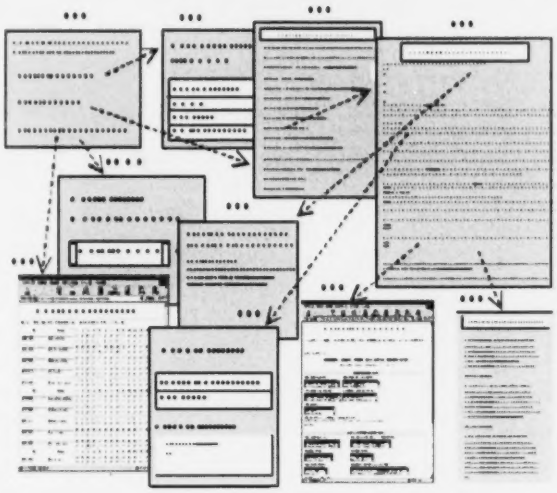


Figure 3. An Example of System Operation

We place great importance on the use of educational methods [6, 7] including "Reading, Writing, and Using an Abacus" to achieve the goal of "autonomous learning and thinking." For students belonging to the categories (1)-(4) mentioned above, the computer exercise model includes the following educational methods. Students in (1) and (3) are asked to read longer programs downloaded from the Web server, write the respective flowchart, update the subparts, and measure their performance in the state of "Exercising" shown in Figure 2.

Students in (2) are asked to define their personal goals before reaching the state of "Exercising" and write a self-evaluation in the state of "Making the Report." In the state of "Exercising," students are given an ambiguous exercise to learn the value of searching for information. In this way, students are encouraged to develop their creativity skills. Moreover, students are strongly advised to use textbooks and dictionaries if they have unresolved questions. Students in (4) are strongly encouraged to use such tools as TGIF and LaTex when preparing a report that includes figures and text. We believe that longer programs particularly enhance their proficiency in using tools. In order to determine an accurate grade for each exercise, we evaluate the reports submitted by the students and their answers to the questionnaires. Since we receive the results of the questionnaires immediately through the Web, we use such results to improve the exercises and coach the students. Moreover, the students can also receive their scores in a very short time. Students can compare each other's scores if they are given access to the statistics. Giving students access to the statistics is regarded as the key to ensuring an environment of awareness [8].

BEST COPY AVAILABLE

4 The results of system operation

Figure 3 represents an example of the operation of the system. Web page number (1) in the figure relates to the state of "Starting the Course." Page (2) is the class registration form. Page (3) gives anchors for information about all 15 exercises included in the course. If a learner selects one of the exercises on the page, he can use the exercise page (4). He can access his record of submissions and re-submissions using Web page (5). After inputting his personal goals using Web page (6), he moves on to the state of "Exercising." When he finishes the exercise, he moves on to the state of "Making the Report" and inputs the questionnaire on Web page (7). The results of the questionnaires are immediately stored in the database. Not only the teacher but also the learners are able to compute the statistics of the results from the database in real time. Page (8) relates to the statistics. Pages (9) and (10) are for teachers' use only. In page (9), each student has 15 check boxes, each divided into an upper and a lower section. If the report evaluation is good in the state of "Waiting for the Evaluation," the teacher puts a checkmark in the upper check box. If not, he puts the checkmark in the lower check box and helps the student so that he re-submits his work. Page (10) is useful for analyzing questionnaires stored in the database. The analysis includes the method of data mining [9] implemented in SQL.

Application of the system operation started at the Department of Hiroshima City University in April 1999. This system motivates students to do their exercises, provides good communication between participants and teachers, and reduces teachers' workload. The evaluation results of questionnaires and examinations related to the exercises are as follows:

(1) Ninety percent of students studied for 0.5-2.0 hours at their homes and were interested in the lecture.
(2) Twenty-six percent of students spent less than 2.0 hours preparing the report and exercising, 53% spent 2.0-5.0 hours, and 21% spent more than 5.0 hours, not including class work.
(3) Seventy percent of the 12 students (25%) previously mentioned understood the C language. Moreover, all students made progress in their studies.
(4) Ninety-five percent of the students reported good understanding of the algorithms used in the exercises. Eighty-seven percent of the students passed the examinations.
(5) The students acquired good skills at using TGIF, LaTex and other programs to write reports.
(6) Seventy percent of the students felt that the teacher did his best in the classroom, and 17% of them barely approved of his performance.

5 Conclusions

We proposed a computer exercise model for the course of "Data Structures and Algorithms II" and developed a Web support system for computer exercises using the model. We place great importance on educational methods including "Reading, Writing, and Using an Abacus" so that our students acquire the skills of "autonomous learning and thinking." Computer exercises using the Web system give students a chance to enhance their capabilities of "autonomous learning and thinking" and "creativity." The system run on the Web server has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participants and teachers, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of the system resulted in students' motivation to do the exercises, good communication between participants and teachers, and a reduction of teachers' workload. In order to achieve more concrete results, the students studied more at home and were enthusiastic about doing their exercises. Moreover, the students learned how to make a report using TGIF, LaTex and other programs.

Acknowledgements

We thank Assistant Professor Dr. Akira Sato of Hiroshima City University for his help with the exercises. We also thank Mr. Jun Ogawa, Mr. Takashi Maesako, and Mr. Kohei Matsumoto, TAs (Teaching Assistants) of Hiroshima City University, for their help with the exercises. This work was supported in part by a Grant-in-Aid of Scientific Research (C) from the Japan Society for the Promotion of Science and a Hiroshima City University Grant for Special Academic Research.

References

[1] Denning P. J., Comer D. E., Gries D., Mulder M. C., Turker A., Turner A. J., and Young P. R.: Report of the ACM Task Force on the Core of Computer Science, Association for Computing Machinery Press (1988).
[2] Computer Science Educational Curriculum for B. A. Degree Program in Computer and Engineering J97, Information Processing Society of Japan, 158p. (1997).
[3] Aho A. V., Hopcroft J. E., and Ullman J. D.: Data Structures and Algorithms, Addison-Wesley (1983).
[4] Leendert A.: Programs and Data Structure in C, Second Edition, John Wiley & Sons (1992).
[5] Fujimoto R., Suganuma A., and Mine T.: Development of a Classroom Management System on the Web, Advanced Research in Computers and Communications in Education (ICCE'99), Ed. by Cumming G. et al., Vol. 55, IOS Press, pp. 756-759 (1999).
[6] Angelo T. A.: Beginning the Dialogue: Thoughts on Promoting Critical Thinking, Teaching of Psychology, Vol. 22, No.1, pp. 6-7 (1995).
[7] Kuhar M. B: Critical Thinking: A Framework for Problem Solving in the Occupational Setting, AAOHN JOURNAL, Vol. 46, No.2, pp.80-81 (1998).
[8] Dourish P. and Bly S.: Portholes: Supporting Awareness in a Distributed Work Group, Proc. of CHI'92, pp.541-547 (1992).
[9] Fayyad Usama M., Piatestky-Shapiro G., Smyth P., and Uthurusamy R.: Advances in Knowledge Discovery and Data Mining, AAAI Press/ MIT Press (1996).

EDASEQ – A log file analysis program for assessing navigation processes

Helmut M. Niegemann
Institute for Media and Communications, Ilmenau Technical University, P.O. Box 100565, 98684 Ilmenau (Germany). Email: helmut@niegemann.de

Research on the effects of hypermedia learning environments often suffers from a lack of systematic control of learning conditions, especially the sequencing of the content. While available tools for logfile analysis are confined to delivering frequencies and other figures, the tool to be presented (EDASEQ: Exploratory Data Analysis for Sequential Data) was developed to facilitate the analysis of the navigation paths of single learners as well as "average" paths of a group of learners. Because standard statistical procedures for handling sequential data are not suitable here, the tool is primarily founded on graphical methods. Navigation processes are represented by transition matrices, and with additional visualizations and trajectories. Apart from descriptive portrayals, the tool also allows for categorizing empirically found navigation patterns on the basis of theoretically defined prototypical patterns. Furthermore, it is possible to compare the patterns of single learners or groups. Results can be used to better explain the effects of self-regulated learning in hypermedia learning environments. Without knowing variables like sequencing, time-on-task, or the number and configuration of examples studied by learners, it is hardly possible to interpret the impact of external learning conditions on the learning outcomes.

Keywords: **learning processes, navigation, hypermedia, methodology, tool**

1 Introduction

A fundamental problem of research on self-regulated learning is the possible variation of learners' behaviors, especially regarding variables like the sequence of content, the time spent with studying different parts of subject matter, the number and arrangement of examples and exercises: Have they really worked through all the relevant information? How many examples were chosen, with what methods of representation and in what combinations? How many exercises were worked through, and to what result, resp. with mistakes of what kind? How long were the learners occupied with what contents? This is valid for every type of research on self-regulated learning, but especially for learning with hypermedia. Even with the same context conditions, quantitatively and qualitatively completely different courses of learning are possible and thus, in consequence, very different results. Even when the learner activities displayed are described exactly, there are differences with respect to the quality of the elaborative treatment; the external conditions of the learning processes, however, are principally controllable. Unfortunately, standard statistical procedures are not suitable to represent an "average path" in an educational hypermedia system: Mean times spent on looking to specific pages or mean frequencies of visits are often not sufficient to explain differences in learning outcomes.

2 Aims of the development of EDASEQ[1]

For the description and categorization of such processes there thus remain graph theoretical procedures. There were already attempts at implementing these some time ago; the best known is probably Flanders' (1970) procedure for the analysis of teaching (cf. also Canter, Rivers & Storrs, 1985). For the treatment and

[1] Supported by the Deutsche Forschungsgemeinschaft (German Research Foundation), grant Az. Ho 649/9-1,2,3).

evaluation of data on the basis of graph theoretical considerations there is, however, as yet no method which is relatively simple to use. It was therefore an aim of the development of methods within the framework of a six year research project on case-based hypermedia learning environments in vocational training to develop a procedure allowing recorded data of learning processes to be so prepared that a) a data reduction is brought about which allows those processes to be analyzed exploratively, b) a categorization of typical processes becomes possible, c) records of several processes can be aggregated and finally d). Comparisons are made possible between (1) single records of processes, in order to see differences and similarities, (2) an individual process and an aggregated one, in order to be able to study deviations of single learners from the typical route taken in their group, (3) two aggregated processes, in order to compare groups under different treatment resp. marginal conditions using experimental designs, (4) a single or an aggregate process with a prototype process that is produced artificially, in order to categorize processes of one or several prototypes within the framework of defined deviations, or to test hypotheses. Apart from the characteristics of the processes, it should also be possible to extract simple statistics: e.g. frequency of the calling up of specific screen pages, specific transition frequencies, length of stay etc.

3 Forms of representation

In order to represent hypermedia navigation processes, there are first of all two different but mathematically equivalent codes: transition matrices on the one hand and aligned graphs on the other. Whilst one can see conspicuous characteristics in the graphical representation, the matrix representation allows the calculation of indices. Since both forms of representation are practicable, both should be taken into consideration. One special feature of well designed hypermedia learning systems is a structured presentation of knowledge given in such a way that learners have the choice of either informing themselves superficially or of going deeper into the subject at any chosen place, or of conbining both courses of action: first gaining an overview, then deepening their knowledge. In order to determine the extent of the "deepening" - assuming an appropriate structuring of knowledge in the medium -, two characteristic values, the mean "depth of elaboration" and the "variance of elaboration" have been developed. The depth of elaboration is a rating for every hypermedia occurrence, which is all the higher, the deeper the corresponding screen page goes into a specific subject. If, for instance, the highest level with the index number 1 is the term "statistics", then pages on the subject "inference statistics" or "descriptive statistics" would have the index number 2 and a page on the subject "log-linear models" would have, for example, the index number 5. The arithmetic mean of the values of all screen pages visited could then give an indication of the extent of the "deepening" or "elaboration" of the material; the measurement is completed by the elaboration variance ascertained analogously. Not least, characteristics of the chronological process should be portrayable.

4 Realization

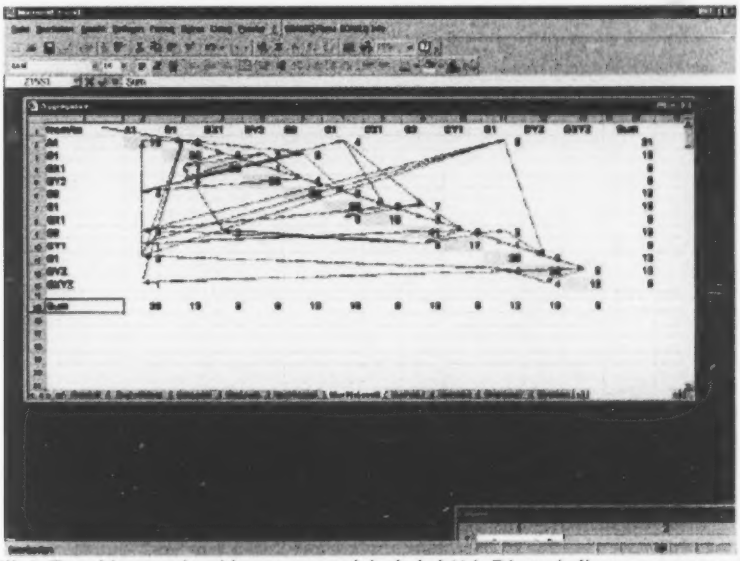
As the first step towards a reduction of process data in the Mannheim research project "Case-based learning problem" - in compliance with the demands - a software-technical evaluation procedure was developed. This enables processes to be transferred rapidly into transition matrices, so that firstly the simple frequencies of the consultation of specific pieces of information and of the transitions between offers of information can be ascertained. The learning programs developed in this project each encompass approx. 150 screen pages; learners need up to five hours to complete the given tasks and corresponding records comprise 3000 - 5000 single entries, each consisting of the time (in seconds after midnight) and the designation of the respective screen page. Log-files existing as ASCII text files are downloaded and converted into MS Excel files. For the simultaneous treatment of a larger amount of records it is also possible to stack them. Process data in the form of transition matrices can furthermore be compared to each other and also aggregated. In order to reduce data one can also stipulate that transitions which are more seldom than a specified threshold value should be ignored.

5 Examples of process representations and indices

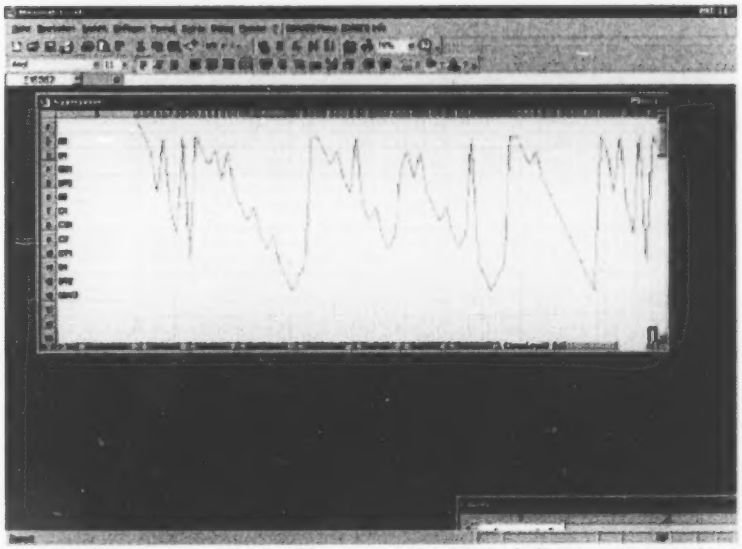
The following representations are based on fictitious data; i.e. records were produced with the specific aim of representing certain processes, in order to determine whether the corresponding characteristics are perceptible. Apart from this the size of these records was to be restricted, in order to enable a written account to be given. shows the evaluation as regards the frequency with which single screen pages were called up, as

well as the length of the stay there (absolute in seconds and relative to the complete time needed). Ills. 1 shows a transition matrix with aligned graphs of the process included (option). One alternative graphical representation ("chronological") is given in Ill. 2. Here, above all, recourses to previous steps are clearly to be seen: the test person would, in this case, have chosen a strategy whereby he/she began by choosing page B1 on the higher level, "deepening" from there straight to BX1, going back to B1, choosing another "deepening" (BY2) etc. The values in the main diagonal indicate how many time units the learner has here stayed on each separate page.

In a third, more concise representation of the process every node (page, screen, chapter etc.) is represented by one cell and the navigation process is shown by arrows between the cells. Analyzing aggregated data, the thickness of the arrows indicates the frequency of the transitions between two nodes. So, a sequence of thick arrows represent a "modal path", i.e. a path used by many users. (Ill. 3)

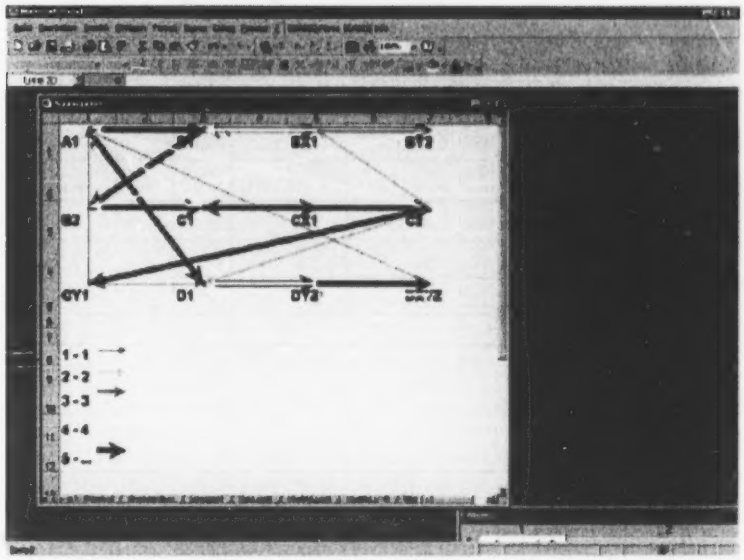


Ill. 1: Transition matrix with process graph included (A1, B1 etc. indicate screen pages)



Ill. 2: Linear representation of the process (A1, B1 etc. indicate screen pages)

BEST COPY AVAILABLE



Ill. 3: Alternative representation of the navigation process (A1, B1 etc. indicate screen pages)

6 Conclusion

The procedure which has been developed is first of all explorative, i.e. data are so prepared and represented that they allow categorizations and comparisons, thus offering a basis for the forming of hypotheses. Very extensive record files, in particular, are reduced. Although the procedure for the analysis of records on navigation was developed in hypertext, resp. hypermedia systems, it is also suitable for the treatment and analysis of data on the observation of teaching or other courses of communication.

References

[1] Bishir, J. W. & Drewes, D. W. (1970). Mathematics in the behavioral and social sciences. New York: Harcourt, Brace & World.

[2] Canter, D., Rivers, R. & Storrs, G. (1985). Characterizing user navigation through complex data structures. Behaviour and Information Technology, 4, no. 2, 93-102.

[3] Clarke, J. & Holton, D. A. (1994). Graphentheorie. Grundlagen und Anwendungen. Spektrum: Heidelberg

[4] Flanders, N. (1970). Analyzing teaching behavior. Addison-Wesley: Reading.

[5] Olson, G. M., Herbsleb,J. D., & Rueter, H. H. (1994). Characterizing the Sequential Structure of Interactive Behaviors Through Statistical and Grammatical Techniques. Human-Computer Interaction, 9, pp. 427-472

[6] Sanderson, P. M. & Fisher, C. (1994). Exploratory Sequential Data Analysis: Foundation. Human-Computer Interaction, 9, pp. 251-317

BEST COPY AVAILABLE

Evaluating educational multimedia: a case study

Elizabeth A. Kemp and Raymond H. Kemp
Institute of Information Sciences and Technology,
Massey University, Palmerston North, New Zealand
E.Kemp@massey.ac.nz, *R.Kemp@massey.ac.nz*

Following constructionist principles, postgraduate students who were studying a paper on Human Computer Interaction were required to build educational multimedia systems and then to evaluate those produced by their colleagues. The experience of developing a multimedia system, together with lectures and access to general material on the topic, enabled them to provide valuable insights into important issues. Nonetheless, the students were not, on the whole, able to transfer all that they had learned when building their own systems into an evaluation framework. The provision of scaffolding was recommended to facilitate transfer.

Keywords: **Multimedia, Evaluation, Constructionism**

1 Introduction

What are the criteria that should be used to judge the effectiveness of interfaces for multimedia tutorial systems? In an experiment with a class of postgraduate students studying Human Computer Interaction (HCI), they were asked to develop their own framework for evaluation. To give them some notion of what to look for and what to expect, they first had to form groups and construct their own multimedia tutorial systems. This approach is based on the idea of constructionism [6]. By collaborating in a group to develop some appropriate product, it is suggested that learners can come to a better understanding of the principles of a subject rather than by just being given the information by a teacher. This is in line with the wry comment from Jonassen *et al* [9] that the people who learn most from instructional materials are the designers.

The students were required to work together with one or two other classmates to produce their own small scale multimedia educational systems. Using the knowledge and experience they had gained, they then had to individually evaluate the interfaces of the other systems. There was no detailed specification about how to carry out these activities. The students had, however, been exposed to the main issues through lectures and discussions. They also had appropriate readings made available to them. The intention, therefore, was to see what the students, themselves, considered appropriate ways of evaluation in the light of their background and their experience in developing multimedia software. An assessment was then made of how much they had learned when building systems and how well the knowledge was applied to evaluating the systems of others.

2 Previous work

Interface evaluation can be carried out for many different purposes. The distinction is usually made between formative evaluation where improvements to a system under development can be determined and summative evaluation which assesses the overall performance [8]. There are a range of methods that can be used depending on the purpose of the study. Preece [12] categorises these purposes as analytic, expert, observational, survey and experimental. Analytic techniques are used to determine the complexity of the interfaces. Expert evaluation involves inviting people experienced with interface issues to identify usability problems. Observational, survey and experimental studies all have in common the involvement of what Preece terms "Real users." Users can be observed using software, provide feedback about the system through interviews or questionnaires or take part in experiments to test the impact of various features of the interface.

A common method of evaluation that does not involve users is expert evaluation where, as noted above, people

with some knowledge of interface issues detect possible problems. This process can be conducted in accordance with the guidelines formulated by Nielsen and Molich [11]. The following aspects of the interface are all considered in what is referred to by these authors as a heuristic evaluation: simple and natural dialogue; speaking the user's language; minimising user memory load; consistency; feedback; clearly marked exits; short cuts; good error messages; prevention of errors, and help and documentation.

An examination of the literature on multimedia reveals little mention of evaluation. Testing is usually discussed but not evaluation [4, 15]. Some important principles emerge, however. Alty [1, p33] points out that "A key question is when to use which media and in what combination to achieve the maximum effect." He also observes that success in multimedia depends more on the *combination* of media rather than on the provision of a rich set of media. Frater and Paulissen [5] note that interactive tutorials should allow the user to choose the starting point and allow the information to be accessed as often as required. They also offer this piece of advice. "Keep in mind that multimedia can make learning much more interesting when animation and sound files are used to explain the topic. Also a quiz is more fun when set up as a game" [5, p362]. Preece [12] points out that navigation, too, is an important consideration in hypertext/multimedia systems. Users, as she notes need to be able to know where they are, how they reached that point, where can they go next and how they get there. This as pect of interface design is actually covered by the first heuristic of Nielsen and Molich [11] which refers to "Simple and natural dialogue." This takes into account navigating through a system. Interface factors in interactive multimedia systems are also considered in Reeves and Harmon [13] and Tannenbaum [14].

One recent taxonomy in the literature provided by Heller and Martin [7] aims to help students on multimedia courses understand the forms of media as well as enabling them to evaluate the work of others. It has two dimensions - the media type and the means of expression (elaboration, representation and abstraction). This classification shows, for example, that text might be fully elaborated (large chunks of narrative), can be abbreviated (represented in bullet points) or might be abstract in nature such as text in a logo. Students are able to check whether a medium has been used in an appropriate fashion. As the authors state, though, the taxonomy takes no account of the effect of combining several media. Nonetheless, it is useful in focusing on the evaluation of each element. Detailed guidelines about how to use each medium, for example text, can also be found in Vaughan [15] and Collins [2].

3 Course structure

"Topics in Human-Computer Interaction" is a single semester paper for postgraduate students in Computer Science and Information Systems at Massey University. Most students have already completed a third year undergraduate paper "Human-Computer Interaction" in which the underlying theory is presented. These students will also have gained some experience in developing interfaces. The aim of this course is to consider issues of current interest such as computer supported co-operative work, innovative interfaces, different ways of evaluating the interface, multimedia systems and interfaces on the World Wide Web. Teaching is carried out through a mixture of lecturing, student seminars, discussion and demonstrations (of software such as Adobe Premiere and Macromedia Director). Students have available to them two books of readings which cover the material taught.

One assignment for this paper involved the students working in groups to develop a small multimedia system with an educational focus. The groups could choose any appropriate subject. Each student was then asked, individually, to evaluate the interfaces to all the other systems. A set of lectures had been given on the topic of multimedia including exposure to several life cycles for developing software of this kind. The topic of evaluation had also received considerable coverage in lectures and student seminars. Students were aware that interfaces can be evaluated for various purposes and in many different ways (for example by heuristic evaluation, interviews, questionnaires etc.)

Guidance on the life cycle that should be followed to develop the multimedia systems and the method of evaluation required was deliberately kept to a minimum. In the light of the teaching on the course and the material available to them, students were expected to make their own informed decisions. In particular, it was hoped that the students' own experiences in developing multi-media software would give them some insight into the criteria that should be employed when evaluating the interfaces to the other students' systems.

4 The student systems

Six groups each developed their own multimedia system. The systems were expected to offer instruction to their users and be interactive. A brief description of the systems follows.

Maori Language Tutoring

This system was designed to help students learn the Maori language. The study material was based on the philosophy that Maori be used wherever possible, with visual and aural stimuli to teach the vocabulary. Words were introduced via demonstrations using pre-recorded video clips. The system, however, also contained explanation in English for students who did not wish to completely immerse themselves in Maori. As well as learning new terms, students could choose to review vocabulary or test their comprehension. Maori music and designs were used in this system where the developers thought appropriate.

Learning the New Zealand Road Code

A written test on the New Zealand road code has to be passed before learner drivers can take their practical driving test. The aim of the road code system was intended to make the learning process more interesting. It was believed that by using animation, audio and video, the learning process would be enhanced. The system included tutorial material on aspects of the road code (for example, how to overtake or what to do when approaching a roundabout) as well as test material.

Earthquake Disaster System

The earthquake disaster system was developed to show people how to behave in the event of a serious earthquake. It included clips from a video developed by Civil Defence. Topics that were dealt with included planning for and coping with an earthquake. The opening screen showed a photograph of the devastation caused by a major earthquake. Music and animation chosen to reflect the theme of devastation accompanied the photograph.

Shape Recognition

The intention of the shape recognition system was to help children learn how to identify both two and three dimensional shapes in a lively and interesting way. Sound, animation and graphics were included in order to make the system appealing to children. Another goal of the developers was to make the system easy to use. There was a particular emphasis on the use of colour which was seen by the developers as making the system attractive to the intended users. The opening screen was designed to capture the attention of children with music and morphing shapes.

Introducing the Internet

This system, as its name implies, was intended to be introductory in nature. Its target group was school children who could find out about concepts such as email, newsgroups, file transfer protocol etc. This system made use of graphics and sound but also included lengthy textual explanations. As with the shape recognition system, there was an emphasis on the use of colour. Ease of navigation was also a major consideration.

Undergraduate Studies in Computer Science

This system allows students to find out about the staff and the papers they teach in a Computer Science department. Photographs of staff members were included. When browsing through the system, users were able to move from a staff page to obtain information about papers taught by the staff member. Contextual information about the location of the building where the Computer Science staff were housed was also provided. The opening screen of the system showed a picture of the university grounds. Other pictures could also be viewed.

5 Educational Issues

Although the course does not deal with issues of computer-based learning, this was the focus of the assignment and gave the students some context for the systems they produced. They were expected to choose an approach to teaching which was appropriate for the subject that was being taught and that they felt would be effective in a multi-media setting. They all propounded the philosophy of their systems during their presentations. It is interesting to compare the different approaches that the students chose for their systems and how this was reflected in the presentation styles.

The Maori language teaching system immerses the student in the subject and attempts to teach by example. As noted earlier, the system can be used without reference to English words or phrases. Maori, like various other languages such as Japanese is very much bound up in the culture of the people and so this approach seemed entirely appropriate. Maori songs, words and phrases in a commentary with accompanying visuals provided a backdrop that was both stimulating and educationally appropriate.

The road code system contains video clips produced by the students themselves which graphically illustrated both correct and incorrect procedures to be followed in various situations when driving. This could be regarded as teaching by presentation and illustration.

Like the road code tutorial, the earthquake disaster system has an emphasis on illustration using video clips and contains other factual information in an appropriate form.

Unlike the previous systems, the shape recognition tutor includes trial and error examples for the student to consider. It takes into account the answers the student gives and does not continue until it judges s/he has fully understood all the current concepts. It could be regarded as a mastery system from this point of view.

The internet system contains a great deal of information in a text-based format, but the presentation was enhanced with appropriate animations. Material is set out in an simple to follow form and subjects can easily navigate around the system to discover what they need to know.

The undergraduate studies in Computer Science system also allowed students to learn about the department of Computer Science in a discovery mode. In some senses this was the package that was the least like a tutorial system, since it just provided information in a non-instructional form.

The underlying objective of the assignment was to determine whether or not students had assimilated a fundamental principle of HCI - that issues concerning functionality should not be divorced from interface concerns. Given the experience of developing a multimedia system, it was hoped that students would take into account the educational aims of the system as well as the multimedia features. It was not the object of the exercise, however, to see whether effective learning took place. It was expected that some variation of expert evaluation would be followed. What was of interest were the criteria that students incorporated into their checklist. Issues it was hoped would be addressed (in the light of the literature on this topic) included the following:

- whether the interface reflected the educational objectives of the system;
- the suitability of the media selected;
- the user appeal of the systems;
- the interface concerns;
- evaluating the execution of the various media.

6 Results

Every student (thirteen in total) appraised all the systems developed by their colleagues. All the students provided a checklist of the criteria used for the evaluation - some were very detailed and others quite brief - from thirty items at one end of the scale to five at the other. The two students with the longest checklists evaluated whether the system fulfilled its objectives, the selection of multimedia components and the execution of the multimedia as well as detail of the interface such as the provision of feedback, ease of navigation etc. There were another three quite comprehensive taxonomies which covered many but not all of the relevant issues. Five students used Nielsen's [10, 11] guidelines for heuristic evaluation without adding to them to deal with the educational or multimedia aspects of the systems. The three students with the short checklists had incorporated rather broad categories such as ease of use, knowledge presentation, navigation, multimedia concerns and quality of knowledge which gave them reasonable but not complete cover of the relevant issues.

Expert evaluation can be carried out by anyone with appropriate skills and by more than one evaluator. In one case, two people evaluated the systems and combined their findings whilst on another occasion the student drew up the framework but did not carry out the heuristic evaluation himself. Some students scored the various items and averaged the results. This enabled systems to be ranked. Others did not attempt to provide an overall score for each system but left the findings to speak for themselves.

1. Did students check to see whether the interface reflected the educational objectives of the system?

In total, eight of the students included questions in their checklist which related to the educational nature of the system. Three of these explicitly mentioned the educational objectives of the systems under review before providing their assessment.

> *"This system is a multimedia tutor system designed to aid students in learning the Maori language. The system uses both visual and aural stimuli to teach words and concepts."*
> *"The system aims to provide information to undergraduate students."*
> *"It aims at helping children to learn a shape through playing which makes learning easy and fun."*

The eight students who considered the purpose of the system, that is its educational aspect, did not all ask the same questions. A variety of issues were covered as follows:

How does the system consider educational objectives?
Is the system suitable for intended users?
Who is the target audience?
Is the system aimed at the right audience?
Does the system have a reasonable informational content?
Is the quality of knowledge sufficient?

The evaluations included comments such as the following:

> *"Good way to teach a student with audio pronouncing the language and seeing the words on the screen."*
> *"Including some information on the properties of the different shapes and showing everyday examples of them would make learning the shapes a richer experience."*
> *"It does not really seem to be an educational system, more an informative system."*
> *"The current system does not seem to have a glossary page, A page for quick lookups and acronyms and jargon would probably be helpful."*
> *"It might have been good to have an option of telling users what the different shapes look like."*

Some of the students, however, not only evaluated the systems in accordance with their checklist but also in the light of their experience in appraising the programs. They mentioned, therefore, other important criteria in their assessments. One student centred her overall assessment around the suitability of a system for its purpose although this was not included in her criteria for evaluation. Two other students, also, mentioned educational issues such as whether the systems provided adequate content and comprehensible instructions.

> *"I had no idea what I needed to do and how the test was being processed."*

2. Did the students consider whether the mix of multimedia selected was appropriate for the stated purposes of the system ?

Only two students included in the guidelines for evaluation the need to consider whether suitable media were selected and used appropriately. One student asked the question "*Is the multimedia actually of use and not redundant*?" The other student checked that the mix of multimedia was used appropriately. This student noted not only occasions when a particular mix of media was ineffective but also when media was missing.

> *"The current system seems to rely too much on textual information. Improvements would be to make more use of video, diagrams and to provide more navigation options. These changes would give the user a more enriching learning experience."*

Many other relevant comments were made by the other students about an appropriate usage of multimedia, although they did not take the issue into account systematically.

"Of all the applications reviewed this has the most appeal due to its excellent usage of graphics and sound. The main area it could be faulted on is the large textual explanations given but these are offset by the following graphical examples."

"It uses multimedia such as sound and text making the system vivid and active."

Only one student fell into the trap of believing that a multimedia system had to incorporate all media. He would criticise a system that did not include video, for instance. No regard was paid to whether adding video would contribute to meeting the goals of the application.

3. Since educational systems have to be appealing to their users, did the students take this factor into account?

With regard to the appeal of a system, this issue was only expressly considered by four students. Related questions were as follows:

Is the system interesting and fun?
Does the user find the system visually appealing?
Has information been presented in an interesting manner?
Has the system an attractive presentation?

Comments made by these students include the following:

"Its creative design of the main menu ... and its appropriate use of the sound medium, make it enjoyable to use the system."
"There was no splash screen introduction. Whilst this may seem superfluous, good splash screens can be used to arouse a user's interest."

Three other students, however, did mention this issue. One of these was the student who did not carry out the expert evaluation himself. After watching the evaluation (according to Nielsen's guidelines as specified), he realised that the system he preferred obtained the lowest rating. He proceeded to base his overall assessment of the systems on whether they had an interesting and attractive interface. A second student also focused on the interest or lack of it in the programs. Of the Maori tutor, she said " *The welcome interface is impressive. The background and the music gives me some feeling of Maori culture.*" According to her, another system was a little bit boring.

An issue that relates to the appeal or attractiveness of a system is the appropriate use of colour. Four students included at least one item in their checklist concerning colour. Questions were as follows:

Are too few or too many colours used?
Is the colour in the system beautiful?
Does the use of colour help to make the displays clear?
Is the use of colour bad, normal, good or excellent?

One system was notable for its use of colour and several comments were made about this

"The very colourful shapes used are appropriate for the school based children as seen as being the intended users."
"The colour used in the system is beautiful."
"Good colour choice, relaxing."

This was not the only the system to make effective use of colour, however and one student observed in his conclusion that no-one made the mistake of using too many colours.

4. What typical interface factors were considered?

All of the students checked for at least one well-known interface concern such as consistency, clearly marked exits etc. Seven of them specifically included the guidelines for heuristic evaluation by Nielsen and Molich [11] or the updated version by Nielsen [10] in their checklist.

It was also expected when considering interface issues that the importance of navigation in interactive instructional systems should be recognised. It should not be just one more item in a checklist. Eleven of the 13 students took account of this issue.

"No stop, rewind or scroll bars for video."
"Gives reasonable freedom to navigate backwards and forwards."
"Not very flexible, very linear in its execution."
"It is very easy to get "lost " while navigating through the system. No "back" button provided."
"Clicking at various places in the window may move you to unexpected screens."
"With the test screens there is no title indicating this."
"Have no idea what I am supposed to do in the first screen."

Four of the students highlighted the importance of navigation. Three incorporated this into their framework as a high level criteria. A fourth not only checked how users moved around the system but whether or not the users would know where they were in the system.

5. Did the students evaluate the multimedia components of the system?

Four students evaluated the execution of the individual media. Two of these assessed the effectiveness of each component: video, sound, graphics, text etc. by rating them on a scale. The third student concentrated on text and icons. His section on text was quite detailed, checking the length of the sentence, whether it just focused on one issue, and whether there was sufficient white space around it. The fourth student checked that the multimedia was not "over the top".

"When the system explained the Maori words, text is well organised."
"I liked the use of Maori music with the splash screen."
"Liked the introduction - morphing shapes."
"Widely accepted icons are used to aid page-based navigation."
"The background music is excellent. The button clicking sounds great."
"Image excellent. When the system first starts, the animation is creative and attractive."

7 Discussion

Reflecting on the results of the assignment, it became clear that learning about multimedia evaluation took place at various points in time. Most of the systems developed by the students were stimulating to watch. As developers the students were clearly aware of the need to use appropriate media in suitable combinations [1] and of the requirement to navigat e easily through the system [12]. Some of what they had learned was reflected in the checklists that they developed for evaluating the systems of others. There was a difference, however, between the criteria specified by students for evaluation and those actually used when making their overall appraisals. These sometimes took additional factors into account that had not been included in the stated checklist. The experience of evaluating the systems themselves, allowed further learning to take place. It will be the more complete list of factors that are considered in the remainder of the discussion since the experience gained from carrying out appraisals is important and should not be discounted.

Eleven students checked to see whether the interface reflected the educational objectives of the system and two of these also considered whether the mix of multimedia was appropriate for the stated purposes. All of the students considered at least one relevant interface factor (consistency, clearly marked exits, etc). Six of the students also realised the need to find out whether or not a system would appeal to users. Four students included assessment of media components in their appraisals, however none of their questions showed a deep understanding of media issues.

It was pleasing from an educational perspective that most of the students when carrying out their evaluations took account of the functionality of the system. This cannot be divorced from interface considerations as for many users the interface is the system and must deliver the appropriate functionality.

Interface issues, too, were seen as important by all of the students. Of these, 11 checked to see whether a user

could easily navigate around the program. This is an important issue in interactive multimedia systems and was recognised as such by the students. Eight of the students carried out a reasonably comprehensive evaluation of traditional interface concerns but for five it was rather rudimentary. This was surprising given the emphasis on the heuristic evaluation in the undergraduate and post-graduate courses.

Overall there were only two students whose evaluation was limited to just those interface issues covered by Nielsen [10, 11]. This meant that they excluded educational considerations, the appeal of the interface, an evaluation of the individual media and whether or not they were used in appropriate combinations.

A major weakness in the student evaluations' overall was the failure to consider whether the mix of multimedia selected was appropriate for the purpose of the system. Whilst the students did consider educational issues at a high level, they found it difficult to move to a detailed perspective, that is were suitable media selected and combined? This may involve greater knowledge of the potentialities and problems of the individual media than the students possessed. They tended, therefore, to have an overall impression of a system. This was reflected again in the failure of two thirds of the students to evaluate the exe cution of each media component.

Around 50% of the students did not take appeal/interest and fun sufficiently into account. This can possibly be attributed to the fact that they were not the intended users of the systems. If they had been drawing up a list of questions for users to answer they may have incorporated this. Nonetheless, it was an important omission as multimedia systems set out to interest and hold the attention of their users.

As the above discussion shows, students were particularly weak in considering what was to them the new area of multimedia. They did not appear to have the knowledge or experience to determine how to evaluate the media. They were given some exposure to these issues in lectures but do not appear to have followed them up. Whilst no one student came up with a complete checklist for evaluating multimedia systems, amalgamating the items in their checklists enables a comprehensive framework to be developed. See Appendix 1 for the main features of this. In future it may be preferable to provide students who have built a multimedia system with some scaffolding to help with the evaluation phase. Scaffolding [3] refers to supports that can be provided by a teacher to students. The main headings in the taxonomy outlined in the Appendix could be provided. The students could then be asked to develop appropriate questions for each area.

8 Conclusions

The students learned a great deal by building multimedia software and evaluating the systems of others. This was reflected in the perceptive comments of the students made in their written assignments. It was not always reflected, however, in the frameworks for evaluation that they developed, only two of which were comprehensive. Certain areas were handled well by the students, for example checking that each system was suitable for its purpose and the importance of navigation. Two significant issues, though, were only identified by a minority of the students – the need to choose appropriate media and to determine how well they had been produced. It appears that because the area of multimedia was new to the students, they needed more scaffolding in place to be able to learn from their own experiences. Instead of developing an evaluation framework from scratch, some initial information can be given to students in future that they then have to flesh out.

References

[1] Alty, J. L., Multimedia – "What is it and how do we exploit it?" In D. Diaper & N. Hammond. (Eds.), People and Computers VI, pp. 31-44, Cambridge: Cambridge University Press, (1991).

[2] Collins, A., "What different media do best", In The Six International Conference on Computers in Education, Beijing, (1998).

[3] Collins, A., Brown J.S., & Newman S. E., "Cognitive Apprenticeship: Teaching the craft of Reading, Writing and Mathematics", In L. B. Resnick (Ed), Knowing, Learning and Instruction, Hillsdale, New Jersey: Lawrence Erlbaum, (1989).

[4] England, E., & Finney, A., "Managing Multimedia", Harlow: Addison-Wesley. (1996).

[5] Frater, H., & Paulissen, D, "Multimedia mania : experience the excitement of multimedia computing", Grand Rapids: Abacus. (1993).

[6] Harel, I. (Ed.), "Constructionist Learning", Boston: MIT Press, (1990).

[7] Heller, R., & Martin, C. D., "A Media Taxonomy", IEEE Multimedia, 2(4), 36-45. (1995).
[8] Howard, S., & Murray, D. M., "A Taxonomy of Evaluation Techniques for HCI", In H. J. Bullinger & B. Shackel (Eds.), Human Computer Interaction. Interact' 87, pp. 453-459, Amsterdam: North Holland. (1987).
[9] Jonassen, D. H., Wilson, B. G., Wang, S., & Grabinger, R. S., "Constructivistic uses of expert systems to support learning". Journal of Computer Based Instruction, 20(3), pp. 86-94, (1993).
[10] Nielsen, J., "Enhancing the explanatory power of usability heuristic", Proc. ACM CHI'94 Conf. (Boston, MA, April 24-28), 152-158. (1994).
[11] Nielsen, J., & Molich, R., Heuristic Evaluation of User Interfaces. In J. C. Chew & J. Whiteside (Eds.), Proceedings of CHI' 90: Human Factors in Computing Systems, pp. 249-256, New York: ACM Press. (1990).
[12] Preece, J., "Hypermedia, multimedia and human factors". In C. Latchem, J. Williamson, & L. Henderson-Lancett (Eds.), Interactive Media, London: Kogan Page, (1993b).
[13] Reeves, T. C., & Harmon S., "Systematic evaluation procedures for interactive multimedia for education and training". In S. Reisman (Ed.), Multimedia Computing: Preparing for the 21st Century, London: Idea Group Publishing, (1994).
[14] Tannenbaum, R. S., "Theoretical Foundations of Multimedia", New York: Freeman, (1988).
[15] Vaughan, T., "Multimedia: Making it Work", Berkeley, Cal: Osborne McGraw-Hill. (2nd ed.). (1994).

Appendix 1

1. Does the system meet its objectives?
   - Who is the target audience?
   - Is the system suitable for the target audience?
   - Does the system include (in the case of educational systems) sufficient content?

2. Has an appropriate mix of multimedia been selected?
   - Have sound and text been used effectively together?
   - Have sound and graphics been used together effectively?

3. Will the program appeal to users?
   - Is the system fun?
   - Will the user find the system visually appealing?
   - Has the system a features that will pall over time e.g. an unusual sound or joke?
   - Has colour been used in an appropriate fashion?

4. Has the interface been properly constructed?
   - Is the interface consistent ?
   - Is help available when necessary?
   - Can users easily navigate around the system?
   - How does the user navigate around the system?
   - How does the user know where s/he is?
   - Is progression through the program logical?
   - Can the user start and stop as required?

5. Have the individual media been well-executed?
   - Is the text /graphics,/sound etc well produced?
   - Are the sections of text too long/too short?
   - Will the text be understood by the target audience?
   - Has text been expressed using elaboration, representation or abstraction?

Evaluation of class organization in the computer literacy education

Akira Harada*, Michio Nakanishi and Masashi Komori***
** School of Human Sciences, Osaka University*
Yamadaoka 1-2, Suita, Osaka 565-0871, Japan
E-mail: {harada, komori}@hus.osaka-u.ac.jp
*** Cybermedia Center, Osaka University*
Machikaneyama 1-30, Toyonaka, Osaka 560-0043, Japan
E-mail: naka@cmc.osaka-u.ac.jp

This paper compares two grouping strategies for teaching computer literacy at the university. The authors and their colleagues have been involved in the computer literacy education to 180 freshmen majoring in Letters and 150 freshmen majoring in Human Sciences for five years. In 1999, 180 students were organized into three classes at the early stage of the semester according to the student's wish, whereas 150 students were reorganized into three classes based on an achievement exam in the middle of the semester. The statistical analysis of exams and students' self-assessment showed that the early class organization was not so effective compared to the mid-term reorganization. The effect of mid-term reorganization was significant in the slow-learners class.

Keywords: **class organization, computer literacy education, self-assessment, teaching strategy**

1 Introduction

Computer literacy education in Japanese colleges and universities is facing a problem of diversity of students' computer skill levels. The reason for this is twofold. One is that very few high schools introduce the computer literacy education is into their curriculum. The other is that as computer price is falling down the number of students is increasing who have learned how to use word-processing or e-mails by themselves at home. This problem led us to study how to help our students learn this subject in good quality.

In Osaka University, the computer literary education has been a required subject for all freshmen since 1994. The computer literacy course consists of 15 sessions, and each session lasts 90 minutes, which includes demonstrations by a teacher and hands-on activities by students. Usually an assignment for each session is also given which will take an hour or two to complete. Three teachers including the authors have been teaching the computer literacy course to over 150 freshmen majoring in human sciences, and our three colleagues have been involved in teaching to 180 students majoring in letters.

In 1999, 150 students majoring in Human Sciences were organized into three parallel 50-student classes according to the enrollment order before the first session. In the middle of the semester, we gave an exam that includes hands-on work, such as word document processing, consulting online dictionaries, and finding web sites. Then we reorganized the three classes based on the exam score. Other background variables (age, gender and future academic field) were not considered for the class organization. The class organization aimed at ability grouping, that would provide non-experienced students with a slower work pace and allow high-achieving students to be sufficiently challenged by more demanding lessons. At the end of the semester, we again gave them an exam that would measure how they made progress.

As for the 180 students majoring in Letters, three parallel 60-student classes were reorganized according to the students' wish based on the questionnaire survey at the fourth session of the course. That is, the keywords of the three new classes, "slow and steady", "intermediate" and "intensive" were shown to students, and each student chose one of the classes.

In this paper, we begin with related work and a brief explanation of our computer literacy course, followed by the methodology of the class reorganization. Then, we present the statistical data analysis to show that class reorganization in the middle of the term was effective.

#1 Change this plain text file to rich text format, then change the font of the marked words to Ryumin 12 point, and place it in the center.
#2 Explain how to use Japanese Kana-Kanji translation and how to register your name in your own dictionary.
#3 Look up the three words (omitted here) in the following dictionaries: English-Japanese, Japanese-English, and Webster.
#4 Draw a tiny picture and insert it into this page.
#5 Find URLs of the National Diet Library and any two online book stores.
#6 Look into "/SharedLibrary/Literature/" and describe what's in it.
#7 What should be considered when you decide your password string?
#8 Find the specified string in the large file and copy the paragraph to the answer sheet.
#9 Describe how to cope with chain mails.
#10 Describe how to limit the line length to fewer than 65 characters in the body of an e-mail.

Table 1 Midterm exam sample in 1999

Touch typing	(poor) 1 2 3 4 5 (excellent)
Mouse operation (click, double click, drag)	(poor) 1 2 3 4 5 (excellent)
Window operation (resize, move, iconify, hide)	(poor) 1 2 3 4 5 (excellent)
Japanese Kana-Kanji translation	(poor) 1 2 3 4 5 (excellent)
File/Folder operation (move, rename, create)	(poor) 1 2 3 4 5 (excellent)
Word document processing (fonts, centering, insert graphics)	(poor) 1 2 3 4 5 (excellent)
Mail (MIME, signature, save to file, reply, delete, re-file)	(poor) 1 2 3 4 5 (excellent)
Web (search engine, book-mark)	(poor) 1 2 3 4 5 (excellent)
Use of online dictionary (Japanese, English)	(poor) 1 2 3 4 5 (excellent)
Canceling your printer job	(poor) 1 2 3 4 5 (excellent)

Table 2 Questionnaire survey for self-assessment

2 Related work

Although there have been much previous research on ability grouping, tracking, and class organization, they are mainly for K-12 school education, e.g. [4,9,10]. Furthermore, as far as the authors know, there has not been any research on class reorganization in the middle of a semester for computer literacy education. The authors have tried class reorganization for five years and presented its result obtained before 1998 in [5]. Our reorganization method is basically based on the exam score, but is not the same as cluster grouping.

3 Computer literacy education

Since the 1970s, the definition of computer literacy has evolved, and many researchers have discussed the courseware and teaching methodology of the computer literacy course, e.g. [2,3,4]. The authors believe that to learn details of word processing and spreadsheet application is not important but to grasp the concept and principal facilities of those applications is a key for students to become literate. Furthermore, the attitude to learn by himself or herself is also a key.

In the latest syllabus of the computer literary course in Osaka University, topics consist of two categories, "*Requisites*" and "*Options*".

Requisite category consists of the following items.

- File system, file operation, floppy disks
- Word processing, kana-kanji conversion (for Japanese characters)
- Concept of the internet, network etiquette
- Electronic mail, web

- Draw and/or paint software
- Spreadsheet

Options are

- Net news
- LaTeX with graphics
- Writing HTML
- Mathematica
- SAS (Statistics)
- Script languages (perl, awk, shell, etc.)
- Computer ethics, social problems

Since one course session lasts 90 minutes and is held once a week, all topics of requisite category are the minimum competencies and are covered in about seven weeks. For the rest of one semester, teachers select some of the items from optional category depending on the students' majors. For example, LaTeX and Mathematica are selected for students majoring in Physics and Mathematics, while spreadsheets and SAS for Economics.

4 Class reorganization in the middle of a term

In this section, we explain the class reorganization method that we adopted in 1999. Then we show the examination scores and self-assessment scores of the three classes.

4.1 Reorganizing three classes by a hands-on performance exam

After we completed topics in requisite category, we set a mid-term examination that demands 1-hour hands on work, because there were differences between students how fast they got accustomed to computer operations in class. Table 1 shows the questions of the mid-term exam. We marked the examination papers out of 100 (each question of 10), and used the scores to reorganize the classes. The students who achieved more than 67 points were grouped into class A. The threshold between class B (50 students) and class C (50 students) was 52 points. The average total score was 60.3 (s=15.7).

The average scores of the new classes A, B, and C were 77 (s=7.4), 60 (s=3.9), 42 (s=7.5) points, respectively. The average score of class A students was more than 5.5 for all ten questions, whereas the students who were grouped into class C got only 2.2 and 2.3 for question #5 (web search) and #6 (file search), respectively, which were significantly lower than the other two classes.

4.1.1 Self-assessment by students

Before the mid-term exam, a questionnaire survey paper was distributed to the students. The survey consisted of 10 questions, which would measure students' mastery of competencies taught by that time (Table 2).

The answers to these questions were collected on a 5-point scale. The scores of the collected questionnaire showed a positive correlation between the exam and the students' self-assessments. That is, class A students felt good at the following competencies: inserting graphics into a document, operation of files/folders, and searching web site, whereas class C students answered that they had not mastered those topics. As for searching files from hierarchical file structure, class C students perceived that they were good at it; however, its exam score is poor. This indicates that class C students did not understand the file structure itself. Touch-typing and Email competencies were not statistically significant between three classes.

4.1.2 Curriculum after the class reorganization

The result of the exam and the questionnaire showed us what we should teach in the new classes after the class reorganization. We provided class C students with a slower work pace and revisited those competencies that they were not good at. For class A students, we gave lectures more extensively than other two classes and gave self-teaching assignment of LaTeX in the summer vacation.

In order to allow them to have an active participation in the shaping and augmenting of their learning, we also introduced self-teaching approach for learning spreadsheets in all classes. That is, after a brief explanation given by a teacher, students followed tutorials on the teacher's web pages. We had two teaching assistants each class, we asked them not to teach detailed step-by-step operations to the students but to help the students to find the way by themselves.

4.2 Evaluation of class reorganization

4.2.1 Statistical evaluations of exam and questionnaire

At the end of the course, we gave a self-assessment questionnaire survey followed by the term-end examination, which required hands-on work of about an hour. Here we begin with the analysis of the exam scores.

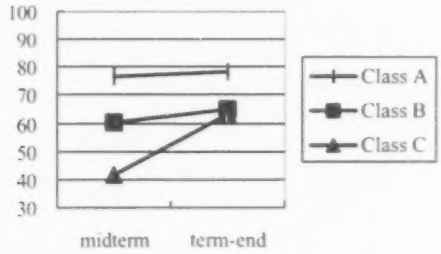


Figure 1 Total scores of midterm and term-end exams

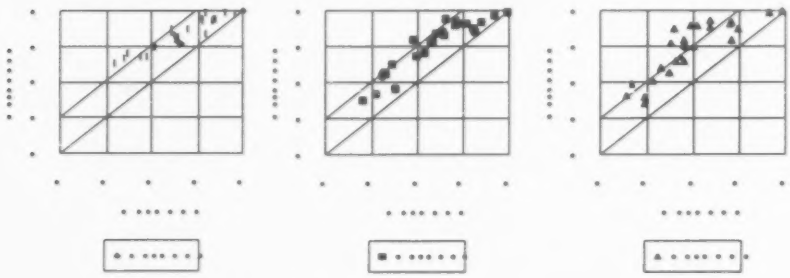


Figure 2 Scores of self-assessment

The total score and the scores of three questions (use of online dictionaries, OPAC search, and limiting line length of Mail body), which are similar in two exams, were considered in a two-way ANOVA. As a result, these four items showed an "interaction" between the two exams and classes ($p < 0.05$).

Figure 1 shows a comparison of the average scores of two examinations. It indicates the existence of the "ceiling effect", that is, the score difference between class A and other two classes decreased after the class reorganization.

As for spreadsheets, two sessions (which means 180 minutes) were assigned for class C, while one session was assigned for class A and B classes using self-learning web based text. But the scores were 8 points in class A and 5 points in class C. The score of writing HTML also supports this tendency. From this fact, it is proved that class A students had higher ability in computer operations than other two class students.

4.2.2 Analysis of self-assessment questionnaire

As for the 27 items that were included both mid-term and term end questionnaires, the average term end exam scores were higher than mid-term scores in all classes in 1998 and in 1999. In Figure 2, the x-axis

shows the midterm score, the y-axis shows the term-end score, and each scatter point in the graph represents the score of one item. Two years analysis showed same tendency.

We took the exam timing (midterm or term-end) and the classes as the factors of the two-way analysis of variance (ANOVA). The following four items of the questionnaire shows that there is an "interaction" between the exam timing and the classes ($p < 0.05$).

- Creating a new folder (directory)
- Editing a word document
- Browsing web pages
- Searching web site

We conclude that class C students perceived they were as self-confident in these items as the students in the other two classes.

Though the exam scores are not significantly correlated with students' self-assessments, we consider the class reorganization was effective for slow learners class students, because it is important for them to have confidence in their computer operations.

5 Comparison of class reorganizations

There is another attempt to reorganize classes. The 180 students majoring in Letters chose one of three classes whose lecture policy are "intensive (class A)", "intermediate (class B)" and "slow and steady (class C)". Teachers expected that computer literate students might choose class A, and novice would choose class C.

To evaluate two class organizations, we discuss the term-end exam scores and result of self-assessment.

5.1 Comparison of the term-end exam score

The students in six classes were given an examination at the end of the term. The full marks of each question were ten points. The following five questions are common to all classes.

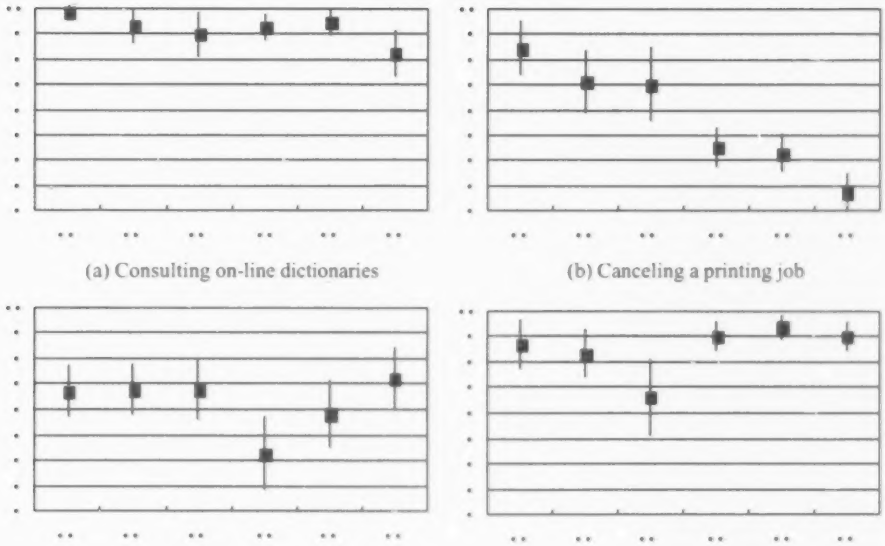
(a) Look a difficult Kanji word up in a Japanese online dictionary.
(b) Explain how to cancel a printing job.
(c) Find Yukio Mishima's book using online public access catalog of the university library.
(d) Explain why 2-byte special characters should be avoided in e-mails.
(e) Show URLs of the companies which sell cars on the web.

In Figure 3, the square(•) indicates the mean score of each class and the vertical line shows the 95% confidence interval of the mean score. To identify a particular class, we use H (for Human Sciences) and L (for Letters) as a subscript of the class name. For example, A_H denotes the "highest-score" class for students majoring in Human Sciences, C_L denotes the "slow-and-steady" class for students majoring in Letters.

The result of the "one-way ANOVA " and the "statistical multiple comparison" shows that questions (a), (b), (c) and (d) have statistical difference ($p<0.05$). Most of the confidence intervals of the class C are bigger than those of other classes, which means the variance of student competencies exists.
The score of the question (b) of "H" classes is higher than "L" classes. This might due to the fact that the operation was not taught in "L" classes.

5.2 Comparison of exam score and result of the self-assessment

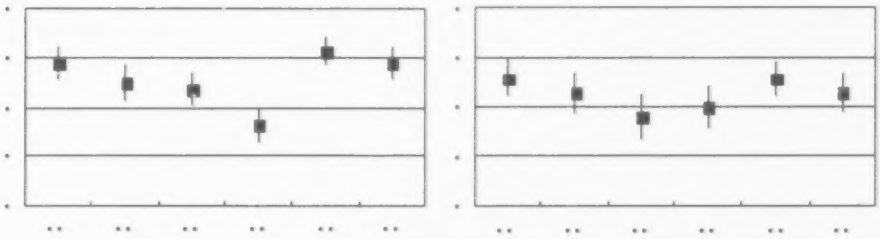
Before the term-end exam, the same questionnaire survey was also distributed to the L classes. Figure 4 shows the distribution of self-assessment score of two items: consulting on-line dictionaries and canceling a printing job. The "one-way ANOVA " and the "statistical multiple comparison" show that the differences of mean scores among classes were significant in the Figure 4 (a) but not significant in the Figure 4 (b).



(a) Consulting on-line dictionaries (b) Canceling a printing job

(c) Accessing on-line catalog of the library (d) Explaining special characters

Figure 3 Distribution of the term-end exam scores



(a) Consulting on-line dictionaries (b) Canceling a printing job

Figure 4 Distribution of self-assessment scores

The comparison between the exam scores and self-assessment shows that all of students who achieved high mark in the exam don't necessarily perceive that they were very good at it. For example, although the scores are high in Figure 3 (a), the result of the self-assessment is not good.

6 Conclusions

In the first half of the paper, we described the effect of class reorganization in the middle of a term, which has enhanced learning outcomes in computer literacy classes. The class reorganization is also a good tool for teachers to know the way to lead students to higher skill level.

Figure 1 and Figure 2 suggest that many students, especially for those who belonged to class C, have made progress during the latter half of the semester. The progress was brought by the two factors, that is, the students' internal motivation and the class reorganization. Moreover, the "interaction effect" of the two factors must be taken into account as a factorial effect. In order to measure the effect of two factors separately, an experiment based on ANOVA model is necessary. However, the score improvement of class C suggests the existence of the class reorganization effect.

In 2000, we will incorporate group work, discussion and presentation for high ability students after the class reorganization.

References

[1] Gilster, P., "Digital literacy", John Wiley & Sons (1998).

[2] Higdon, J., "The evolution of computer literacy for preservice teachers", Proc. of 6th Int. Conf. of the Society for Information Technology and Teacher Education (1995).

[3] Keizer, J. and Wright, V., "Constructivism implementation in undergraduate computer application classes", Proc. of 8th Inf. Conf. of the Society for Information Technology and Teacher Education (1997).

[4] Mills, R., "Grouping students for instruction in middle schools", ERIC Digest, EDO-PS-98-4 (1998).

[5] Nakanishi, M. and Harada, A., "Reorganizing computer literacy classes in the middle of a term", Proc. of 7th Int. Conf. on Computers in Education, pp.507-514 (1999).

[6] Nakanishi, M. and Harada, A., "Ability grouping for teaching computer literacy classes", Proc. of ED-MEDIA, pp785-790 (2000).

[7] Raiford, P. and Braulick, L., "Computer literacy class for preservice teachers at university of Texas at Austin", Proc. of 6th Int. Conf. of the Society for Information Technology and Teacher Education (1995).

[8] Rogers, K.B., "The relationship of grouping practices to the education of the gifted and talented leaner", http://www.ucc.uconn.edu/~wwwgt/rogers.html (1999).

[9] Weinbrenner, S. and Devlin, B., "Cluster grouping of gifted students : How to provide full-time services on a part-time budget", http://www.kidsource.com/kidsource/content2/cluster-grouping.html (2000).

[10] Wiggins, G.P., "Assessing student performance: exploring the purpose and limits of testing", Jossey-Bass Publishers (1993).

Evaluation of the Web-Based Learning System "The Basic of Digital Media Communication "

Liu Huifen, Yu Lei, Liu Fang and Bao Su
Department of Communication, Tsinghua University, Beijing 100084,P.R.China
Tel: 86-10-62788647 Fax: 86-10-62785736
E-mail: liuhf@tsinghua.edu.cn

The web-based learning system "The Basic of Digital Media Communication" creates an interactive learning environment, which includes all the knowledge and aspects needed for the course. During the course, each student can choose freely either In Class Learning (ICL) or Web-Based Learning (WBL). Based on the questionnaires after the course, the paper evaluates the courseware system from the view of teaching and learning processes, interactive learning environments and learning effects. After the comparing study between ICL and WBL, it can be concluded that better computer and Internet environment can promote the students to accept the way of WBL, and WBL can enhance students' ability of self-study. Compared with ICL students, WBL students take less time and get higher score, and they are usually more efficient and individualized. The impact of traditional way of learning and interpersonal communication will exist for a long time, and there should be multi-way of learning to meet the different students.

Keywords: **Web-Based Learning, Evaluation, Interactive Learning Environments, Teaching and Learning Processes**

1 Introduction

The course, "The Basic of Digital Medial Communication", is a combination of computer application, communication and art design and it consists of basic theories, applications and creative design. That is, the basic knowledge of this course is about how to use the computer to organize, edit and deliver multimedia information. During the course, students need to do a lot of design works on computer. Because the content is so practical nowadays, the course is very popular among students. But since the course opened in 1996,it has confronted different problems concerning education mode and content. Firstly, the registration of the course is always limited by classroom and computer laboratory. Secondly, some of the reading materials were renewed and expanded nearly every year. Thirdly, because of the characteristics of the course, the most efficient way of learning and teaching is with the help of multimedia and network. Therefor, in the process of education reform, the course has experienced three ways of teaching and learning mode, that is, traditional learning, multimedia-assisted learning and Web-Based Learning. While improving the course gradually, a web-based courseware • The Basic of Digital Media! Communication• have been developed[1]. This courseware system constructs a comprehensive and interactive learning environment. The data capacity of the courseware is about 1 Gega Byte totally, and it includes all information and aspects needed for the course, such as the schedule, learning materials, experiment instruction, reference materials, demonstration and examples, answering questions, homework handed in and feedback, discussions and so on.

The object of the courseware is to construct a new learning mode, which should inspire the students' creativity and innovation. While instructed by teacher and assisted with modern education technologies, the students should be the center in the teaching and learning process. The course is carry on in an open and interactive environment, and the main features are as following:

(1) Open Computer Laboratories of the University are opened for the students, and they can visit the courseware at anywhere and on anytime if they logon to Internet. All the information about the course is published on the courseware, and the latest news or notice is always renewed according to teaching and learning process. The students can ask questions and discuss them with others through the courseware.

(2) According to the schedule, the students should finish a serial of media design work step by step. All the works can be handed in through web. Not long after hand in, each student can look up the web and get the score and comment from the teacher for each design work. The excellent works and the teacher's comments will be published on the web on time, and the students can refer to and discuss about the works.
(3) In class lectures are based on the courseware, which will be projected on multimedia classroom. Discussing classes are arranged during the semester, which are also based on the courseware and projector. In this paper, we call this way of learning as In Class Learning (ICL).
(4) Except the ICL, the students can also choose the way of Web-Based Learning (WBL). In this way, the students need not attend the in class lectures, but they should finished all the design work and final test by self-leaning through the courseware system. The requirement of design work and final test are the same for both ICL and WBL students.

At first, the courseware system was used in a course composed of 30 students. Then, in the fall of 1999, it was used in a selective course opening to all the undergraduates and each student can freely choose the way of ICL or WBL, While the design work requirements and the test for both way are the same. At the end of the semester, two kinds of questionnaires were carried out among two group chose different learning modes. The questionnaires were designed in three aspects: the courseware system, the teaching and learning process and the learning effect. Compared and analyzed the feedback from the two groups, it can be concluded that, the web-based courseware system and learning mode have reached expected objects, and the learning effects have connection to the computer environment, the self-study ability of students and the impacts of traditional way of learning.

2 Web-Based Learning is the trend of modern education development

At the beginning of the semester, only 25% of the total 70 students chose the way of WBL. The others either chose ICL or couldn't make their mind yet. After a period of time, when they got more familiar with the courseware system, all the students uncertain and 18% of those chose ICL originally turned to WBL. Consequently, the WBL students have made up of 61% of the total students registered. According to the investigation, the students' choice could be affected mainly by three factors, that is, self-study ability, computer and Internet environment and the basic knowledge for the course.

Among all the students, 72% of the juniors and seniors chose WBL, while only 46% of the freshmen and sophomores chose WBL. Those who chose the WBL consider it a better way, because the place, time and learning schedule can all been controlled freely by themselves. This in turn requires the students to be of higher ability of self-study. Most juniors and seniors prefer WBL, for they are usually better at self-study. From this point of view, higher ability of self-study is needed for WBL, and WBL will improve their ability of self-study, which is also the basic ability for life-long learning.

In order to visit the courseware without the limitation of time and space, Internet logon is the basic environment for the students. There are about 500 computers connected to Internet in the Open Laboratory of our University, but it's always full of the students. More and more students have their own computers in dormitories, and more and more dormitories are connected to the Internet via high speed cable. From the investigation, most students chose WBL have better computer and Internet environment than those chose ICL. Therefor, the better the computer & Internet environment, the more the students who will accept WBL.

Because of the course's feature, computer is both the tool and object of learning the course. Compared to ICL group, most WBL students consider they had basic idea about the course at the beginning of the semester. That means that WBL students have basic ability of computer application, which could been called as digital literacy and it's the basic literacy demand in the information age [3]. So, the digital literacy is another factors that can affect their choices. In the process of WBL, computers and web are basic tools of learning, and it will definitely improve one's ability for computer application or digital literacy.

3 Web-Based Learning is of more efficiency and individuality

WBL has more advantages over traditional way of learning. WBL has changed the traditional relationship between teacher and students, where the teacher is the initiative disseminator and the students are passive receivers. The courseware enables the students to study individually. They can decide how long to visit the courseware each time and which part to concentrate on. What's more, they can do the homework or design work at the same time while reading the courseware, which is more efficient than traditional way of in class

lecture and then design work.

Take the learning procedure of one chapter in the course for an example. In the teaching schedule, 6 in class hours are planed to finish the chapter and the relative design work. Analyzing the percentage of students and the total hours used to finish this chapter' s learning and design work (Fig 1), the statistic result shows that the hours used by WBL students tend to be more changeable. The average hours used by WBL and ICL are 6.5 and 8 hours respectively, while the average scores of this design work are 77.7 and 79.8 respectively. That is, WBL group turns to be take less average time and get higher marks.

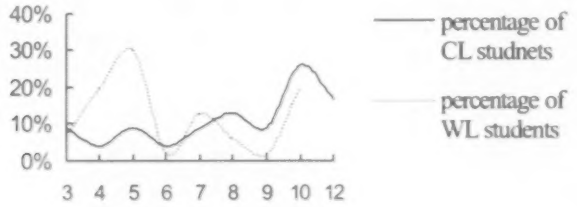


Fig 1: Percentage of students and the total hours used to learn chapter 7

Study the total time used for the course (Fig 2), it also shows that the ICL students tend to arrange their learning time according to teacher' s schedule, while WBL students tend to arrange their time individually. From the statistic of how WBL students read the courseware, only about 35% of them learn systematically and about 45% of them consult the courseware only if they need help. But WBL students' average total score is 84, higher than 80 of ICL students. Although scores are just one way to test the effect of learning, from all statistic results and analysis, it shows that WBL is of more efficiency and individuality.

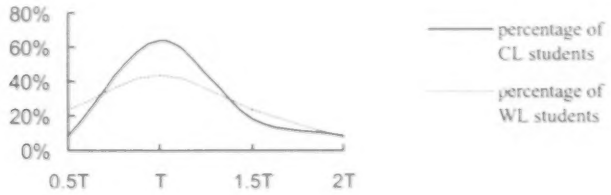


Fig 2: Percentage of students and the total time used for the course
(note: T is the total in class time of the course' s schedule)

4 The courseware system plays an important part in the learning process

The courseware is both the learning object and an effective learning tool, so it is very important in the learning process. At the beginning of the semester, teacher announces the schedule, homework requirement on the courseware. Then the Students can learn the knowledge from the courseware step by step according to the schedule, hand in their homework, ask questions and discuss relevant topics through the courseware. The answers to the common questions, the score and comment of everyone' s homework are also published on the courseware. The latest news on the courseware is renewed at least two times a week. Though parts of the learning materials are almost the same with the textbook, the courseware is more attractive because its multimedia, multiform and interaction.

The courseware is the main learning materials for the two groups, and more than one third of the students completed the learning only by the courseware. The top successful aspects of the course from the two group are showed in Table 1. When designing the courseware system, it was not expected that homework hand in and feedback by the courseware would be so popular among the students. The students whose excellent design work is published on the courseware are very proud about it, and the others would be greatly inspired and they will make their efforts to improve their own works too. So in the courseware, not only the database of learning material but also the interactive environment has played very important part in the teaching and

learning process. Both WBL and ICL students evaluate the course highly, and the courseware system has reached its expected objects.

	ICL	WBL
1	Get the latest news from the courseware	Web-based learning
2	Homework hand in and feedback via the courseware	Homework hand in and feedback via the courseware
3	Discussing class by projector	Get the latest news from the courseware
4	In class lecture by projector	

Table 1: Statistic of the top successful aspects of the course

5 There should be multi-way of learning to meet the different students

At the end of the semester, most students feel satisfaction to the learning mode they chose, no matter WBL or ICL. Meanwhile, they all have good evaluations to self-study abilities. The two groups have different options about "discussing class". 68% of the ICL students think the discussion is indispensable and should be emphasized, for they can have chance to communicate with others in person, while 21% of the WBL students think it's unnecessary, for they can "discuss" in the courseware. It's clearly showed that, ICL students tend to be more rely on the interpersonal communication, while WBL students tend to be more rely on network communication. The weakening of interpersonal communication is a new problem emerging in the information age, and it will influence learning effect [4].

Analyzed which is "the best way of learning in college", 27% of all the students accept WBL completely, while 58% consider the best way is combining WBL and ICL, that is what we have done in the course. This kind of combination is suitable for students with different basis. For those tend to WBL, they can learn individually by the courseware system and consult the teacher in discussing class when they want. For those tend to ICL, they can get systematical instruction from the teacher in classroom, and use the courseware resource after class. In a long term, coexistence of multi-way of learning is a practical solution, which will instruct the learning and motivate creativity of students simultaneously.

6 Conclusion

Web-Based Learning has many advantages over traditional way, while it will take a long period of time for it to be perfected. Web-Based Learning has not only changed the teaching and learning process, but also the education mode and teaching thoughts. Its success depends on the network hardware, courseware and the efforts of the teacher and the students. In the course "The Basic of Digital Media Communication", the students are so eager for knowledge and so interesting in the educational reform. In fact, the courseware system is developed and improved during the teaching and learning process.

Web-Based Learning is the trend of education in today's information age. This kind of learning is different from comp letely self-study. Though the interactive learning environments of the courseware system, the teacher instructs the students how to learn, and encourages them to study independently. Although the content is professional, the structure and learning mode of the courseware system have common sense for other courses. In order to satisfy different students and enhance their ability as well, the in class lectures will be decreased gradually, but discussing classes will be remained both for interpersonal communication and for answering the question face to face. In order to cultivate the higher qualified students in the information age, the education mode should stress the ability of acquiring knowledge and self-learning. This in turn, requires the teacher to be higher qualified too.

References:

[1] Courseware system "basic of digital media communication". http://166.111.107.2/digit-media/index.htm

[2] Liu Huifen & Wang Yue. "The Design and Development of Web-Based Interactive Learning Courseware in High Education", Proceeding of ICCE '99, Advanced Research In Computers and Communications in Education , Vol 2, 1999, Japan.

[3] Liu Huifen, Zhang Xing & Wang Yong. "Education Structure and Method Study for Computer Mediated Communication" Proceeding of ICCE '98 ,Global Education On the Net, Vol. 3, 1998. Beijing.

[4] Liu Huifen. "The Impact of interpersonal communication in Distance learning" ,Proceeding of GCCCEY2K, May, 2000 Singapore

Everything in Moderation? Developing successful collaborative projects between European initial teacher education students

David Owen *, Brian Hudson*, Alison Hudson, Eila Jeronen***, Jan Morawski****, and Peter Schurz*******

**Pedagogy and New Technologies Research Group*
School of Education
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
Tel: +44 144 225 2448
Fax: +44 114 225 2324
D.H.Owen@shu.ac.uk *and* B.G.Hudson@shu.ac.uk

*** Centre for Multimedia in Education*
Learning and Teaching Institute
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
A.R.Hudson@shu.ac.uk

****Department of Teacher Education*
University of Oulu
P.O.B. 222
90571 Oulu
Finland
ejeronen@ktk.oulu.fi

*****Department of Education and Social Studies*
Hogskolan Darlana
S-781 88 Falun
Sweden
jmo@du.se

******Pädagogische Akademie des Bundes in Oberösterreich*
Kaplanhofstrasse 40
A-4020 Linz
Austria
schuerz@pa-linz.ac.at

Computer mediated collaborative projects have the potential to strengthen the European Dimension in teacher education whilst giving students an appropriate context to develop their computing and collaborative skills. This paper evaluates the success of such a project through the completion of a three-year action research enquiry involving student teachers from four European countries. The results of three cycles of development are presented. The project was evaluated using student questionnaire data, participation in tutor meetings, and analysis of students' web page development and bulletin board contributions. Results suggest that successful collaborative project work depends on ease of access to

reliable computer networks, giving equal weighting to resource production and levels of international communication, and effective moderation of the project by all tutors involved. The paper concludes by detailing future developments in European cooperation involving the partner institutions. These developments involve using the Ecoschool communication networks to discuss pedagogic and multi-media design issues involved in a cross-curricular CD-ROM which has been developed by the same group of partner institutions.

Keywords: **computer mediated communication, European co-operation, moderation.**

1 Introduction

This paper reviews a three-year cycle of telematics curriculum development and action-research in initial teacher education. The project has been made possible by funding via the SOCRATES European Module ECOSCHOOL (1997-2000). The project has two aims; to develop learning by using the World Wide Web (WWW) and email across Europe, and to learn about the social and economic aspects of the participant's home city. The outcomes of the project include the creation of a collaborative open learning course that teacher education students can follow as part of their training.

The Ecoschool developments originated from European collaboration on the EUROLAND project (1996-99). It brings together partners from Austria, England, Finland and the Netherlands in building the European Dimension into the curriculum of schools and teacher education courses (Hudson et al, 1997 and Hudson et al, 1999). Teacher education institutions and departments lead both projects in close collaboration with partner schools and teachers in each country. The resources that have been produced by both the Ecoschool and Euroland projects have been used as the basis for the development of pedagogic approaches with teachers on intensive in-service training courses, which have been supported under the Comenius 3.2 Action of SOCRATES.

The paper reports on four aspects of the Ecoschool project; the three year cycle of curriculum development, the tutor and student evaluation of the project, lessons learned regarding telematics pedagogy, and future developments that link the outcomes of the Euroland and Ecoschool projects.

1.1 Participants in the project

The participants are primary teacher education students from Linz and Sheffield together with students on an international teacher education course at Oulu. A more recent partner to this development is the University of Darlana in Sweden. This has led to the participation of a group of social studies student teachers from Falun in Sweden. English was used as the medium for communication and a total of eighty five students took part over the three years.

1.2 Collaboration and communication

A key aim of the project has been to promote the European Dimension and the use of Information and Communications Technology (ICT) in teacher education across Europe. The development of the European Dimension provides ample justification for collaborative communication but such projects can also reflect sound pedagogic principles. The pedagogical approach is based on a socio-cultural communicative perspective, which owes much to the works of Vygotsky (1987). Collaborative learning is at the heart of the Ecoschool project and has been used during the three cycles of student work. Many authors, including Hudson (1998) and English and Yazdani (1999) see such an approach as essential in developing students' learning skills when using ICT or learning without the aid of new technology.

2 Use of new technologies

The resources and tools being used are university email communications and the resources provided by the ProTo environment at the University of Oulu– *Project Learning Tools on the Web*. This is an open learning environment that has been developed at the University of Oulu. Students can access the ProTo system via

the World Wide Web. They have a password that allows them to create simple web pages and enter messages on a bulletin board. Students also created web pages using Netscape Composer and posted them on their home pages. In cycle three they used an electronic bulletin board as well as using ProTo and email.

Use of such technology is now a key focus in the education of teachers across Europe. Student teachers in England and Wales follow the National Curriculum for Initial Teacher Training (DfEE 1998). This curriculum requires students to show evidence of using and creating multi-media presentations, and of using web technologies to communicate with colleagues. In addition, recently published guidance detailing an ICT primary school curriculum (QCA, 1998), suggests that children aged ten should be able to design and evaluate simple multi-media presentations, and children aged eight should be able to take part in an email exchange. Clearly student teachers need the confidence and skills to develop these abilities in their pupils. The Ecoschool gives students this experience through their participation in a computer mediated collaborative project and by their evaluation of its potential use in their future educational roles.

2.1 Pedagogic approaches

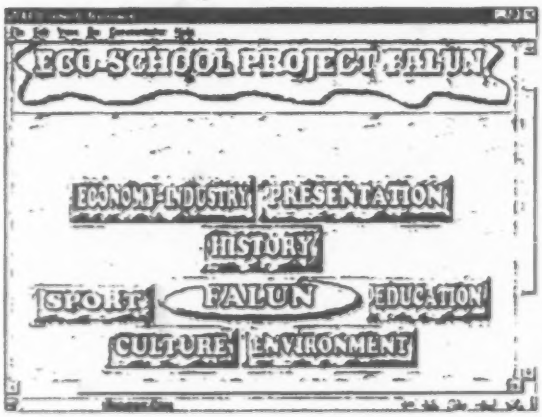
As previously stated the Ecoschool project uses a pedagogic approach that seeks to promote learning through 'electronic talk' in collaborative groups. These groups use a plan, do and review strategy as proposed by Kolb (1984) in his model of experiential education and by Schon (1987) describing the planning cycle used by reflective teachers and learners. The groups planned the construction of webpages, constructed and evaluated their own pages and those of other groups, then finally evaluated the whole project. Tutors developed their own pedagogy of distance learning during the project. The success of the tutors' approaches are analysed using guidance developed by McGee and Boyd (1995) to facilitate dialogue during computer mediated communication.

3 The three cycles of curriculum development

3.1 Cycle One

Focus : comparing students' home cities
Outcomes: web pages explaining local city

Figure 1: Work from the Swedish students posted to the ProTo learning environment.



Students in each country worked in collaborative groups to produce a short illustrated report on one of the following aspects of their home city. This involved a general description of the city, an explanation of the environmental situation and the employment structure of the city, and an analysis of the regional or national education system.

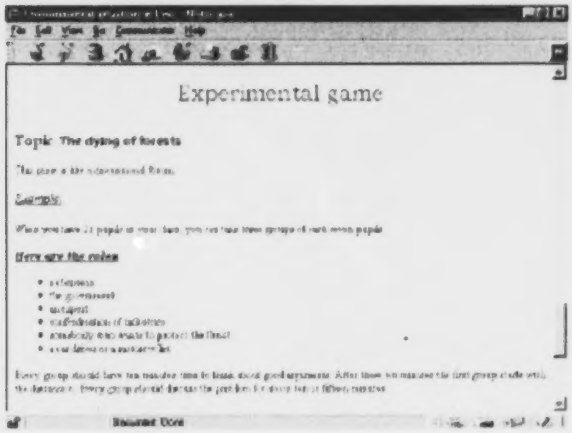
Subsequently they presented these reports as web pages by writing them in to the ProTo learning environment. Figure 1 shows a page produced by the Swedish students. They also emailed their work to other students in the partner countries who were presenting the same topic. Once all web pages were complete, they read their partner's pages, asked questions and made comments about them on the bulletin board. Each group evaluated their work using the same criteria designed by the tutors in each country. The tutors then read each group's pages, assessed the pages and provided feedback to the each group. The students' work was assessed against the criteria and graded A to C. The tutors posted written feedback on the bulletin board.

BEST COPY AVAILABLE

3.2 Cycle Two

Focus : Comparing lesson planning
Outcomes: web pages giving examples of lesson plans

Figure 2: Teaching and learning about the environment in Lin

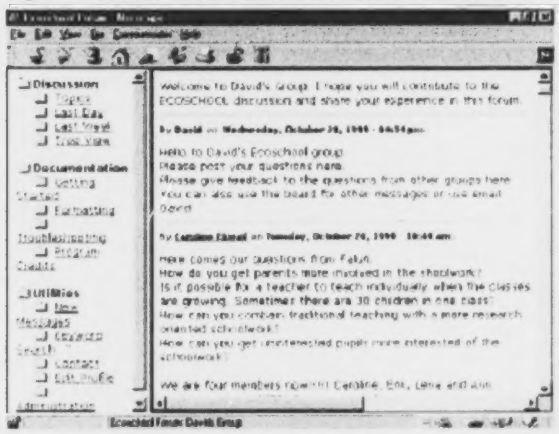


The aim of this round of co-operation was for students to share lesson plans and teaching ideas. Each group of students planned lessons with the aim of children learning more about their local town or city. Again, students presented these as web pages on the ProTo system or, in the case of the Swedish students, on their university home pages. Each group of students again evaluated the pages of their partner groups, responded to each other's questions, and received feedback from the tutors in each country. Students' work was again assessed.

3.3 Cycle Three

Focus: suggesting and solving educational problems
Outcomes: range of solutions to five educational problems

Figure 3 The Euroland and Ecoschool discussion and chat site.



The Ecoschool project ran during autumn 1999 with several new developments. The students were in internationally composed groups rather than from one single country and the focus of the project was to choose an educational problem and present a solution to this by co-operating using ICT. The students could use email, create their own web pages, use ProTo2 (a more sophisticated version), or use the Ecoschool bulletin board (see Figure 3). The majority of students chose to use the bulletin board to present their problem and solutions although some students did use the ProTo2 learning environment. Again tutors gave feedback to the students and responded to their questions although the work was not graded.

4 Methods of curriculum development and evaluation

Ecoschool developments have followed an action research model, as the aim of the project was to develop a successful curriculum for initial teacher education over the three years of the project. The Ecoschool curriculum was developed in face-to-face planning meetings and followed up by email communication between partners in Austria, Finland, Sweden and England. The results of student and tutor evaluation were fed into the curriculum planning at the end of each cycle. The following methods have been employed in gathering evaluation data:

BEST COPY AVAILABLE

Student evaluation questionnaire. All students completed a questionnaire by email or on paper. Many groups posted the results of their evaluation on the ProTo system or on the Ecoschool bulletin board. The questionnaire requested information on student expectations of the project, levels of interaction, the role of the tutor, use of new technology and ideas for the future.

Tutor evaluation. A tutor from each country completed a written evaluation of their experience at the end of each cycle and presented the document for discussion at the annual Ecoschool development meetings.

Web page analysis. The students created web pages of differing levels of complexity during cycles one and two. The web pages construction process is evaluated against the six components of infomedia literacy as proposed by Lee (1999, pp.147-149). These components are:

1. An understanding of the nature and functions of infomedia and their impact on individuals and society.
2. The development of critical thinking ability.
3. The skill of efficient searching and critical selection of information.
4. Knowledge of multi-media production using appropriate technology.
5. Aesthetic appreciation of hypertext, graphic design and visual images.
6. Social participation in influencing the development of infomedia technology.

ProTo communication log analysis. The record of tutor and student communication during cycles one and two was analysed using Boyd and McGee's (1995) guidance on facilitating dialogues using computer-mediated communication. They suggest that facilitators provide both technical and content-specific support; are responsible for regularly communicating with the group; communicate in ways that require a response; and model standards of high quality interaction

Ecoschool bulletin board observation. The Ecoschool bulletin board was set up in September 1999 and provided the student groups with a shared electronic space for presenting and discussing their ideas. Each group had a separate area for their own use. The frequency and quality of communication was analysed as well as the level of interaction between group members.

5 Evaluation Results

Student evaluation questionnaire data was collected from 12 of the 16 student groups over the three years. The key points arising were:

- In cycles one and two students who were apprehensive about using the technology felt that had been successful and the majority of students found that resource production was enjoyable and had developed their ICT skills.
- Communication between groups was successful in cycles one and two but sporadic in cycle three. This was attributed to pressure of work from other areas of their degree (Oulu), lack of clarity in terms of the aims of the project and technological problems in Linz and Sheffield.
- In cycle three, two of the five groups were critical of the lack of commitment of their partners.
- Students in Sheffield requested formal computer sessions where they could meet and use university facilities for the project. All students felt that their tutors had supported them in cycles one and two, but three groups wanted clearer guidance in cycle three.
- By cycle three the students from Falun and Oulu requested the use of chat and video conferencing technology in any future work. Individual students in Linz and Sheffield experienced technical difficulties during November 1999 due to network problems at their institutions.

Minutes of three *Tutor evaluation* meetings and five written reports state that:

- The role of the tutor was clear in cycles one and two but not in cycle three
- Cycle three was seen as a radical departure from previous work and was viewed as 'experimental'
- Students in Linz, Oulu and Sheffield were hampered by block teaching practices taking place during key times in the project.
- Tutors were pleased with the progress made by their students in cycles one and two and had discussed how work in cycle three could be improved.

Web page analysis using Lee's concept of infomedia literacy reveals:

- Only two groups took a critical approach to the sources they used when constructing pages about their

home city in cycle one.

- Three groups overtly discussed the problems of representing people and places on their web pages in cycle two.
- Four groups of students in cycle one saw the pages as similar to written text so did not exploit the advantages of hypertext fully.
- All students changed from passive users of web pages to active publishers of their own content.
- The students from Falun produced a website in cycle two that clearly demonstrated a collaborative approach and a high level of aesthetic appreciation in regard to page design.
- Students from Oulu and Falun were in general more adept at making critical comments about their own and other's work than the Linz and Sheffield students.

ProTo communication log and *Ecoschool bulletin board observation* using McGee and Young's guidance shows:

- In cycles one and two tutors adequately fulfilled the roles of moderator, mediator and facilitator.
- Tutors communicated with the participants by asking one or more questions, giving examples from their own experience to add to discussions and modelling high quality interaction.
- The cycle three work led to the production of questions and solutions but little discussion. In general tutors did not moderate the discussion effectively as they were unsure of their roles.
- The decision to limit the role of the tutor in cycle three had a negative effect on the level of interaction and quality of discussion. Student evaluations reveal uncertainty about technical issues as well as pleas for stronger leadership and rigid deadlines.

6 Discussion

The cycles of curriculum development and evaluation have identified many important features in the development of collaborative ICT projects. Establishing an international electronic community requires access to reliable technology for the students and also skill and commitment on the part of the tutors. Asynchronous communication is seen as one of the great advantages of electronic communication and university tutors may take their own ease of access for granted. In a study of barriers to student computer usage McMahon et al (1999) found that students identify real problems in accessing computers to complete course tasks. A Sheffield student reflects their conclusions when evaluating her experience in cycle three:

> *If we had been given time in our lectures to get together and a set routine with correspondence time every week then we would have got more out of it. As a group of people we are all in different (teaching) groups, so getting together is difficult and finding a PC when we have free time is also difficult.*

This highlights the question of computer access as well as the importance of study and group work skills in such a project. Very clear project goals and explicit expectations on student participation are also needed. Is it the students ' responsibility to meet and organise communication sessions during their own time, or will better levels of communication occur by booking computer access during student practical classes? If this is done are the benefits of asynchronous communication being demonstrated? An unexpected outcome of this project has been to highlight the importance of developing students' teamworking skills.

Once access is assured, the roles of the tutor as moderator, mediator and facilitator are crucial. A key finding from the evaluation is that communication was much more successful when the tutors had a strong moderating role in cycles one and two. When planning for cycle three, tutors limited the moderation role and gave the student groups much more independence. The majority of the students interpreted this as poor planning and one group described it as 'lack of leadership'. This highlights the complexity of the moderator's role and a recommendation from this project would be that the tutors spend time in the final evaluation meeting exploring their experiences in this role.

Developing a successful collaborative curriculum is dependent on creating a fine balance between resource production and communication. In cycle one the web pages produced were basic, but quality of interaction between students was high. In cycle two the web-based products were much more sophisticated but students paid less attention to communication, perhaps because more academic credit was gained for page development rather than communicating with fellow students. Student's work in the final cycle showed some evidence of sound international cooperation, but less in-depth critical analysis. Experiences gained

during the three cycles have led to the development of a formal curriculum unit (see http://www.shu.ac.uk/schools/ed/teaching/dho/). Students will gain high grades only by giving equal weighting to communication, resource production and critical evaluation in their group work.

Finally, teacher education students need to transfer their learning to a classroom situation. One student has already set up a similar project whilst on teaching practice. In this example infant school children communicated via email with children in Bermuda and compared their localities, hobbies and homes as part of English and geography learning. Tutors need to set up opportunities for students to use their newfound confidence and skill in the classroom. Nook Lane Primary School in Sheffield is now linked with partner schools in Linz and Oulu as a result of the project, and students can now contribute to the development of this partnership.

6.1 Future developments

As a result of ongoing evaluation the following developments have been planned for 2000-2001. A chat facility had been added to the Euroland/Ecoschool discussion area in addition to the bulletin boards. Building on the success of a trial video-conferencing session held in November 1999, students will be able to use this form of communication from September 2000 in all countries. Students and teachers can also now access the communication tools via the Hallam Geography Education web site as well as from the Euroland web pages. Finally, with the imminent completion of the Euroland CD-ROM, the two projects will be brought together. Students and teachers will be able to use the CD-ROM as a focus for collaboration and discussion in the areas of infomedia literacy and multi-media development, the pedagogy of computer-mediated collaboration and the comparison of European social and environmental learning.

7 Conclusion

The Euroland and Ecoschool projects represent successful examples of how an international perspective can be developed in the university and school curricula. Sustained and effective communication is the key to such initiatives, alongside ease of access to computing facilities and a focus on the crucial role of the tutor as moderator. Both projects have provided tutors, students and pupils with membership of an expanding European network, which is a solid platform for the development of further collaborative work.

8 References

DfEE (1998) High Status: High Standards Circular 4/98. HMSO.

English, S and Yazdani, M. (1999) Computer-supported co-operative learning in a Virtual University. *Journal of Computer Assisted Learning*, 15, 2-13.

Hudson, B. (1998) A social perspective on learning in the context of Computer Mediated Communication in teacher education. *Proceedings of ICCE 98: International Conference on Computers in Education*, Beijing, China, 14-17 October 1998, 627 – 632.

Hudson, B., Hudson, A. & Schürz, P. (1997), Euroland: A Collaborative European Cross-Curricular Project using CD-ROM. *Proceedings of ICCE 97: International Conference on Computers in Education*, Kuching, Sarawak, Malaysia, December 1997, 1006-1007.

Hudson, B., Schürz, P. and Hudson, A. (1999), The Euroland/Ecoschool projects: Promoting Collaboration in a European context using CD-ROM and the WWW, Paper to Subnetwork D: Powerful Learning Environments in Teacher Education. *Conference of the Thematic Network on Teacher Education in Europe (TNTEE)*, Lisbon, 1999, http://tntee.umu.se/lisboa/

Kolb, D.A. (1984) *Experiential Education: Experience as the source of learning and development*. Prentice-Hall.

Lee, A.Y.L (1999) Infomedia Literacy: An educational basic for young people in the new information age. *Information, Communication and Society* , 2, 2, 134-155.

McGee, P.A. and Boyd, V (1995) *Computer-Mediated Communication: Facilitating Dialogues* at http://www.coe.uh.edu/insite/elec_pub/html1995/173.htm . Visited 4/10/00.

McMahon, J. , Gardner J., Gray, C., and Mulhern. G. (1999) Barriers to student computer usage: staff and student perceptions. *Journal of Computer Assisted Learning*, 15, 302-311.

Schon, D.A. (1987) *Educating the Reflective Practitioner: towards a new design for teaching and learning in the professions*. Jossey-Bass.

QCA (1998) Information *and Communications Technology: A Scheme of Work for KS1and KS2*. QCA.
Vygotsky, L.S. (1987) *The Collected Works of L.S.Vygotsky*, Vol.1 Plenum Press, NY.

http://www.shu.ac.uk/services/lc/cmeweb/Euroland/chatgroups.htm
The Euroland and Ecoschool discussion and chat fora.
http://ProTo.oulu.fi/
The ProTo open learning environment.
http://www.du.se/~lmh98lae/
Ecoschool pages created by students form Falun, Sweden.
http://wwwedu.oulu.fi/homepage/ejeronen/eco/index.htm
All cycle one and cycle two work can be viewed at this location.

Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers

ROSEMARY LUCKIN AND BENEDICT DU BOULAY,
School of Cognitive & Computing Sciences
University of Sussex
Brighton BN1 9QH UK.
E-mail: *rosel@cogs.susx.ac.uk* and *bend@cogs.susx.ac.uk.*

In this paper we discuss our observations of a group of 10 and 11 year old children using an Interactive Learning Environment called the Ecolab. The design of this software was informed by our interpretation of Vygotsky s Zone of Proximal Development in which *Interaction* and *Collaboration* are definitive characteristics. The relationship between the differences in interaction/collaboration style and the learning gains made by the children are discussed. The results show that children can be grouped into profiles according to the differences and similarities in their use of the system and that common interaction features are influenced by the design of the software being used. We suggest that children are poor at managing their own learning experience with technology even when the software offers both opportunities to complete challenging activities and support to ensure success. The children in this study needed explicit direction towards activities which were beyond their ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity: a suggestion from the system about what and how to proceed is often sufficient.

Keywords: **Interaction, Collaboration, ZPD, ILE.**

1 Introduction

Computers are now an accepted part of classroom life for most young learners whether they are used for communication, visualization, simulation experience or simply for fun. But how do children actually interact with computers? Does the nature of their interactions vary from child to child in a way that could inform the design of the software which engenders these interactions? This paper explores children s use of an Interactive Learning Environment (ILE) called the Ecolab which was designed to help children learn about ecology. The system attempts to fulfill the role of a more able learning partner for the child and invites collaborative interaction. The collaboration is thus between the system and the child and not between children. Here we describe the nature of the interactions that a class of children had with this system. The nature of these interactions is considered in the light of pre- and post-test learning gains to explore the relationship between learning and interaction style. The Ecolab software has been designed using a framework derived from our interpretations of the Zone of Proximal Development (ZPD) [10, 11]. The ZPD describes the most fertile interactions which occur between the more and less able members of an educational culture and focuses attention on how the more able can help learners to learn. The ZPD offers a theory of instruction which emphasizes the inseparability of the teaching and learning processes and thus recognizes the inherent interactivity of children s learning with computer software. It also stresses the need for learners to have the help of a collaborative learning partner in the form of a peer, a teacher or in the case of the Ecolab, a computer. Within a Vygotskian, socio-cultural model of education human activity is mediated by tools and sign systems that have arisen through social interaction. Developmental explanations are used to address the complex internalisation process by which the interpsychological relations between partners in social interaction becomes intrapsychological

within the individual learner. Interaction and Collaboration are therefore definitive characteristics of the ZPD which form the linchpin of the socio-cultural framework and thus form the focus of our investigations of children using the software.

In this paper we provide a brief description of the Ecolab software before discussing an evaluation study of its use. We report the results with particular emphasis upon the nature of the Interaction and Collaboration profiles we were able to construct from our records of system use. We provide examples of individual learner s use of the system and discuss the relationship between the nature of the interactions and the learning gains recorded after system use.

2 Ecolab Software

Ecology is a subject that involves the study of relationships between organisms within our environment. These relationships can be extremely complex; they can also be introduced in a simplified manner through concepts such as food chains and food webs. These form the foundations of more complex ecosystems and are part of the curriculum for primary school children in the United Kingdom. The Ecolab software provides 10 and 11 year old children with the facilities to build, activate and observe the ecological relationships which exist between members of a simple food web in a woodland ecosystem. It provides a simulated ecology laboratory environment into which the child places the animals and plants of her choice. This environment can be viewed by the child from several different perspectives or *views*, including:

World - a picture of a woodland environment and the organisms the child has chosen to place within it.
Web - a traditional text book style diagram of the organisms in a food chain and food web.
Energy - a graphical representation of the energy levels of the organisms currently alive in the Ecolab.
History - a linear narrative of what has happened in the Ecolab world to date, which animal has eaten which other animal for example.

As we have already stated the nature of the relationships that can exist between organisms in the real world can be very complex. We wished to allow each of the children using our system to learn about relationships at a level of complexity that was appropriate to them. We therefore built the learning environment in a manner that would allow children to learn about relationships ranging from the simplest, between just two single organisms, to the much more complex network of relationships that could exist in a very simple ecosystem involving populations of organisms. The complexity of the relationships represented within the Ecolab can be varied at any stage during the child's interaction with it. It is also possible to alter the abstractness of the terminology used to describe the organisms in the Ecolab so that a snail, for example, can be described by the words "herbivore", "primary consumer", or "consumer" as well as the word "snail".

In addition to this simulated laboratory environment, the system acts as a collaborative learning partner for each learner which can provide assistance of the following sorts:

Extension of the learner s knowledge through increasing the complexity of the relationships she is asked to study and/or the abstractness of the terminology used to describe what is happening in the Ecolab.

Collaborative Support which can take the shape of *Activity Differentiation:* in the form of alterations to the difficulty of the activities the learner is asked to complete, or context sensitive *Help* of variable levels of quality and quantity.

At the start of this paper we discussed our use of the Zone of Proximal Development to underpin our system design and the importance of *Interaction* and *Collaboration*. In order to explore the nature of the interactions children had with our software, the collaboration that might occur between system and learner, and the relationship between interaction, collaboration and the changes in learning outcome recorded after system use, we varied the manner in which collaboration from the system was offered to the learner. The Ecolab consists of three system variations: VIS (Vygotskian Inspired System), WIS (Woodsian Inspired System) and NIS (Non-theoretically Inspired System). These three system manipulations implement different design elements in order to adjust the assistance they provide (see [4] and [5] for more detail). The way in which each of the system variations adopts a different approach is summarised in Table 1. In particular, VIS makes more decisions than WIS which makes more decisions than NIS. In other words NIS gives the learner most freedom of choice to the learner and VIS the least.

3 Interactions with the Ecolab

An exploratory evaluation of the Ecolab software was conducted with a class of children aged 10 and 11 years. We wanted to investigate the extent to which the system would be able to adjust to learners of differing abilities, and also the ways in which the interactions and collaborations between user and system varied with users of different abilities. The children's school assessments were therefore used to allocate each child to one of three ability grouping: High, Average and Low. Prior to using the software each child completed a written and a verbal pre-test, the latter of which was in the form of a structured interview recorded on audio tape. Each child used the Ecolab software as an individual for a total of 60 minutes over two sessions. In addition, a 20 minute initial session with a smaller 'demo' versionensured that all children were comfortable with the mouse skills required and the interface. After the system intervention subjects were given a written and verbal test, identical to the pre-test, and a short additional extension interview. A delayed post-test was conducted 10 weeks after the end of the original post-test. Of the 30 children who started the study only 26 completed all sessions between, and including, pre and post-test. The four who did not complete these sessions had either left the school or been absent during the evaluation period. Only 24 completed all sessions including the delayed post-test. Once again the reason for non-completion was absence from school.

Table 1 Collaborative Support within Ecolab

Collaborative Support within Ecolab			
	VIS	**WIS**	**NIS**
Levels of Help Available (different levels provide differing qualities of help - 5 represents the greatest and 1 the least)	5	5	2
Decision about Level of Help made by	system	system and child	child
Levels of *Activity Differentiation* Available	3	3	3
Decision about type of Activity and Differentiation level made by	system	child - system makes suggestions	child
Extent of Learner Model maintained by the system and used to make decisions about the support to be offered to the learner.	Bayesian Belief Network (BBN) of values representing the system's beliefs about child's ZPD formed from its knowledge about the amount of collaborative support used to date.	Record of help used to enable contingent calculation of next help level. Record of curriculum nodes visited maintained to permit suggestions.	Record of Curriculum nodes visited maintained to help child keep track.
Abstractness of Terminology selected by	system	child	child
Area of the Curriculum and complexity of the next activity selected by	system	child - system makes suggestions	child
Ecolab View selected by	mostly child	child	child

The results of the pre- and post-test were used to assess the efficacy of the three variations of the Ecolab software. This work is reported elsewhere [4, 5] and is not the main focus of the current paper. It is the character of the interactions between each child and the system that we will focus upon here. We wanted to investigate what sorts of interactions had resulted in the greater learning gains and which systems had supported and encouraged various types of interaction and collaboration in order to inform the design of our next system. For each child a summary record of their interactions was produced from the detailed logs maintained during their two sessions of system use and this was used to build up a picture of the types of interactions each child experienced with the system (for full information see [4]).

Cognitive or learning styles have been a subject of active interest in recent years [1, 3, 6, 8], for a brief review see [9]. The influence which a learner's style can have upon the way they interact with technology has also been

recognised [7]. Within this literature there are examples of classification systems which differentiate learners according to their learning preferences; for example, as serialists or holists [6]. The analysis of the annotated interaction summaries of children's experiences with the Ecolab software takes a fresh perspective on classification using only the styles of interaction or *Profiles* which can be found in the records of each child's system use and emphasizing our interest in the nature of *Interaction* and *Collaboration*. Characteristics were identified and children categorised through:

- **Interaction Profiles** according to the character of their interactions with the Ecolab.
- **Collaboration Profiles** according to the nature of the collaborative support provided by the system for the child.

4 Results

One aspect of the evaluation looked at whether the different variations of the Ecolab had been more or less effective in increasing the child's learning gain in terms of her understanding of the feeding relationships which exist in a food web as reflected in the pre- and post-test data. This indicated that the system variation (VIS, WIS or NIS) which the child used was relevant to her subsequent learning gain and a detailed discussion of these results can be found in [5]. Here we wish to concentrate upon the analysis of the records of interaction which was used to try and pinpoint the elements of VIS and WIS which led to their superior performance with particular ability groups.

4.1 Interaction profiles.

There were two characteristics which could clearly be seen as either present, or largely absent within the children s interactions. These were referred to as:

- **Busyness** and
- **Exploration**

Busyness was considered to be a characteristic of interactions in which the children completed an average or above average number of actions of any type, such as adding an organism to their Ecolab world or making one organism eat another. The interaction summaries of these children contained an above average number of events. The opposite of Busyness is referred to as **Quietness**.

Exploration was considered to be a characteristic of an interaction if the child had been involved in some sort of action which allowed her to experience more than one level of complexity or more than one level of terminology abstraction, beyond her initial starting levels. The opposite of Exploration is referred to as **Consolidation**.

Some children also switched frequently from one type of interaction to another. For example, they might switch from attempting to make one animal eat another, to looking at their organisms in a different view (i.e. perspective), to accessing a new activity entirely. Their interactions contained no or few series of repeated actions of the same type. They were particularly prone to frequent changes of view. These users have been characterised as **hoppers**. Other learners exhibited a more persistent approach, with sets of actions of a similar type grouped together. These users have been referred to as **persisters**.

These characteristics allow the children to be categorised , in principle, into 1 of 8 (2x2x2) possible Interaction Profiles.

The three parameters of categorisation: Busy/Quiet, Exploration/Consolidation and Hopper/Persister bear some similarity to features found in other categorisation systems. Pask's [6] differentiation of tendencies in learners towards being either "top-down" holists or being "bottom-up" serialists shares some common ground with the Hopper/Persister characteristic, for example. The differentiation of exploration from continuing activity at a level of consolidation is likewise similar to the challenge/safety division of [2]. However, the motivation for the analysis reported in this paper was not the presentation of a generally applicable categorisation system. The aim was twofold:

- To investigate the relationship between interaction style and learning gain.
- To examine how each of the system variations (VIS, WIS and NIS) of the Ecolab supported and encouraged particular learning styles.

Children fell into 6 of the 8 possible Interaction Profile groups. The distribution within these groups is illustrated in Table 2.

Table 2 Interaction Profile Membership

Profile Description	% of children in Profile group
Busy - Exploring - Persister (BEP)	28%
Busy - Exploring - Hopper (BEH)	12%
Busy - Consolidating - Persister (BCP)	8%
Busy - Consolidating - Hopper (BCH)	12%
Quiet - Consolidating - Persister (QCP)	20%
Quiet - Exploring - Persister (QEP)	20%

4.1.1 Examples of User Interaction Profiles

S10 (Gene) was a typical example of the *Busy - Exploring - Persister* style of interacter. Her first action was to switch from world view to energy view and then back to world view. She then added 15 organisms to the Ecolab and visited energy view again. Upon switching back to world view she made one of her organisms eat another, switching to energy view to see the effect. This pattern of making organisms act, either eating or moving and looking at the effect in an increasing number of different views continued. Introductory, investigative and rule-definition activity types were completed for the first two nodes in the curriculum before her first session drew to a close. She chose not to save her current Ecolab world which meant that at the start of her next session her first actions were the addition of organisms. Once again she added all 15 and then moved into the next phase of food web complexity and used more abstract terminology to view her organisms. Whilst the nature of the actions she completed was now more advanced and several instances of help were used, her pattern of activity remained one of initiating an action or actions appropriate to the evident goal. Actions were often completed in pairs and were followed by viewing the result from different perspectives (most commonly, energy, web and world). She did not experiment with writing a program or attempt to escape from completing the activities offered to her.

This profile group contains only high and average ability children from the VIS and WIS system user groups. In terms of performance at post-test there was a tremendous spread: A *Busy - Exploring - Persister* style learner attained the lowest learning gain, another, the second highest learning gain. The high ability children within the group all achieved an above average learning gain, but within the average ability children there was a wider spread of learning gain scores. Membership of this group was limited to VIS and WIS users, of whom the VIS users all achieved above average post-test learning gains, including the highest learning gain within this user group.

4.2 Collaboration profiles.

Two characteristics were found to be the most useful for differentiating collaborative style within the interactions: Amount of support and Depth of support used. These collaboration characteristics were used to group the children into one of four Collaboration Profile groups.

Amount of support: the average amount of activity differentiation (i.e. the degree to which the activity is presented in a simpler form) and the average number of help instances for the experimental group was calculated. An above average amount of either activity differentiation or instances of help was the criteria necessary for a child to be considered as using 'Lots' of collaborative support.

Depth of support: this characteristic was based upon the level of help and level of differentiation used. Once again the average levels used within the experimental group were calculated. Help or differentiation above the average level resulted in a child being considered as using 'Deep' or higher level support.

Interactions could be grouped into all 4 of the possible Collaboration Profiles. The first group was the largest and was further divided in accordance with the type of support which was most prevalent. The distribution of children into these groups is illustrated in Table 3.

Table 3 Distribution of children within Collaboration Profile groups

Profile Description	% of children in Profile	Profile sub-group Description	% of children in Profile sub-group
Lots and Deep (LD)	53%	Differentiation and Help	19%
		Differentiation	19%
		Help	15%
Lots and Shallow (LND)	12%		
Little and Deep (NLD)	16%		
Little and Shallow (NLND)	19%		

4.2.1 Examples of User Collaboration Profiles

S1 (Jason's) use of the available support was typical of the *Lots and Deep* profile group and of a user of above average amounts of both help and activity differentiation. He used level 4 help early in his first session of system use to achieve success in making organisms eat each other. His initial activities were completed with maximum differentiation of level 3. This was gradually reduced and then increased again. During his first session of system use he completed a range of activities for three nodes in the first phase of the curriculum. All instances of successful help were at level 4 or level 5. Fewer activities were completed during his second session. However, these activities were at a lower level of differentiation and there were fewer instances of help.

This Collaboration Profile group was the largest and was subdivided to account for the type of support used. Only VIS and WIS system users shared the profile. Jason was a member of the subgroup which used above average amounts and levels of both activity differentiation and help. This subgroup again consisted only of high and average ability children whose mean learning gain is above the average for the whole class (16% as compared to the class average of 11.5%). The subgroup of children who used greater levels of differentiation than help contained children from all ability groups. This second subgroup also produced above average learning gains at post-test (18% as compared to the class average of 11.5%). The last subgroup of children, who used greater amounts of help than differentiation, were all average ability children. Their average learning gain was well below the class average (3.9% as compared to the class average of 11.5%).

System variation had a greater impact upon the nature of the Interaction and Collaboration profiles than ability. A Pearson Chi-squared statistical test was also used to assess the relationship between the Ability groups, System Variation Groups, Interaction Profile Groups and the Collaboration Profile Groups. There was a significant association between System variation membership and Collaboration Profile membership (X^2 = 28.52, df = 6, $p < .0001$), and also between System variation membership and Interaction Profile membership (X^2 = 25.79, df = 10, $p < .01$).

So far little has been said about the NIS user group, they have not belonged to either of the Profiles used in the examples. In fact, all the NIS users belonged to a Consolidating Interaction profile; there were no explorers in this system user group. In addition, and as has previously been mentioned, no NIS users were in the Lots and Deep Collaboration profile group.

S9's (Tim's) Interaction profile which was that of a Quiet, Consolidating Persister, was typicalof a NIS system user. His initial session consisted of adding a single snail and then making 11 view changes to look at this organism from all perspectives. This initial stage was followed by a series of organism additions (commonly in blocks of 4); single actions, such as move or eat commands, in blocks of 1 to 5; and view changes which were almost always in pairs. In session 2 he adopted the commonly seen approach of adding a considerable number of organisms to start (in this case 12) and then once again completing single actions and view changes.

Likewise S26 (Karlie)s Collaboration profile reflecting low use of all types of help (Little and Shallow: NLND) was typical. She placed herself at the far extreme of food web complexity and started dealing with populations of organisms straight away. She only completed one type of action during both sessions of computer use: she built food webs using the *build web* command. Initially she made errors and used only occasional low level feedback, persisting until successful. The children in this profile group were all of high or average ability, but their average learning gains were well below average (5.2% as compared to the class average of 11.5%)

A further difference found within the NIS user group relates to the relationship between ability and learning gain. In the VIS and WIS user groups it was the higher ability children who achieved the greatest learning gains. By contrast, amongst the NIS users none of the high ability children made an above average learning gain, in fact the only learners who made above average learning gains were the low ability children. Whilst the numbers are small and the study exploratory this result is interesting and is certainly informing our current research. We had expected that of all three systems, the one which left most control within the hands of the learner would be most effective with the more able learners. Our results indicate that the opposite was in fact the case in our study.

5 Conclusions

This is an initial exploratory study with small numbers of children. However, there are several observations which are informative in building up a picture of the sorts of interactions which children experienced with the version of the system they used. VIS was the system which explicitly selected the next curriculum area for the child to complete and controlled the complexity and abstractness of the learning environment. Not surprisingly, all VIS users were members of profile groups with the 'Exploring' characteristic present. The split between 'Busy' and 'Quiet' was almost even. Only two of the VIS users scored a below averagdearning gain at post-test and both were in the same 'Quiet, Exploring, Persister' profile group. The majority ofWIS users were also 'Exploring' profile group members and only one did not belong to a 'Busy' profile group.However, whilst all the WIS above average learning gain achievers were members of 'Exploring' profile groups, the below average achievers were all members of different profile groups, with no common features between all of them. The WIS system variation did not set the curriculum area for the users, but did make suggestions which resulted in it being easier for a WIS user to avoid being an 'Explorer' thana VIS user. The NIS users were the children with the greatest freedom and the least finely tuned help system. It is perhaps not surprising therefore that none of them belonged to a profile group with the 'Exploring' characteristic. They were evenly split between being 'Busy' and 'Quiet' and the majority were 'Persisters'. Only two NIS users achieveabove average learning gains and unlike the WIS and VIS users, both were in profile groups which shared the 'Comfortable' characteristic, they were also both in the low ability group.

These results suggest that simply providing children with the means for extension through becoming involved in challenging activities is not enough to ensure that these challenging activities are undertaken. The child needs also to be explicitly directed towards activities which are beyond her ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity. The success of WIS indicates that a suggestion about what and how to proceed is often sufficient. The consistency within the high and average ability groups across the different systems for above average learning gain achievement to be linked to the 'Exploring' profile characteristic isnot reflected in the low ability group. The definition of the 'Exploring' characteristic may of coursebe too crude to encompass the possibility that the low ability children were 'Exploring' within interactions in a single phase of the Ecolab.

The manner in which each variation of the system collaborates with the child is a design feature of that variation and as such a big influence upon the resultant user Collaboration Profile. It was no surprise, therefore, that there was a significant association between system variation and collaborative support profile membership. However, it is possible, in principle, for a user of any of the variations to interact in line with any of the Collaboration Profiles described. In reality Collaboration Profile 'Lots and Deep' was exclusive to VIS and WIS users, whereas Collaboration Profiles 'Lots and Shallow' and'Little and Deep' were exclusive to WIS and NIS users. The only system which allocated both help and differentiation to users was VIS, so the fact that VIS users all used a high quantity and quality of help is unsurprising. WIS users often used a high level of assistance too, but in smaller quantities, they all belong to profiles where the support used was of a high level. In contrast, all NIS users are in profile groups in which the level of support is low. The choice of help

available to NIS users was admittedly more limited being of only two levels, however none of the users ever chose to use the higher level of help offered.

The absence of some forms of assistance from the interaction summaries of the less successful users offers support for the suggestion that it is the combination of being challenged, or extended, plus the provision of ample quantities and qualities of support which is important for learning. The lower ability children present a somewhat different picture as there is no apparent consistency between the use of collaborative support and learning gain. The only tentative conclusions are that this group responded to interactions in which the extent of the challenge was limited and that the nature of the assistance the system could offer was not effective for them. Those who were successful took up less different types of assistance and tackled less of the curriculum than their successful more able peers. There is also evidence that these children were not good at managing their own learning. The NIS Interaction and Collaboration profiles in particular would suggest that children who are given control for their own learning experience are not good at setting themselves challenging tasks or indeed seeking collaborative support. Our current work with children is investigating this issue in more depth.

Acknowledgments

This research was sponsored by the Economic and Social Research Council. Thanks are also due to David Wood and Yvonne Rogers for useful discussion and insightful comment upon this work, and to the children and teachers of Blacklands School, Hastings for being enthusiastic participants in the evaluation study.

References

[1] Goodyear, P. Njoo, M., Hijne, H. and van Berkum, J. J. A., Learning processes, learner attributes and simulations , *Education and Computing*, Vol. 6, No (3/4), pp. 263-304, (1991).

[2] Groat, A. &. Musson, T., Learning styles: individualising computer-based learning environments , *Association for Learning Technology Journal*, Vol. 3, No. 2, pp. 53-62, (1995).

[3] Kolb, D. A., *Experiential learning: Experience as the source of learning and development* , Englewood Cliffs, NJ: Prentice-Hall, (1984).

[4] Luckin, R., *Ecolab: Explorations in the Zone of Proximal Development* , (CSRP No. 486). School of Cognitive and Computing Sciences, University of Sussex, (1998).

[5] Luckin, R. & du Boulay, J.B.H., Ecolab: The Development and Evaluation of a Vygotskian Design Framework , *International Journal of Artificial Intelligence and Education*, Vol.10, No. 2, pp. 198-220, (1999).

[6] Pask, G., Styles and strategies of learning , *British Journal of Educational Psychology*, Vol. *46*, pp. 128-148, (1976).

[7] Riding, R. &. Rayner., S., The information superhighway and individualised learning , *Educational Psychology*, Vol. 15, No. 4, pp. 365-378, (1995).

[8] Riding, R. &. Read, G., Cognitive style and pupil learning preferences , *Educational Psychology*, Vol. 16, No. 1, pp. 81-106, (1996).

[9] Valley, K., Learning styles and courseware design , *Association for Learning Technologies Journal*, Vol. 5, No. 2, pp. 42-51, (1997).

[10] Vygotsky, L. S., *Mind in society: the development of higher psychological processes* , (M. Cole, V. John-Steiner, S. Scribner, E. Souberman, Trans.). Cambridge, MA: Harvard University Press, (1978).

[11] Vygotsky, L. S., *Thought and language* , Cambridge, MA:MIT Press, (1986).

Implementation of an Internal Execution Simulator and its Application to Computer Literacy Education

Takako SHIMIZU* Mario NAKAMORI and Kanji AKAHORI*****
**Graduate School of Engineering, Tokyo University of Agriculture & Technology, 2-24-16,Nakacho, Koganei, Tokyo, 184-8588, Japan,E-mail:tshimizu@al.ei.tuat.ac.jp*
***Faculty of Technology, Tokyo University of Agriculture & Technology, 2-24-16,Nakacho, Koganei, Tokyo, 184-8588,Japan,E-mail:nakamori@cc.tuat.ac.jp*
****The Center for R & D of Educational Technology,Tokyo Institute of Technology, 2-12-1,Ookayama, Meguro-ku, Tokyo, 152-8552,Japan, E-mail: akahori@cradle.titech.ac.jp*

Today, computer literacy courses in general education are common in Japanese universities. Usually, such courses include word processing and spread sheet calculation, in which the control operation is given by clicking a mouse cursor on a computer display. Students tend to pay attention only to the mouse and the display, which are situated at the most external level of the computer. Thus, it is very difficult for many students to understand what is going on in the internal level of the computer and the present status of learning. The above point of view has led us to the following hypothesis: Observing the movement of data and control of the operating system in the internal level helps students understand the essence, which will be a basis of their further studies on computers. We have designed and implemented two kinds of computer simulators: (1) The one that visualizes the internal execution of a computer, and (2) the one that does not visualize the internal execution. We made experimental uses of both simulators in an actual course and compared the two results. We concluded that the simulator visualizing internal execution has a better effect. Furthermore, we obtained the following result: Presenting the movement of the data and control of the operating system helps students understand the computer operation.

Keywords: **computer literacy, internal execution, computer operation, visualization**

1 Introduction

As the availability of computers increase, more computer literacy education is widely offered at universities, including those departments affiliated with the liberal arts. The instruction offered usually includes how to use word processors, spreadsheets, and how to access the Internet. The operating system used in most cases is Microsoft Windows and the most commonly used input device is a mouse.

It is often observed that students have a perfunctory and vague attitude when responding to their manipulation of fragmentary data appearing on the screen with a mouse. However, if students are able to comprehend what is taking place inside the computer and also have a general idea of the state of the OS (operating system) at each moment, they will be able to understand the fundamentals of the computer operation. This, in turn, would make subsequent learning easier. In other words, the potential of further understanding the computer is limited when only superficial operating procedures are learnt. Therefore, we hypothesized that visualizing the computer's internal operations would contribute to the student's higher understanding of the process, such as how a file is moved to a storage location by the current manipulation, which is one step beyond the computer display. In "The Report on General Information Processing

Education"(1) published by the Information Processing Society of Japan, the importance of computer literacy education is mentioned. However, many universities are struggling to come up with effective teaching methods. (2),(3)

In the past, there were researches done (4),(5) in education that used computers to simulate the computer itself, for example. Further researches on dynamically visualizing the contents of learning include an algorithm animation (6),(7),(8),(9),(10), a program execution and visualization of calculation operations (11),(12),and visualization of OS (13),(14). Most of these researches are concerned with students of computer science, whereas this paper takes up an internal simulation of Windows OS, which is frequently used in the general computer literacy education including that offered to liberal arts students. In this study, a system was developed that simulates computer operations that goes one step deeper than the normal computer "exterior". The authors then carried out an experiment using the system to a group of liberal arts students and evaluated it.

The purpose of this study is to increase the learner's understanding and subsequent learning by providing visualization of the permanent storage, file movement, and the change in OS controls within the computer.

2 Development of the Simulator

2.1 Structure of the Simulator

The computer system used in the simulator includes a computer, display, keyboard, printer, and a floppy disk. Two locations inside the computer are shown schematically; The one is a hard disk, which we will be calling a "permanent storage" in the following sections, where files and software are stored; the other one is a memory area, which we will be calling a "temporary storage", used as working space, where files and software retrieved from the permanent storage are transferred to. The OS used was Windows and the word processing software Microsoft Word was simulated. Visualization of two word processing operations involving,

(1) change in the OS control

(2) file (data) transfer

were devised, and two types of simulators were developed.

The one, which we call type A in the following sections, visualizes the computer's internal permanent and temporary storages along with the previously mentioned computer equipment, and simulates the movement of the Windows OS controls and the file transfer. The other one, which we call type B, simulates only the Windows OS controls and file transfer operations; in other words, the internal parts of the computer is not included in type B.

Furthermore, the learner's use of the simulator can be recorded to show a learning history. Visual Basic Ver. 5 was used as the language for developing the simulators.

2.2 Simulator Functions

2.2.1 Type A Simulator Functions

When the simulator starts, the same environment is presented as when the learner uses MS Word. The input-output devices as well as the computer's internal permanent and temporary storage locations that cannot be seen from the outside are displayed (see Figure 1). Although the data in the permanent storage are maintained even if the power supply is turned off, the data in the temporary storage are lost.

The simulator has a color display in order to make it easier to understand visually. Initially, the entire background is in gray and only the computer display, like the real one, is in black. The color red is used for important items. When the power is turned on, the computer display turns into a light cyan color and becomes ready for operation. At each stage, significant colors are assigned to regions where files and software such as Windows and Word are allocated. The colors are assigned based on the operations and the timing when such operations occur. When the permanent and temporary storage areas become ready for use, the background changes to light blue, and when the software or files are executed, that region's color changes to yellow, and then changes to orange the next time something is added to it. When quitting,

although the area returns to the gray color, if there is text in the memory, the text is shown in black to indicate that it remains as part of the memory.

In addition, an arrow (=>) is employed to show the controls relating to Windows and Word, and another arrow (->) is used to show the file and data transfer.

In the simulator, the internal operations of the computer are reproduced according to the state transitions, and expressed according to the commands contained in Word's File menu. The names of the software, devices and areas are those of the simulator used in the simulator's screen display.

(1) Before turning on the power, the student enters his/her student identification number and name in the spaces on the screen in response to prompts for the purpose of recording the learning history.

(2) Power is turned on.
A red power switch (alternates between "on" and "off") located at the bottom right-hand corner of the display is pushed. Windows starts up from files stored in the permanent storage and the Word icon is displayed at the bottom of the display.

(3) Starting Word
Word is started using the Word icon. The permanent storage, temporary storage, and the display regions for Word are set up. [File (F)] for the file menu appears in the upper left corner of the screen. An arrow is displayed to indicate that the file transfer and the text editing operations are under Word's control.

(4) The work is proceeded by selecting the following prescribed menus from the "File" menu.

- New Document (N)
  Text is input and shown in two yellow areas indicating the temporary storage and the display. An example is shown in Figure 1.
- Open (O)
  The name of the saved document is input into the dialog box that appears on the screen. The saved file is displayed in the temporary storage and the display.
- Close (C)
  The display and the temporary storage are closed. The text of the document located in the permanent storage is displayed.
- Save (S)
  The text is added to the document in real time. It is saved in the permanent storage in the same location as the original document.
- Save As (A)
  When an arbitrary file name is input into the dialog box presented on the screen, the document in the temporary storage is transferred to the permanent storage. An example is shown in Figure 2.
- Print (P)
  The document in the temporary storage is shown for printing.
- Quit (X)
  Word is shut down and the text in the temporary storage and the display disappears. The contents of the permanent storage remain, and the region turns into gray.

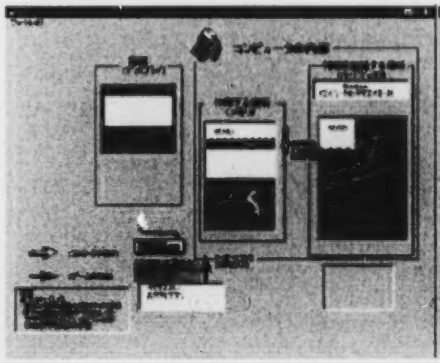


Figure 1 Example of the "New Document" menu by simulator A

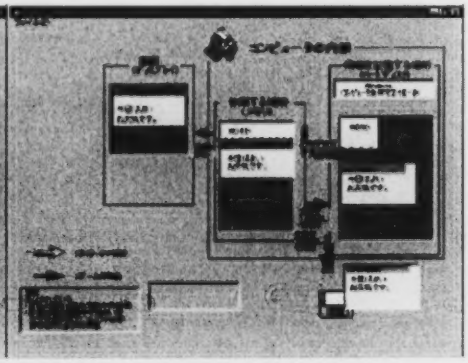


Figure 2 Example of the "Save As" menu by simulator A

BEST COPY AVAILABLE

(5) Quitting Word
To quit Word, the Quit (X) command from the File menu is selected. The learning history during the use of the simulator is saved.
(6) Power is Turned Off
The power is turned off when the power switch is pressed.

2.2.2 Type B Simulator Functions

The display of simulator B does not show the internal parts of the computer including the permanent and temporary storages unlike the previous simulator. Consequently, only the display, keyboard, printer, and the floppy disk that are seen during a normal operation of the computer are displayed. All the simulator functions related to these devices are exactly the same as the simulator A. An example of the "Print" menu is shown in Figure 3.

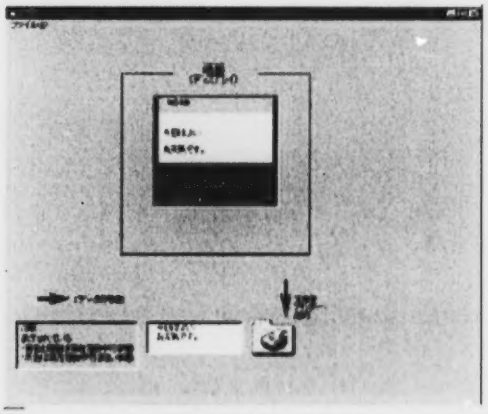


Figure 3 Example of the "print" menu by simulator B

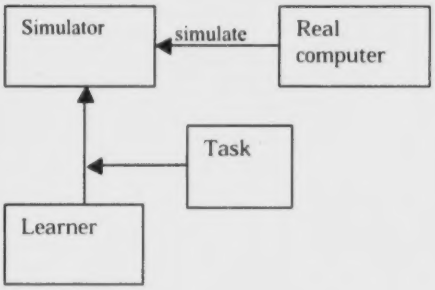


Figure 4 Usage of simulator

3 Experiment Using the Simulator

3.1 Method of the Experiment

Experiments were conducted using the two simulators, A and B. Subjects included 77 students (ranging from freshmen to seniors) from the law department of a private university. The subjects had already learned a word processing application (Word) and how to access the Internet in the first half of the semester in a beginner's computer course. Subjects were divided into two groups, with 39 subjects using the simulator A and 38 subjects using the simulator B. Both groups answered questionnaires prior to their participation, performed a variety of tasks using the simulators, and answered questionnaires at the end of the study. Contents of the questionnaires were the same for both simulator A and simulator B groups. The initial questionnaire asked about the subject's personal characteristics and 16 questions on the use of Word. The post-study questionnaire included the same 16 questions and additional ones related to their final impressions of using the simulator. The subjects were asked to select one of four answers (correct, probably correct, probably incorrect, and incorrect) in order to assess the subject's degree of confidence when answering.

3.2 Description of the Experiment

The following three tasks were given to both simulator A and simulator B groups during usage:
(1) Turn on the power, start Word, input text into a new document, and save the document as a named file.
(2) Open the saved file and print it.
(3) Add text to the saved file and save. Turn off the power.

These tasks were conducted in sequence and performed once without exception. The second time subjects used the simulator, they were permitted to perform any of the available functions they found interesting

without limitation. The usage of simulator is shown in Figure 4.

4 Results of the Experiment

4.1 Analysis of Variance of Results

Scores are analyzed by analysis of variance. The sources of variance included (1) method: the two methods employed in simulator A and simulator B respectively, (2) time: pre- and post-simulator usage, and (3) questions: the 16 questions in the questionnaire.

The answers to the questions were weighted according to the following scheme: Correct (4 points), probably correct (3 points), probably incorrect (2 points), and incorrect (1 point). The analysis of variance is shown in Table 1.

A significant difference of 1% level of significance($p<0.01$) was observed between the methods used for simulator A and Simulator B. A significant difference of 1% level of significance($p<0.01$) was also observed for time and for questions respectively. There was also interaction of 1% level of significance($p<0.01$) between time and the questions. However, there was no significant interaction between the remaining combinations, that is, between method and time, method and questions, or method, time and questions.

Table 1 Analysis of variance in simulator usage experiment

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F	
Method (type A ,type B)	1	5.769	5.769	10.30	0.0013	**
Time (pre,post)	1	14.344	14.344	25.62	0.0001	**
Question	15	312.882	20.859	37.26	0.0001	**
Time*Question	15	23.786	1.586	2.83	0.0002	**
Method*Time	1	0.355	0.355	0.63	0.4262	
Method*Question	15	5.274	0.352	0.63	0.8541	
Mthd*Time*Qstn	15	6.294	0.420	0.75	0.7350	
Error	2400	1343.71	0.560			

**$p<0.01$

An analysis of variance of pre- and post- usage of simulator A and simulator B was conducted using the mean of each subject's total scores. The results are shown in Table 2.

A significant difference of 5% ($p<0.05$) was observed with regards to pre- and post- usage of simulator A suggesting that the simulator experience had a significant effect. The pre- and post- usage of simulator B also showed a difference of less than 10% significant tendency ($p<0.10$).

In contrast, no significant difference was observed between pre-usage of simulators A and B, nor between post-usage of simulators A and B.

Table 2 Analysis of variance of pre- and post- usage of simulator

	pre	post
type A	54.744	57.564
type B	53.579	55.632

(Mean of Tatal score)

type A : Test of the difference between pre- and post- usage

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Time	1	155.13	155.13	5.25	0.0247 *
Error	76	2245.03	29.54		
Total	77	2400.15			

* $p<0.05$

type B : Test of the difference between pre- and post- usage

	DF	Sum of Squares	Mean Square	F Value	Pr > F
Time	1	80.05	80.05	3.32	0.0726
Error	74	1786.11	24.14		
Total	75	1866.16			

4.2 Discussion of Analysis of Variance of the Experiment

As mentioned in 4.1, a significant difference of 1% ($p<0.01$) was seen between simulators A and B. In addition, a significant difference of 5% ($p<0.05$) was seen between the pre- and post-usage of simulator A. Thus, it is regarded that the learners' understanding increased as a result of visually experiencing the computer's internal processes and the movement of files with simulator A. Understanding how files actually move inside a computer in relation to the operations they have already learned may have contributed to clearing learners' ambiguous understanding about how computers handle files. We can therefore conclude that visualizing the internal operations of the computer by simulator A was effective.

On the other hand, there was also a significant tendency in the results of the use of simulator B. The fact that exercising conventional operations in a similar operational environment still had an effective tendency suggests that the use of the simulator helped them acquire a condensed or simplified perception of how the files are manipulated. This could also be understood from the impression gained after analyzing the post-simulator usage questionnaires.

5 Changes in student's understanding for each problem

(1) "Windows" goes into operation at start-up.
(2) "Word" is under "Windows" management.
(3) Text that is not saved will disappear when the computer is shut down.
(4) Saved files can be retrieved again.
(5) "Word" goes into operation by double-clicking an icon.
(6) The document stored inside the computer disappears when it is printed.
(7) In order to protect against lightening, long text should sometimes be saved while inputting.
(8) When a file is closed, the text displayed on the screen or in temporary storage does not disappear.
(9) When a file is opened, it is shown on the display or called to the temporary storage.
(10) When a file is closed, the saved document disappear.
(11) When a file is saved, it is contained in the storage(floppy disk or hard disk).
(12) If a blank screen is saved, the file is empty.
(13) When you quit "Word", the text is displaying on the screen.
(14) When you open a file and change the content, then it is impossible to save again.
(15) You should specify a name when retrieving a file.
(16)• It is not guaranteed that the document is saved when the system or software quits suddenly.•

Table 3 Summary of Questionnaire

The problems were 16 questions relating to the use of "Word". A simple summary is shown in Table 3.

An analysis of variance was conducted with respect to the pre- and post- usage of simulator A. The results are shown in Table 4.

The results of the F-test indicated changes before and after the simulator usage in the following situations.
(1). For simulator A, answers to Q2 (Word is controlled by Windows) showed a significant difference of 1% ($p<0.01$), Q13 (Quitting Word) also showed a significant difference of 5% ($p<0.05$), and Q5 (Word icon) showed less than 10% significant tendency of less than 10%. The post-usage effect of simulator A on questions related to the OS was quite apparent. Use of simulator A is thus thought to be successful since the students were able to grasp the general notion that the application being used was operating under the control of the OS. In particular, correct answers to Q2 increased as much as 60% with respect to the before and after ratio using simulator A, and this increase is far greater than that for simulator B (34%). This result shows that displaying the internal operations of the computer system was highly effective.

(2) Q9 (Opening a saved file) and Q11 (Saving a file) involve retrieving data from and storing data in the permanent storage which are basic file manipulation operations. In simulator A, the permanent storage and transfer operations are visualized, and showed a significant effect with a significant difference of 1% ($p<0.01$) seen for both Q9 and Q11.

Table 4 Analysis of variance of each question
pre- and post- usage of simulator A

Question	pre-typeA Mean	post-typeA Mean	F Value	Pr > F	
1	3.92	3.92	0.00	1.0000	
2	2.95	3.79	37.55	0.0001	**
3	3.56	3.56	0.00	1.0000	
4	3.90	3.95	0.71	0.4020	
5	3.21	3.56	2.90	0.0929	†
6	3.74	3.77	0.07	0.7952	
7	3.28	3.51	1.99	0.1623	
8	2.56	2.46	0.17	0.6838	
9	3.23	3.69	7.30	0.0085	**
10	3.54	3.62	0.21	0.6448	
11	3.51	3.87	7.32	0.0084	**
12	3.00	3.05	0.04	0.8408	
13	3.26	3.62	4.28	0.0421	*
14	3.79	3.74	0.20	0.6585	
15	3.82	3.90	0.77	0.3818	
16	3.46	3.54	0.28	0.5986	

number of samples : 39

** • $p<0.01$

* • $p<0.05$

† : $p<0.10$ significant tendency

6 Conclusions

Two types of simulators that simulate the operation of Word under the Windows OS were developed for the computer literacy education. Operation tests involving 77 university students were performed using both types of simulators. The results indicated that simulator A, which simulated the internal operations of the computer, was more effective.

We believe that when learning how to operate a computer, learning only the operating procedures makes it

difficult to understand the status of the computer at any given moment.

Therefore, in order to help students understand what is going on in the present situation of learning, we developed a simulator that visualized internal executions. The results of the experiment using simulator A, which showed the internal executions, and simulator B, which did not, revealed the following.

(1) A significant difference of 1% ($p<0.01$) was observed between simulator A, which displayed the computer's internal executions, and simulator B, which did not. A significant difference of 5% ($p<0.05$) was seen between the pre- and post- usage of simulator A. It indicates that simulator A was more effective.

(2) Using simulator A, internal operations such as OS control, retrieving data from the permanent storage area, and saving data to the permanent storage area were well understood.

These results indicate that visualization of the internal executions of a computer is effective in computer literacy education.

Acknowledgements

The authors would like to thank Ms.Sari Shimizu for her considerable assistance, Mr.Takayuki Nakajima for his technical advice, and also Ms.Valerie Hansford and Ms.Narumi Shimizu for their useful advice and encouragement.

References

[1] Curriculum committee on the B.A. degree for computer science,"1992 Report on the curricula of computer science for general education (A research project of the Ministry of Education, Science, Sports and Culture)", Transactions of the Information Processing Society of Japan,p.182, (1993).

[2] Etsuko HARADA," Informatics and Computer Science Education for Non-Computer Science Undergraduate Students :Objective and Issues", IPSJ Magazine, Vol.41,No.3,pp.227-233.

[3] Koichi ODA(2000)," Computer Literacy Education in a Communication Department", IPSJ Magazine, Vol.41,No.3,pp. 234-238, (2000).

[4] Takako SHIMIZU, Oichi ATODA, Nobumasa TAKAHASHI,"The Use of EDSAC for an Introductory University Course on Computers and Programming", Transactions of Information Processing Society of Japan, Vol.24,No.3• pp.281-292, (1983).

[5] Takako SHIMIZU, Masahiro ISE, Mario NAKAMORI," An Environment of Laboratory Exercises of Elementary Computer Programming for the B.A.Degree in Computer Science", Transactions of the Institute of Electronics, Information and Communication Engineers A, Vol.J71-A,No.9,pp.1734 •• 1741, (1988).

[6] Stasko,J.T.,"Using Student-Built Algorithm Animations as Learning Aids", ACM SIGCSE,Vol.29,No.1, pp.25-29, (1997).

[7] Brown,M.H.," Zeus:A system for algorithm animation and multi-view editing", In Proceedings of the 1991 IEEE Workshop on Visual Languages,pp.4-9, (1991).

[8] Gloor,P.A.," AACE - algorithm animation for computer science education" , Proceedings of the 1992 IEEE Workshop on Visual Languages,pp.25-31, (1992).

[9] Roman,G.C., et al.," Pavane: A system for declarative visualization of concurrent computations", J.Visual Languages and Computing,Vol.3,No.2,pp.161-193, (1992).

[10] Katsuyuki INOUE, Katsuyasu FURUKAWA, Takeya IGARASHI, Hirotaka UOI, Masaru SUDO, "A Framework and a System for New Style Algorithm Animations", Transactions of Japanese Society for Information and Systems in Education, Vol.15,No.2,pp.55-64, (1998).

[11] Masaaki NISHI,"Learning of Computer System using a Simple Model Computer", IEICE Technical Report,Vol.99,No.332, ET99-43,pp.31-36, (1999).

[12] Ken ISHIKAWA,Mitsuo YAMAGUCHI,"Development of a Computer Simulator Based on Micro-Operations",The Transactions of the Institute of Electronics,Information and Commu nication Engineers A, Vol.J75-A,No.2,pp.422-430, (1992).

[13] Yoshiyasu ITOH,Eiichi HAYAKAWA,Mitarou NAMIKI,Nobumasa TAKAHASHI," A design and Implementation of OS Visualizer for Learning Support", Information Processing Society of Japan SIGOS, Vol.97,No.20,PP.171-176, (1997).

[14] Yusuke NOGUTI,Masataka Goto,Hideo TANIGUTI,Kazuo USHIJIMA," Facility for Visualizing Operating System", Information Processing Society of Japan SIGOS,Vol.96,No.38, pp.55-59, (1996).

The Criteria and Evaluation of Metadata/Keywords in Image Retrieval

Toru FUKUMOTO* and Kanji AKAHORI*
**Department of Human System Science*
Graduate School of Decision Science and Technology
Tokyo Institute of Technology
2-12-1 Ookayama, Meguro-ku, Tokyo, JAPAN
Tel/Fax: +81-3-5734-3233
E-mail: fukumoto@mail.club.ne.jp

Nowadays a large amount of digital images are being stored worldwide in Internet. As an educational means, images stored in Internet have a big potential. Teachers can show the students pictures or images instead of actual things. The Internet is so rapidly expanding and becomes so complicated that the ways to retrieve images effectively from Internet database are now getting more difficult. In this paper we consider an image database about metadata type. We place a special emphasis on keyword itself in the metadata, and show the criteria of keyword, not the framework of them. Good keywords are needed in the database so that the retriever can get what he/she really wants. First we survey the necessity of metadata: especially keyword for image database. Next we consider and present the criteria for consistent and appropriate keywords, distinguishing subjective keywords from objective ones. And we examine and assess them. Furthermore we append a new item, importance, to our criteria.

Keywords• **Image Retrieval, Metadata, Criteria**

1 Introduction

Over the years large amounts of computer-aided images are being stored in Internet owing to widely available digital recording devices, such as digital cameras, scanners, and economical large size storage. For the effective management of those digital images, an image album or an image filing system has the subject of study and it has remarkably developed. And the Internet is so rapidly expanding and becomes so complicated that the effective retrieval methods of images from database becomes more and more important.

As an educational means, image presentation is very important. Because teachers cannot usually bring actual thing into classrooms, they show students the pictures or images instead. Or when the students use the Internet by themselves the images surely help them to learn fast and effectively.

There are 3 kinds of image database: feature type, sensitiveness type, and metadata type. Feature type (cited as [1] and [2]) is based on the colors or shapes of object in the images. When the retriever puts in color or shape, the system starts searching directly the database with color histograms or shape. In the case of sensitiveness type (cited as [3] and [4]), the retriever puts in sensitive words and the system exchanges them for color information and searches the database. In the case of metadata type (cited as [5]), each image in the database is already given metadata, which explains its characteristics by texts or digits, and the retriever searches the database using the metadata.

Our concern in this paper is of metadata type. Of this type, first, database creators define the structure or the framework of metadata. Second, database administrators attach metadata to images according to it in the database. Third, a retriever specifies texts as a key to the database. Finally the database system searches images using the metadata which is given by administrator and also using the texts which are keyed in by the retriever. Examples of metadata are keywords, texts, classification items and so on.

The metadata of image database system metadata needs consistency and appropriateness. If it often happens

that some of metadata are irregular or incomplete, the retriever cannot find images which he/she really wants. Especially of commercial systems, the reputation of the database is determined by the quality of metadata.

We place special emphasis on keywords in the metadata because they are the basic component of metadata. In Section 2 the necessity of metadata, especially keyword of image database, is discussed. In Section 3 the criteria of consistent and appropriate keywords is considered. In Section 4 the criterion, which we discussed in Section 3, is examined. In Section 5 our conclusion is presented and the future work is discussed.

By the way, we are not concerned here the structure or the framework of metadata. It needs another consideration. In ISO, the structure of metadata for multimedia contents description, MPEG-7 [6], is now being standardized. MPEG-7 will provide the distribution and utilization of multimedia contents with content-based retrieval. The application will be distance learning, a stream database, a personal TV, and so on. MPEG-7 will become International Standard at September 2001.

2 Metadata and Keyword

Good metadata is needed in the database so that the retriever can get what he/she really wants. In storing database with images, we give texts, especially words as metadata to them. These words can be defined as keywords. They are given to images and used when a retriever searches the database. Database system searches images based on keywords which he/she specifies.

Therefore when incompatible keywords are given to images in the database, a retriever cannot get images which he/she really wants, even if he/she puts in any compatible keywords. In next Section we show the criteria of good keyword, which discussed and experienced before in [7].

3 The criteria of keyword

We shall discuss the criteria of keyword in detail.

- Giving <u>appropriate</u> keywords

  A retriever depends only on keywords. Therefore the images need to be given beforehand the keywords which represent them precisely. For example, we should distinguish "people" from "doll" because he/she may really want the image of a doll, not of people. Or it depends on the retrievers of the database which is appropriate "car" or "BMW". The database administrator should expect how the retriever uses keywords when he/she gives keywords to the image.

- As <u>many</u> keywords as possible

  An image has a lot of views. For an example, in Figure• ; some people takes it for the figure of pond, some of others for monument. Obviously only a single keyword is not adequate to describe its whole concept.

  Therefore, a number of keywords should be given to an image so that it can precisely correspond to the keywords. The retriever can more easily obtain the images which he/she really wants.

- Distinguish <u>subjective</u> keywords from <u>objective</u>

  We can define a lot of keywords for one image. They may be divided into two types. One is objective; the other is subjective. In figure• ; objective keywords are, for example, "pond", and "monument". Whereas "summer" and "shine" are subjective factors, because they are viewer's impressions of this image. They are subjective keywords. The former is more general than the latter.

You might think that you need only objective keywords. However, a retriever's needs are generally divided into two types: subjective and objective. In Figure• ; he/she wants a summer picture. "Summer" is a subjective word. If the database does not have subjective keyword, he/she cannot find such an image. He/she must hit objective keywords instead of "summer". Accordingly there are subjective needs in so many cases that subjective keywords are to be needed. For this reason, both subjective and objective keywords are needed in an image database.

And subjective keywords are to be distinguished from objective ones. Here is an example. A retriever wants

an image of "sea atmosphere". In a database, one image represents the impression of sea, that is, "beach". The other image represents the sea itself. When he/she specifies a keyword "sea", the database system searches an image with keyword "sea". It hits two images: the sea itself and the beach. However, what he/she really wants is the sea image, not a beach one. So that a subjective keyword should be given a subjective marker in the database, to distinguish it from objective one. The retriever finds the image more easily and precisely by putting in the keywords with a subjective marker. Such is the criteria of keyword.

4 Examination and Assessment of the criteria

We examined above mentioned criteria to assess the effectiveness.

We arranged seven persons (5 males and 2 females; all adults). First of all, we showed them our criteria discussed in Section 3 as a book-style. We call it "keyword book". Next, we show them 20 images, one per one paper. The contents of them are sight, animals, texture and so on. We included pictures of various image types. We scanned, digitized and printed pictures by a color laser printer. Then we let them give keywords to these images. They gave keywords to the images referring the keyword book as many as they liked. We did not limit the number of keywords for each image.

Finally we let 3 specialists give keywords to same images separately. And we compared the former keywords (by 7 persons) with the latter keywords (by 3 specialists) so that we might assess the contents of both keywords. In the following section we discuss about the result of this examination.

4.1 Number of keywords and the appropriateness

The result of our experiment are presented in Table• ; Total number of keywords is 416 for 20 images. In average there are about 21 keywords for an image. The relationship of keywords and object in each image is roughly as many. The specialists added total 103 keywords to those given 7 persons.

It is the tendency that specialists give keywords to the small objects in each image. Especially there are a lot of objective keywords, which are given to images that has many objects. 7 persons and 3 specialists gave the same keywords to Figure• ; But to Figure • •7 persons gave only 5 keywords: while 3 specialists did 29. And the keywords by 7 persons are different from the ones by 3 specialists.

The keyword is for retrieval. We need not say that keywords should be given to as many as possible to improve the preciseness simply because the objects in the image are very small. Generally the more keywords the image is given, the easilier it can be searched out. But, on the contrary, from the point of appropriateness, we claim that the images should be added the information regarding the objects in it; for example, how large it is, or what impression a person has when he/she looks at it. This is to help the retriever to obtain the image which he/she really wants. The database should have such information. However, there is no information about them in our criteria.

It follows that an index is needed to show the importance of keywords or square measure of objects in the image: for example, the keyword "monument" and importance "3", or monument has one-fifth (of the image).

To the images that cannot be distinguished by the object such as texture and patterns, the keywords of 7 persons vary widely compared with ones by specialists. For example, in Figure • •7 persons gave "red", "water-drop" and "discomfort". The object in it is so hard to define that they are difficult to give keywords to this texture and pattern. In educational situation, this is a serious matter because students are not generally able to hit such keywords to retrieve them. In short, we point out that metadata type is of limited use when images are given in pattern or texture style. So that it seems reasonable to say that feature type retrieve is better for them than metadata type.

4.2 subjective/objective keywords

In Table• ; subjective keywords are 81, 21 % of total keywords. And the specialists gave 7 subjective keywords, which is 10 % of 7 persons' keywords. On the other hand, the specialists gave 96 objective keywords.

Regarding subjective keywords, there is little difference between 3 specialists' and 7 persons'. On the contrary, regarding objective keywords, 3 specialists' are different from 7 persons'. In addition to this, 7 persons' keywords are lacking of uniformity. There are only a small number of common subjective keyword that both 3 specialists and 7 persons.

Therefore it follows that there are limited words that express the character of images subjectively. The number of subjective keywords using these limited words is so small. On the other hand, regarding the objective keywords, 7 persons mostly attached them to even the objects which occupy the main part of the image, while 3 specialists gave them to even the small objects. We may say that that caused the increase of their keywords.

	Total	Subjective	Objective
Seven Persons	313	74	239
Three Specialists	103	7	96
Total	416	81	335

Table• •Number of Keywords

4.3 Discussion about our criteria

As mentioned above, we must modify our criteria because they will be to include the importance of each keyword.

• Appropriateness• The database administrator should expect how the retriever uses keywords when he/she attaches keywords to the image. As mentioned above, he/she distinguishes or identify "car" w..a "BMW". If the database is for general use, both general noun "car" and proper noun "BMW" are also given.

• Number of keywords• It needs the number of object that the image has and at least one subjective keyword which express the characteristics of image.

• Importance• It newly is appended our criteria. Importance: 3 is that the object is very large in the image or that it express the characteristics or the main theme of the image. Importance 1 is that the object is as small in the image as people try to find. The other object or character in the image is importance 2. For example, in Figure • ; keyword: keyboard, importance: 1; keyword: PC importance: 2 and in Figure• ;keyword: cat, importance:3.

• Subjectiveness/objectiveness• objective keywords should be given for all object in the image and subjective ones are given to at least one word for the impression by the image. Each keyword is appended subjective/objective marker or one s coded to numerically.

5 Conclusion

In this paper, we considered and the criteria of metadata, especially keywords for image database and image retrieval. We emphasized importance of consistency and appropriateness. We examined the criteria by experimenting 10 testers and verified them. And we added a new measures, "Importance" to our criteria

When a lot of persons give keywords to images, such criteria are indispensable. In our future study, we will concerned and define the structure or the framework of metadata. Furthermore, We will integrate metadata type and feature type for pattern or texture.

In the future, we hope that multimedia retrieval with metadata will be much easier for all people. So the teachers will be able to utilize more accurate images in education, and the students will be able to easily retrieve images from Internet.

References

[1] Kazuhiko KUSHIMA et.al., "Content based Image Retrieval Techniques based on Image Features", Trans. IPS. Japan Vol.40 No.SIG3 (TOD1), pp.171-184 (1999).

[2] M.Flickner et.al., "Query by Image and Video Content: The QBIC System", IEEE Computer, Vol28 No.9pp.23-32 (1995).

[3] Haruo KIMOTO, "An Image Retrieval System Using Impressional Words and the Evaluation of the System", Trans. IPS. Japan Vol.40 No.3, pp.886-898 (1999).

[4] Shoji TANAKA et.al., "A Study Concerning Automatic Addition of Impression Keywords to Natural Images", Tech. Report of IEICE HIP96-20, pp.19-24 (1996).

[5] Yasushi KIYOKI et.al., "A Semantic Search Method and Its Learning Mechanism for Image Databases Based on a Mathematical Model of Meaning", Trans. IEICE Japan D-• Vol.J79-D-• No.4, pp.509-519 (1996).

[6] MPEG Web Page: http://drogo.cselt/it/mpeg (accessed on July 1, 2000).

[7] Toru FUKUMOTO, "The Keyword Attachment Reference for the Integration of Image Retrieval", Conference Proceedings of the 1999 Conference of Japan Society for Educational Technology, pp.169-170 (1999).

[8] Hiroaki OOBA et.al., "Image Retrieval by Natural Language", JSAI SIG-HICGT-9202-4, pp.25-34 (1992).

Figure• • an example of image

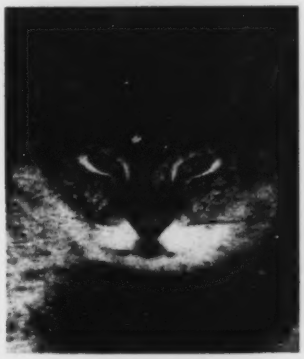
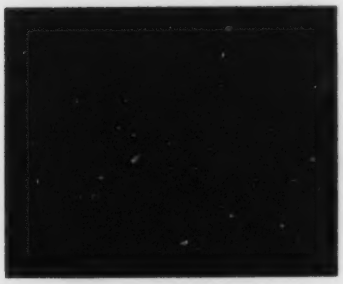


Figure • • image with one object

Figure• • image with many objects



Figure• • Texture

The Research on Difficulty of Asynchronous Learning Materials Based on Studying Time Distribution

Wu-Yuin Hwang and Rueng-Lueng Shiu
Information and Computer Education
National Kouhsiung Normal Univeristy
wyhwang@nknucc.nknu.edu.tw

The purpose of asynchronous distance learning systems is to enhance students' learning performance in the internet. In this paper, we investigate the characteristics of the asynchronous materials and propose the criteria to evaluate them. Employing the criteria, the materials could be adjusted to meet most students' learning pace. First, the TDC (time-distributed curve) which is a learning curve is derived from students' studying time distribution. By the TDC, it is obtained that the more difficult the materials of the chapter are the steeper the TDC becomes. Also the total learning time of each chapter indicates the quantity of the matter. Employing the total time of each chapter, we could evaluate whether the quantity of the matter is sufficient to match students' learning desire.

Keywords: **distance learning· learning portfolio· learning behavior· learing time distribution**

1 Introcduction

1.1 The distribution of learning time with learning attitude

Teachers could interact with their students immediately at the classroom. Thus, they could get the learning behavior of their students by students' response. The learning behavior is regarded as a good measure to evaluate learning performance. But it is really hard to obtain every student's learning process and attitude because there are at least 30 students in each class. However, employing the database technology in asynchronous learning systems, it is possible to obtain all of the student's learning process and studying time.

1.2 Learning time distribution

In traditional education, students learning together in the classroom at the fixed time, and teachers control the course proceeding. But it is difficult to pay attention to all students. However, asynchronous learning systems not only provide a brand-new perspective to long-life learning but also keep track of learning time of all students. In accordance with the learning time of all students, teachers could modify the matter to match learning goals.

2 Experiment and analysis

The experimental course in our asynchronous learning system is "Basic computer concept", the materials of the course are divided into 12 chapters. The progress-control mechanism is that students need to finish the homework of the chapter in order to be promoted to the next chapter. Thirty participants engage in this experiment and they are all teachers.

The student' s learning time and login time are recorded by technologies of ASP(Active Server Page) and Database. Therefore, we could get which chapter students read and how long they read the chapter. The important curve, Time-Distributed Curve (TDC), is generated by linear regression analysis. From the slope and the area of TDC, some characteristics and results are obtained.

2.1 TDC and DCA (Degree of Course Acceptance)

Student' s reading time each chapter is recorded in our experiment. The recorded time begins from the date when the teaching materials are put in the internet for 15 days. In each chapter, all of the student' s learning time everyday is summed up.

Employing the recorded data and derived chart, each chapter has a unique TDC (time-distributed curve) by linear regression analysis. According to the time-distributed curve, teachers may decide whether the materials should be improved.

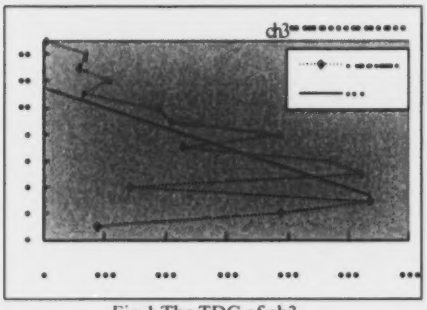


Fig.1 The TDC of ch3

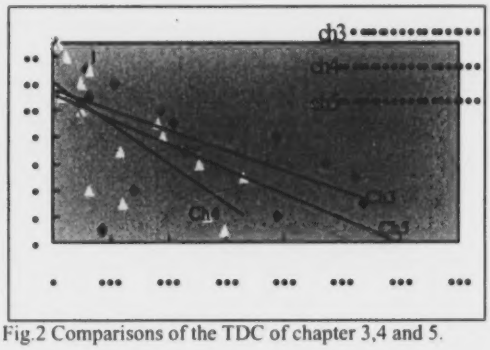


Fig.2 Comparisons of the TDC of chapter 3,4 and 5.

In Fig. 1, the X axle indicates time value and its time unit is one minute not an hour and The Y axle indicates days. For example, the total time on the 4th day is approximate 150 minutes. The slope of the TDC is minus because the total studying time would decrease while students proceed to study the matter.

The value of the slope is required to be concerned. The larger the value of the slope is, the smoother the TDC becomes. For example, figure 2 made comparisons of the TDC of chapter 3,4 and 5. Obviously, the TDC of chapter 4 has the smallest slope because it is the steepest one. And the TDC slope of chapter 3 is slightly larger than that of chapter 5. Thus, it is the most difficult to read chapter 4 and it is the easiest to read chapter 3. The reasons why the materials are hard to study may be either the materials are complicated or the user interface is not friendly to read. According to the above description, the slope of TDC could be termed as Degree of Course Acceptance (DCA, It means the harder the topic to read the smaller is the DCA.)• Besides the TDC' s slope is proposed to determine the degree of materials acceptance, there is another important characteristic, the area of the TDC, to influence the amount of learning time.

Based on the area and slope of TDC, the difficulty and quantity of the materials could be evaluated. According to the above description, it is shown that the quantity of materials would affect the amount of 'earner' s studying time, also the difficulty of materials would affect the length of learning period. Due to these reasons, there are two margin lines, quantity and difficulty, in Fig. 3. The two margin lines are termed e are "Margin Line Of Quantity (MLOQ)" and "Margin Line Of Difficulty (MLOD)". There are plentiful materials on the right of MLOQ, but there are poor on the left side. The upper of MLOD the materials are located the harder they are read, but lower are easy.

Since the features of MLOQ,MLOD,DCA and the area of TDC are proposed, there are four kinds of situations that the TDC represents as follow:

1. It is easy to read the material, and the contents are plentiful.
2. It is easy to read the material, but the contents are poor.
3. It is hard to read the material, but the contents are poor.
4. It is hard to read the material, and the contents are plentiful.

BEST COPY AVAILABLE

The MLOQ and MLOD could be employed to enhance discriminating the difficulty of the materials if the DCA and the TDC's area of the chapters are different. Finally, how is the value of the MLOQ and MLOD obtained? The MLOQ is the average of all students' learning time of one chapter. The MLOD is the average of all students' learning days of one chapter.

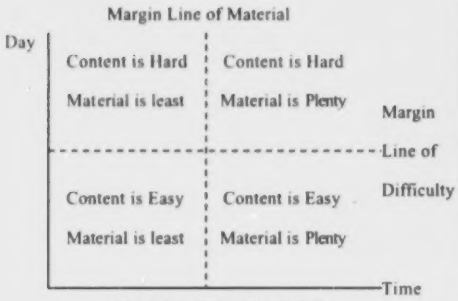


Fig.3 MLOQ and MLOD

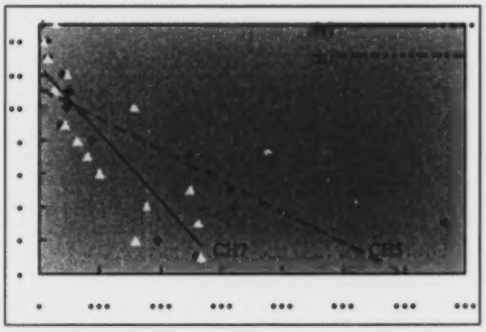


Fig.4 Compares the TDCs of the ch5 & 7

2.2 Time distribution of the interdependent course

What else may affect one's effort in the course? There are relationships between two topics. For example, there are relationships of dependency between chapter 5(Internet I) and 7(Internet II). Generally, the topic "Internet I" is dedicated to construct the fundamental concept and "Internet II" introduces the advanced ideas and practice. According to the normal teaching policy in both topics, the "Internet I" should have fewer and simpler materials than the "Internet II". Thus learners spent much less time to study "Internet I" than "Internet II".

Fig.4 compares the TDCs of the two chapters. As shown in Fig. 4, it is easy to find out chapter 7 has a smaller DCA (the slope of TDC), that is, chapter 7 is harder than chapter 5. Furthermore, the area of chapter 7 is less than that of chapter 5. The TDC of chapter 5 is located at approximately 11 on Y axle and 600 on X axle and the TDC of chapter 7 located at 12 on Y axle and 280 on X axle. According to MLOQ and MLOD as shown in fig.3, we concluded that "The chapter 7 is more difficult than chapter 5, but its quantities are much less". It is different from we described before, "Internet I" should have fewer matters than "Internet II". In our experiment, we provided much more contents in chapter 5 than chapter 7. Therefore the amount of materials in chapter 5 should be reduced.

3 Conclusions

The asynchronous learning service is an on-line collection of hypertext that provides us a new way to learn. Their students with different native intelligence come from any place and go to learn when they would like. It is very important to design and evaluate the asynchronous teaching matters so as to match teaching goals. This paper proposed some basic criteria to investigate the characteristics of teaching matters, then gave an advise to modify them to meet the learning desire. The basic criteria, the area and slope of TDC, are derived from learning time distribution. Through the basic criteria, instructors could modify the materials in accordance with most students' learning pace and talent. Especially, our proposed mechanism is worth much attention to develop the adaptive learning system. Once the asynchronous learner's studying portfolio is available, the materials could be real-time adjusted to match the learner's state.

Reference

[1] • • •

Which Chinese Input Methods Is More Suitable for Sixth-Grade Pupils? Keyboarding or Non-Keyboarding

Weichung Wang* and Tainshu Ma
Department of Mathematics Education, National Tainan Teachers College
Tainan 700, Taiwan
**E-mail: wwang@ipx.ntntc.edu.tw*

Computers have been wildly used in elementary schools and to input characters is usually necessary while manipulating computers. However, inputting Chinese characters is a burden for Taiwanese pupils. Keyboarding is a traditional method used for inputting Chinese characters. On the other hand, other user-friendlier input tools like speech and handwriting recognition provide alternative choices. We observe three 12-year-old pupils, who have different backgrounds, how they use these different methods to input Chinese characters. Experiments results show that all three pupils make progress after short-time practice for all input methods. Different pupils, however, would choose different input method depending on their own preference and background.

Keywords: **Chinese input method, keyboarding input by pronunciation, speech recognition, handwriting recognition**

1 Introduction

Computers have been widely used in many educational applications like computer-aided learning. For a pupil in Taiwan, one of obstacles that he or she may encounter for using computers is to input Chinese characters.[1] In this study, we intend to explore pupils' behaviors on Chinese characters inputting and then make recommendations in under what conditions what kind of input methods may be used.

Keyboarding and non-keyboarding are two main categories of characters input methods. For keyboarding method, users type Chinese characters either according to their pronunciations or by "dismantling" the characters. For the non-keyboarding methods, handwriting and speech reorganization are two popular methods for inputting Chinese. While keyboarding has been used for longer time and almost always each computer is equipped with a keyboard, non-keyboarding input methods are developed recently and extra equipments and software are needed.

When keyboarding is used, most students input each single Chinese character by spelling its pronunciation.[5] Main reasons are: (1) Students are familiar with the pronunciation. What they have to learn is to memorize the position of each key on the keyboard corresponding to the pronunciations. (2) Psychology indicates that human beings think in the form of tone (of characters), but not the font of the characters.[4] However, disadvantages of this input method exist. (1) Students may not spell pronunciation correctly especially when they encounter new words. (2) Many different Chinese characters have same pronunciations.[3,7] Pupils thus need to choose the target character and the input speed is slowed down. Non-keyboarding input methods, especial the voice reorganization, is one of the hottest research topic in computing. People use natural ways like handwriting or speech to communicate with computers. The computers then analyzed the data to identify what people mean and output the data in a text format.[6]

We conduct the study to find out pros and cons of each input methods. Three sixth grade (12-year-old) students with different computing backgrounds are chosen, based on interviewing and simple tests. Student A has a lot of computing experience, student C has little computing experience, and Student B is in between. All three students come from National Tainan Teachers College Affiliated Primary School. For keyboarding input, they use the input method of spelling words' pronunciation that is included in the Windows 98

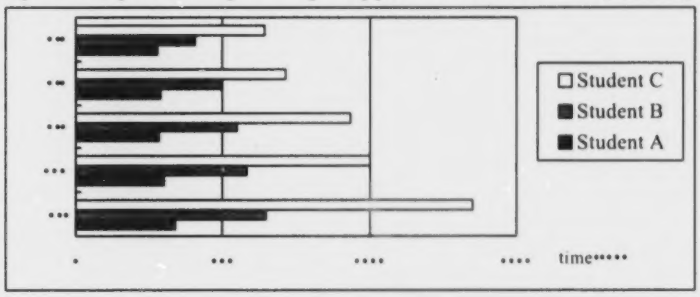
operation system. For handwriting reorganization, they use "Pen Power Jr." For speech reorganization, they use the product named "IBM ViaVoice." The essay that students input is extracted from the newspaper China Times. There are 142 characters in the essay. To evaluate the performance of different input methods, each pupil has five chances to input the Chinese essay by pronunciation based keyboarding, speech reorganization and handwriting reorganization. Between each of chance, they have a period of 30 minutes to practice. In the next section, we summarize our observations and statistical results toward the problems in each of the sub-sections.

2 Findings and discussion

2.1 Can short-time trainings improve performance of pronunciation based keyboarding?

Figure 1 shows timing in seconds that student A, B, C took to finish the essay in five trials. They are asked to input all characters correctly. All three pupils made progress for the short-time practice. Comparing the first and the fifth performances, we found that student A, B, and C had 19%, 37%, and 53% of progress, respectively. Although student A made less progress, the student actually finished the essay quickest. Beside, students A, B, and C had an average progress of 16, 60, 178 seconds. We noticed that both student B and C kept making progress, but student A had a downgrading performance from the third to the forth trial. The difference between the third and forth trial for student A, however, is not significant. Based on the experimental results, we conclude that short time training does benefit three students in different background. Furthermore, the student with the least computing background actually made the most significant progress.

Figure1. Comparison of input timing using pronunciation based on keyboarding.



2.2 How does the speech recognition input method affect the input efficiency?

Figure 2 shows the percentage of the speech recognition software correctly identify the characters. Both student A and B perform similar from the first to the fifth trial, while student B tends to be better in the first of four trials. Besides, student B makes a great progress from the first trial (77%) to the second trial (92%). Student A and B reached a 100% correct recognition and student C achieved almost 90% correctness. This suggests that, after reasonable training, students with different background can manipulate the speech input method nicely.

Figure 2. The correct recognition percentage of speech recognition.

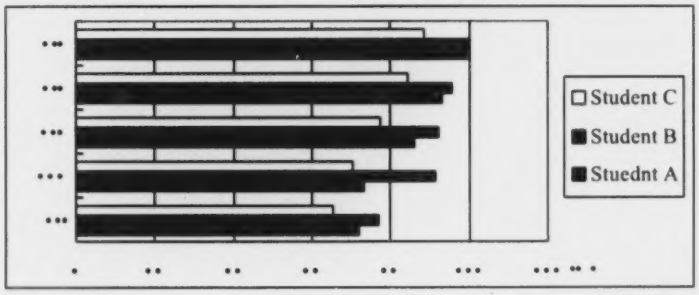
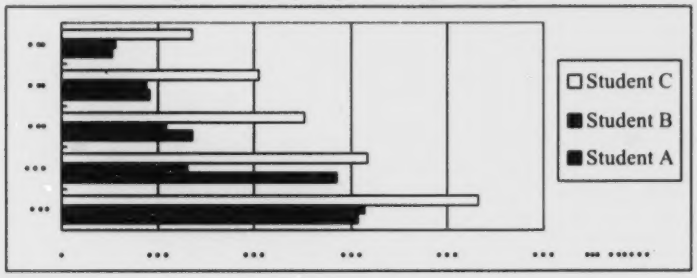


Figure 3 demonstrate timing the pupils took in five trials with emending the wrong characters. When the correct recognition rate is high, the input method can be very efficient, about 160 characters in one minute for student A and B. However, this is not a universal situation. Take student C as the example, the pupil speaks in such an ambiguous tone that the computer simply could not correctly recognize the essay. As the result, the student spent a lot of time to emend the wrong characters and greatly slow down the speed of inputting. Such observations show that there is room for improving the correct recognition rate.

Figure 3. Timing of speech recognition input.



2.3 How does the handwriting recognition input method affect the input efficiency?

Figure 4 reveals the percentage of the handwriting recognition software correctly identify the characters. Both student A and B perform similar from the first to the fifth trial, while student B tends to be better. Besides, student B reached 100% correct recognition at the last two trials, and student C achieved 92% correctness. This suggests that, after reasonable training, students with different background can manipulate the handwriting recognition input method nicely.

Figure 4. The correct recognition percentage of handwritten recognition.

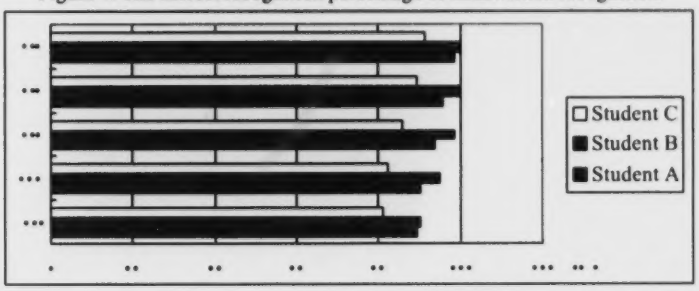
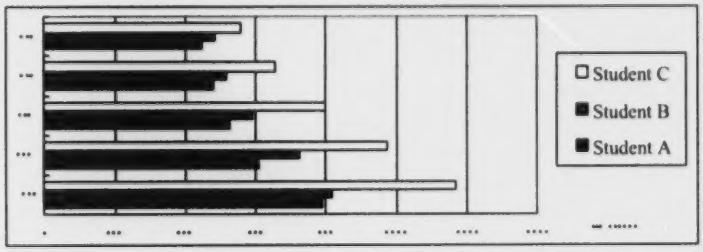


Figure 5 demonstrate timing the pupils took in five trials with emending the wrong characters. We find that both student B and A perform similarly and nicely, though slight differences exist. Main reason why student B outperforms other two students at the correct recognition percentage is the way he wrote Chinese characters. Student B usually writes in a way that the characters strokes are clear and distinct. In contrast, student C tends to write Chinese characters apart and thus make the software consider as several words. Furthermore, student A writes very fast and his written characters strokes are also clear, though a little behind the ones of student B. This characteristic affect the timing of input, while the correct recognition percentage of student A is lower than B, he should took more time in inputting, instead, the timing of input with emending is less than that of student B.

Figure 5. Timing of handwriting recognition input.



2.4 For different students, how the input methods help students to input more efficiently?

For student A, to use keyboarding as input tool is better than the one by non-keyboarding. Because he is familiar with keyboarding and input Chinese even becomes a basic ability as using computer.[2] So that in the test of keyboarding, he exceeded others very much at first, but just for the same reason, he could not make further progress. In inputting by non-keyboarding methods, he did not do such a good job as keyboarding. Take speech for instance, everyone spent almost the same time when they did not need to emend the wrong words, but he spent much more time then student B when emending is needed. Similar result can be found for handwriting method. The recognition rate of student B is better than A.

For student B, to use non-keyboarding as input tool is better than the one by keyboarding. One reason is that he is not as familiar with keyboarding as A does. He usually uses computer to play games or surf the Internet. He actually just needs to use mouse as a tool to communicate with computer. In keyboarding, although his effect is not better than student A, but he has a better progress than student A. If non-keyboarding method is used, no matter speech or handwriting, he did a better job than student A and C. We emphasize that, these three students never use speech or handwritten before, and the result shows that the learning effect of student B is better than the other two students.

For student C, to use keyboarding seems better than non-keyboarding. He made a better progress in keyboarding. In input method of keyboarding, at the last time of test, his input time was even less than that of student B's first trial. This result showed that after short-time training, student C made the greatest progress in keyboarding (53%). For non-keyboarding methods, student C seems had difficulty to adjust his speech tone and handwriting to fit the software. But we think this is the place that software developers should work on. It should be the software developers' responsibility to develop software that is capable of adapting different speech tone and handwriting habit.

3 Conclusions

We have observed the behaviors of using keyboarding and non-keyboarding Chinese input methods. We suggest the following. For students who are familiar with computer and takes inputting as a basic skill, like student A, keyboarding best fits. For those who learn new things very fast, are interested in them, and speak or write well, (like student B) then the non-keyboarding is fit. For a student like the C, who does not learn new things very well and maybe he does not speak or write well, and he is used to input by keyboard, then the keyboarding is fit.

References

[1] Chen, Y.L., "The Input Method of Speech Recognition-Make You Speak Aloud", PC Computing, pp. 3-18, (1999).

[2] Ho, Rong-Guey and Wang, Hsue-Yie and Shyu, Huey-Jiun. "An Adaptive Strategy on Keyboarding: Using Adaptive Drill System Model", http://content.edu.tw/primary/info_edu/tp_tt/content/other/paper2.htm, (1997).

[3] Li, M.C., "The Development of Input Method by Words' Pronunciation", Information and Education, No. 30, pp. 18-22, (1992).

[4] Richard E. Mayer., "Educational Psychology", Taipei: Yuan-Liou, 3rd Edition, (1997).

[5] Suen, D.S., "Let's Use The Special Input Method", Info. Com, No. 218, pp. 91-93, (1998).

[6] Tzeng, U.M., "The Development and Application of Speech Recognition in Computer", Information and Education, No. 52, pp. 10-13, (1996).

[7] Wang, C.F., "The System of Chinese Speech Recognition in Computer", Information and Education, No. 52, pp. 2-8, (1996).

The Usability Aspects of an Universal Brokerage and Delivery System for the Pan-European Higher Education

Borka Jerman-Blažic
University of Ljubljana, Faculty of Economics and Jož ef Stefan Institute
Jamova 39, Ljubljana, Slovenia
Borka@e5.ijs.si

This paper gives short overview of a recently launched EU project for universal exchange of university course units for the higher education based on a brokerage and delivery system model. The basic components and characteristics of the approache are described. More attention is given to the approach that will be used for assesment of the innovation and for evaluation of the learning and educational achievements.

Keywords: **distance learning, brokerage and delivery system**

1 Introduction

The new technologies are transforming the ways business operate and the ways people work. They are also reshaping the expectations, needs, and opportuniies in education and learning. The customers of the education market are forcing the education to become demand-led, rather than production driven. The current technologies are providing basis for a new just in time, on demand approach the electronic educational products to be offered by virtual or classical universities through special platforms acting as intermediaries between the consumers and the suppliers of educational material. It is clear that the new tecnology alone will not make this new model of more efficient education to happen by itself. Rather, new innovative models of production, brokerage, delivery and presentation are needed that will put together the participants of the education process to collaborate globally and to use the advantages of the powerful technology.

The European project »UNIVERSAL-brokerage and delivery system for exchange of university course units for the Pan European Higher education« [1] is one of the attempts this model to start to work. The project is part of the Vth Framework program of User friendly information society [2] funded by the Commission of European union. The project started in March this year and will last 3 years. The conzortium of the project is large as it encompassess 17 partners from EU[3], among them twelve higher education instituitions from all over Europe, two research organisations, one SME[4] and two telecom service providers. The consortium has also partners from outside Europe as the model developed is expected to have global applications. These are: the Moscow research institut, HEC from Montreal and Nanyang Technological University from Singapore.

The model and the implementation in UNIVERSAL is based on an education brokerage and delivery system being developed to incorporate training by provision of valued-added services to both the customers of the system and the suppliers of the educational material. The major characteristic of the system is offer of different types of learning and delivery of the educational material and its distributive nature. There is no central site for delivery of educational material. Additional characteristic of the model is the system that will be developed for pan-european acreditation of the purchased and performed university course units by the participants belonging to institutions of the European higher education system. At this early stage of the

[1] UNIVERSAL –IST-1999-11747
[2] URL:http://www.ispo.cec.int
[3] EU stands for European Union
[4] SME- Small or Medium Size Enterprise

project is not possible to predict all expected circumstances and consequences that such system may have in the furure development of the educationa nad training. Brokergae approach in provision of distance education must first address a number of technological and educational issues which are part of the UNIVERSAL work program. In depth discussion of the pedagogical paradigms that may take place as well as te number of technological issues of the work program are not possible to be discussed in this article because of space restriction. Here, we concentrate on the basic characteristic of the model; highlithing the implementation scenario and giving more information about the usability aspects of the technology that will be evaluated through monitoring of the educational.

2 The model and the architecture of the system

The model being developed is based on creation of an open, cross-border, educational market environment coupling brokerage and delivery of "live" and "packaged" [5] courses. The proposed framework accommodates and adds value to the various business models and course structures employed in European HEI[6] institutions. It will enable:

- a single faculty wishing to experiment with the simple import of external material to enrich a specific course,
- an existing alliance between institutions to make their exchange more efficient and to enrich it with types of course units not previously exchanged,
- an Open University to extend the range and depth of its courses.

The UNIVERSAL brokerage platform is an interactive hypermedia environment offered to the academics and administrators of European educational institutions to plan and select courses. It de-couple offers and course units provision on the supply side from enquiry, booking and delivery on the demand side. The most important element that enable this de-coupling is the catalogue of offered educational material and the supporting processes, that adequately describes all the properties, educational and technological of the course units. This approach is implemented as brokerage platform and a number of delivery platforms, see Fig.1.

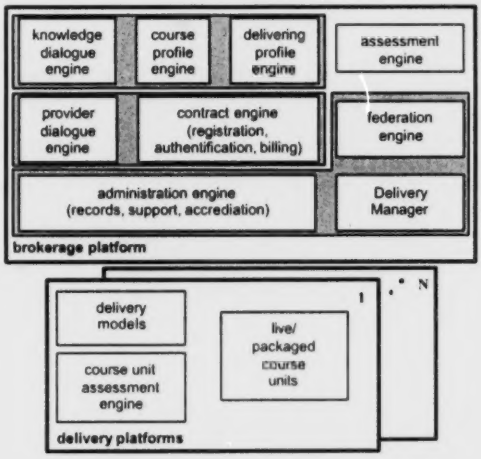


Fig.1 The general architecture

The brokerage platform is further divided in a customer part, a provider part and an administration part. In the customer part, a knowledge dialogue engine is responsible for the dialogue to the demanding institution or to the enquiring student. When interacting with customers, the dialogue engine establishes their background knowledge and guides them in the selection of a course unit. Prospective customers are

[5] Packaged courses are multi-media textbooks and WWW based courses, live courses are CWCS broadcasted courses

[6] HEI stands for Higher Education Institution

presented with choices according to a) pre-requisites and conditions attached to different types of courses (course profile engine), b) the suitability of different Institutions offering courses and c) the different delivery modes available for a particular course (delivery profile engine). Students will be able to make inquiries and express interest in course units that their home institutions have pre-selected and are willing to recognise and give credit. [7]In the provider part a provider dialogue engine is mainly used for feedback from the system back to the content provider. It is also used to handle the offer of content provision to the brokerage system to help academic and administrator users to plan new courses, submit course units, obtain customer records as well as learning progress profiles and assessment results. Demands for course units are sent to the administration engine, which looks for, offered course units fitting into the demand profile. The contract engine sets up the contract between offering and demanding side, thus it is dealing with registration, authentication and billing. In the administration part the system is driven by the administration engine, which is mainly a service database combined with a search engine. The tasks of observing and managing course scheduling and delivery issues, as well as timed interactions between the system and customers to enable the provision of joint courses are the responsibility of the delivery manager. The federation engine is dealing with distribution issues of the engineering implementation, like consistency, caching, forwarding of requests.

For each class of course unit there is an appropriate delivery platform. Variations in delivery platforms are due to the nature of the interactions and differences in media content and formats. The project will implement a limited range of delivery platforms, linked to the brokerage platform, sufficient to show the potential of the model. Each delivery platform contains an inherent delivery model and specific elements dealing with the media content itself.

3 The technology applied

The technology used is ubiquitous, Internet based, offering common, portable solutions and large-scale, shared, cross-border systems. These systems include, but are not restricted to:
Brokerage system is WEB based with Internet links. It is a central point of information, control and administration and logically will be centralized which means that only certain parts will be distributed or redundant for reasons of performance and high availability. The brokerage system will essentially be an E-business system that uses technologies like XML, Java / RMI, CORBA / ODP traders or agent based systems. standard security technology and intrinsic service negotiation for content delivery. Advanced transaction and billing functionality based on AAA[8] security technology, implement sophisticated administration and monitoring interfaces to the delivery systems and the integration of assessment capabilities

Delivery system similarly to the brokerage platform consists of an existing product/technology plus some enhancements ("glue" or "shell" around it), that acts as mediator between the delivery system and the brokerage platform. Defining a unique architecture for this interfacing allows adding additional systems / products by just implementing the appropriate interfaces that plug into the general architecture. A delivery system within the general architecture (see Fig.1) consists of content source, network and content sink. The content source can be a standalone system or part of a broader platform. The same applies to the content sink. The following delivery systems previously tested and used will cover the required functionality: Non-real-time delivery systems: retrieval of non-real-time mono-media and multimedia contents (e.g. browsing through text and hypertext information, download of content files). Real-time A/V systems: Real-time retrieval of multimedia contents (stored and live contents including A/V material like MPEG-2 streams) in synchronous and asynchronous manner (on-demand, live and scheduled broadcast scenarios) using IP technology (unicast, multicast), and broadband technology (ATM, ADSL,). CSCW systems: Videoconferencing and Computer supported co-operative work (CSCW) to enable interactive forms of tele-lectures combining parallel transmission of A/V streams and course material (e.g. slides) with the possibility to interact with the lecturer as well as with other parts of the audience. This family of delivery systems shall also support real-time experiments, simulations and case studies.

---

[7] Scheduling of actual course units remains the prerogative of the institutions and booking of places on courses is considered to be an internal function of the institutions

[8] AAA stands for Authentication, Authorization and Access Control

All delivery systems are inter-working with the brokerage platform and content provider systems to synchronise announcement and content delivery, to guarantee controlled user access, and to manage selection, compatibility and resource usage in delivery. All supported delivery modes will be available as profiles of the A/V delivery family. This means that each content provider can easily select the appropriate profile according to the nature of his contents and his network resources. It is important to note that used the A/V delivery technology is not based on the current average bandwidth and quality availability of the ubiquitous Internet. It will offer real high quality of A/V contents as broadband communication over the Internet (with technologies like ADSL) for a relevant number of users is available in Europe as well as the broadband services emerging in the convergence technology market (broadband over Satellite or cable-TV, interactive digital TV services) are expected to boost the widespread usage of broadband A/V information in the global IT environment. CSCW technology applied follows the principle of standards compliance and openness as for example the powerful CSCW tool ISABEL, developed in the RACE and ACTS projects ISABEL and NICE, then the standards-based (e.g. ITU H.323) COTS products (e.g. MS NetMeeting), MBONE multimedia conferencing tools (VIC, VAT, WB) developed within project MECCANO etc.

4 Content provision and description

The general architecture and model envisaged as a point of interaction of "sellers and buyers" on one hand, and of "place of commerce for actual content" requires an intelligent abstract description of the contents. Therefore, meta-data standards for multimedia contents and for educational environments are applied in the catalogue building of course units. The meta data system used is based on the specification of the IEEE LOM 3.8 meta-data scheme[9] with some extensions relevant to the platform developed as for example: attributes that specify the copyright and IPR[10] protection, attributes that describe information about digital signatures, watermarking, attributes that describe the network requirements for provision of appropriate quality of service, attributes relevant to live content and attributes defining the type of the course unit which may be: packaged, live, CSWC or mixed. The content provision and course description is based on a meta-dada system selected from available standard documents or previous projects results (1).

Several projects, that have investigated the management of information retrieval and the utilization of metadata for education and training have already proposed sets of meta-data requirements, like the Instructional Management System (IMS) project in the US (2) or the GESTALT (3) project in Europe. Some of the proposed sets have been evaluated and selected for the use in the UNIVERSAL project.

They are:

- **Learning resource content meta-data:**

Learning resource content meta data that enables cataloguing of contents of arbitrary aggregation level. UNIVERSAL supports the following granularity levels: *Fragment (Course Unit)*, *Lesson*, *Module* and *Course*. Each learning resource submitted by the "seller" is classified according to the aggregation levels and is added to the UNIVERSAL catalogue. UNIVERSAL supports "packaged" learning content, which is asynchronous in nature and synchronous learning content. Synchronous learning content is delivered as live transmissions of lectures, optionally supplemented by synchronous group ware communication technology. The special or unique features of the live content is described by specially developed attributes that are not part of the current existing meta-data standards.

- **Course structure meta-data:**

The UNIVERSAL brokerage platform not enables "buyers" to locate, use and re-use single course units. A functionality of the brokerage platform enables combination of single course units into higher levels of aggregation e.g. for full subject. This allows production of "custom" tailored complete courses. This is reflected in the course structure meta enabled by Course Structure Format (CSF) defined by the AICC and the ADL (1).

---

[9] IEEE Learning Objects Metadata document by WG 12 of IEEE Learning Technology Standardization Committee, URL:http://ltsc.ieee.org/wg12/scheme.html

[10] IPR stands for Intellectual Property Rights

- **Contents packaging meta-data:**

Like many other LMS, the UNIVERSAL platform offers the possibility to access packaged course units, which are mainly pre-recorded. Packaged courses enable an interaction with the contents itself, the interaction with the lecturer is usually not offered. UNIVERSAL packaged courses are described according to well-defined rules, specified e.g. in available standards like the IMS CPS (Content Packaging Specification).

- **Descriptive information about assessment procedures:**

Assessment is an important concept in on-line education and learning. Although the UNIVERSAL platform is not designed to assess the student's advancement and the learning achievement, it will enable consumers or "buyers" to assess the functionality and usability of the platform and the delivery process. The assessment is performed with on line involvement of the students. Student's responses will be captured using some form of structured mechanism with designed template(s) for such purpose. This is especially required in the cases when questions in the templates involve multiple choice, matched items, text selection, etc. Several structures exits for this purpose already: QML, SATML, and the IMS "Question and Test Interoperability Information Model" (QTI), UNIVERSAL team will decide which of the proposed template will be used for particular part of the platform and the delivery system used.

- **Meta-data for synchronisation:**

The asset management is important if the system is built up from re-usable learning resources e.g. units of lower aggregation level as is the case with UNIVERSAL catalogue. . In such cases the lifecycle management of the unit must be supported e.g. a component is not deleted from the asset management system in cases when the course unit is added to a module or larger course. This property of the system is described within the meta-data for synchronisation.

The UNIVERSAL consortium brings together a selected group of engineering and business schools across Europe who are interested in pooling their academic resources for the purpose of broadening the choice of courses and pedagogical materials offered to students and teachers and to provide opportunities for international collaborative learning. Although a few of its members have already established bi-lateral academic exchange programmes, in the initial phase of the project, partners are collecting course units developed within particular partner or outside in order to build a catalogue for the greatest market potential for the brokerage platform. The catalogue contains in addition to the meta-data information also: brief description of the educational objectives of the academic content for the students to whom courses are offered. In addition to that, brief description of teaching methodology used at each institution, description of the academic calendar for each institution, and description of the academic accreditation process for each institution are also information provided in the catalogue. Currently course units are collected from the following fields: Introduction to Information Systems, Regional Economic Development and Telecommunication, Global Marketing Management, Business Case studies, Metallurgy simulations and experiments, Foreign Languages and Cross-cultural Behaviour, Statistics for Economist, Tele-management.

The UNIVERSAL brokerage platform enables to locate, use and re-use single course units and combine single course units into higher levels of aggregation. This approach makes possible a definition of custom tailored structure for a complete course, which will lead, to a definition of a standard system of granularity for learning resources with the other projects from the IST cluster "Flexible University".

Several institutions already made suggestions for a hierarchy of aggregation levels. The IEEE LTSC and the IMS so far define four levels of granularity: *Fragment*, *Lesson*, *Module* and *Course*. Some other US based systems of aggregation can be found in the bibliography enclosed (8).

A course structure representation defines all of the course elements, the course structure, and all external references necessary to represent a course and its intended behaviour. The ADL together with the AICC, IEEE and IMS have developed the so-called Course Structure Format (CSF) which was the recommended approach for the UNIVERSAL project. The CSF promotes reuse of entire courses and encourages the reuse of course components by exposing all the details of each course element. The CSF is intended to reduce or eliminate dependency of a course on a particular LMS implementation.

The CSF is also intended to represent a wide variety of course structures and content "aggregations".

Content structures can be represented by the CSF that range from very small "chunks" of content – as simple as a few lines of Hypertext Markup Language (HTML) or short media clip – to highly interactive learning content that is tracked by an LMS. The CSF is neutral about the complexity of content, the number of hierarchical levels of a particular course (i.e., "granularity"), and the instructional methodology employed to design a course.

The UNIVERSAL platform incorporates continuous assessment of content and the system itself based on the interactions between the customers using the delivery of course units and the system itself. This information will be used to improve the overall scheme and the content to teachers, administrators and other possible customers.

5 The usability and evaluation

"Evaluation is the activity that throughout the planning and delivery of innovative programs enables those involved to learn and make judgement about the outcomes of the innovation concerned "[11]. The UNIVERSAL project aims also to develop tools to monitor the innovation process of education and learning and to develop best practice guidance.

The assessment of the content and the overall system, components for functional assessment are incorporated in both the brokerage system and in each of the delivery systems. Results from previous projects including the deployment of trans-national multimedia learning schemes[12] have shown that it is vital that all participants involved in the creation of the exchange platform and its educational content have a mutual understanding of the platform's operations, functions and of the components' interaction. To fulfill this goal it is necessary to give the users the tools enabling an easy the use of the exchange platform such as: an administrator guide, oriented towards the management of the platform, from a technical ("how to use") point of view as well as from a content ("what to do") point of view; a user guide, describing the day-to-day use of the system e.g. to a teacher wishing to use content available through the platform (how to access the catalogue, how to book a live course, etc). In addition, in the case of "live" delivery systems (on-line live courses with CSWC), experience have shown that it is necessary to organise "hands-on" training sessions to free the teacher from the fear of new tools and to strengthen their "moderation" skills when working with a geographically distributed class through a TV-like systems. Classes in the live courses will be mainly cross-border meaning that most participants will not be working in their mother tongue and there will be a mix of cultures present in any one of the classes. As part of the preparation for participation in the main trials a short "Language & Behaviour" courses that will (I) help participants with their colloquial English (since the majority of the courses will be held in English) and (II) help them be aware of differences in cultural behaviour, e.g. questioning style will be provided.

The student/teacher ratio varies greatly among the UNIVERSAL consortium partners. A set of software monitoring tools are being studied to be implemented into the brokerage platform to make it possible for students to continuously assess their personal progress and to choose the academic path best adapted to his or her acquired knowledge and skills; for course unit providers tools will be used to improve the effectiveness of programmes offered to learners and modify content accordingly; tools will be used also to analyze the way learners use the courseware provided; to enable a global assessment of the usability of the platform etc. The monitoring tools as well as the usability evaluation techniques used for assessment of the innovation technology approach are being developed/selected in accordance with the ACTS Usability Evaluation Guidelines[13]. These guidelines define the testing and evaluation methods, experiments design, definitions of interviews, observations, heuristic evaluation and surveys.

The evaluation instruments for courseware evaluation and corresponding measures will include:

- Pre-task/post-task questionnaires
- Task experience questionnaires
- Computer experience questionnaires
- Exams or assessment of performance
- Post course questionnaires

---

[11] Stern(1988) in Evaluation of Learning Technology Implementation, by Barry Jackson, URL:http://ltdi.icbl.hw.ac.uk

[12] Project LEVERAGE AC 109 from the IV Framework Program-ACTS

[13] USINACTS – AC224, IV Framework Program -ACTS

- Knowledge quizzes
- Logs - logging times

The approach for educational assessment will follow the practical guidelines developed within the LTDI technology developed within the Learning Technology Dissemination Initiative funded by the Scottish Higher Education Funding Council[14]. As a result of this a set of guidelines identifying best practices for future users of an academic brokerage platform will be produced. Academic partners will have the possibility to review the existing experiences and pool their lessons learned from prior involvement in flexible, distance, and collaborative teaching and learning programmes. This information cover issues such as the choice and format for resources provided to students and teachers, access to tutors or teachers, methodology, independent study and collaborate work, learner motivation, learner monitoring, course accreditation etc.

6 Conclusion

The UNIVERSAL is a project that implements the EU policies regarding the development of the European higher education and the user-friendly information society in particular:

- By improving the quality and diversity of the pan-European HE system
- By promoting the globalisation of the exchange of HE course units
- By enabling partners from economically disadvantaged regions, particularly in Central and Eastern Europe to participate in these developments and helping them to strengthen and enrich their course offerings and the foster the education in general.

Most of the activity within the project will be tightly connected with the usability aspects of the applied methods and technology. Usability evaluation and proposed improvement will be based on the past experiences, guidelines and standards developed within projects that have addressed this issue of modern technology in depth. The consortium expects wide acceptance among the higher-level education institutions in Europe.

References

[1] Advanced Distributed Learning Network (ADLNet), *http://www.adlnet.org*

[2] Instructional Management Systems project, *http://www.imsproject.org*

[3] GESTALT:Getting Educational Systems Talking Across Leading-Edge Technologies, *http:www.fdgroup.co.uk/gestalt/*

[3] SCORM, Sharable Courseware Object Reference Model: *http://www.adlnet.org/Scorm/docs/scorm_2.pdf*

[4] IMS Question & Test Information Model, *http://www.imsproject.org/question/index.html*

[5] SATML Standardised Assessment & Testing Markup Language *http://www.engr.ucf.edu/aim/research/1998/tess/satml/default.htm*

[6] QML Question Markup Language, *http://www.questionmark.com/qml/index.htm*

[7] IEEE LTSC WG17: Content Packaging Working Group, *http://ltsc.ieee.org/wg17/index.html*

[8] IMS Content Packaging Specification, *http://www.imsproject.org/content/index.html*

[14] LTDI, Philip Crompton: Evaluation: A practical guide to methods and Stephen Draper: Observing, measuring or evaluating courseware URL:http://www.icbl.hw.ac.uk/ltdi

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

Xiagen Hu* & Scotty D. Craig**
The University of Memphis
University of Memphis, Department of Psychology, Memphis, TN 38152-6400
(901) 678-3608
*E-mail: *xhu@memphis.edu, **scraig@memphis.edu*

Xtrain is a program for scripting and presenting multimedia displays. This program was developed in the Advanced Learning Technologies Laboratory at the University of Memphis and has been used in variety of psychological experiments. This program can combine such multimedia formats as Microsoft agent, Macromedia flash, director and many others that are available for scripting under a GUI Windows environment. Furthermore, Xtrain offers a variety of options for testing styles.

KEYWORDS: **Conversational agents, multimedia applications, Xtrain, Microsoft Agent**

1 Introduction

The idea of embodied conversational agents has generated considerable interest in the realm of HCI recently. Unfortunately, for the most part this has been metaphorical, because computers could not support the needed software. In order for the computer to fully support embodied conversational agents, they would need software that could produce and control many human-like characteristics, such as conversational behaviors, with the ability to mediate the flow of conversation by the use of such things as facial expressions, hand movements and voice intonations [1].

Microsoft made one such attempt at this with their Microsoft Agent program. Microsoft Agent is an interactive interface with conversational capabilities that are embodied in an animated character agent. One example of this is the helper agent in newer versions of Microsoft products such as Microsoft Word and Microsoft PowerPoint. Microsoft Agent is also an optional program for windows 9x operating systems and is available for free download at the Microsoft site. It is compatible with all MS Windows platforms starting with Windows 95. Thus, this agent is readily available for widespread use [5]. The purpose off this paper is not to review Animated Agents for a review, see Johnson, Rickel, and Lester [4].

Furthermore, recent research has shown that the correct use of multimedia presentations can enhance the learning and memory from presented materials. Multimedia in this case refers to any type of pictorial information presented with textual information. However, this form of learning works best with pictorial information shown as an animation that is then coordinated with a narration of any textual information that would be needed [6]. Under the cognitive theory of Multimedia learning, there are three main rules that should be considered for scripting of a multimedia presentation: Spatial contiguity, Temporal contiguity, and Modality. The spatial contiguity effect states that relevant and related concepts should be presented in the same general area of each other (e.g. labeled words should be closer to the object they label than other objects on the screen). The temporal contiguity effect informs us that the various forms of media used during a presentation should correspond with each other by occurring at the same time. Lastly, the modality effect says that if two types of information are presented in the same type of modes, it will hinder learning. However, this can be overcome by presenting information in two modalities. So, printed text and animation on a computer screen would be a hindrance to learning, but a narration and an animation would not [7; 8].

Since Microsoft launched the first version of Microsoft Agent, users and developers have provided a lot of resources for use with the program (e.g., some information can be obtained

fromhttp://www.msagentring.org/agentringmain.html). There are several innovated approached both in the use and the scripting of Agents. For example, mash.exe (http://www.bellcraft.com/mash/) provide a very useful scripting tool for agent programming. Many of these programs have been examined, including Mash, and while they have the ability to control Microsoft Agent, they are lacking the ability to synchronize the Agent program with other forms of multimedia.

The Advanced Learning Technologies laboratory at the University of Memphis developed Xtrain as a way to incorporate embodied agents (Microsoft Agent) and other forms of multimedia into instruction, research, and presentations. Psychologists have used products such as Mel©and Super lab©to run experiments, but these programs cannot incorporate newer technology. Xtrain provides ways to script many different kinds of presentations, including Microsoft Agent, audio and video clips, HTML, Macromedia flash files, Macromedia Director files, and many graphics file formats [2, 3].

This software program serves a duel purpose. It is both an authoring tool and presentation tool. These work together to form a powerful and versatile tool for the presentation of various multimedia displays as well as data collection.

2 Authoring tool

The authoring side of the program has two levels (a) overall organization of frames and (b) detailed construction of individual frames. The overall methodology is similar to the SuperLab program used in experimental psychology. The Presentation is organized in terms of a tree structure with each node in the tree as a pointer to presentation frames. Each frame consists of the smallest unit of information and the frames are logically contingent upon each other. Such tree structure serves as basic navigation guidelines. However, the navigation path can be quite flexible depending on the needs of the user. The tree structure can be created using a user friendly GUI. Each frame corresponding to the tree nods can be any of several formats such as text art, pictures with hotspots, video/audio clips, agent interactions, and animations.

Xtrain has extensive options for frame editing. The program has been arranged so that the different editing functions displayed as individual property tabs. Each tab corresponds to a specific multimedia format. A description of the property tabs will follow.

Property Tabs

2.1 Frame Property Tab

The Frame property tab allows the basic outline of the frame to be determined. From here frame duration is set, alone with the frame' s properties, and the frame type. The duration can be anywhere from self-paced to any amount of time desired measured in milliseconds. The type of multimedia desired can be selected under a Frame properties drop-down menu. Under the Frame type dropdown menu, the type of frame can be specified: Normal, Title, Review, Test, or Interaction.

2.2 Agent Property Tab

This is the general tab that is used to control the agent. Each frame can have up to three agent actions assigned to it. These actions are denoted as agent1, agent2, and agent3. However, these can be assigned as needed for example one agent can be given as many as three actions or three agents can be given one action each. These are selected from the available agents using the Agent dropdown menu. Just below this dropdown menu is a dropdown menu that specifies when the agent will be used. For example, "Action over frame" can be selected so the agent is active while the rest of the frame is running. Just below this are three additional tabs that specify (a) the agent's position on the screen, (b) what the agent will say in each frame, and (c) balloon formatting, if the agent has this option. These are the Action and Gesture tab, Speak and Play tab, and Balloon Setup tab, respectively.

Of these tabs, the Speak and Play tab is of the most importance. This frame in its most basic form allows for text to be entered into a text box. The agent reads this text using a text to speech engine. However, this text box can also contain simple markup within the text. This markup includes such speech parameters as volume, emphasis, pitch and speed. These markup tags can be inserted into the text by inputting the

desired values into the box beside the parameter name on the right portion of the tab and then double clicking the name. This list of parameters also includes a few special tags that can control the flow of the information delivery. These tags permit the agent to skip to a specific frame in the tree structure (Show Frame), or to go to specific frames in a selected Shockwave Flash movie (Go to Frame in Flash Movie). The remaining tag option is Insert Special action. This set of tags allows the user to start, stop, and restart a flash movie, and provides a tag that terminates the program at the end of a presentation. The Speak and Play tab allows for assignment of actions to the selected agent. These actions vary according to the abilities of the selected agent, and can be assigned either at the beginning or the end of the text the agent speaks.

Similar to other agent scripting tool, such as MASH, this agent property editor uses all available Microsoft agents controls. In addition, Xtrain utilizes the bookmark function of MS Agent to control the overall flow of the presentation. In fact it is the use of these bookmarking functions that make it possible to control Multimedia synchronization, such as with Flash animation, which is lacking in the other agent programs.

2.3 Text Display Tab

The text display tab is used to insert text to be displayed on the screen. Doing this involves clicking on the display area, typing in the text to be displayed, and then clicking update. The text will then appear in the display area in the same way that it will be displayed on the screen during the presentation.

2.4 Multimedia Tab

The Multimedia tab allows you to assign audio files, movie files, and wallpaper to the frame. The program supports wave files (.wav) and Enhanced Linguistic files audio formats. If an Enhanced Linguistic file is used Microsoft Agent can be made to appear to speak the file. The movie files available from this tab are AVI (.avi) and Mpeg (.mpg). A Bitmap (.bmp) image can be set as a background that either covers the whole screen or centered.

2.5 Pictures Tab

Using the picture tab, a picture can be added to the frame and manipulated. Xtrain supports two types of graphic files: Bitmap (.bmp) and GIF (.gif). The picture can be located at any point on the screen, centered, or can move from point to point. A hotspot option can be added to the picture to be used to give commands to the agent or to play audio files. Each hotspot can have information, such as text and tagged markup, to be sent to any selected agent.

2.6 Shockwave Tab

Under this tab, there are two options: Flash Movie and Shock Wave Movie. Flash movies and shockwave animations are among the most frequently used multimedia format. Xtrain uses activeX control from macromedia so both types of movies can be manipulated. By loading flash movie from this tab, detailed frame information can be examined so Agents can navigate through the movie. In addition, Xtrain uses FSCommand of flash movie to control Agent and the tree navigation.

2.7 Frame Summary Tab

The frame summary tab gives summary information both at the scripting phase and at the presentation phase. At the scripting phase, it gives a brief overview of the selections made in the other tabs for that frame. If the frame is a test frame, it also contains the correct answers to the questions given in the test frame. After viewing on the other half of this frame, responses are shown. If it was a test frame, the student' s responses are listed along with whether the response was correct.

2.8 HTML Tab

The program allows for the incorporation of html documents into presentations. This allows greater flexibility in terms of specialized displays. The format allows for html documents that are locally saved in the Xtrain directory to be displayed and navigated during presentations.

2.9 Test Tab

One other important feature of Xtrain is the testing option. During the scripting phase, frames can be assigned as testing frames on the frame property tab. These frames can be used to capture information from the user. They allow input in such forms as multiple-choice questions, short answer questions, and even essays. At the end of the presentation phase, input from the participant is automatically saved as an ASCII text file. The agent can also be programmed to give dynamic feedback, when the participant gives wrong answers.

3 Presentation Tool

The presentation of the scripted material is as easy as selecting the run drop-down menu and selecting the run entire session option. Alternatively, the Xtrain presentation file (.xtr) can be ran by double clicking its icon in the strain folder. This action occludes all other objects on the screen: only the scripted presentation and a control bar are visible. This control bar is a flash file that allows for the following actions: go back, continue, help, and progress. The presentation continues forward until it reaches the end of the presentation.

4 Summary

Xtrain is a program that is able to integrate multimedia files into one presentation format. The authoring side of the program takes advantage of many Windows' standards for ease of use. It provides a standard Windows interface window with icon buttons and drop-down menus, such as File, Edit, Window, and Help. These offer such options as open and save in the File menu, as well as, cut, copy, and paste in the Edit menu. Xtrain also offers a special drop down menu labeled Run. This menu offers the options of running the entire session or of previewing a selected frame. See Figure 1 for a view of the program. The frames are structured in a tree format that is located on the left of the screen. This tree is created via buttons labeled Brother, for frames on the same level, and Child, for frames on a branching level. Each frame can be scripted using nine different property tabs: Frame Property, Agent Property, Text Display, Multimedia, Picture, Shockwave, Frame Summary, HTML, and Test. These tabs may be individually associated with each frame. It is from these components that the script is produced to set the required tone for the information to be presented. Microsoft agent can also be used to control the flow between frames, so that if the need arises the agent can direct the presentation to any frame in the tree. Furthermore, if a Shockwave Flash file is used, the agent also has the ability to direct the flash movie to any frame within the movie. These options allow for maximum flexibility for the user when scripting a multimedia presentation. In addition to this freedom in scripting, Xtrain offers an easy presentation method that either selecting run entire session from the run menu or by simply double clicking on the created Xtrain file.

References

[1] Cassell, J., Bickmore, T., Billinghurst, M., Campbell, L., Chang, H., Vilhjalmsson, H., Yan, H., "Embodiment in Conversational Interfaces: Rea." Proceedings CHI' 99. Pittsburgh: ACM. (1999).

[2] Craig, S. D., & Hu, X. Xtrain: Expert training and data collection system. Presented at the 1999 meeting of The Society for Computers in Psychology. Los Angeles, California. (1999, November).

[3] Hu, X. "Xtrain 1.0 [computer program]." The University of Memphis: Author. (1998).

[4] Johnson, W. L., Rickel, J. W. & Lester, L. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. International Journal of Artificial Intelligence in Education, Vol. 11, in press, (2000).

[5] Microsoft. Microsoft Agent 2.0 [computer program]. (1998).

[6] Mayer, R. E. Multimedia learning: Are we asking the right questions? Educational Psychologist, 32, 1-19, (1997).

[7] Mayer, R. Using Illustrations to Promote Constructivist Learning from Science Text. Psychology of Science Text Comprehension. (Submitted).

[8] Moreno, R., & Mayer, R. E. Cognitive principles of multimedia learning: The role of modality and contiguity. Journal of Educational Psychology, 91, 358-368, (1999).

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS

Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings

HOME

Proceedings

Content

▶Full & Short Papers (Globalization vs. Localization)

Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives

▲HOME

Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective

Jill Slay* and Kam W. Li*
**School of Computer and Information Science*
University of South Australia, MAWSON LAKES, SA 5095, Australia.
Jill.Slay@Unisa.edu.au. li@cs.unisa.edu.au

Western research recognises [1] within the CS academic community pressure on its curriculum and teaching methodology brought about by the "evolutionary" nature of the discipline. This continuing need to avoid obsolescence in curriculum, which is produced by changing needs of industry and advances in research, is accompanied by other international and more local issue issues. Current research identifies several techniques which may be used to motivate and support CS learning in such an environment. This paper examines the implications of these findings to Asia, and particularly to mainland China, based on the personal reflections of this researcher on her own studies in China.

Keywords: **Computer Science Education, Cross-Cultural**

1 Areas of concern in Western CS education

Some modern issues of concerns in CS education [1] include attrition due to poor motivation/learning difficulty at CS1 level, dealing with students from a wide range of backgrounds with different learning styles and teaching the problem-solving and lifelong learning skills demanded by industry and research

2 Physical solutions

2.1 Providing Motivation Through Active And Participatory Learning

Active [2] and participatory learning [3] are techniques that are proposed to help motivate learners. Some methods which can be used include providing opportunities in "modified lectures" for paired response to questions posed by the lecturer or students discussing the notes they have taken during the lecture and helping to correct misunderstandings. Others have used role-play to demonstrate structures and protocols eg. arrays, linked lists or token passing protocols.

2.2 Learning programming through pattern recognition

In dealing with the learning of programming at the basic level, many researchers have examined the issues of teaching CS1. There is much interest in the use of patterns in aiding students' comprehension of basic programming and the integration of this knowledge [4 Clancy & Linn].

Clancy and Linn comment on the fact that design patterns are of great importance in software engineering and OO design and that to, to some extent, programming knowledge consists partially, at the cognitive level, as patterns (or schemas). However they show that, while the use of patterns is helpful in integrating knowledge, new programmers do not naturally infer patterns and sometimes find it difficult to understand "expert patterns". Clancy and Linn [4] and Johansson [5] advocate the use of a wide-range of contextualised examples and case studies to support the teaching of basic programming skills.

2.3 Adapting pedagogical styles to deal with social, cultural and gender issues

Research shows that students from different cultures or of different genders display different attitudes to computers and learning. In a two-year study of female and international CS students at Carnegie Mellon

University [6] issues which arose included the perception by some female students that the 'purpose' of computing needed to be defined within introductory CS courses. While they displayed a high-level of interest in the computing process they needed to be able to contextualise this process "within a larger purpose". They also displayed a lower level of "attachment" to their computers than did male students on the same course and expressed some relief as they discovered that CS education covered a wide-range of topics

Other research [7] [8] points out that there is a link between culture and learning style. Assertions made in this research indicate that Chinese students (studying overseas) would find it easier to understand and apply theoretical principles within programming than would a similar group of Western students. In their study, Fisher, Margolis and Miller [6] discovered that international female students on their course showed the least "attachment" to computers or computing and used pragmatic reasoning (such as employability) for their choice of major.

The conclusion here is that some allowance has to be made for cultural and gender preferences within the teaching of CS. While it is possible to provide an inclusive focus within lectures, there is, however, some may be a more pressing need to be able to adapt tutorial material for different styles and preferences.

2.4 Problem-solving for lifelong learning

It has been noted [9] that many students who have difficulties across the first year of CS as a whole do not know where to start with a task, regardless of the subject area.

Some effort has been made to incorporate training in problem solving skills and techniques in to early CS education to deal with this problem . This ranges from the use of Edward de Bono's tools for lateral thinking to the development of Polya's approach of Understand, Design and Review [9] for problem solving and offering courses in these techniques within, or parallel to, early programming subjects

2.5 Web-Mediated solutions

With the problems imposed by large classes, and the large range of individual approaches needed to deal with some of student learning issues raised above, CS academics have been some of the first to develop and use web-mediated learning environments for enhancing student learning in CS.

As I have pointed out ([8], [9]) the Web provides a vehicle for the development of the learning environment and teaching can be structured to develop lifelong learning skills and to cater for the expectations and learning styles of students from different cultures and backgrounds.

Early Australian examples of this style of teaching in CS education are many. Recent Australian examples of the use of the WWW in CS education abound. Boalch [10] provides an examination of the use of the WWW as a support medium for the delivery of a first year unit in Information Systems at Curtin University. He provides an evaluation of site utilisation and user feedback in the case where subject information and course details were provided on the WWW for students.

The Eklunds [11] examine the use of the WWW to supplement traditional IT teaching. They provide case studies of two examples of the re-structuring of traditional forms of IT course for Web-delivery. Jones [12] of Central Queensland University gives details of case study involving the design, presentation and evaluation of an undergraduate unit in Systems Administration taught completely via the WWW to on-campus and distance students.

3 Reflection on CS Education in Mainland China

The following two stories are taken from some interpretive tales which I wrote after two separate periods of studying and teaching in China. They draw a picture of the role of the computer on campus in Nanjing 1995) and in Jinan (1998).

A Visit To The Computer Centre 1995

I managed to pay a visit to the University Computer department (I was a Computer lecturer myself at the time in Australia). This was a definite culture shock. The computers, 386s and old at the time, were

kept in a special air-conditioned and carpeted room. People wore white coats and slippers if they wanted to use them. Most students (and only the best study computers) were doing basic Basic programming. I tried to investigate whether they used Windows, or anything modern, but the lecturer was only interested in the length of computer courses in Australia. There seemed to me to be no parallels in our courses at all. The students seemed only to learn Basic programming *[I wondered what job this would qualify them for!]* . It seemed to that things like word processing *[the Chinese have a special keyboard and it takes 5 keys together to create one character]* were a matter for female secretaries and did not enter the arena of the university. I tried to explain the issue of the 'computer as a tool' but I could see that the body language was saying 'Crazy Westerner!' when I tried to put across the concept of teaching less-able, or even all students, to use computers. Computers are for the young and highly intelligent in China.

A Visit to the Internet Centre 1998

It was surprised to find the computer was still as remote as ever from the everyday life of the average student. Computers, 486s by now, still lived in splendid isolation in carpeted rooms, and students still wore special slippers to use them. Still no Windows and still basic Basic.

I had imagined that the cutting edge of technology would be a little different to that which we had at home. I was a little surprised though to find out the process which I had inadvertently become involved with. I worked for six weeks with some highly creative young teachers to try and develop an intranet from an old CAD classroom (486s with no hard disks), one modern Pentium in a building several hundred metres away, one modem and a collection of legal and not-so-legal software. The Internet Centre turned out to be a heavily guarded room about the size of an average Western kitchen with a little row of computers along one wall, filled with a large collection of discarded technology and useful pieces of wire.

Major problems for the Chinese academics was their lack of ability in reading English as the 'install' dialogue boxes sped past on the screen. The problem for me was that I read Chinese much more slowly than they could read English. All the online-help in the world did not help us, installation was a slow process! We often laughed at the problems because we were all engineers and computer scientists. Not really the type of people who are famed for their linguistic abilities, but the monopoly of the Internet by the English language is certainly a problem in China.

I left before the networking was done. I did manage to complete a bilingual virtual library and an English home page for the Institute (with the help of some young teachers) and to teach a couple of them to use FrontPage. I gave lectures to many of the final year students and their teachers. Certainly no lack of enthusiasm here – just a lack of technology and English teachers!

3.1 Chinese Teaching Practice and Computer Based Education.

The combination of a Confucian philosophy and commonly accepted teaching models means that, in universities and colleges, all subjects are taught lecture-style to large groups. However to a Western none of the common CS teaching problems established above is observed in daily teaching and research.

From a Western perspective motivation remains very high among students as they strive to master modern hardware and software. Gender issues and the ability to attract female students do not appear to be a great concern and classes appear to display a balance between males and females. Learning problems do not appear to be the major difficulty experienced and researched in the West.

The major problem appears to be curriculum. The Chinese system has been one that has relied on a national curriculum in all sectors of education and changes in the software and hardware used and taught have not been allowed. During April 1998 (China Daily, 1998) the Ministry of Education announced major adjustments in the University system with corresponding changes to the High School curriculum and schoolbooks, which provide some hope that this issue will be addressed.

A national curriculum which has not kept pace with changes computing practice in Chinese industry and commerce, and even the home, has caused a demand for Western computer manuals in Chinese translation and the increase in number of private providers offering training in modern computer applications and the Internet. Many young teachers and their students are becoming competent users of modern software (eg Windows 98/NT, Office97, object-oriented software) which is not available within the Higher Educational system by turning to these private providers. This leads to disaffection and difficulties for both teachers and their students.

3.2 The Future

As well as the obvious improvements to connections, access speeds and call charges which are currently being made by CERNET, wider issues to be faced are the development of Chinese language software and WWW pages to improve the take-up of the Internet in China as a whole. This is being carried out in an environment of large-scale educational reform which will need to take into account the effect of the Internet on accepted Chinese teaching practice and pedagogy.

4 Conclusions

It is hard to imagine that, even within the next ten years, the Chinese economy might begin to develop and maintain a systemic hardware and software infrastructure within higher education. While it is easy to envisage the limited availability of the Internet for research students, and especially in the nationally funded universities and those around Beijing, the provincial lecturer has the doubly difficult task of persuading the older and therefore more powerful academics to accept new technology and to make drastic changes to their teaching style to incorporate it.

I have proposed elsewhere [9] that an effective conceptual framework for the development of an online learning environment might be one which is based on expected pedagogical outcomes. Therefore one model for China would be to concentrate on the development of online teaching content which would be a resource for guided and collective discovery learning (see above). This might begin with the development of Chinese language link pages to English language resources such as comprehensive virtual libraries and databases.

Academic staff development in technology is both very easy and very difficult. Young Chinese academics are as adept as their Western counterparts in their understanding and use of cutting-edge technology. Their progress is however hampered by their English language skills. This is especially apparent when one is made aware of the lower standards of English language required for technical subjects and the datedness (or nonexistence)of the technical vocabulary taught at university level. This appears to be one of the most pressing problems for the Chinese universities to grapple with and solve.

CS education research has shown a need for pattern recognition, motivation and problem solving skills as aspects of life-long learning. These can be supplied through the medium of web-mediated adaptive tutoring which can be used to augment face-to-face teaching but great efforts will need to be made to use these effectively within the current Chinese pedagogical framework.

References

[1] Tucker, A.B. "Strategic Directions in Computer Science Education". ACM Computing Surveys, **28**(4), (1996).

[2] McConnell, J.J. "Active Learning and its use in Computer Science." Integrating Technology into C.S.E. Barcelona, Spain, (1996).

[3] Jenkins, T. "A Participatory Approach to teaching Programming." *ITiCSE*, Dublin Ireland, (1998).

[4] Clancy, M.J. & Linn, M.C. "Patterns and Pedagogy." SIGCSE, New Orleans, USA. (1999)

[5] Fisher, A., Margolis, J. & Miller, F. "Undergraduate Women in Computer Science: Experience, Motivation and Culture". SIGCSE97. (1997)

[6] Cobern, W.W. "World view theory and science education research." NARST Monograph No. 3. Manhattan, KS: National Association for Research in Science Teaching. (1991)

[7] Slay, J."Unpublished Ph.D thesis". Perth,WA: Curtin University of Technology. (2000)

[8] Slay, J. "Using the WWW to Create an Effective Cross-Cultural Learning Environment. Hong Kong Web Symposium 98, Hong Kong University. (1998)

[9] Slay, J., "Using the World Wide Web to Create Foundations for Lifelong Learning - An Australian Perspective." Teleteaching, IFIP World Computer Congress98, Vienna. (1998).

[10] Boalch, G. "WWW as an Educational Support Medium: An Australian Case Study." Paper presented at AusWeb96, Gold Coast, Australia, (1996).

[11] Ecklund, J. & Ecklund, P. " Integrating the Web and the teaching of technology: Cases across two universities." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

[12] Jones, D. "Solving some problems of University Education: A Case Study." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

Reflections on Educational Technology from Female Asian Faculty's (FAF) Perspectives

Doris Lee*, Amy S.C. Leh, Mei-Yan Lu*** and Mei-Yau Shih******
**Pennsylvania State University -Great Valley, School of Graduate Professional Studies 30 East Swedesford Rd., Malvern, PA 19355, USA, YDL1@psu.edu*
***Instructional Technology, California State University, San Bernardino, San Bernardino, CA 92407, USA, aleh@csusb.edu*
****Instructional Technology, San Jose State University, San Jose, California 95192-0076, USA, meiyan@email.sjsu.edu*
*****Center For Teaching, University of Massachusetts Amherst, Amherst, MA 01003, USA, mshih@acad.umass.edu*

Four panelists in this panel session will briefly present their perspectives on how the instructional technology field has influenced current Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Presenters will address their challenges as female Asian faculty in Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Suggestions and solutions will be discussed during the panel session.

Keywords: **Faculty development, Corporate training, In-Service teacher education, Pre-service teacher education, reflection, and perspectives**

Introduction

Each panelist will offer their unique perspectives in the field of instructional technology. Our focus questions are:

1) Has instructional technology field influenced current:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S. C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

2) What are the challenges do female minority faculty encounter in:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S.C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on In-service teacher education (Dr. Amy S.C. Leh)

Technology advancement is altering our society and our education. New technology standards grant opportunities, and policy reflect the change currently happening in our education. In September of 1997, the National Council for Accreditation of Teacher Education (NCATE) released a report addressing the importance of integrating technology into instruction. New technology standards clearly indicate that teachers must be competent of using technology in their teaching. Moreover, the Department of Education (DOE) has spent millions of dollars on grants to support teachers' training. The grants have brought many

university faculty members, school district administrators, and school teachers together to work on the task –technology integration. In the annual conference of Association for the Advancement of Computing in Education (AACE) 2000, Tom Carrell, director of PT3 grants addressed the influence of technology on our education and the need for organizational change. Some schools, for example, decided to only hire teachers who are competent of the use of technology.

At present, training teachers the use of technology has become a strong nation-wide movement and in-service teachers are expected to become technology literate through in-service training. The strong demand of teachers' training has invited many international scholars to participate in the movement of training US teachers the use of technology. The international scholars were mostly born outside of the United States, came to the USA for their higher education, e.g. Ph.D. degree, and are currently university faculty members at US universities.

The international faculty' participation brought new blood and tremendous strength into US in-service teacher education due to their educational experiences in both the USA and their native countries. Their experience with both educational systems allows them to compare how students learn in two different nations and to employ the strengths of each nation in the USA. For example, how an Asian student learns math is different from how a student in the USA. Asian students' math practice involves word problems (concepts) while the USA students' practice focuses on page after page calculation. An Asian Mathematics faculty, who was differently trained, might use a variety of effective teaching strategies due to the exposure to different ways of learning. Similarly, international Instructional Technology faculty may provide different perspectives in in-service teachers training. Because they are foreigners in the USA, they encounter challenges, especially international female faculty. Reports show that the percentage of female faculty in higher education is low. Some reports even indicate that they encounter more challenges than male faculty, e.g. in promotion. In this case, international female faculty would be minority within a minority and consequently encounter greater challenges. Below are examples of challenges:

"I felt that my viewpoints were not valued." (from an international male faculty)

"I felt that I was transparent in many meetings. They didn't seem to see my presence." (from an international female faculty)

"She [an international female faculty] couldn't get tenured because she was a foreigner." (from a US female faculty)

"You [an international female faculty] are double minority. You're female and foreign..You need to be firm and stand up for yourself." (from a US female faculty)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Corporate Teaching (Dr. Doris Lee)

Today, employees in the corporate settings operate in a rapidly changing, high tech environment. Each employee, in order to accommodate the increasingly rapid rate of technology change, must continually re-tool and upgrade his or her skill sets through life-long learning. The delivery medium for life-long learning, most likely, will use instructional technologies. Instructional technologies refers to computer technologies that can integrate texts, graphics, audio, video, animation, or film clips for the creation of instructional or training packages. Recently, instructional technology also includes the use of the World Wide Web, WWW, in which instruction can be delivered over public or private computer networks and can be displayed by a web browser. Dr. Doris Lee, one of the panelists has taught corporate trainers for more than 10 years in the areas of instructional technologies and design and development of computer-based and web-based training. Based on such an experience, Dr. Lee's discussion in this panel will focus on the impact that the instructional technologies have on corporate training, and what are the challenges and perspectives that she faces as a female instructor for corporate trainers. Below details her experiences and views on these topics.

Generally, most corporations believe that the use of instructional technologies would provide an additional tool to the face-to-face training, can be designed to integrate multiple options including video, audio, and text to accommodate employees' preferred learning styles, and is valuable in providing consistent and current training to employees. In addition, the use of instructional technologies to deliver training can be time and place independent and therefore, costs associated with employees' travel and classroom training can be reduced. However, some companies express concerns in using instructional technologies. These concerns include employees' lack of computer and/or Internet skills, the design and development issues, and the software and hardware limitations.

To convince my students, who are corporate trainers, to consider all the important organizational factors and design issues while using instructional technologies is the biggest challenge. Most of the corporate trainers are female and work in a male-dominate environment. It is imperative for a female faculty to emphasize the importance of front-end analysis even if the analysis is not desirable by their male supervisors. When a company is considering using instructional technologies, a female trainer should never feel intimated to ask important questions including human, machine and political readiness. Questions such as, are the employees comfortable with computers and are they ready to learn, need to be asked. Next, technology readiness is another factor. Hardware, software, and the availability of a technical support staff are some examples of the areas that need to be evaluated. Also, financial readiness pertains to budgeting for upgrades to hardware and software, the purchase of courseware, and developing staff. Plus, political readiness concerns the support of instructional technologies by upper management, middle management, employees, and the training department. Finally, skill readiness looks at whether the staff involved with supporting and developing the training has the skills necessary to do so.

Reflection on educational technology from female Asian faculty' s (FAF) perspectives on Pre-service Education (Dr. Mei-Yan Lu)

Educational technology has played a major role in influencing pre-service education. For example, In the 60s, 70s, it was the audio-visual education. In the 80s it was computer assisted instruction (CAI), BASIC programming and Logo programming. In the 90s, it was multimedia, web-based learning.

As a female Asian faculty who has taught in major teacher training Institutes, I would like to share some of the unique challenges for preparing future teachers (per-service teachers) the past 16 years.

Challenge no. 1: Most pre-service teachers are young female white adults. Many of them do not have experiences in working with Asian faculty. For example, a typical K-12 school in San Jose, California, has mainly white teachers/administrators, in many cases, 100% white teachers/administrators while many of their students are from a diverse cultural background. Sometimes, a school student body is from 72 different language and cultural background.

Challenge no. 2: Most teacher preparation institute has mainly white faculty. For example, in the College of Education at San Jose State University which graduate, on the average, 600 credential teachers annually, has about 110 full time faculty. Out of the 110 full time faculty, only 6 are Asian faculty (Chinese, Japanese, and Korean).

Challenge no. 3: Most Asian female faculty are "foreign born'. The fact that we are different can offer unique perspectives to our students and colleagues. However, sometimes, our background and cultural differences can be barriers as well. For example, the accent issue. Some students and faculty complain that Asian faculty have heavy accent. However, they rarely complain the European Born faculty who has heavy European accent. Many times, they found European accent charming, while Asian accent distracting.

Challenge no. 4: The field of educational technology generally does not pay attention to solutions and strategies in designing instruction for audience from diverse cultural background. For example, in 1999 AECT convention, there were only two presentations in the entire conference program addressed the issue of designing for international and diverse cultural audience. As one of the popular instructional media – World Wide Web and distance learning is gaining more attention, we as instructional designers/faculty should pay more attention to the international audience.

My goal is to prepare technologically competent teacher candidates that are also culturally sensitive to work with diverse student population. With this goal in mind, I like to recommend:

1. Increase the representation of diverse student body in the field of educational technology both within the United States and outside of the United States.
2. Recruit more faculty of color. Therefore, students will have opportunity to work with both faculty and students from different cultural background.
3. Look beyond the "accent" issue. The point that I am trying to make is that more of the main stream Americans have no trouble "comprehend" accented English. They just do not like the way it "sound". In addition, people who speak with an accent are capable of speaking more than one language and be able to function effectively in another culture. Why not take their unique experience and learn how to design instruction for an international audience?

4. Encourage more educational technologists to research the cultural issues in designing instruction such as in the area of World Wide Web and distance learning.

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Faculty Development (Dr. Mei-Yau Shih)

The use of instructional media in the classroom has long been identified as a "fourth revolution" in education (Ashby, 1967). It has the potential to reshape the role of the instructor from a knowledge conveyer to a guide and coach, while students take a more active role in the learning process. No longer are the textbook and instructor the sources of all knowledge; instead, the faculty member becomes the director of the knowledge-access process (Heinich 1996 et al,). Instructional technology refers not only the actual use of technological tools it also stresses the importance of the process of developing overall goals and strategies for enhancing teaching and learning. At its best, technology-based learning can help teachers support a wider range of learning styles, facilitate active learning in the classroom, use faculty time and expertise more effectively, and familiarize students with technology that will be vital for their futures in the world of work.
In our experience, university faculty are both greatly excited and daunted by the promise and power of teaching technologies. Our students have grown up in a "high technology" environment and are well adept at the use of TV, videotape, computers, and the Internet as information exchange tools. Many faculty, on the other hand, struggle to learn new technologies and to see how they might be useful to them as teachers (Shih & Sorcinelli, 2000). . The higher education is encountering the new trends of the changing student body, teaching practices, and the new roles and identities of faculty in universities. It is imperative, therefore, to remains a holistic view while helping faculty develop their technological skills with an understanding of the educational values and systems where the teaching and learning take places.

The perspectives from a foreign born female faculty developer, whose first 20 years of educational training differs massively from the majority of US university faculty on educational technology, reflect not only a personal challenge, they also underscore the important tasks of any faculty develop who serves as the chang agent in helping the transformation of teaching practice with instructional technology. These tasks include, first, effectively represent the instructional technology to faculty to help them see the integration of technology involves more than physical setup and technical support; it requires some curricular modifications and instructional strategy shifts; second, take in the cultural and educational differences in educational systems to design the strategies in energizing faculty and inspiring them trying innovative ways of teaching, and made them conscious about their purposes in the classroom; third, establish credibility and earn trust of the faculty to represent effectively the benefits of using technologies for teaching and learning; forth, remain alert and sensitive to the campus culture to help enhance the collegiality on campus, and maintain a supporting network of "exemplars" who would be eager to take risks and become "mentors" to colleagues who express interest in instructional technologies. Of most importance task as an Asian, female developer working for rising faculty technological skills is to help faculty recognize the diversity in college classroom, to make them conscious of the various student learning styles, ages, genders, race and ethnicity, and digital have's and have-not's issues in classroom. Effectively carry out these tasks is the means to the ends to help best researchers use and understand the instructional technologies to become a better and effective teacher in the 21st century.

REFERENCES

[1] Ashby, E., (1967). "Machines, Understanding, and Learning Reflections on Technology in Education." The Graduate Joumal, 7, pp. 359-373.

[2] Heinich, R., Molenda, M., Russell, J. & Smaldino, S. (1996). Instructional Media and Technologies For Learning. 5th Edition. Englewood Cliffs, New Jersey. Prentice-Hall, Inc.

[3] Shih, M. Sorcinelli, M.D.. (2000). "TEACHnology: Linking Teaching and Technology in Faculty Development." To Improve the Academy. V(18). POD Network. Anker Publishing Company, Inc. Bolton, Massachusetts.

ICCE/ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS

Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsor
Related Websites
Discussion Board
Proceedings

HOME

Proceedings

Content

Full & Short Papers (Humanities and Learning Technology)

Integrating Information Technology with Language Pedagogy for a Second Language Online Writing System
Integrating Web-based Materials into Course Design
Is Everyone On Board: Learning Styles and the Internet
Research on Teaching Da-Yi Chinese Keyboarding by Using Adaptive Input Interface
Strategies for Searching in the WWW
The Criteria and Evaluation of Metadata/Keywords in Image Retrieval
THE INTERNET-BASED EDUCATIONAL RESOURCES OF THE U.S. FEDERAL GOVERNMENT
Which Chinese input method is more suitable for sixth-grade pupils?keyboarding or non-keyboarding

▲ HOME

Integrating Web-based Materials into Course Design

Lilly Lee Chen
Rice University
6100 Main Street, Houston, Texas, USA 77005-1892
Tel: 713-348-2820
Fax: 713-348-5846
E-mail: Lchen@ruf.rice.edu

1 Introduction

This paper is a report on a project in which Web pages were crucially incorporated in the design of a new college course titled anguage and Culture in Taiwan." There were two main reasons for making the Internet an integral part of the course: (1) the wide range of topics covered in this very general introductory course requiring the wealth of information sources easily accessible on the Internet and (2) necessity of frequent updates of information due to the fast and volatile nature of the political evolution in Taiwan, particularly during the presidential election year when this course was offered. The consideration of user factors was also important. The Internet responds well to today's college students who demand relevance (of issues that pertain to the here and now) and immediacy, and are as adept in clicking on the keyboard surfing the Internet as flipping the pages of a book.

More serious, though, in our course design is the educational philosophy that a college's mission is not so much to transfer knowledge as to create environments and experiences that bring students to discover and construct knowledge for themselves [1]. Exposure to the vast amount of knowledge on the Web necessitates focus and careful choice of relevant materials. As part of course assignments students were expected to present on topics of their choice. This ensured that they researched the subject matters in greater depth before presenting them in class, as they would be presenting to an audience of their peers.

2 Method and content

The ready accessibility of the Internet for both the students (practically all students have a PC) and instructor (to add to or update the course page), especially outside of class, altered in-class activities from those of traditional teacher-centered instruction to student-centered discussion and presentation. The utilization of e-mail also facilitated out-of-class preparation. Students were informed by e-mail to go to a certain new site or link for a new development of events. Similarly, the student e-mailed the instructor for information or help. The more out-of--class preparations the students have, the better the quality of in-class discussions the instructor can expect.

The syllabus was essentially a structure of links organized according to the class schedule of topics and activities. It is also a display of the scope and structure of the contents of the course. It changed dynamically as new links were discovered and added throughout the semester. The syllabus appears as a navigation bar. To facilitate learning we have minimized visual search by displaying this syllabus bar consistently on top of each page[2]. Students can easily navigate from site to site, not only to preview but also to review. Besides a general page of topics with their links to available Web sites, the page of each session further highlights some particular links to topics of the session, along with a list of references available on reserve in the library.

The contents of this course consist of two major areas: (1) culture and (2) language. The former includes a wide range of topics, such as a profile of Taiwan, history, political parties, customs, festivals, family relations, literature, world view of Taiwan, and the future of Taiwan. Generally each topic or a group of related topics was covered at a weekly session, which lasted two and a half hours, of which the first half was devoted to cultural discussions and the second half, instruction of language. The culture part of the course

was conducted in a seminar format along with presentations by students.

By dividing the content area into culture and language, we were not forgetting that language always operates in a culture [3]. Besides teaching phrases and sentences applicable in social situations, other aspects of the language, such as kinship terms, nursery rhymes, proverbs, songs, etc., abounding with traditions and cultural values, were also taught. The language part of the course contained sound files. Some had two types of reading, a slower one and a faster one, to facilitate learning. Taiwanese expressions in each language lesson generally contain both literal and free translations. This makes self-study very easy and convenient, as long as they could access the Web. Sound files were indispensable as Taiwanese is a tone language and furthermore has seven tones and possesses an elaborate tone sandhi system [4].

This Web program was produced entirely in the instructor's office by using Netscape Composer, SoundRecorder, and other freeware downloaded from the Internet [5]. The exercise part of the course, which features filling in of blanks, multiple choice, short answer, etc., was made possible by the ExTemplate program developed at Rice University Language Resource Center [6]. The ExTemplate application creates exercises that will be stored in a database for future retrieval [7]. It allows students to submit exercises via the Internet and be graded by the instructor also via the Internet. The language lesson sound files were integrated into ExTemplate. This feature was very useful particularly for tonal distinction exercises.

Our classroom was equipped with a multimedia Podium which allowed us to go on the Internet, show videos, movies, documents, play CD , etc. The Podium came in handy when a demonstration on the classroom screen was called for. Not only did the instructor use the Podium, students were encouraged to do their class presentations by using PowerPoint or by going to their own personal homepages where they collected Web links or images related to their topics for classroom presentation.

3 Conclusions

By incorporating the Internet into course design, we were able to create a more accommodating learning environment for the students and to give students more control over the learning process. As this was our fist attempt at teaching the course with Web-based materials, further refinements of many aspects of the course need to be made. For example, we can make pages less cluttered with text and add more digitized videos. Also researches can be conducted to determine students' reactions in terms of attitudinal factors and learning efficiency. Taiwanese on the Web is an on-going project. We solicit help and comments. This project attempts to raise awareness in the global community of the vitality of a culture less known and rarely covered in college courses. As universities generally suffer from budget constraints, by making this program available on the Web we hope to encourage teaching of this subject matter.

References

[1] Bar, Robert B., & Tagg, John, "From teaching to learning - a new paradigm for undergraduate education", Change 27-6 Nov./Dec., pp. 13-25, (1995).

[2] Aspillaga, M., "Screen design: Location of information and its effects on learning", Journal of Computer-based Instruction, 18(3), 89-92, (1991).

[3] Walker, G., & Noda, M., "Remembering the future: Compiling knowledge of another culture", Reflecting on the Past to Shape the Future, (eds.) Birckbichler & Terry, National Textbook Company, pp. 187-212, (2000).

[4] Chen, L., "Grammaticalization and Tone in Taiwanese", the 27th Forum of Linguistic Association of Canada and the United States (LACUS Forum 27), (2000).

[5] Chen, .L., Chang. J., Lai, S., & S. Yuen, S., "Web Based Instruction", Proceedings of the 8th International Conference of Chinese American Educational Research and Development Association (CAERDA2000), St. John's University, New York, September 16-17, (2000).

[6] Chen, L., Bartlett, C., & Verm, J., "ExTemplate: a tool for foreign language web editing", Proceedings of the South Central Association for Language Learning Technology (SOCALL 2000), Louisiana State University, Baton Rouge, Louisiana, April 7-8, (2000).

[7] ExTemplate Lesson Server: Online courseware authoring, http://lang.rice.edu/extemplate/, (accessed on August 1, 2000).

Is Everyone on Board: Learning Styles and the Internet

Michelle Hsiang*, Ellen Storey Vasu, Marsha Alibrand***, Nancy Atkins**** and Jane Steelman*******

** Research Triangle Institute/ NC State University. Email: mhsiang@rti.org*
*** NC State University. Email: esvasu@unity.ncsu.edu*
****NC State University. Email: marsh@cape.com*
*****NC State University. Email: atkinsn@he.orange.k12.nc.us*
******NC State University. Email: ravendoc@aol.com*

For many years, educators and practitioners have been implementing, enhancing and innovating variety of teaching methods to best fit students learning styles for eliciting the potential of students. As stated by Corno and Snow [2], "the success of education depends on adapting teaching to individual differences among learners", the teaching methods taught are to accommodate, meet, and elicit the diverse learning needs. Technology is becoming accessible to most segments of the United States population. As more and more classrooms are connected to the Internet and online-lesson plans are adopted to teaching and learning, it is important for teachers to ensure that the diverse needs of every student is addressed. This research study contained the quantitative analyses relative to learning styles and web design.

Keywords: **Humanities and Learning Technology, Instructional Design, Web-Based learning**

When computer technology increased its popularity in 1980's, Computer-Assisted-Instruction (CAI) in the form of drill, practice and tutorials was superior to traditional instruction [1] and outperformed those who received traditional instruction [7]. While providing feedback to reinforce learning in CAI, Pritchard [6] recommended that the use of computers in CAI require a specific learning style of paying attention to details for accuracy, so that students are able to work alone. Davidson et al [3] further examined learning styles and performance in computer concept and programming skills in BASIC, and found that learning styles had a significant effect on performance of a computer course. By 1997, 72% of the schools in the USA had online access. As teachers adapt their teaching to the use of the World Wide Web as a medium for resources, and to publish their class websites, the information delivery system has been changed from paper format to digital format and from fixed text to unlimited hypertext. The visual graphic representation has been switched from static to animated/multi-dimensional and from limited colors to millions of colors. With the advance of the technology, sound and movies can be incorporated into webpages to enhance teaching and learning environment. With the release of many HyperText Markup Languages (HTML) editors, e.g., Adobe PageMill, DreamWeaver, Front Page, it becomes very easy for anyone to create and publish webpages, therefore it is essential for educators to investigate the different learning styles of individual students when designing webpages.

Study Purpose and Sample Setting

The purpose of this study is to examine two different webpage designs regarding to students learning styles. A total of 44 students who enrolled college courses in graphic design, computer application and web design were selected in the study. Students in these classes had little or some knowledge of the Internet and Webpage design.

The two web designs were developed by the authors and used for the study: one-frame versus two-frame designs with the incorporation of colors, animation, buttons, and hypertexts. The one-frame design used a top-down sequential technique for web design. To begin, users must access from the main menu in order to navigate to other pages. The two-frame web design contained two displays located side-by-side. The left-frame normally contains the potential links, the right-frame displays the corresponding information. Users can make random selection of different links at any given time provided on the left-frame that served as the main menu.

Measurement and Procedures

In the beginning of the semester, the Gregorc Style Delineator [4] was administered and the scores were tallied to determine students prefer learning styles in (1) Concrete sequential; (2) Abstract sequential; (3) Concrete random; or (4) Abstract random. At the end of the semester, students were given an Uniformed Resources Links (URL) to review the two different styles of web designs as mentioned earlier. After review, an instruction was provided for the students to fill out an open-ended questionnaire to reflect their selection and to make their comments.

Selected Results:

Two-frame selection: Students preferred the two-frame design to the one-frame arrangement with a ratio of approximately 3:1. This again stressed the importance of design in CAI that emphasized gaining attention, guiding learning, informing learners of objectives, and presenting stimuli with distinctive features. The reasons why users were in favor of the two-frame design included that it was easier to navigate with left-frame controlling the right-frame. With all the links listed on one-frame and information displayed on the other, it provided a quick access to the viewer.

One-frame selection: Students who preferred the one-frame design to the two-frame one like the fact that it was easy to follow and less confusion, simple but effective. Information straight down on a page was easier to read and to understand than a two-frame design. It kept attention intact and was readily for research. Some found that it was easy to use for computer illiterate people.

Discussion

The two-frame design is a newer approach than the single frame design. Students used to the one-frame design and some still prefer the same way of accessing information, even though the two-frame design has pleasing results and is reportedly easier to use than the one-frame design. In summary, this research suggested that the major reasons why the students disliked the two-frame design were because they were simply unfamiliar with the structure. Additional training and more exposure to the two-frame design would help them overcome the barrier. As the popularity of the Internet increases and the HTML editors become easier to use, it is important to emphasize these design factors, so that the webpages can be designed more accessible and user friendlier as technology advances.

Reference

[1] Burns, P. K. & Bozeman, W. C. (1981). Computer Assisted Instruction and Mathematics Achievement: Is there a Relationship? Educational Technology, 21, 32-37.

[2] Corno, L., & Snow, R.E. (1986). Adapting teaching to individual differences among learners. In Handbook of research on teaching, 3rd ed. Ed. M.C. Wittrock, New York: Macmllan.

[3] Davidson, G., Savenye, W., & Orr, K. (1992). How do learning styles relate to performance in a computer applications course? Journal of Research on Computing in Education, 24, 348-358.

[4] Gregorc, A. (1976). Learning Styles Inventory. Storrs: University of Connecticut.

[5] Kulik, J., Bangert, R. & Williams, G. (1983). Effects of Computer-Based Teaching on Secondary Students. Journal of Educational Psychology, 75, 19-26.
[6] Pritchard, W.H. (1982). Instructional Computing 2001: A Scenario. Phi Delta Kappan, 65, 322-325

Research on Teaching Da-Yi Chinese Keyboarding by Using Adaptive Input Interface

Ming-Chung Chen*, Hwa-Pey Wang and Lih-Ching Chen Wang*****
**National Chiayi School for the Mentally Retarded*
123, Sec 2, Shi-Shian Rd. Chiayi city,Taiwan.
E-mail:mtchen@blue.com.url.com.tw
***National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan.
E-mail: hpwang@icon.ntnu.edu.tw
****Cleveland State University*
1860 E. 22nd Street, 1438 Rhodes Tower, Cleveland, OH 44114 E-mail: l.c.wang@csuohio.edu

The purpose of this study was to examine the effects of teaching three students with moderate mental disability in a specialized high school in Taiwan to learn Da-Yi Chinese keyboarding by using adaptive input system. A single-subject multiple-probe baselines design across subjects was used. The students used the Unlimiter system as the adaptive input interface to learn to differentiate the locations of the Da-Yi character roots on a keyboard and to learn Chinese keyboarding with Da-Yi character roots. The result shows that all three students can distinguish the locations of the Da-Yi character roots without extra instruction and interact with the computer with Da-Yi input method. The applicability and effectiveness of teaching high school students with moderate mental disability in learning Da-Yi Chinese keyboarding was supported.

Keyword: **adaptive computer system, Da-Yi Chinese Keyboarding, special education, mental disability**

1 Introduction

With the rapid advancement of the Internet, our life has become more tied to the Internet and the utilization of the computer is becoming increasingly important. In daily life, people are becoming more familiar with Internet shopping and using email to communicate. In educational planning, many countries are putting emphasis on classroom computers and the Internet [5][6]. Moreover, various Internet-based learning modes are the focus of research in those countries [12][13] in hope of using the Internet to assist students to learn anytime and anywhere and are consequentially achieving the ideal of equal educational opportunity and quality education.

However, for the disabled, because of their disability in the functions of the body, senses, and cognition, it is hard for them to use the technology of computers and the Internet. Enabling the disabled in utilizing these technologies with an accessible environment is an important issue facing the educators.

The government in Taiwan views the establishment of a computer environment with accessibility for the disabled as a priority. When the Department of Education started putting the infrastructure of computer classrooms and Internet access in place in K-12 schools in 1998, it purchased a batch of computers with specialized Internet accessibility for the local school districts and special education schools in hopes that the disabled students can use the specialized equipment to learn computer skills and the Internet, thus enabling them to further their learning with the help of the computer and Internet.

Specialized computer accessories can reduce the problems that the disabled encounter in input and output so

that they can use the computer more easily. Therefore, as far as input device accessibility is concerned, the emphasis is on the input interface, for example, keyguard, touch-screen, trackball, replacement keyboard -- mini-keyboard and enlarged keyboard, etc. Although these input devices make the computers more accessible and easier to use, no matter which accessible input interface is employed, a user still has to learn a method of Chinese input to be able to use the computer in learning and communications.

Currently, four kind of Chinese input mechanisms are used: keyboarding, voice input, writing input, and optical scan. Keyboarding is the most common input method among them[4][14][15]. In fact, although the other ways are more convenient , keyboarding is more useful for individuals with more severe mental disability, since they experiences difficulty with cognition, speech, and motor skills [8][9].

Whichever input method is employed, keyboarding has to be utilized to complete the process of interfacing with the computer in Chinese. Furthermore, keyboarding, per se, is not restricted to finger typing on a keyboard. It is broadly viewed as using the key codes on the keyboard to spell characters and words. A user can input by clicking the keys with a mouse on a displayed mini-keyboard on the computer monitor, by using a replacement keyboard, by using a single on/off key in conjunction with menu scanning, or even by using Morse code. Thus, it is an important key issue to know how to help the disabled, intellectually and/or physically, to learn effective computer keyboarding that enables them to communicate with people.

There are several methods for typing Chinese characters on the computer. These input methods can be grouped into two categories: One is phonetic-coding input; the other is pattern-coding input. The former is inputting Tzu-Yin phonetic symbols or Han-Yu phonetic spelling to have the computer display the homonyms, while the latter is inputting the codes of disassembled basic character patterns, for example, Chang-Jay pattern coding and Da-Yi pattern coding to have the computer display a corresponding Chinese character. Among the current methods, Tzu-Yin, Chang-Jay and Da-Yi are most commonly used[3].

The authors chose Da-Yi as the input method in this study based on the reasons below:

A. The prerequisite of using Tzu-Yin input method is that one must be able to pronounce and spell out a character[7]. This is difficult for students with mental disabilities.
B. Chang-Jay input method was developed based on the character-construction rules while Da-Yi keyboarding starts with writing-stroke rules. This way, the students could keyboard with the sequence of writing.
C. Some research results show that students with mild mental disability perform worse in using Tzu-Yin keyboarding than in using Chang-Jay [10]. The students spent a lot of time learning. Students with moderate mental disabilities could learn to use the Da-Yi input method quickly.
D. Da-Yi input method may be worthwhile for students with mental disabilities to learn in the information age. But how can we assist the students in learning Da-Yi more effectively and less frustratingly?

Therefore, the purpose of this research was to explore if the students can learn to use the Da-Yi input method on the keyboard.

2 Research Methodology

2.1 Experimental Subjects and Setting

Three high school students with moderate mental disability in the Chia-Yi special school participated in this research. The subjects were selected on the basis of three criteria. First, they were capable of using verbal communication. Secondly, their emotions were stable. Thirdly, their fine motor movement, especially that of the hands, could be controlled by themselves.

Although they are too old to take an IQ test, they were all identified as having moderate mental disability when they entered this school. In order to realize the subjects' characteristics, the researchers reviewed their IEP files and interviewed their teachers. A summary of the subjects' characteristics appears in table 1.

Instruction was conducted by the researchers in the school's counseling room. A personal computer with an Unlimiter computer interface system (called the U1 system by special education educators in Taiwan) were placed on the table. The U1 system was designed by the Assistive Technology Foundation. It is a kind of programmable keyboard that can be designed by the instructor[2]. The subject sat in front of the table and operated the U1 system while the instruction took place.

Table 1 Subject's Characteristics

Subject	Age	Grade	Gender	Experience in Computer Use?	Performance of literature
• •	17y4m	12th	Male	Yes	Can read and write some common words, Articulation disorder Received speech-language therapy.
• •	17y11m	12th	Female	No	Can read and write some common words, oral expression is good
C	18y7m	10th	Male	No	Oral expression is good. Can read printed words excluding his personal information, e.g. name, address.•

2.2 Stimuli

2.2.1 Character roots instruction

There are 253 character roots in the Da-Yi input method. These character roots are divided into 40 groups depending on their attributes. The researchers chose the most frequently used 2 characters for each group, which were a total of 80 characters (see Figure 1).

2.2.2 Keyboarding instruction

328 words that were divided into 4 sequent groups according to the construction of the word were chosen for the keyboarding practice. These four groups are: group A "from left to right" (•), group B "from top to bottom " (•), group C "combination of the previous two types" (•), and group D "from outside to inside" (•). These words were chosen based on their frequency of use and the explicitness of the word formation. The subjects practiced keyboarding from easier character root formations to more complicated ones.

2.2.3 Words for generalized testing

Three groups of tests were designed. The first group contained 28 new words that were never practiced before. The second involved 21 sentences and 172 words that were practiced in the instruction period. The third group were some written articles.

2.4 Apparatus

This study uses a multimedia computer with a 19-inch monitor and Unlimiter, an adaptive input system. Unlimiter is a kind of programmable keyboard for which the user could design the layout to suit their purpose. In this study, the researchers designed a layout as an alternative keyboard for the subjects. The content of the layout is in Figure 2.

2.5 Definitions of Independent and Dependent Variables

The independent variable was the instructional design that contained the arrangement of the keyboarding practice words based on the explicitness of word formation and the use of the Unlimiter computer input system.
The dependent variables were effectiveness of learning (percentage of correctly keyboarded target words) and efficiency of learning (numbers of sessions the subject required in order to reach the master criteria).

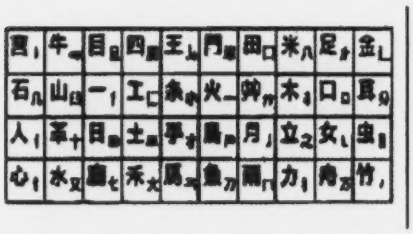


Figure 1 the table of Da-Yi character roots

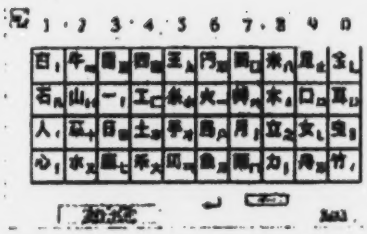


Figure 2 the layout of Da-Yi input method

2.6 Design

A multiple-probe baseline across subjects was used. The particular strengths of the multiple-probe baseline design were: (a) the treatment was not reversed, (b) prolonged baseline measures were unnecessary, and (c) the design permitted the evaluation of academic learning [i][11]. A constant time delay technique was selected for instruction in this study, and verbal praise was used as reinforcement.

2.7 Procedure

The research was divided into two steps: instruction of Da-Yi character roots followed by the instruction of the Da-Yi input method. Researchers randomly decided prior to the instruction which subjects would receive instruction. The next group of subjects received instruction when the previous student group entered the "from upper to lower" keyboarding instruction.

2.7.1 The instruction of Da-Yi character roots

In this step, subjects learned about the 80 Da-Yi characters roots on the layout. The subject would not go to the second step, the instruction of the Da-Yi input method, until he or she reached the master criteria, which was 90% correct responses in three continuous sessions.

2.7.2 The instruction of the Da-Yi input method

There were three periods of instruction. They were baseline, instruction sessions, and maintenance & generalization. During the baseline period, the subjects were measured on their accuracy of keyboarding with the Da-Yi input method. The percentage correct measured after testing each group of target words was used as the subject's baseline performance.

During the instruction sessions period, researchers taught the students the necessary keyboarding rules for the sequence of writing. The instruction started from group A"from left to right". The subject practiced and took a test with the *Microsoft Excel* software. The researchers demonstrated keyboarding the target word if the student could not keyboard it correctly in the 20-second time-delay period. The student could not advance to practicing the next group until he or she reached the master criteria, which was a 90% correct response in three continuous sessions.

In order to examine whether the subjects could maintain and generalize their keyboarding abilities, we continued to assess the subjects' performance of new words, sentences and articles without prompting.

2.8 Reliability

In order to assess the subjects' response accurately, we immediately recorded the results of subjects' keyboarding in *Microsoft Excel*.

3 Result

3.1 Da-Yi Character Roots

The three subjects were measured for their familiarity with Da-Yi character roots by having them indicate the target key on the layout. The results showed that all three students could indicate the 80 character roots under the researchers' order. It meant that the subjects could go to learn Da-Yi input method without supplemental learning of character roots.

3.2 Keyboarding- Four groups of words

The percentage of correctly keyboarded training words in the four groups during the instruction sessions for each subject is presented in Figures 3, 4, and 5. For these three subjects, it is obvious that they could learn to keyboard with the Da-Yi input method. Student A could type these four forms of words almost 100% correctly. The performance of Student B indicated that she fulfilled the criteria in every measurement except the first trial of group A and group D.

Student C only fulfilled the mastery criteria for group A. However, student C could reach the mastery criteria and learn how to keyboard with the Da-Yi input method.

According to the performance of these three subjects, we found that teaching keyboarding to moderately mentally disabled students with the Da-Yi input method using Unlimiter as an adaptive input system is a valid method, especially when student C did not recognize these characters.

The instruction was efficient. Student A reached the mastery criteria in the minimal number of sessions. Student B used three sessions for groups B and C, and four sessions for groups A and D. Student C spent three sessions on group A, four sessions on group C and group D, and five sessions on group B. They all could learn to master the keyboarding rules with the Da-Yi input method with short-term instruction.

3.3 Maintenance & Generalization.

3.3.1 New words

The subject was measured on their generalization of a group of new words after their mastery of the four groups of words with different word formations. The results are presented on table 2. They could generalize the rules of keyboarding for words not practiced before.

3.3.2 Sentence

Students were asked to keyboard 21 sentences and 172 words composed of the words they practiced. The results on table 2 indicate that the three subjects could keyboard almost 100% correctly.

3.3.3 Articles

Due to time limitations, student B only finished article one, and student C did not have the opportunity to type the articles with the Da-Yi input method. As the results in table 2 show, student A and student B could keyboard almost all the content of the articles although some words were never practiced.

Therefore, the three subjects could generalize the rules of keyboarding with the Da-Yi input method they had learned into new words, sentences, and articles.

Table 2 Numbers of correct inputting of the three subjects in generalization test

	New words (n=28)	Sentences (n=172)	Article one (n=130)	Article two (n=227)	Article three (n=142)
Student A	28	172	127	225	136
Student B	25	170	125		
Student C	24	172			

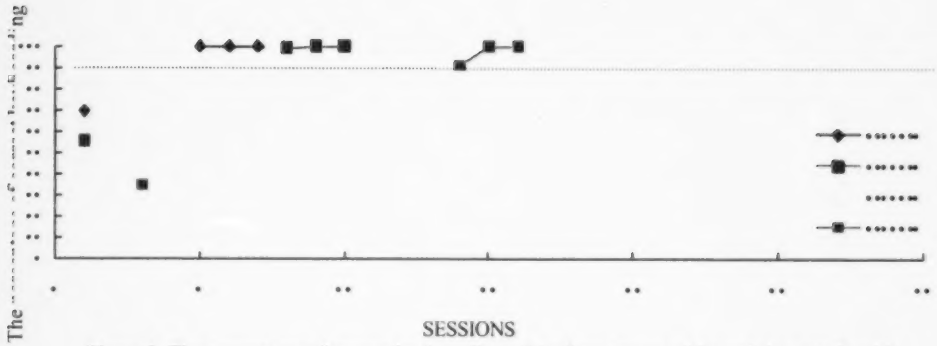


Figure 3. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student A

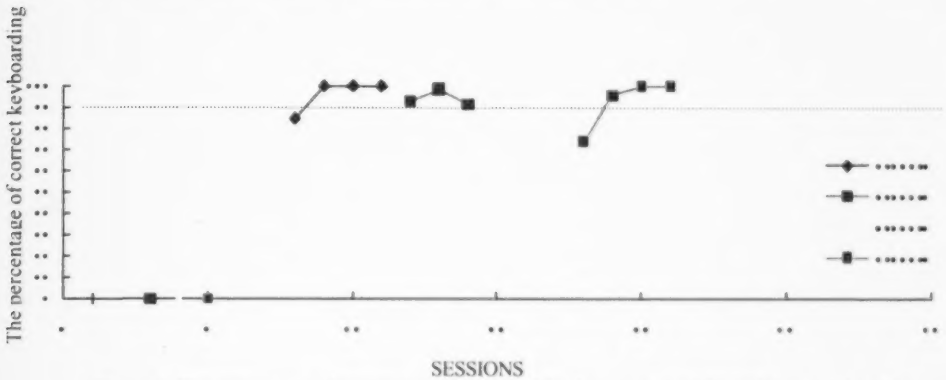


Figure 4. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student B

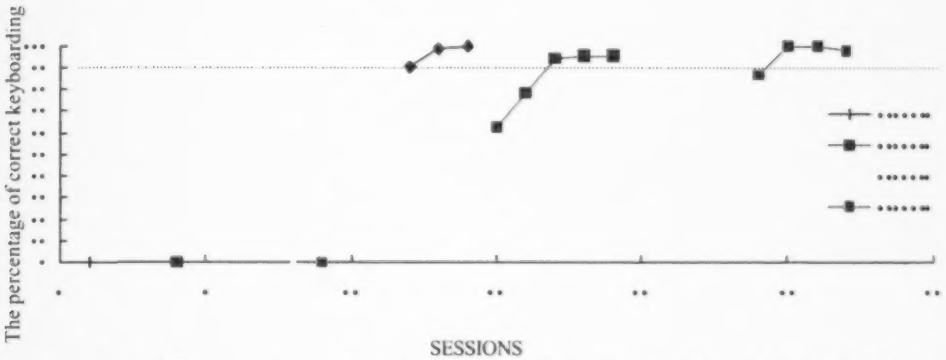


Figure 5. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student C

4 Conclusions

The purpose of this study was to examine the effects of teaching students with moderate mental disability in a special high school to learn Da-Yi Chinese keyboarding by using an adaptive input system. The results indicated that all three subjects could learn to keyboard with Da-Yi input method by using adaptive input system. In other words, it was an effective and an efficient way to teach students with moderate mental disability to learn Da-Yi input method by using adaptive input interface. In fact, using the alternative keyboard could provide the students with a simpler keyboard, but more prompts would be needed to discriminate the position of the Da-Yi character roots.

According to the result of this research, special educators may help students with moderate mental disability to learn Da-Yi Chinese keyboarding by using an adaptive input interface system as an input method.

Reference

[1] Alberto, P.A., & Troutman, A. C., Applied behavior analysis for teachers, Englewood Cliffs, New Jersey: Prentice-hall, Inc, 5th Edition, (1999).

[2] Assistive Technology of Foundation., "The handbook of Unlimiter", Taipei: Assistive Technology Foundation, (1999).

[3] Chou, F. S., Lee, T. Z., & Lin, C. C., "Evaluation and redesign of Da-Yi keyboard layout", Journal of National Cheng Gong University• Vol 27, pp. 69-82, (1992).

[4] Dai, J. F., " The study on comparing the Chang-Jay input method and Da-Yi input method", Bulletin of Chinese of the University of Zhong-Shan, Vol 2, pp. 211-234, (1998).

[5] Department of Education of Taiwan, R.O.C., "The infrastructure of information and computer education", . http://www.edu.tw:81/information/expand/expand.html(accessed on March 10, 2000).

[6] Department of Education of USA, "FY2000 Major Initiatives and Funding Opportunities", http://www.ed.gov/inits/FY2000/index.html#21cclc(accessed on March 8, 2000)

[7] Huang, Y. H., "Introducing to Chinese character, input and recognition-part B", the Newsletter of Academic Sinia Computer Centre in Taiwan, Vol 14, No. 26, pp. 240-241, (1998).

[8] Lin, B. C., Chang, C. F., & Huang, U. C., "The study on investigating the language disability of the students with mental retarded in Taiwan", Taipei: the Department of Special Education of Taiwan Normal University, (1992).

[9] Lin, B. C., & Qiu, S. Z., "The study of the language ability of students with mental retarded", The Academic journal of Taiwan college of education, Vol 8, pp. 197-228, (1983).

[10] Lui. Z. H., "The study on teaching the students with mental retarded in the middle school to learning Computer Chinese input", unpublished, (1998).

[11] Tawney, J. W., & Gast, D. L., Single subject reseach in special education, Columbus, OH: Charles E. Merrill publishing Co, (1984)

[12] The Center for Highly-Interactive Computing in Education at the University of Michigan, "Foundations of Science: Using Technology to Support Authentic Science Learning", http://hi-ce.eecs.umich.edu/apers/foundations_of_science_using /index.html(accessed on December 15, 1999).

[13] University of Toroto, "Web Knowledge Forum", http://www.learn.motion.com/lim/kf/KF0.html(accessed on December 15, 1999).

[14] Xu, H. J., "An adaptive strategy on keyboarding", Master dissertation, National Taiwan Normal University, (1994).

[15] Zeng , S. X., "Introducing to Chinese input method", The Newsletter of Academic Sinia Computer Centre in Taiwan, Vol 13, No. 8, pp. 85-88, (1997).

Strategies for Searching in the WWW

Meng-Jung Tsai
Center of Teacher Education, Tunghai University
181, Sec. 3, Taichung-Kang Rd., Taichung, Taiwan 407
Tel: +886-4-3590121
Fax: +886-4-3580601
E-mail: mjtsai@mail.thu.edu.tw

Searching information in the WWW effectively and efficiently is an important vehicle for 21st century citizens to become lifelong learners. This study was to identify effective information-seeking strategies by comparing the strategies employed by the Internet novice user and those by the expert user. A searching task followed by an interview were undertaken in order to observe the strategies used by the subjects. Pre-task and post-task surveys were also administered to collect data relating to subjects' background and self-efficacy toward using the Internet. Protocol analysis was used to analyze the verbal data collected in this study. The results showed that the expert and the novice employed different information-searching strategies in the following six aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving.

Keywords: **Searching Strategies, Lifelong Learning, WWW**

1 Introduction

Lifelong learning has been recognized as an important goal of education in the twenty-first century [14]. With increasingly tremendous information to face everyday, searching desired information effectively and efficiently becomes a necessary skill for learning in such an information age [4, 6]. Due to its efficiency and popularity, the World Wide Web (WWW) is becoming a powerful vehicle for reaching the goal of lifelong learning.

However, it seems not easy for Internet novice users to search information effectively and efficiently via the web. For example, disorientation was reported as a problem that the novice explorers might have while navigating within a hyperspace [2]. It was often to lose directions if they were lack of self-conscious in searching motivation, strategies, results, and meanings. Borgman suggested future research to compare novice and expert users' cognitive behaviors while they are doing a specific searching task in order to find the key factor to accomplish the task [1].

Prior research indicated that users' metacognitive ability, orientation conscious, system knowledge, domain knowledge, and system design influenced users' searching strategies while navigating in a hypermedia environment [6, 10]. Users' computer knowledge and information processing skills were particularly emphasized as important factors to determine a successful searching [4]. Except by improving the system design to help users perform self-reflection during the information-seeking process [9, 7], future research was suggested to evaluate the application of metacognitive skills in an Internet-based learning context [4, 5].

According to the literature about metacognitive strategies [12, 16], learners need not only to have self-conscious about their own learning but also have to know what strategies they can use and how to use them in order to enhance their metacognitive abilities. In addition, it is more important for students to know how to learn than what to learn in order to reach the goal of lifelong learning [14]. Teaching students about how to learn has been demonstrated to be effective to improve students' achievement and attitudes in various learning domains [8, 13]. However, little research explored the strategies specifically for searching information in the WWW.

Hill [5] described a conceptual framework for how users formulate and employ information-seeking

strategies in open-ended information systems (OEISs), e.g. the Internet. Two stages of information seeking were presented in this model. The first was navigational stage, which included the following processes: purposeful thinking, acting, and system responding. The second was process stage, including evaluation, transformation and integration, and resolution. With limited metacognitive ability and unawareness of computer application skills, novice users tended to suffer information overloading. They often repeated the behaviors which were recognized in the navigational stage, but seldom performed the actions belonged to the process stage. However, experienced users were able to utilize the searching strategies that were recognized in both stages [5]. They also showed how to control and manage their searching process. It seemed that users' self-awareness about their own searching ability, self-reflection, self-control and self-management about their searching process were keys for successfully seeking information on the Internet.

In order to become lifelong learners, all citizens of the next century must know what strategies they can use for searching information effectively and efficiently on the WWW and how to use them. If the Internet is an important vehicle for lifelong learning, then identifying effective WWW searching strategies should be the first step to reach the goal.

2 Purpose

The purpose of this study was to identify effective WWW information-seeking strategies by comparing the strategies used by Internet novice users and experienced users. Therefore, the research question of this study was: What are the differences between the strategies used by Internet novice users and those used by Internet experienced users while searching information on the WWW?

3 Methodology

Two in-deep case studies followed by a between-case comparison were used to answer the research question. A college freshman, as an Internet novice user, and a college graduate working at a computer technology company, as an Internet expert user, were volunteered to participate this study. Both subjects were asked to perform a searching task alone through the WWW by using a web browser, Internet Explorer. The goal of the task was to find a freshmen course schedule of a specific department in a large university in Taiwan. The searching processes were both videotaped for observing subjects' searching paths, number of websites visited, and the time spent on each site. During the search, subjects were asked and continuously reminded to perform think-aloud in order to collect verbal information for protocol analysis [3] of their searching strategies. Pencils and blank answer sheets were issued to subjects for taking notes or answers.

Before searching, a survey was administered to collect subjects' Internet background, including their Internet using history, frequencies of Internet access, Internet access availability at home, Internet courses taken before, and self-efficacy about searching information on the WWW. Right after the searching task, subjects were given another survey to reflect their self-satisfaction toward their performance in the task. Subjects were further interviewed by the researcher if there was a need to clarify on the videotape. Subjects' searching paths, actions, responses, and think-aloud protocols were analyzed for each case and then compared between cases.

4 Results

Comparing the data collected from pre-task and post-task surveys, searching paths, verbal scripts and blank answer sheets, several different characteristics showed between the Internet novice user and expert user. First of all, the expert finished the task and got desired information after visiting 30 in 18 minutes, whereas the novice visited 19 websites in 24 minutes with a blank answer. Except for different searching results between the cases, this also showed that the expert's navigating speed was as about twice as the novice's. In addition, the expert spent less than one minute on each website, whereas the novice spent more than one minutes on five websites. This indicated that the expert processed and evaluated the information shown on computer screen much faster than the novice.

Besides, verbal scripts to complaint about system like "I hate it! It is so slow..." or to critique the website

design like "This is a poor website full of redundant information..." showed 9 times during the expert's searching and 0 during the novice's; however, anxiety or worrying responses like "How come I cannot find it..." or " I cannot..I cannot..I just cannot find it..." showed 12 times during the novice's searching but 0 during the expert's. This suggested that the expert was confident to and believed being able to find the desired information; however, the novice users were coping with tremendous amount of anxiety toward reaching the goal of the task. This was concurred with their reflections in pre-task survey about their self-efficacies toward using computer technology.

Furthermore, navigation disorientation and system problems did not happen during the expert's searching process, but happened in the novice's searching process. The novice responses with "I understand it but just don't know where to start..." "How did I get here..." and "Oh! My god. I made a mistake. What's wrong with this?" This revealed that the novice user tended to get lost and became nervous after an error occurred. However, the expert showed confidence in controlling and regulating their searching process no matter what happened in the process.

Finally, the expert was familiar with how to use search engines and data base query systems; however, the novice showed some problems with them. This implied that knowing how to use helpful searching tools on the WWW is an important issue for successful searching. Besides, the novice showed little try-and-error strategies when problems occurred; however, the expert used this strategy a lot when a bottle net occurred. This indicated that try-and-error was an important problem solving skill for a successful searching in the WWW.

5 Discussions

Based on the results of this study, the differences of strategies utilized by the Internet novice user and the expert user can be summarized as following six aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving. Computer self-efficacy [11] means how users perceived their abilities toward utilizing computer technology. The expert user tended to have higher computer self-efficacy than the novice user. This strategy relates to users' prior computer experience and believes about learning computers. Changing the novice users' views or believes about their computer abilities might be a solution to enhance their searching effectiveness and efficiency.

Task anxiety refers to worrying about not being able to reach the goal of a searching task. This strategy relates to environmental expectation and support. Group searching task with peer support might be a solution to help the novice search information on the WWW. Search aids indicates to users' knowledge and abilities to use tools that help search on the WWW, e.g. search engines and data base query systems. This relates to users' prior-knowledge and experience of using a data retrieval system. Providing a metaphor of such a system and practicing the query skills could enhance the novice users' abilities in this aspect.

Information processing refers to the ability to read in information from computer screen, select main ideas, evaluate, transfer, and integrate the information, and finally make decisions for the next destination. Strategies like looking through headlines and hyperlinks immediately after visiting a web page could help novice users to encode web information. Except encoding, many other strategies belong to this aspect. They include differentiating, monitoring, formulating, integrating, extracting, angling, collecting, controlling, decision-making, and reflecting [5]. In addition, this study shows evidence to support Hill's [5] conceptual framework of seeking information in an open-ended information system. Because the novice did repeat the behaviors of the navigational stage [5], but seldom performed the actions belonged to the process stage [5]; however, the expert in this study did perform the actions of both stages and show how to control and manage his searching process.

Concentration means the ability to keep attention on the searching task. The novice was easy to be interrupted by unrelated program messages or outside interferes. Have the mouse pointing to text which is currently being processed or read the text loudly might help the novice concentration on searching task. Problem solving means the ability to use try-and-error strategy when problems occur during searching. This strategy relates to users' creativity and problem solving styles. This strategy may be enhanced by successful practice experience.

6 Conclusions

The Internet novice users and expert users utilize different strategies to seek information in the WWW, an open-ended information system. Although the system design and users' system knowledge and domain knowledge may influence users' searching efficacy, users' metacognitive searching strategies may be enhanced through teaching and practice. By comparing the novice's and the expert's strategies used for seeking desired information through the WWW, this study identified six different aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving. Future research should further investigate each aspect and examine the effects of the training of these strategies on users' searching efficacy.

References

[1] Borgman, C. L., "Why are online catalogs hard to use? Lessons learned from information-retrieval studies", Journal of the American Society for Information Science, Vol. 37, No. 6, pp. 387-400, (1986).

[2] Dias, P., Gomes, M. J., & Correia, A. P., "Disorientation in hypermedia environments: mechanisms to support navigation", Journal of Educational Computing Research, Vol. 20, No. 2, pp. 93-117, (1999).

[3] Ericsson, K. A., & Simon, H. A., "Protocol analysis: Verbal reports as data", Cambridge, MA: MIT Press, (1984).

[4] Hess, B., "Graduate student cognition during information retrieval using the World Wide Web: a pilot study", Computers & Education, Vol. 33, pp. 1-13, (1999).

[5] Hill, B., "A conceptual framework for understanding information seeking in open-ended information systems", Educational Technology Research & Development (ETR&D), Vol. 47, No. 1, pp. 5-27, (1999).

[6] Hill, J. R., & Hannafin, M. J., "Cognitive strategies and learning from the World Wide Web", Educational Technology Research & Development (ETR&D), Vol. 45, No. 4, pp. 37-64, (1997).

[7] Kashihara, A., Uji'I, H., & Toyota, J., "Reflection support for learning in hyperspace", Educational Technology, September-October, pp. 19-22, (1999).

[8] King, A., "Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain", American Educational Research Journal, Vol. 31, No. 2, pp. 338-368, (1994).

[9] Lin, X., Hmelo, C., Kinzer, C. K., & Secules, T. J., "Designing technology to support reflection", Educational Technology Research & Development (ETR&D), Vol. 47, No. 3, pp. 43-62, (1999).

[10] MacGregor, S. K., "Hypermedia navigation profiles: cognitive characteristics and information processing strategies", Journal of Educational Computing Research, Vol. 20, No. 2, pp. 189-206, (1999).

[11] Oliver, T. A., & Shapiro, F., "Self-efficacy and computers", Journal of Computer-Based Instruction, Vol. 20, No. 3, pp. 81-85, (1993).

[12] Pressley, M., & Wolshyn, V., "Cognitive strategy instruction that really improve children's academic performance", Cambridge, MA: Brookline Books, (1995).

[13] Rosenshine, B., Meister, C., and Chapman, S., "Teaching students to generate questions: A review of the interaction studies", Review of Educational Research, Vol. 66, pp. 181-221, (1996).

[14] Titmus, C. J., "Lifelong education for adults: An international handbook", Elmsford, NY: Pergamon Press, (1989).

[15] Weinstein, C. E., & Hume, L. M., "Study strategies for lifelong learning", Washington, DCL American Psychological Association, (1998).

[16] Weinstein, C. E., & Mayer, R. E., "The teaching of learning strategies", Handbook of research on teaching, NY: MacMillan, 3rd Ed., pp.315-327, (1986).

The Internet-based Educational Resources of the U.S. Federal Government

Andy Wang* and Krishelle Leong-Grotz**
**University of California at Berkeley,*
2325 Blake Street, #201, Berkeley, CA 94704,
andy@café.berkeley,edy
***Case Western Reserve University*
School of Medicine, Class of 2003,
ktl3@po.cwru.edu

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right information on a particular topic for their students takes time. Current initiatives, such as FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning resources. This paper aims to introduce some of the United States' successful programs.

1 Introduction

One of the main priorities of the Clinton administration is to make sure that all Americans have the best education in the world. One of the goals of this "Call to Action for American Education" is to bring the power of the Information Age into all schools in the United States. This initiative requires connecting every classroom and library to the Internet, making sure that every child has access to multimedia computers, giving teachers the training they need to be as comfortable with the computer as they are with the chalkboard, and increasing the availability of high-quality educational content. When America meets the challenge of making every child technologically literate, children in rural towns, suburbs, and inner city schools will have equal access to the same knowledge base.

United States Federal agencies have made significant contributions to expanding this knowledge base. For example, "White House for Kids," is a home page with information on the history of the White House. NASA has a K-12 initiative, allowing students to interact with astronauts and to share in the excitement of scientific pursuits such as the exploration of Mars and Jupiter, and the experiments conducted on the Space Shuttle. Students participating in the GLOBE project (Global Learning and Observation for a Better Environment) collect actual atmospheric, aquatic, and biological data and use the Internet to share, analyze, and discuss the data with scientists and students all over the world. With support from the National Science Foundation, the Department of Energy, and the Department of Defense's CAETI program (Computer-Aided Education and Training Initiative), the Lawrence Berkeley Laboratory has developed a program that allows high school students to request and down-load their own observations of the universe from professional telescopes.

Of these government programs, four of these are as follows:

2 FREE (Federal Resources for Educational Excellence)

On April 18, 1997, President Clinton asked Federal agencies to determine what "resources you can make available that would enrich the Internet as a tool for teaching and learning." In response, more than 40

Federal agencies formed a working group to make hundreds of federally supported education resources available on the FREE website.

Some of the subjects of the FREE include arts, educational technology, foreign languages, health and safety, and mathematics. Agencies involved include Centers for Disease Control and Prevention, National Gallery of Art, National Science Foundation, Peace Corps, Consumer Product Safety Commission, and the Smithsonian Institution.

3 GEM (Gateway to Educational Materials)

GEM began in 1996 after the National Library of Education (NLE) Advisory Task Force sought to find ways to apply library and information science skills to help educators find lesson plans and teacher guides on the Internet. GEM provides links to free Internet materials, partially free materials, and to resources that require a fee or registration to be used. There are two ways to access the education resources on GEM —Browsing and Searching. Browsing GEM is sampling from lists of predetermined categories (e.g. mathematics, language, education by grade level). Searching GEM is looking for any information containing the keywords of the query (e.g. algebra lesson plan). This website provides access to educational materials found on various federal, state, university, non-profit, and commercial Internet sites.

4 ERIC (Educational Resources Information Center)

The Ask ERIC service (Education Resources Information Center), supported by the Department of Education, has a virtual library of more than 900 lesson plans for K-12 teachers, and provides answers to questions from educators within 48 hours -- using a nationwide network of experts and databases of the latest research. Abstracts of some 1,300 (Educational Research Information Center) ERIC Digests are available online and text-searchable. A menu of services offered on the Internet not only introduces the user to ERIC documents, but also leads to other databases in education. It began in 1992 as a project of the ERIC Clearinghouse on Information and Technology and is now, with the ERIC Clearinghouse, a component of the Information Institute of Syracuse at Syracuse University. Today, Ask ERIC encompasses the resources of the entire ERIC system and beyond. Got an education question? Ask ERIC! The main components of Ask ERIC are:

1. Ask ERIC Question & Answer (Q&A) Service
   Need to know the latest information on special education, curriculum development or other education topics? Just Ask ERIC! When you submit your education question to Ask ERIC Q&A, you' ll receive a personal e-mail response from one of our network information specialists within two business days! We will send you a list of ERIC database citations that deal with your topic and will also refer you to other Internet resources for additional information. It' s that easy!

2. Ask ERIC Virtual Library
   The Ask ERIC Virtual Library contains selected educational resources, including 1000+ Ask ERIC Lesson Plans, 250+ Ask ERIC Info Guides, searchable archives of education-related listservs, links to Television Series Companion Guides, and much more!

3. Search the ERIC Database
   The ERIC database, the world' s largest source of education information, contains more than one million abstracts of documents and journal articles on education research and practice. By searching Ask ERIC' s web-based version of the ERIC Database, you can access the ERIC abstracts, which are also found in the printed medium, Resources in Education and Current Index to Journals in Education. The database is updated monthly, ensuring that the information you receive is timely and accurate.

5 Parents Guide to the Internet (16 page informational booklet)

This new, 16-page booklet, produced by the U.S. Department of Education, gives parents an introduction to the Internet and is "intended to help parents --regardless of their level of technological know-how--make use of the on-line world as an important educational tool. The guide cuts through the overwhelming amount of

consumer information to give parents an introduction to the Internet and how to navigate it. Most importantly the guide suggests how parents can allow their children to tap into the wonders of the Internet while safeguarding them from its potential hazards.

This guide was produced with the sort of collaborative effort that American schools need in order to succeed. U.S. Department of Education staff worked with leaders from parent and education organizations, the private sector, nonprofit groups and others in order to give parents a clear and comprehensive overview of the Internet and its vast educational potential. In the same way, schools need support from every corner of the community in order to provide students with a high-quality education.

6 Conclusion

More than ever before, a high-quality education offers Americans the best path to a rewarding career and a fulfilling quality of life. As citizens of the Information Age, Americans must include access to technology among the elements of an education that is based on high standards of achievement and discipline. But incorporating technology into the Nation's schools is too big a job for the schools to tackle on their own. Teachers need support and involvement from parents, grandparents, businesses, cultural institutions and others in order to make effective in-class use of the wonders of technology.

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right resource on a particular topic for their students takes time. And time is in short supply for our teachers. Current initiatives, such as those outlined, FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning.

References

1. Becker, Henry J. Information Technology in Teacher Education: Survey of Current Status. Washington, D.C.: National Technical Information Service, U.S. Department of Commerce, March 1994.
2. Bernie Poole's EdIndex, Web Resources for Teachers and Students, http://www.pitt.edu/~poole/edmenum.html
3. Consortium for Policy Research in Education. CPRE Policy Briefs, June 16, 1995.
4. Cotton, E. G. (1998). "The Online classroom: Teaching with the Internet, third edition." Bloomington, IN: EDINFO Press. (ISBN-1-883790-29-8). (ED 413 606)
5. Educational Resources Information Center (ERIC) web site, http://www.askeric.org/
6. Federal Resources for Educational Excellence (FREE) web site, http://www.ed.gov/free/.
7. Gateway to Educational Materials (GEM) web site, http://www.thegateway.org
8. Junion-Metz, G. (1996). "K-12 resources on the Internet: An instructional guide." Internet workshop series, number 5. San Carlos, CA: Library Solutions Press. (ISBN-1-882208-14-5). (ED 389 316)
9. K-12 computer networking. (1995). "The ERIC Review," 4(1). (ED 392 413)
10. Lankes, R. D. (1996). "Bread and butter of the Internet." ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 402 925)
11. Maeroff, Gene I. Changing Teaching: The Next Frontier. The National Foundation for the Improvement of Education, 1994.
12. McKinnon, P. Alistair, and Clesson S. Bush. "Technology for Education: What is the Federal Role?" Educational Technology 4 (1993): 37-41. Michalski, Jerry. Release 1.0: Esther Dyson's Monthly Report. New York: EDVenture Holdings, Inc., May 1995.
13. Milken Family Foundation. Expanding Classroom, Shrinking World: Resource Guide. Los Angeles, May 4, 1995.
14. National Center for Education Statistics, U.S. Department of Education. Advanced Telecommunications in U.S. Public Schools, K-12. Washington, D.C.: U.S. Government Printing Office, 1995.
15. National Center for Education Statistics, U.S. Department of Education. Annual Revenues and Expenditures: Public K-12 Schools. Washington, D.C.: U.S. Government Printing Office, 1991 and 1994.

16. Parents Guide to the Internet web site, http://www.ed.gov/pubs/parents/internet/
17. Serim, F. & Koch, M. (1996). "NetLearning: Why teachers use the Internet." Sebastopol, CA: Songline Studios, Inc. and O'Reilly & Associates, Inc. (ED 396 700)
18. Tennant, R. (1996). Internet basics: Update 1996. ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 392 466)
19. U.S. Congress, Office of Technology Assessment. Teachers and Technology: Making the Connection. Washington, D.C.: U.S. Government Printing Office, April 1995.
20. U.S. General Accounting Office. School Facilities: America's Schools Not Designed or Equipped for 21st Century. Washington, D.C.: U.S. Government Printing Office, 1995.

Which Chinese Input Methods Is More Suitable for Sixth-Grade Pupils? Keyboarding or Non-Keyboarding

Weichung Wang* and Tainshu Ma
Department of Mathematics Education, National Tainan Teachers College
Tainan 700, Taiwan
**E-mail: wwang@ipx.ntntc.edu.tw*

Computers have been wildly used in elementary schools and to input characters is usually necessary while manipulating computers. However, inputting Chinese characters is a burden for Taiwanese pupils. Keyboarding is a traditional method used for inputting Chinese characters. On the other hand, other user-friendlier input tools like speech and handwriting recognition provide alternative choices. We observe three 12-year-old pupils, who have different backgrounds, how they use these different methods to input Chinese characters. Experiments results show that all three pupils make progress after short-time practice for all input methods. Different pupils, however, would choose different input method depending on their own preference and background.

Keywords: **Chinese input method, keyboarding input by pronunciation, speech recognition, handwriting recognition**

1 Introduction

Computers have been widely used in many educational applications like computer-aided learning. For a pupil in Taiwan, one of obstacles that he or she may encounter for using computers is to input Chinese characters.[1] In this study, we intend to explore pupils' behaviors on Chinese characters inputting and then make recommendations in under what conditions what kind of input methods may be used.

Keyboarding and non-keyboarding are two main categories of characters input methods. For keyboarding method, users type Chinese characters either according to their pronunciations or by "dismantling" the characters. For the non-keyboarding methods, handwriting and speech reorganization are two popular methods for inputting Chinese. While keyboarding has been used for longer time and almost always each computer is equipped with a keyboard, non-keyboarding input methods are developed recently and extra equipments and software are needed.

When keyboarding is used, most students input each single Chinese character by spelling its pronunciation.[5] Main reasons are: (1) Students are familiar with the pronunciation. What they have to learn is to memorize the position of each key on the keyboard corresponding to the pronunciations. (2) Psychology indicates that human beings think in the form of tone (of characters), but not the font of the characters.[4] However, disadvantages of this input method exist. (1) Students may not spell pronunciation correctly especially when they encounter new words. (2) Many different Chinese characters have same pronunciations.[3,7] Pupils thus need to choose the target character and the input speed is slowed down. Non-keyboarding input methods, especial the voice reorganization, is one of the hottest research topic in computing. People use natural ways like handwriting or speech to communicate with computers. The computers then analyzed the data to identify what people mean and output the data in a text format.[6]

We conduct the study to find out pros and cons of each input methods. Three sixth grade (12-year-old) students with different computing backgrounds are chosen, based on interviewing and simple tests. Student A has a lot of computing experience, student C has little computing experience, and Student B is in between. All three students come from National Tainan Teachers College Affiliated Primary School. For keyboarding input, they use the input method of spelling words' pronunciation that is included in the Windows 98

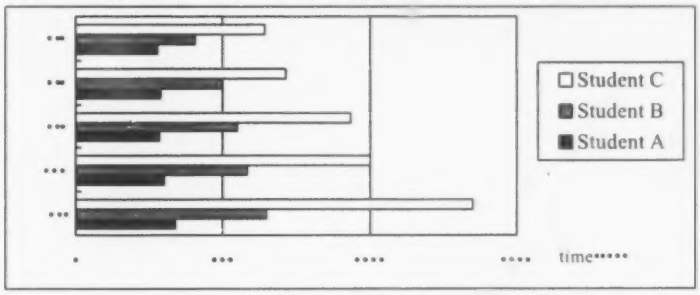
operation system. For handwriting reorganization, they use "Pen Power Jr." For speech reorganization, they use the product named "IBM ViaVoice." The essay that students input is extracted from the newspaper China Times. There are 142 characters in the essay. To evaluate the performance of different input methods, each pupil has five chances to input the Chinese essay by pronunciation based keyboarding, speech reorganization and handwriting reorganization. Between each of chance, they have a period of 30 minutes to practice. In the next section, we summarize our observations and statistical results toward the problems in each of the sub-sections.

2 Findings and discussion

2.1 Can short-time trainings improve performance of pronunciation based keyboarding?

Figure 1 shows timing in seconds that student A, B, C took to finish the essay in five trials. They are asked to input all characters correctly. All three pupils made progress for the short-time practice. Comparing the first and the fifth performances, we found that student A, B, and C had 19%, 37%, and 53% of progress, respectively. Although student A made less progress, the student actually finished the essay quickest. Beside, students A, B, and C had an average progress of 16, 60, 178 seconds. We noticed that both student B and C kept making progress, but student A had a downgrading performance from the third to the forth trial. The difference between the third and forth trial for student A, however, is not significant. Based on the experimental results, we conclude that short time training does benefit three students in different background. Furthermore, the student with the least computing background actually made the most significant progress.

Figure1. Comparison of input timing using pronunciation based on keyboarding.



2.2 How does the speech recognition input method affect the input efficiency?

Figure 2 shows the percentage of the speech recognition software correctly identify the characters. Both student A and B perform similar from the first to the fifth trial, while student B tends to be better in the first of four trials. Besides, student B makes a great progress from the first trial (77%) to the second trial (92%). Student A and B reached a 100% correct recognition and student C achieved almost 90% correctness. This suggests that, after reasonable training, students with different background can manipulate the speech input method nicely.

Figure 2. The correct recognition percentage of speech recognition.

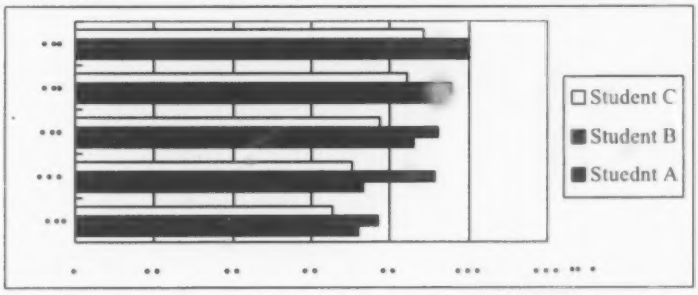
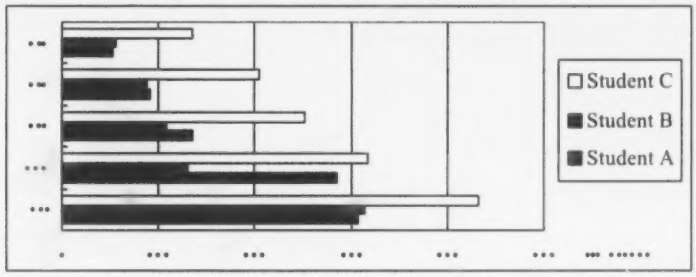


Figure 3 demonstrate timing the pupils took in five trials with emending the wrong characters. When the correct recognition rate is high, the input method can be very efficient, about 160 characters in one minute for student A and B. However, this is not a universal situation. Take student C as the example, the pupil speaks in such an ambiguous tone that the computer simply could not correctly recognize the essay. As the result, the student spent a lot of time to emend the wrong characters and greatly slow down the speed of inputting. Such observations show that there is room for improving the correct recognition rate.

Figure 3. Timing of speech recognition input.



2.3 How does the handwriting recognition input method affect the input efficiency?

Figure 4 reveals the percentage of the handwriting recognition software correctly identify the characters. Both student A and B perform similar from the first to the fifth trial, while student B tends to be better. Besides, student B reached 100% correct recognition at the last two trials, and student C achieved 92% correctness. This suggests that, after reasonable training, students with different background can manipulate the handwriting recognition input method nicely.

Figure 4. The correct recognition percentage of handwritten recognition.

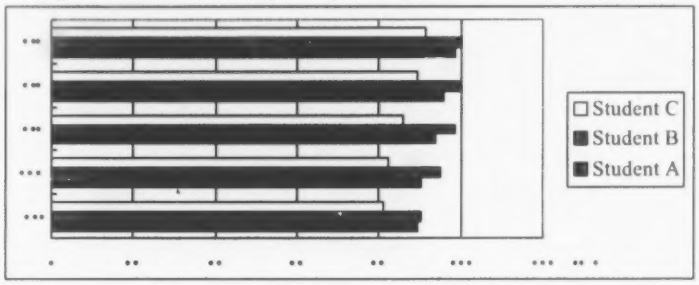
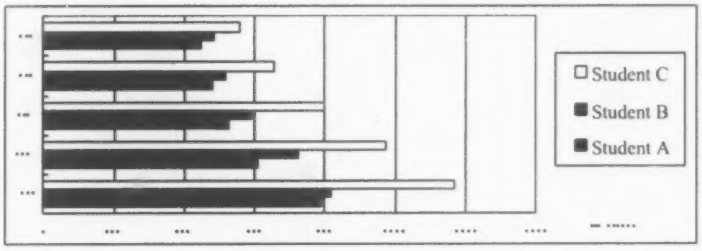


Figure 5 demonstrate timing the pupils took in five trials with emending the wrong characters. We find that both student B and A perform similarly and nicely, though slight differences exist. Main reason why student B outperforms other two students at the correct recognition percentage is the way he wrote Chinese characters. Student B usually writes in a way that the characters strokes are clear and distinct. In contrast, student C tends to write Chinese characters apart and thus make the software consider as several words. Furthermore, student A writes very fast and his written characters strokes are also clear, though a little behind the ones of student B. This characteristic affect the timing of input, while the correct recognition percentage of student A is lower than B, he should took more time in inputting, instead, the timing of input with emending is less than that of student B.

Figure 5. Timing of handwriting recognition input.



2.4 For different students, how the input methods help students to input more efficiently?

For student A, to use keyboarding as input tool is better than the one by non-keyboarding. Because he is familiar with keyboarding and input Chinese even becomes a basic ability as using computer.[2] So that in the test of keyboarding, he exceeded others very much at first, but just for the same reason, he could not make further progress. In inputting by non-keyboarding methods, he did not do such a good job as keyboarding. Take speech for instance, everyone spent almost the same time when they did not need to emend the wrong words, but he spent much more time then student B when emending is needed. Similar result can be found for handwriting method. The recognition rate of student B is better than A.

For student B, to use non-keyboarding as input tool is better than the one by keyboarding. One reason is that he is not as familiar with keyboarding as A does. He usually uses computer to play games or surf the Internet. He actually just needs to use mouse as a tool to communicate with computer. In keyboarding, although his effect is not better than student A, but he has a better progress than student A. If non-keyboarding method is used, no matter speech or handwriting, he did a better job than student A and C. We emphasize that, these three students never use speech or handwritten before, and the result shows that the learning effect of student B is better than the other two students.

For student C, to use keyboarding seems better than non-keyboarding. He made a better progress in keyboarding. In input method of keyboarding, at the last time of test, his input time was even less than that of student B's first trial. This result showed that after short-time training, student C made the greatest progress in keyboarding (53%). For non-keyboarding methods, student C seems had difficulty to adjust his speech tone and handwriting to fit the software. But we think this is the place that software developers should work on. It should be the software developers' responsibility to develop software that is capable of adapting different speech tone and handwriting habit.

3 Conclusions

We have observed the behaviors of using keyboarding and non-keyboarding Chinese input methods. We suggest the following. For students who are familiar with computer and takes inputting as a basic skill, like student A, keyboarding best fits. For those who learn new things very fast, are interested in them, and speak or write well, (like student B) then the non-keyboarding is fit. For a student like the C, who does not learn new things very well and maybe he does not speak or write well, and he is used to input by keyboard, then the keyboarding is fit.

References

[1] Chen, Y.L., "The Input Method of Speech Recognition-Make You Speak Aloud", PC Computing, pp. 3-18, (1999).

[2] Ho, Rong-Guey and Wang, Hsue-Yie and Shyu, Huey-Jiun. "An Adaptive Strategy on Keyboarding: Using Adaptive Drill System Model", http://content.edu.tw/primary/info_edu/tp_tt/content/other/paper2.htm, (1997).

[3] Li, M.C., "The Development of Input Method by Words' Pronunciation", Information and Education, No. 30, pp. 18-22, (1992).

[4] Richard E. Mayer., "Educational Psychology", Taipei: Yuan-Liou, 3rd Edition, (1997).

[5] Suen, D.S., "Let's Use The Special Input Method", Info. Com, No. 218, pp. 91-93, (1998).

[6] Tzeng, U.M., "The Development and Application of Speech Recognition in Computer", Information and Education, No. 52, pp. 10-13, (1996).

[7] Wang, C.F., "The System of Chinese Speech Recognition in Computer", Information and Education, No. 52, pp. 2-8, (1996).

Proceedings

Content

▸Full & Short Papers (Instructional Design)

An experiment of situated learning on college students
An approach to modeling an educational domain
Design and Implementation of Teaching Models in Web-based Teacher Training
Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.
Is Everyone On Board: Learning Styles and the Internet
✓Learning Digital Logic Design by Concept Mapping
Making the Most of the Internets Potential for Education
Online Education: A Learner-Centered Model with Constructivism
Schema theory-based Instructional Design of Asynchronous Web-based Language Courses
Student Learning Issues: factors to consider prior to designing computer-assisted learning for higher education
Students' Attitude toward WPSS in Supporting Classroom Learning
✓The Application of Scaffording Theory on the Elemental School Acid -Basic Chemistry Web
The Development of a Multimedia Program for Teachers to Integrate Computers into the English Curriculum
The Impact of Learning Style on Group Cooperative Learning
The Production of Web-based Interactive Video From Structured Script
Towards a model of using Information Technology in education for pre-service teacher education

▲HOME

//

An experiment of situated learning on college students

Fonchu Kuo*, Hin-chung Wong, Gin-Fon N. Ju***, P.M. Chen*, T.W. Lin*, Shu-Hui Liu** and Hsiao-Chiao Hung****

**Department of Computer Science, Soochow University, Taipei, Taiwan, R.O.C., P. O. Box 14-135, Taipei, Taiwan*

E-mail: kfc@cis.scu.edu.tw

***Department of Microbiology, Soochow University, Taipei, Taiwan, R.O.C. No. 70, Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

wonghc@mail.scu.edu.tw

****Department of Psychology, Soochow University, Taipei, Taiwan, R.O.C., No. 70,Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

gju@cis.scu.edu.tw

Several experiments of situated instruction have been done in elementary school. We conduct the inaugural experiment on college students. A group of 44 students who are taking food microbiology course involved in this experiment. We designed a science fiction named "Save the Taiwan", which is a story regarding a Microbiology technician handles a disease crisis. A student can learn how to deal with the crisis and solve the problem of an infectious disease when he uses this CAI software. The evaluation practice consists of four dimensions, subject domain demands, instructional demand, user interface demand, and pragmatic demands. The result of evaluation shows notable effect on college students.

Keywords: **situated learning, evaluation of CAI, Microbiology**

1 Introduction

The advantage of traditional instruction is that the knowledge that students learned can be "stiff knowledge". The stiff knowledge can not be smoothly applied to solve the actual problem in a real environment (Brown, 1989). Situated cognition bases on the theory that the learning should be constructed at real situation. Only when the learner derive the knowledge from the real situation then he realizes the real meaning of the learned knowledge and cherish the value of knowledge and take it as the tool for solving the problem. (Cognition and Technology Group at Vanderbilt, 1990)

There was experiment on elementary school student (Tsu, 1997). The experiment was focus on learning simple mathematics calculating. We conduct the experiment on college student, trying to find out if situated learning can be succeed on the domain of higher education. The students of Department of Microbiology have to take laboratory classes during the period of 4 years college. They always have the problem of how and where to apply what they have learned in the class. The instructive goals of laboratory class are diverse. Lazarowitz & Tamir (1992) believe that learning is a process of construction. Despite of learning the laboratory skill, oral discussion between instructor and students should be part of the learning process. In addition, a more inexpensive and more efficient instruction method, such as computer aided instruction or simulations, should be adapted in the class. Anchored situated instruction adapts computer technology to implement situated cognition theory. (Cognition and Technology Group at Vanderbilt,1990) In our software, we develop a pseudo but can be real situation, embedded the learning materials in the circumstances. Through the interaction between user and CAI software, learner can then practice the process of collecting and filtering information as well as the methods to solve the problem.

2 Design features of our approach

The script was written and designed by a professor of Department of Microbiology. We adopt several principles in our design.

1. Provide vivid circumstance. Multimedia allows us to design a vivid environment, so that the situation can avoid over-simplified and lack of context. (Yang, 1995). Multimedia also provides plentiful visual symbols, e.g. video images, graphic charts, sound as well as text to make the play more fun and close to real environment.

2. To hide useful information in the story, a learner may have trouble to transfer what he has learned to different situation if he was teaching in a simplified or provided obvious cue environment. Whereas, a learner can learn to justify what information can be useful and what information is not useful for solving the problem in a simulated situation.

3. To randomize the plot of the story, the learner can memorialize the plot if he has experienced in using this CAI software. This can then cause the learning process in vain. We use Random function in our design; one of the bacteria was picked randomly and then, in turn, develop different story.

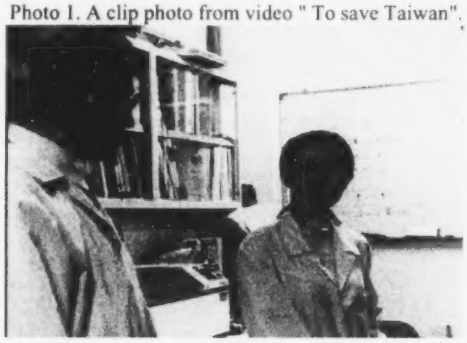
4. To have productive result, there may be only one answer or solution in a traditional instruction. However, in a real environment, there may be more than one solution to solve the problem. They may be pros and cons from one to one, but they may all workable. We do not provide firm answer to user instead, we provide an open-ended environment for user to construct his own path and solution.

3 The story

3.1 Outline of the story

There is a food mediated infectious disease occurs in a small town that locates at the seashore of Taiwan island. Within a few days, this infectious disease has spread to nearby counties and caused many cases of death. Tai-shang (see photo 1), the leading actor, a technician of the local public health administration office, is responsible for finding out the etiologic agent of the disease. In the story, Tai-shang is facing many challenges like the ones in real life. His girl friend, professor and colleagues are all in the plot and interactive with him. After the accident happened, he had faced the pressure from his superior, public media, even from a local councilor. He must acts like a detective who searches the cue and a scientist who seeks for the truth of problem. Finally, with the encouragement of his college instructor, Ta-shang successfully finishes his task.

Photo 1. A clip photo from video " To save Taiwan".



3.2 Goal of learning

a. Cognitive aspect

a. Assessment of identifying the virus, fatal virus can not be classified from appearance. Thus, the learner

has to make a judgement base on the information gathered from the plot and then decide how to proceed the process of bacteria identification.

- b• Learning of the skills of bacteria identification, there are skills, e.g. Stain, biochemical test, can be practiced.
- c• Usage of bacteria identification index table, after the preliminary result of biochemical test, the learner needs to learn to use bacteria identification index table for final judgement.

h• Attitude • •

- a• Right attitude of science work, through playing the role in the game, the learner can identify the spirit of scientific work, diligence and concentration, as the attitude of being a scientist.
- b• Social caring, since the story has a local background, we hope the learner can improve the caring of local society by solving the problem for local society.

4 Evaluation of our experiment

There are four criteria of the evaluation of the designated software. The criteria is based on the character the teaching subject, human learning theories, and research on user interfaces• Kuittinen, 1998• ? The criteria consist of four types of requirements: subject domain, instructional, user interface design and pragmatic matters. We invited two batches of domain experts, the faculties of Department of Microbiology and industry professionals to evaluate subject domain. They focused on examining if the concept and methods of this domain are generally applied in our software, which means they checked the relevancy to instructional aims. The group of 20 experts showed their positive opinion at the following chart.• Table 1 •The instructional demand is a student-centered approach. We divide a group of 44 college students who are taking food microbiology into two groups. The 22 randomly selected members of test team used our software for average 6 hours in a period of a week. A cognitive examination was taken after one week. The result shows that the test team has better performance in cognitive aspect. Table2• The interactivity, display elements and connections between them are examined as the criteria of user interface. We use questionnaire to test team and found out that the team members show satisfaction of the user interface.• Table 3• As the pragmatic criteria, the hardware and software requirements are evaluated to see if a specific and /or expensive equipment or environment is required to use the software. Our software can be used in a common Microsoft Windows environment plus Pentium compatible personal computer. A learner can run our software either at computer room in campus or at his own PC.

Table 1. The result of experts poll

	number	Min	Max	Average	standard deviation	variance
Can the instructional goal of " assessment of identifying pathogenic bacteria " be reached?	12	3	4	3.67	0.49	0.242
Can the instructional goal of " learning the identification methods " be reached?	12	2	5	4.00	0.74	0.545
Can the instructional goal of " usage of diagnostic table for the identification bacteria " be reached?	12	2	5	4.08	0.79	0.629
Can the instructional goal of " influence on right scientific attitude " be reached?	12	2	4	3.58	0.79	0.629
Can the instructional goal of " influence on social caring" be reached?	12	2	4	3.25	0.87	0.750
Does the content of software cover" common foodborne pathogenic bacteria and their characteristics"?	12	2	5	3.92	0.79	0.629
Does the content of software cover" procedures of identification of pathogenic bacteria"	12	4	5	4.33	0.49	0.242
Does the content of software cover" knowledge for assessment of methods used in bacterial identification"	12	2	5	4.17	0.83	0.697

Table 2. Evaluation on the cognitive improvement of the software

Item		n	Average	SD	F-value	df	t-value
Score of Midterm examination	Control group	23	61.96	6.92	2.54	42	-0.34
	Exp. group	21	62.90	11.03			
Semester score	Control group	23	80.09	9.66	1.00	42	1.59
	Exp. group	21	75.48	9.65			
Cognitive Examination	Control group	23	29.74	6.11	1.09	42	-3.14**
	Exp. group	21	41.29	6.98			
Situated Questions	Control group	23	3.57	2.64	1.04	42	-3.73**
	Exp. group	21	6.57	2.69			
Questions on Microbiological Skill	Control group	23	26.17	5.07	1.08	42	-5.47**
	Exp. group	21	34.71	5.28			

Table 3. Evaluation of user interface of the software

	number	Min	Max	average	standard deviation	variance
I do not need tutoring before I use this software	21	2	5	3.95	0.92	0.848
I can easily know how to jump to next screen	21	1	5	3.76	1.18	1.390
I can exit the software anytime, anywhere.	21	2	5	4.52	0.93	0.862
I do not have the situation that I can not proceed because that I did not memorize the previous information while I use this software.	21	2	5	4.19	0.87	0.762
It's easy to modify my answer before I press the "confirm" bottom	21	2	5	4.10	0.94	0.890
I can receive the system feedback anytime when I use the software.	21	2	5	3.90	0.77	0.590
The system feedback is clear enough and no need to be explained.	21	2	5	3.81	0.81	0.662
I can use the software without reading the user's manual in ahead	21	2	5	4.19	0.87	0.762
I think the execution speed is proper to me.	21	2	5	3.95	0.80	0.648
I can handle the execution speed of my own.	21	2	5	3.81	0.75	0.562
I am satisfied the quality of the video.	21	1	5	3.29	1.01	1.014
I can use the software without knowing how to operate Window NT	20	3	5	4.55	0.60	0.366
Total score	21	39	55	47.81	4.12	16.962

5 Conclusions

We completed situated learning software "To save Taiwan" which attract the user to learn the microbiology knowledge and skills. This interactive software provides multimedia and random plots, which enable user to play the role in the story. It can also served as the tool to convey the right scientific attitude and social caring to learners.

The evaluation of this study showed promising results. It is possible and valuable to adapt situated learning to other disciplines in higher education. A disciplinary can construct the learning process on a situated

environment. By using the multimedia software, a learner can learn knowledge as well as the attitude in a near true story. He can then realize the meaning of the knowledge and identify himself with what he has learned and then applied to real environment.

References

- 1. Hsu, H.Y. "Design of anchored instruction" Audio-Visual Instruction bimonthly. 37(1), page14-24, (1995)
- 2. Yang, C. H. "The situated instruction theory and hypermedia learning environment". Instruction technology and media. August, 1995. page41-48. (1995)
- 3. Brown, J. S.Collins, A., & Duguid, P., " Situated cognition and the culture of learning", Educational Researcher, 18,32-41. (1989)
- 4. Cognition and Technology Group at Vanderbilt., "Anchored instruction and its relationship to situated cognition ", Educational Researcher, 19,P2-10, (1990)
- 5. Lazarowitz, R., and P. Tamir.. "Research on using laboratory instruction in science. In: Handbook of research on science teaching and learning". Ed By D.L. Gabel. P. 94-127. MacMillan Publishing Company, New York., (1992)
- 6. Kuittinen, M. "Criteria for evaluating CAI applications", Computer & Education 31, 1-16, (1998)
- 7. Winn, William,"Instructional design and situated learning: Paradox or partnership?" Educational Technology 33(3), page 16-21,(1993)

An approach to modeling an educational domain

Gennadiy ATANOV
Donetsk Institute of Social Education; DISO, Donetsk, 83000, Ukraine
E-mail: atanov@dongu.donetsk.ua

The paper develops a topic of construction of the normative student model. The subject student model is a part of it representing a sum of demands to the curriculum of the subject, to students' knowledge and skills, and a semantic model of the domain. The subject student models pick out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain. Examples in physics are given.

Keywords: **student modeling, domain modeling, knowledge, skills, semantics**

1 Introduction

A fundamental concept of modern didactics and pedagogical psychology is the student (learner) model. It arose within computer technologies of education and was provoked by the necessity to formalize our representation about students. Of course such representations had been worked out long before any appearance of computers, and definite formalization of them began together with didactics. But it is computer technologies that gave a new impulse to development of these representations, transformed them into an object of deep investigations, transferred to a qualitatively new level [8,9].

In the widest sense, the student model is our knowledge about a student. There are two sides here: (1) knowledge about how the student is, and (2) knowledge about how we want to see him/her. The first knowledge is determined by the way of analyses of student's behavior, and it is natural to call it a behavioral student model. It is changing together with the student's change therefore it is also called dynamic, or current, one. Mechanism of construction of this model is the cognitive diagnostics [9].

Knowledge about how we want to see students, that is, demands to their final state is a normative student model. As a rule, this knowledge is various. It consists of demands to personal qualities of future specialists, their professional qualities and skills, their knowledge and skills in different subjects, characteristics of their physical and psychological state, and so on. The final aim of teaching is achievement of such a state when the behavioral student model concurs with the normative one.

2 The subject student model

A part of the normative student model determining domain knowledge is a subject student model [3]. In knowledge engineering, it is called expert knowledge, or domain model [5,6]. The subject student model picks out the educational domains from all the multitude of the domains, so the subject model is a model of an educational domain, or a model of a subject. Let us note that if the dynamic modeling is quite a developed branch of Artificial Intelligence, the domain modeling is developed to a lesser degree. It is clear, as specialists in Artificial Intelligence, as a rule, are not the ones in any other domain.

Under knowledge they understand the main conformities to natural laws helping us to solve particular problems (production, scientific, economic, and others) [5]. Facts, concepts, algorithms, intercommunications, rules, strategies of making decisions, and so on make up knowledge. The pithy sense of the concept «knowledge» is that knowledge reflects our imagination about domains and expresses a system of concepts, as well as relationships and dependencies between them.

According to the classification, there is a division of domain knowledge into declarative and procedural ones.

The first is statements about properties of the subjects of a domain and relationships between them. The declarative knowledge is often called a factual one, and this reflects its essence very well. The procedural knowledge describes the order and character of the transformation of the domain objects. Its another appellation is rules. In our opinion, it is not quite right, as the declarative knowledge, giving relationships between the objects, is also rules. Thus the procedural knowledge is not simply rules but rules of transformation.

The final aim of instruction is formation of way of acting. The way of acting is realized via skills in the practical activity [7]. The mechanism of this is operation with knowledge (both the declarative and procedural) being displayed in the behavior of a person. Therefore, in a wide sense, skills are attributed to knowledge, namely behavioral one [9]. The procedural knowledge is realized in skills. And sometimes, skills are called the procedural knowledge but, as we could see, the term "procedural knowledge" has been already occupied. Definition "operation knowledge" reflects the essence of the things clearly and in the most unambiguous manner. Thus, the subject student model has to contain skills that are to be formed in the process of instruction. Let us call a list of such skills the operational subject student model.

The declarative component of the domain knowledge makes up a semantic part of it, namely the semantic student model.

One of the distinctive properties of knowledge is that it has a certain structure. It is very important, especially for the instructional material, to define its structure. It is well known that to master a portion of the instructional knowledge is to determine its place in the structure of the instructional material. Therefore, one of the problems while constructing the subject student model must be determination of the subject knowledge structure. Studying the structure of the instructional material is a theme of an independent important and deep investigation. The subject student model must give more or less extended ideas about what the subject knowledge is. Such ideas are an essential part of any curriculum. A usual way here is a thematic approach when themes are enumerated. Let us call a list of themes liable to studying the thematic subject student model.

In teaching, it is very important methodologically to determine which role either knowledge plays and which functions it carries. In other words, it is necessary to fulfil a functional structuring of the instructional knowledge. It can be done with the help of a list of functional rubrics. The functional knowledge will be determined in such a way. Within it, there is knowledge performing both nontransforming functions (for example, facts, conclusions) and transforming ones (algorithms, methods, instructions). The functional knowledge makes up the functional subject student model.

In such a way, we suggest a four component subject student model consisting of thematic, functional, operational, and semantic parts. Such a subject student model in physics is carried out at the physics and didactics of physics department of the Donetsk State University [1-3].

3 The thematic subject student model

The thematic subject student model has been well known for a long time. In essence, it is a usual curriculum of the course, its program. It is built just according to the thematic principle, sections and themes liable to studying are enumerated in it. The model reflects the structure of the course. The program can be worked out in detail to different degree but it is always neither knowledge itself, nor its content but its names. In fact, this is a define characteristic of the subject knowledge, some knowledge about the subject knowledge. Knowledge about knowledge is called metaknowledge. Thus, the thematic subject student model is a metaknowledge.

It is a natural and convenient model for planning and organizing the instructional process. The more, it is an obligatory normative document. Preparation of any course begins with its creation (that is, creation of the course curriculum). Nevertheless, it is excessively general to use it for diagnostics.

As a rule, knowledge in many computer tutoring systems is structured according to the thematic student model.

4 The functional subject student model

The functional subject student model shows which role either knowledge plays; and it is also metaknowledge. It has a define structure in the horizontal direction, which may be given with the help of some rubrics. The role of knowledge and its functions depend on a particular subject. For example, we picked out the following rubrics for physics courses: *concepts, wordings, laws, properties, consequences, conclusions, reasons, formulas, equations, models, methods, and algorithms* [3]. The rubrics have a filling that, nevertheless, also does not reflect semantic of the subject and is metaknowledge.

It is the subject student model that allows working out in details what students must know. Let us give an example from the molecular physics. Students have to know: definitions of the concepts: *mole, thermodynamic system, pressure, temperature, density, concentration, ideal gas, equation of state*, and so on; wording and consequences of: *Pascal's law, Maxwell's and Bolzmann's distributions, Kirchhoff's law*, and so on; deductions of: *the mine equation of kinetic theory, equation of the adiabatic process, law of atmospheres*, and so on.

5 The operation subject student model

As it was noted, the operation subject student model is a list of skills liable to mastering by students. Let us note that skills in education make up a hierarchical system [2]. It consists of five groups of skills: fundamental, methodological, general, inter-subject, subject. Subject skills take the highest position in the hierarchy of skills.

We pick out three classes of the subject physical skills: general, particular, and experimental. The general skills are, on the first hand, methodological ones. Spectrum of the particular skills is far wider, for example, there are more than 200 them in the list in physics. According to the contents of the instructional material, the following skills are picked out: *to find, to determine, to fix, to build, to obtain, to calculate, to compute, to estimate, to distinguish, to pick out, to sort, to take into account, to represent, to traverse, to decompose, to compose, to generalize, to put in practice, to use, to formulate.*

There is a fragment of the list of the skills below:

3.1. General skills

To analyze physical processes and phenomena, to estimate orders of physics magnitudes and determine essential factors, to build physical models, to build mathematical models of particular physical processes and phenomena, to determine boundaries of applicability of the models, and so on.

3.2. Particular skills

3.2.2. Molecular Physics and Thermodynamics

To estimate quantity of particles and their mass in particular conditions, to determine parameters of state of gas, to determine number of degrees of freedom and molecular mass of a gas and mixture of gases, to determine possibility of the use of the model of an ideal gas, to make use functions of distribution to find average values of physics magnitudes, and so on.

Experimental skills are divided into three groups: *to measure physical magnitudes; to reproduce independently physical phenomena and processes; experimental particular skills.*

There is a hierarchical structure of the subject skills corresponding to the development of the subject in instruction. Besides that all of them also have a definite structure in the horizontal dimension because they are complicated, or composed, skills. In order to master them, a wide spectrum of skills both of the lower levels and subject is necessary. For example, skill *to solve physical problems* is composed of ten simpler skills: *to pick out the necessary information from the condition of a problem to solve it, to code the condition of the problem in a word form, to draw a picture to the problem, to choice a rational method of solving*, and so on.

6 The semantic subject student model

Semantic knowledge in different subjects is contained in textbooks, other training literature. There are two parts in the content of any textbook: CON-1 and CON-2 [7]. CON-1 is knowledge making up the content of

a domain directly, CON-2 is knowledge attending the CON-1 (for example, knowledge from other subjects, interpretations, explanations, examples from life). In fact, it is the CON-1 that is the semantic knowledge of a domain. Nevertheless, this knowledge is not picked out especially, it is distributed all around the textbook, interacts with another knowledge, and is not formalized.

Semantic knowledge represents the declarative component of the subject knowledge as the procedural knowledge is realized in skills (operational knowledge). Thus to construct a semantic student model on the basis of a textbook, it is necessary to pick out domain facts from it and group them in a definite order. According to their structure, facts may be of a great variety. As a rule, they are compound ones. Nevertheless, elementary facts may be picked out that, appearing in different relationships, form the compound facts. General questions of representation of facts in instruction are considered in works [4]. For example, expression "*Translational motion is the motion that all the point of a solid body have identical trajectory*" is a compound fact as it can be represented as a set of the following elementary facts: (1) *a solid body moves; (2) all the point of the body have identical trajectory; some motion is called the translational one.*

One can easily see that the elementary facts do not carry any semantic loading of the domain although they contain domain terms. Only on gathering together in a compound fact they acquire some doma in sense. Such compound facts are finished thoughts and they are represented by finished sentences, or expressions. Let us call them the *semantic* facts. As a matter of fact, the semantic facts are a unit of the domain knowledge, as smaller portions of it have no domain sense. The objects of the expression are concepts, phenomena, processes, laws, principles, theorems, conclusions, consequences, reasons, properties, rules, and so on.

It is the full set of the semantic facts that is the semantic subject student model. The order of their disposition is subordinated to the logic of the development of the course.

Such a semantic subject student model was firstly constructed in Gas Dynamics and than in Physics [1]. Those were very small brochures because there were no calculations, proofs, and explanation in them. Nevertheless, they contained all the statements of the courses. These brochures received the title *semantic synopsis*. As an example, there is a fragment from a physics semantic synopsis below:

3.1. The elementary work of a force is defined as the scalar product of the elementary displacement of the point of the force application.

3.2. The work of a force is defined as a line integral from the elementary work along the trajectory of the point of the force application.

3.3. The unit of the work is one joule that is equal to a work done by a force of one newton on a displacement of one meter.

In the opinion of instructors and students, the synopsis turned out an effective means while consolidating the instructional material, preparing to seminars. It helps to size up the structure of the instructional material, pick out and easily memorize the most essential its moments. It is very important that student remember them for a longer time.

The synopsis allows carrying out fast and regular control students' knowledge during a lecture. In this case, the expressions serve as a base for the open type test tasks being created by missing some keywords in the expressions. Students note a great value of the synopsis while preparing to the examinations when there is a danger do not pick out and master the main statements of the course.

Let us note that the semantic facts are distinctive rules as they define character of relationships between the elementary facts. In other words, they are rules according to which the elementary facts are connected between themselves. This circumstance stipulates possibility to represent the semantic knowledge by means of the production method. It is done with the help of rules of a kind "if A than B" where A and B are some facts. An example of such a representation of the above mentioned definition of the translation motion is given below:

If *< a solid body moves>* and
< all the point of the body have identical trajectory>
than *<such a motion is called the translational one>*.

Each of the expressions may be represented in such a way. Thus the production knowledge base of the subject will be constructed. Its constructing is considered in details in work [4]. As our practice shows, constructing production knowledge bases by students while learning is an effective kind of learning activity.

7 Conclusion

An approach to construction of the subject student model as a part of the normative one is described. The model consists of four components: thematic, functional, operation, and semantic. The thematic model gives ideas about the structure of the subject, the semantic one reflects its content, functional one determine what students have to know, and operation one does what students have to be able. The approach allows constructing more detailed current student models and reaching the main aim of teaching, namely forming the way of acting, more successfully.

References

[1] Atanov, G.A., Belaya, T.D., Beshevly, B.I., etc. "The base synopsis in physics". Kyiv, NMK VO, (1993) (in Russian).

[2] Atanov, G.A., Efros, T.I. "System of skills in instruction as a part of the learner model". Proc. of the Intern. Conf. on Computer Assistant Learning CAL-97. Exeter, UK, pp. 369-372, (1997).

[3] Atanov, G.A., Martynovitch, N.N., Tokiy, V.V. "Curriculum of Physics Course as a Student Model". Proc. of the Intern. Conf. on Computer Technologies in Education ICCTE'93. Kyiv, Ukraine, p. 138 (1993).

[4] Atanov, G. A., Pustynnikova, I. N. "Representation and Structuring of Domain Knowledge by the Semantic Networks and Productions Methods". Proc. of the 8th Intern. PEG Conf.: Meeting the Challenge of the New Technologies. Sozopol, Bulgaria,, pp. 392 - 393 (1997).

[5] Brachman, J., Levesque, H.J., Reiter, R. "Knowledge representation". MIT Press, (1992).

[6] Dean, T.L., Allen, J., Aloimonous, J. "Artificial intelligence: Theory and practice". Benjamin/Cummings (1994).

[7] Mashbits, E.I. "Psychological and pedagogical problems of computer assistant learning". Pedagogika, Moscow (1988) (in Russian).

[8] Self, J. "Dynamics of Learner Models. Artificial Intelligence and Education". IOS Press, Amsterdam (1994).

[9] Wenger, Å "Artificial intelligence and tutoring systems. Computational approaches to the communication of knowledge". Morgan Kaufmann, Los Altos (1987).

Design and Implementation of Teaching Models in Web-Based Teacher Training

See-Min Kim*, Shin-Chon Kang, Young-Kyun Back****
** CRADLE, Tokyo Institute of Technology*
2-12-1, Ookayama, Meguro-ku, Tokyo, Japan 152-8552
Tel: +81-3-5734-3233, Fax: +81-3-5734-2995,
E-mail: kim@ak.cradle.titech.ac.jp
*** Korea National Universty of Education*
Darak-ri, Kangne-myon, Chongwon-kun, Chugbuk, Korea 363-791
Tel: +82-431-230-3431, Fax: +82-431-233-0664,
E-mail: skytop@chollian.net

The reform of teacher training started in May 1995 in the Republic of Korea with reform of the educational system. The core of the reform was reinforcement of teacher training activity and introduction of a DTTS(Distance Teacher Training System). Then, in order to introduce a DTTS, the project for distance teacher training model development started in September 1997. This paper is related to a design and implementation of a teacher model in a DTTS. The teaching models of the following 4 types were carried out. 1) Problem-Solving type, 2) Seminar type, 3) Lecture-Practice type, 4) Courseware type. This system was in operation from October 1998. Current problems of this teacher models include: 1) Poorness of course contents, 2) The difficulty of checking a learning process, 3) Insufficiency of feedback to a trainee etc.

Keywords: **Distance Teacher Training, Teacher Model, Web-Based Learning**

1 Introduction

In Korea, reform of teacher training started on May 31, 1995 with the announcement of a reform of the educational system proposal. Philosophical bases for reform of teacher training are the spirit of the opened education, enshrining the principles of, opened an educational opportunity, the learning speed, the contents of learning, and the learning method, etc. The contents of reform are as follows[5]:

1) Obligation of periodical training;
2) Execution of distance education that introduced high technology of information communication engineering;
3) Reflection to the personnel affairs and the salary of a training result;
4) Authorization of a special course completion result in a graduate school and a social-education organization;
5) Attempt to the improvement of the training organization that enabled selection of the training organization by the teacher and let competition pass in qualitative.

These are summarized the following: 1) reinforcement of teacher training activity 2) introduction of a DTTS(distance teacher training system). It aimed at an expansion of the training opportunity, and overcoming restriction of time and space, with a reduction of training expenses. The project of DTTS development started in September 1997. It was sponsored by the Korea Multimedia Education Center. This project was divided into 4 sub-projects: Develop a training support model, design for teaching model, courseware development, and development for system management model. This paper is related to a design and implementation of a teacher model in a DTTS.

A teacher model is dependent on the contents of course, the learner characteristic, learning environment, etc. [6]. According to the questionnaire for the teachers and educational professionals of Choi [2], the suitable course for distance teacher training is as follows.

1) Various culture subjects (humanities a subject and a theoretical field).
2) Teaching methods expected such as discussion and workshop, then a lecture.

In Korea, as a training course into the distance teacher training, the culture subject of 11 was chosen. These were, "Foreknowledge of the future society and a counter plan", "Understanding of traditional culture", "The world in the 21st century and the Korea", "An information society and a computer", "Environment and education", " Raising of national morality nature", "An information society and multimedia education", "Theory and practice of open education", "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education for a unification counter plan".

In consideration of the characteristic of subjects and learner, strategies of WBI(Web-Based Instruction)[1], the teaching model of the following four types was proposed. 1) Problem-solving type, 2) Seminar type, 3) Lecture-practice type, 4) Courseware type. These are described at length in sections 2-4.

2 Design of the Teaching Model

In this project, the model of distance teacher training was divided into the macro model and the micro model, and was developed accordingly. A macro model is the framework of the whole DTTS, and a micro model is the course of training, that is, a teaching model. A macro model and a micro model are unified and distance teacher training is managed.

2.1 Web-Based Instructional Strategies

The acquisition process of the knowledge in WBI and the approach of the learning of constructivism are very similar. The most basic principles of constructivism concern fundamental philosophical assumptions about knowledge and learning[4]. The first, more generally accepted principle is that what a person "know"is not passively received, but actively assembled by the learner. The second principle is that learning serves an adaptive function. That is, learning is not the storage of "truths,"but of useful personal knowledge. This means the importance of the context of learning. Context has a lot to do with what is perceived as useful knowledge and how what is learned is integrated with existing knowledge. And the assumption that education is about acquiring universal truths. Since each person has different experiences and constructs an individual account of these experiences, each persons' s reality is slightly differenbt. New expereriences are interpreted within the context of these individual realities, implying that each person "know"a particular thing in a slightly different way.

We introduced the application of a repertoire of cognitively oriented instructional strategies implemented within a constructivist and collaborative learning environment, utilizing the attributes and resources of the internet[1]. The instructional strategies may be designed the following ways:

1) Support to the interaction between a lecturer- learner, and a learner-learner.
2) Introduce a hyper-textual function and support individualization learning.
3) Various learning materials provide in real time or non-real time (multimedia support)
4) The contents of learned and an evaluation results are analyzed rapidly and correctly, and it offers feedback to learner and system side.
5) Provide of DB Retrieval Function for learning information
6) It cooperates with other educational networks, and mutual reference can be carried out.

2.2 The contents-characteristic of subjects

The courses designed by the DTTS were culture subjects of 11. Generally, the contents of culture subject in a training course are unlike 'learning subject' that gains new knowledge. The culture subjects are mainly implicated that the contents of knowledge or skill newly asked for with a social change. And it takes into consideration that learning environment is being home, designed so that it might participate in learning not passive position but positively.

1) Show many concrete examples so that positive and concrete study can be performed.
2) Show or introduce the newest data and the newest present condition. And a learner performs creation of a report, discussion, and practice based on this.
3) In order to check rationally learning process which is the blind spot of home study, a small-scale subjectivity formula or report is required of an evaluation item.

4) The teaching contents are selected based on an opinion of the highest specialist of the field.

2.3 The learner-characteristic of in-service teacher and consult the needs analysis

In designing we considered the needs analysis of teacher needs[2]. And also considered the spirit of teacher training reform, that is the open educational opportunity, the learning speed, the learning contents, and the learning method, etc.

3 Proposed Teaching Models

3.1 Problem-Solving type Model

This model is used the following three subjects with "understanding of tradition culture", "information society and a computer "and "environment and education". The characteristics of contents of these subjects have much problem socially now. For example, the latest children cannot have understand about traditional culture, and do not understand value either. Moreover, although environmental problems are scattered in the familiar place, the problem consciousness does not exist. It is the learning which considers how it is efficiently introduced, how solving these problems at an educational field.
Problem-Solving type model is shown in **Figure 3.1**.

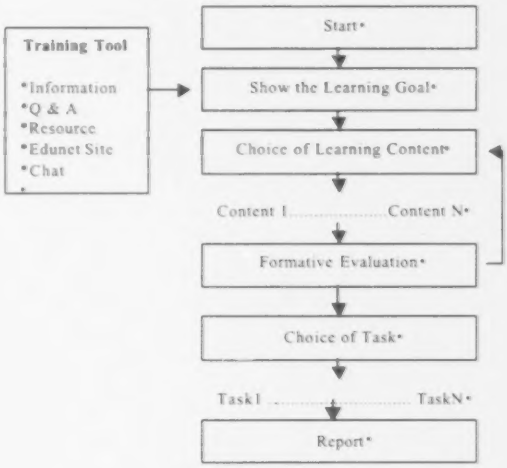


Figure 3.1 Problem-Solving type Model

3.2 Lecture-Practice type Model

Two subjects, "An information society and multimedia education" and "Theory and practice of open education" used this model. It is designed so that it might practice how theoretical knowledge may be reflected in the actual educational field. Through these courses, teacher can to help a child learn the capability that it can count measure to an information society, and how a teacher should just utilize the concept and the technology of multimedia for lesson activity. And more recently, it often pleads the open education. While introducing the concept of the open education and the example of the practice, teacher also gives an opportunity to consider an educational-practical use proposal directly.

3.3 Courseware type Model

Since three subjects, "Foreknowledge of the future society and a counter plan", "The world in the 21st century and the Korea", " Raising of national morality nature" were the contents of the type learned as new knowledge.
After having chosen the learning unit from the table of the learning contents, and learning using various data, composition which finishes a course through formation evaluation and generalization evaluation was designed.

3.4 Seminar type Model

This model uses the following three subjects. That is "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education of a unification counter plan". At first a group is constructed by the theme and to be performed learning in Seminar form so that learner might have an opportunity to expand the view and develop the main point by the mode of opinion exchange.

Seminar type model is shown in **Figure 3.2** below.

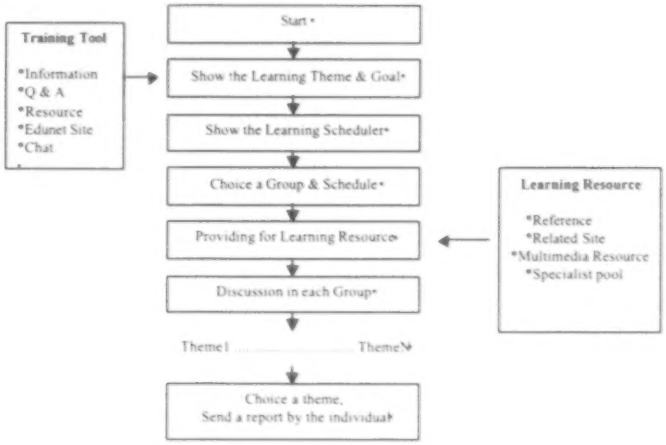


Figure 3.2 Seminar type Model

4 Implementation

The proposed model went into test implementation from October 1998. And now the model is used for qualification study of elementary and the 1st class positive teacher of middle, and general training of an elementary deputy schoolmaster.

As problems of this teaching model the following may be mentioned: 1) Poorness of course contents, 2) The impossibility of checking a learning process, 3) The insufficiency of feedback to a learner etc.

5 Conclusions

The distance education which used the high technology of information communication engineering in Korea started in 1997[3]. Insufficiency of a lecturer and restriction of a training opportunity are well said as a problem in teacher trainings. As one proposal for solving this problem, the project of "Development of a distance teacher training system" started and virtual teacher training actually started from October 1998. Thereby, little by little, teacher training environment becomes better and we think that the opportunity of training and the improvement in qualitative teacher training may also be anticipated.

There are problems that should still be correct and complement continuously in this training system. But the problems that should solved urgently are preparing the method of evaluation, the monitor staff who helps training, and a specialist pool.

References

[1] Bijan B. Gillani & Anju Relan., "Incorporationg Interactivity and Multimedia into Web Based Instruction", Web-based instruction, Badrul H. Khan, (Eds.), Educational Technology Publications, Inc., pp. 231-237, (1997).

[2] Choi, Sang-gun., "Development of Distance Teacher Training System", Seoul: Korea Education Research Institute, (1995).

[3] C. H. Lee., "Pre-service & In-service Teacher Training for Computer Education in Korea," Advanced Research in Computer and Communications in Education. G. Cumming et al.(Eds.), IOS Press, pp. 433-440, (1999).

[4] Mark Grabe & Cindy Grabe., "Integrating Technology for Meaningful Learning", Houghton Mifflin Company, pp.32-76, (1998)

[5] Pang, Myung-suk., "Teacher's Information Literacy Training in the republic of Korea", Seoul; Korea Multimedia Education Center, (1998).

[6] Willis, B., "Instructional development for distance education," (ERIC Document Reproduction Service NO. ED 351 007), (1992).

Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.

Jacques Viens*, *Université de Montréal*, **Geneviève Légaré****, *Université Concordia*

*Jacques Viens
Faculté des Sciences de l'Éducation, Université de Montréal,
C.P.6128, succursale Centre Ville
Montréal (Québec) H2C 3J7
Tel.: (514) 343-7033
E-mail: viens@scedu.umontreal.ca
**Geneviève Légaré
Department of Education, Concordia University
1455, boul. De Maisonneuve Ouest
Montréal (Québec) H3G 1M8
Tel.: (514) 848-2030
E-mail: legare@vax2.concordia.ca

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centered approach to a more genuine learner-centered approach. Using student interventions in telediscussions and the pedagogical scenarios as data sources, we outlined two general trends. First, students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their constructivist values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply constructivist principles to their productions, where the learners are truly at the centre of their learning.

Keywords : **On-line education, teaching and learning processes, pre-service teacher education, socio-cons tructivism**

1 Introduction

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centred approach to a more genuine learner-centred approach. To do so, we are using, as data sources, the student interventions in telediscussions and the pedagogical scenarios (hereafter integrative scenarios) that were produced on the web.

2 Context

Students registered in our teacher education programme have to take a minimum of two courses about the integration of ICTs in the classroom. The first course (ETA1700) is a general overview of the various technologies that could be integrated in a given learning environment. The final assignment consists of producing, as a team, a complete and fully working integrative scenario that will be available on the Web, for the benefit of their colleagues and the teaching community. To develop their scenarios, the students have access to our instructional model that favours a scaffolding strategy. The creation of the scenario includes the following steps : needs analysis, development of the content, selection of a learning approach and the development of a lesson plan. In a socio-constructivist approach, students are free to choose the subject-matter, the grade level, the pedagogical approach, the teaching tools and medium. As the teams develop their integrative scenarios, individual members are invited to participate in telediscussions. For the course ETA1700, four themes are provided : the impact of ICTs on society, the effective use of ICTs in educational settings, the changing role of teachers and learners and continuing education of teachers. Since learning to use the technology is a sub-goal of the course, students are requested to make at least one contribution for each theme, as well as offer one reply to one of their colleague.

The second course, PED2000, is a full year course, offered to second or third year students and mostly at a distance. Team members are free to meet as they please. Using the same scaffolding approach, students have to produce a more comprehensive scenario for a situation of their choice. However, prior to designing their scenario, students have to contact an in-service teacher who will let the students conduct their intervention in his or her classroom. The field experiment allows the teams to conduct a formative evaluation of their project. PED2000 students also have access to electronic forums of discussion, with the difference that no themes have been pre-determined. It is the students who create and launch topics of discussion. An on-line tutor is available to guide the students in their creative process.

3 Description of the project

3.1 Object of research

As we mentioned earlier, our goal is to understand better the perceptions that students might have about the impact of technology on their future role as elementary school teachers. Ultimately, the research results will be used to improve an to enrich our scaffolding approach, in order to help the students not only discuss the socio-constructivists principles but adopt them in practice. To do so, we explored the links between the discourse held in the telediscussions and the application of the principles in the integrative scenarios.

3.2 Sampling

For this paper, we used only the one of the multiple sections of the ETA1700 course. We selected four integrative scenarios representing 18 students, who contributed 80 messages on the two relevant themes (perception about the role of the teacher and effective use of ICTs in the classroom). Since our goal is to explore the factors influencing the application of socio-constructivist principles, we retained the projects that demonstrated some interdisciplinary and collaborative flavour.

3.3. Criteria for analysis

3.3.1 Integrative scenarios

To assess the students' perceptions about their changing role as teachers, we referred to some of the criteria described in Viens (1993) [1], as well as the general constructivist principles (Lave & Wenger, 1991; Brown, Collins & Duguid, 1989) [2] [3]. Even though we used a Likert scale to evaluate each criterium, our intention was not to cumulate frequencies. We rather used the scales to guide our critical analysis of the constructivist aspects of each scenario. Consequently, the results are more descriptive in nature.

The criteria are as follows :

Learning strategies . Notwithstanding the specific learning strategy to be used, we assessed whether the learner's during the instructional strategy was « directed », « guided », « rather guided », or «free ».

Team work. We examined whether the students planned to have their learners work individually, in teams but to conduct a fragmented task, or in teams to conduct a collaborative and collective task.
Content. Did the students determine a specific content or did they leave it completely opened for their learners to decide of their subject, as it is usually done in project-based learning?
Pedagogical goals. Aside from the usual well-stipulated instructional goals, did the students add other learning objectives such as transversal competencies? To what extent did they consider incidental learning?
Interdisciplinary. Did the students focus on one subject matter or did they use the opportunity to integrate several disciplines?
It is to be noted that all criteria were considered simultaneously in order to assess the global constructivist flavour of each scenario.

3.3.2 Forums

For the forums we proceeded differently. First, we focused on two aspects : the positive/negative attitude toward the ICTs. Secondly, we looked at the perception of the teacher' s role. In addition, we attempted to assess the student' s capacity to reflect critically, that is we observed whether the students were able to develop and support their thoughts rather than merely contributing an unsubstantiated opinion (Quellmaz, 1987; Ennis, 1987) [4] [5].

4 Preliminary results

4.1 Forums

Attitude towards ICTs
After conducting the preliminary analysis of the telediscussions for the course ETA1700, we noticed that the students positions about the integration ICTs in the classroom are not radical as one might expect. The majority seems relatively sensitive and cautious about technologies. In fact, several interventions were concerned about the fact that the computer will never replace the teacher and that the human factor is essential for the development of the pupils. In other words, aspects such as empathy, communication, emotional support are still essential for the learners development.

Perceptions of the role of the teacher
After listing all relevant interventions, we noted three recurrent themes that could constitute categories. Some interventions directly mentioned the role of the teacher, whereas others were more or less related to the topic, but still touched on the perceptions of the teacher' s role. The third group of interventions were concerned about more specific tasks of the teacher. We chose to use these categories to present the results about the perceptions.

Although not all interventions under the theme « Perception of the role as teacher » referred directly to the subject, it is interesting to discover that the perception of the role is indeed changing. The students did mention that the ICTs will help shift from a traditional role of « content deliverer » to one that assumes more guidance, more facilitation. Terms such as « facilitator », « animator », « councillor », « advisor » were used relatively frequently. However, we discovered that the students limited their intervention at the opinion level. They only named or listed the role without providing an explanation or a definition of what they meant by « facilitator » for example. Furthermore, they did not establish a priori what they view as a « traditional role ». Very few went as far as mentioning « content deliverer » or « lecturer ». In other words, students talk about the changing role without defining their assumptions. No one proceeded to compare and contrast the two positions or provide an illustration to support their thought. Indeed, the participants merely identified keywords and did not attempt to engage in a more critical discussion.

Some interventions were also addressing the issue of the changing role, but indirectly. Some students talked about the fact, for example, that the ICTs will provide the opportunity for the pupils to be more active in their learning process. Here, the guiding role of the teacher is implied in the discussion. Participants mention the possibility that ICTs will encourage the active construction process and consequently, will contribute to a more significant learning experience. In fact, in those indirect interventions, the learners are considered to be at the centre of their learning, actively engaged in the construction of their own knowledge and experience.

In sum, those students seem to think that ICTs can be used to favour collaboration between the learners as long as the learners' needs are respected. It seemed that participants perceive the ICTs as an integrated tool to teaching that favours self-learning.

The same group of students also discussed a specific aspect of teaching that will be affected by the technology : the impact of a broader access to information. Some students recognise the fact that a wider access to information will bring new tasks for their learners. One student mentioned that their pupils will have to « clarify their own research goals, define their information seeking strategy, make choices in the information, and sort the information ». This type of anticipation regarding « transversal » competencies was certainly an interesting discovery.

However, the same students who demonstrated their critical thinking abilities, still perceived themselves as the authority figure for their students. In fact, they mentioned that it will be their responsibility to assess the quality of information gathered on the Web as well as to judge the relevance of the source. Instead of making the link between the role of guide or facilitator as it would be expected in a constructivist fashion, it seems that the higher cognitive skills required, such as analysis and evaluation, will remain in the mind of future teachers, as their own territory.

4.1 Integrative scenarios

Two interesting trends have been identified in this analysis. First, the students who are more able to support their opinions by providing examples, using the literature, explaining their thoughts, seem to be more capable of producing a scenario that uses a genuine constructivist approach. In fact, if all the constructivist criteria are applied whenever it is reasonable to do so, the tone used to describe the learning activity is more opened, more respectful of both the freedom of the teacher and the learners. Here, we noticed that teams who produced a constructivist integrative scenario, were constituted of at least two members who demonstrated critical thinking abilities.

In the second trend, it seems that the students who claim that the role of the teacher is changing but who do not support their opinion, do not apply their values and perceptions in their integrative scenarios. In the telediscussions, they claim to be constructivist, but they fail to transfer their thoughts in practice. As we anticipated, the majority of the scenarios produced were meant to be constructivist. Some teams for example, will have their students work in teams but in a fragmented fashion (individual students will provide parts that will make a whole); the content will be determined and not opened for change; the learner will be rather guided in the learning process.

Two sources or information reveal the lesser constructivist approach : the instructional goal statement and the description of the lesson plan. Statements of the instructional goals in those scenarios tend to be highly fragmented, clearly measurable, well stated. Often, the students will refer to the Ministère de l'éducation du Québec programme to write the goals. There is no reformulation of the goals to suit their situation or needs. Also, there is no interpretation or critical analysis or re-evaluation of the goals. The students just take them as they come.

The design of the lesson plan is another indicator that a scenario might not represent a good application of constructivist principles. Lessons plans tend to be very organised and directed as well. The outcomes, ensuing the instructional goals, are well planned. In fact, the pre-service teachers, remain perfectly in control of the predetermined outcomes. Despite their good intentions, the students remain in control of the learning process. The steps are not only too well defined, that are also not flexible. The outcomes of the intervention using ICTs are still [illegible]-determined and nothing else, that is no incidental learning is considered.

5 Conclusions

In this exploratory research we highlighted two trends. Students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply the constructivist principles to their productions. They will remain in control of their pupils' learning. The

next logical step will be to determine how we could support the development of critical thinking skills in the telediscussions, in order to encourage a better transfer of the socio-constructivist principles to the development of integrative scenarios.

References

[1] BROWN, A. L. The advancement of learning. *Educational Researcher*, November, 4-12, (1994).

[2] BROWN, J.S., COLLINS, A. & DUGUID, P. Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42, (1989).

[3] COGNITION AND TECHNOLOGY GROUP AT VANDERBILT. Anchored instruction and its relationship to situated cognition. *Educational Researcher*, August-September, 2-10, (1990).

[4] DEAUDELIN, C. et VIENS, J. Éditeurs *Nouvelles technologies et formation : impacts sur les contenus et les stratégies d'enseignement/apprentissage*. Actes du colloque du CIPTE tenu au sein du 64e colloque de l'Acfas à l'université McGill. *Educatechnologiques* Volume électronique. http://www.fse.ulaval.ca/fac/ten/reveduc, (1997).

[5] ENNIS, R. H. A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company, (1987).

[6] GERVAIS, F., GARANT, C., MAINGUY É et VIENS J. "Nouvelles formules pédagogiques en formation des maî tres : mise en commun." dans Gervais C., Garant, C., Gervais, Fl. et Hopper, C. Formation des maî tres entre cours et stages... un partenariat INTRA-universitaire? Sherbrooke : Éditions du CRP, (144 p.), p. 114-125, (1998).

[7] LAVE, J., & WENGER, E. *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press, (1991).

[8] QUELLMAZ, E. S. "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105, (1987).

[9] RIOUX, S. et, VIENS, J. Les télédiscussions comme outil de construction des connaissances dans la formation des enseignants. *In Guir, R. (Ed.), La formation des enseignants et des formateurs aux nouveaux usages et aux nouvelles pratiques des technologies de l'information et des réseaux, Volume 2: Les implications sur la formation des enseignants aux TIC*. Paris : Éditions De Boeck, (à paraî tre , automne 2000).

[10] VIENS, J. *Vivre une expérience d'auto-apprentissage collaboratif*. Seconde édition de l'INFODUC, le répertoire Internet de l'éducation. Québec : Septembre Média, p. 264-269, (1998).

[11] VIENS, J. Modelisa, a constructivist learning environment to foster collaborative self-learning and metacognition. In Hilding Sponberg, Zdena Lustogova & Stanislav Zelena (Eds.) *Telecommunications for Education and Training*. Prague : Charles Uninersity. p. 156-163, (1997).

[12] VIENS, J. Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106, (1993).

[13] VIENS, J. et RIOUX, S. À propos du forum de discussion comme pivot d'une formule bi-modale d'enseignement. *Distance*. Automne 2000. 16 p., (à paraî tre).

[14] Site des Scénaristes : http://facvirtuelle.scedu.umontreal.ca/scenaristes

For example:

[1] VIENS, J. (1993). Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106.

[2] LAVE, J., & WENGER, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

[3] BROWN, J.S., COLLINS, A. & DUGUID, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42.

[4] QUELLMAZ, E. S. (1987). "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105.

[5] ENNIS, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company.

Is Everyone on Board: Learning Styles and the Internet

Michelle Hsiang*, Ellen Storey Vasu, Marsha Alibrand***, Nancy Atkins**** and Jane Steelman*******

** Research Triangle Institute/ NC State University. Email: mhsiang@rti.org*
*** NC State University. Email: esvasu@unity.ncsu.edu*
****NC State University. Email: marsh@cape.com*
*****NC State University. Email: atkinsn@he.orange.k12.nc.us*
******NC State University. Email: ravendoc@aol.com*

For many years, educators and practitioners have been implementing, enhancing and innovating variety of teaching methods to best fit students learning styles for eliciting the potential of students. As stated by Corno and Snow [2], "the success of education depends on adapting teaching to individual differences among learners", the teaching methods taught are to accommodate, meet, and elicit the diverse learning needs. Technology is becoming accessible to most segments of the United States population. As more and more classrooms are connected to the Internet and online-lesson plans are adopted to teaching and learning, it is important for teachers to ensure that the diverse needs of every student is addressed. This research study contained the quantitative analyses relative to learning styles and web design.

Keywords: **Humanities and Learning Technology, Instructional Design, Web-Based learning**

When computer technology increased its popularity in 1980's, Computer-Assisted-Instruction (CAI) in the form of drill, practice and tutorials was superior to traditional instr ction [1] and outperformed those who received traditional instruction [7]. While providing feedback to reinforce learning in CAI, Pritchard [6] recommended that the use of computers in CAI require a specific learning style of paying attention to details for accuracy, so that students are able to work alone. Davidson et al [3] further examined learning styles and performance in computer concept and programming skills in BASIC, and found that learning styles had a significant effect on performance of a computer course. By 1997, 72% of the schools in the USA had online access. As teachers adapt their teaching to the use of the World Wide Web as a medium for resources, and to publish their class websites, the information delivery system has been changed from paper format to digital format and from fixed text to unlimited hypertext. The visual graphic representation has been switched from static to animated/multi-dimensional and from limited colors to millions of colors. With the advance of the technology, sound and movies can be incorporated into webpages to enhance teaching and learning environment. With the release of many HyperText Markup Languages (HTML) editors, e.g., Adobe PageMill, DreamWeaver, Front Page, it becomes very easy for anyone to create and publish webpages, therefore it is essential for educators to investigate the different learning styles of individual students when designing webpages.

Study Purpose and Sample Setting

The purpose of this study is to examine two different webpage designs regarding to students learning styles. A total of 44 students who enrolled college courses in graphic design, computer application and web design were selected in the study. Students in these classes had little or some knowledge of the Internet and Webpage design.

The two web designs were developed by the authors and used for the study: one-frame versus two-frame designs with the incorporation of colors, animation, buttons, and hypertexts. The one-frame design used a top-down sequential technique for web design. To begin, users must access from the main menu in order to navigate to other pages. The two-frame web design contained two displays located side-by-side. The left-frame normally contains the potential links, the right-frame displays the corresponding information. Users can make random selection of different links at any given time provided on the left-frame that served as the main menu.

Measurement and Procedures

In the beginning of the semester, the Gregorc Style Delineator [4] was administered and the scores were tallied to determine students prefer learning styles in (1) Concrete sequential; (2) Abstract sequential; (3) Concrete random; or (4) Abstract random. At the end of the semester, students were given an Uniformed Resources Links (URL) to review the two different styles of web designs as mentioned earlier. After review, an instruction was provided for the students to fill out an open-ended questionnaire to reflect their selection and to make their comments.

Selected Results:

Two-frame selection: Students preferred the two-frame design to the one-frame arrangement with a ratio of approximately 3:1. This again stressed the importance of design in CAI that emphasized gaining attention, guiding learning, informing learners of objectives, and presenting stimuli with distinctive features. The reasons why users were in favor of the two-frame design included that it was easier to navigate with left-frame controlling the right-frame. With all the links listed on one-frame and information displayed on the other, it provided a quick access to the viewer.

One-frame selection: Students who preferred the one-frame design to the two-frame one like the fact that it was easy to follow and less confusion, simple but effective. Information straight down on a page was easier to read and to understand than a two-frame design. It kept attention intact and was readily for research. Some found that it was easy to use for computer illiterate people.

Discussion

The two-frame design is a newer approach than the single frame design. Students used to the one-frame design and some still prefer the same way of accessing information, even though the two-frame design has pleasing results and is reportedly easier to use than the one-frame design. In summary, this research suggested that the major reasons why the students disliked the two-frame design were because they were simply unfamiliar with the structure. Additional training and more exposure to the two-frame design would help them overcome the barrier. As the popularity of the Internet increases and the HTML editors become easier to use, it is important to emphasize these design factors, so that the webpages can be designed more accessible and user friendlier as technology advances.

Reference

[1] Burns, P. K. & Bozeman, W. C. (1981). Computer Assisted Instruction and Mathematics Achievement: Is there a Relationship? Educational Technology, 21, 32-37.

[2] Corno, L., & Snow, R.E. (1986). Adapting teaching to individual differences among learners. In Handbook of research on teaching, 3rd ed. Ed. M.C. Wittrock, New York: Macmllan.

[3] Davidson, G., Savenye, W., & Orr, K. (1992). How do learning styles relate to performance in a computer applications course? Journal of Research on Computing in Education, 24, 348-358.

[4] Gregorc, A. (1976). Learning Styles Inventory. Storrs: University of Connecticut.

[5] Kulik, J., Bangert, R. & Williams, G. (1983). Effects of Computer-Based Teaching on Secondary Students. Journal of Educational Psychology, 75, 19-26.

[6] Pritchard, W.H. (1982). Instructional Computing 2001: A Scenario. Phi Delta Kappan, 65, 322-325

Making the Most of the Internet for Potential for Education

John Wang* and Dilek Sanver**
**RS Information Systems, Inc./university of California, Berkeley*
3402 Sepulveda Blvd, #421, Los Angeles, CA 90034, USA
Telephone: (805) 982-3312
Fax: (805) 982-2659
Email: jgwang@csua-berkeley.edu
***University of California, Irvine*
Irvine, CA 92697,USA
Telephone: (310)390-7429
Email: dsanver@uci.edu

Who is building Web sites today? Entrepreneurs, writers, hobbyists, educators and students from the elementary grades and up are building them, not Java programmers, In fact, very few Web sites are actually built by professional programmers That is why strategies for making the most of Internet's potential for education is important: It brings the power of Internet to non-programming Web-builders like teachers and their students. Internet is an exciting, dynamic technology that is challenging for education. With new specifications, new classes, and general updates, one must accept the fact, when integrating Internet Technology into instruction, that the course will never be the same because the subject matter is in a never-ending state of change. In today's technological environment, curriculum development must be iterative; in other words, it is an ongoing repetitive process that is required due to the constant change of the subject matter and the technology. In order to be making the most of Internet's potential for education, we proposed these six basic phases--- understanding, planning, research, development, refinement and implementation. This article describes how to effectively use this six-phased approach Follow these phases, the educators and learners can collaborate to enhance existing material and produce new innovations for education.

*The paper was not available by the date of printing.

Online Education: A Learner-Centered Model with Constructivism

Kam Hou VAT
Faculty of Science & Technology
University of Macau, Macau
fstkhv@umac.mo

This paper describes the initiative to construct a WWW-enabled course and project support environment for undergraduate education, aimed to uphold the constructivist's ideas of active learning. The system is intended to create learning experiences that invite students to construct knowledge and to make meaning of their worlds of learning. In particular, we discuss the educational framework of our design through the Problem-Based Learning (PBL) approach, from the perspectives of the architect of the intellect. We also describe the incremental prototyping process of software development, through scenarios of participatory design of our students in Software Engineering at the author's affiliated faculty. The paper concludes by discussing the challenge of implementing the fully functioning constructivist WWW-based environment through blending the art and science of teaching into creative cognitive designs.

Keywords: **Constructivism, Problem-Based Learning (PBL), Learner-Centered Philosophy**

1 Introduction

With the advent of the World Wide Web (WWW or Web) towards the end of the 20th Century, the use of this Internet-based hypermedia technology in education has become the trend of today. The Web is aimed to facilitate learning in different disciplines, and is becoming the major driver to construct numerous experimental Web-based support environment in campuses around the globe. However, online education in the form of Web-based instructions (WBI) or Web-enabled learning environment, without an anchoring philosophy of education, could easily become a technology-rich educational wasteland. The theme of this paper is to investigate how the insights of our educational visionaries [5] could be designed into our Web-based support environment, to suit the unique schemata of individual learners. Actually, such designs require rigor in identifying certain essential elements of the constructivist architecture. And they represent challenges to the learning in our daily classrooms, which has typically involved having students repeat newly presented information on tests or in reports. Constructivist teaching practices help learners internalize, or transform new information, which in turn makes further understanding possible. Therefore, as instructional designers, the guiding question in tackling our Web-based design is this: How do we create a technology-enhanced learning environment that engages students in the types of activities that will take on their initiative and responsibility for their own learning?

2 Project Background

In the spring of 1999, a group of junior students in Software Engineering, initiated an informal study group (ISG) [15] with the author's facilitation. The ISG's mission is to help students develop their team-based technical interest in preparation for their graduation project. And we started exploring the ongoing development of Web-based distributed applications with online education as one of our first discussion topics. During the discussion, the author, as an instructor, expressed his difficulties in traditional classroom setting, to recognize students' intellectual and motivational problems, to explain to them a difficult part of the subject matter, to provide clear tasks, and to coach students in specific problem-solving activities. These issues indeed go far beyond the classroom walls. As students, they expressed their need for a learner-centered atmosphere whose focus is put on the needs, skills, and interests of the learners, and whose goal is

to encourage active exploration and construction in the course of learning activity. Likewise, we developed the initial dea of creating an environment where anyone is free to learn, to construct and refine new meaning in one's own learning, and to have enough channels to ask for help, when necessary, in the form of some extended service of a good teacher. We continue our expedition into Web-based technology to turn out the project ideas of creating a) a course support environment for active learning, and b) a project support environment for problem-based learning (PBL). The former has been given the project name **REAL** [13] to imply a Rich Environment for Active Learning, while the latter, **SUPER** [14] to denote SUitable and Practical Educational Resources for group-based project work. And in either project, we have not ruled out the familiar face-to-face classroom interactions between teacher and students, as one of the essential aspects of the learning process.

3 Pedagogical Intakes

In selecting the pedagogy of our Web-based environment, we have borrowed from the legacies of our educational visionaries in blending the art and science of constructivist teaching. John Dewey's designs embedded learning in experience [3]. He advocated field studies and immersion in experiences to stimulate learning. Jean Piaget's work influences constructivist educators through designs of discovery learning [9]. Students manipulate subject matter and objects representing the subject matter as they interpret their findings. He believed that learners' internalization leads to structural changes in how they think about something as they assimilate incoming data. Today, constructing meaning on the basis of one's interpretation of data is the heart of science inquiry, problem-based learning models, and case studies. Lev Vygotsky's theory [16] suggests that we learn first through person-to-person interactions and then individually through an internalization process that leads to deep understanding. This belief in the social process of idea making permeates today's interactive classroom led by skillful teacher questioning. Reuven Feuerstein's mediated learning theory [4] refutes the concept of an unchanging intelligent quotient (IQ) and leads to intense examination of how the classroom affects students' metacognition. He believes that the discovery process requires intervention from the teacher to guide learning. On examining the varied work of the master architects, and trying to crystallize the essential elements of the constructivist architecture, we see an array of tools emerging. They include a learner-centered curriculum; enriched environments; interactive settings; differentiated instruction; inquiry, experimentation, and investigation; mediation and facilitation; and metacognitive reflection.

4 Instructional Design

We expect the instructional design of our Web-based support should increase student participation and communication through re-designing the delivery of college lectures to incorporate more student online activities and instructor's feedback before, during and after the contact session. The environment is expected to develop students' abilities to generate problems, to engage in collaboration, to appreciate multiple perspectives, to evaluate and to actively use knowledge. From the designers' standpoint, we have included the following enabling ideas:

a) *Enable students to determine what they need to learn through questioning and goal setting.* It is believed that students should work to identify their knowledge and skill deficits, and to develop strategies in the form of personal learning goals for meeting those deficits. The emphasis is to foster a sense of students' ownership in the learning process. If teachers, through the Web-based support environment, can guide the students in identifying what they already know and what they need to learn, then knowledge gaps and mistakes can be viewed in a positive way such as another opportunity to learn. And students can assume more responsibility in addressing their own learning needs during any instructional unit.

b) *Enable students to manage their own learning activities.* It is believed that students should be enabled to develop their learning plans, which should describe priorities, instructional tactics, resources, deadlines, roles in collaborative learning situations, and proposed learning outcomes, including presentation and dissemination of new knowledge and skills, if applicable. Traditionally, these instructional events are arranged by teachers to be obeyed by students, in order to accomplish a specified set of pre-determined objectives. Yet, it is not advantageous for students to learn to be self-directed. To manage their own learning activities, students must be guided and supported by the teacher, through the Web-based environment, slowly taking on more and more responsibility of their own learning.

c) *Enable students to contribute to one another's learning through collaborative activities.* It is believed that

students should be encouraged and supported to discuss and share their personal findings. Particularly, we should enable students to become co-builders of the course/learning resources through evaluating and refining the entries their peers put into the Web-based depository. Collaborative group-based learning seems appealing to achieve the purpose. Students, nevertheless, must be educated to recognize what they are trying to learn in group-work, value it, and wish to share that value with others. Teachers can provide this sense of accountability and belonging by structuring students' work in the support environment with such concept as computer-supported cooperative work (CSCW).

It is convinced that the efficacy of the learning environment is a function of many complex factors, including curriculum, instructional methodology, student motivation, and students' developmental readiness. Trying to capture this complexity onto the design of our Web-based environment, is more an ongoing iterative process than a one-time activity. So we develop scenarios of situated learning support applicable to both individual course taking and group-based project work. These scenario-based supports are then incorporated into the environment incrementally, subject to our students' participatory testing.

5 Scenario-Based Support

Imagine attending a class where the instructor, after giving an introduction of what the course is entailed, invites you to visit his/her course support environment on the Web. On entering the Web-based environment, you are offered the privilege of creating your own personal space in the form of a customizable Web page guarded by your self-assigned identifier and password. Within your personal Web space, you are furnished with some tools to start your Web-life. These include a communications facility to keep one another in touch (email and newsgroup); a calendar planner to track your appointments or commitments (meetings or homework due dates, or project deadlines); and a frequently-asked-questions (FAQ) tool to send for instructor's help when encountering difficulty in housekeeping the personal space. Also, there are pathways to other service modules:

a) Course Information. This module provides such information as the course description, pre-requisite requirements, evaluation policy, references list, and other details such as time and location of the lectures. It also includes links to the instructor's contact details, his/her teaching/research profile, and the course schedule showing timetable for class with links to the study materials before, during and after contact sessions. Also included is the announcement service representing the most up-to-date information sent to the students from the instructor.

b) Course Resources. This module comprises the study materials prepared by the instructors, and the contributions representing students' submitted or reported work of interest to other students. Study materials can further be cataloged and managed as different resources: study notes, tutorial handouts, supplementary lecture details, or Web-links in the Internet. It could also include FAQs of the course: homework, quiz's, tests, examinations, and projects.

c) Course Assessment. This module keeps track of students' performance. The score each student obtained after completing a specific activity is recorded with enough details for evaluation at the end of the course. Students are encouraged to propose their own study plan to earn the accumulated score required, to complete the course. This service is designed into the Learning Contract [7] component to individualize the learning process for any individual learner. Typically, a student is required to write a formal agreement, which details what will be learned, how the learning will be accomplished, the period of time involved, and the specific evaluation criteria to be used in judging the completion of the learning.

d) Course Inquiry. This module fulfills several requirements of the teacher-student inquiry interaction. These include: a) a sense of dedicated space for an extended collaboration between teacher and student; b) an incremental delivery of inquiry results from teacher to student; and c) visibility of the inquiry interactions to avoid duplicating effort, and to encourage discovery of related interests. When an inquiry is initiated by a student, a request Web page is generated which is specific to that interaction and to which the teacher and student return frequently for their interaction. This request Web page (meeting space on the Web), contains the relevant material required for the specific inquiry interaction, say, contact details of the student and the teacher in the form of Web links or email addresses. Each request Web page supports several types of interaction: posting comments, recording actions, uploading/downloading files. These can be carried out at any time in any order. This feature is designed to support the often-time extended discussion and incremental result delivery of the teacher-student collaboration. Also, since the completed

request Web page could be visible to any registered student or teaching staff within the Faculty intranet, this increases the general awareness of the teacher's activities in consulting students, and avoids duplicating efforts of other staff in dealing with similar questions from students. More importantly, when users browse the inquiry activities over the Web, they are always exposed to information as to who was involved in what, and eventually they will learn about one another's specialties and interests. Hopefully, they will form communities centered about specific knowledge and interest; such are considered as important assets of any educational institute.

Now, on visiting the Web-based support environment and reading the latest announcement for the next lesson, you are aware that the next lesson is about group-based project work. According to the instructor's message, group project work is an essential component of any academic degree; many professional societies worldwide emphasize project and group work as preparation for professional practice. Also, you are to follow the problem-based learning (PBL) approach to work in teams. And you will be introduced to the teaming process and the PBL support of the Web-based environment.

6 Problem-Based Learning (PBL)

It is understood that project work is recognized as having many educational and social benefits, in particular providing students with opportunities for active learning. However, teaching, directing and managing group project work is not an easy process. This is because projects are often: *expensive* demanding considerable supervision and technical resources; and *complex* combining design, human communication, human-computer interaction, and technology to satisfy objectives ranging from consolidation of technical skills through provoking insight into organizational practice, teamwork and professional issues, to inculcating academic discipline and presentation skills. In preparing our students to get started with group-based project work, we have oriented towards the PBL learning model. According to the literature [1, 2], the modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management.

6.1 PBL Pedagogy

The PBL approach focuses education around a set of realistic, intrinsically motivating problems to fit the interests and needs of the learners. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how [10]. When applied to the course setting, PBL should encourage students' active participation, and develop in them self-directed learning and problem-solving skills while they interact, discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and final reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

6.2 PBL Activities

Students, on being presented with a problem or scenario, are made aware that initially they will not possess enough prior information to solve the problem at hand or to clarify the scenario immediately. These problems are often ill-structured, but devised according to concrete, open-ended situations. They are reminded that they must identify, locate, and use appropriate resources, and ask questions referred to as "learning issues" on the various aspects of the problem. These learning issues should help them realize what knowledge they require to construct a solution, and thus focus their learning efforts and establish a means for integrating the information they acquire. Often, they are encouraged to perceive themselves as managers of their own in terms of time, material resources, and the complexity of the problems that can be handled one at a time by the group. It is expected that the PBL students have to iterate through some relevant stages of activities: analysis, research, and reporting, with discussion and feedback from peers and the instructor at each stage.

• *Analysis.* Throughout this stage, students organize their ideas and prior knowledge related to the problem, and start defining its requirements. This helps them devise a specific statement of the problem. Meanwhile, they are encouraged to pose learning issues, defining what they know and what they do not know. This helps them assign responsibilities for research, eliciting and activating their existing knowledge as a crucial step in

learning new information.

• *Research.* Throughout this stage, students collect necessary information on specific learning issues raised by the group. They may conduct library searches, seek sources on the Internet, collect data, and interview knowledgeable authorities. More importantly, students teach themselves as they research their learning issues. It is intended that when they come to realize the complexity and texture of the problem, they may often see that information is a means to the ends of managing problems effectively.

• *Reporting.* At this stage, students report their findings to the group. Individual students become "experts" and teach one another. Subsequently, their discussion may generate a possible solution, or new learning issues for the group to explore further. Final solutions are constructed, and the facilitator's feedback should help students clarify basic information, focus their investigations, and refine their problem-solving strategies, besides addressing whether the original learning issues were resolved and whether the students' understanding of the basic principles, information, and relationships is sufficiently deep and accurate.

6.3 PBL Teamwork Experience

It is important that PBL students are taught how to work in teams and positively experience the team process because the team skills they acquire are applicable throughout their future careers. The PBL team process requires each team composed of 3-5 students, to be assigned a supervisor (instructor) and a client if applicable. The client's role is to clarify the project, and to resolve ambiguities as they arise, whereas the supervisor's is to guide, motivate and provide feedback to the team. Also, one of the team members is designated the team leader for the duration of the project, whose role is to coordinate the team activities, and to ensure effective team communications. The leader also has to interface with the supervisor, arrange meetings with clients when necessary, and facilitate meeting through setting agendas, taking minutes, and allocating tasks. Each team member has to help set the team goals, accomplish tasks assigned, meet deadlines, attend team meetings and take a turn editing a document to be submitted at the end of each major stage of project development.

Meanwhile, PBL students are made aware of the difficulties in teamwork throughout the project period. These include setting realistic project goals, carefully allocating tasks to team members, managing time, and communicating and managing shared group documents. Teams have regular meetings in which they invite their supervisor, and in which they organize themselves to manage the project. Students are often reminded of setting appropriate agendas before meeting, assigning enough time to the agenda items during meeting, restating the decisions made at the meeting, and converting decisions into action items after meeting. They are also advised on clearly separating the social and work aspects in meetings, and assessing each meeting for doing it better next time. Moreover, it is suggested that teams plan their project around major deadlines of individuals in the team thereby acknowledging the other commitments team members may involve.

Deadlines represent the milestones set down for the PBL students to submit project documents and to receive evaluation. Each team member is assessed by their supervisor and their team peers. The supervisor's evaluation is based on what each team member adds to the meetings and what the instructor perceives each member's contributions to the team to be. The peers' evaluation is based on a confidential rating sheet, to be completed by each team member at the end of each major phase of the project. This rating sheet should include each team member's contribution for that phase with explanatory comments. And the overall project assessment is made up of the group grade and the individual grade. The former is the same for each group member and is based on the quality of the documents produced and the product developed. The individual component is based on the quality of the student's contribution to the documents and the product, their participation in group-meetings, their commitment to the team process, and their professional attitude developed.

7 Scenario-Based PBL Support

Imagine you have just attended the second lesson on PBL and group project work. And you realize that the PBL support available in the Web comprises both the learning and performance aspects. These are actually a series of strategies and Web-based solutions that use instructional design principles to improve students' work-based performance according to the real-life PBL activities. And you are invited to visit the PBL-specific Web site to register as a PBL-user. The registration process invites you to fill in a Web form including a simple questionnaire for teaming purpose. You are now allowed to enter the PBL-support environment with your PBL identifier and personal password returned after the registration.

And for exploratory purpose, you have just navigated to the PBL Web page for the Software Engineering course *SFTW 300 Software Psychology* (Figure 1). Here you are presented with a number of projects to express your preferences to join through filling in another Web form activated by clicking the link "Join a Team" in the same page. You can then find out which team and project have actually been associated with you by clicking the link "Identify Your Team" also in the same page. On knowing which project to engage, you could click the suitable PBL Space link, i.e., "S300F99P3" in this case, to navigate to the suitable PBL Space (Figure 2). The PBL Space is assigned for each PBL group for project management on the Web. It contains links to the project itself, the PBL Group (including its members' links), the PBL Client, and the PBL Supervisor. Each of such links is associated with a set of related links for information and support of the project. Among the numerous support links in the PBL Group, you can find the *Work Space* link, which leads to the "Group Work Space" (Figure 3) Web page. This page contains links to individual group members and to specific PBL support, as well as to the project interim progress. Clicking on the individual member's link (PWS) leads to the "Personal Work Space" (Figure 4), where each group member's progress in terms of PBL activities (analysis, research, reporting, implementation) is tracked.

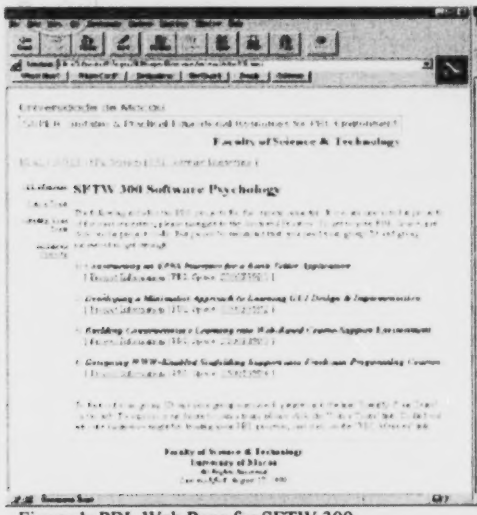


Figure 1: PBL Web Page for SFTW 300

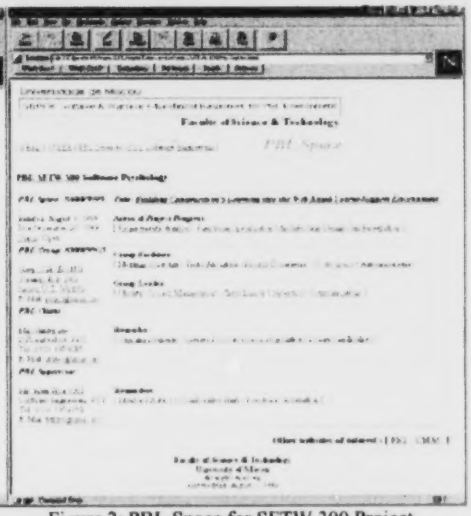


Figure 2: PBL Space for SFTW 300 Project

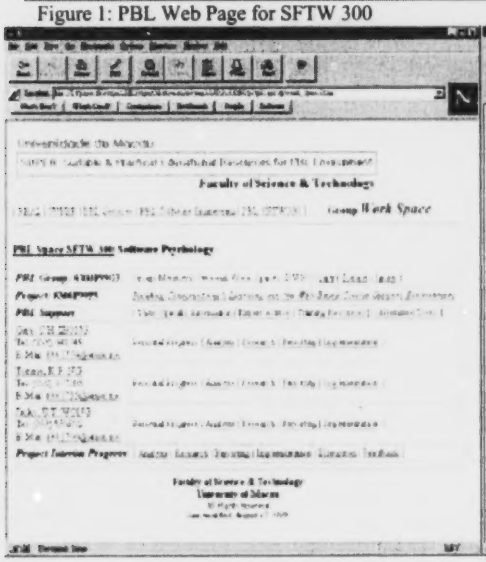


Figure 3: Group Work Space for a SFTW 300 Project

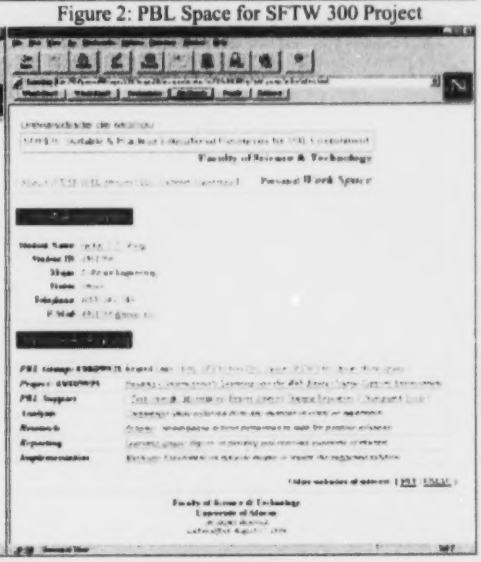


Figure 4: Personal Work Space for a SFTW 300 Project

BEST COPY AVAILABLE

8 Software Development

Our database-driven Web-based support environment has been developed as a series of distributed applications, by employing a mixture of object-orientation, client/server, and Internet (Web browsers, Web servers – HTML, HTTP, FTP) technologies, to deliver the desired support functionality. Such applications are largely event-driven because of the intensive graphical user interface (GUI) programming (e.g., handling the points and clicks) and/or because of the message exchanged between clients and servers over the Web. The specific types of individual Web applications constructed can be categorized into such classes as: a) static HTML-based, b) server-side (CGI-based) and c) client-side (Java-based or JavaScript-based). And the major steps followed to develop the distributed applications could be abstracted as follows:

a) Analysis. Establish users' requirements of what information are needed by whom and when, in terms of functionality, performance, security, operability, and management of the distributed applications. And develop an object model that shows conceptually how the information will be organized, accessed, manipulated, and presented in terms of objects.

b) Architecture. Partition the architecture concerns into: *data architecture*, determining what data sources (HTML, files, databases) will be needed, where they will be located, and how they will be accessed; *software architecture*, determining what will be written as CGI/Java code, what will be constructed as modules called by CGI/Java, where will the various objects/modules reside, and how they will be invoked (CORBA, RPC); *infrastructure architecture*, determining the servers where the home pages and the objects/modules will reside, the type of gateways that will be employed, the type of middleware that will be needed to invoke remote services and objects (CORBA, ActiveX, RPC, SQL), and the type of computing platforms (PC Windows, UNIX, Linux, Windows NT) used.

c) Implementation and Deployment. Build the HTML pages (including the Java-powered pages) by coding HTML or using filters that generate HTML from other data sources (e.g. Word documents). Then develop and test the software modules and objects. If necessary, purchase the appropriate infrastructure components. Fourth, test, install and deploy the system, followed by maintenance and the iterative re-design process.

9 Prototyping Process

The Web-based support in our online environment is developed incrementally through a user-driven iterative prototyping process, which involves our instructional designers, teachers, and students in the participatory development. This involves creating a series of function prototypes used to clarify the objectives of the system in light of design exploration between the designer and the users (teachers and students), so that the users gradually understand what can be achieved with the technology. Our knowledge of requirements, design and implementation may be incomplete in any one cycle; however, there has been progressive build-up of a structure, which will lead to the desirable system. Specifically, we have referred to the Dynamic Systems Development Method (DSDM) [12] for project guidance, which walks us through four main phases of the DSDM life cycle.

The *feasibility study* phase is to define the high level functional requirements of the environment, which refer to the educational support issues. This phase should produce an outline prototyping plan and establish the main non-functional requirements, such as the hardware and software to develop and deliver the system. The *functional prototype iterations* phase is to clarify the detailed requirements for the system. Its output includes a series of prototypes that demonstrate the main system functionality. These early visual prototypes are mainly used to clarify the system objectives between the designers and users. The *design prototype iterations* phase is to refine the functional prototype into a robust product after a more situated evaluation of system requirements. It involves satisfying all the non-functional requirements; i.e., producing a system that will work effectively on the target hardware in the organizational setting. It is understood that all the possible components of the system do not have to be developed in unison. Some may move on to the design and build phase while others are still at the functional clarification stage. The *implementation* phase involves placing the system in the user environment, carrying out any required training, reviewing the system and assessing further developments. The output should include a delivered system, user manuals/training, and project review document.

10 Conclusion

It is experienced that the conventional approach to education remains the instructivist one, in which knowledge is perceived to flow from experts to novices. This transmissive view of learning is most evident in the emphasis on lectures, in the use of textbooks to prescribe reading, and in the nature of tutorials and assessment methods. It assumes that the process of good teaching is one of simplification of the truth in order to reduce student confusion. Yet, this simplification could deny students the opportunity to apply their learning to dynamic situations. We question the transferability of the instructivist learning and ask how much of that which is assigned to academic learning ever gets applied to actual scenarios, when there is such a rapid surge in knowledge commonly associated with the birth of the "Information Age." This is a transference problem. Actually, the content product of learning is assuming a less important role relative to the process of learning as the life of information content shortens and the need for continual learning increases. In designing the Web-based support of our learner-centered environment, we have tried to reoriented towards a meaningful direction by reducing the obsession with knowledge reproduction. And PBL represents one such relief from the constructivist pedagogy. Greening [6] describes it as a vehicle for encouraging student ownership of the learning environment. There is an emphasis on contextualization of the learning scenario, providing a basis for later transference, and learning is accompanied by reflection as an important meta-cognitive exercise. Also, the implementation of PBL is done via group-based work, reflecting the constructivist focus on the value of negotiated meaning. Besides, it is unconfined by discipline boundaries, encouraging an integrative approach to learning, which is based on requirements of the problem as perceived by the learners themselves.

Undeniably, constructivism is a philosophy of learning that is having a major effect on the way that education is conducted today. In this paper, we have tried to spell out the working characteristics of constructivism [11], which have actively shaped the design of our Web-based support. These include: 1) Meaning is not transmitted. Instead, learning occurs as a process of adjustment of existing concepts. 2) Understanding is based on interaction among a complex weave of factors, such as the learners' goals and existing concepts, the content of the learning experience, the context where the learning occurs. 3) Puzzlement motivates learning. This sense of dissatisfaction emerges from experiences that threaten existing conceptual structures. 4) Social negotiation and viability are the principle forces involved in the evolution of knowledge. They ensure that learning is anchored both by the learning community and by the need to test constructions against reality. The effects of such testing are the adjustments in the structure of concepts held by the learner. So, one thing is evident: constructivist learning experiences can exert high cognitive demands on learners [8], and not all learners could respond well to the challenge. We believe the constructivist ideas assembled here make up what we might call pragmatic constructivism. Namely, constructivism could be viewed as a toolbox for problems of learning. If a particular approach does not solve the problem, try another. In keeping with this flexibility, active, social and creative learning can play out in rather different ways, depending on the circumstances. Although the term constructivism suggests a single philosophy and a unique potent method, there is not such thing as a one-size-fit-all. Rather, our suggestion is to look at constructivism like a Swiss knife with various blades for various needs. That is also the learner-centered philosophy behind our Web-based support for online education.

References

[1] Albanese, M., and Mitchell, S., " Problem-Based Learning: A Review of Literature on Its Outcomes and Implementation Issues," Academic Medicine, Vol. 68, No. 1, 1993, pp. 52-81.

[2] Barrows, H., " How to Design a Problem-Based Curriculum for the Pre-Clinical Years," New York: Springer, 1985.

[3] Dewey, J., " Experience and Education," New York: Macmillan, 1938.

[4] Feuerstein, R., " Instrumental Enrichment: An Intervention Program for Cognitive Modifiability," Baltimore: University Park Press, 1980.

[5] Fogarty, R., " Architects of the Intellect," Educational Leadership, Vol. 57, No. 3, 1999, pp.76-78.

[6] Greening, T., " Scaffolding for Success in Problem-Based Learning," Medical Education Online, 3(4) 1998, pp.1-15. http://www.utmb.edu/meo/

[7] O' Donnell, J.M., and Caffarella, R.S., "Learning Contracts," In M.W. Galbraith (Ed.), Adult Learning Methods. Malabar, Florida: Krieger Publishing Company, 1990, pp. 133-160.

[8] Perkins, D.N., "What constructivism demands of the learners?" In T.M. Duffy & D.H. Jonassen (Eds.), Constructivism and the Technology of Instruction: A Conversation (pp. 161-165). Hillsdale, NJ:

Erlbaum 1992.
[9] Piaget, J., "Piaget's Theory," In P. Mussen (Ed.), Carmichael's Manual of Child Psychology. New York: Wiley, 1970.
[10] Ryan, G., "Student Perceptions about Self-directed Learning in a Professional Course Implementing Problem-Based Learning," Studies in Higher Education, Vol. 18, 1993, pp. 53-63.
[11] Savery, J.R., and Duffy, T.M., " Problem-Based Learning: An Instructional Model and its Constructivist Framework," Educational Technology, 35(5) 1995, pp. 31-38.
[12] Stapleton, J., "DSDM: Dynamic Systems Development Method – The Method in Practice.," Addison Wesley, 1997.
[13] Vat, K.H., "REAL: Towards a WWW-Enabled Course Support Environment for Active Learning," Faculty Technical Report, FST/SE-1999-01, University of Macau, Macau.
[14] Vat, K.H., "SUPER: Towards a WWW-Enabled PBL Support Environment for Software Engineering Education," Faculty Technical Report, FST/SE-1999-02, University of Macau, Macau.
[15] Vat, K.H., "Training E-Commerce Support Personnel for Enterprises through Action Learning," In Proceedings of the 2000 ACM SIGCPR Conference, Chicago, Illinois, USA, Apr. 6-8, 2000, pp.39-44.
[16] Vygotsky, L.S., "Mind in Society: The Development of Higher Psychological Processes," Cambridge, MA: Harvard University Press, 1978.

Schema Theory-based Instructional Design of Asynchronous Web-based Language Courses

C. Candace Chou
Interdisciplinary PhD Program in Communication and Information Sciences
University of Hawaii
Email: chou@hawaii.edu

Instructional design (ID) provides a framework to facilitate both teaching and learning activities. ID also prescribes desirable learning outcomes. This paper introduces the implementation of an ID template in web-based language courses. The ID template incorporates several cognitive strategies based on schema theory. A schema-theory-based model provides a useful framework for knowledge organization and information processing. In a course that emphasizes reading comprehension, schema theory accounts for how learners construct meaning from texts based on the information they encounter, the prior knowledge they already have, and the way they interact with the new information. The ID template consists of four instructional sequences. The cognitive strategies, ID examples, and purposes for each sequence are illustrated. The sequences include warm-up activities, preparatory activities, core activities, and post activities. Each sequence is interconnected with the others and looped back to the beginning in each lesson unit. The preliminary evaluation results indicate the degree of student satisfaction for the ID template for various external and internal factors.

Keywords: **instructional design, schema theory, cognitive strategies, web-based foreign language instruction**

1 Introduction

Instructional design (ID) plays a critical role in the success of distance education. ID is an interdisciplinary science that provides a theoretical background for the design and implementation of instructional units to achieve desirable learning outcomes. ID principles encompass theories in both learning and instruction. Although the instructional design for web-based instruction does share some common principles with instructional design for traditional classroom teaching, the modes of instruction and learning are quite different from each other. The roles of learners and instructors continue to go through fundamental changes as well. What kind of instructional theories can be best applied to web-based education? There is no one single universal theory for all instructional design as the objectives, learning contexts, subject matters, and expected learning outcomes vary from one field to another. The development of ID also depends on the pedagogical principles that the instructors or instructional designers adapt to. The views on instructional design can be approached from different perspectives such as behavioral (Gropper, 1983); systematic (Gagne, Briggs, & Wager, 1992); structural (Scandura, 1983); motivational (Keller, 1983), transactional (Merrill, 1997); and cognitive (Tennyson, 1990; West et al., 1991). Cognitive schema theory especially receives prominent attention in the field of instructional design and language education for its emphasis on the use of aid for perception, learning, comprehension, and recall (Anderson, 1984; West et al., 1991). This paper focuses on the application of schema theory to the instructional design of language courses delivered through the World Wide Web. The preliminary evaluation results are summarized at the end.

2 Theoretical Framework

Why is ID important in web-based distance education? Reigeluth (1983) argued that ID is a linking science between theory and practice. This linking science was further elaborated by Tennyson and Schott (1997): "As a field of study, it provides a theoretical foundation to principles of instructional design, a research base confirming the theoretical foundations, and a direct involvement in the application of those principles" (p. 1). ID theories prescribe the variables and conditions required for certain learning outcomes. Furthermore, the practice of ID utilizes various methods and technologies to develop learning environments based on these theories (Tennyson & Schott, 1997). Many ID models have been developed and the theoretical bases vary greatly. A typical model includes the following five steps: "(1) setting the *objectives;* (2) *preassessment*, that is, determining whether the target students have the prerequisites to benefit from the instruction; (3) *planning the instruction*; (4) *trial*, that is, presenting the instruction for developmental purposes; and (5) *testing* and *evaluation*" (West et al., 1991). Each step can be further divided into more detailed instructional sequences. The focus of this paper is on planning the instruction based on cognitive learning theories. Schema theory is an especially appropriate cognitive learning theory because of its emphasis on knowledge organization and representation.

There is no one single theory called schema theory. It has evolved and become the basic component of many cognitive learning theories. According to cognitive theorists, schemas or schemata are mental data structures that represent our knowledge about objects, situations, events, self, sequences of actions and natural categories (Anderson, 1985; Rumelhart, 1981). Schemata are also like scripts of plays (Schank & Abelson, 1977). In other words, schemata are chunks of knowledge stored in the human mind by patterns, structures, and scaffolds (West et al., 1991). Based on Rumelhart's definition (1981), schemata serve the function of "scaffolding." Knowledge is perceived, encoded, stored, and retrieved according to the chunk of information stored in the memory. Schemata facilitate information processing. Schema can be "instantiated" by specific examples of concepts or events. For example, one's schema for "teaching" can be instantiated by viewing a scenario on the interaction between a teacher and students. As soon as schemata are instantiated, one can associate or recall more similar scenarios (Bruning et al, 1995). Schema theory is appropriate for language instruction due to its powerful explanation of memory and recall. In the case of reading comprehension, schema theory accounts how learners construct meaning from texts based on the information they encounter, the prior knowledge they already hold, and the way they interact with the new information (Bruning et al, 1995, p. 275). As summarized by Andre (1987), schemata serve the following important function in reading comprehension:

1. Providing the knowledge base for assimilating new text information
2. Guiding the ways readers allocate their attention to different parts of reading passages
3. Allowing readers to make inferences about text materials
4. Facilitating organized searches of memory
5. Enhancing editing and summarizing content
6. Permitting the reconstruction of content (Bruning et al., 1995, p. 275).

Schemata provide the backgrounds for learners to comprehend a text by inference. Schemata also make it possible to summarize a passage by selecting the parts that are important to them. These processes cannot be completed without the knowledge structures that schemata provide. Since one of the elements of schema theory is making predictions based on what learners already know, making the link between the old information and the new information has generated a great deal of research interest. Two areas of research in this direction are advance organizer and schema activation.

Advance organizers employ the structure of some materials that the learners are already familiar with as the framework of the new materials. In other words, advance organizers are designed to offer "ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows" (Ausubel, 1968, p. 148). Advance organizers are relevant introductory materials that are introduced in advance of the core texts. Recent studies have also shown that providing short and concrete examples for upcoming events are more useful to readers than abstract, general, and vague learner organizers (Corkill et al., 1988).

Schema activation refers to the design of activities for the purposes of activating learner's knowledge in

similar fields prior to learning new subject matters (Bruning et al., 1995). They are often in the forms of short questions. In a way, schema activation serves similar purposes of advanced organizers by linking new information with old information that the learners already know. However, schema activation relies more on the learners to generate information from their previous knowledge base. Schema activation works better if the schema activating activities are relevant to the to-be-learned information. A study on the reading comprehension of a group of fifth-graders showed that the group with relevant schema activation remembered the reading texts better than the groups with non-relevant schema activation (Peeck et al., 1982).

There are also many other cognitive strategies that help students with reading comprehension. These strategies are designed to help students in gaining control of their learning process for the purpose of comprehending reading texts. Bruning et al. (1995) summarized the following five strategies for reading comprehension:

1. *Determining importance:* Instructional activities can be designed to help learners locating the main ideas of the text. Without knowing the main ideas, readers would have a hard time understanding the text.
2. *Summarizing information:* Students should not only learn to summarize the main ideas in a passage but also generate a text that represents the original one. Students' reading skills improve when their summarization skills improve.
3. *Drawing inferences:* Studies have shown that the ability to make inferences is positively associate with reading skills (Dewitz et al., 1987; Raphael & McKinney, 1983). Good readers are usually good at guesswork.
4. *Generating questions:* Good readers ask questions frequently. Through self-questioning or peer-exchanged questions, learners will have a better understanding of texts.
5. *Monitoring comprehension:* Readers should have the ability of knowing when they understand the text and when they do not. A good reader also has the ability to detect errors and inconsistencies in the reading materials. When they become critical of the reading texts, they do a better job in detecting errors. Peer editing or peer-critiquing is a good way to monitor comprehension (Bruning et. al., 1995, p. 279-284).

The next section describes how some of the cognitive strategies can be employed in the instructional design of web-based language courses.

3 Instructional Design Template for Web-based Language Courses

The web course introduced in this paper is the first one in a series of Asian language courses using the same instructional design templates. There is a lack of higher-level language courses (3rd year and above) in Less Commonly Taught Languages (LCTLs) such as Asian languages and other non-Roman languages in American universities and colleges. Yet, the need for higher-level language courses does exist for students who would like to continue language studies. The objectives of the web courses are to provide opportunities for students whose institutes do not provide language courses in LCTLs and to disseminate information on the ID model of pedagogically sound language instruction. The first course that is currently offered through the University of Hawaii systems is a Chinese reading and writing course at the 3rd and 4th year level. A Chinese listening/reading/writing course and a Korean reading/writing course will be offered in fall 2000. More courses in Japanese and other LCTLs are in the planning stage at present. The instructional design template is summarized as follow:

Goal: To improve Chinese reading and writing skills.

Objectives:

1. Students will possess the skills to decipher reading materials through a series of cognitive strategies.
2. Students will improve writing skills through continuous revisions, peer-critique, and teacher feedback.
3. Students will have a good command of vocabulary in the subject matters covered in the course.
4. Students will co-construct knowledge together through collaborative tasks in building word bank, grammar clinic, and essay database.

Content: The content covers a wide variety of topics based on authentic teaching materials collected from China and Taiwan, including topics such as cuisine, travel, medicine, celebrities, university, and so on. These materials were developed into ten self-directed reading lessons on a CD-ROM. The web course uses the CD-ROM as the core reading materials. Each web lesson unit was designed to enhance the understanding of the equivalent core text in the CD-ROM.

Format of the Instruction: The World Wide Web and the CD-ROM were selected to deliver the instruction and course content. Asynchronous communication via email and web-forum are the means for student-student and student-teacher interactions.

Table 1 Instruction design template for web-based language courses

ID Sequence & Modules	Cognitive Strategies	ID Examples	Purposes
1. Warm-up activities	Schema activation	Word bank	Brainstorming on terminology Co-construction of knowledge base
2. Preparatory activities	Advance organizer	Picture matching	Preparation for forthcoming texts
3.1 Core activities	Determining importance Drawing inferences	Working on CD-ROM reading activities	Determining the importance of information
3.2 Core activities	Generating questions	Q&A	Self-questioning
3.3 Core activities	Scaffolding	Small Group Discussions	Debate/Discussion/Role Play Use input for other activities
3.4 Core activities	Monitoring comprehension	Grammar Clinic	Peer editing with teacher feedback
4.1 Post activities	Modeling	Sample essay	Teacher demonstration
4.2 Post activities	Recall	Language work	Monitoring comprehension
4.3 Post activities	Summarizing information	Composition & revision	Individual output with collective database on writing samples

Sequence of Instruction: The framework of the instruction sequence is adapted from Hiple and Fleming's (1996) work which is specifically designed for foreign language instruction. The ID examples are developed by the instructors Fleming & Lu (1999) for web-based language courses. There are eight units in each web course. Each unit employs the following four sequences of instruction.

1. *Warm-up activities:* These activities employ simple and short questions to activate learners' previous knowledge relevant to the subject matter. For example, on the unit for cuisine, students are asked to write down two or three things they know about Chinese cooking. Their responses are put into a database called the "word bank." By the end of each unit, students have accumulated an abundant collection of glossary under a specific language topic.
2. *Preparatory activities*: Students are asked to match some descriptions with pictures. These pictures provide a background information of the lesson and prepare the students for the forthcoming texts.
3. *Core Activities*: There are four components in Core Activities: working on the CD-ROM, Q & A forum, Small Group Discussions, and Grammar Clinic. Students first go through the reading activities in the CD-ROM. They then post questions about the content of the CD-ROM on the Q & A web forum. Following that, they are divided into three-member or two-member small groups to carry out a conversational task. Take the cuisine unit for example, they have to make up their minds on which restaurant to go to for dinner. One conversation example is provided so that students know in advance the scope and depth of the expected conversation. In Grammar Clinic, the instructors pick several erroneous sentences from the Small Group Discussions and post them

at the Grammar Clinic (a web forum) for peer editing and critiquing. All these sentences are posted anonymously.

4. *Post Activities*: In the final stage the learners model from teacher's examples and peers' writings before they work on their own essays independently. First, the teacher provides a sample essay and a language matching exercise to reinforce the key words in the essay. Gradually, teachers withdraw help and let the student compose their own essays. If they have a hard time starting, they can view other students' submissions of essays in the database to come up with more ideas.

Among the eight units, the last two units are designed for language exchange with native speakers from the country of the target language. For more details, please refer to the web site (http://www.lll.hawaii.edu/yuedu). The ID template can be modified for different language instruction. The Word Wide Web is an especially perfect media since all information is recorded and saved in the database. Students can always go back to review the collective database for their own review.

4 Evaluation of the web course

In the evaluation process, the instructional design team is interested in student feedback on the sequences of instruction. At the end of each unit, students are asked to fill out an anonymous feedback form that consists of 10 questions on a five-point Likert scale. Comment areas are provided for each question. Table 2 shows the preliminary partial results on the ID template evaluation.

Students had provided valuable feedback to the instructional design team. The team was able to use this feedback to adjust course content and activity design. Generally speaking, students agreed that most instructional design modules are useful for their learning. The degree of helpfulness varies from module to module. However, it seems that the students generally did not like the use of the CD-ROM. One reason is that the CD-ROM could only be used on a Macintosh while 95% of the students in the class used PC-compatible computers. PC users were restricted to use campus Macintosh computers to access the content in the CD-ROM. Furthermore, since the CD-ROM was developed for self-directed learning, there was also a lack of interaction between students and teachers. Finally, there were some bugs in the programming of the CD-ROM. Students were not enthusiastic about the programming bugs. The team is in the process of converting the CD-ROM into cross-platform media and fixing the bugs.

Table 2 Feedback on Instructional Design Lesson Template

1 = Strongly disagree; 2 = Disagree; 3 = Slightly Agree; 4 = Agree; and 5 = Strongly Agree		Unit 2 (mean)	Unit 4 (mean)	Unit5 (mean)	Unit7 (mean)
	Post Unit feedback questions	(n=11)	(n=9)	(n=11)	(n=9)
Q1	I have gained new knowledge from this unit.	4.09	3.78	3.73	3.56
Q2	When I ask for help, the instructors respond in a timely way.	4.45	4.33	4.09	3.33
Q3	When I ask questions, the instructors give me the answers I need.	4.36	4.33	4.09	3.67
Q4	The warm-up activities are useful. (i.e. contributing and sharing vocabulary)	3.73	3.78	3.73	3.44
Q5	The preparatory activities are useful. (i.e. matching pictures to text)	3.91	3.67	3.36	3.22
Q6	The content of the core lessons (CD-ROM) is well designed.	3.18	3.33	2.91	NA*
Q7	The forum discussions (i.e. Q&A, role-play, small group discussion) are useful.	4.09	3.78	3.73	3.33
Q8	The grammar clinic is helpful.	3.45	3.89	3.73	NA*
Q9	The language work is at the proper level of difficulty.	4	4.00	3.55	3.56
Q10	The essay writing is at the proper level of difficulty.	4.09	4.22	4.09	3.67
	Average	3.94	3.91	3.701	3.473

* Unit 7 is designed for language exchange. The questions on CD-ROM and Grammar Clinic are not applicable.

As for the web-based instructional modules, the warm-up activities were not deemed as useful as the instructional design team had expected them to be. When monitoring student online activities through the server-tracking program, it was found that most of them did not go back to use the database after submitting

the required entries. The instructor started requiring the students to incorporate the vocabulary into their essays towards the end of the semester. By then, it may have been too late to see how the change in instructional strategy would affect the way the students utilize the database. This is a good lesson for instructional designers. All instructional sequence should be interconnected and continuously looped back to the beginning. If the instructional modules are designed as stand-along units, students will not see the purpose of building on the knowledge based that they have co-constructed.

Finally, there seems to be a slight decline in the helpfulness of the ID modules when comparing the average in table 2. The perceived helpfulness declines especially in unit 7. The change in instructional format (i.e., language exchange) and the more specialized topic (i.e., movies) may have posed a greater challenge for less competent students. Interviews with the student may help to find out the real reasons. Nevertheless, the comments from students were overall positive. Here are a few comments from the students.

" The warm-up activities have been very helpful in preparing for the entire lesson."

"The preparatory activities makes one think harder about the subject material."

"Small group discussion wasn't as interesting as the previous units because there were a little interactions among students."

" I believe I would not have learned all of the new words from a textbook. Contributing and sharing vocabulary for this unit has really helped my ability to read the Chinese newspaper's entertainment section."

"The text for this section was presented in a way that forced me to focus and analyze more fully the meaning. A good challenge which I enjoyed."

" This unit helped me to learn unique vocabulary for discussions with almost any Chinese speaker. I am more confident that I can carry a conversation with a Chinese speaker about my favorite movie."

"While on occasion some vocabulary has been a little bit difficult, once I put the sentence or paragraph into context, the usage of the vocabulary became more clear."

5 Conclusions

ID sets up a framework for desirable learning outcomes. The incorporation of cognitive strategies helps students to efficiently achieve the learning objectives. It can be found from their comments that the students valued greatly the aspects of online interaction and co-construction of a knowledge database. It is through the collaborative tasks that they are able to interact for a purpose, i.e., for the completion of a task that has a real-world application. The overall ID objectives have been met through the instructional sequences. Nevertheless, there is not much evidence supporting the effectiveness of the ID modules other than students' own remarks. Further study on the comparison of the actual online activities (e.g. tracking the mouse clicks) with their perceptions on the usefulness of each ID module can provide more insight into the effectiveness of the instructional design. In addition, an objective panel of language experts to evaluate the performance of the students could also provide assessment to the final learning outcomes.

References

[1] Anderson, R. C. (1984). Role of reader's schema in comprehension, learning, and memory. In R. C.

[2] Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[3] Anderson, R. C. (1985). *Cognitive psychology and its implications*. New York, NY: Freeman.

[4] Andre, T. (1987). Questions and learning from reading. *Questioning Exchange, 1*, 47-86.

[5] Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart and Winston.

[6] Bourdeau, J., & Bates, A. (1997). Instructional design for distance learning. In S. Dijkstra, N. Seel, F. Schott, & R. Tennyson (Eds.), *Instructional design international perspective: Solving instructional design problems* (Vol. 2, pp. 369-397). Mahwah, NJ: Lawrence Erlbaum Associates.

[7] Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1995). *Cognitive psychology and instruction*. (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

[8] Corkill, A. J., Bruning, R. H., & Glover, J. A. (1988). Advance organizers: Concrete vs. abstract. *Journal of Educational Research, 82*, 76-81.

[9] Dewitz, R., Carr, E. M., & Patberg, J. P. (1987). Effects of inference training on comprehension and comprehension monitoring. *Reading Research Quarterly, 22*, 99-119.

[10] Fleming, S., & Lu, J.-Y. (1999). *CHN399a: Chinese Reading and Writing Course*. Available: http://www.lll.hawaii.edu/yuedu.

[11] Gagne, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of instructional design*. (4th ed.). Fort Worth: TX: Harcourt Brace.

[12] Gropper, G. L. (1983). A behavioral approach to instructional prescription. In C. M. Reigeluth (Ed.), *Instructional-design theories and models* (pp. 101-161). Hillsdale, NJ: Lawrence Erlbaum Associates.

[13] Hiple, D., & Fleming, S. (1996). *Stages of a receptive skill lesson development*. Available: http://www.lll.hawaii.edu/workshops/chinesenet/lessons/stages.html.

[14] Keller, J. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[15] Merrill, M. D. (1997). Instructional transaction theory: An instructional design model based on knowledge objects. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design international perspective: Theory, Research, and Models* (Vol. 1). Mahwah, NJ: Lawrence Erlbaum Associates.

[16] Peeck, J., Bosch, V. D., & Kruepeling, W. (1982). The effect of mobilizing prior knowledge on learning from text. *Journal of Educational Psychology, 74*, 771-777.

[17] Raphael, T. E., & McKinney, J. (1983). An examination of fifth- and eighth-grade children's question answering behavior: An instruction study in metacognition. *Journal of Reading Behavior, 15*, 67-86.

[18] Reigeluth, C. M. (1983). *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[19] Rumelhart, D. E. (1981). Schemata: The building blocks of cognition. In J. T. Guthrie (Ed.), *Comprehension and teaching: Research reviews* (pp. 3-26). Newark, DE: International Reading Association.

[20] Scandura, J. M. (1983). Instructional strategies based on the structural learning theory. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[21] Schank, R. C., & Abelson, R. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[22] Tennyson, R. D. (1990). Integrated instructional design theory: Advancements from cognitive science and instructional technology. *Educational Technology, 30*(8), 14-21.

[23] West, C., Farmer, j., & Wolff, P. (1991). *Instructional design: Implications from cognitive science*. Englewood Cliffs, NJ: Prentice Hall.

Student Learning Issues: factors to consider prior to designing computer-assisted learning for higher education.

Paul Wilson* **and George Coghill****
Christchurch Polytechnic, PO Box 22-095, Christchurch, New Zealand
Email: wilsonp@cpit.ac.nz
***The University of Auckland, Private Bag, Auckland, New Zealand*
Email: g.coghill@auckland.ac.nz

Significant research has shown that most computer assisted learning systems in higher education are failing to meet the expectations of the developers, and students learning needs. The use of computer assisted learning systems is still not commonplace and there are factors negating increased usage. This paper reviews a number of human development and learning theories that should be considered before design of any learning experience. The major focus is on the behavioural and cognitive approaches that are believed to have the most importance when considering the design of computer assisted learning systems. Current research in student learning in higher education is included as is an outline of individual variations in learning experiences. It is concluded that an awareness of the behavioural learning processes and cognitive theories when designing CAL systems in the various categories could provide enhanced learning opportunities for the students using the systems. The application and use of appropriate learning strategies to improve student learning outcomes is in accord with current research in traditional teaching areas

Keywords: **learning theories, higher education, computer assisted learning system design**

1 Introduction

A study of 104 projects using information technology (IT) in developing course material for use in higher education found that many students learned less from IT programs than from face-to-face teacher contact; "fewer than a third of programs offered through information technology improve student learning"[2]. The report went on to say, "that while many of the projects did benefit students and academics, inadequate staff development and students' unsophisticated understanding of learning meant IT was not always being put to maximum use". While this study is confined to IT projects in Australian universities it is thought likely that similar dire results would be obtained in most other countries and learning environments.

Despite more than two decades of research and development in the area of computer assisted learning (CAL), the usage of these systems is still not common place in any more than a few isolated areas; "few have survived the realities of large-scale implementation in typical classrooms and those that have report significant implementation problems"[7]. Two of the major contributing factors negating the wide spread acceptance and use of computer technology are the high resource cost, for both hardware procurement and courseware development, and the low level of enabling teacher development to allow them to use this new resource to its maximum potential.

CAL is the most popular term in Europe while Computer Aided Instruction (CAI) is more often used in North America and Asia. The use of the word instruction has a special significance. It usually means that the package is not only conceived and designed by a teacher but that the effective control remains with him/her at every stage. The content and its delivery, including the degree of elaboration, the rate of flow of information and the order of presentation are decided by the teacher only. Being teacher-centred, the design is expository rather than explanatory in nature.

In contrast, CAL is designed to have student-centred activities. The student decides how much she/he needs to learn, in what sequence, to what depth and at what rate. The learning process is usually exploratory. Theoretically, the need to take care of individual differences amongst students is much higher in designing a CAL package than in a CAI package.

Significant scope remains for research and development of CAL in the higher education context, just as it does in the junior and senior school environments. "We need to understand better the relationship between technology, pedagogy, project oriented curricula, and student learning" [9]. It is believed that one of the more crucial areas required for success in development of any teaching / learning package, be it traditional or computer assisted, is an understanding of student learning issues in the higher education context.

In this paper the major human development theories are briefly outlined with respect to research in student learning. This work allows student learning theories and approaches to be discussed in more detail, especially with respect to student learning in the higher education environment. Some of the more important variations that may impact on the overall outcomes of the students' learning are then outlined. The final contribution of the paper is to integrate relevant issues from the various student learning theories and recent research with respect to systematic design of CAL systems.

2 Human Development

The major theorist in this area is the Swiss psychologist Jean Piaget who formalised a theory of cognitive development based on four discrete stages. These four stages, with approximate relevant ages are (adapted from Woolfolk [13]);

1. Sensorimotor, from 0 to 2 years of age.
   Involving the senses and motor activity. Concepts of object permanence and goal-directed actions.
2. Pre-operational, from 2 to 7 years of age
   The stage before a child masters logical mental operations. Develops language and ability to use symbols to represent actions or objects mentally.
3. Concrete Operational, from 7 to 11 years of age
   Able to solve 'hands-on problems' in logical fashion. Able to classify, arranges objects in sequential order, and understands concepts of conservation and reversibility.
4. Formal Operational, from 11 to 15 years of age.
   Able to solve mental tasks involving abstract thinking and co-ordination of a number of variables.

Most psychologists agree that there is a level of thinking more sophisticated than concrete operations, but the question of how universal formal-operational thinking actually is, even among adults, is a matter of debate. According to some, the first three stages of Piaget's theory are forced on most people by physical realities [8]. Formal operations are not, however, so closely tied to the physical environment.

It is essential to realise that although a student might be participating in a higher education experience, that it is not necessarily congruent that they are able to think hypothetically about every problem that is presented to them. In many cases the students may be in a higher education environment only because of their ability to memorise formulas or lists of steps. "These systems may be helpful for passing tests, but real understanding will take place only if students are able to go beyond the superficial use of memorisation – only if, in other words, if they learn to use formal-operational thinking"[13].

Before continuing, it is worth noting that there have been a number of adaptations and alternatives proposed by psychologists to Piaget's theory of cognitive development in children. Most of these have come about in relatively recent research work that is well documented in Woolfolk[13]. One major alternative viewpoint is that culture shapes cognitive development in a child by determining what and how the child will learn about the world. The major spokesperson for this view is that of the Russian psychologist Lev Vygotsky who died more than 50 years ago. Recent translations of his work show that he provided an alternative to many of Piaget's ideas [13]. The concept of culture shaping learning styles is also supported in more recent studies [12].

3 Learning Theories

There are two main approaches to the study of learning: the behavioural and cognitive perspectives.

3.1 Behavioural Approach

The behavioural approach to learning assumes that the outcome of learning is a change in behaviour and emphasises the effects of external events on the individual. All behavioural learning theories are thus explanations of learning that focus on external events as the cause of change in observable behaviours. The four major behavioural learning processes are: contiguity, classical conditioning, operant conditioning, and observational learning.

3.1.1 Contiguity

This principle was the foundation for research in learning in the early parts of the twentieth century. The principle of contiguity states that whenever two sensations occur simultaneously and repeatedly, they will be become associated. If at some time later only one of the sensations occurs (a stimulus), the other will be recalled (a response). Learning by association, or the repetitive pairing of a stimulus and correct response, can be found in many educational contexts – consider for example spelling drills and multiplication tables.

3.1.2 Classical Conditioning

An extension of the contiguity principle is found in the theories of classical conditioning discovered by Ivan Pavlov in the 1920's. Classical conditioning allows for the association of automatic responses with new stimuli. Pavlov determined that in the first instance an unconditioned stimulus produces an unconditioned response. After conditioning (or 'learning'?) a previously neutral stimulus becomes a conditioned stimulus that can produce a conditioned response to the same extent that occurred with the unconditioned stimulus and unconditioned response pair. Pavlov's work also identified that conditioned responses are subject to the processes of generalisation, discrimination, and extinction. In many cases the emotional reactions to various learning situations are themselves learned in part through classical conditioning. We must acknowledge that emotions and attitudes are learned as well as facts and ideas in any learning environment.

3.1.3 Operant Conditioning

Contiguity and classical conditioning both focus on involuntary or automatic actions in response to stimuli. These involuntary actions are also referred to as respondents. It is obvious that not all human learning is automatic and that in many cases people actively operate on their environment to reach particular goals or cause certain effects. These deliberate, goal directed actions are called operants and the learning process involved in changing operant behaviour is called operant conditioning.

In operant conditioning people learn through the effects of their deliberate responses to their environment and as such is most applicable to classroom type learning environments. For an individual, the effects of consequences following their action may serve as reinforcement or punishment. Positive and negative reinforcement will strengthen the response while punishment may decrease or suppress the response. The scheduling of reinforcement can influence the rate and persistence of responses. Ratio schedules encourage higher rates of responses while variable schedules encourage persistence of responses [13].

3.1.4 Observational Learning

Social cognitive learning theorists emphasise the role of observation in learning and in non-observable cognitive processes. There are two main modes associated with observational learning. First, learning through observation can occur through vicarious conditioning. This is when a student sees others being rewarded or punished for various behaviours and so modifies their behaviours as if they had received the consequences themselves. Second, the observer imitates the behaviour or actions of a model even though the model receives no immediate reinforcement or punishment while the observer is watching. This mode is when the model is demonstrating something that the observer wants to learn and expects to be rewarded for mastering. There are four major elements associated with observational learning; paying attention, retaining information or impressions, producing behaviours, and being motivated to repeat the learned behaviours [13].

3.2 Cognitive Approach

The cognitive approach to learning emphasises how students perceive, remember, and understand

information. Cognitive psychologists focus on changes in knowledge and believe that learning is an internal mental activity that cannot be observed directly. There is no single combining theory and thus the cognitive view of learning can best be described as a generally agreed-upon philosophical orientation [13].

Under the cognitive approach, knowledge is categorised into different types (after [13] and [5]):

- General knowledge is information that is useful in many kinds of tasks or that may be applied to many different situations.
- Domain-specific knowledge is information that is useful in only a particular situation or that applies to only one specific topic.
- Declarative knowledge is *knowing that* something is the case, facts, beliefs, theorems, opinions, names, rules, poems, and the like. This type of knowledge has a tremendous range and may be organised into small units or larger units, which themselves may consist of several well-organised smaller units.
- Procedural knowledge is knowledge that is demonstrated when performing a task, that is *knowing how*.
- Conditional knowledge is *knowing when and why* to apply declarative or procedural knowledge.

The most influential and thoroughly studied model of cognitive research is the information processing model that provides an explanation of the cognitive processes involved in learning. It has grown from the work of a number of theorists (e.g. [3] and [6]).

3.2.1 Information Processing

In the information processing model the learning is approached primarily through a study of memory. A schematic representation of a typical information processing model of learning is shown in Figure 1(after [[13] and [5]).

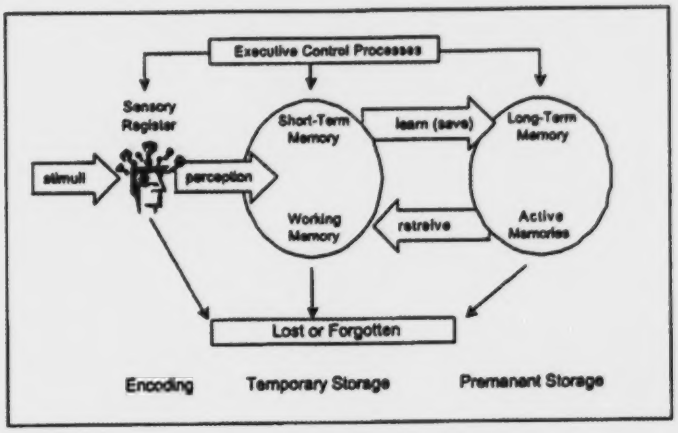


Figure 1 – The Information Processing Model

The three stages of the information processing system are the sensory register, short term memory and long term memory. The sensory register encodes some or all of the information received from the senses. Some of the information is not registered at all, some is ignored and some is simply forgotten. Perception determines what will be held in short term memory for further use.

The working memory only has a limited capacity so the information must be processed immediately or it will be forgotten. For information to be retained for longer than a few seconds it must be actively learned and stored in the long-term memory. Retrieval is the process of locating and recalling information to short-term memory.

The executive control processes guide and direct the processes involved in transferring information from the external environment to the long-term memory. These processes include directing attention, selecting strategies, and monitoring progress towards goals and motives.

BEST COPY AVAILABLE

Learning in the information processing model involves the construction of information in the memory, rather than the direct transfer of information from external environment to long-term memory. Learners use learning or cognitive strategies to actively acquire and manipulate information from the environment and their memory.

3.2.2 Metacognition

Metacognition literally means knowledge about cognition and has two aspects. The first aspect refers to an awareness of, and knowledge about, cognition. It includes the *declarative* and *procedural* knowledge of the skills, strategies, and resources needed to perform a task effectively, and the *conditional* knowledge needed to ensure successful completion of the task [13].

The second, and more important aspect, relates to the control and regulation of cognition, as this is the aspect that controls and regulates the use of strategies that are known by the learner. The control and regulation aspect includes three general processes: planning, monitoring and self-evaluation. Planning helps learners decide which strategies to use and how to process information effectively. Monitoring helps learners understand the information and integrate it with their existing knowledge. Self-evaluation helps learners check and correct their learning behaviour as they work through a learning task.

3.3 Constructivist

The constructivist approach to learning emphasises that people construct knowledge for themselves as a result of their interactions with their environment. Through this construction process, individuals build their own understandings and ways of looking at the world and the information sources in it. This does not mean that each person constructs knowledge in their own way that may be totally different from others. In most cases knowledge and understanding are constructed in an agreed and shared social context.

The constructivist approach subsumes a variety of theories, including information processing and social cognitive theories. The principal theorists in this area are Gagne [6], and Brown et al. [4].

Constructivist views of learning are important because they inform teachers of where to direct their effort in order to promote effective learning. The important features include the basic cognitive processes, strategies to guide these processes, knowledge about those strategies and one's own thinking processes, knowledge about the world in general, motivational beliefs, goals and overall cognitive style.

The immediate implications for learning are that students must be active learners and must be able to use a variety of learning strategies that will help them learn with understanding [5].

4 Variations

Learning is a complex multivariable phenomenon with respect to both process and outcomes [10]. Each student will be subject to intrinsic and extrinsic factors and driving forces that will impact on their learning. These factors and driving forces must be acknowledged and, if possible, allowed for in both traditional and computer assisted teaching environments. The first three of the factors outlined below are referred to as the 'big three' of student learning behaviours and essentially explain contrasting individual forms of engagement with the content and context of learning. The remaining factors can be used to construct more complex multivariable models for individual approaches to learning.

4.1 Intention

All students have some objective in mind when they start a course of study in higher education, the *what* question. Each student's individual response to this question may reflect a variety of contrasting intentions, or even a multiple intention. The most basic distinction is between the internal transformation of information into knowledge (construction of personal meaning), and the accumulation and reproduction of information (storage and recall). Other strategic intentions may be focused on the outcomes of higher education.

4.2 Motivation

Closely coupled with intention is the motivation for learning, the *why* question. Students are motivated by a wide range of feelings that traverse the entire spectrum of human experience. Abraham Maslow has had a great impact on the psychology of motivation and his hierarchy of needs model sets the foundation for research into human motivation. Other aspects to be considered in student motivation are arousal, goals, attribution, and beliefs [13].

4.3 Process

A materialistically motivated strategic intention to achieve high marks, for example, will not guarantee that high marks will be achieved. At even the most basic level in higher education some type of organised cognitive process or learning method will be required, the *how* question. Process is not simply a mental consideration in learning activity; it is at least partially influenced by the underlying intention and motivation.

4.4 Context

A students learning behaviour will be shaped by perceived circumstances or situational demands. Correctly identifying and applying the cues embedded in the context of learning (especially those related to task demands) are an important part of what might be called 'skill in learning' [10]. Perceptions that students form about the context of learning are closely associated at the individual process level with other sources of variation.

4.5 Regulation & Locus of Control

It has been demonstrated that various forms of regulatory mechanisms, such as those that clarify and direct learning activities, can help explain individual learning variations [11]. Individuals also vary to the degree to which they perceive causal attribution for academic success to be within, or beyond, their control [10]. Studies have determined the importance of locus of control as a determinant of learning outcomes in higher education.

4.6 Student Conceptions

Students differ considerably in their conceptions of what learning is. In broad terms the conceptual distinction lies between accumulative, the quantitative collection of knowledge for possible future use, and transformative, the use of knowledge to internally rearrange and construct new knowledge for developing personal meaning. These contrasting conceptions of learning are associated with differing forms of learning behaviour [10].

4.7 Cultural Factors

Recent research in the area of cultural impact on student learning has demonstrated that there is danger in assuming a culture-free interpretation of basic learning processes [10]. Indeed, culturally embedded values and practices must also shape any student learning behaviour model.

4.8 Gender

"The issue of gender related differences in learning behaviour does create some controversy" [10]. However, recent work in this area has shown that basic sources of variation used in student learning model construction may be defined differently in terms of gender specific responses – which, as a logical consequence, raises the possibility of gender specific models of student learning.

4.9 Discipline Specificity

The possible causes of variations outlined to this point have one thing in common; they are all general in nature and should be considered for any learning situation. As most learning in a higher education setting is essentially content focused there is an obvious need to address variations that may be specific to a particular discipline. These variations may be either a function of the content itself (for example higher level

mathematics) or the broader context in which they are embedded and is perceived to be a part of (for example higher mathematical concepts in an electrical engineering course).

5 Student Learning Issues of Importance in the Systematic Design of Computer Assisted Learning Systems

Other researchers in the field of CAL have recognised the relevance of considering issues from cognitive psychology in the design of CAL systems. The areas of cognitive theory concerning perception and attention, memory, comprehension, active learning, motivation, locus of control, transfer of learning, and individual differences have previously been identified as being most important to CAL design [1].

However, it is believed that the consideration of cognitive theory to the exclusion of other learning issues can only lead to an incomplete analysis of the wider learning issues affecting all students in a higher education environment. Of even more concern is the concept of a CAL system being designed with no consideration given to any of the student learning issues. This could be a partial explanation for the poor results reported in the survey of Alexander & McKenzie [2].

Issues considered to be of importance in the systematic design of CAL are as follows:

5.1 Use of Formal-Operational Thinking

There are few instances in CAL in higher education where students are not required to proceed beyond the superficial use of memorisation. Therefore it is vital that a CAL system design ensure that the students are required to use formal-operational thinking to achieve the learning required.

5.2 Cultural Aspects

With the increasing globalisation of education there are many instances in a higher education environment where there may be several cultures in any particular group of students. The design of a CAL system must not allow one cultural group to be advantaged, or disadvantaged, at the expense of others due to the predominance of a particular learning style or cultural influence in the system.

5.3 Behavioural Influences

CAL systems may include learning experiences ranging from simple drills to complex simulations. An awareness of the behavioural learning processes when designing CAL systems in the various categories could provide enhanced learning opportunities for the students using the systems. Of most benefit are the operant conditioning and observational learning processes. Research from operant conditioning shows that the scheduling of reinforcement, or CAL system feedback in this particular instance, must be designed to ensure that the aim of the system is achieved – that is, higher rates of responses or persistence of responses. Research from observed learning shows that mastery can be achieved through observation – how this observation can be achieved in a CAL system needs careful consideration during the design process.

5.4 Cognitive Influences

The work of Alessi & Trollip [1] has gone some way towards setting a base for the use of cognitive theory in designing CAL systems. Recent research has increased the awareness, and importance, of metacognition in student learning. The control and regulation of the cognition aspect of metacognition shows the importance of considering this aspect when designing CAL systems. The application and use of appropriate learning strategies to improve student learning outcomes is in accord with current research [5]. Just because a student is 'learning' from a computer does not mean that they would not benefit more from an increased awareness of learning styles and strategies.

5.5 Constructivist Approaches

The constructivist approach to student learning also has a great deal to offer designers of CAL systems. In this approach, students must positively interact with their environment – they must become 'active learners'.

One of the most enabling features of properly designed CAL is its ability for interaction with the student. However, too much of one thing can soon become tiring and thus eventually negatively motivating, therefore this is one area that needs more research to ensure the much heralded benefits of CAL systems eventuate.

5.6 Individual Variations

Meyer [10] notes that learning is a complex multivariable phenomenon with respect to both process and outcomes. Alessi & Trollip [1] also note that the often praised and supposed advantage of CAL to individualise is, just like interactivity, not often taken advantage of. All of the outlined individual variations must be at least considered when designing a CAL system. The big three of intention, motivation and process should always be factored into CAL system design. Context, regulation and locus of control, and discipline specificity may provide significant opportunities for the CAL system designer to truly individualise the system for the learners.

6 Conclusions

Many of the learning issues outlined in this paper are only now starting to be recognised as important aspects for students in higher education [5], [10]. With an increasing reliance on computer and information technology in higher education it is now imperative that the opportunity is taken to consider learning issues as a first step in the systematic design of computer assisted learning systems.

This paper has outlined some of the more important human development, learning theories, and learning approaches considered relevant to the systematic design of CAL systems. Significant research effort is being undertaken in applying these theories and approaches to 'traditional', or face-to-face, teaching in higher education. As any CAL system is no more than an extension of the existing traditional methods it is imperative that similar research work is conducted in the CAL design area.

Work remains to be carried out in developing a systematic approach to integrating teaching concepts, in addition to that completed in this paper on learning issues, in the design of CAL systems.

It is concluded that only once a complete understanding of those learning and teaching issues in higher education are mastered, will a comprehensive and systematic design approach for CAL systems be able to be developed.

References

[1] Alessi, S.M. & Trollip, S.R.,. "Computer based instruction: methods and development", Englewood Cliffs: Prentice Hall, (1985).

[2] Alexander, S. & McKenzie, J., "An evaluation of information technology projects for university learning", Canberra: Australian Government Printing Service. (1999).

[3] Atkinson, R.C. & Shiffrin, R.M., "Human memory: A proposed system and its control processes", in K Spence & J Spence (Eds.), "The psychology of learning and motivation", Vol. 2, New York: Academic Press, (1968).

[4] Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. "Learning, remembering and understanding", in P.H. Mussen (Ed), "Handbook of child psychology", Vol. 3 (4th Edn, pp.77-166), New York: John Wiley & Sons, (1983).

[5] Chalmers, D. & Fuller, R., "Teaching for learning at university", London: Kogan Page, (1996).

[6] Gagne, R.M., "The conditions of learning", 4th Editiion, New York: Holt, Rinehart and Winston, (1985).

[7] Ladewskii, B.G., Krajcik, J.S., & Harvey, C.L., "A middle grade science teacher's emerging understanding of project based instruction". Elementary School Journal, Vol. 94, pp. 499-515, (1994).

[8] Neimark, E., "Intellectual development during adolescence", in F.D. Horowitz (Ed.), "Review of Child Development Research", Chicago: University of Chicago Press, (1975).

[9] Mergendoller, J.R., "Moving from technological possibility to richer student learning: revitalised infrastructure and reconstructed pedagogy", Educational Researcher, Vol.25, No. 8, pp. 43-46, (1996).

[10] Meyer, J.H.F., "A medley of individual differences" in B. Dart & G. Boulton-Lewis (Eds.), "Teaching & learning in higher education", Melbourne: Australian Council for Education Research Ltd., (1998).

[11] Vermunt, J.D.H.M, & Van Rijswijk, F.A.W.M., "Analysis and development of students' skill in self regulated learning". Higher Education, Vol. 17, pp. 647-682, (1988).

[12] Watkins, D. "Assessing approaches to learning: A cross-cultural perspective" in B. Dart & G. Boulton-Lewis (Eds.), "Teaching & learning in higher education", Melbourne: Australian Council for Education Research Ltd., (1998).

[13] Woolfolk, A., "Educational psychology", 5th Edition, Needham Heights, Ma: Allyn & Bacon, (1993).

Students' Attitude toward WPSS in Supporting Classroom Learning

Hsiu-Ping Yueh
Department of Agricultural Extension, National Taiwan University,
#1, Sec. 4, Roosevelt Rd, Taipei 106, Taiwan
Tel: 886-2-23630231-2750
FAX: 886-2-23647221
Email: yueh@ccms.ntu.edu.tw

While the web-based learning environment has become more flexible and has more functions than traditional instructional media as well as many computer-assisted instruction, the EPSS has also become an expanding area within the field of education. This paper first describes the features of and rationale behind electronic performance support system as well as web-based performance support system; demonstrates the implementation of the web-based performance support system in assisting students' learning in a real-time multicast distance classroom; discusses the research methodology; explores the effectiveness of the use of the web-based performance support system in supporting students' learning; and provides conclusions and implications for the filed of education.

Key Words: **Distance Education, Electronic Performance Support System (EPSS), Web-based Performance Support System (WPSS)**

1 Introduction

Electronic Performance Support System (EPSS) was originally defined as a system that provides just-in-time information, advice, learning experiences, and tools in the form of electronic to help people perform a task with the minimum support from other people [3]. Based on the early definition, EPSS was perceived by many people as an interactive computer-based environment which attempts to facilitate or improve human performance such as problem solving abilities within some target application domain. To help organizations design and develop EPSS with a broader systems thinking approach, Raybould (1995) proposes that an EPSS is "the electronic infrastructure that captures, stores and distributes individual and corporate knowledge assets throughout an organization, to enable an individual to achieve a required level of performance in the fastest possible time and with the minimum of support from other people"(p.66)[6].

A number of existing technologies have been selected and integrated into design and development of an EPSS, such as artificial intelligence (AI), hypermedia, computer-based training (CBT), intelligent tutors and microworlds [5]. With the impact of the growth and development of network technology, internet or intranet has become one of the most important delivery vehicle for the EPSS. A Web-based Performance Support System (WPSS) is an innovative approach by utilizing the technologies of the world-wide-web (WWW). For a WPSS, the web is not only a delivery medium, it also provides contents and serves as subject matter experts (SMEs) as well. The DISTED (Distributed Information System & Training for Educators at a Distance Education) as an example of a WPSS has successfully functioned as a system which helps educators design, delivery and evaluate teaching in the interactive distance education [7]. The WPSS has been proved to be a better design than the traditional EPSS in terms of it's features such as cost-effectiveness, open architecture, universal acceptance and pervasive delivery [2].

Many training experts contended that Electronic Performance Support Systems are the learning tools of the 21st century [4]. While most of the major developments and applications of EPSS were designed for industrial and

commercial settings, more and more educators in many academic organizations have begun to adopt the concept and implement EPSSs in their classes. As the educational environment becomes more dynamic, the possibility of adequately imparting necessary knowledge to learners within a limited instructional schedule is increasingly challenging. Considering that our knowledge base is expanding rapidly and information is being updated at the speed of telecommunications, some educators therefore started to employ an integrated use of EPSS to facilitate learners' information retrieval. For example, Schwen, Goodrum, & Dorsey (1993) used the EPSS to create an enriched learning and information environment [8]; Law (1994) employed the metaphor of "cognitive training wheels" to describe EPSS as it facilitates learners' acquisition of skilled performance.

According to the early definition of EPSS, there are usually four major components embedded in a performance support system which includes information, training, advice and tools. To improve the functions and the design and development of a better performance support system, many researchers proposed different models of putting together an EPSS with necessary components. Gery (1991) listed three levels of functionality with four components at each level, they are user interface, help, coach/advisor, and tutor [3]. McGraw (1995) suggested that the components of an EPSS should include the human-computer interface, the help system, the coaching/advisor system, and the tutor component [5]. Baker and Banerji (1995) proposed an approach to design and implement of EPSS facilities based upon the use of a multi-layered model containing four basic levels including human-computer interface, generic tools, application specific support tools, and application domain [1]. In general, an EPSS should have four typical components including tools, information base, advisor, and learning experiences [9] to be able to support performance.

While we are moving into the resource-based learning environment in the field of education, the way of teaching and instruction has been changed accordingly. Teachers are no longer experts but facilitators or guilders; textbooks is also instead by a variety of learning resources and media. Internet is a very good tool in terms of providing the resource-based learning environment. The world-wide web with hypertext markup language (HTML) provides an easier way to present large volumes of text electronically, using efficient client/server architecture to transfer different kinds of data, such as texts with fancy fonts, colorful graphics, even sound and video clips in packets across the internet. As an integrated tool, WWW allows users to share and transfer data files easily, as well as communicate and interact more effectively. Also as a self-directed learning tool, a WPSS provides a rich environment with up-to-date information, real-world learning experiences, as well as worldwide learning resources, with which students can self-pace, monitor, and evaluate their learning.

2 Method

The purpose of this study were to investigate the effectiveness of the WPSS in supporting students' learning as well as to understand students' attitude toward this system. The target population for this study is a class of students (82 students totally) registering in the distance education course titled "Web-based Instruction and Training" in Spring 1999. A WIT Web Site was designed and developed as a web-based performance support system to assist students' learning of this course. At the end of the semester, a copy of questionnaire was also designed and distributed to students to collect their perception toward this Web Site. Moreover, students' answers to a posttest essay of the final exam were reviewed for the purpose of evaluation. The data collected were analyzed by means of Descriptive Statistics, correlation, and regression study.

3 Results

For the attitude survey, most students showed positive attitude toward content information (usefulness, richness, helpfulness), format design (screen design, visual images design, layout consistency, links arrangement), and composition (organization, presentation, delivery, references) of this WIT Web Site. Besides, students' comments also showed that most students thought this Web Site is a useful tool in general especially it meets different learning needs of students. Furthermore, the results showed that there is a moderate correlation between students' attitude with their final exam scores. And findings suggest that most students are willing to use this kind of supporting system in their learning if other courses could provide in the future.

4 Conclusions

1. Evidence from students' attitude survey and feedback comments shows that the web based performance support system is a powerful tool in terms of assisting learning especially in the distance education learning environment. It serves as a self-directed learning tool with which students can self-pace, monitor, and evaluate their learning, which may in turn facilitate students in developing life-long learning skills.

2. Results of this study also shows that the WIT Web Site provides a powerful communication channel between instructor and students, as well as students at different learning sites in the distance education course. More specifically, the web-based discussion boards were claimed by students to be a very useful tool to expand the interaction and communication outside classroom.

3. Most Electronic Performance support Systems were used in the industrial settings in the past, however, results of this study has approved that a WPSS can also be an excellent tool for providing just-in-time assistance in the learning environment of formal education. Students perceived it as a good learning tool in many aspects including the application to future study in other contexts or subject areas. This experience of facilitating students learning on the internet can be applied in other curriculum at different levels of schools.

Reference

[1] Baker, P., & Banerji, A., "Designing electronic performance support systems, Innovations in Education and Training International, 32(1), 4-12. (1995)

[2] Chang, C. C. (1999). Designing, developing and evaluating an electronic performance support system for performing and learning instructional designing tasks. In G. Cumming et al. (Eds.), Advanced Research in Computers and Communications in Education (Vol. 2, pp. 423-426). Ohmsha: IOS Press.

[3] Gery, G., "Electronic performance support systems: How and why to remake the workplace through the strategic application of technology". Tolland, Mass: Gery Performance Press. (1991).

[4] Hoyt, B.R., Stockman, M., & Thalmann, J., "Design and implement custom electronic performance support systems (EPSS) for training in project based classes. ASCUE Proceedings, 100-107. (ED document 410925) (1997)

[5] McGraw, K.L., "Selecting appropriate functionality and technologies for EPSS, Innovations in Education and Training International, 32(1), 13-22. (1995).

[6] Raybould, B., "Making a case for EPSS, Innovations in Education and Training International, 32(1), 65-69. (1995)

[7] Remmers, E. (1998). Guidelines for WWW-based support environments for education professionals. URL: http://mw75.student.utwente.nl/~elka/litstudy/

[8] Schwen, T. M., Goodrum, D.A., & Dorsey, L. T., "On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), 5-9. (1993)

[9] Yueh, H., Liu, F., & Wang, P., "Assessing the effectiveness of a web-based EPSS. Paper presentated at the Annual Conference of the Association for Educational Eommunication and Technology, St. Louis, MO. (February, 1998).

The Development of a Multimedia Program for Teachers to Integrate Computers into the English Curriculum

Ya-Fung Chang
Center for Teacher Education, Tamkang University
151 Ying-Chuan Road, Tamsui, Taiwan 251
Tel: +886-2-26215656-2149
Fax:+886-2-26229751
Email: yfchang@mail.tku.edu.tw

A self-learning multimedia program was developed for English teachers' professional development in the integration of computers into the English curriculum. This program consists of four parts: (1) study guide (2) application cases (3) computer resources, and (4) related documents. In addition, a tool box is provided to gain access to a word processing system for taking notes, or to connect to a network discussion system for ideas exchange. This program was found satisfactory based on a preliminary evaluation. However, it will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use.

Keywords: **Multimedia, System development, ESL teaching, Teacher professional development**

1 Introduction

It is said that the use of computer technology can create authentic and rich learning environments where learners' communication skills in English may be enhanced greatly.[1][2] To have such benefits, it is important to integrate computers into the English curriculum. In so doing, many factors such as computer technology, subject matters, learners, and even the environments all need to be taken into consideration. Above all, the key factor to successful integration is the school teacher. Teachers eventually need to take the responsibility of determining when and how to use computers, and assessing the effectiveness of computer use with their students.[3] However, a survey report in 1999 by the National Center for Educational Statistics still indicated such problem since only less than 20% of current teachers in American reported feeling very well prepared for technology integration.[4] The teachers in Taiwan also have the same problems. Neither do they know what kind of computer resources available, nor do they know how to apply them to their classroom instruction. In view of this, a multimedia program was developed for middle school English teachers so as to increase their competence and confidence in the instructional use of computers, and consequently to help them integrate computers into their instruction.

In the age of information technology, teachers are required to learn about technology. On the other hand, technology can be used to promote teacher professional development. For example, Hawkes proposed the use of network-based communication for teachers to gain access to professionally relevant knowledge.[5] However, the network installation is more complicated compared to that of cd-rom. Furthermore, the quality of Internet transmission for large amount of data such as videos is still below our satisfaction. Therefore, this multimedia program for English teachers currently resides on a cd-rom instead of a web site. However, technical support is available via telephone calls or e-mails. In addition, teachers can share ideas with others by connecting to a network discussion system.

2 The Developing Process

The Systems approach to instructional design has been adopted to guide the production of this multimedia program and thus to ensure the quality of its end product. [6][7] On the whole, the process includes four phases, namely, analysis, design, development, and evaluation/revision.

2.1 Phase of Analysis

Based on the review of the literature, there is a need to enhance teachers' willingness, competence, and confidence in the use of computers in their English classrooms. Due to the advantages of convenience and flexibility, a self-learning multimedia program is proposed. Basically this program attempts to achieve the following goals: (1) to stimulate teachers to rethink the new roles of teachers in an information society, (2) to help teachers understand the principles and strategies of the classroom use of comoputers, and thus generate some possible ways of applications, and (3) to encourage teachers to follow the application cases and lesson plans provided by this program and actually apply computers to their classroom instruction

2.2 Phase of Design

After several discussions with English teachers, English teaching experts, and instructional designers, a framework of this program is finally settled as shown in figure 1. The "study guide" gives an overview of the program' s goals, operation procedures, and contents to help users get an overall view of this program in a short time. Thus the users are able to decide the best way to use the program to meet their own needs. The "application cases" provides several cases about teachers' classroom use of computers in English teaching. Since these cases are realistic, it is believed that they would give teachers strong inspirations and implications. Each case contains useful information including: (1) background of the school and the teacher, (2) lesson plan of using comp uters in his or her classroom, (3) "teaching on the spot" in the video format, (4) student reactions based on the questionnaire and interview data, (5) teacher reflections about this practice, and (6) related issues pointed out by the designer.

The "computer resources" lists the titles of cd-roms and web sites useful for English teaching. The publisher of each cd-rom and a short description of its content are provided. The address of each web site, a short description of its content, and the computer screen of its homepage are displayed. The "related documents" includes a set of helpful information regarding implementing computer technology. For example, the "future education" outlines schools, teachers, and English teaching in the future. The "use of computers" describes the strengths of computers, identifies types of applications, and presents samples of lesson plans. The "user guide" points out the issues of intelligence properties and computer ethics. It also includes software evaluation sheets. "The Imp lementation guide" reminds teachers of some factors that need to be taken into consideration in implementing computers in their classrooms. Finally, the "references" lists the titles of related articles and books so that teachers can get more detailed information if needed. In addition, a tool box is provided to gain access to the word processing system for teachers to take notes whenever they need, and to connect to a network discussion system for ideas exchange and sharing.

2.3 Phase of Development

The programming tool for this multimedia program is Authorware 5.0, and the program resides on a cd-rom to enable easy distribution. To collect the data for the "application cases", the whole teaching process of each case is video taped. Afterwards, the teaching process is divided into several steps. Accordingly, suitable video screens are selected for each step. These video screens are then transformed and stored in mpeg files. At the end of instruction, the student is asked to fill in an attitude questionnaire. Furthermore, the teacher and several students are interviewed. The whole questionnaires are then analyzed statistically, while the interview data are examined in depth.

2.4 Phase of Evaluation/Revision

English teachers, English teaching experts, and instructional designers are invited to participate in a preliminary evaluation of this program. The focus of this evaluation includes content, screen design, media effects, interface design, and system operations. This program will thus be revised and expanded according to their opinions and suggestions. In the future, a detailed study will be followed to investigate the effectiveness of its use.

3 Results and Discussion

Based on a preliminary evaluation reports by two English teachers and one instructional designer, it was found that the program's content is plentiful and practical on the whole. Moreover, the screen design is of high quality, the interface design is user friendly, and the program's operation is easy and consistent. However, some of the video screens in the "application cases" look gloomy. Sometimes, it takes efforts to identify the key plot of these screens. Finally, it is suggested to increase the quantity and variety of the cases in this program.

In regard to the quality problem of the video screens, it is because the teacher turned off all the lights in the classroom to make more readable the computer displays by a portable projector. Consequently the quality of video recording was affected. As to the small number of the cases, it is because few English teachers ever used computers in their classrooms. Most of them dare not try it. The availability of the computer hardware is another problem. At that time, there was no computer lab available for English teachers. Therefore, the three cases currently included in this program all occurred in the regular classrooms where cd-roms, a notebook computer, and a portable projector were used.

To increase the quantity and variety of the cases in this program, two cases are collected afterwards. The two cases all occurred in the computer labs. In addition, e-mails and Internet resources were used. The program will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use. Questionnaires on computer literacy, and attitudes toward this self-learning program, as well as the design of lesson plans will be used to collect the outcome data. The net discussion tracking system, and the journal writing will be used to collect the process data. In addition, relevant suggestions will be provided regarding optimal strategies and necessary supports which go well with the use of this self-learning multimedia program.

4 Conclusions

A self-learning multimedia program was developed for English teachers' professional development in the integration of computers into the English curriculum Based on a preliminary evaluation, the program was found satisfactory. However, it will be upgraded continueously in the future. At the same time, a detailed study will be followed to investigate the effectiveness of its use.

References

[1] Kumar, V. S. ,Anjaneyulu, K.S.R,• Gupte, U. A , "VIDYA:A situated CALL environment", Computer Assisted Language Learning, Vol. 10, No. 2, pp149-172, (1997).

[2] Zhao, Y., "Language learning on the World Wide Web: Toward a framework of network based CALL", CALICO Journal, Vol. 14, No. 1, pp37-57, (1996).

[3] Keith, W.• Ines, C., "An evaluation of technology integration in teacher education for bilingual and English as a second language education majors", Journal of Research on Computing in Education, Vol. 30, No. 4, pp379-395, (1998).

[4] Schrum, L., "Technology professional development for teachers. Educational Technology", Research and Development, Vol. 47, No. 4, pp83-90, (1999).

[5] Hawkes, M., "Exploring network-based communication in teacher professional development", Educational Technology, Vol. 39, No. 4, pp45-52, (1999).

[6] Dick, W., & Carey, L., "The systematic design of instruction", Glenview, IL:Scott Foresman Company, (1985).

[7] Seels, B. & Glasow, Z., "Exercises in instructional design", Columbus: Merrill, (1990).

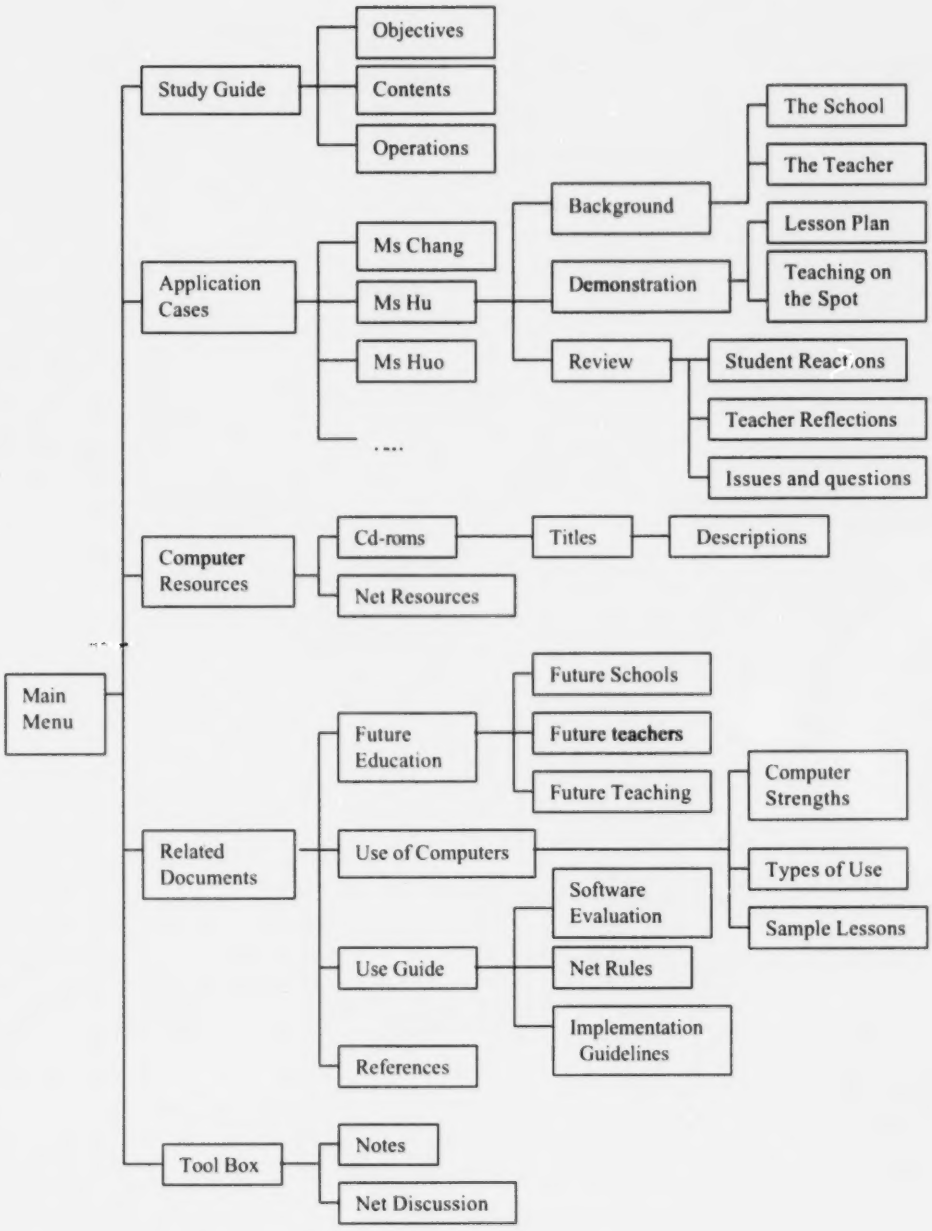


Figure 1 Framework of the multimedia program
Figure 1 Framework of the multimedia program

The Impact of Learning Style on Group Cooperative Learning

Fang-yi Hu* and Nian-shing Chen*
** Dep. of Information Management, National Sun Yat-sen University*
70, Lian-hi Road, Kaohsiung, Taiwan 804
Tel: +886-7-5252510
E-mail: fyhu@power2.nsysu.edu.tw; nschen@cc.nsysu.edu.tw

Cooperative learning has been around a long time and there are many researches and practical uses of cooperative learning. This study is to examine students' attitude toward group cooperative learning processing with individual's underlying learning style. We use Gregorc's Learning Style Delineator to group students heterogeneously and use some factors of Social Cognitive Theory to measure group processing. The findings indicate students with concrete/sequential learning style are tentative to be lack of self-efficacy on setting their goals and therefore teachers should take more care of them while doing group cooperative learning activities.

Keywords: **Cooperative Learning, Learning Style, Social Cognitive Theory**

1 Introduction

Cooperative learning means students working together to accomplish shared learning goals and to maximize their own and their group members' achievements (Johnson & Johnson, 1994). Cooperative learning is widely adopted by the educators since 1980s. Students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). A vast amount of evidence from research in related areas suggest that in cooperative learning situations there is a positive interdependence among students' goal attainments.

Although cooperative learning makes students to learn much better than competitive learning and individual learning in groups, there are still many potential barriers to make group effective, such as lack of sufficient heterogeneity, lack of groupthink, free riding, and lack of teamwork skills (Johnson & Johnson, 1994; Johnson & Johnson, 1996). The basic elements of making cooperative group with high performances are positive interdependence, face-to-face promotive interaction, individual and group accountability, appropriate use of social skills, and group processing (Johnson & Johnson, 1996). Thus how students interacting with other group members and groups processing are the critical successful factors in cooperative learning. By considering individuals' underlying learning style, the purpose of the study is to examine students' attitude toward group cooperative learning processing.

In the Bostrom, et al. (1988) framework individual difference variables define the cognitive aspects of human activities. Thinking process is at the heart of all such activities including learning. Learning style is one of the cognitive traits, which are static aspects of information processing affecting a broad range of variables (Bostrom, et al., 1990). To aim for sufficient heterogeneous grouping, this study chooses learning style as the main variable concerning the impacts of group cooperative learning.

To examine individual's interaction during group processing, this study use Social Cognitive Theory (SCT) (Bandura, 1986), a widely accepted and empirically validated model of individual behavior (Compeau & Higgins, 1995), to reflect the cognitive aspects of students' learning activities, such as self-efficacy. SCT emphasizes the triadic reciprocal causation of behavior, cognitive and some personal factors and environmental events (see Figure 1). Three aspects of Social Cognitive Theory are especially relevant to the organizational field (Bandura, 1988; Wood & Bandura, 1989): the development of people's cognitive, social, and behavioral competencies through mastery modeling, the cultivation of people's beliefs in their capabilities so that they will use their talents effectively, and the enhancement of people's motivation

through goal systems.

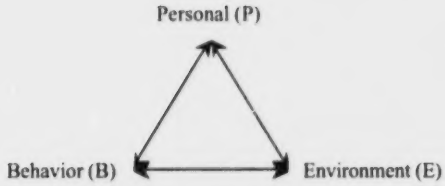


Figure 1. Schematization of the relations among behavior (B), cognitive and other personal factors (P), and the external environment (E) (Bandura, 1986; Wood & Bandura, 1989)

According to Social Cognitive Theory, many researches showed that past performance, self-efficacy and goal setting are the main personal factors effecting performance. Although there are many other factors in the range of the theory, we just discuss the impact of learning style on self-efficacy and goal setting in this study.

There are some other factors exerting considerable influence over group performance. For example, group cohesiveness and group norms. Cohesiveness means all forces (both positive and negative) that cause individuals to maintain their membership in specific groups. Group cohesion means the mutual attraction among group members and the resulting desire to remain in the group. Norms means the rules or expectations that specify appropriate behavior in the group and the standards by which group members regulate their actions (Johnson & Johnson, 1996). Group performance is affected by the combination of cohesiveness and group norms rather than cohesiveness alone (Langfred, 1998). In this study, we also investigate the impact of learning style in group cohesiveness and norms.

2 Method

2.1 Subjects

The subjects were 43 girl's senior high school students who participated in the AJET (Advanced Joint English Teaching, *http://ajet.nsysu.edu.tw*) project, which was supported by MOECC (Ministry of Education Computer Center, APNG-Education (Asia Pacific Networking Group) and I*EARN in Taiwan (*http://www.iearn.edu.tw*). Therefore there are no differences in sex and age among them. The subjects were run in groups and Table 1 is their proportion of learning style. We'll explain the types of learning styles later.

Table 1. Learning Style Frequencies

Learning Style	AR	CR	AS	CS	Total
Students Numbers	15	17	7	4	43

Every group was assigned a project to make English web pages about one topic: Signs or Foods in 6 weeks. Every week they had tow hours on learning how to make homepages by Microsoft FrontPage 98 and doing their group's project as exercises in the computer classroom. Before the experiment, they had learned some basic skills for building their own personal webs.

2.2 Procedure

During the 6 weeks, there were three 2-week sections in the experiment. In the first week, the subjects were asked to fill out the self-efficacy, goal setting and group cohesiveness questionnaires. The same questionnaires were conducted in every section. And in the second week, they were asked to fill out the group norm and satisfaction questionnaires after their performance measurement made by the teachers.

2.3 Measure

According to the procedure, this study assessed learning style and 5 constructs: group norms, group cohesiveness, self-efficacy, goal setting and satisfaction.

2.3.1 Learning Style

In this study, the Gregorc Learning Style Delineator was used to measure the learning style (Gregorc, 1982). Gregorc' s model is one of several models developed to improve understanding of the way students learn and the way teachers teach and is a cognitive model designed to reveal two types of abilities, perception and ordering. Perceptual abilities mean through which information is grasped, translate into two qualities; abstractness and concreteness. Ordering abilities are the ways the learner organize information, either sequentially (linearly) or randomly (non-linearly) (Leuthold, 1999). Thus there are four learning categories: abstract/ random (AR), concrete/random (CR), abstract/sequential (AS) and concrete/ sequential (CS).

2.3.2 Group Norms

Group norms was measured by 5 items on 7-point scales, which indicate the amount of effort put into work, the attitudes toward work load, the willingness to give up free time to work, the feeling of responsibility for work goal attainment, and the feelings of self-worth when work is accomplished well. This measure is developed based on the literature of group work norms (Langfred, 1998). The Cronbach alpha for the group norms measure was .839.

2.3.3 Group Cohesiveness

Group cohesiveness was measured by 6 items on 7-point scales, which defines the feeling of individual group members toward other members and the group. This measure is based on the literature of Langfred (1998). The Cronbach alpha for the group cohesiveness measure is .79.

2.3.4 Self-efficacy

Self-efficacy was measured by 8 items, which asked the respondents to rate their expected ability to accomplish the project with different levels of goal. For example, the respondents were asked whether they could accomplish fifty percent of the project and how much confidence they have. This measure is developed based on an extensive review of the literature of self-efficacy (Compeau & Higgins, 1995). The Cronbach alpha for the self-efficacy measure is .963.

2.3.5 Goal setting

Goal setting was measured by 4 items, which asked the subjects' commitment to their goal of the projects. This measure is developed based on the literature of goals (Locke, 1984). The Cronbach alpha for the goal setting measure was .68.

2.3.6 Satisfaction

Satisfaction was measured by 5 items on 7-point scales, which asked the subjects' satisfaction of the performance of their group project. This measure is developed based on the literature of satisfaction (Dennis, Kinney & Hung, 1999). The Cronbach alpha for the satisfaction measure was .913.

3 Results

Since the Cronbach alpha values of all experiment measures are .891, .8767 and .8646 respectively, this experiment was reliable. An overview of the data is displayed in Table 2, and the results are displayed in Figure 2, 3, 4, 5 and 6.

Table 2. The mean of every measure

Mean	Group Norms	Group Cohesiveness	Self-efficacy	Goal setting	Satisfaction
Section 1	5.16	4.90	529.77	5,66	4,94
Section 2	4.90	4.60	561.16		4,56
Section 3	4.86	3.76	574.42	5,60	5,05

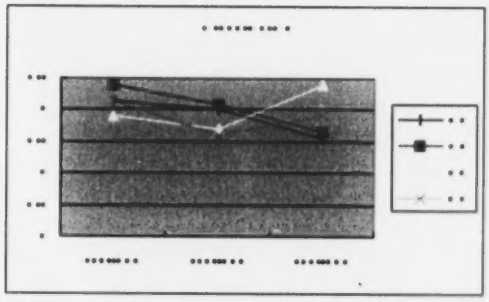


Figure 2. Effects of Learning style on group norms

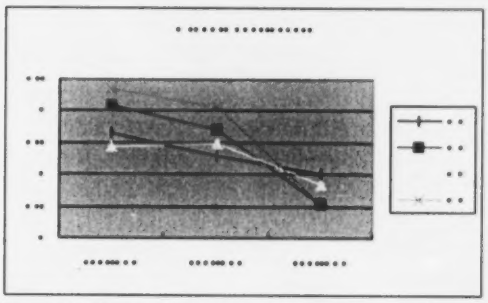


Figure 3. Effects of Learning style on group cohesiveness

The effects of learning style on group norms and group cohesiveness in the three 2-week experiments are not statistically significant, and the results are showed in Figure 2. Because the subjects were grouped since three months ago in the beginning of the semester, the group norms were already statically existed and were identified with group members.

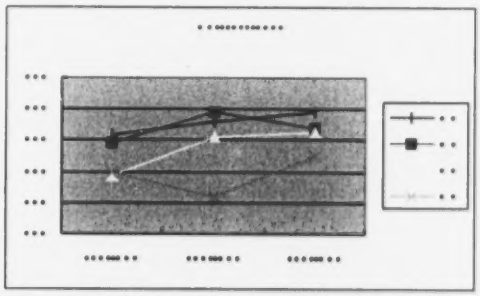


Figure 4. Effects of Learning style on self-efficacy

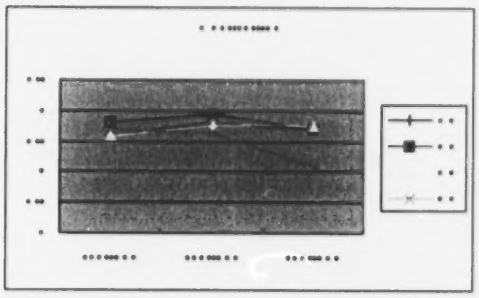


Figure 5. Effects of Learning style on goal setting

BEST COPY AVAILABLE

The effects of learning style on self-efficacy and goal setting are more significant than group norms and group cohesiveness. The results are showed in Figure 3. Students with concrete/sequential learning style had less self-efficacy during the experiment and were afraid to set their goal higher. Maybe the CS style students feel difficult to make web pages since it is somehow an abstract skill and needs to think randomly.

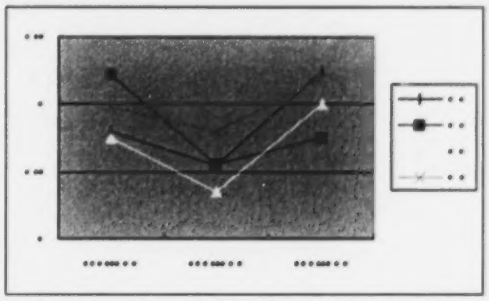


Figure 6. Effects of Learning style on satisfaction

The effects of learning style on satisfaction don't have significant differences, and the result is showed in Figure 4. It showed that all students enjoyed group cooperative learning and were satisfied in this way of learning.

4 Conclusions

In general, all students performed well in the group cooperative learning and felt satisfied with group processing. Although the students with concrete/sequential learning style were few and far between the subjects in this experiment, a quarter of general students would be this kind of learning style. Teachers should give them more encouragement to make them getting more self-efficacy and setting the right goal. Moreover, this study only uses Gregorc Learning Style Delineator to examine students' learning style. There are many other kinds of learning style evaluations, such Kolb's (1976) Learning Style Inventory (KLSI), Canfield's (1988) Learning Styles Inventory, etc. Future researches may use these questionnaires to examine which one is more suitable for cooperative learning.

And about the Social Cognitive Theory, there were many studies showed that the triadic aspects could form some models, which would affect each other in some relationships. Since the sample size is too small, this study doesn't prove the model by statistic methods. This is a limitation of this study. Understanding the effects between group norms, cohesiveness, self-efficacy and their performance will be an interesting research topic.

References

[1] Bandura, A., "Social Foundations of Thought and Actions: A Social Cognitive Theory", Englewood, Cliffs NJ: Prentice-Hall, (1986).

[2] Bostrom, R. P., Olfman, L. & Sein, M. K., "End User Computing: A Framework to Investigate the Training/Learning Process", Human Factors in Management Information Systems, H. M. Carey (ed.), Ablex Publishing Corporation, Norwood, NJ, pp. 221-250, (1988).

[3] Bostrom, R. P., Olfman, L. & Sein, M. K., "The Importance of Learning Style on End-User Training", MIS Quarterly, pp. 101-119, (1990).

[4] Compeau, D. R. & Higgins, C. A., "Application of Social Cognitive Theory to Training for Computer Skills", Information Systems Research, Vol. 6, No. 2, pp. 118-143, (1995).

[5] Dennis, A. R., Kinney, S. T., Hung, C., "Gender Differences in the Effects of Media Richness", Small Group Research, Vol. 30, No. 4, pp. 405-437, (1999).

[6] Deutsch, M., "Cooperation and Trust: Some Theoretical Notes", In M. R. Jones (ed.), Nebraska Symposium on Motivation, Lincoln: University of Nebraska Press, pp. 275-319, (1962).

[7] Johnson, D. W. & Johnson, R. T., "Cooperation and Competition: Theory and Research", Edina, MN: Interaction Book Company, (1989).

[8] Johnson, D. W. & Johnson, R. T., "Learning Together and Alone: Cooperative, Competitive and Individualistic Learning", 4th ed. Allyn and Bacon, (1994).

[9] Johnson, D. W. & Johnson, R. T., "Joining Together: Group Theory and Group Skills", 6th ed. Allyn and Bacon, (1996).

[10] Kolb, D. A., "The Learning Style Inventory Technical Manual", McBer and Company, Boston, MA, (1976).

[11] Leuthold, J. H., "Is Computer-based Learning Right for Everyone", Proceedings of the 32nd HICSS, pp. 1-8, (1999).

[12] Loke, E. A., Frederick, E., Lee, C. & Bobko, P., "Effect of Self-efficacy, Goals and Task Strategies on Task Performance", Journal of Applied Psychology, Vol. 69, No. 2, pp. 241-251, (1984).

The Production of Web-based Interactive Video From Structured Script

Cheng-Huang Yen
Dept. of Management & Information, National Open Univ.
172 Chung-Cheng Road, Lu Chow, Taipei County, Taiwan 24702
Tel: +886-2-22894846
Fax: +886-2-28484944
E-mail:yench@mail.nou.edu.tw

The use of AV (audiovisual) media has had great impact on instruction in distance education. However, lack of a systematic methodology, existing instructional video programs cannot be used as effectively on Web as in the case of TV broadcast. Simply by digitizing video programs to AV streams will not gain much from learners' view. In our research, we propose the notion of structured script writing. The design and production of Web-based interactive video from structured script enhances reusability of content modules and reduces demand on network bandwidth. Most importantly, learners are able to conduct a hyperlink-style learning process which turns out to be much more effective than viewing video programs sequentially. Learning activities are also easily integrated with digitized media.

Keywords: **Web-based learning, Distance education, Audiovisual media production**

1 Introduction

TV production has been an effective, though expensive way to create AV media for instructional purposes. Every finished video includes an amalgamation of elements recorded in a script. A script simplifies production by specifying what and how settings, action, and actors become part of the video so the director can plan ahead. Although TV production runs routinely, the quality and effectiveness of every instructional video differs significantly. It has been evidenced that the script stage is critical for successful TV production. In our research, we take script writing to another level; i.e., structured script. The major goals are as follows:

1. *Enhance reusability of content module:* The video programs can be partitioned into reusable modules such that instructional elements may be reused or shared among different programs. Structured scripts lead to a natural partition of video programs.
2. *Facilitate the design of Web-based learning material:* The notion of hyperlinks has been used in the production of Web-based learning and training material. Embedded standard and extended tags appeared in structured scripts can map video content to HTML-like format. The mapping can be automated by software.
3. *Reduce the demand on network bandwidth:* Without partition, video programs are streaming down to users' computers which are normally hooked up to the Internet by low bandwidth access lines. A proper partition by topic will eliminate the need to transfer the whole program and thus save 30% to 70% of bandwidth usage.
4. *Automate the production of Web-based interactive video:* A typical distance education institution produces an average of 40 video programs per semester. The length of a video program ranges from 30 minutes to 20 hours. This amounts to a mass production of instructional video programs within a very short timeframe. It is both a need and a demand to automate the transformation of traditional video program to Web-based interactive video. The channels of distribution can also be diversified.
5. *Enable flexible learning sequences:* Traditional TV broadcast forces learners' to follow a non-stop sequential format which is inconvenient and against the nature of individualized open learning. Web-based open learning provides a variety of learning sequences and formats.

2 Related Research

In our research, video-based instructional media refer to traditional studio production or live instructional activities recorded on tape for later broadcast or distribution [8]. From learners' point of view, simply by watching the instructional video offers no experience of interaction. However, the visual content along with good design at the script stage could provide great assistance to learners, especially in the area of distance education. The use of interactive video in instruction and learning has been practiced extensively in both academic and corporate environments [3,5]. Improvised video programs can hardly provide effective assistance in a formal learning situation which requires precision and in-depth coverage.

Including the script stage in the video production process is a legitimate choice in most successful cases [4,8]. However, the sequential and flat nature of traditional script does not leave much room for integration with other media and for adding interaction. Structured scripts, like HTML in WWW, open a new way for producing effective Web-based interactive video. Recent advances in virtual university and network-based education suggest widespread use of computer-based media [1,2]. AV media can become part of the computer-based media [7]. However, traditional institutions need to pay for extra investment on video production and distance education institutions need to find a way to transform their video assets to digital merchandise. Structured scripts will help solve the dilemma.

3 A Definition of Structured Script

A typical script includes a video and an audio part presented along a sequential timeline. Various techniques can be used to enhance the presentation of instructional content in a video program. The elements of a script may appear in any format listed in Table 1. The adoption of these formats depends on the nature of the program, the design by content and media expert, etc. A script may contain a combination of several different formats of presentation.

Table 1. Popular presentation styles

1	*Commentary*
2	*Single performer*
3	*Interviews*
4	*Talk shows*
5	*Illustrated talk*
6	*Demonstrations (music/dance/computer)*
7	*Drama*
8	*Electronic insertion*

Most script writers are aware of different formats of presentation. However, few of them notice the formats' implications on how the video programs can be partitioned. Table 2 lists a typical script that follows traditional style. Based on the script, the director knows when, what and how to record on the tape. The actor is also aware of what should be performed by viewing the script. By the time the video program is finished, we need to scan through the tape to find a way to divide the program into video content modules. Just by looking at the script will not give us much clue about how the partition should be made.

Table 2. Non-structured scipt

Video	Audio
TC Java Basics 1. basic concepts 2. resources 3. related topics	Java is an object-oriented programming language. JDK (Java Developer's Kit) provides Java compiler and other tools for developing Java applications. .....
SP	Java is noted for its support for cross-platform software development. Many Internet applications are written in Java.

Without making too much change, we re-write the same script as shown in Table 3, the so-called structured script. In our definition, a traditional script is composed of a video and an audio part synchronized along the timeline. A structured script is, on the other hand, distinguished by the following features:

1. *The margin of divisible units should be clear.* Suppose the video program will be partitioned by topics, the start and end of a topic should be signaled by some sort of tags. For example, the STC tag in Table 3 denotes the start of the topic, Java.
2. *There exists a hierarchy that organizes and inter-relates all units.* For example, the script in Table 3 reveals a hierarchy shown in Figure 1. The elements in the video part must be organized by certain content-specific criteria.

Table 3. Structured script

Video	Audio
STC Java	(music)
TC Java basics	Java is an object-oriented programming language. JDK
1. basic concepts	(Java Developer's Kit) provides Java compiler and other
2. resources	tools for developing Java applications. .....
3. related topics	
SP cross-platform	(Java is noted for its support for cross-platform software
software development	development. Many Internet applications are written in
	Java.)
Demonstration	.....
My first Java program	Step1. Enter MS-DOS mode,
	Step2. Type in a Java program,
	Step3. Compile and test the program.

Table 1 suggests a taxonomy of video contents by the formats of presentation. There are other ways to classify the same information in a script; e.g., the table of contents of a course or a lesson. No matter which classification scheme is chosen, the content of a script will be structured according to some sort of criteria. The resulting structure leads to reusable content modules. In the design of Web-based content, these modules can easily be organized in hyperlink-style Web pages. In our research, structured script writing follows well-defined style guide which can be specified by the tags' syntax and semantics. In a practical situation, a structured script editor can be used to help follow the rules.

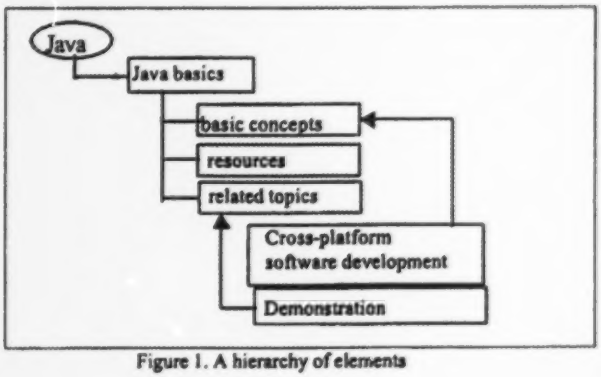


Figure 1. A hierarchy of elements

4 The Process and Methodology

Although TV broadcast still plays a major role in reaching most audience, network-based media have been growing in a pace much faster than traditional media. Since all kinds of media can be digitized and integrated into computer files, there is possibility that video-based instructional media can also be distributed in the form of network-based media. However, the design and production of traditional video-based instructional media has not been guided along this direction. Most existing instructional tapes are not able to function at least as well on the network, not to mention adding learning activities or interaction to these video programs.

Our research is focused on establishing a methodology and a mechanism for producing instructional video that works for broadcast and is able to help learners on the network. We are not aimed to investigate technical details on post-production of digital media. Instead, we are trying to look for answers on the following question, "what kind of content in what format should be included in instructional videos and how?" Figure 2 shows an overview of the production process. TV broadcast is more expensive and less flexible than distribution through Web hosts. However, Web access consumes a significant amount of network bandwidth for AV streams. On the other hand, studio production of videos is expensive. In the same professional area, many topics are likely to overlap in different programs. To reduce cost and enhance effectiveness, we can take advantage of studio production of video programs by changing the process of the script stage in a way that finished videos can easily be transformed to Web-ready media. The script stage is critical since later production steps are all based on the finished script.

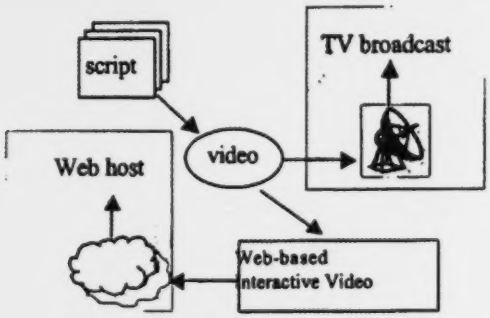


Figure 2. An overview of the production process

In order to achieve optimality among cost and effectiveness factors, there is a need to divide video programs to well-defined units. By well-defined we mean the unit should be complete and self-explanatory. Once the video program is divided into units, Web-based media will be feasible since viewers will not need to download the entire video program. The problem of reproducing the same content can also be avoided since the video unit is reusable. Obviously, the script stage is the most critical step toward a favorable solution. We re-shape the script writing process in the following ways:

1. *Component-based script creation*: Script writers or designers must be able to identify the components appeared in the script. Instead of dividing a script into components, we suggest a practice of component-based design at the beginning. Every component is identified by certain criteria; e.g., topic, presentation format, etc.
2. *Hierarchical planning*: The content of a script comes from a course or a lesson. The structure of the course or lesson is embedded in the script. At the script stage, how the content is divided or inter-related should be planned ahead. Later production of Web-based material will benefit from the pre-built hierarchy. Since the hierarchy is strongly content-specific, content expert should play the key role in this process.
3. *Extended tag set:* Existing notations used in script writing do not provide enough modeling capability for automated partition of structured scripts. We use an extended tag set. Part of the set is listed in Table 4. With this addition, it becomes feasible to develop a software editor for the creation and processing of structured script. The syntax and semantics of these tags are part of the style guide for structured script writing.

Table 4. Extended tag set for script writing

Tag	Usage
STC	The starting point of a topic
TC	Tele-card
SP	Superscription
VC	Video clip
CV	Computer video
CM	Commentary

Once the script is created structurally, studio production can proceed as usual. The next step is to import digital Beta-cam video source onto a post-production workstation. The video source becomes computer files. Since the original structured script contains meaningful tags, we can divide the video file into content modules based on the semantics of these tags. Figure 3 shows that the content modules can then be incorporated in the design of Web pages. These pages may be used and reused in various lessons, courses, and curriculum. There exists a transition between toc (table-of-contents) style and hyperlink style domain-specific contents.

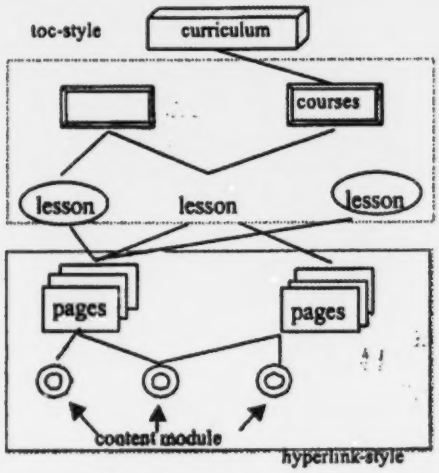


Figure 3. From toc-style to hyperlink style content presentation

The video content modules have no interaction at all. To add interaction to Web-based material, a variety of learning activities can be designed and integrated with various instructional media [6]. Figure 4 depicts the flow of learning activities. Learners start to work on the assignment through the interface of the Web browser. The assignment has been designed to help learners follow a sequence of steps to get result for discussion. The learning process can be evaluated and repeated. After finishing the assignment, learners may perform a test to see their own progress and head to the next assignment. In Figure 4, we can see that the video components produced from structured scripts are used for creating Web-based learning material. With the addition of the interactive design, the original video components are transformed to interactive video.

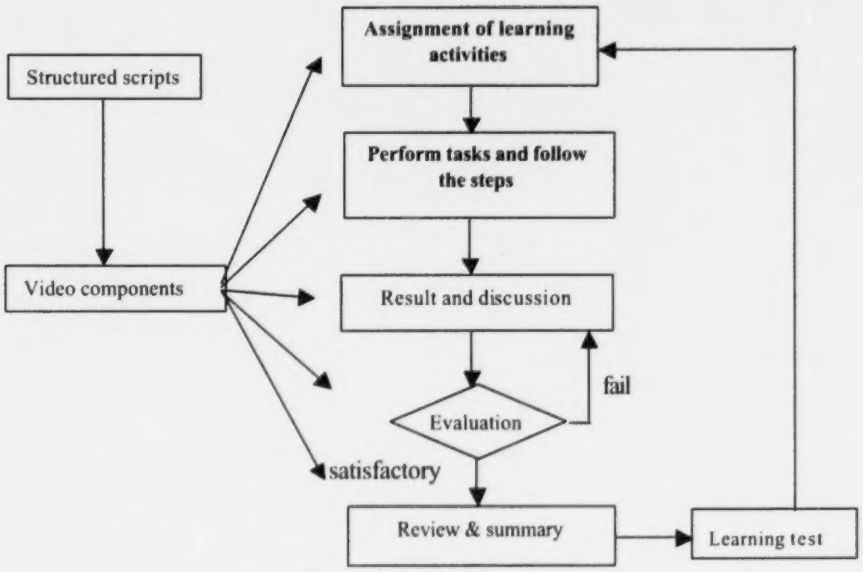


Figure 4. Interactive learning component

5 Experience Report

We choose a computing course, Data Structures, to exemplify the reference model resulted from the research. The reference model describes a formal process for producing instructional video suitable for integration with other digitized instructional media. Feedback and analysis collected from activities and experience of teaching the course is used to explain the strength and weakness of our approach.

1. Learning with interaction provides essential experience for successful learning.
2. Video programs alone are not able to provide required interaction.
3. Structured scripts are helpful for designers of Web-based instructional material.
4. The extended tag set for structured scripts should be clear and easy to use.
5. The reference model needs more instances to exemplify the use of tags, style guide, partition criteria, etc.

6 Conclusions

The learning experience by viewing a video program is different from browsing through a CBT (Computer-Based Training) lesson. However, the video part of both; i.e., traditional video programs and CBTs, may come from the same studio production process. Structured scripts have the potential of making video programs suitable for both TV broadcast and Web hosting. Content experts will take more responsibility on improving the quality and effectiveness of instructional videos. Media experts should carry on to provide assistance on the integration of learning activities with video content modules. Technical staff will then have enough information to build Web-based interactive video and other related learning and instructional material.

References

••••Burgess, W. E. *The ORYX Guide to Distance Learning*. 2nd Ed. ORYX PRESS, 1997.

••••Chellappa, R., Barua, A., and Whinston A. B. ``An Electronic Infrastructure for a Virtual University". *Communications of the ACM*, pp. 56-58, 1997.

••••Collis, Betty. *Tele-learning in a Digital World : The Future of Distance Learning*. Thomson Computer Press, 1996.
••••Eustace, G. *Writing for Corporate Video*. Focal Press, 1990.
••••Hall, Brandon. *Web-Based Training Cookbook*. John Wiley & Sons, 1997
••••Horton, W. *Designing Web-Based Training*. John Wiley & Sons, 2000.
••••McCormack, C., et al. *Building a Web-Based Education System*. Wiley Computer Publishing, 1997.
••••Millerson, G. *Effective TV Production*. Focal Press, 1983.
••••Swain, D. V. *Scripting for Video and Audiovisual Media*. Focal Press. 1981.

Towards a model of using Information Technology in education for pre-service teacher education

Kai-ming LI, Yiu-sing LAM, Pak-hung LI and Kwok-leung WU
Department of Curriculum and Instruction,
Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T. Hong Kong
kmli@ied.edu.hk, yslam@ied.edu.hk, phli@ied.edu.hk, klwu@ied.edu.hk

This paper reports the present scenario of using computer and traditional instructional media for primary class teaching in HKSAR. 323 primary teachers who have attended staff development seminars and refresher training workshops in the use of IT in education were invited to provide information for the study. The teaching time in a week and the teaching modes with 16 instructional media including computer technologies were examined. Results showed that textbook, blackboard and printed text materials remain the dominant instructional media in current practice of teaching in primary schools. The use of computer technology is rare despite the expectation that computer and computer-related technologies will make learning more effective and efficient and even to replace the traditional "educational technologies". The findings also indicated that technologies were used mostly as information delivery tools. Teaching strategies were limited to mass teaching and teacher-centered presentation. This phenomenon may have relationship with the ineffective training in the use of IT as indicated in many researches though courses in this area have been included in most teacher education programmes around the world. The last section of this paper will discuss on the contents of IT courses and to suggest a teaching model of using IT in education for pre-service teachers education programmes.

Keywords: **Methodologies, Teaching and Learning Process, Instructional Design**

1 Introduction

The Hong Kong Special Administration Region (HKSAR) government has already launched a five-year strategic plan of promoting the use of Information Technology (IT) in education aiming at enabling our students to be competitive and technological competent in the international arena since 1998 [1]. A total of about three billion dollars in capital cost and five hundred million dollars in annual recurrent cost will be used.

Computer and computer related technologies were expected to make teaching and learning more effective and efficient when it entered the classroom in 1980s [2]. Many teacher education programmes around the world have already started incorporating computer courses as basic requirement for teacher certification. In HKSAR, the previous colleges of education[1] have also started to include computers in education and computer applications courses in the Educational Technology subject which is compulsory to all the pre-service teachers in late 1980s. However, despite the provision of this training in many teacher education programmes, many researches report that the actual usage of new technologies in teaching was very limited. Teachers are not prepared to use new technology effectively in the classroom [3] [4]. Abdal-Haqq (1995) [5] even stated that "...few teachers routinely use computer-based technologies for instructional purposes" (p.1). In U.K., the HMI also commented that "new teachers make little use of Information Technology in the lessons"[6].

The purpose of this study is to find out the present scenario of the use of instructional technologies in primary

---

1 The previous colleges of education were amalgamated into the Hong Kong Institute of Education in 1994.

school teaching. The teaching time and the modes of using computer and traditional technologies are examined and compared. Such information will act as the base line for future investigation on the changes in teaching modes, strategies, and the use of new technologies in the 21st century classrooms. The last part of this paper will discuss on the contents and a teaching model that may be useful for preparing pre-service teachers to use computer more effectively in their future class teaching.

2 Method

2.1 Participants

The participants in this study were 323 primary teachers who attended staff development seminars and refresher training workshops in the use of IT in education offered by the Department of Curriculum and Instruction of the Hong Kong Institute of Education in 1999. 76% of them were female primary teacher. 95% of them possessed personal computers at home. 56% of them have received computer training in pre-service teacher education programme. This sample was further divided into three groups according to their teaching experiences: 27%, under 5 years; 25%, 6-10 years; 48% over 10 years.

2.2 Data Collection

The participants were asked to complete a survey at the beginning of the seminar and workshops. The first part of the survey was the demographic data of the participants while the second and third part required the participants to respond to the time spent in a week and the different modes of using 16 instructional media selected for this study respectively (see Table 1 and 2).

3 Results

3.1 The time of using instructional media in a week

Table 1 shows that board writing remains the most frequently used medium in the classroom. About 75% of the participants spend more than half of their teaching time with it. The second frequently used medium is board drawing (about 38%) while the third one is printed medium (about 30%). The table also reveals that 10 items have their using time less than half of the total teaching time in a week (item 6-11 and 13-16). It is also obvious to see that computer technologies were seldom used in class teaching at this stage. This phenomenon may be well explained by the un-readiness of computer facilities in most of the primary schools in the period of this study.

However, the figures revealed in the mean percentage of the use of traditional media in Table 1 show that about a quarter of the participants did not use any traditional instructional media and about 57% of them taught with these media less then half of the teaching time in a week. Only 17% of them used them for more than half of the teaching time in a week. This result shows that "text-book" teaching remains the dominant strategy in most primary school teaching despite those traditional instructional media have already placed in the schools as standard equipment.

Types of Media	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
Traditional Media					
1. Blackboard/Whiteboard Writing	1.5	2.9	20.4	33.8	41.4
2. Blackboard/Whiteboard Drawing	2.9	28	31.5	22.6	15
3. Realia/Model	1.9	51.3	33.2	10.6	3
4. Graphics	3.3	53.1	32	9.6	2
5. Printed Material	3.6	32.4	34	18.4	11.6
6. Photo	13.1	69.3	12.8	4.5	0.3
7. Slide	71.8	23.1	4.2	0.6	0.3
8. Overhead Transparency	40.8	38.7	17	1.9	1.6
9. Audio Tape	30.8	44.8	17.4	3.5	3.5
10. Video Tape	35.5	42.8	15.8	4.9	1

11.	Tape-Slide Programme	88.5	8.9	1.6	1	0
12.	Learning Package	13.1	49.4	25.6	9	2.9
Computer						
13.	Computer Generated Texts and Graphics	53.8	32	11.3	1.9	1
14.	Computer Presentation Programme	82.8	12.7	3.2	1.3	0
15.	Computer Assisted Learning Programme	86.4	9.1	3.9	0.6	0
16.	Internet	94.8	2.9	1.3	0.7	0.3
	Mean Percentage :	79.45	14.18	4.93	1.13	0.33

Table 1: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Primary Teachers of the Study (N=323)

3.2 The modes of using instructional media

Participants who have used the instructional media were asked to respond to the types of instructional modes of how these media were used. Table 2 shows that for the first three frequently used media as identified in last paragraph, they were used mostly for teacher's presentation (82%, item1; 79.2%, item2 and 66.7%, item4). The average percentages for group learning and individual learning activities for traditional media are 16.6% and 8.2% while those for computer are 8.6% and 4.5% respectively. These figures show that teacher's presentation is still the major mode of teaching among primary teachers at the present moment.

Types of Media		Teacher's Presentation (%)	Group Learning Activity (%)	Individual Learning Activity (%)
Traditional Media				
1.	Blackboard/Whiteboard Writing	82	-	-
2.	Blackboard/Whiteboard Drawing	79.2	-	-
3.	Realia/Model	66.4	30.6	9.5
4.	Graphics	66.7	23.5	7.6
5.	Printed Material	31.5	47.4	36.7
6.	Photo	48	24.5	9.8
7.	Slide	20.5	4.3	3.7
8.	Overhead Transparency	41.3	15	6.4
9.	Audio Tape	36.4	10.4	6.1
10.	Video Tape	35.5	8	4
11.	Tape-Slide Programme	11	3.1	1.5
12.	Learning Package	40.7	32.4	13.5
	Mean Percentage :	46.6	16.6	8.23
Computer				
13.	Computer Generated Texts and Graphics	26.3	17.1	9.5
14.	Computer Presentation Programme	9.2	7.3	3.7
15.	Computer Assisted Learning Programme	7.3	5.5	3.1
16.	Internet	4	4.6	1.5
	Mean Percentage :	11.7	8.63	4.45

Table 2: The Percentage of Responses to Teaching Modes Used with Instructional Technologies by Primary Teachers of the Study (Respondents can select more than one mode)

3.3 Effects of difference in gender and teaching experience on the use of instructional media

Since the sampling was not randomized, normal distribution of the sample could not be assured. A non-parametric analysis using the Mann Whitney U test was then used to compare the difference of the distribution of the responses between female and male primary teachers and the three groups of teachers with different teaching experiences.

Types of Media	Gender	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
3. Realia/Model*	Female	1.3	46.4	37	11.9	3.4
	Male	4.1	67.5	21.6	5.4	1.4
4. Graphics*	Female	3	48.1	35.1	11.7	2.2
	Male	4.2	70.4	21.1	2.8	1.4
5. Printed Material*	Female	3	31.8	30.5	20.3	14.4
	Male	5.6	34.7	44.4	12.5	2.8
6. Photo*	Female	11.8	66.8	15.1	5.9	0.4
	Male	17.8	76.7	5.5	0	0
7. Slide*	Female	74.8	19.7	4.3	0.9	0.4
	Male	61.6	34.2	4.1	0	0
11. Tape-Slide Programme*	Female	90.9	6.9	1.7	0.4	0
	Male	80.8	15.1	1.4	2.7	0
13. Computer Generated Texts and Graphics*	Female	58.7	30.6	8.1	1.3	1.3
	Male	37	37	21.9	4.1	0
14. Computer Presentation Programme*	Female	89.8	7.7	2.1	0.4	0
	Male	60.3	28.8	6.8	4.1	0
15. Computer Assisted Learning Programme*	Female	91.5	6.4	1.7	0.4	0
	Male	69.4	18.1	11.1	1.4	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Table 3: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Female and Male Primary Teachers of the Study

Significant differences were found in the distributions of 9 items between female and male teachers. In Table 3, referring to the "never use" column, it is interesting to see that female teachers used simple and traditional media (item 3,4,5 and 6) more than male teachers while male teachers used more complicated traditional media (item 7 and 11) and computer technologies (item 13,14 and 15) in this study. Similar analysis was conducted among the teachers with different teaching experiences. Only one item was found to be statistically different between the less experienced and more experienced teachers. Table 4 shows that experienced teachers used slide more than the less experienced teachers.

Types of Media	Teaching Experience	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
7. Slide*	Group A	82.4	14.1	3.5	0	0
	Group B	66	29.1	4.3	0.7	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Group A: Teaching experience less than 5 years; Group B: Teaching Experience greater than 10 years

Table 4: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week Between Two Groups of Primary Teachers with Different Teaching Experience of the Study

Analysis on the teaching modes of using these instructional media, however, showed that no significant differences were found between the female and male teachers and also among the three groups of teachers with different teaching experiences.

4 Discussion

From the above findings, it is obvious that the use of instructional media including computer technologies was limited. The teaching strategies employed by most primary teachers were still very teacher-centered although they have already completed instructional technology and related courses in the teacher education programme. Computer uses were rare even though more than 50 % of the participants have attended computer courses while receiving their pre-service teacher training and 95% of them possess home computers. It is evident that future teaching is influenced by the learning experiences that pre-service teachers gained in their tertiary education [7]. Researches also show that the provision of instructional models for classroom implementations

of technology is far more important than the training of the "know-how" skills [8]. The instructional strategy should act as the model and should be student-centred rather than terminology and hardware centred [9]. Task-based or problem based activities are more effective than skill drilling of certain hardware or computer software by direct demonstration. A course with well–designed contents and effective teaching model for the use of IT in education is believed to have positive influence on the actual implementation in school teaching.

4.1 The Contents

We suggest that for an IT in education course to be successful, the following areas should be included. We believe that such contents allow our pre-service teachers to have more comprehensive mastery of knowledge and skills of using IT in education and enable them to put theories and practical skills into real practice in primary school teaching.

1. Understanding the development, trends, advantages and limitations of using IT in education.
2. Understanding the roles and contributions of IT and teachers in the communication and learning process.
3. Designing and producing instructional materials with IT.
4. Operating computer hardware and application software while producing and using computerized instructional materials
5. Selecting and deriving learning activities with computerized instructional materials and resources
6. Evaluating the effectiveness of computerized instructional materials and programmes that involves the use of IT.

4.2 The Teaching model

Figure 1 is a proposed teaching model of using IT in education for teacher preparation programme. This model is informed by constructivist views of learning in which the learner is the center and the actor of learning. There are six major components in the model:

1. The teacher – is the one who build this model, creates a constructivist learning environment, acts as the resource, guide and the facilitator of the learning process and models the actual implementations and strategies of using IT in an authentic context.
2. The learner – is the master of this model, comes with different background and learning style, interacts with other components of this model and to construct the knowledge and skills actively.
3. Resources and support – assist the learner to complete his/her task throughout the learning process.
4. Integration – is the experience that the learner gains when applying IT in teaching and learning in an authentic situation.
5. Reflection – is the introspective thinking allowing the learner to have deeper understanding of the IT applications and be able to examine related issues critically.
6. Monitoring strategies – provide clear instructions and directions allowing the learner to have a complete picture of the objectives and significances of the learning, the tasks to be completed and the access to relevant resources and support.

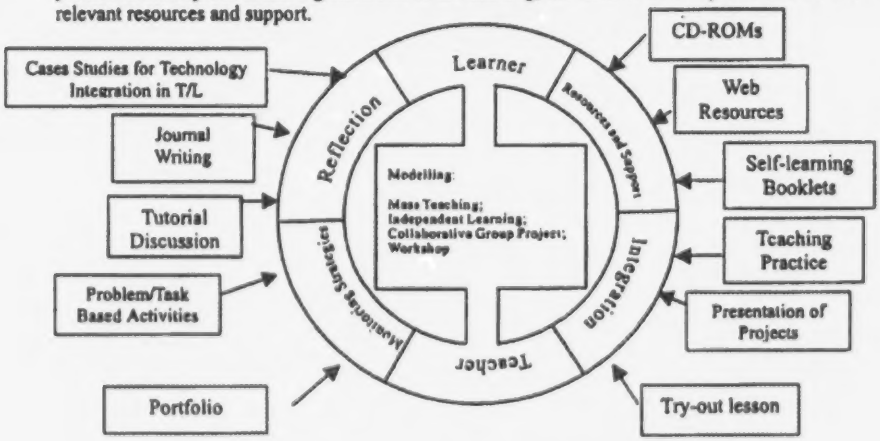


Figure 1: A teaching model of using IT in education for teacher education

5 Conclusion

The components of the teaching model guide the development of various strategies, learning activities and resources that can be found in Figure 1. Evaluation of the effectiveness of this model has been started and the results will be reported in due course. The findings of the survey in the first part of this study signal the ineffective use of instructional media both in terms of teaching time and strategies in primary school teaching. Change is expected if our students are to be really benefited by the five-year strategy of using IT in education. Teacher education, therefore, places an important role in this aspect.

References

[1] Education Manpower Bureau (1998). Information Technology for learning in a new era: 5-year strategy 1998/99 to 2002/03, November 1998, HKSAR.

[2] Goodlad, J.I. (1984). *A place called School*. New York: McGraw Hill.

[3] Bosch, K.A. and Cardinale, L. (1993). Preservice teachers' perceptions of computer use during a field experience. *Journal of computing in Teacher Education*, 10(1), 23-27.

[4] Office of Technology Assessment (OTA)(1995) Teachers and Technology: Making the Connection. US: OTA 1995 Report.

[5] Abdal-Haqq, I., "Infusing technology into pre-service teacher education", ERIC digest. (ERIC Document Reproduction Service #ED 389699). (1995)

[6] Her Majesty's Inspectors (1993). *The new teacher*. London: HMSO.

[7] Adams, P.E. and Krockover, G.H. (1997), Beginning science teacher cognition and its origins in the pre service secondary science teacher program. *Journal of Research in Science Teaching*, 34, 633-653.

[8] Novak, D. and Knowles, J. (1991). Beginning elementary teachers' use of computers in classroom instruction. *Action in Teacher Education*. 8(2), 43-51.

[9] Bigum, C. (1990). Situated computing in pre-service computer education. In A. McDougall and C. Dowling (Eds.). *Computers in Education*. North Holland: Elsevier Science.

Proceedings

Content

Full & Short Papers (Intelligent Tutoring System)

A Framework for Internet Based Distributed Learning
A Fuzzy-based Assessment for Perl Tutoring System
A Learning Environment for Problem Posing in Simple Arithmetical Word Problems
A Method of Creating Counterexamples by Using Error-Based Simulation
Adaptive Programming Language Tutoring System on the Web
Agent-based Collaborative Learning Environment for Intelligent Tutoring Systems (ITS)
An Agent-Based Intelligent Tutoring System
An Educational System that can Visualize Behavior of Programs on the Domain World
An Environment for Learning by Design : In the Case of Learning of Search Algorithms
An on-line ITS for elementary algebra
Automatic Background Knowledge Construction Using Genetic Algorithms
AWETS: An Automatic Web-Based English Testing System
Case-Based Evaluating Assistant of Novice Programs
CBR-Tutor: A Case-Based Reasoning Approach to an Internet Agent-Based Tutoring System
Controlling Problem Progression in Adaptive Testing
Development of Intelligent Learning Support System with Large Knowledge Base
Educational Agents and the Social Construction of Knowledge: Some Issues and Implications
Generating interactive explanations by using both images and texts for Micro World
Intelligent Interactive Learning Environment: Design Issues
Meta-Knowledge Agent: Creates the context for thoughful instructional systems.
Modeling the Tutor Using Reinforcement Learning
Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language
Multimedia Intelligent Tutoring System for Context-Free Grammar
MyEnglishTeacher A WWW System for Academic English Teaching
Navigation Script for the World Wide Web
Organization of the introductory and motivational stage of activity in a computer tutoring system
The Application of Uncertainty Reasoning for an Intelligent Tutoring System

The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS

Traversing the Case Graphs. A Computer Model for Developing Case-based Learning Systems

Use of abstraction levels in the design of intelligent tutoring systems

Using Decision Networks for Adaptive Tutoring

▲ HOME

A Framework for Internet-Based Distributed Learning

Andreas Braun* and Andreas G. Harrer**

**Andersen Consulting, Maximilianstr. 35, D-80539 München,* andreas.braun@ac.com

***Technische Universität München, Orleanstr. 34, D-81667 München,* harrer@in.tum.de

Communication technology as well as the communication infrastructure are both changing rapidly. As a consequence, systems that support web-based learning need to be adapted due to changes in technology. This paper describes a model for web-based learning with intelligent tutoring systems (ITS) that allows separation of the concrete communication from the ITSs' implementation. The resulting framework provides a technical solution to distribute any ITS over a network. The ITS SYPROS is used to illustrate how a classical ITS can be extended to a web-based tutoring system with a maximum of code-reuse. The framework may be used freely with any ITS. To accommodate the needs of various ITSs, our model supports several architectures for distributed adaptive tutoring, including the three different models described in [3]: Master-Slave, Communicating Peers and Centralized Architectures. Our main goals are: • •Make the ITS usable for a wide range of users by supporting any web browser on any operating system.• •Offer a simple, extendable and platform independent framework to ease web-based tutoring.• • Provide a solution without royalties.• •Separate the communication technology from the client and server implementation.• •Enable method invocation and parameter passing semantics over the HTTP protocol to virtually support any web browser and users behind firewalls.• •Offer an simple user accounting and user communication functionality.• •Provide a wrapper to connect to an existing ITS. The Java source code is freely available: http://www.in.tum.de/~herzog/sypros.

Keywords: **Web-Based Learning, System Design and Development, Intelligent Tutoring Systems**

1 Introduction

Classical intelligent tutoring systems (ITS) are often platform dependant and not distributed. Modern, distributed intelligent tutoring systems (DITS) provide a more attractive solution with respect to usability and platform independence. Therefore, a modern distributed infrastructure like the internet with communication techniques like CORBA or RMI is suitable. A stable, safe and extendable basis for communication and cooperative work is needed. However, technology in this area is rapidly changing on the one hand. On the other hand communication technologies like CORBA or RMI are (still) not usable with every client, browser or platform and still have several drawbacks which prevent their usability at least for some users: Macintosh users and users with old browsers or behind firewalls/proxies who also want to use secure socket factories, only to name some.

This paper discribes a model and the resulting framework to overcome such problems. We propose to address these problems by providing an API with the semantics of object oriented remote method calls over HTTP and Servlets. Further functionality that is most likely in common for any DITS (such as user accounting and identification, security and administrative functionality) is implemented and encapsulated for ease of use.

In the current version, SYPROS is an ITS in the domain of the synchronization of parallel processes with semaphores [4], a domain of programming problems.

All the typical modules of an ITS [15] like the expert module with different types of cooperating domain experts [13], the instructional module with different tutoring strategies, the student model with cognitive and motivational traits [12], and the interface module with several support facilities, are fully implemented in SYPROS.

The current version system is a classical ITS for single-user mode and is written in C for UNIX systems. The user interface is based on the X Windows system and therefore the ITS is platform dependent. There is no direct support for multiple clients and no accounting, access control or WWW support as it would be needed for a web-based group learning system, which is our ultimate goal [11]. In the current implementation the user interface is divided at function level from the 'intelligence' and database functionality, but is linked to one single executable. The proposed model will provide an application interface (API) for the client and server side. The API will encapsulate various ways of communication over a network using an abstract factory pattern [2,10]. Concrete implementations for Java RMI and servlets are provided. This model is designed to be easily extendable by other means of network transportation (e.g., CORBA or even Sockets). It will include conceptional security at an eligible level. Further, various ways of interfacing to an existing ITS on the server side are given (Java native calls to C/C++ and the connectivity to shell scripts). This factory can also be easily extended. Figure 1 shows the distribution of SYPROS. The servlet proxy Server enables connection for old webbrowsers, running not necessarily on the same machine as the `SyprosServer` implementation. Two clients are connected: "**Old Webbrowser**" connects using the servlet proxy, "**New Webbrowser**" can either use servlet communication or RMI[17]/ CORBA[22] (or anything else).

This work covers two more aspects: a security discussion for the provided model with a special focus on security issues for an ITS and a usability discussion for various platforms and webbrowsers.

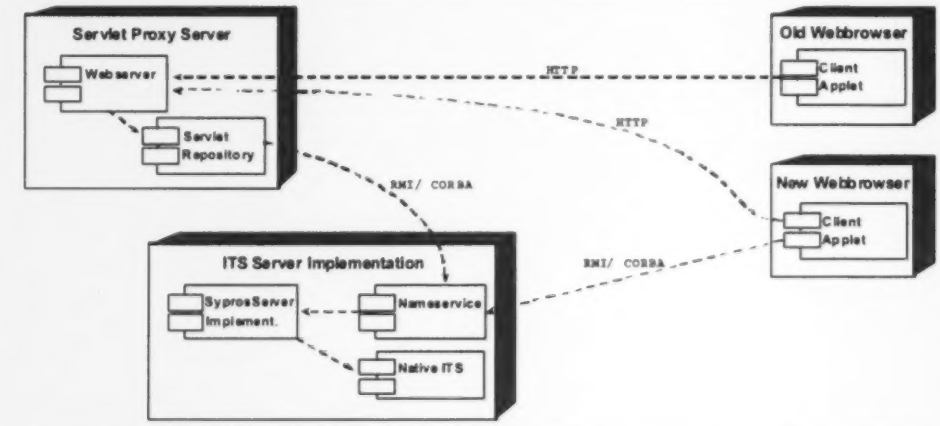


Figure 1. Distribution of client, server and servlet proxy in SYPROS (UML[19]).

Figure 2 shows the different layers for communication and levels of abstraction for a client initiated request. The dotted line between the implementation (application) level and the abstraction denotes that both the client and server implementation are separated from the underlying concrete communication. This model provides transparency in terms of process transparency. (That is, the machine on which the function or method is executed isn't known to the client's application level.) This can be compared to remote procedure calls (RPC) where the client stub and the server skeleton provide a similar transparency. In addition to that, our framework separates the concrete communication (the lowest layer in figure 2) from the application layer using the abstract communication layer. This provides transparency regarding the concrete communication technology used and therefore unburdens the application programmer from changing the application to support new technologies.

For some concrete communication implementations our framework supports language transparency as far as the client's implementation language may differ from the server's (e.g., for CORBA or Servlets).

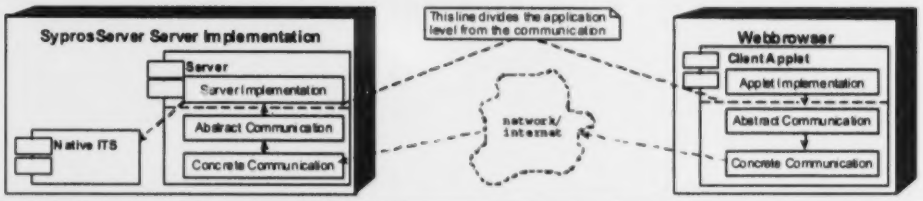


Figure 2. Levels of abstraction and layers for a request initiated by the client (UML deployment diagram).

2 Requirements

All base functionality for a distributed system is implemented. Remote method invocations are implemented independently from the Java RMI package over a `ComObject` which is JDK 1.1[9] compliant. User accounting, login procedures and access control as well as connection state information is supported directly in the framework.

A wrapper is provided to connect to an existing ITS over Java Native Interface (JNI[14]) or shell script invocation.

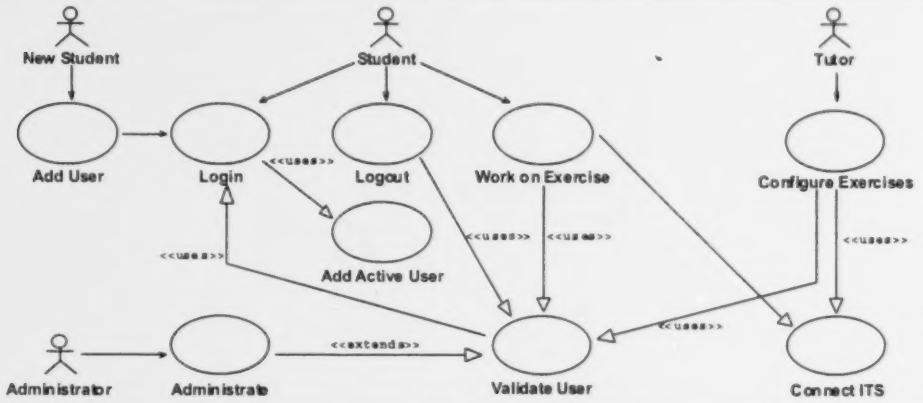


Figure 3. Some interactions among actors and use cases in SYPROS (UML use case diagram).

The use case diagram in figure 3 shows some of the use cases for SYPROS. Four types of human actors are shown in their interaction with the use cases. "**Student**" denotes an actor who is already known to the system. Therefore, "**Student**" logs into the server by passing the "**Login**" use case. "**Login**" performs authentification for which it `<<uses>>` the "**Validate User**" use case, which has knowledge of all valid user entries and so on. After accepting the user's login request some state information for that connection will be stored "**Add Active User**" and a `UserTicket` object is returned to allow stateful and secure client interaction. (`UserTicket` might be encrypted.)

"**New Student**" is an actor who is not known to the system. (Guests are handled identically.) Therefore, she can create a new user database entry herself ("**Add User**"). Later, the gathered information will be used to log into the system as described before.

An active user ("**Student**") might also use other services on the ITS server side. For example, the "**Work on Exercise**" use case first validates the call against the active users database and then uses "**Connect ITS**" (which interfaces the ITS using the wrapper) to work with the tutoring system.

"**Tutor**" is a human actor who might use the "**Configure Exercise**" use case to set up some exercises or check the student's results. The differing permissions (compared to a student) are handled by the "**Validate User**" use case.

BEST COPY AVAILABLE

An "**Administrator**" user will not use the client interface to connect to the server in this model. The administrator configures the databases and configuration files. Therefore, "**Administrate**" extends "**Validate User**".

Resulting from the requirements given before our model and the framework should further satisfy the following nonfunctional requirements, pseudo requirements and design goals: The server-side installation should be simple and conceptionally platform independent. It should not be addicted to any specific web server and should work with freely available products such as Apache.

The framework is designed to be fully platform independent using the Java programming language. However, some platform dependencies exist from possible webbrowser incompatibilities and the existing ITS. In order to support old webbrowsers or users behind a firewall or proxy, a servlet repository which acts as a proxy and a servlet based client communication is provided. The communication implementation may be switched online in the client implementation[1].

The SYPROS system can be used by four groups of people: students, guests (users who are not known to the system by now), tutors and administrators (tutors who fulfill administrative functions). Therefore, the framework supports users at different level of permissions (similar to e.g., UNIX or WindowsNT).

The client applet should be small so that it is suitable even for slow modem connections. The classes needed for communication on the client side are less than 20 KB in size (without JCE security). Once the Applet is loaded, the response time of the user interface is short, as it is running locally on the client side.

The response time resulting from the security key generation and secret key exchange (Diffie-Hellman for example) of the Java Cryptography Extension (JCE) is rather long especially for strong keys and due to JCE's implementation in Java (see discussion in section 4).

Performance of the network communication depends on the underlying infrastructure. With most browsers, servlets will have a more overhead than CORBA or RMI.

The communication framework aims to support three possible client-server bindings: Static (the server name is stored in the client application), semi-static (the client locates the server once, e.g., at login time) and dynamic (the client looks up the server each time it needs to connect). Client server binding uses name resolution to find a suitable ITS server in the network. The toolkituses a server string such as "***//{hostname|ip-address}/{service-name}***", just like RMI for either underlying communication infrastructure. At client implementation level, the programmer may decide whether to use static, semi-static or dynamic binding.

Together with the way of client-server binding, stateless and stateful client server connections using tickets are possible. User tickets are invented as "high-level" stateful client-server connection for two reasons: first, the underlying ITS needs to know about the caller; tickets provide an easy way to identify the caller during a learning session. Second, encrypted ticket objects can be used to prevent attacks by intercept and replaying messages (see section 4).

Calling a remote function is somewhat dangerous if the programming language used supports *call-by-reference*[2]. For Java, *call-by-reference* is replaced by a *call-by-copy/restore* semantics. (See Java `RemoteObject` for RMI). A *call-by-copy/restore* semantics can be simulated for servlets using the `EventListener` model. In that case, the servlet proxy uses a `RemoteObject` for the server communication if the communication between the servlet proxy and the server is based on RMI and returns the object to the client using the event model. This may also be encapsulated in the framework.

In case of middleware communication such as CORBA/ RMI the *call-by-copy/restore* semantics can directly rely on the appropriate native semantics. The framework supports synchronous method invocations. Asynchronous calls can be realized using *call-by-copy/ restore*.

---

[1] This feature should be omitted for maximum compatibility with old browsers and Java engines (JDK level 1.1).

[2] Function calls that use *call-by-reference* parameter passing deliver a pointer to the value or data the parameter stores. In a distributed system with different address spaces this triggers side-effects[20].

Java's `try-catch`-statements are used for error handling. Therefore, the framework's error semantics is *at-most-once* by default. At application level, return values might be used to signal unexpected behavior. The SYPROS `login()`-Method for example returns `null` for the `UserTicket` if the server can't accept the login request. Although there are several possible reasons for that (e.g., unknown user, wrong password) their origin is not a communication error.

The resulting framework is described using UML notation for scenarios, use cases and object models[2,19]. The API description is given in standard Java notation[9]. The use of our framework is illustrated by the SYPROS sample.

3 A Model for the Communication Framework

Figure 4 shows the UML diagram for the SYPROS server implementation using the communication framework. The diagram shows two possible extensions for `SyprosServer`: `ComCORBA` and `ComRMI`. In the realworld implementation the programmer has to decide either to use CORBA *or* RMI, as Java does not allow multiple class inheritance.

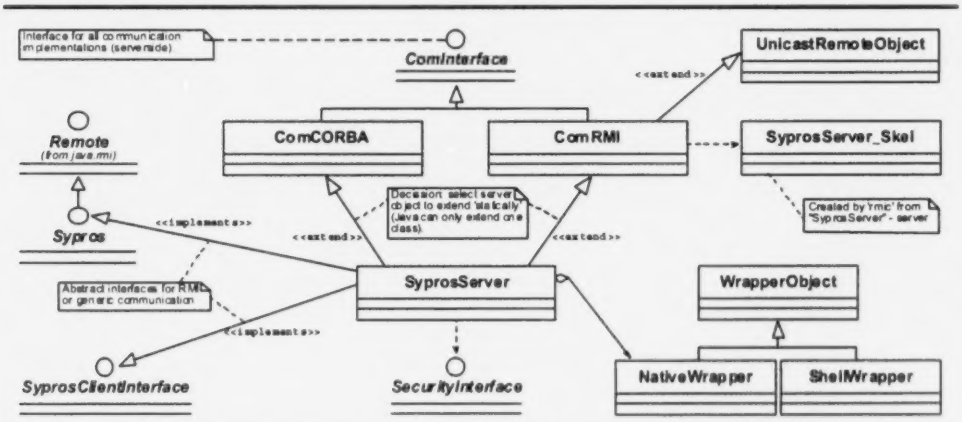


Figure 4. SYPROS server implementation. Class attributes and methods are omitted. (UML class diagram)

Therefore, there are some specialties in the server implementation: depending on the selected communication technology, the programmer has to change the head of the class definition to extend the right `ComInterface`. Further, the server has to implement the `Sypros` interface which defines the exported functions (for the RMI case). `SyprosClientInterface` contains the same definitions like `Sypros` but doesn't depend on the Java RMI classes. This ensures usability for old webbrowsers (with old Java virtual machines, VM) or clients that don't support RMI for other reasons (Macintosh).

```
import sypros.util.*;
import sypros.com.util.*;
import sypros.com.server.ComRMI;

public class SyprosServer extends} ComRMI implements Sypros {
  public  SyprosServer(String hostName, String servName) throws RemoteException
{
    super(serverHost, servName);   // create bindings
  }
  public static void main(String args[]) {
    setSecurity();                 // setup default security
  }
}
```

Figure 5. Client applet implementation for the SYPROS sample.

BEST COPY AVAILABLE

Figure 5 shows the class definition for the SYPROS server implementation using RMI. The underlined statements would have to be changed for a different type of communication technology.

The client implementation allows dynamic switching of the communication technology. Figure 6 shows the UML class diagram for the SYPROS client Applet. As the client communication model uses an abstract factory pattern [2,19] to create the appropriate concrete communication, the client might be a Java Applet or a Java standalone application. (The server could also be connected using the servlet URLs from HTML or other languages.)

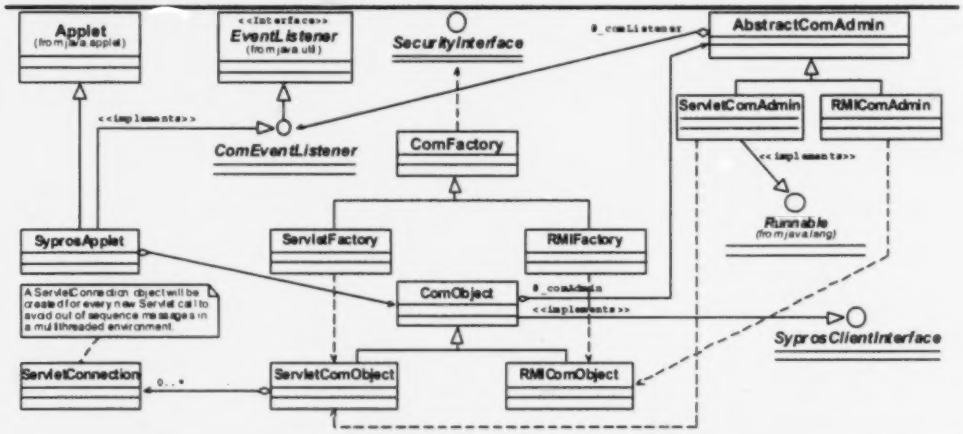


Figure 6. Client applet implementation for the SYPROS sample (UML class diagram).

The classes in the client model can be seen in three categories. First of all, SyprosApplet is the implementation for the SYPROS client interface. (Plus `Applet`, the parent.) As described before, the implementation needs not to be changed for changing communication technologies.

Then the communication classes themselves: `ComFactory`, `ComObject` and their concrete implementations provide the application interface for the implementation. `ServletConnection` is a helper that provides a per-servlet connection for persistent calls in a multithreaded application.

The `AbstractComAdmin` and its concrete implementations for servlets and RMI currently realize notification for server to client messages using the `EventListener` model and can be used for *call-by-copy/restore* type parameter passing.

4 Conceptual Security

Any internet-based application requires a special focus on security issues. The history of designing secure systems, however, teaches the inadequacy of enhancing existing systems with additional security functionality [8]. To integrate the security functionality for secure web-based tutoring, we included security policies in the framework with a top-down approach. We start by specifying the security requirements as part of the security policy:

Authentification:	All subjects and objects of the system have to be authentificated.
Total access control:	Every access to protected units has to be supervised.
Non repudiation:	Every action performed by a subject can be assigned to it's originator.
Communication privacy:	Dataflow over unsafe networks has to be adequately encrypted.
Availability:	Denial-of-Service attacks should be identified.

To meet the authentification, total access control and no-denial requirements, the framework offers integrated functionality that can be adapted or extended to your application needs. Communication privacy

BEST COPY AVAILABLE

is provided using encrypted transmission (encrypted object serialization) based on the Java Cryptography Extension (JCE). JCE offers secret key agreement protocols (e.g., Diffie-Hellman) and encryption (e.g., Blowfish) with variable key lengths.

Ensuring the availability of a web-based service against denial-of-service attacks is maybe the hardest task. The Servlet-Proxy allows load-balancing, where the typical communication load of an ITS application (little amounts of data, long periods of thinking, infrequent transmissions) can be used to identify attacks.

5 Conclusions and Outlook

Our framework offers an easy and extendable basis for web-based distributed tutoring. The communication technology, security and ITS-integration can be easily adapted to the specific needs of an existing ITS as well as to changing communication or security technologies without rewriting the implementation for the ITS clients or server.

User accounting and access rights deliver the basis to support groups of students. However, support for cooperative work should be included in the ITS itself, like for example in SYPROS.

6 List of tested Browsers

✓: tested ok. no: tested, but failed. –: browser/ OS combination not available for testing.

Webbrowser	Version	Win98/NT		Linux		Solaris/x86		Solaris/Sparc		Macintosh	
		Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI
Netscape	4.04	✓	✓	–	–	✓	–	–	–	✓	no
Netscape	4.05	✓	✓	✓	✓	–	–	✓	✓	-	no
Netscape	4.7	✓	✓	✓	✓	✓	✓	–	–	-	no
Netscape	4.72	✓	✓	–	–	–	–	–	–	✓	no
I-Explorer	4.0	✓	no	–	–	–	–	–	–	–	–
I-Explorer	5.0[3]	✓	✓	–	–	–	–	–	–	–	–
Java Plugin	1.2	✓	✓	✓	✓	✓	✓	✓	✓	–	–

References

[1] Braun, A., "A Client-Server Model for an Intelligent Tutoring System" (transl.), Technische Universität München, Diploma Thesis, May 2000.

[2] Brügge, B., Dutoit, A.H., "Object-Oriented Software Engineering: Conquering Complex and Changing Systems", Prentice Hall, Upper Saddle River, NJ, Oct. 1999.

[3] Brusilovsky, P., Ritter, S., Schwarz, E., "Distributed intelligent tutoring on the Web", in: Proceedings of the 8th. World Conference of the AIED Society, Kobe, Japan, Aug. 1997.

[4] Dijkstra, E.-W., "Cooperating sequential processes", in: F. Genuys (editor), Programming Languages, Academic Press, New York, Oct. 1968.

[6] Duncan Davidson, J., "Java™Servlet Specification v.2.2", Sun Microsystems Inc., Oct. 1999.

[7] Eckert, C., "Matching Security Policies to Application Needs", Proceedings of the IFIP TC11 11th Internation Conference on Information Security, Cape-Town, South Africa, May 1995, p.237-254.

[8] Eckert, C., "On Security Models", Proceedings of the IFIP TC11 12th International Conference on Information Security, Samos, Greece, May 1996.

[9] Flanagan, D., "Java in a Nutshell", O'Reilly & Associates, third edition, 1999.

[3] RMI-Patch applied by Microsoft Service Pack.

[10] Gamma, E., Helm, R., Johnson, R., Vlissides, J., "Design Patterns -- Elements of Reusable Object Oriented Software", Addision Wesley Publishing Company, Reading Mass., tenth edition, 1997.

[11] Harrer, A., Herzog, Ch., "SYPROS Going IDLE -- from a Classical ITS to an Intelligent Distributed Learning Environment", in: Proceedings of ICCE '99, 7th International Conference on Computers in Education, p.836-839, Sep. 1999.

[12] Harrer, A., "Both sides of the coin -- blending cognitive and motivational aspects into a tutoring strategy", in: Proceedings of the International Conference on Computers in Education, ICCE97, p.188-195, 1997.

[13] Herzog, Ch., "Cooperation and competition of syntax-oriented and execution-oriented problem solvers in intelligent programming tutors", in: Artificial Intelligence in Education -- Knowledge and Media in Learning Systems, Proc. AI--ED 97, Kobe, Japan, p.309-316, 1997.

[14] —, "Java Native Interface", JDK Documentation, Sunsoft, 1996.

[15] Martha C. Polson, Richardson, J. J., "Foundations of Intelligent Tutoring Systems", Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1988.

[16] —, "Java Remote Method Invocation -- Distributed Computing for Java", Whitepaper, http://java.sun.com/marketing/collateral/javarmi.html, Sun Microsystems Inc., 1999.

[17] —, "Java Remote Method Invocation Specification", Revision 1.50, JDK 1.2, Sun Microsystems Inc., October 1998.

[18] —, "RMI-IIOP Programmer's Guide", http://java.sun.com/products/jdk/guide/rmi-iiop/rmi_iiop_pg.html, Sun Microsystems Inc. and IBM Corporation, 1999.

[19] Rumbaugh, J., Jacobson, I., Booch, G., "The Unified Modeling Language Reference Manual", Addision Wesley Longman, Inc., Reading Mass., Dec. 1998.

[20] Tanenbaum, A. S., "Modern Operating Systems", Prentice Hall Inc., 1992.

[21] McPherson, Scott, "Java Servlets and Serialization with RMI", in: Java Developer Connection, http://java.sun.com/developer/technical/Articles/RMI/rmi/index.html, Maczieg Software, 1999.

[22] —, "The Common Object Request Broker: Architecture and Specification", Object Management Group, Wiley, New York, 1995.

A Fuzzy-Based Assessment for Perl Tutoring System[1]

Tang Ya*, Keith C.C. Chan*, Albert Wu and Pinata Winoto*****
**Department of Computing*
Hong Kong Polytechnic University, Hong Kong
Email:{ csytang, cskcchan } @comp.polyu.edu.hk
***Faculty of Education*
Chinese University of Hong Kong, Hong Kong
Email: albertwu@cuhk.edu.hk
****School of Business and Management*
Hong Kong University of Science and Technology, Hong Kong
Email: pwinoto@ust.hk

In this paper, we present a fuzzy-based assessment for Perl Tutoring system. The Perl Tutor is implemented in a multi-domain framework so that it can teach target domain knowledge by giving supporting knowledge to reinforce the learning. In order to assess supporting knowledge, an assessment is performed *before* the tutoring begins. Its main purpose is to test student's previous declarative knowledge of computer programming. At the end of it, a directed tutoring graph will be generated to optimize the tutoring process.

Keywords: **fuzzy rule, assessment, student modeling, multi-domain tutoring**

1 Introduction

There exist many works on optimized assessment process concerned with the efficiency of testing and its completeness. *Granularity*, *prerequisite relationships*, *Bayesian propagation* and *neighborhood of knowledge states* are some of the successful attempts employed to increase the efficiency of testing [2,5,6,13,17]. Yet, even though they could increase the efficiency significantly, they still have too many burdens given the large knowledge spaces. Fortunately, not all the student models need to be precise to be useful [10]. To ease the burden to student modeling, a fuzzy approach has been used and has so far worked quite well [3,10,11].

The purpose of this paper is to present the fuzzy approach in the assessment of student's knowledge in the Perl Tutoring System [16], which teach programming language (Perl) by reinforcement from other supporting languages (C++ and/or Java). For the effectiveness of reinforcement, the system should quickly evaluate the student's knowledge of supporting languages. But the assessment needs not to be in high precision. Other works related to student modeling almost put their emphasis on the adaptive assessment *during* tutoring [14,15,17]. Yet due to the nature of our Perl tutor, we apply an assessment module *before* tutoring begins and it consists of two parts: questionnaire and testing. During the questionnaire part, students are asked to self-assess their knowledge by filling out a form provided by the system. In order to evaluate their statements, a testing part is given based on those statements. At the end of the assessment, the tutor will have a general picture of students' prior knowledge of supporting languages: with which part they are familiar etc. Since the goal of the assessment is only to get a rough knowledge states for supporting purpose, it should not take too long to complete. Thus, a coarse granularity with imprecise mastery level is appropriate.

In the next part of this paper, we briefly discuss the Perl tutoring system followed by the fuzzy logic. Then we will describe the questionnaire part and the testing part and end with discussion.

[1] The work related to this paper is funded under the Hong Kong Polytechnic University research grant No. PolyU5072/98E.

2 Overview of the Perl Tutoring System

Figure 1 illustrates the directed tutoring graph in the system [16]. The three pieces of knowledge items presented to students are: data type, logical operators and control structures. In the figure,

- Each vertex represents a sub-domain;
- Each pair of the sub-domain may be connected with a unidirectional or bi-directional arc.
- Each arc represents the relationship between two sub-domains.

Moreover, each sub-domain may consist of several vertices, which are the sub-sub-knowledge items of their parent domain. For example, under ' data type' , we also have ' integer' , ' float' , ' boolean' etc.

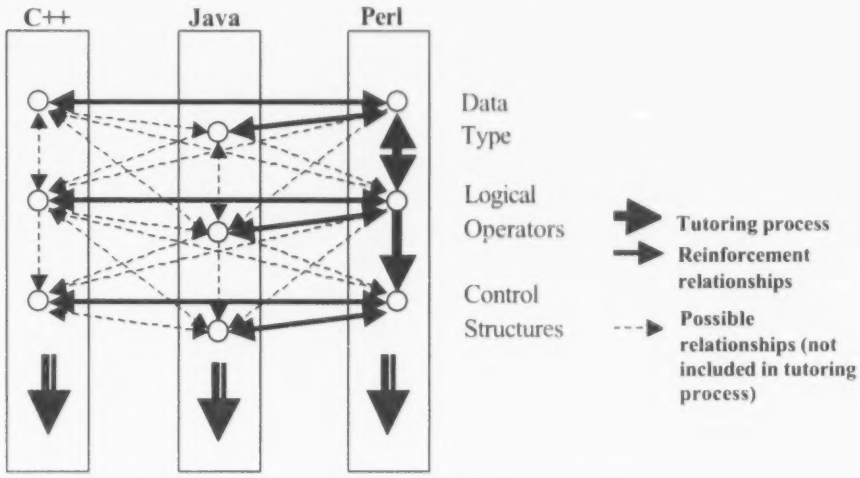


Figure 1 A Digraph of the Perl Tutoring System

C++ [1] and Java share many similarities with Perl, although they, of course, have their own features. See Table 1 for a comparison.

CDR terms (General)			Knowledge piece in PERL	Knowledge piece in C++	Knowledge piece in Java
Operators	Numeric operators		+,-,*,/, %, **	+,-,*,/, %,	+,-,*,/, %,
	Relational operators		<,<=,>,>=,<=>(**for numeric**) lt,le,gt,ge,cmp(**for string**)	<,<=,>,>=	<,<=,>,>=
	Equality operators		=,!=**(for numeric)** eq,ne**(for string)**	==,!=	==,!=
	Logical operators(binary)		&&,||	&&,||	&&,||
	Logical operators(unary)		!,	!,-	!,-
	Bit manipulation operators		&, |, ^, ~	&, |, ^, ~	&, |, ^, ~
	Bit shift operators		<<, >>	<<, >>	<<, >>, >>>
	Auto-increment & auto-decrement operators		++,--	++,--	++,--
	Speical operators	Conditional operators	?:	?:	?:
		Other operators	•,x(string operators) , >,\(**dereference/reference operator**	Sizeof ,	Instanceof
	Multiple operators			+=, -=, *=, /=, %=, &=, |=, <<=, >>=, ++=, --=	+=, -=, *=, /=, %=, &=, |=, <<=, >>=, >>>=, ++=, --=
Control structures			If,if/else, unless/else, While, do/while, for, continue, goto Notes:labled loops can be used within for, while, or do	If, if/else, while, do/while, for, continue, goto, switch, break	if, if/else, while, do/while, for, continue, break, switch Notes:labled loops can be used within for, while, or do
		Special structures	**Foreach** **Redo**	Exit	

Table 1 Similarities and differences in C++, Java and Perl

CDR represents 'cross-domain reference' which serves as a dictionary for the domains. It is composed of basic terms used across the computer language regardless of which language is being referred. If the student has learned computer language before, he will develop a clear picture of the terms or concepts used, which serves as a guide for the learning of Perl. Besides, he will also integrate his former learning into his current. Through this knowledge transfers, the time spent on learning Perl will be greatly reduced [8].

Before tutoring begins, a weight is assigned to every direction of arc that represents the easiness of the acquisition of one sub-domain (target) after acquiring another (source). Since different students have different knowledge levels, the weight assigned to the same arc may not be the same. Thus, the weight across domain is jointly determined by the student model and the characteristics of knowledge (for detailed explanation, refer to [16]), i.e.,

$$w_{ij} = f(\mathbf{d_{ij}}, \mathbf{m_{ij}})$$

Where, w_{ij} is the weight of arc from i to j.

$f: R^n \times R^m \rightarrow R$, is a non-decreasing function.

$\mathbf{d_{ij}}$ is an n-dimensional vector representing the similarity of i and j. $\mathbf{m_{ij}}$ is an m-dimensional vector representing the student model, i.e., the student's knowledge level of i.
The dimension of $\mathbf{d_{ij}}$ and $\mathbf{m_{ij}}$ depends on the number of attributes considered. Moreover, the value of $\mathbf{d_{ij}}$ is predetermined and the value of $\mathbf{m_{ij}}$ is determined based on the student model. Thus, the system would carry an assessment module to test the knowledge of a student towards a specific supporting domain knowledge *before* tutoring begins. In this paper, we focus on the determination of $\mathbf{m_{ij}}$.

3 The Assessment Model—A Fuzzy Approach

Since the main purpose of the model is to test student's overall abilities, it is not necessary for us to gain a very accurate picture of it (although it helps). And somehow we also cannot gain a clear picture of student history. Thus, we choose a fuzzy approach in analyzing the student's performance, and we believe that the imprecise assessment of the student's prior knowledge level is adequate.

3.1 The 'neighborhood of knowledge states'

The *knowledge state* has been defined as the subset of knowledge items from a large item pool that can be mastered by students [4]. Remember that knowledge items in different domains are identified by their names, which in turn are determined by a cross-domain vocabulary. Besides, each item is characterized by its relationship with other items. The neighborhood of a knowledge state was defined by Falmagne and Doignon [7] as all other states within a distance of at most one. It has been utilized for adaptive assessment by Dowling *et. al.* [6]. In our system, we will not measure the exact distance within knowledge items, but we adopt it from another perspective. We define the neighbors of a knowledge item as the possible knowledge items which could be mastered in association with it. Let us have a look at an example.

Example 1.

1. '<','<=' represent 'less than' and 'less than or equal to' respectively, and they are relational operators.
2. '>','>=' represent 'greater than' and 'greater than or equal to' respectively.
3. '==','!=' represent 'equal to' and 'not equal to' respectively, and they are equality operators.
4. '<','<=' can be used for both numeric and strings.
5. '>','>=' can be used for both numeric and strings.
6. '==','!=' can be used for both numeric and strings.
7. Numeric is data type.
8. Strings are data type.
9. The relational and equality operators can be used for all data types, numbers, expressions or their combinations.

Let $M_S(X)$ denotes the student is sure to have mastered X. And $M_l(Y)$ denotes the student is likely to have mastered Y. Where X,Y are sets of knowledge items. Then,

$M_S(X) \rightarrow M_l(Y)$ can be interpreted as "if the student is sure to have mastered X, then he/she is likely to have mastered Y."

Then we will have:

1. $M_S(1) \rightarrow M_l\{2,4,7,8\}$
2. $M_S\{3\} \rightarrow M_l\{6,7,8\}$
3. $M_S\{4,5,6\} \rightarrow M_S\{7,8\}$
4. $M_S\{9\} \rightarrow M_S\{1,2,3,4,5,6,7,8\}$

For example, if the student knows well how to make comparisons for numeric and strings, then we assume

that he/she is sure to have mastered: what is numeric, what is a string and the usage of the operators. Although we cannot determine that whether he masters other data types or not (that is, he is likely to have mastered other data types such as float etc), we can assess student's knowledge state without having to extensively test his abilities of each knowledge item he/she may have learned. Therefore, test items in our model may test knowledge items in a wider ranger than similar work by Collins *et. al.* [2].

3.2 Fuzzy Logic

To express precisely the notion "sure", "likely" or "unlikely", we adopt fuzzy set methods and therefore using fuzzy rule for the inferences. For example, we define

Answer = {True, False}. And A1, A2 $\subset$ Answer, thus

$$Ai = \mu_{Ai}(T)/True + \mu_{Ai}(F)/False$$

Confidence = {unlikely, likely, sure}. And B1, B2 $\subset$ Confidence, thus

$$Bi = \mu_{Bi}(u)/unlikely + \mu_{Bi}(l)/likely + \mu_{Bi}(s)/sure$$

Assume we have two rules: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2

Then, by Mamdani's direct methods:

$$B' = A' \circ R$$

Where, $R = R1 \cup R2$

$$Ri = \begin{pmatrix} \mu_{Ri}(T,u) & \mu_{Ri}(T,l) & \mu_{Ri}(T,s) \\ \mu_{Ri}(F,u) & \mu_{Ri}(F,l) & \mu_{Ri}(F,s) \end{pmatrix} \quad \text{and} \quad \mu_{Ri}(x,y) = \mu_{Ai}(x) \wedge \mu_{Bi}(y)$$

Note here that all operators used, such as: +, /, $\subset$, $\wedge$, $\cup$, and $\circ$, are defined in fuzzy domain.[2]

To illustrate it, let us assume that A1 is "doing well in bit shift operator", A2 is "doing bad in bit shift operator", B1 is "understand bit manipulation if doing well in bit shift operator", and B2 is "understand bit manipulation if doing bad in bit shift operator". Then, we can assign values such as:

A1 = 1.0/T A2 = 1.0/F

B1 = 0.5/l + 0.5/s B2 = 1.0/u + 0.1/l

And satisfied: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2. Thus,

$$R1 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B1}(u) & \mu_{B1}(l) & \mu_{B1}(s) \\ 0 & 0.5 & 0.5 \end{array} \\ \begin{array}{c} \mu_{A1}(T)\ 1.0 \\ \mu_{A1}(F)\ 0 \end{array} & \begin{bmatrix} 0 & 0.5 & 0.5 \\ 0 & 0 & 0 \end{bmatrix} \end{array}$$

$$R2 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B2}(u) & \mu_{B2}(l) & \mu_{B2}(s) \\ 1.0 & 0.1 & 0 \end{array} \\ \begin{array}{c} \mu_{A2}(T)\ 0 \\ \mu_{A2}(F)\ 1.0 \end{array} & \begin{bmatrix} 0 & 0 & 0 \\ 1.0 & 0.1 & 0 \end{bmatrix} \end{array}$$

[2] Many books [18,19,20] in fuzzy set theory provide good explanations on these operators. We are not going to explain it further in this paper due to limited space.

With two rules, the fuzzy relation Ri is made from the implication Ai → Bi (in this case, i=1,2). The compiled fuzzy relation R is given as Mamdani' s method:

$$R = R1 \cup R2, \text{ computed as:}$$

$$R = \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix}$$

Now, assume after a series of testing, a student performance show A' = 0.9/T + 0.2/F in doing bit shift operator. Then, we can calculate his performance in bit manipulation as:

$$B' = A' \circ R$$

$$= \begin{array}{cc} & \begin{array}{ccc} u & l & s \end{array} \\ \begin{array}{c} T \quad F \\ [0.9 \quad 0.2] \circ \end{array} & \begin{array}{c} u \\ l \end{array} \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix} \end{array}$$

$$= [(0.9 \wedge 0) \vee (0.2 \wedge 1.0),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0.1),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0)]$$

$$= [0.2 \quad 0.5 \quad 0.5]$$

$$B' = A' \circ R = 0.2/u + 0.5/l + 0.5/s$$

Which shows 0.5 likely to understand, 0.5 surely to understand and only 0.2 unlikely to understand bit manipulation.

4 Questionnaire and Testing

The questionnaire part consists of a series of knowledge items to be checked by students. The knowledge items are grouped into several groups based on the their similarities and difficulties. Then, students are asked to fill the form about their mastery level in each group. Five grades are provided for each answer, i.e., very familiar, familiar, moderately familiar, not familiar, and never heard. After students provided their answers, the system retrieves a series of testing questions based on the difficulty (upper limit) of students' answers, especially for the items marked 'moderately familiar'. But it does not mean that the presumably mastered items are not tested at all. Even the items marked 'very familiar' will be tested, but with a very low probability. Testing could be in the forms of short program lists or short questions, which are made as short, clear, and simple as possible. The reason is to avoid noise or errors which do not come from student knowledge iteself. In order to avoid ambiguity in judging knowledge level when the question is not answered well, every question only consists few higher level concepts to be handled.

Moreover, an average of membership value is used if the same item occurs in several questions. (We can use Bayesian update but with higher cost, i.e., to set all the conditional probability among every question).
For example, if from question 1, 2 and 3, a student performance on 'bit manipulation' shows

0.8/T + 0.2/F, 0.9/T + 0.3/F, and 1.0/T + 0.1/F respectively,

then the overall performance is, simply, the average, i.e., 0.9/T + 0.2/F.

If the question needed does not exist in the database, then a similar question is retrieved. The measure of similarity is based on the maximum number of high level concept appeared.

Prerequisite relationship

In addition to the neighborhood relationships, prerequisite relationships are also applied. The prerequisite relationship provides not only test item ordering criteria in a "strong" sense, but also in a "weak" sense. In ordinary prerequisite criteria P(A, B) denotes "A is prerequisite of B". In our extended criteria, we introduce A' as:

If A' is closely related to A and $M_S(A') \sqsupset M_S(A)$

then we have $P'(A', B)$, that is, A' is weakly prerequisite of B.

So, if students have mastered item A', we have: they are sure to have mastered B without testing whether they have mastered item A or not. By doing this, we can largely tighten the testing items and thus save more time.

5 Discussion

To know student's learning history and his knowledge level, we cannot ask them too detailed questions in order to gain a more full picture of their knowledge state (although it helps) since it will make student modeling itself a kind of a complex system. But we need them to aid in the assessment, so how much trust should we have in the student's own assessment? This is the question we need answer before we proceed. In our system, we will not generate the tutoring graph solely based on their answers. Our solution is to test by giving them several pre-stored test items: if they can write out the outcome correctly, we assume that he has mastered the knowledge pieces and rules needed for this program.

Thus, the assessment will proceed. Test items need not to be like traditional testing questions in classrooms. They can be mini-programs or short questions provided that they can be used as a guide to assess students' mastery level of declarative knowledge.

Furthermore, we also should consider the nature of the language. For example, If the student has studied both Prolog and Java before, considering the respective relationship of them with Perl, we will still use Java as supporting knowledge because it is closer to Perl. This factor is called Knowledge Relation (K-R), and it will be assigned to $\mathbf{d_j}$.

At the end of the self-assessment section, a directed tutoring graph is generated. And student will be tutored based on it.

Currently, we are constructing the fuzzy rules which are applied for the assessment module, followed by the implementation and evaluation of it.

References

1. Capper, D.M. "Introducing C++ for Scientists, Engineers and Mathematicians", U.K., Springer-Verlag, (1994).
2. Collins, J.A., Greer, J.E. & Huang, S.X. "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the 3d International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
3. Derry, S.J. & Hawkes, L.W. "Toward fuzzy diagnostic assessment of metacognitive knowledge and growth", Proceedings of the Annual Meeting of the American Educational Research Association, San Francisco, CA, (1992).
4. Doignon, J.-P. & Falmagne, J.-C. "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, Vol 23, pp.175-196, (1985).
5. Dowling, C.E. & Kaluscha, R. "Prerequisite relationships for the adaptive assessment of knowledge", Artificial Intelligence in Education, pp. 43-50, AACE: Charlottesville, VA, (1995)
6. Dowling, C.E., Hockemeyer,C., Ludwig, A.H. "Adpative assessment and training using the neighbourhood of knowledge state", Proceedings of the 3d International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
7. Falmagne,J.-C. & Doignon,J.-P. "A Markovian procedure for assessing the state of a system", Journal of Mathematical Psychology, Vol. 32, pp. 232-258, (1988).
8. Harvey, L. & Anderson, J.R.. "Transfer of declarative knowledge in complex information processing domains", http://act.psy.cmu.edu/ACT/papers/Harvey_Anderson95.html, (accessed on August 1, 2000).
9. Juliano,B.A. & Bandler,W. "Tracing Chains-of-Thought", Heidelbert: Physica-Verlag, (1996).
10. Katz, S., Lesgold, A., Eggan, G., & Gordin, M. "Approaches to student modeling in the Sherlock tutors", Proceedings of the Third International Workshop on User Modeling, Germany, pp. 205-230, (1992).

11. Lesgold, M., Eggan, G., Katz, S. & Rao, G. "Possibilities for assessment using computer-based apprenticeship environments", Cognitive Approaches to Automated, Hillsdale, Lawrence Erlbaum Associates, (1991).
12. Matsubara, Y., Nagamachi, M. "Motivation system and human model for intelligent tutoring", Proceedings of the 3rd International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada. LNCS 1086, (1996).
13. McCalla, G. I., Greer, J. E. "Granularity-based reasoning and belief revision in student models", Student Modelling: The Key to Individualized Knowledge-Based Instruction, pp. 39-62. Springer-Verlag, Berlin, (1994).
14. Nguyen-Xuan, A., Joly, F., Nicaud, J.F., Gelis, J.M. "Automatic diagnosis of the student' s knowledge state in the learning of algebraic problem solving", Proceedings of the Conference on Artificial Intelligence in Education, Japan, (1993).
15. Sime, J.-A. "Modeling a learner' s multiple models with Bayesian belief networks", Proceedings of the Conference on Artificial Intelligence in Education, Edinburgh, Scotland, pp. 426-432, (1993).
16. Tang, Tiffany Ya. & Wu, Albert. "The implementation of a multi-agent intelligent tutoring system for the learning of computer programming", To appear in the 16th IFIP World Computer Congress — International Conference on Educational Uses of Communication and Information Technologies (ICEUT 2000) Beijing, China, (2000).
17. Villano, M. "Probabilistic student models: Bayesian belief networks and knowledge space theory", Proceedings of the 2nd International Conference on Intelligent Tutoring Systems (ITS' 92), Montreal, Canada, pp. 491-498, (1992).
18. Zadeh, L.A "Fuzzy sets", Information and Control, Vol. 8, pp. 338-353, (1972).
19. Zadeh, L.A. "A fuzzy-set-theoretic interpretation of linguistic hedges", Journal of Cybernetics, Vol. 2, pp. 4-34, (1973).
20. Zhu, Q. & Lee, E.S. "Fuzzy and Evidence Reasoning", Physica-Verlag, Germany, (1995).

A Learning Environment for Problem Posing in Simple Arithmetical Word Problems

Akira Nakano, Naoki Murakami, Tsukasa Hirashima and Akira Takeuchi
Kyushu Institute of Technology Department of Artificial Intelligence
680-4 Kawazu, Iizuka 820-8502, Japan
E-mail : nakano@minnie.ai.kyutech.ac.jp

Several researchers indicate that to pose arithmetical word problems is an important way to learn arithmetic. However, the problem posing practice actually is not popular. In this paper, we describe an Intelligent Learning Environment which realizes the problem posing practice. In the problem posing practice, the learners pose problems by using the tools provided by the ILE. The ILE has a facility to diagnose the problems posed by the learners. By using the result of the diagnosis, the ILE indicates whether the problems are correct or not, helps the learner to correct the wrong problems, and provides the next step of problem posing. We used the ILE in three different situations for evaluation. The subjects were elementary school teachers and elementary school students. We also report the results of the evaluation. In the ILE, the interface was implemented in Java, and the diagnosis module was implemented in Prolog. So it can be used on World Wide Web. The current environment deals with simple arithmetical word problems.

Keywords: **intelligent learning environment, problem posing, intelligent tutoring system, interactive education, World Wide Web**

1 Introduction

The main purpose of the practice to solve arithmetical word problems is to make learners recognize the relations between concepts and numerical relations, and master to use the relations. Although the problem solving practice is the most popular way, it is not the only way. Several researchers indicate that to pose arithmetical word problems is also effective. However, the problem posing practice actually is not popular.

The main reason is that the problem posing practice is strongly required teachers to deal with each learner individually in comparison with the practice of problem solving. We aim to realize computer-based learning environments for the problem posing practice [1]. For the problem solving practice, many ILEs are developed so far [2-6]. However, there are few ILEs for the problem posing practice until now.

This paper describes an Intelligent Learning Environment for the problem posing practice for simple arithmetical word problems that can be solved by the addition of one time or the subtraction of one time. The main characteristic of the ILE is the function to diagnose the posed problems. By using the results, the ILE indicates errors in the posed problems and suggests that the next step of problem posing.

Interface of the ILE was implemented in Java, and the diagnosis module was implemented in Prolog. Therefore, if only users have a computer connected to Internet with a popular internet browser, they can use the ILE through WWW: E-mail: nakano@minnie.ai.kyutech.ac.jp http://www.minnie.ai.kyutech.ac.jp/~nakano/problem-posing.shtml (currently Japanese only).

In this paper, the first, the necessity of problem posing and an Intelligent Learning Environment for it are described. Then, interface and diagnosis module of the ILE are explained. The results of preliminary evaluation of the ILE are also reported.

2 Background

2.1 The necessity of an ILE for problem posing

Several researches about problem posing of arithmetical word problems suggested that problem posing was important to learn arithmetic, for example, analysis and investigation about the task of problem posing [7,8], investigation about effect of the problem posing practice [9], investigation in the problem posing practice at arithmetic class [10,11]. Besides, the Curriculum and Evaluation Standards for School Mathematics (in USA, 1989), and Professional Standards for Teaching Mathematics (in USA, 1991) also indicated that it was important for learners to experience to pose problems.

However, the practice actually is not popular in arithmetic class in comparison with problem solving practice. In the practice of problem solving, every problem has an answer and one or a few solution methods. Therefore, the teachers can easily judge the results of problem solving by learners. Then when the answer is wrong, to tell the correct answer or the solution method is not meaningless.

In contrast with problem solving practice, to prepare every correct problem in the problem posing practice is very difficult. Besides, the correct problem that a learner is trying to pose, after depends on the wrong problem posed by the learner. Therefore, the teachers have to examine each problem whether the problem is correct or not, and where of the problem is wrong.

Based on this consideration, we believe that to realize an ILE for problem posing with problem diagnosis function is the promising way to make learning by problem posing popular.

2.2 The problem posing dealt in the ILE

Silver has noted that the term "problem posing" is generally applied to three quite distinct forms of mathematical cognitive activity [12]. They classified three types of problem posing: (1) presolution posing, in which one generates original problems from a presented stimulus situation, (2) within-solution posing, in which one reformulates a problem as it is being solved, and (3) postsolution posing, in which one modifies the goals or conditions of an already solved problem to generate new problems. The problem posing deal in our ILE is (2) within-solution posing. In the ILE, because, in the ILE, first, a learner decides a calculation formula to solve the problem, and next, he/she is trying to pose problem solved by the calculation.

Currently, the LIE can deal with only Change-Problem[13]. In Change-Problem, the quantity in the initial situation is changed to the quantity in the final situation by the change action. The Change-Problem usually consists of three sentences: the first sentence describes the initial situation, the second sentence describes the change action, and the third sentence describes the final situation. Therefore, we prepare a "problem template" that composed of three single sentence templates. By filling in the blanks of three single sentence templates, the problem is completed.

In the ILE, the template of Chang-Problem is composed of the tree single sentence templates that describe: initial situation, change action, and final situation, respectively. The initial situation has the four information: "owner", "object", "number", and "unit". This means that "owner" has "object" and the number of "object" is "number", then, the unit of the number is "unit". The change action has the five information: "actor", "object", "number", "unit", "action". Several actions, for example, "take" has two more information: "from" and "to". The final situation has the four information: "owner", "object", "number", and "unit".

3 ILE for problem posing

3.1 Configuration of the ILE

The current version of the ILE consists of clients and server shown in Figure 1. A client is an interface of the ILE. The interface provides learners the tools to pose problems and gives them guidance to promote problem posing. Inter face is explained in more details in this section 3.2.

The server has two modules: the one is Problem Diagnosis Module and the other is Advice Generator. First, the ILE receives the posed problem, and diagnoses it in Problem Diagnosis Module. Next, in Advice Generator, the ILE generates advice for each learner by using the result of diagnosis. These are explained in

more details in this section 3.3.

Because the ILE deals with several learners by one server, the ILE manages ID, PW, and Learner Model in Private Information Manager.

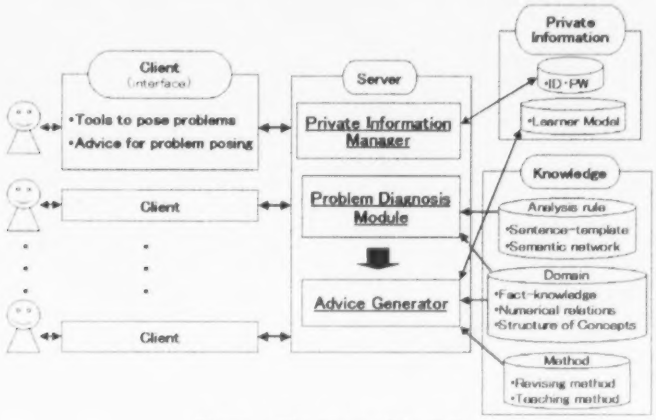


Figure 1: The frame of the ILE

3.2 Interface

Figure 2 shows the interface of the ILE. Current interface deals with only Japanese. In Figure 2, Japanese was translated into English for this paper. The parts of the interface are expressed as follows.

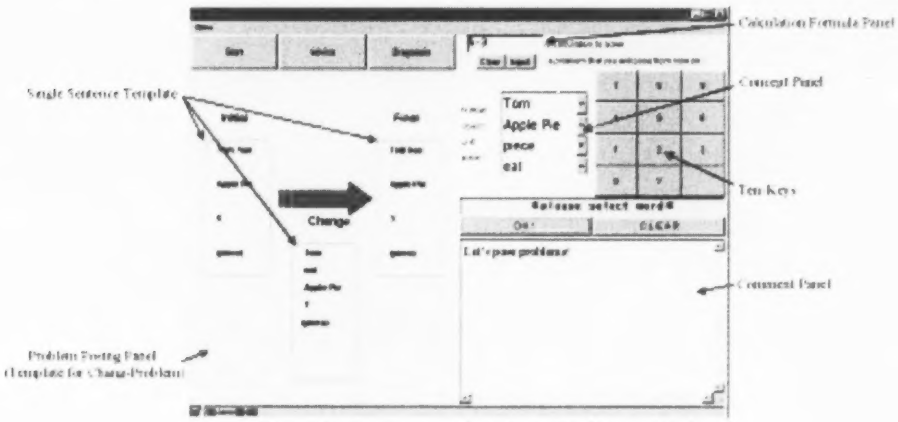


Figure 2: the prototype Interface (English version)

• Calculation Formula Panel

In this panel, a learner gives calculation formula. The learner poses problems which can be solved by this calculation formula.

• Concept Panel

This panel provides concepts to fill in blanks of sentences (three single sentences templates). The concepts that are provided in the Concept Panel are classified in the five categories: "human", "object", "unit", "action", "number".

• Ten-key

BEST COPY AVAILABLE

Numerical values are put into blanks of sentences with Ten-key.

• Problem Posing Panel

In the current version, this panel provides the template of Change-Problem. The ILE asks a learner to fill in blanks of sentences. In the order of the blanks, the ILE gives questions. By answering the questions, the blanks are filled in. Here, the learner has to select concepts from Concept Panel. By using Figure 3, posing a sentence of initial situation in Chang-Problem is explained. The left side of the figure shows questions.

For example, the initial situation in Chang-Problem is composed of four elements: "owner", "object", "number" and "unit". So, the ILE asks the learner "Who has?", "What the person has?", "How many?", "What is unit?". The learner also should decide what number is the answer by selecting the question mark in Ten-key.

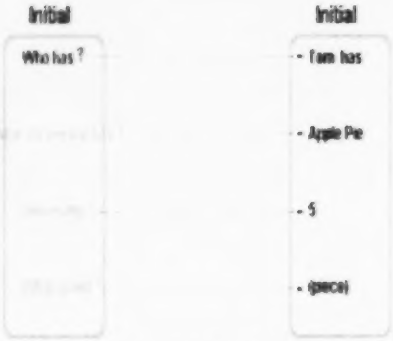


Figure 3: An example of posing sentence by using Single Sentence Template

The right side of the figure shows an example which the learner answered the questions. The result shows "Tom has 5 pieces of Apple Pies".

By answering the all questions, learners pose problems For example, Figure 2 shows the correct problem in Problem Posing Panel: the initial situation is "Tom has 5 pieces of Apple Pies", the change action is "Tom eats the 3 pieces of Apple Pies", and the final situation is "How many pieces of Apple Pies does Tom have?".

• Comment Panel

This panel shows advice and suggestion massages that are generated based on the diagnosis of the posed problems.

3.3 Problem posing in the ILE

A learner poses a problem by the following process.

(1). Giving a calculation formula

First, the learner gives a calculation formula. The calculation formula consists in three elements. That is, two operands and an operator. Because the calculation formula is the way to get the answer of the problem, we call it solution.

The solution can be applied to several numerical relations. For examples, if the learner assigned "5-3" to the solution, the solution can be applied to the following four numerical relations: (a) "5-3=X", (b) "5-X=3", (c) "3+X=5", (d) "X+3=5" (the current version of the ILE only handles natural numbers). Here, numerical relation (a) means the answer is the number in the final situation, numerical relation (b) and (c) mean the answer is the number in the change action, and numerical relation (d) means the answer is the number in the Initial situation.

(2). Selecting concepts from Concept Panel and combining them with the template of Change-Problem

The template has several blanks, and the ILE asks the learner to pose a problem by filling the blanks with the concepts. Then, if the learner selected a concept from the set of wrong concepts, the ILE can give the learner feedback, which suggested that the concept is wrong.

(3). Request to diagnose a problem

When the learner clicks the "diagnosis button", the problem is sent to the server and is diagnosed.

(4). Revising the wrong problem by using the suggestion given in the Comment Panel

When the posed problem is wrong, the learner receives feedback that indicates an error at Comment Panel.

The ILE generates the message by using the result of the diagnosis.

(5). Posing the new problem by using the suggestion

When the learner posed the correct problem, the learner receives feedback which is suggests to pose the new type of problems.

3.4 Problem Diagnosis Module and Advice Generator

Problem Diagnosis Module and Advice Generator are functions of the server in the ILE. Problem Diagnosis Module diagnoses problems sent by the client, and Advice Generator generates messages that are provided for each learner.

The ILE, first, diagnoses a single sentence and then diagnoses the problem composed of three sentences, and compares the solution given by a learner with the problem posed by the learner. In the first step, the module has knowledge about acceptable sentences (initial situation, change action, final situation). We call each sentence "basic relation", and the knowledge "single sentence schema". The single sentence schema checks each basic relation to find the errors in a sentence.

In the second step, the relation among the sentences is diagnosed. The module has the knowledge about acceptable relations among basic relations. We call the knowledge "problem schema". The problem schema checks the numerical relation between the sentences to find the wrong sentence in the problem.

In the third step, the relation between the solution and the problem is diagnosed.

In the following section, the diagnosis process is explained. Then, the feedback made by the diagnosis result is presented.

3.4.1 Diagnosis of the posed problems

Diagnosis of the posed problems is carried out in three steps: the first step is the diagnosis of a single sentence. The second step is the diagnosis of the problem composed of three sentences. The third step is the diagnosis of the relation between the problem and the solution.

(1). Diagnosis of a single sentence

In this diagnosis, two types of errors are detected: (1-a) errors in the relation between object and action, and (1-b) errors in the relation between object and number. Here, Mismatch of blanks (that is, object blank or action blank and so on) and concepts is already checked in the interface.

An example of (1-a) is a sentence that "Tom eats his 2 sheets of postcards." "Tom has 5 cups of apple pies" is an example of (1-b). These errors are detected by checking with sentence schema in that the acceptable relations between object and action or object and number are described.

(2). Diagnosis of problem

In this diagnosis, three types of errors are detected: (2-a) errors in the final situation, (2-b) errors in the change action and (2-c) no relation errors. (2-a) means that the initial situation can be changed by the change action, but cannot be changed to the final situation. (2-b) means that the initial situation can be changed to the final situation, but cannot be changed by the change action. (2-c) means that the initial situation cannot be changed by the change action and to the final situation. These errors are detected by comparing by problem schema in that the acceptable relations among the situations and the change action are described.

An example of (2-a) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats Tom's 3 pieces of apple pies" and "how many pieces of lemon pies does Tom have?" An example of (2-b) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats her 3 pieces of apple pies, and "how many pieces of apple pies does Tom have?"

(3). Diagnosis of the relation between the problem and the solution

The diagnosis module can generate an equation from the problem. In this diagnosis, first, the module solves the equation. Then the calculation to derive the answer is compared with the calculation posed by the learner as the solution. When the two calculations do not correspond, an error in the relation between the problem and the solution is detected.

3.4.2 Feedback for the client

(1). Indication of an error

If the diagnosis module finds an error, the ILE indicates it. Even if the problem includes several errors, the

ILE indicates the error detected first.

(2). Suggestion of the next step of problem posing

The ILE suggests the next step of problem posing when the posed problem is the correct one. In the diagnosis, the module diagnoses not only whether the problem is correct or not, but also what concepts, actions or equations are used in the problem. Based on the results, the ILE can suggest more difficult problem posing by specifying concepts or an equation type to be allowed to use in problem posing.

4 Preliminary evaluations

A prototype of the ILE has been already developed. We used it in three different situation for evaluation, as follows: (1) Use by teachers of the elementary school, (2) Use by students of elementary school in arithmetic classes, (3) Use by students of elementary school outside the class.

In (1), we asked the teachers to evaluate the ILE from the viewpoint of teaching. Then, two of them permitted us to use the ILE in their arithmetic class. So, we had two opportunities to evaluate the ILE in the second situation. In (2), we asked the students of elementary school to pose arithmetical word problems with the ILE in two arithmetic classes. In the trial, although we collected the answers for our questionnaires, we failed to record logs of problem posing. Therefore, we could not get the data about the number of posed problems, and the students behave for feedback from the ILE. In (3), we gathered several students again, and asked them to use the ILE out of class. Here, the students used the ILE for the first time.

In this section, we report these results.

4.1 Use by the teachers of the elementary school

To evaluate a learning environment, the evaluation by teachers is important. We asked five teachers of elementary school to use the ILE. After they posed several problems by using this ILE, we asked them several questions. The questions are as follows: (1) How do you evaluate the effect of problem posing to learn arithmetic? (2) How do you evaluate the way of problem posing used in the ILE? (3) How do you evaluate the interface? (4) How do you evaluate the indications for the errors in posed problems? (5) How do you evaluate the advises to suggest the next step of problem posing? Table 1 shows the results.

Table 1: Evaluation of the teachers

	Good	So-so	Bad
(1)	5	0	0
(2)	3	2	0
(3)	2	3	0
(4)	4	1	0
(5)	5	0	0

Table 1-(1) means that all teachers think to learn arithmetic by using problem posing is effective. Table 1-(2) suggests that the ILE realizes an useful environment for learning by problem posing. Two teachers out of three teachers who answered "Good" to the question (2), gave us opportunities to use the ILE in classes. A few teachers also indicated that the limitation of concepts that were allowed to use in problem posing should be revised. This is one of our future works. In Table 1-(3), three teachers answered "So-so". The result means that the interface is not always easy to use. In Table 1-(4), four teachers answered "Good". The result suggests that the indications for the errors in the posed problem are acceptable. However, several teachers also indicated that the sentences of the indications may be difficult for elementary students. In Table 1-(5), the all teachers answered "Good". This result means that the teachers think the suggestions to make learners progress the next step of problem posing adequately support learning by problem posing.

4.2 Use by the students of elementary school in arithmetic classes

We used the ILE in two classes: the one was composed of 25 students in third grade and the other was composed of 30 students in fifth grade. In each class, 15 minutes were used to explain the use of the ILE, and 20 minutes were used for the problem posing practice with the ILE. In this problem posing practice, students were two people one set, and they operated one personal computer with two. Then two assistants assisted them to operate the ILE in the experiments.

Table 2: Evaluation of the

		Yes	No Answer	No
Third -grad	(1)	22	0	2
	(2)	22	0	2
Fifth-grad	(1)	27	2	1
	(2)	25	4	1

We asked two questions after the problem posing practice: (1) Are you interested in problem posing by using this ILE? (2) Do you want to pose more problems by using this ILE? The result is shown in Table 2.

The results suggested that most students were interested in problem posing with the ILE. But we were not able to get enough data to confirm that the students pose problem well.

4.3 Use by the students of elementary school outside the class

Subjects were one student of fourth-grade, and threes students of sixth-grade in elementary school. In the experiment, we used 15 minutes in the demonstration of this ILE, and 25 minutes in the problem posing practice. The results were as follows. In Table 3, *Diagnosis* indicates the number of time of request to diagnose.

Table 3: Logs of the problem posing

Diagnosis	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
i	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**
ii	**α-C**	**α-C**	**β-W**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**		
iii	**α-C**	**α-C**	**β-C**							
iv	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**	

α: A±B=X, **β**: A±X=C, γ: X±B=C (A,B,C are numerical values. X is a variable)

C: Correct, **W**: Wrong

In Table 3, equations named by Greek (α, β, γ) specify the type of problem posed by subject. "A" is the number in the initial situation, "B" is the number of the change action, and "C" is the number in the final situation. "X" is the number that is derived by the solution. In the α type, the answer is in the final situation. So this type of problem is the easiest one. In the β type, the answer is in the change action. In the γ type, the answer is in the initial situation. In this order, problems become difficult. The ILE can judge not only "C (correct)" or "W (wrong)", but also the type of problem whenever the student requests the diagnosis.

In Table 3, three subjects (i, ii, iv) tried to pose the problems of the all types, and subject-iii tried to pose the two types of the problems. The subject-i posed the wrong problem of the γ type on the 3rd request to diagnose in the practice. And the subject was repeating to revise it in seven times. As a result, the subject posed the correct problem of the γ type in the 10th trial. And the subject-ii posed the wrong problem of the β type on the 3rd request to diagnose in the practice, then the subject posed the correct problem of the β type in the 4th trial. And the subject-iv posed the wrong problem of the γ type on the 3rd request to diagnose, then the subject posed the correct problem of the γ type in the 9th trial, too. But, the subject-ii gave up to correct the wrong problem of the γ type, although s/he was repeating to revise the wrong problem in three times. The results suggest that the feedback is effective to forward the learner to revise the wrong problem.

In the current ILE, if a learner corrected the problem, the ILE suggests the next step of problem posing. The first step is problem of the α type. the second step is problem of the β type. and the third step is problem of the γ type. In Table 3, all subjects follow the suggestion. In the results, when a learner posed a correct problem, the learner can not poses only the same type of problem again, but also other types of problem by using the feedback. This suggests that the feedback is also effective to advance the next step of problem posing.
Conclusions

5 Conclusion

In this paper, we described ILE for problem posing in simple arithmetical word problems. The ILE provides the template to pose Change-Problem in current version. And the ILE can diagnose the problem that learners fill blanks of the template with several concepts, values, and question mark. Besides, the ILE can support

each learners by using the results of diagnosis. We used the ILE in three different situations for evaluation. In the results, we consider that this research provides basis functions to realize the problem posing practice by ILE about simple arithmetical word problems.

In future work, we will refine functions in the ILE. For example, in the ILE, we will deal with not only Change-Problem, but also the other types of problems. And we will develop a function in which teachers can customize concepts provided for their students in their problem posing practice, because teachers hope to use concepts which are popular in their classroom. Then, we will evaluate the ILE again in order to investigate about the effect to learn arithmetic.

References

[1] Nakano・A.・T.Hirashima・A.Takeuchi・"Problem-Making Practice to Master Solution-Methods in Intelligent Learning Environment・" Proc of ICCE'99・pp891-898・1999.

[2] Barr,A., Beard, M., Atkinson, R.C., "The Computer as a Tutorial Laboratory: the Stanford BIP Project". Int.J. Man-Machine Studies, Vol.8, pp.567-596, 1976

[3] MaCalla, G.I. "The Search for Adaptability, Flexibility, and Individualization:Approaches to Curriculum in Intelligent Tutoring ILEs", In Jones, M. and Winne P.H.(Eds.), Adaptive Learning Environment: Foundation and Frontiers, Springer-Verlag, pp.91-122, 1990

[4] Hirashima, T., A.Kashihara, J.Toyoda : "Toward a Learning Environment Allowing Learner-Directed Problem Practice". Proc. of ITS'96 Lecture Notes in Computer Science 1086, pp.466-474,1996

[5] Hirashima, T., A.Kashihara, J.Toyoda : "Providing Problem Explanation for ITS", Proc. of ITS'92 Lecture Notes in Computer Science 608, pp.76-83, 1992

[6] Hirashima, T., T.Kohno, A.Kashihara, J.Toyoda : "Development of Support Facilities for Arithmetical Word Problem Exercises in Intelligent Tutoring ILE". Electronics and Communications in Japan, pp.22-33, 1992

[7] Silver・E.A.・Mamona.J.・"Posing Mathematical Problems:An Exploratory Study・" Journal of Research in Mathematics Education・vol.27・No.3, pp293-309・1996.

[8] Lyn D. English・"Children's Problem Posing Within Formal and Informal Contexts・" Journal of Research in Mathematics Education・vol.29・No.1, pp83-106・1998.

[9] Ellerton, N. F., "Children's made up mathematics problems: A new perspective on talented mathematicians," Educational Studies in Mathematics, 17, pp261-271, 1986.

[10] Silverman, F. L., Winograd, K., Strohauer, D. "Student-generated story problems. Arithmetic Teacher," 39, pp6-12, 19992.

[11] Silver・E.A.・Cai,J.・"An Analysis of Arithmetic Problem Posing by Middle School Students・" Journal of Research in Mathematics Education・vol.27・No.5, pp521-539・1996.

[12] Silver, E.A, "On mathematical problem posing. For the Learning of Mathematics," 14(1), 19-28

[13] Kintsch, W., Greeno, J.G., "Understanding and Solving Word Arithmetic Problems," Psychological Review, vol.92, No.1, pp109-129, 1985.

A Method of Creating Counterexamples by Using Error-Based Simulation

Tomoya Horiguchi* and Tsukasa Hirashima**
**Faculty of Information Engineering, Kobe University of Mercantile Marine*
5-1-1, Fukaeminami, Higashinada, Kobe 658-0022 JAPAN
Phone: +81-78-431-6263, E-mail: horiguti@ti.kshosen.ac.jp
***Department of Artificial Intelligence, Kyushu Institute of Technology*
680-4, Kawatsu, Iizuka, Fukuoka 820-0067 JAPAN
Phone: +81-948-29-7618, E-mail: tsukasa@ai.kyutech.ac.jp

The method of creating counterexample by using educational simulation is proposed. Error-Based Simulation (EBS) is used for this purpose, which simulates a learner's erroneous equation in mechanics problem. A learner's error is visualized as unnatural motion of a physical object. In order for EBS to be effective as counterexample, the followings are essential: (1) A learner can recognize the difference of unnatural motion in EBS from natural one in correct simulation, and (2) EBS must provide a learner sufficient information to understand the cause of error and to reach correct understanding. The former has been studied in the authers' previous works. In this paper, the latter is discussed. To identify a learner's error, misconceptions are classified based on problem-solving model, and are linked to their appearance on a learner's answer (error-identification rules). Then, to indicate the cause of error by EBS, unnatural motions in EBS are classified and linked to the misconceptions which they suggest (error-visualization rules). These functions are realized as rule-base systems. The architecture of EBS management system, which judges a learner's error and generates the suitable EBS using these functions, is proposed.

Keywords: **counterexample, simulation, mechanics, error, student model, motion perception**

1 Introduction

It is well known that cognitive conflict promotes learning process. It often occurs when a learner encounters the fact which is contradictory to her/his idea. Cognitive conflict motivates a learner to reconsider her/his idea, and often causes conceptual change [Gagne 85, Fujii 97].

Counterexample is useful for creating cognitive conflict. It provides a case in which a learner's idea doesn't account for the fact, or her/his procedure doesn't produce the correct solution.

However, one must be careful in using counterexample, because a learner often ignores or refuses it. Even when she/he accepts the counterexample, she/he needs some kinds of help to reach correct understanding. Without any assistance, a learner often comes to an impasse, or makes ad hoc rules which explain the exception only. Therefore, in using counterexample, the followings are essential [Fukuoka & Suzuki 94, Nakajima 97]:

(1) Counterexample must be recognized to be meaningful and acceptable. When the difference is clear and reliable between counterexample and a learner's expectation, she/he easily accepts it and reconsiders her/his idea.

(2) Appropriate assistance must be provided to lead a learner to correct understanding. Counterexample must include sufficient information for this. It will be helpful to explicitly describe the distinguishing attributes of counterexample.

Error-based Simulation (EBS) is an educational simulation which provides a learner counterexample. It simulates an erroneous equation made by a learner in solving mechanics problem. In EBS, a learner's error often appears as unnatural motion of a physical object, which differs from her/his prediction (She/he can usually predict the correct motion).

The authors have developed the method of generating effective EBS mainly from the above viewpoint (1) [Hirashima et al. 98, Horiguchi et al. 99]. The condition on which a learner can recognize the difference between EBS and correct simulation was formulated (Criteria for Error-Visualization: CEV), and the mechanism to estimate the quality of difference was proposed, which considers both clarity and reliability of the difference.

However, though such an EBS motivated a learner by indicating the existence of errors, it was not sufficient to lead her/him to correct understanding. It didn't provide sufficient information for this.

Therefore, this paper proposes the method of managing EBS from the above viewpoint (2). EBS must justly indicate the cause of a learner's error, and suggest how to correct it. The followings are the requirements and approaches for this purpose.

(a) The function which identifies the cause of error behind a learner's erroneous equation or her/his handwriting diagram.
Approach: First, construct a problem-solving model of mechanics. Secondly, based on the model, classify the misconceptions which occur in problem-solving as causes of errors. Thirdly, classify the appearances of the misconceptions on a learner's equation or handwriting diagram. Lastly, appearances and causes of errors are linked together correspondingly. These are called *Error-Identification Rules*.

(b) The function which generates the EBS indicating the identified cause of error by unnatural motion of a physical object.
Approach: First, classify the unnatural motions in EBS. Then, link them to the corresponding causes of errors, considering what kind of unnaturalness suggests what kind of misconception. These are called *Criteria for Cause-of-Error-Visualization*. With these criteria, EBSs are estimated their effectiveness. When there is no EBS which is judged effective, other teaching methods will be considered.

2 Previous works in Error-Based Simulation

Before proceeding to the main topic of this paper, we outline the stream of study in Error-based Simulation, which may be helpful to clarify the present problem and the position of this paper.

Stage 0 **[Hirashima et al. 98 for summary]**

The fundamental idea of EBS is very simple. In mechanics problem, many learners feel difficulty in thinking by equations, so EBS maps their equations from mathematical world to physical world. It embodies a learner's error as unnatural motion of a physical object, which makes it much easier to recognize the error. Here, we assume that unnatural motion in EBS is differ from a learner's prediction, that is:

Precondition-1: A learner can predict the correct motion (in spite of her/his erroneous equation).
This precondition is set through all stages of the research of EBS.

Stage 1 **[Hirashima et al. 98]**

Apparently, the key of this method is how a learner sees the difference between the unnatural motion in EBS and the predicted natural motion. At least, the difference must be noticed by a learner. When the difference of two motions is small, she/he may not notice it, or cannot judge which motion is correct (unfortunately, the ability of human vision is not so sensible). Therefore, we set the following assumption:

Assumption-1: EBS must satisfy CEV-1 and/or CEV-2 below to indicate the existence of error.
Condition for Error-Visualization 1 (CEV-1): There is a qualitative difference between the motion in EBS and the one in correct simulation, that is, the qualitative values of a physical object's velocity are different between them.
Condition for Error-Visualization 2 (CEV-2): There is a qualitative difference between the change of motion in EBS and the correct simulation, that is, the qualitative values of the derivative

of a physical object's velocity are different between them.

***Stage 2* [Horiguchi et al. 99]**

When regarding EBS as counterexample, the viewpoints (1) and (2) in chapter 1 are important. We previously worked out how to estimate the effectiveness of EBS from the viewpoint (1). It is subdivided into two viewpoints: (1-1) how clear the error appears in EBS, and (1-2) how reliable the EBS is as counterexample.

From the viewpoint (1-1), the more CEVs the EBS satisfies, the more effective it is. In general, changing parameters of the mechanical system makes EBS satisfy more CEVs. for example, in Figure 2, the EBS based on erroneous equation m2a = T + μm2g (Figure 2d) satisfies CEV-1. (The qualitative value of relative velocity between two blocks is [+], while it is [0] in normal case.) But, when the mass of m2 increases, the EBS becomes to satisfy CEV-2 besides CEV-1. (The velocity of m2 increases, while it decsreses in normal case.) We categorized the methods of parameter-change and their influence on the clarity of errors.

However, from the viewpoint (1-2), such parameter-change harms the reliability of EBS, because a learner feels it factitious to change parameters too largely. The smaller parameter-change the EBS has (no change is the best), the more reliable it is. This discussion is summarized as follows.

Assumption-2: From the viewpoint of clarity, EBS should satisfy more CEVs.
Assumption-3: From the viewpoint of reliability, EBS should have less parameter-changes.

***Stage 3* [just this paper]**

In estimating the effectiveness of EBS, there is another, and important viewpoint: whether the EBS provides appropriate information for correcting the error, that is, the viewpoint (2) in chapter 1. Stage 0-2 have been mainly concerned with how to make a learner notice the error, while at this stage, our concern is how to make him correct the error.

For example, consider the erroneous equation m2a = T + μm2g (Figure 2d). From the viewpoint of reliability (1-2), the EBS shown in Figure 2c is generated. But it shows the string between two blocks shrinking, which may suggest something is wrong about tension of the string. It is misleading because the real cause of error is the friction of m2. In this case, the EBS in Figure 2e should be generated to indicate the cause of error. (It is generated when taking the viewpoint of reliability (1-2), but by accident.)

Of course, the viewpoints (1-1) and (1-2) are useful to impress on a learner the existence of error. However, in considering the error-correction, to generate EBS from the viewpoint (2) becomes necessary. It is the very topic of this paper.

3 Mechanism for Identifying the Cause of Errors

Now, we'll explain how to realize the functions described in chapter 1. The mechanism for identifying cause of errors is realized as follows:

1. to generate the correct solution by problem-solving model.
2. to specify the erroneous part of a learner's solution by comparing with the correct solution.
3. to identify the cause of error by applying the Error-Identification Rules, which link the appearance of erroneous part to its cause.

Here, a learner's solution means the equation and handwriting diagram made by her/him, from both of which the information about her/his problem-solving process is derived.

3.1 Problem-Solving Model

We deal with the mechanics problems of high school level, which ask a learner to set up equation of motion by using Newton's second law. The problem-solving process is divided into three steps [Robertson 90, Plötzner 94]:

step-1 to predict the motion of physical objects in the mechanical system qualitatively.
step-2 to enumerate the forces acting on each object.
step-3 to compose the enumerated forces and substitute them for the left side of formula F = ma.

Table 1. Force-Enumerating Rules (FERs) (abstract)

force	Rules for enumerating forces		
gravity	R0: r0-c1	Objects-1 has mass m > 0	
	→		
	r0-a1	Gravity F to Objects-1	Qualitative
	r0-a2	Dvection: vertically downward	Qualitative
	r0-a3	Magnitude: F = mg	Quantitative
friction	R3: r3-c1	Objects-1 and Objects-2 are touching together	∧
	r3-c2	coefficient of friction of touching surface μ > 0	∧
	r3-c3	normal force N acting on touching surface	∧
	r3-c4	Objects-1 and Objects-2 are moving oppositely along the tangent	
	→		
	r3-a1	friction Ff1 to Objects-1	Qualitative
	r3-a2	friction Ff2 to Objects-2	Qualitative
	r3-a3	Dvection(Ff1): opposite to the velocity of Objects-1	Qualitative
	r3-a4	Dvection(Ff2): opposite to the velocity of Objects-2	Qualitative
	r3-a5	Magnitude: Ff1 = Ff2 = μN	Quantitative

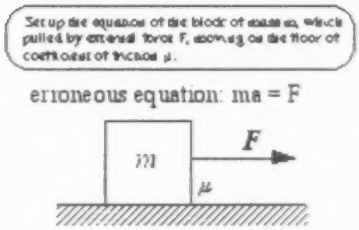


Figure 1. Example Problem-1

In step-1, a learner predicts the motion of objects in the system, and gives each object acceleration vector. Approproate axes are also set up. In step-2, she/he enumerates the forces which aren't given in problem description. Both qualitative knowledge (what kind of force acts in which direction?) and quantitative one (algebraic description of the magnitude of force) are used. In step-3, she/he decomposes/composes the enumerated forces along the axes, and substitute them for the formula F = ma.

In this paper, we don't model the error-occurring process in step-1, because it is presupposed that a learner correctly predicts the qualitative motion of objects in using EBS (Precondition-1 in chpter 2). We also omit the occurrence of error in step-3, which mostly concerns the knowledge of vector calculation.

Therefore, modeling step-2 is our central issue. Takeuchi and Otsuki (1997) considered that a learner constructs a model of causal structure of mechanical system, with which she/he infers the occurrence and propagation of forces. They formulated this process as a set of production rules. We modify them considering their qualitative/quantitative characteristics. A part of our model is shown in Table 1. The rules are called Force-Enumerating Rules (FERs).

3.2 Error-Identification Rules

In our model, a learner's errors are considered as the ones of FERs. The errors of FERs themselves and the ones in their application are included. In fact, these errors appear as the missing/extra/errors of the term of force in equation, or of the arrow of force in handwriting diagram. They are also linked to the strategies for correction.

For example, in Figure 1, the term of friction (-μmg) is missing in the erroneous equation. The cause of this error and its instruction are considered as follows:

1) A learner doesn't know the concept of friction itself, that is, doesn't know the rule R3 (Table 1).
   Instruction: Re-teach the concept/definition of friction.
2) A learner is overlooking the preconditions of R3, that is, overlooking the fact that the block is touching the floor (r3-c1), or the fact the coefficient of friction is nonzero (r3-c2).
   Instruction: Re-show the problem and indicate the corresponding part of the diagram.
3) A learner is missing the force which causes the friction, that is, missing the normal force (r3-c3).
   Instruction: Proceed to the correcting strategy of normal force.
4) A learner doesn't think the block moves along the floor, that is, missing the relative velocity of them (r3-c4).
   Instruction: This is the erorr of prediction of movement. So, out of the range of this paper. But, it may be useful to indicate the force which causes the block's motion.

Through such a consideration, the appearances of errors and their causes are classified as shown in Table 2. These are the Error-Identification Rules (EIRs), which are applied to the erroneous part of a learner's answer (specified by comparing with the correct solution), to identify the cause of error.

In Table 2, each error has its strategy for correction. Note that, it is not necessary to use EBS for every case. Of course, when other instruction method is more appropriate, it should be used. However, the aim of this paper is to clarify what kind of errors EBS is effective for, and how to estimate its effectiveness. For this purpose, we need to study the unnaturalness of physical objects' motion in simulation.

4 Criteria for Cause-of-Error Visualization

The identified error must be corrected. In this chapter, we formulate the criteria for judging whether an EBS is effective for the error. It means that EBS rightly indicates the cause of error and suggests the way of correction.

4.1 Motion and Forces

In EBS, it is the motion of physical objects (or their relationships) to be observed. Therefore, we classify the motions and connect them to the mechanical concepts they suggest.

Table 2. Error-Identification Rules (EIRs)

force	appearance	cause of errors	correcting strategy
external force/ gravity	missing	missing knowledge of gravity (R0)	re-teach the concept/definition
	extra error	misunderstanding the problem (r0-c1)	re-show the problem and educate the corresponding part
tension	missing	missing knowledge of tension (R1) overlooking the string (r1-c1) missing the force which causes tension (r1-c2)	re-teach the concept/definition re-show the problem and educate the corresponding part proceed to the correcting strategy of that force
	extra	believe that string propagates tension (r1-c2) overlooking that spring loosens string (r1-c2)	re-show the problem and educate the corresponding part educate that tension is extra
	error	error of the force which causes tension (r1-c2) error of direction/magnitude (r1-a2/3)	proceed to the correcting strategy of that force educate that direction/magnitude is erroneous
normal force	missing	missing knowledge of normal force (R2) overlooking the contact/attachment (r2-c1) missing the force which causes normal force (r2-c2)	re-teach the concept/definition re-show the problem and educate the corresponding part proceed to the correcting strategy of that force
	extra	believe that normal force works (r2-c2) extra of the force which causes normal force (r2-c2)	educate that normal force is extra proceed to the correcting strategy of that force
	error	error of the force which causes normal force (r2-c2) error of direction/magnitude (r2-a2/3)	proceed to the correcting strategy of that force educate that direction/magnitude is erroneous
friction	missing	missing knowledge of friction (R3) overlooking the contact together (r3-c1) overlooking that coefficient of friction $\mu > 0$ (r3-c2) missing normal force (r3-c3) believe that normal force doesn't work (r3-c4)	re-teach the concept/definition re-show the problem and educate the corresponding part re-show the problem and educate the corresponding part proceed to the correcting strategy of normal force educate that friction is missing
	extra	missing that coefficient of friction $\mu = 0$ (r3-c2) extra of normal force (r3-c3) believe that normal force works (r3-c4) extra of the force which causes friction (r3-c4)	re-show the problem and educate the corresponding part proceed to the correcting strategy of normal force educate that friction is extra proceed to the correcting strategy of that force
	error	error of normal force (r3-c3) error of the force which causes friction (r3-c4) error of direction/magnitude (r3-a3/4/5)	proceed to the correcting strategy of normal force proceed to the correcting strategy of that force educate that direction/magnitude is erroneous
propagating force	missing	missing knowledge of force propagation (R4/5) overlooking the contact together (r4/5-c1) missing of the force which causes force propagation (r4/5-c2)	re-teach the concept/definition re-show the problem and educate the corresponding part proceed to the correcting strategy of that force
	extra	believe that force propagates (r4/5-c2) extra of the force which causes force propagation (r4/5-c2)	educate that propagating force is extra proceed to the correcting strategy of that force
	error	error of the force which causes force propagation (r4/5-c2) error of direction/magnitude (r4/5-a2/3)	proceed to the correcting strategy of that force educate that direction/magnitude is erroneous
other	extra	impetus	educate that impetus is extra

BEST COPY AVAILABLE

How does a human perceive and recognize moving objects? Though it is well known that their figurative characteristics (figure, size, texture, etc.) and composition (position, direction, symmetry, etc.) have great influence on the arising images, it is difficult to generalize them because they much depend on the cultural factors. Therefore, we limit our target to the physical world of simulation, in which things are thought in the sense of mechanics.

When observing an object to move, a human feels its motive 'force' working. Of course, this kind of 'force' is of naive impression and doesn't always correspond to the real force. But it appeals to human's intuition so much more. Bliss & Ogborn (1992) classified such naive concepts of force according to the stages of child development. Based on their findings, we consider the relations between the mo tions in EBS and the forces they suggest.

4.2 Motion of a single object

A moving object arises the feeling of force working. (e.g. A falling down ball suggests gravity.) Therefore, the object moving unnaturally in EBS is supposed to suggest the erroneous force acting on it. (e.g. gravity, friction etc.) Unnatural motions of a single object are classified as follows:

(a) Directions of both velocity and acceleration are opposite to the ones of correct motion.
(b) Direction of only velocity is opposite to the one of correct motion.
(c) Direction of only acceleration is opposite to the ones of correct motion.
(d) Directions of both velocity and acceleration are same as the ones of correct motion.

Here, it is assumued that human can distinguish at most the qualitative difference of velosity or acceleration of an object in motion [Hirashima et al. 98, Horiguchi et al. 99].

For example, in case (a), when a learner observes an object moving in the opposite direction to her/his prediction (which is correct), she/he will recognize that the force is missing which acts in the predicted direction, or that the force is extra which acts in the present direction.

Table 3 shows the relations between unnatural motions and the errors they suggest. They are called Criteria for Cause-of-Error Visualization (CCEVs).

4.3 Relative Motion of two objects

Moving plural objects also arises the feeling of force working. We limit to two objects. When observing two objects moving together, the force maintaining their relative motion is felt. (e.g. A moving dolly pulling another one connected by string suggests tension.) Therefore, two objects relatively moving in unnatural manner in EBS are supposed to suggest the erroneous force interacting between them. (e.g. tention, normal force etc.) Unnatural relative motions of two objects are classified as follows:

(e) Two objects are closing with each other, which are connected by string. (String shrinks.)
(f) Two objects are going away from each other, which are connected by string. (String stretchs.)
(g) Two objects are overlapping each other.
(h) Two objects are parting from each other, which are attached together.

For example, in case (g), when a learner observes such unnatural relative motion, she/he will recognize that the normal force is missing or too small which interacts between two objects.

Table 4 shows the relations between unnatural relative motions and their suggesting errors. They are also called Criteria for Cause-of-Error Visualization (CCEVs).

Note that, all of the motions in Table 3 and 4 have at least some kinds of qualitative difference from the correct motions. This is because, however precisely an EBS indicates the error, it isn't effective unless a learner recognizes it as 'unnatural.' The difference is judged with Criteria for Error-Visualization (CEVs) [Hirashima et al. 98, Horiguchi et al. 99].

Table 3. Criteria for Cause-of-Error Visualization (CCEVs) (for single object)

[illegible]		difference	suggesting errors
correct [illegible]		–	–
[illegible] (a)		velocity. opposite acceleration. opposite	missing of the force opposite to moving direction ◎ extra of the force same as moving direction ◎ larger of the force same as moving direction ○ smaller of the force opposite to moving direction ○
[illegible] (b)		velocity. opposite acceleration. same	missing of the force same as moving direction △ missing of the force opposite to moving direction ◎ extra of the force same as moving direction ◎ extra of the force opposite to moving direction △ larger of the force same as moving direction ○ smaller of the force opposite to moving direction ○
[illegible] (c)		velocity. same acceleration. opposite	missing of the force same as moving direction ◎ extra of the force opposite to moving direction ◎ smaller of the force same as moving direction ○ larger of the force opposite to moving direction ○
[illegible] (d)		velocity. same acceleration. same	missing of the force opposite to moving direction △ extra of the force same as moving direction △

note 1. ◎ . able to suggest the error by itself with great effect
○ . able to suggest the error by itself with small effect
△ . need to be modified some parameter(s) to suggest the error

note 2. The error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction.

Table 4. Criteria for Cause-of-Error Visualization (CCEVs) (for two objects)

[illegible]		[illegible]	suggesting errors
correct [illegible]		constant distance	–
[illegible] (e)		closing strong dynamics	extra/larger of the tension ◎ extra/larger of the propagating force ○
[illegible] (f)		going away strong dynamics	missing/smaller of the tension ◎ missing/smaller of the propagating force ○
[illegible] (g)		overlapping	missing/smaller of the normal force ◎ extra/larger of the normal force ○ missing/smaller of the propagating force ○ extra/larger of the propagating force ○
[illegible] (h)		parting from each other	missing/smaller of the normal force ○ extra/larger of the normal force ◎ missing/smaller of the propagating force ○ extra/larger of the propagating force ○

note 1. ◎ . able to suggest the error by itself with great effect
○ . able to suggest the error by itself with small effect

note 2. The error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction.

5 Examples

In this chapter, we illustrate the process of identifying the cause of error and generating the EBS which indicates the error. The example problem is shown in Figure 2.

5.1 A Simple Case

First, the solution (correct equation and diagram: Figure 2a) is generated by problem-solver. Then, it is compared with a learner's answer (Figure 2b) to specify the erroneous part. In this case, it is the erroneous

BEST COPY AVAILABLE

value (too large) of tension beside block m2. Secondly, EIRs (in Table 2) are applied to identify the cause of error. It is identified as the error of magnitude of tension. According to Table 2, the correcting strategy of this error is to indicate the fact. Then, CCEVs (in Table 3 and 4) are applied, to find that the motion (g) satisfies this demand.

Based on the erroneous equation of Figure 2b, the EBS shown in Figure 2c can be generated, in which block m2 moves faster than its normal case, consequently the string shrinks. This unnaturalness is equal to the one of motion (g). Therefore, this EBS is judged to satisfy the instructional demand, and shown to the learner.

5.2 A Complicated Case

Consider the erroneous answer of a learner in Figure 2d. In this case, the erroneous part is the erroneous direction of friction acting on block m2. By EIRs, the cause of error is identified as the error of direction of friction, and the correcting strategy is to indicate the fact. Since the error of force in direction is divided into the missing of the force of correct direction and the extra of the force of incorrect direction (see note 2 of Table 3), the motions (a), (b), (d) satisfy this demand.

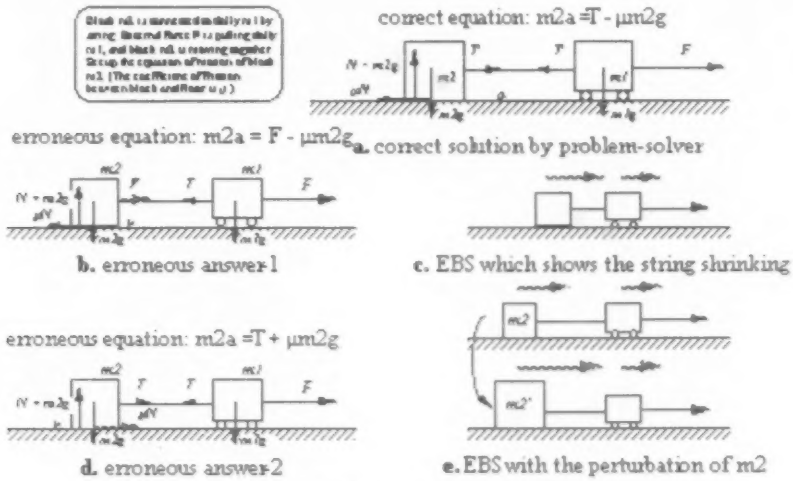


Figure 2. Example Problem-2

Based on the erroneous equation of Figure 2d, however, it is impossible to generate the EBS which contains the motion (a) or (b). In addition, even when the EBS containing the motion (d) is generated (it is possible), it causes the unnatural relative motion (e), which indicates another error. In fact, the EBS, in which block m2 is closing to dolly m1 (the same as Figure 2c), strongly suggests the error of tension. This misleads a learner.

Therefore, in this case, the EBS must be modified to precisely indicate the identified error. Perturbing the mass of block m2 is a promising method. When the mass m2 increases, in EBS, the velocity of the block increases (Figure 2e). This is a strange change of motion. Observing this, a learner may think some physical amount is wrong which concerns the mass m2. She/he may notice the erroneous friction acting on block m2.

As for the EBS of Figure 2e, the difference from the correct simulation is not so much clear and reliable as the EBS of Figure 2c. Instead, it provides precise information for correcting the error, while the EBS of Figure 2c doesn't. In general, plural EBSs can be generated from one erroneous equation. The best should be chosen according to the purpose.

6 Concluding Remarks

In this paper, we proposed a method of creating effective counterexamples by using Error-Based Simulation. The effectiveness of EBS is judged mainly from the viewpoint whether it provides sufficient information to recognize the cause of error and correct it. The mechanism for identifying the cause of error and for

generating the EBS which satisfies the instructional demand was also proposed. We are now implementing the mechanism. The experiment to evaluate our method is planned.
Our future works are as follows:

1. *Cooperation with other instructional tools:* Of course, EBS isn't sufficient for all of the error correction in Table 2. It must be studied to use other instructional tools (textbook, normal simulator etc.), and to coordinate them with EBS.
2. *Refinement of the problem-solving model:* Our model for problem-solving is very simple, so the range of the error it covers is limited. We are going to refine the model, especially considering the process in which a learner qualitatively predicts the motion of mechanical system.
3. Consideration of conflict among CCEVs: As is noted in section 5.2, the effects of plural unnatural motions sometimes conflicts each other. One unnatural motion may invalidate the effect of other unnatural motion. Therefore, it is necessary to set some kind of preferences to CCEVs.

References

[1] Gagne, E.D. (1985). The Cognitive Psychology of School Learning, Little Brown and Company.

[2] Fujii, T. (1997). Mathematical Learning and Cognitive Conflict, In Japan Society of Mathematical Education (Ed.), Rethinking Lesson Organization in School Mathematics, Sangyotosho, Tokyo (in Japanese).

[3] Fukuoka, T. & Suzuki, K. (1994). A Case Study on Lower Secondary School Pupils' Conceptual Changes through Demonstration of Counterexamples: The Concept of Dynamics in the Case of Roller Coaster Models, Bulletin of Society of Japan Science Teaching, Vol.35, No.2, pp.21-32 (in Japanese).

[4] Nakajima, N. (1997). The Role of Counterevidence in Rule Revision: The effects of instructing metaknowledge concerning non adhocness of theory, Japanese Jour. of Educational Psychology, 45, pp.263-273 (in Japanese).

[5] Hirashima, T., Horiguchi, T., Kashihara, A. & Toyoda, J. (1998). Error-Visualization by Error-Based Simulation and Its Management, Int. Jour. of Artificial Intelligence in Education, Vol.9, pp.17-31.

[6] Horiguchi, T., Hirashima, T., Kashihara, A. & Toyoda, J. (1999). Error-Visualization by Error-Based Simulation Considering Its Effectiveness: Introducing Two Viewpoints, Proc. of AI-ED99, pp.421-428.

[7] Robertson, W.C. (1990). Detection of Cognitive Structure with Protocol Data: Predicting Performance on Physics Transfer Problems, Cognitive Science, 14, pp.253-280.

[8] Plötzner, R. (1994). The Integrative Use of Qualitative and Quantitative Knowledge in Physics Problem Solving, Frankfurt: Peter Lang Verlag.

[9] Takeuchi, A. & Otsuki, S. (1997). An Intelligent Tutor for Kinetic System Modeling, Proc. of AI-ED97, pp.340-346.

[10] Bliss, J. & Ogborn, J. (1992). Steps Towards the Formalisation of a Psycho-logic of Motion, In A. Tiberghien & H. Mandl (Eds.), Intelligent Learning Environments and Knowledge Acquisition in Physics, Heidelberg: Springer-Verlag.

Adaptive Programming Language Tutoring System on the Web

Jin-woo Choi and Chong-woo Woo
Department of Computer Science, Kookmin University
861-1 Chongnung-Dong, Sungbuk-ku, Seoul, Korea
Tel: +82-2-910-4795
Fax: +82-2-910-4799
Email: cwwoo@kmu.kookmin.ac.kr

Many of the web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing proven techniques from the stand-alone Intelligent Tutoring System(ITS). Some recent web-based ITS researches show this efforts by employing the techniques selectively, and this needs to be studied further to support more effective web-based instruction. In this paper, we describe the design and the development of a Web based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting previous ITS techniques into the system successfully. Especially our focus is on the three levels of the instructional planning mechanism, which can generate lesson contents dynamically whenever it is requested. This way we do not need to crate all the lesson contents in HTML forms which must reside in the system in advance. In addition, the system has adapted CORBA structure to support the user more consistent and reliable performance. Together, the system behaves more adaptive and interactive, than the existing non-ITS based web systems. The test domain of the system is learning C programming language for the first year computer science student.

Keywords: **Web-based learning system, Intelligent Tutoring System, Instructional planning**

1 Introduction

Many recent web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing techniques from the stand-alone ITS. Brusilovsky[2] states that some ITS techniques can be adapted into a web-based educational system, and divides the techniques into three distinctive parts, such as, automatic creation of curriculum, dynamic problem solving, and intelligent analysis of student model. However, most of the recent web-based ITS research show the efforts by employing the techniques selectively[2][3][4][7], such as adapting student modeling or problem solving capability at some level. Therefore, this needs to be studied further to enhance the overall capabilities of the system at the previous stand-alone ITS level. For instance, automatic generation of curriculum or lesson plan is necessary to provide a flexible instruction for each individual user.

In this paper, we describe the design and development of Web-based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting many techniques from the stand-alone ITS into the web-based systems. First, we designed the knowledge base using the object-oriented method in order to handle flexible management of object inheritance and tutorial strategies. Second, the student modeler can avoid the network traffic by designing the modeler stays in the server-side at the beginning of the session for maintaining necessary administration duties, and creates an individual student model in the client side. And the third important approach is having the instructional planning mechanism, which generates lesson contents dynamically for each individual user. This is important feature for moving towards the web-based system, because most web-based educational systems

creates all the lesson contents in HTML forms in advance, and they must reside in the system physically. And then the user navigates the system for learning, such as in ELM-ART[2] or CALAT[4]. Intelligent navigation strategy might be one of the intelligent way of guiding the user to learn the material, but rather inefficient compare to the dynamic generation of lesson contents. WALTS only generates the necessary lesson contents whenever it is requested by the system, which can be another advantage. In addition, we have approached distributed architecture by employing CORBA(Common Object Request Broker Architecture) structure to support the user more consistent and reliable performance while the user using the system. The initial web-based educational systems are mostly developed by using the CGI(Common Gateway Interface) techniques, which often results in bottleneck problem when many users access the system at the same time. In this sense, our structure might avoid such a problem, and the system could also be easily updated when we need to revise some part of the system. Together, the system behaves more adaptive and interactive, than the existing non-ITS web-based educational systems. The test domain of the system is learning C programming language for the first year computer science student.

The rest of the paper is organized as follows. In section 2 we described a distributed infrastructure of WALTS system. Section 3 presents each components of the system and also some intelligent aspects of the system. We conclude the paper in section 4.

2 Distributed infrastructure

The previous web-based educational systems have been built as either a server-based architecture or a client-based architecture[6]. Each of them has some advantages and disadvantages. The server-side architecture mostly rely on CGI techniques, which has shown some problems of handling complex client/server communication because of its connectionless feature. Also client-side architecture needs to have all the plug-ins installed on client computer before using the system. Therefore the recent web-based applications tend to adapt CORBA or Java based distributed infrastructure. That is free from the connectionless or stateless problem, and also has some advantages of distributed system technology, such as message passing, RPC(Remote Procedure Call), and proprietary communication protocol. The client connects to the server using the HTTP protocol only for the initial connection, and after the downloading the specific mobile code application(for example, client side application, JavaScript, Java Applet, and etc), the client use the proprietary protocol(non-HTTP), so it does not communicates with web server, but communicates with proprietary server(non-Web server).

WALTS employed CORBA to adapt this kind of distributed infrastructure. The system is designed by HTTP server which takes care of user requests and responses, and CORBA-based server which performs the capabilities of the ITS. Also the system could be easily re-organized if we want to modify the structure later on [see figure 1]. In short, one of the major advantages of WALTS is that it can easily avoid the bottle-neck problem of CGI techniques, and also we believe that this style of architecture might be another best solution for building web-based client/server educational system.

3 Basic architecture of the system

The basic architecture of WALTS is designed by typical ITS structure primarily, including expert module, the student modeler module, and the instructional planning module.

3.1 The expert module

The expert module of the system consists of the object-oriented knowledge base, and the problem solver.

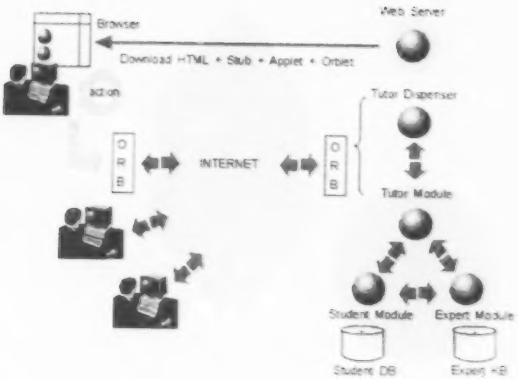


Figure1 The main architecture of the WALTS

Object Oriented-based knowledge base. First, we employed the frame knowledge representation techniques for the main knowledge base. Because the domain knowledge does not require any complex causal relationships, but rather it is consists of simple C language concepts. The object-oriented approach make it easy to modify the data type, can reduce the knowledge base reference by having slot values as member data, and can provide more flexibility for updating or manipulating tutoring strategy [5].

In this system we designed a frame with several meaningful slots, and each frame does not have to have the same number of slots, since the inference engine can get all the necessary informations due to the inheritance feature of the system. The 'type' slot can possess a concept, example, or quiz. The 'source' slot points to its superior frames. The 'Pfame' and 'CFrame' slot is necessary when we need to show the related nodes in linked list structure. The 'reference' slot may contain all the necessary frame names that are related to the current frame. This kind of slot structure is very common in every frame structure, and also important in object-oriented structure, because each frame can have common attributes and can generate an object of having its own attribute. Also, the system allows an abstract class, which plays the backbone of the system, and supports a hierarchical structure, and the definition of the method can be done only in the lower class [figure 2].

Frame Variable Declaration Quiz
[Source] Chapter1-3-1-1
[Type] Quiz
[Title] Variable declaration Quiz
[Template] Data Type | Variable | General Grammar
1 : Select the correct %type variable declaration
2 : ...
[PFrame] Variable Declaration
[CFrame] Null

Figure2 Variable declaration quiz frame

The Problem Solver. WALTS can generate a problem dynamically depending on the current topic. Since the planner knows what is being taught at the moment by generating a lesson unit, the tutor can decides whether it is 'teaching concept' or 'show example' or 'quiz'. At the moment, we have only three styles of lesson unit. If it is a 'teaching concept', the planner sends the lesson unit to the user in HTML form. If it is a 'quiz' type, then planner requests the problem solver to generate a question. The problem solver first creates a problem table by referring to the current lesson unit. The generating and solving a problem occurs at the same time, and the solver stores the correct answer. And then, it presents the generated questions to the user in appropriate HTML form through the HTML generator. This method can provide different styles of questions for different users even though they are accessing the same lesson unit, which can be another advantage of WALTS. Since the column name of the table is object's name, the planner can reply to the user's request, such as hint or help, by referencing this table.

BEST COPY AVAILABLE

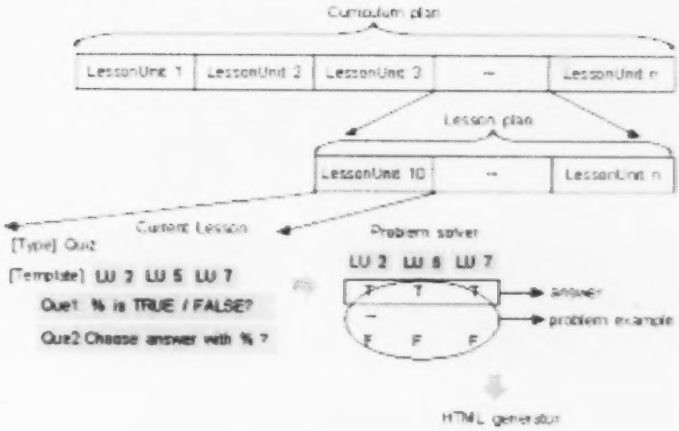


Figure3 Creation of a quiz for 'variable declaration'

The strategy of asking user for answering quiz is multiple choices. So that we need to generate problems along with the appropriate multiple choice answers also. For instance, let us think about a simple quiz about asking user 'a data type'. A typical 'data type' is consists of three parts, for example, 'int x ;'.The 'int' is a data type integer, 'x' is a user-defined variable name, and ';' is needed for ending a sentence in C language. We are trying to generate this simple data type declaration statement sentence as follows. First, the data type 'template' slot consists of three parts as in [Figure 3]. Then we can generate eight different answers as in [Figure 5], since each one part of a statement can be correct or incorrect. And we can select some of them randomly including correct answer; the numbered answers are selected ones in the figure. And also we can obtain designated unit object's content as in [Figure 4]. The generated correct answer is stored in memory, and then later it is compared with the user's answer. For example, if the user selected number 2 as in [figure 5], we can analyze that the user does not know about reserved word. And the planner needs to revise the lesson plan to correct the misconceptions by giving special messages, such as hint or help, and then the planner re-organizes the lesson plan including 'reserved word' lesson unit. The [figure 6] shows a sample session of solving a generated quiz.

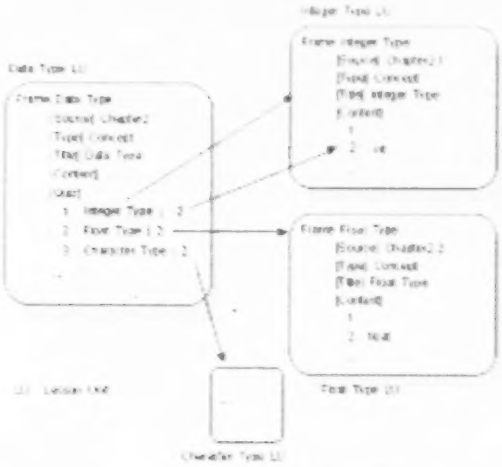


Figure4 Data type unit frame

Data Type	Variable	General Grammar	
T	T	T	← ④
T	T	F	
T	F	T	← ②
T	F	F	← ①
F	T	T	
F	T	F	← ③
F	F	T	
F	F	F	

Figure5 Table for possible answers for data type quiz

3.2 The Instructional Planner

The most web-based educational systems built upon hypertext, which is hard to make hyperlink in every HTML pages, and also needs to have carefully designed navigation strategy[2]. And also all the lesson contents are built as HTML pages in advance, and must reside in the system physically. We believe that generating a lesson plan dynamically, for each individual user, is more efficient than the above approaches. Therefore, we adapted the traditional ITS instructional planning mechanism into the system. The instructional planning of the WALTS can be further divided into 3 steps, a curriculum planning, a lesson planning, and a delivery planning. The curriculum planning of WALTS generates a curriculum in tree structure; the curriculum planner extracts information from the knowledge base and creates a curriculum hierarchically in the order of prerequisites. Then the lesson planning sets up the lesson sequence within a single lesson unit. The role of delivery planning is limited to presenting the selected lesson content to the user.

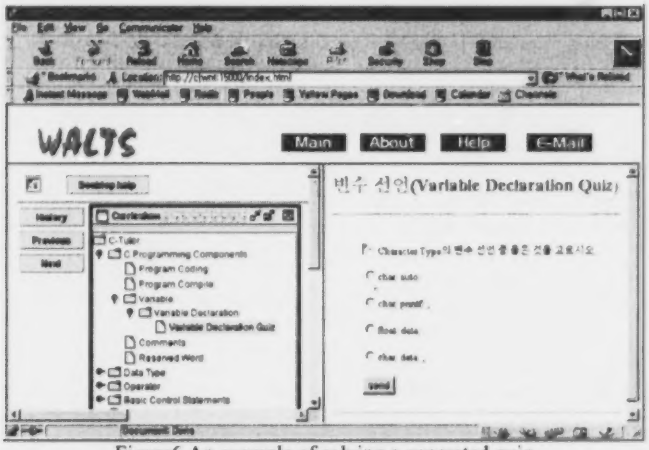


Figure6 An example of solving a generated quiz

Curriculum planning. The purpose of the curriculum planning is to provide a curriculum to the user, in other words, to provide an individualized optimal learning path to the user[1]. The generated curriculum is in the form of a tree structure. It is constructed by creating an initial node by referencing the value of the attributes in the lesson unit slot, and further expands the structure in the order of the way the student must learn, which will be accessed as linked list structure. The lesson unit of the system is organized according to some b[illegible] rule, such as the student must learn prerequisite concept first and the move to the next topic. So the curriculum is set up in the form of hierarchical and linear sequence.

Lesson Planning. The lesson planner generates a lesson plan by referencing the curriculum and the student model. The information from the student model shows the results from single lesson unit and based on this record, the planner sets up appropriate lesson plan for the student. When the student selects other learning path on purpose before the current lesson plan is finished, the system must decide what to do next, such as whether to store the current lesson plan and execute the user's request, and then resume the current plan or destroy the current plan and re-plan the whole sequence all over again. In that sense, WALTS uses re-planning strategy when the user wants to quit the current topic, and move to another learning path. Another

BEST COPY AVAILABLE

case of re-planning occurs when the student made an error on the selected quiz lesson unit. If the student made a mistake on this, the current lesson plan is suspended, and another new lesson plan is created to correct the student's error. After the remediation process is finished, the suspended plan will be resumed.

Delivery Planning. The lesson unit has been generated by lesson planner and needs to be delivered to the user. The possible delivery tactic in this domain could be "present concept, show example, give exercise, and etc". Of course if the system allows mixed-initiative control, the delivery planning needs to be more sophisticated in order to handle all the user request or questions. The delivery planning part of the WALTS is made of simple structure, and will be enhanced further in the next research.

The HTML generator. The very distinctive feature of the system is the HTML generator. This feature can be regarded as the interface part of the system. When the delivery planner decides the immediate unit lesson, the content of the lesson is converted into HTML form by the HTML generator. The HTML generator generates HTML pages according to the HTML2.0 protocol and inserts "next" or "previous" button in order to navigate adaptive learning path. But if the lesson unit contains some applet, the system directly searches the physical location and sends the URL to the student's browser without consulting HTML Generator. The [figure 7] describes the HTML generator sends two different results to two different users, since their learning background is different.

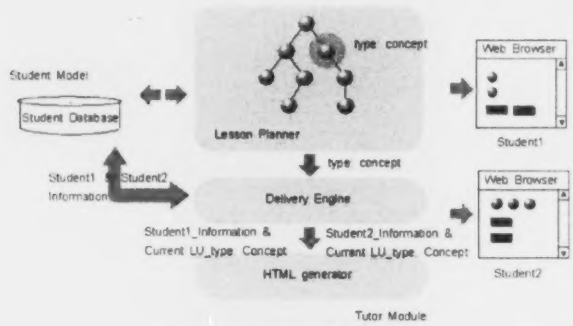


Figure7 The HTML generator

3.3 The student modeler

The strategy for building the student modeler is the simple overlay, which simply reflects user's learning process about current topic. And this should be enhanced by including the buggy information later on. But an important enhancement is that the student modeler of WALTS can avoid the unnecessary network traffic. For instance, if the system maintains the student model in the server-side, then whenever the user accesses the system the server needs to update the user's student model in the server. This may cause another bottleneck problem, and the most CGI-based systems still have this problem. Our approach on the student modeler is as follows. The server-side student modeler creates a table, and keeps all the necessary administrative informations on the server-side, such as initial student's ID, password, e-mail address, the access time[figure 8], which can be used for various administrator purposes. And the information regarding the student's learning process is stored in the student model[figure9], which is created in the client-side machine for each individual user whenever they logged on. The student model has several parameters that reflect the student's learning history, and each parameter has unique meanings. For example, the 'HelpCount', means how many times the user has been helped, and 'HintCount' means how many times the user has requested hints, and they can be updated only when the 'unit lesson' is quiz. The 'ReferenceCount' means the user is weak at the current unit lesson since the specific lesson has been accessed more often than other frames. The 'LessonLevel' stores information about how the level of the current topic, and the 'LessonType' means whether the current unit lesson is concept, example, or quiz, and so on.

BEST COPY AVAILABLE

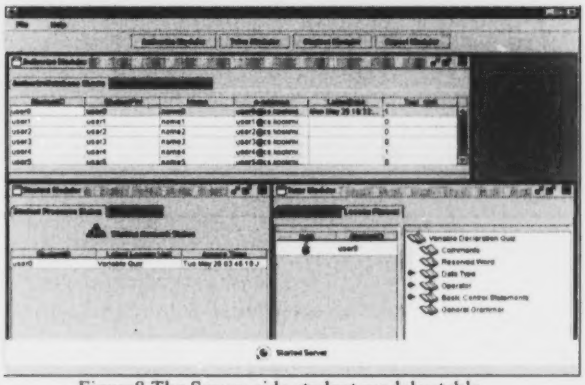
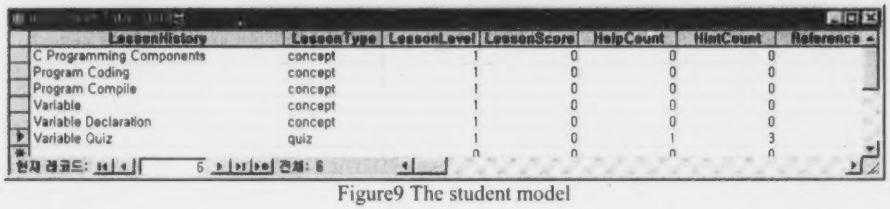


Figure8 The Server-side student modeler table



LessonHistory	LessonType	LessonLevel	LessonScore	HelpCount	HintCount	Reference
C Programming Components	concept	1	0	0	0	
Program Coding	concept	1	0	0	0	
Program Compile	concept	1	0	0	0	
Variable	concept	1	0	0	0	
Variable Declaration	concept	1	0	0	0	
Variable Quiz	quiz	1	0	1	3	
		0	0	0	0	

Figure9 The student model

4 Conclusion

We have designed and implemented a web-based ITS, WALTS, which is a learning C programming language tutor aiming for the first year computer science students. The main goal of this paper is, first, the adaptation of the existing ITS techniques into the web platform. Therefore, we have designed and implemented the system based on the major ITS architecture, and this brings us several advantages over traditional HTML-based educational systems. First, the main knowledge base is created as an object-oriented concept, which can provide more flexibility for manipulating frame objects and tutoring strategy also. Second, we have generated a quiz dynamically by the problem solver and also can solve the problem. Third, we designed a student modeler that can avoid the network traffic in the minimal, by having the modeler in the server-side, and creates an individual student model in the client-side. Fourth, the instructional planner can generate an instructional plan dynamically, and this is another advancement of building web-based ITS, since the current web-based ITS research shows further work on this subject. Additional issue of the paper is that we designed the system as the distributed infrastructure using CORBA as backbone of the system. This structure solves the bottleneck problem of previous CGI dependent systems, and also gives some benefits of better performance and also gives flexibility in the case of further enhancement of the system.

References

[1] P. Brusilovsky. "Adaptive Educational Systems on the World-Wide-Web: A Review of Available Technologies" http://www-aml.cs.umass.edu/~stern/webits/itsworkshop/brusilovsky.html

[2] P. Brusilovsky, E. Schwarz, and G. Weber. "ELM-ART: An Intelligent Tutoring System on the WWW." The Proceedings of ITS'96, pp261-269, Springer, (1996).

[3] J. Kay and R.J. Kummerfeld "An Individualized Course for the C Programming Language." The Proceedings of 2nd International WWW Conference, Chicago, IL, pp17-20, (1994).

[4] K. Nakabayashi, M. Maruyama, Y. Koike, Y. Kato, H. Touhei, and Y. Fukuhara. "Architecture of an Intelligent Tutoring System on the WWW." The Proceedings of AI-ED'97, pp39-46, (1997).

[5] K. Nakabayashi, H. Touhei, S. Hitoshi, and Y. Fukuhara. "An Object-Oriented Architecture for a Web-based CAI System", The Proceedings of EDMEDIA'98, (1998).

BEST COPY AVAILABLE

[6] A. Silva, M. Silva, and J. Delgado. "A Survey of Web information Systems." The Proceedings of WebNet'97, pp520-530, (1997).
[7] M. Stern, B. Woolf, and J. Kurose, "Intelligence on the Web?," The Proceedings of AI-ED'97, pp490-497, (1997).

Agent-Based Collaborative Learning Environment for Intelligent Tutoring System (ITS)

Teresita C. Limoanco and Raymund C. Sison
ccstcl@ccs.dlsu.edu.ph, ccsrcs@ccs.dlsu.edu.ph
College of Computer Studies, De La Salle University, Professional Schools Inc.
Manila, Philippines

This paper proposes a general architecture illustrating how students can learn through peer interaction in an interconnected environment. Three (3) predominant components comprise the architecture: *the student model, the tutor model* and *a pedagogical agent* known as *SPY*. The use of pedagogical agents is the essential part in the proposed architecture, in which information received from other students will be used as one of the tutoring strategies to assist students in learning. Collaborative/cooperative learning is achieved between students and the tutor, or among students, through pedagogical agent interaction. Moreover, the architecture supports a collaborative learning environment that helps improve students' comprehension.

Keywords: **collaboration, collaborative learning, agents, intelligent tutoring system**

1 Introduction

With the advancement in technology, computers have become essential tools in developing systems that cater to the different needs of users. Currently, many works have been done in the field of education. Systems known as *intelligent tutoring systems (ITSs)* were developed to teach students on specific topics, test their knowledge by giving exercises, and provide remediation on topics students did not perform well. An *intelligent tutoring system* is a computer program for educational support that can diagnose problems of individual learners. Such diagnostic capability enables it to adapt instruction or remediation to the needs of individuals [5]. Currently, the state of ITSs is focussed on one-on-one learning instruction. Specifically the kind of learning modality used is centered on *learning by being told* [2]. However, in reality, students can also learn through interactions with his/her peers or work in a team (or a group). The information students receive from his peers can help improve his comprehension on the topics at hand. A new learning paradigm has emerged aiming on this area and this new learning paradigm is known as *collaborative learning*. Collaborative learning emphasizes on how students function in a group and how the students' interaction with his peers or work in a team can help improve students' learning. This can be seen as either gaining new knowledge or verifying the correctness of what the students had learned so far.

Meanwhile, one of the major issues in Distributed Artificial Intelligence involves multi-agency. The agents in a multi-agent system are designed to solve a kind of problem. This is based on the fact that agents are autonomous and can recognize their own existence and the existence of other agents. Agents help each other in order to achieve a common purpose within a certain environment. Agents can assist each other by sharing the computational load for the execution of subtasks of the overall problem, or through sharing of partial results that are based on somewhat different perspectives of problem solving on the overall problem. Moreover, this form of cooperation addresses the nature of communication between cooperating agents.[1,6] Due to the social ability[1] and proactivity[2] of agents, many research, and works whether related on education (i.e., ITSs) or interface learning have been done with the incorporation of agents. Some works include defining software agents to analyze the collaboration in a virtual classroom [3]. [2] proposed a system that is a CSCW environment with

---

[1] Ability of agents to interact with other agents and human agents through some kind of an agent communication language. [3]

[2] Agents do not simply act in response to its environment, but they are able to exhibit goal-directed behavior by taking the initiative. [3]

artificial agents assisting students in their learning tasks. Furthermore, it uses a tutor agent partially replacing the human teacher. [4], on the other hand, showed that the tutoring knowledge in ITS can be designed and organized as a team of interacting pedagogical agents. These agents communicate with the student depending on the tutoring function they fulfill. Some tutoring functions include domain presentation, domain assessment, problem solving type of exercises, topic selection, problem-step solving, domain explanation, and the like.

This paper presents a new approach to collaborative learning using agents. The collaboration of agents is seen as sharing of information in the environment. The main thesis is that information received from other agents can be used as one of the tutoring strategies of other students learning in the network. The paper is organized as follows: Section 2 describes the general proposed collaborative learning architecture, the different components associated and their interrelations. Section 3 presents how artificial agents can support the learner and describes the kind of learning strategy each agent should posses in the system. The last section summarizes some issues that need to be considered in the proposed architecture.

2 Collaborative Learning Environment

The learning comprehension of a student on certain topics can be improved if the student is allowed to interact with his peers and not only with the tutor. This is because the way a student understands a topic can be applied as the same approach for other students who have difficulty comprehending the same topic. For example, two students (Student A and Student B) are studying at the same time on the same topic. They may be physically present but in different places. Student A is able to understand the topic well, but B is having difficulty with the topic. Instead of leaving the topic without fully understanding it (for the current topic may have an effect on the succeeding topics), B can either collaborate with his tutor or with A. Since B's tutor may use the same approach in explaining the topic as he did earlier, B "collaborates" with A. The collaboration may be in the form of using the same tutoring strategy used for A. With this, it is essential to develop ITSs that allows students' interaction that goes beyond the student-tutor relationship.

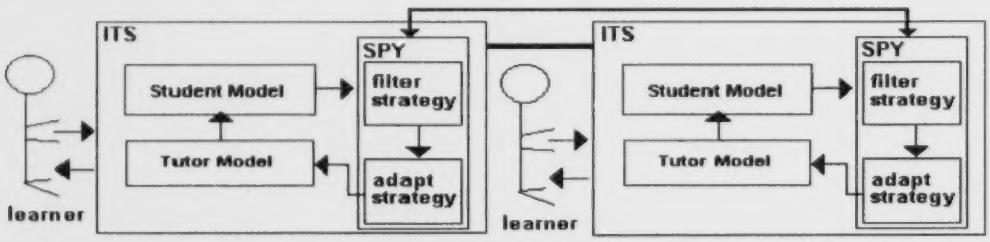


Figure 1: Agent-based Collaborative Learning Architecture

Figure 1 shows the proposed agent-based collaborative learning environment of an ITS system. The proposed architecture intends to illustrate collaboration that is not limited to student-tutor relationship but allowing students to interact directly or indirectly with his peers. In addition, this is done through interaction of the pedagogical agent SPY with the other agents of ITSs in the environment. It is assumed in the architecture that there can be several ITSs in the environment for a given domain. Though there may be the same set of tutoring strategies for the ITSs, it is possible that different tutoring strategies are used for the same topic. For instance, both student A and student B are currently studying lesson 1. However, the tutoring strategy used for A is presentation of lectures with illustrations, while B uses simple presentation of lectures. Furthermore, these ITSs are interconnected in a reliable network. The architecture can be implemented in either an Internet or Intranet infrastructure. Thus, it is good and useful for open and distance learning education.

There are three (3) main components in the architecture and these are the *tutor model*, *the student model* and *a pedagogical agent* known as *SPY*. Each of these is discussed below:

- ***Student Model:*** This module contains information about students' profiles and behaviors. Such information involves what the student has learned so far, has not learned, will be about to learn, and the possible misconceptions and their explanations on topics presented during the learning activity. Furthermore, the student model keeps track of the performance level of the students.

- ***Tutor Model:*** This module is responsible for the delivery of topics to students. Moreover, the tutor model also determines and delivers exercises to be solved by students. It is inherent in the tutor model that when presenting the exercise it considers student's level.

- ***SPY***: Each student is assigned an autonomous agent in the learning environment. This agent is responsible for gathering information such as the tutoring strategy used, the topic where the tutoring strategy is applied and the performance of students during his interaction with the ITS. Furthermore, SPY collaborates with other agents in the environment, with or without the presence of the student and the tutor. This means that SPY persists even if the student is not using the ITS. The information gathered will be used to determine the appropriate tutoring strategy for a particular topic for a student.

Specifically, the student interacts with the ITS in order to learn new concepts or to verify the correctness of what he has learned so far. During the learning activity, the student model monitors the performance of the student, keeping track of what the student has learned and is currently learning and his performance during the learning session. Any misconceptions the student may have are also being monitored. The tutor model presents topics according to the level of understanding of the student. The same approach is done when presenting exercises to students. The student's level of understanding can be determined from the student model. Information stored in the student model is then passed to the agent SPY, which in turn uses the information to determine which students have similar profile as its human student (i.e. relatively same performance, same learning style and relatively of the same level). From this interaction, the agent will gather data such as how other students were able to solve similar problems and how the topics were presented to them (i.e. tutoring strategy used). Moreover, SPY will keep track of the topics where the tutoring strategy was used and the student's performance. The rational behind this is that it is possible for SPY to determine in advance the tutoring strategy used for topics that are not yet presented to its human student. Consequently, this will allow the tutor model to adapt tutoring strategies depending on the status of its student.

The architecture illustrates two (2) forms of collaboration. The first is where the student collaborates with other students through communication medium and tools provided by the environment. These tools include chat, exchanging of emails/messages, discussion groups, newsgroups and the like. In this way, students can get actual explanations of how their peers understood the topics, concepts and solutions of problems presented during the learning activity. The second form of collaboration is where agents interact with other agents in the environment. Such interaction is abstracted from the students. The collaboration seen here is the sharing of information among agents about the students they are associated with.

To illustrate the second form of collaboration in the proposed learning architecture, consider this example: Students may or may not use the ITSs at the same time and study the same concepts or topics. In either case, the respective agents of each ITS in the network will still have to communicate and obtain information from other agents. Assuming there are two students, A and B who are present in the network and are interacting with their respective ITSs. Student A is currently studying topic 1 and student B is studying topic 2. Any interactions both students do during their learning activity are being monitored by their respective student models. While A is studying topic 1, his corresponding SPY agent is interacting with other agents (including the agent SPY assigned to student B) keeping track of topics other students have learned or is learning, the kind of tutoring strategy used, and the students' performance. By the time A is about to study topic 2, the tutor model A will adapt the tutoring strategy used for student B. This is with the assumption that the tutoring strategy used in B is effective (i.e., student B was able to understand topic 2 well, as this can be seen by his performance on that topic). If the adapted tutoring strategy is not appropriate to A (i.e., the student did not perform well in the corresponding exercises) another tutoring strategy will be used or by default will use the tutoring strategy of the tutor model.

It can be seen from the second form of collaboration that adaptation of tutoring strategies exists. Moreover, it is possible for the tutor model to change the current tutoring strategy used depending on the performance of the student during his interaction. The first form of collaboration allows students to directly apply what he/she has learned from the interaction.

3 The Pedagogical agent SPY

The agent SPY is introduced in order to allow students to share to their peers what they have learned and how they have learned the concepts. Specifically, SPY continuously communicates with other agents in the network keeping track of the approach or strategy used by other tutor models in teaching the concepts. Once information is gathered, SPY will perform 2 main operations: (1) filtering the strategies acquired from other agents and (2) transform the acquired strategy into a representation that can be adapted by the tutor model. The filtering of strategies is done in order to choose the appropriate strategy that can be applied to the current topic or concepts the student is studying. During the agent interaction, each agent can gather more than one kind of tutoring strategy possibly for the same topic or concept. These strategies can be arranged in many forms or classifications. For instance, strategies can be arranged according to its effectiveness based on students'

performance. This means the strategy with a student receiving the highest score will be adapted and used by tutor models of other students. If such strategy is not applicable to the current student, then the next highest scored student's tutoring strategy is applied. It is also possible for the agent SPY during the filtering of strategies to combine similar strategies into one strategy. Or better yet, arrange the different tutoring strategies according to the topics or concepts that have been presented or learned by students.

Once a strategy is selected, it will be transformed into a representation recognizable by the tutor model. This is done by following an adaption algorithm. The adaption algorithm should be flexible such that it can adjust to and apply any kind of strategies. However, it is possible that the adapted tutoring strategy is the same as the intended tutoring strategy of the tutor model. In this case, this will serve as a "confirmation" to the tutor model that the pre-planned tutor strategy is effective to its human student.

The objective of introducing a pedagogical agent in designing an ITS is to support the student in learning by adapting different approaches in presenting the topics. This is with the hope of improving students' learning comprehension. Furthermore, SPY assists the tutor model as to what kind of teaching strategy to use for certain concepts. In addition to being adaptive and reactive to the needs of students, SPY agents are proactive and goal-oriented in the sense that they act in the environment through its initiative.

4 Conclusion

In this paper, a proposed agent-based collaborative learning architecture for designing an ITS is presented. The architecture is general and at the moment no implementation has been made. The architecture has shown how a pedagogical agent can be used to model collaborative learning. There are three (3) main components in the proposed architecture and the predominant component is the inclusion of a pedagogical agent known as *SPY*. The agent *SPY* is introduced to assist the tutor model in determining which teaching strategy it will be used in presenting topics/ concepts to students. This also includes the presentation of exercises and possible remediation on topics students are having difficulty with.

This paper also showed a different form of collaboration that is not the same as the usual collaboration or teamwork that is seen in reality. The paper proposes a form of collaboration in which there is a sharing of information among the agents and students in the environment.

Certainly, much progress has to be made towards reaching the complete architecture in reality. Particularly, in-depth study and implementation of the said proposed architecture is needed to see if the architecture can provide improvement in student's learning comprehension. Moreover, there are several issues on the proposed architecture that needs to be studied carefully. Some issues include the learning capability of the tutor model to adapt new tutoring strategies from the SPY agent; representation and storage of strategies (i.e., how can strategies be represented in the form of rules and how to store them in each agent); filtering of strategies (i.e., how to determine which of the acquired strategies are useful and appropriate to the current performance of the students). In addition, a criterion needs to be defined on how to determine students with similar profile.

References

[1] Cammarata, Stephanie, McArthur, David, Steeb, Randall. "Strategies of Cooperation in Distributed Problem Solving". Readings in Distributed Artificial Intelligence. Morgan Kaufmann Publishers, Inc. San Mateo, California. pages 102-105. (1983)

[2] Florea, Adina Magda. "An Agent-based Collaborative Learning System". Advanced Research in Computers and Communications in Education, G. Cumming et al (eds), IOS Press, 1999. International Conference on Computers in Education '99, pages 161-164. (1999)

[3] Jaques, Patricia Augustin, de Oliveira, Flavio Moreira. "Software Agents for Analysis of Collaboration in a Virtual Classroom". Enable 99: Enabling Network-based Learning, Espoo, Finland, June 2-5. (1999).

[4] Lelouche, Ruddy. "An Interacting Team of Pedagogical Agents for Intelligent Tutoring of One Student". Advanced Research in Computers and Communications in Education. G. Cumming e al. (Eds). IOS Press. International Conference on Computers in Education 1999. pages 157-160. (1999)

[5] Sison, Raymund, Numao, Masayuki and Shimura, Masamichi. "Multistrategy Discovery and Detection of Novice Programmer Errors". Machine Learning, 38, 157-180. Kluwer Academic Publishers. (2000).

[6] Smith, Reid, Davis, Randall. "Frameworks for Cooperation in Distributed Problem Solving". Readings in Distributed Artificial Intelligence. Morgan Kaufmann Publishers, Inc. San Mateo, California. pages 61-69. (1981)

An Educational System that can Visualize Behavior of Programs on the Domain World

Taketoshi Ando*, Yoshinobu Kawada*(†), Ryoji Itoh*, Tatsuhiro Konishi*, Yukihiro Itoh*

* *Department of Computer Science, Shizuoka University.*
Johoku3-5-1, Hamamatsu, Shizuoka, 432-8011, Japan.
Tel: +81 - 53 - 478 – 1474•• Fax: +81 - 53 - 478 – 1499
E-mail: s5005@cs.inf.shizuoka.ac.jp

In this paper, we discuss extension of our educational system that gives domain-oriented-explanations of programs. A programmer solves problems on a world where elements necessary to describe the problems and the solving processes of them (objects in the problems, relation among the objects, and so on) are represented. We call such a world 'the domain world' of the problem. Our system has a domain world model and simulates a target program on the model, to understand behavior of the program. By analyzing the result of understanding, it generates an explanation. Outputs of our original system are only verbal explanations. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the program. Therefore, we are trying to add a facility of generating explanations by using animations (visual explanations) to the system. Our extended system can generate both visual and verbal explanations (bimodal-explanations) in various abstraction levels. We discuss the method of generating bimodal-explanations from the result of simulation.

Keywords: **Intelligent Tutoring System, Programming Education, Algorithm Animation System, Bimodal-explanation**

1 Introduction

The purpose of our research is to construct an educational system that helps novice programming learners by explaining domain-oriented-functions of programs. We take Pascal as our target programming language.

Programming is generally carried out in the following process.

Step1. A programmer understands a problem that must be solved.
Step2. He considers the solving process of the problem on a world where the problem is present. We call such a world 'the domain world' of the problem. For example, when he considers a solving process of sorting, he imagines a world in which he pays attention to numerical order such as greater and lesser (we call this world the world of greater and lesser).
Step3. He implements the algorithm: selects data structures suitable to represent the domain world and translates the algorithm into a programming language.

Usually, relatively simple problems are set in novice class of programming. So it is rare that learners fail in the step 1. But they tend to confuse because they cannot distinguish between step 2 and 3. So many novice programmers cannot find whether the causes of bugs are hidden in the algorithm or in their implementation. On the basis of this idea, we proposed an educational system explaining programs using vocabularies on a domain world[2][5][6][7]. Difference of our system from existing educational systems of programming [1][8] is that the purpose of our system isn't pointing out bugs in learner's programs, but rather helping learners find bugs by themselves. Our system helps learners in the following way:

- To help learners to understand sample programs given by a teacher by explaining them.
- To help learners to find and fix bugs in their own programs by explaining the faulty behavior of them.

Our previous system outputs sentences using vocabularies on a domain world as the explanation. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the

(†) *Presently with System Integration Group, VICTOKAI, LTD.*

program. If animations of the behavior of programs are shown with the senten. 's, learners can easily understand their algorithms. Therefore, we realize the ability to generate animations (visual explanations) that show behaviors of the target programs. In this paper, we discuss the way to generate visual explanations for programs in the domain world of greater and lesser.

Existing algorithm animation systems can be classified into two types: The first one is a system such as courseware editors embody particular commands to target programs in order to generate visual explanations, like Zeus[3] and TANGO[9] system. So, this type of systems can generate visual explanations of high quality by using concrete objects on the domain world. For example, a length of bar is used to concrete values of variables on the visual explanation of XTANGO system. The second type of system doesn't need embodying particular command to target programs, like UWPI[4] and tracers. However, this type of systems cannot generate any visual explanation using concrete objects on the domain world. They can only generate visual explanations showing structure of data and changes of contents of variables. Our system can generate a visual explanation using concrete objects on the domain world without embodying any special commands to programs. It generates visual explanations on the basis of the result of "simulation based program understanding[5]". So it can accept buggy programs and generate visual explanations of buggy behaviors of the programs. Moreover, it can also generate verbal explanations on the basis of the result of program understanding.

In the next section, we illustrate an overview of our previous system. In section 3, we point out some functions necessary to generate an effective explanation by using both verbal explanation and visual explanation (a bimodal-explanation). In section 4, we describe the method of constructing the bimodal-explanation system. Then, we show examples of bimodal-explanations by our system.

2 Our Previous Work

2.1 Overview of our previous system

Our previous system is composed of the static analyzer, the simulation based analytical unit and the explanation unit (Figure 1). In this paper, we omit detail of the system (For further details, please see our previous papers[2][5][6][7]). The static analyzer parses target programs and analyzes information necessary for the simulation such as data flow. The simulator simulates target programs, and the observer observes the world model while simulation, and recognizes some important characteristics of data or patterns of structured data. The explanation generator generates verbal explanations of target programs.

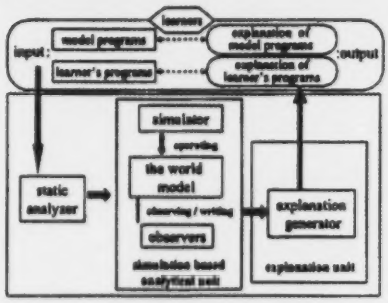


Figure 1: Configuration of our system

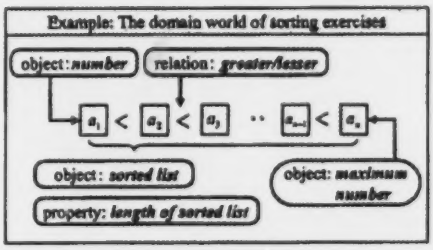


Figure 2: An example of domain world

2.2 Domain world models

We examine programming exercises and classify them into 15 types. We prepare domain world models designed for each type of exercises [2].

A domain world model consists of four types of elements called 'object', 'property', 'relation among objects' and 'change'. For example, Figure 2 shows the domain world model of greater and lesser as an example. In order to recognize specified characteristic or patterns in the domain world, our system has daemon units called "observer" which are burnt when they are observed. In the Figure 2, the object *'maximum number'*, *'sorted list'* and property *'length of sorted list'* are recognized by observers. There are some cases that some observers take outputs of the other observers as their inputs. Then the outputs of observers make hierarchy. When a result of observation is output on the basis of a result of another observer, the former has larger grain-size than the latter and implies the fact corresponding to the latter.

2.3 Generation of a verbal explanation

The explanation unit generates verbal explanations of the target program by using results of simulation and outputs of observers. The results of observations have a hierarchical structure, as mentioned above. The system generates a hierarchical verbal explanation by using the hierarchical structure (it also uses syntactical structures of programs). In other words, the system notices the largest grain-sized result of the observation firstly, in order to generate the verbal explanation. Secondly, if learners request the detailed verbal explanations, the system generates the explanation using results of observation having smaller grain size. Figure 3 shows the example of verbal explanations generated by our system. It illustrates the verbal explanation of behavior of a sorting program on the domain world of greater and lesser. The indentation in the figure means that *behavior 1* and *behavior 2* are executed sequentially and that *behavior 2* is equivalent to the sequence of *behavior 2-1, behavior 2-2,* and *behavior 2-3*. Each Behavior is implemented by a single statement or a sequence of statements. When a verbal explanation for a behavior implemented by a sequence of statements is clicked, more detailed verbal explanations showing the way to implement the behavior are displayed.

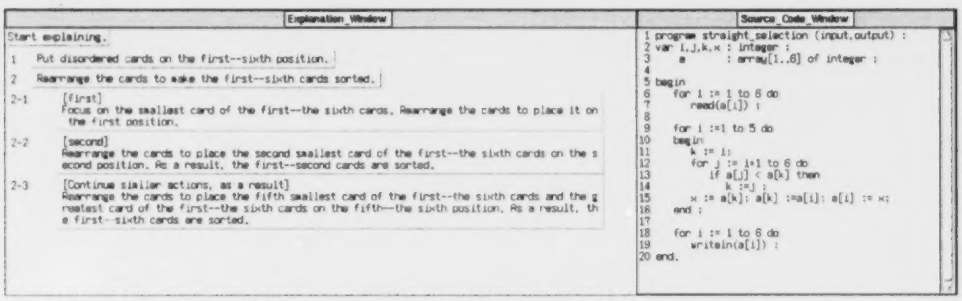


Figure 3: An example of the verbal explanation of a target program

Next, we show procedures for generating the hierarchical verbal explanation like Figure 3. An input is a result of simulation of some statements (For further details, please see our previous paper[7]).

(1). The case that a certain behavior is implemented by a sequence of statements.
The system observes differences of the states of the domain world model before and after execution of the sequence of statements. According to these differences, the explanation unit selects a template and generates verbal explanations for the statement. Now we show an example of a template.

- The case that extension of the sorted list is observed.

  The differences are composed of the following three elements.

  Object(s) recognized at the state before execution of some statements: a sorted list
  Object(s) recognized after execution of the statements : an extended sorted list
  Recognized changes of states of objects : an extension of the sorted list

  A template for the extension of the length of a sorted list is applied (Please see Figure 3).

  Template: "Rearrange the [Type of added object] to place [An added object] on [The position of the insertion] position. As a result, [A sorted list at the after state] [Type of inserted objects] are sorted."

  "[]" means a procedure which generates a certain pattern of string.

  [An added object]
  : A procedure that generates a noun phrase expressing the new object added to the sorted list.

  [A sorted list at the after state]
  : A procedure that generates a noun phrase expressing the range of the sorted list at the after states.

(2). The case that a certain behavior is implemented by a single statement.
The explanation unit calls each procedure corresponding to types of the statement. The procedures are defined for each structure of the program like sequential structures, selective structures, iterative structures, an assignment statement, a statement for input, and a statement for output. Same as the case (1), templates are prepared for each structure of the program. For example, we show a template of 'if' statement.

Template: "if [explanations of the conditional clause], [explanations of the 'then' clause] (otherwise [explanations of the 'else' clause]) "

[explanations of the conditional clause]
: The procedure that explains the conditional statement of 'if' statement.

[explanations of the 'then' clause]
: Apply the procedure for generating the verbal explanation to the clause recursively.

[explanations of the 'else' clause]

BEST COPY AVAILABLE

. Apply the procedure for generating the verbal explanation to the clause recursively.

Thus, the system can generate hierarchical verbal explanations. When a verbal explanation generated by the procedure (1) is shown and a learner requests more detailed explanation, the system tries to apply the procedure (1) recursively to make such an explanation. If it cannot generate any explanation, it applies the procedure (2).

3 Functions necessary to generate an effective bimodal-explanation

In order to construct a system generating effective visual explanations, we have to consider what visual explanation is effective for learners to understand an algorithm or behavior of a target program. By designing mock up visual explanations repeatedly, we find that the effective visual explanation has following three facilities.

(1) The facility to generate visual explanations with various grain-sizes.
When learners learn programming by using a system explaining behaviors of programs, they need various grain-sized explanations. For example, when a learner wants to grasp algorithm roughly, a large grain-sized explanation would be effective. On the other hand, when he wants to understand a precise method of implementation, smaller grain-sized explanations are effective. Moreover, when he wants to diagnose his own program at a glance, he needs the largest grain-sized explanation. When he wants to find buggy codes, he needs smaller ones. In order to generate such various grain-sized visual explanations, the system should be able to :

- regard a sequence of statements as a blackbox and generate a visual explanation showing its function.
- generate a visual explanation showing a function of each statement sequentially.

(2) The facility to explain a function of a program by using both animations and verbal texts.
If a system shows only visual explanations, learners sometimes cannot understand behavior of target programs clearly, because such learners cannot understand what phenomena are essential. Thus, it is necessary for our system to have the facility to generate verbal explanations showing a major phenomenon of each step of visual explanations. Thus our system should have a facility of generating combination of verbal explanations and visual ones (bimodal-explanations).

(3) The facility to generate explanations on the total effect of a sequence of statements.
Generally, a task is achieved by a sequence of statements, and each sub-task is achieved by each sub-sequence of the statements. When the system shows a sequence of explanations each of which has a certain grain-size corresponding to a sub-task, a learner sometimes cannot find the fact that the task has been achieved. In order to prevent learners from such misunderstanding, the system should show them a verbal explanation remarking the fact.

4 Methods to realize the functions to generate bimodal-explanations

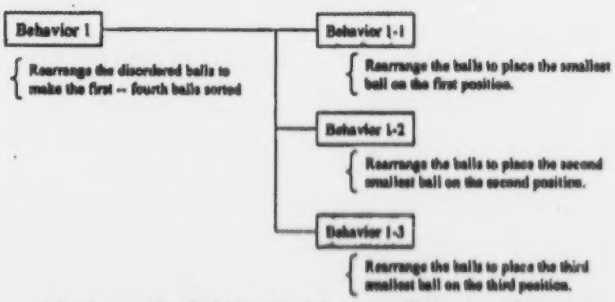
4.1 Basic ideas

(1) The method of generating visual explanations on various grain-size.
As we describe in section 2, our system can generate hierarchical verbal explanations. In other words, it can understand behavior of a target program on various grain-size. And the system holds the result of understanding as hierarchical data. Therefore we can realize a system generating visual explanations on various grain-size, by developing a method to generate a visual explanation from a result of understanding.

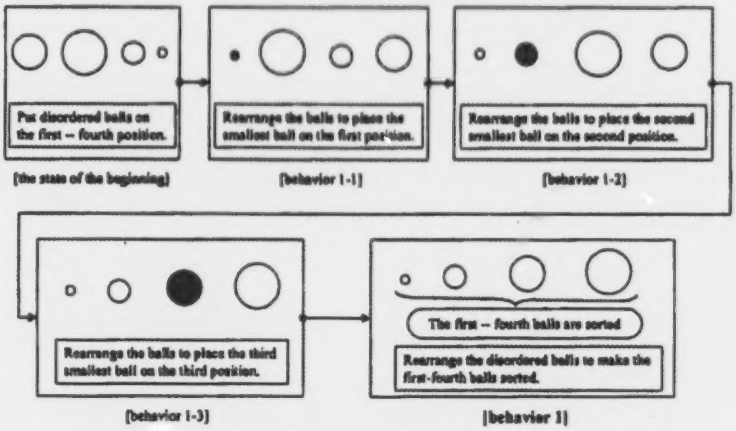
(2) The method of generating combination of verbal explanations and visual explanations.
Our program understanding mechanism can recognize the major phenomena in the domain world. And we have already developed a method to generate verbal explanations from the result of program understanding. Thus, if the system can generate a visual explanation from the result of it by the method (1), it becomes to be able to generate both visual explanations and verbal explanations remarking major phenomena from common data.

(3) The method of generating explanations on the total effect of a sequence of statements.
By generating an explanation remarking that a task is achieved just after explanations of sub-tasks are finished, the system can generate explanations on the total effect of the task. The explanations of the task and the sub-task can also be generated by the method (1) and (2). For example in Figure 4, just after the explanation corresponding to the behavior 1-3 is finished, the system generates the explanation corresponding to the behavior 1 as the explanation of the total effect. As a result, the explanation shown in Figure 4 is generated.

In consequence, if we can realize the method (1), the method (2) and (3) can also be realized. Therefore we discuss the detail of the method (1) in the next section.



(a): An example of a hierarchical structure of behaviors of a program



(b): Generated explanations

Figure 4: An example of a bimodal-explanation of a total effect

4.2 Generating visual explanations

The system visualizes behavior of the target program in various grain-size. The generated animations are shown with verbal explanations. The detail of our method to generate verbal explanation is seen in [6], so we omit it in this paper.

At first, the system starts explaining with the largest grain-size, then shows more detailed explanation on an action of which detail a learner wants to see.

The methods to draw a step of animation are classified into the following two types:

1) The method of visualization for a function implemented by a single statement.

2) The method of visualization for a function implemented by a sequence of statements.

The detailed process of 1) and 2) is discussed in 4.2.1 and 4.2.2 respectively.

4.2.1 How to generate a visual explanation of a function implemented by a single statement

In order to generate a visual explanation on a statement, we prepare specific procedures for each type of a statement. The statements of inputting, assignment, selection, and iteration have their individual procedures.

Procedures for inputting statement should be classified into several types in order to generate effective explanations. For example, the basic function of inputting statement "read (A);" must be "a datum is input to the variable A". However, showing only the basic function is not always a good explanation. If a meaningful datum has been stored in the variable "A" before inputting, the system should also explain that the datum is deleted by the inputting. Therefore, the procedures for inputting statement are classified according to some conditions on the role of the statement in the target program and the domain world: for example, the condition whether the datum stored in the destination variable of inputting has been referred before the input sentence or not (if it has been referred, it must be meaningful).

Similarly, procedures for assignment statement should also be classified. For example, the basic function of the statement "A:=B;" is "the datum in the variable B is copied and the copy is written on the variable A". But, if the datum in B will never be referred after the assignment, the explanation " the datum in B is moved to A" must be better because it represents the role of the statements more directly. We show an example of a condition to classify procedures for assignment statement and a procedure corresponding to the condition, by using the statements illustrated in Figure 5.

The condition and procedure for assignment statement meaning the copying process of objects in a sorting program is as follows.

Condition: [the datum in B represents an object in the world of greater and lesser]
and [B is referred during *2] and [A is also referred during *1]

Procedure: Seen in Table 1. And the visual explanation generated by the procedure is seen in Figure 6.
Table 1 also shows the templates for generating verbal explanations in this condition.

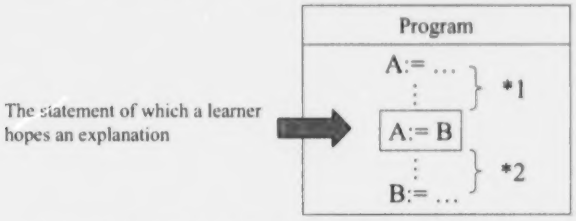


Figure 5: An example of an assignment statement in a program

The system doesn't generate visual explanations corresponding to statements of selection and iteration. For example on "if-then-else" statement, it generates visual explanations corresponding to 'then' block or 'else' block, while it generates verbal explanations whether the condition part of the statement is true or false. By the verbal explanation, a learner can understand why the 'then' block or the 'else' block is executed. Templates used to generate such verbal explanations are not the ones mentioned in 2.3 because of the following reason:

- In general, verbal explanations can be abstract. For example, we can explain a sorting process of N pieces of balls.
- Visual explanations must be concrete. For example, the system has to decide how many balls exist in the domain world in order to draw sorting process.
- Therefore, verbal explanations corresponding to visual explanations have to be generated by templates designed for bimodal-explanation.

Table 1: Examples of procedures and templates for generating explanations of an assignment statement

order	Procedures for generating visual explanations.	Templates of verbal explanations
1	Show a ball having an assigned value with a black color.	Focus on [a ball holding an assigned value].
2	Show a copy of the ball having the assigned value.	Prepare a copy of this ball.
3	Show a ball assigned the value with a gray color.	Remove a ball on [an assigned position].
4	Draw an arrow from the copy of the ball having the assigned value toward the ball assigned the value.	Move the copy of this ball to [an assigned position].
5	Show the copy of the ball having the assigned value at an assigned place.	Move this ball to [an assigned position].
6	Show a state of end.	

As mentioned above, "[]" in template means a procedure by which a certain pattern of string is generated. The bimodal-explanation corresponding to a single statement is composed of 3 ~ 5 scenes.

4.2.2 How to generate an explanation of a function implemented by a sequence of statements

In order to generate such a visual explanation, the system needs to display the states before/after the function has been applied. In order to decide designs of both states, the system generates a sequence of visual explanations on the statements by which the function is implemented. The generated explanations are only stored in a database without being displayed to a learner. The system picks up the initial state and the final state from the database and displays them one after another.

In addition, the system also needs to explain an effect of the sequence of statements directly. In order to generate an explanation of a total effect of statements, the system should generate a verbal explanation remarking the total effect and a step of animation showing the effect directly. The system can generate the verbal explanation by applying templates to the result of simulation. In order to generate a step of animation, we

prepare procedures for visualizing a concept recognized as a result of the simulation. For example, brace and the words attached to it in Figure.4 (b) are drawn by such procedures. The number of such procedures is nearly equal to the number of template for the result of simulation (illustrated in 2.3.(1)).

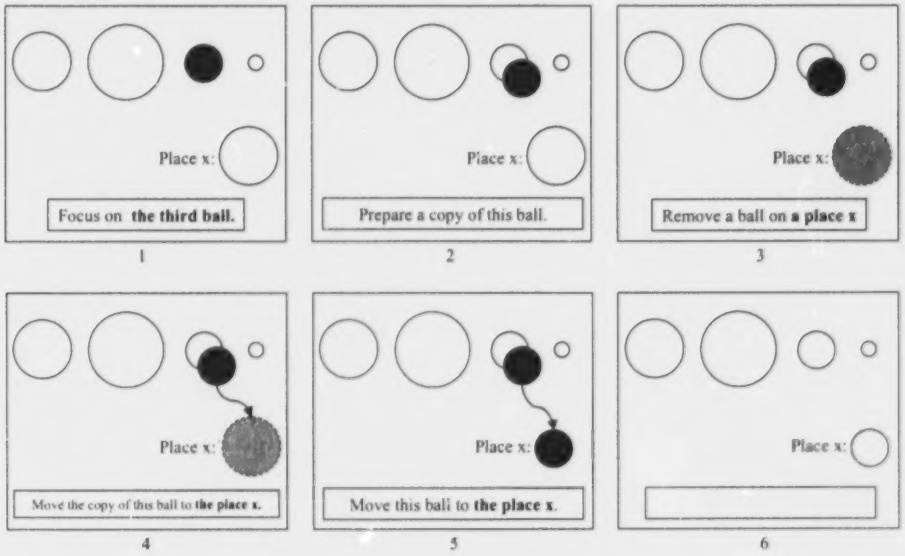


Figure 6: The visual explanation corresponding to each statement

5 Implementation

The system is developed on Unix workstations. The unit of generating bimodal-explanation is implemented by Tcl/Tk. Now we have finished implementation of procedures generating bimodal-explanations of statements of input, assignment, selection and iteration. Figure 7 shows an example of bimodal-explanations generated by our system. The target program is sorting by straight insertion. The system explains the process of sorting five balls according to their sizes. Figure7-1 shows the state just after that the smallest ball (in this figure, it is the 4th ball from the left end) has been found, the ball has been copied to the 'place x', and it has been removed. After that, the following processes are explained one after another.

- The copy of the first ball is moved to the fourth position (Figure7-2, 7-3).
- The ball on the 'place x' is focused (Figure7-4).
- The ball on the first place is removed (Figure7-5).
- The ball on the 'place x' is moved to the first position (Figure7-6, 7-7).

By these explanations, learners can imagine the process that the smallest ball is moved to the first place. The explanation after Figure7-8 continues in a similar way. The system also shows the process that the second - fifth smallest ball is moved to the second - fifth place respectively. Thus, the whole process of the sorting is illustrated. The original messages generated by our system are Japanese, but we add corresponding English messages to this figure.

6 Conclusion

In this paper, we proposed a method of generating a bimodal-explanation. Our system accepts the result of simulation and generates bimodal-explanations. Our current system can deal with only on the domain world of greater and lesser. Constructing procedures for the remaining types of a statement and applying this system to other domain worlds will be our future work.

Acknowledgments

This research was supported in part by Grant-in-Aid for Scientific Research (c)(11680216) from Japan Society for the Promotion of Science.

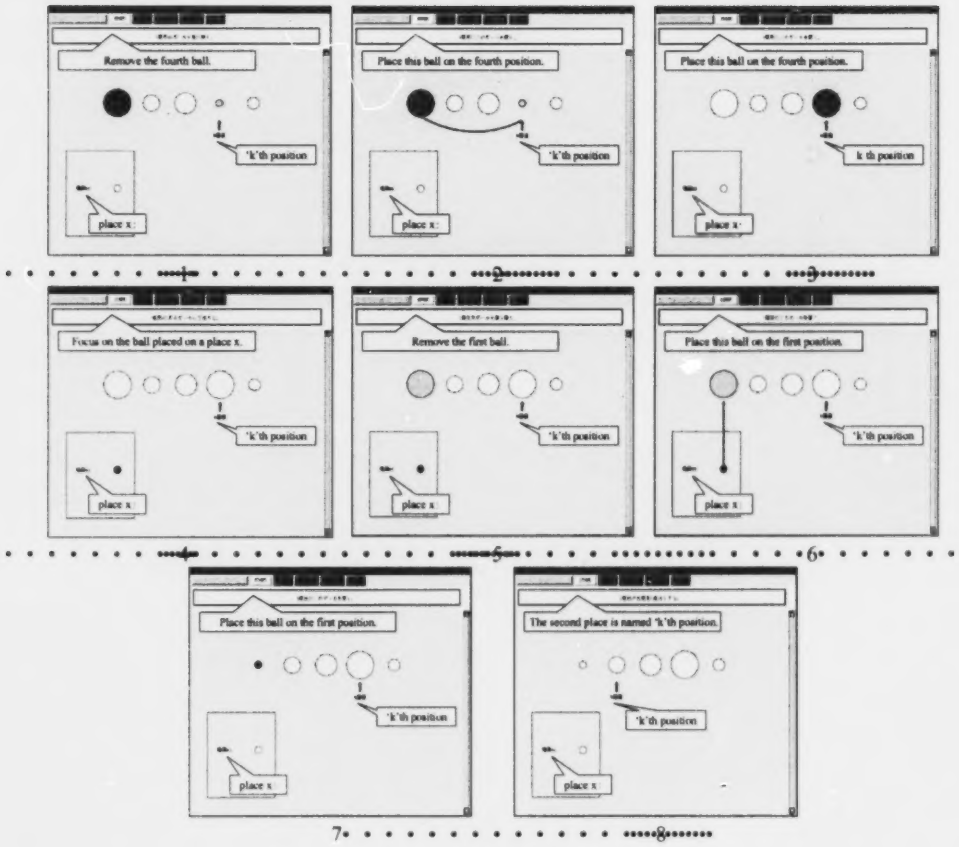


Figure 7: Outputs of our bimodal-explanation system

References

[1] Adam, A., Laurent, J.P.: "LAURA, A system to debug student programs", Artificial Intelligence, Vol.15, pp.75-122, (1980)

[2] Ando, T., Itoh, R., Konishi, T., Itoh, Y.: "Extension of the Educational System that Generates Domain-Oriented-Explanations of Programs – On Methods for Designing Domain World Models and for Simulation", Proc. of ICCE'99, Chiba, Japan, Vol.1, pp.856-860, (1999)

[3] Brown, M. H.: "Zeus: A system for algorithm animation and multi-view editing (research report No.75)", DEC systems research center, (1992).

[4] Henry, R. R., Whaley, K. M., Forstall, B.: "The university of Washington Illustrating Compiler ", Proc. of The ACM SIGPLAN'90 conference on programming language design and implementation, pp.223-233, (1990).

[5] Itoh, R., Nishizawa, M., Konishi, T., Itoh, Y.: "On analysis of novice PASCAL programs based on simulation to extract Information for education", Proc. of ICCE'97, Kuching, Sarawak, Malaysia, pp.485-492, (1997)

[6] Itoh, R., Nishizawa, M., Konishi, T., Itoh, Y.: "A programming learning system which makes Domain-Oriented-Explanations", Proc. of ICCE'98, Beijing, China, Vol.1, pp.432-440, (1998)

[7] Itoh, R., Konishi, T., Itoh, Y.: "On Constructing a programming Education System that makes domain-oriented-explanations", Journal of JSAI, Vol.15 No.2, pp.362-375, (2000), in Japanese.

[8] Johnson, W.L., Soloway, E.: "PROUST:knowledge-based program understanding", IEEE Software, vol.11, no.3, pp. 267-275, (1985)

[9] Stasko, J. T.: "Tango: A framework and system for algorithm animation", IEEE computer, Vol.23, No.9, pp27-39, (1990).

BEST COPY AVAILABLE

An Environment for Learning by Design
- In the Case of Learning of Search Algorithm -

Tsukasa HIRASHIMA, Hidenori IKEMATSU, Mayt Kalayar, Akira TAKEUCHI
Kyushu Institute of Technology, Department of Artificial Intelligence
680-4, Kawazu, Iizuka, 820-8502, JAPAN
TEL: +81-948-29-7618, FAX: +81-948-29-7601
tsukasa@ai.kyutech.ac.jp

This paper described a learning environment for search algorithms. In the learning environment, learners can build search algorithms by combining several parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. In the diagnosis, errors in the algorithms are detected. By using the results of this diagnosis, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms. We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising.

Keywords: **Learning by design, Error diagnosis, Search algorithm**

1 Introduction

An effective way to learn procedural knowledge in depth is to make learners apply it to various cases. However, although the learners may master how to use the procedure through the experience, it is not enough to answer the question "what the procedure is". Several investigations [1-4] suggested that "learning by design" is a promising way to promote the learner's understanding about "what that is". For example, in order to understand a machine in depth, assembling it from its smaller parts is the best way. In the case of the understanding of procedure, to build up the procedure by trial and error is useful in order to understand it.

This paper reports about a learning environment for learning by design, targeting basic search algorithms taught in an introduction to artificial intelligence lecture, that is, depth-first search, breadth-first search and three heuristics searches (best-first, minimum consuming cost, and A algorithm). In the lecture, usually, the procedure of each search algorithm is taught and learners carry out the searches following the procedures by hand. Some of them understand the meaning of the algorithms through the practice, but some of them only memorize the procedures. Our environment provides several parts of the search algorithm as icons. Learners can assemble them by direct manipulation in the environment. The environment interprets the assembled parts as a search algorithm and diagnoses it, for example, as to whether it falls into the loop or not. Then, the environment gives feedback for the algorithm to revise it or to try to build the next one. The tree structures that are generated as the results of the searches following the algorithms are also presented to the learners. These feedbacks are necessary to realize learning by design effectively.

In this paper, first, the model of the search algorithm that is the basis of the design of this environment is described. Then, the configuration and functions of the learning environment are explained. The preliminary evaluation of the environment is also reported.

2 Interactive Learning Environment of Search Algorithms

Figure 1 shows the configuration of the ILE. It is composed of the interface and reasoning module. In the interface, learners design and build search algorithms, and receive feedback from the system. In the

reasoning module, the algorithms are diagnosed and feedback messages for them are generated. The interface is implemented in Java as a client and the reasoning module is implemented in Prolog as a server. Therefore, the ILE can be used on the Internet.

In this section, first, the model of search algorithms used in the ILE is described. The modeling is indispensable for designing the interface for algorithm building and in order to diagnose algorithms. Then, the interface where learners can build the search algorithms by direct manipulation is presented. The diagnosis of the algorithms and the feedback generated based on the results of the diagnosis are also explained.

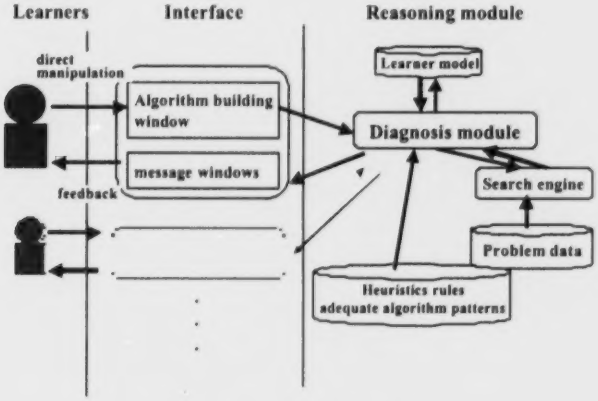


Figure 1. Configuration of the ILE

2.1 A Model of Search Algorithm

Search algorithms taught in the introductory lecture of artificial intelligence share the same procedure as follows. Here, both "Open" and "Closed" are lists composed of search nodes.

1) The start node is put into Open.
2) If "Open == []" then "the end of the search is in failure".
3) Pick up one node at the head of Open (the node is called *n*)
4) If "*n* == goal" then "the end of the search is in successful".
5) Generate child nodes from *n*.
6) Put the child nodes into Open.
7) Put *n* into Closed.
8) Return to Step-2.

The differences between the search algorithms are characterized by the operation of Step 6. For example, depth-first search is characterized as the algorithm in which the child nodes are put into the head of Open in Step 6. Breadth-first search is characterized as the algorithm in which the child nodes are put into the tail of Open in Step 6. In heuristics searches, the way to sort Open is an essential characteristic. In addition, for every algorithm, the method of selection of child nodes to put into Open is also an element that characterizes the search algorithms.

In our system, search algorithms are characterized by the combination of the following three list operations used in Step 6: "selection," "connection" and "sort." There are two types of selection operations: the first is "to select nodes that are not included in a list," and the other is "to select nodes that are not included in a list or are lower in cost than the same node in the list." Connection also has two types. The first is "to put nodes into the head of a list" and the other is "to put nodes into the tail of a list." The referred list is usually Open. We prepared three types of sorts: "to sort in the order of the consumed cost (minimum consumed cost search)," "to sort in the order of predicted cost (best-first search) " and "to sort in the order of the total of the consumed and predicted cost (A algorithm)."

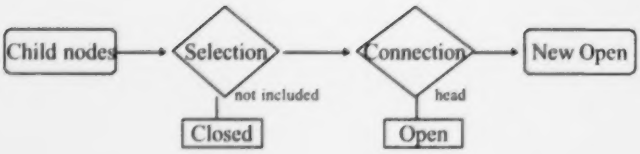


Figure 2. An example of the model of Search Algorithm

Figure 2 shows an example of a search algorithm built by the operations. The lozenge is the operation, and the rectangle is the list. The parameter that indicates "referred cost" or "head or tail" to specify the operator is presented at the bottom right of the lozenge. Therefore, Figure 2 means that "the child nodes that are not included in Closed are put into the head of Open." This is a kind of depth-first search that prunes using Closed.

Every part described above is necessary to build the search algorithms taught in the introductory lecture to artificial intelligence. In order to make learners understand search algorithms more deeply, our ILE provides an environment where learners can build search algorithms freely, and can receive feedback for the algorithms. In the following section, the ILE designed based on the model of search algorithms is described.

2.2 Building Search Algorithms

The interface for building search algorithms is shown in Figure 3 (currently, the interface is written in Japanese. Explanations in Figure 3 are translated to English for this paper. Japanese version is shown in [5]). Learners

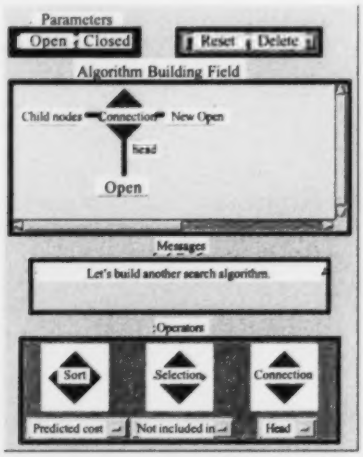


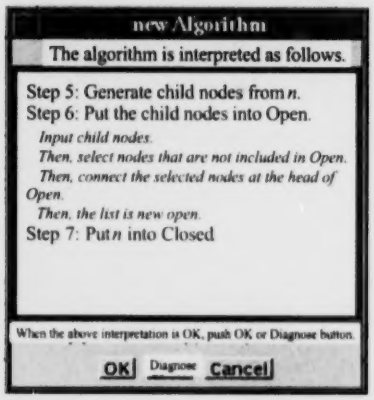
Figure 3. The Algorithm Building Field.

build search algorithms in the "building field" by assembling parts provided in the interface. At the bottom of the Interface, three operators are provided in the lozenges. The parameters specifying the operators are selected from the menu under the lozenges. The reference lists of the operators are selected from the box at the upper left. All manipulation in the interface can be done with a mouse. The algorithm in the building field is a depth-first search without having pruned.

Learners can confirm the algorithm built by themselves in two ways: a written explanation and a trace of the

BEST COPY AVAILABLE

search tree. The explanation is generated by interpreting the operations in order of sequence in the building field. Figure 4 is the explanation of the algorithm shown in Figure 3. A search tree is generated by showing the trace results in a search space. The search spaces are provided as mazes in the environment. Figure 5 is an example of search tree that is the results of the search for the maze shown in the right in the figure.



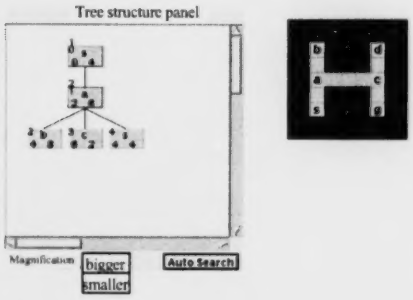


Figure 4. An Example of Explanation an Algorithm. Figure 5. An example of search tree.

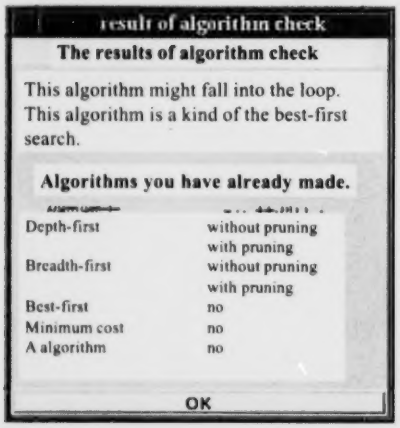


Figure 6. An Example of the Results of Problem Diagnosis.

Learners can also ask the system to diagnose the algorithms built in the building field. The reasoning module has both the adequate combinations of operations and heuristics rules to criticize the algorithms that are not adequate. By using the adequate combinations, the adequate algorithms can be detected. By using the heuristics rules, the errors in the inadequate algorithms are detected. If no errors are detected by the heuristics rules, the reasoning modules can not judge the type of the errors. The heuristics rules are prepared from the following three points of view: the kind of algorithm, redundancies in the algorithm and the covering of the search space. An example of messages generated from the results of the diagnosis is shown in Figure 6. In the following section, the diagnosis of the search algorithms is described.

2.3 Diagnosis of Search Algorithms

In the reasoning module, the algorithms are diagnosed using heuristics rules. The heuristics rules of each viewpoint are shown in this section.

BEST COPY AVAILABLE

In the experiment, we recorded the following data: (1) the number of algorithms built by the learners, (2) the number of adequate algorithms, (3) the number of inadequate algorithms that could be diagnosed with heuristics rules, (4) the number of inadequate algorithms that couldn't be diagnosed, and (5) the number of types of the adequate algorithms the learner made. The results are shown in Table 1. After the experiment, we asked four questions: (a) Are you interested in the system? (b) Is the system easy for you to use? (c) Would you like to use the system more? (d) Do you understand the search algorithms better than before? The results are shown in Table 2.

Table 1. The results of the students algorithm building.

Student number	(1)The total number of algorithms	(2)Adequate algorithms	(3)Inadequate algorithms (be diagnosed)	(4)Inadequate algorithms (not be diagnosed)	(5)the type of the algorithms
No.1	26	11	15	0	5
No.2	24	10	6	8	5
No.3	16	10	6	0	5
No.4	38	17	13	8	5
No.5	44	13	20	11	5
No.6	48	10	26	12	5
No.7	21	8	8	5	3
No.8	26	15	9	2	5
No.9	23	14	4	5	5
No.10	16	5	6	5	1
No.11	43	24	11	8	5
No.12	20	8	12	0	5
No.13	16	9	7	0	5
	361	154	143	64	

Table 2 . The Results of Questions.

	Yes	Maybe yes	No	No answer
Qusetion-a	10	3	0	0
Question-b	1	7	5	0
Question-c	7	5	0	1
Question-d	3	3	4	3

In Table 1, the total number of algorithms the learners made was 361, that is, 27.8 per student. The total number of adequate algorithms was 154, that is, 43 % of the algorithms. The total number of inadequate algorithms was 207 (57%). The number of diagnosed errors by heuristics rules was 143. This means that the system could detect the errors in 69 % of the inadequate algorithms. Among thirteen students, eleven students made every type of algorithm.

In Table 2, the results of Question-a and –c suggest that most of the students had interest in the learning environment. The result of Question-b indicates that the interface is not easy for the students to use. For Question-d, four students answered "no", and three students didn't judge, that is, more than half the students didn't think they gained a deeper understanding by using the learning environment.

Students made many algorithms in the experiment and they answered that the learning environment was interesting. In addition most of them could make every type of algorithm. These results suggest that the learning environment is promising. The answers for Question-b mean we should improve the interface. In Question-d, Six students thought they got deeper understanding by using the environment, but seven students didn't think so. When we gathered students, we told them that we would ask them to use a learning environment for search algorithms. Therefore, most of the students participating in the experiment might have confidence about their understanding of search algorithms. This is one reason for the result for Question-4.

2.3.1 Type of Algorithm

The algorithms built by the learners are categorized by the following heuristics rules.

* When, after child nodes are put into the head of Open, either any nodes are not put into the head of Open or Open is not sorted, the algorithm is categorized as depth-first search.
* When, after child nodes are put into the tail of Open, either any nodes are not put into the tail of Open or Open is not sorted, the algorithm is categorized as breadth-first search.
* When, after child nodes are put into Open, Open is finally sorted in the order of consumed cost, the algorithm is categorized as minimum consumed cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of predicted cost, the algorithm is categorized as predicted cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of the total of consumed cost and predicted cost, the algorithm is categorized as A algorithm.

When the algorithm has no characteristics checked by the above rules, the kind of algorithm cannot be specified.

2.3.2 Redundancy of Algorithm

When the algorithms include the following operators, the diagnosis module judges that the operators are redundant in the algorithms.

* The same operators are used continuously.
* When several operators of sort are used, only the operator of sort used at the end has meaning.
* After using the connecting operator with a list as the parameter, the execution of the selection operation with the same list as the parameter results in deleting the added nodes.

2.3.3 Covering of the Search Space

Several search algorithms that can be built by learners can not find goals that exist in a search space. The reasoning module diagnoses whether or not the algorithm can cover the search space, by using the following heuristics rules.

* When several child nodes which might imply goals are not put into Open, the algorithm might fail to reach the goal included in the search space.
* When the algorithm that isn't categorized as breadth-first, minimum consuming cost or A algorithm doesn't include the selection operator with Closed as the parameter, the algorithm falls into the loop.

2.4 Feedback based on the Diagnosis

Based on the results of the above diagnosis with heuristics rules, the messages to criticize the algorithm are provided in the interface. Figure 7 shows an example of the messages. When the type of an algorithm is judged, the type is indicated. When the algorithm includes the redundant operators, the operators and the explanation of the redundancies depending on each heuristics rule are provided. When the algorithm might not cover the search space because several child nodes fail to be input into Open, the explanation prepared for the heuristics rule is shown. When the algorithm might fall into the loop, the possibility of falling into the loop is indicated.

When the algorithm includes a pruning operation, the fact is also indicated. In the interface shown in Figure 7, to motivate learners to build the next algorithms, the algorithms the learner has made correctly and hasn't made yet are shown.

3 Preliminary Evaluation

For a preliminary evaluation of the learning environment, we gathered thirty college students and asked them to use the learning environment. Those who were in the second grade or in the third grade have already taken the lecture of artificial intelligence. Their participation was voluntary. Before the experiment, we explained how to operate the environment for ten minutes. Then, we asked them to build search algorithms in the learning environment for an hour.

As for the results, the experiment suggests that the learning environment is promising to be used in the real world, but the effect couldn' t be confirmed clearly.

4 Conclusions

This paper described a learning environment for learning by design in the case of search algorithms. In the learning environment, learners can build search algorithms by combining parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. The heuristics rules detect errors in the algorithms. By using the results of this diagnoses, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms.

We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising to be used in the real world and that is promising, but the effect couldn' t be confirmed clearly. In the next step, we will use the learning environment in class and evaluate it in a real learning context.

References

(1) S.Papert: Mindstorms, Basic Books, Inc(1980).

(2) G.Fisher, K.Nakakoji: Empowering Designers with Integrated Design Environments, Proc. of the First International Conference on Artificial Intelligence in Design, pp105-117(1991).

(3) A.Repenning: Programming Substrates to Create Interactive Learning Environments, Interactive Learning Environments, Vol.4, No.1, pp.45-74(1994).

(4) E.Soloway, M.Guzdial, K.Hay: Learner-Centered Design: The Challenge for HCI In The 21st Century Interactions,Vol.1, No.2, pp.36-48(1994).

(5) H.Ikematsu, Myat, T.Hirashima, A.Takeuchi: Interactive Learning Environment for Search Algorithm, Proc. of Research Meeting of Kyushu Division of Information Processing Society of Japan, 3A-5, pp.101-108(2000)(in Japanese).

An on-line ITS for elementary algebra

Li Yi-Ping*, Chan Kan-Kan**

University of Macau
P.O.Box 3001, Macau
Tel: 853-3974323
Fax: 861095
*fstypl@umac.mo , **fedrc@umac.mo

The objective of this research is to reinforce the concepts and procedures of elementary algebra that students learn in junior schools. Students react to teacher's instructions in various way. However, in a traditional class, the ratio of teacher to student is still too great. The question of how to help all the students with limited number of teachers arises. This paper describes how to achieve the above objective with the help of an intelligent tutoring system. It discusses the design outline and the system architecture of the proposed system. The tutor tracks student's performance and uses this information to provide most suitable instruction to each student dynamically.

Keywords: **Web-based learning environment, intelligent tutoring system, elementary algebra**

1. Introduction

In a class of forty students, it is hard for teachers serving every student's questions within a class of forty minutes. Teachers teach students concepts and methods or techniques to solve problems in group. Then related exercises are given to students to practice at home. Students who have no doubts in class might cope with the exercise and learn well while some might not master the technique that teacher has taught. They always frustrate when they cannot solve the problem. In this situation, some advice from teacher is very helpful in their learning process. However, teachers are not always available while they need help. Also teachers might not be able to answer many students' doubts at the same time. This research is conducted with the aim of using computers to support the knowledge acquisition process that is adjusted to the capabilities of individual student. Students just need to have a web browser to connect to school network and would get assistance right away.

Many existing CAI applications do help a bit in students' learning process but they do not consider the background knowledge of students. This means that they might provide inappropriate feedback to students which in turn affects student's progress in learning. In order to overcome this situation, research has been investigated on intelligent tutoring system which includes functions for guiding students towards proper knowledge acquisition, according to observation of the student's problem-solving process and identification of the causes of student error.

We first depict the learning environment of our system in section 2and then the overall architecture of our system is mentioned with detail description of main components of ITS in section 3. The final section concludes our work.

2. Learning Environment of on-line ITS for elementary algebra

ITS for elementary algebra is designed as a problem solving environment to be used in class. Therefore we assume that student is familiar with the basic concepts of elementary algebra and know the ways to factorize a polynomial. Students use the system as a tool at home or during class practice. Since the condition that students

use it lacks teacher's support, an interactive problem support should be built into the system. With this feature, students might get help on steps of problem solving where he has difficulty.

In order to access the on-line tutoring system, a student just needs a web browser and types the address where the system locates. An instance of the system will be created in student's computer in the form of ActiveX control. Although it might argue that there is great network delay in loading the system in student's computer, interactivity and userfrindliness deserve a short delay. In fact, in a local environment, the network traffic is not so congested. Therefore this is not a real problem. Instead, students can use it as if any Windows program and do not have to worry about its maintenance or compatibility issues. The control serves as a communicator betweent the system and the student. It transfers student's action to the system and returns the reponse of the tutor to the student.

Every student has his own session during the learning process. When a student enters the system with his user name and ID, a model of student performance is created or opened to set his learning environment. ITS selects a problem according to student's level for him to work or waits for the student to enter a problem which he has doubts. In both situations, the student solves it with the guidance of the tutor in a step-by-step way. The system keeps track of every step of the student in background. If nothing goes wrong, it remains quiet otherwise it prompts student's error. His problem solving procedure is kept in the system for future reference.

3. Overview of on-line ITS for elementary algebra

Our system follows the standard architecture of client-server model. The system resides on the server side. The basic components of the learning system are the domain module, pedagogical module, student modeler and the interface.

The domain expert module consists of two main programs. One is a problem solver which is capable of solving problems in its knowledge base. The other one is question generator that creates new problems according to the instruction of pedagogical module. In order to achieve its mission, the knowledge base is composed of both rules and cases. The expert model is capable of solving general problems by the rules coded in its module. As for miscellaneous problems, they are indexed as cases with problem characteristics and solving techniques so that the domain expert knows how to retrieve the relevant solving technique with the detected problem features.

The domain that we have chosen is factorization of algebraic polynomial for students in elementary classes. Given a polynomial, factorization is to express an integral polynomial as a product of prime polynomial. Therefore a polynomial is not completely factored unless each factor is either a monomial or a prime integral polynomial. Generally, there are 4 basic methods to factorize an algebraic formula. They are: (1) obtaining the common factor (2) using identities (3) cross-method and (4) divide the polynomial into groups and then simplify groups to find factors.

The pedagogical goal is to let junior students master the methods to factorize a polynomial smoothly. Students are taught the basic method to factorize an algebraic formula. However, they always get lost in the actual application to find the factors of a given formula. Therefore, we have organized the pedagogical knowledge by constructing groups of problems according to the level of difficulty, problem characteristics and solving technique. Within each level, there are pre-requisite question types which a student must understand before a certain question type will be generated. Figure 1 shows part of the relation among question types. There are several groups having polynomial problems as bellows:

- Problems, which just need one method to solve. They are polynomial with common factors, problems that satisfies the characteristics of perfect square: $(a\pm b)^2 = a^2\pm 2ab+b^2$, difference of 2 squares: $a^2-b^2=(a+b)(a-b)$, sum or difference of 2 cubes: $a^3\pm b^3 = (a\pm b)(a^2\mp ab+b^2)$, or perfect cube: $(a\pm b)^3 = a^3\pm 3a^2b+3ab^2\pm b^3$ and problems of trinomials with a degree of 2 i.e. $x^2+(a+b)x+ab = (x+a)(x+b)$
- Problems that need 2 methods to solve are posed, for example: ab^2-4a. There are a few combination of solving techniques like common factor with standard equation, common factor with cross method or cross method with standard equation.
- Problems with more than 4 terms that need to be divided into groups of terms before they can be solved by the general methods.
- Problems that require special techniques to solve like adding terms, splitting terms etc.

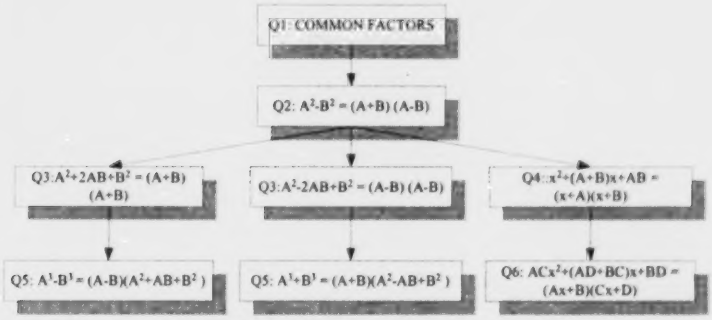


Figure 1. Part of the pedagogical knowledge

A student modeler tries to understand the mental state of a student so as to provide a more accurate estimation of individualized instruction. The task of building a student model is extremely difficult as the amount of information to capture is huge. Although it has been pointed out that this task is intractable[1], an incomplete student model is still very useful in the process of tutoring [2] [3].

The student modeler evaluates the solution of the student and the ways he factorizes the polynomial with respect to the one solved by domain expert. Although the solution path for a given problem of a student might be different from that of domain expert, the student's solution is still correct if it answers to the problem. In our case, if all the factors that the student found are irreducible, his answer is correct. The tutor would suggest him another way to solve the problem if it is found that his solution path is different. In this way, students are guided to know that there is always another way or a better method to solve a problem. Referred to table 1, student is asked to factorize a problem $4a^2-16b^2$, the second column shows the ways that he solves the problem. The student answers the question correctly and his student model is updated accordingly. Although his problem solving procedure differs from the sample, this would not affect his student model. Only the tutor would suggest him its way for the student as reference.

Problem: $4a^2-16b^2$			
Student	Reason	Tutor	Reason
$=(2a-4b)(2a+4b)$	$a^2-b^2=(a+b)(a-b)$	$=4(a^2-4b^2)$	Common factor
$=2(a-2b)2(a+2b)$	Common factor	$=4(a+2b)(a-2b)$	$a^2-b^2=(a+b)(a-b)$
$=4(a-2b)(a+2b)$	Multiply numbers		

Table 1. Procedure that the student and the tutor solves a problem.

The student model in ITS for elementary algebra contains a general information about the student, history of student's performance such as previously solved problem, information about the usage of factorization techniques and what kind of problems he is able to solve according to the pedagogical knowledge. All these information is important to allow students to receive more instruction and perform more problem-solving questions in areas in which they are relatively weak. An array of integer is used to keep the system's belief of student's mastery of a certain skill.

The interface of our system shown in Figure 2 is designed to be user friendly. It is divided into 3 main regions: upper part shows "Check answer" and "New problem" buttons; lower part is the area where the tutor provides feedback. The student interacts with the system mainly at the left side of middle part of interface. He may enter a question by himself or the system might generate one based on his experience. A list of actions is listed for him to explore the problem solving technique. He may select an action to tell the system how he would solve the problem. Every action selected would be given an appropriate feedback to the student. In this way, he might discover what is the consequence of selecting an action. An input area is allocated for the student to enter auxiliary data needed for his selected action. When the answer button is clicked, the student's solution is evaluated and his student model is updated accordingly.

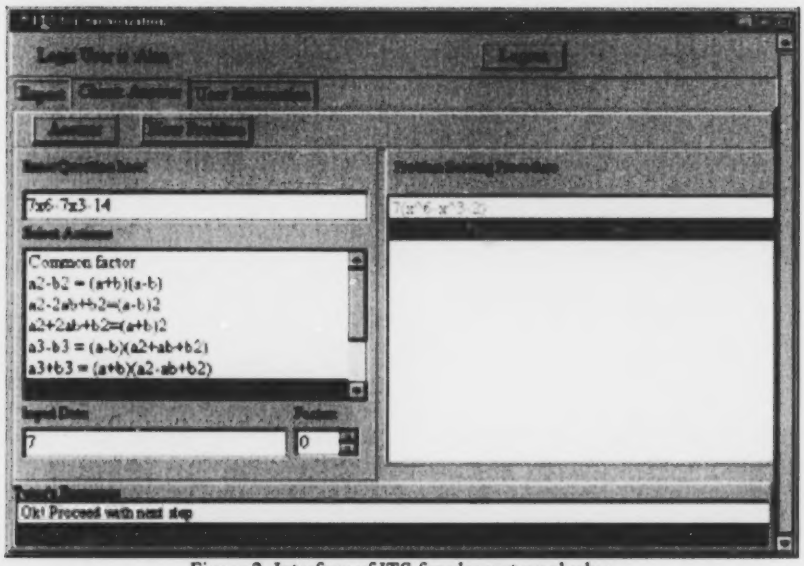


Figure 2. Interface of ITS for elementary algebra

3.1 Evaluation

In our experiments to simulate the problem solving procedure of students using the system, we found that it follows the overall design. It is able to provide individualized instruction, appropriate feedback and model student's performance. For major types of the factorization problem in junior school, the tutor is able to solve and guide the students. However, there are also questions that it fails to solve and guide. There are also cases that the available action for students to use in the problem solving process is not enough.

4. Conclusion

In this paper we have described an on-line intelligent system with interactive problem solving support and curriculum sequencing. A prototype system designed with some learning theory is implemented. The system helps students to reinforce the factorization technique. Our intention of building this system is to increase the learning progress of students and it shows to be a successful tool according to informal evaluation

Since the success of an ITS depends greatly on the student model, we are planning to improve our system with a more accurate student model in the near future. The user interface will be reconstructed to improve the interactivity between users and the system. The implemented domain knowledge is quite limited in this stage and we are developing larger domain knowledge.

Reference

[1] Self J., "Bypassing the intractable problem of student modeling", Intelligent tutoring system: at the Crossroads of Artificial Intelligence and Education, (1990).

[2] Self J., "Formal Approaches to Student Modeling", Student Modeling: The key to individualized knowledge-based instruction, (1994).

[3] Woolf B.P. and Murray T., "Using Machine Learning to advise a student model", Student Modeling: The key to individualized knowledge-based instruction, (1994).

BEST COPY AVAILABLE

Automatic Background Knowledge ConstructionUsing Genetic Algorithms

Jeffrey T. Chua and Raymund C. Sison
E-mail: ccsjc@ccs.dlsu.edu.ph; ccsrcs@ccs.dlsu.edu.ph
College of Computer Studies, De La Salle University, Professional Schools, Inc.
Manila, Philippines

This paper is a work-in-progress report on a proposed method for automating the task of background knowledge construction (including its possible extension) using an unsupervised model of learning. More specifically, we propose to apply the genetic algorithm operations of crossover and mutation to discover the discrepancies (bugs) between a correct solution and a set of student solutions. To illustrate the approach, we consider as a very simple example binary subtraction as problem domain.

Keywords: **buggy, crossover, mutation, GA**

1 INTRODUCTION

An Intelligent Tutoring System (ITS) is a computer program for educational support that can diagnose problems of individual learners. This diagnostic capability enables it to adapt instruction or remediation to the needs of individuals [6].

The background knowledge of an ITS is composed of the correct model of the solution and a collection of misconceptions – which is referred to as bug library. This background knowledge is constructed and is dependent specifically on the problem domain in consideration. There are problem domains wherein the background knowledge (more specifically, the misconceptions) can be completely specified, for example, arithmetic operations. For more complex problems, however, a complete specification is not a trivial activity, and in fact may not be achievable at all. In such cases, the best alternative is to enable the system to have the capability to extend its background knowledge.

The construction of the background knowledge starting from zero, and its further extension are difficult tasks. Considering that ITS is a field of computer science, it is ironic to note that the common practice is to perform the above-mentioned tasks by hand. Development of tools or methodologies that will help if not completely automate the construction and extension of the background knowledge is an important research problem.

Currently, there are very few systems with such capabilities; these include PIXIE [7], ASSERT [1], and more recently MEDD [6]. These systems use Artificial Intelligence (AI), more specifically, machine learning techniques, in the automated construction of the background knowledge.

Genetic algorithm [4] is model of learning using evolution as inspired by nature as the basis of their design and implementation. So far, it has not yet been (fully) studied whether an automated background knowledge construction can be achieved using unsupervised learning via genetic algorithms. In this paper, we propose a method for automatic background knowledge construction using genetic algorithms.

The paper is organized as follows. A brief discussion of genetic algorithms is given in section 2. It is then followed in section 3, by a description of the general framework of the proposed automatic background knowledge construction scheme. Section 4 presents a simple example considering binary subtraction as the problem domain to partly illustrate the proposed approach. Finally, the concluding remarks are given in Section 5.

2 GENETIC ALGORITHMS

Genetic algorithm is a computational model of machine learning inspired by evolution in nature. The computer based model is realized by describing a population of individuals represented by chromosomes. A chromosome is in turn (simply) described as a string that models the genetic information (also known as DNA). The species in the population are subjected to genetic operations such that after several generations the string pattern would have changed, thus modeling the concept of evolution.

There are basically two genetic operations, namely crossover and mutation. The crossover (also called recombination) operation computes the genetic information of an offspring as the crossover combination of the chromosomes of its parents. The main reason behind crossover is that, genetic information of "fit" parents should be passed on to their offspring. On the other hand, mutation occurs when a portion of the genetic information is altered (not due to crossover), sometimes in random. Mutation is the operation that allows the population of individuals to become more diversified. It should be noted that genetic information about individuals are tested against some fitness function. If the individual is tested to be "fit" then its genetic information (or part of it) are passed onward to the next generation.

3 PROPOSED METHOD FOR AUTOMATIC BACKGROUND KNOWLEDGE CONSTRUCTION

We propose the application of genetic algorithms to the problem of automatic background knowledge construction and extension. The general framework of our approach is illustrated in Figure 1.

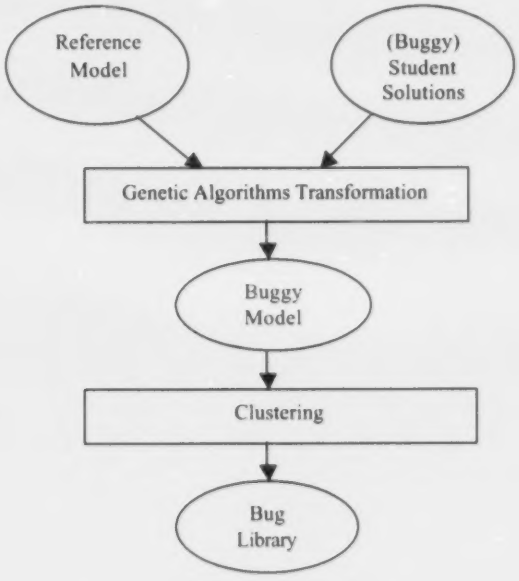


Figure 1. General Framework of Our Approach

The inputs are (i) the correct model of the problem domain, referred to as the *reference model* and (ii) the student's (possibly buggy) solutions to the problem. A model can be viewed as a set of rules for solving problems in a domain. In our proposed approach, a sequence of genetic algorithm operations (i.e., crossover and mutation) are applied on the reference model to compute a buggy model that covers all or most of the student's buggy solutions. A buggy model may possibly contain multiple bugs. Thereafter, the bugs in the buggy model are subjected to a clustering algorithm such as COBWEB [3] or MMD [6] to determine the primitive bugs. The output is a set of primitive and compound bugs to be placed in a bug library.

Encoding

A series of bits will be used to represent the individual rules that make up a model for a particular domain Notice that a rule will probably need to be tested for multiple conditions joined by logical AND operator. The rule will have to be broken down to several sub-rules. Each sub-rule will test only for an atomic condition.

The (sub)rules that were followed to perform a correct subtraction is encoded as a string. Another string that encodes the (possibly buggy) subtraction solution of a student will also need to be found. It is possible that the student's solution may have violated more than one rule. A collection of such "buggy" strings will comprise a discrepancy set.

GA Transformations

The initial population is set to the reference model which represents the rules for a domain. The buggy student solutions are then examined to determine which rules in the reference model were violated. Frequency count are computed per rule violated. GA operations are then performed on the most frequently violated rules, and the fitness function, which is equal to the percentage of the buggy solutions satisfied is computed. Then evaluate the fitness function again. If the fitness function satisfies a user-redefinable parameter, the procedure terminates; else GA operations are performed again.

Step 1. Buggy Model reference model

Step 2. Determine frequency of violated rules

Step 3. Perform GA operations (crossover or mutation) on frequently violated rules in buggy model

Step 4. Compute for fitness function

Step 5. Evaluate fitness value of buggy model

Step 6. If fitness function > user-redefinable parameter, then stop; and return the buggy model; else go back to Step 3.

Clustering

It is possible that multiple bugs are encoded in a single model. Moreover, there are strings that would contain possibly the same set of bugs. To group similar bugs, we propose to use a clustering scheme, for example COBWEB or MMD, to separate primitive bugs from compound bugs and results are stored in the bug library.

4 ILLUSTRATIVE

To illustrate our approach, we consider as example, a simple problem of binary subtraction as the target problem domain. Binary subtraction may be performed by using "borrows" just as in the decimal system. In binary subtraction, a borrow is made from 10; thus, 10 - 1 = 1. For example,

```
  10  10      - borrows

1 0   0 1     - minuend
0 1   1 0     - subtrahend
---------------
0 0   1 1     - difference
```

Binary subtraction can be summarized using the following table:

Rule	Minuend	Subtrahend	Previous Borrow	Borrow	Difference
1	0	0	0	0	0
2	0	0	1	1	1
3	0	1	0	1	1
4	0	1	1	1	0

5	1	0	0	0	1
6	1	0	1	0	0
7	1	1	0	0	0
8	1	1	1	1	1

The table shown above represents the reference model, which serves as the initial buggy model.

Given the buggy student solutions shown below,

```
1]    110        2]    101        3]    100
     - 011            -011             -011
     -------          -------          -------
      100              100              100
```

Note that the first rule that was violated was rule number 3 in the table above. Performing a GA operation, specifically mutation, we would now have a new buggy rule 3 which is:

Rule	Minuend	Subtrahend	Previous Borrow	Borrow	Difference
3'	0	1	0	1	0

One we now computes for the fitness function given the revised buggy model as equal to the percentage of buggy solutions satisfied. If the fitness value is greater than a user-redefinable parameter then we stop; else we perform GA operations again as above.

An approach to automatic bug library construction and extension using genetic algorithms was outlined, and illustrated using the problem of binary subtraction. Much has still to be done, but we think that our preliminary work on the problem presented is worth pursuing.

REFERENCES

[1] Baffes, P. and Mooney, R. "Refinement-based Student Modeling and Automated Bug Library Construction", Journal of Artificial Intelligence in Education, 7(1), 75 – 116, (1996).

[2] Burton, R. "Diagnosing Bugs in a Simple Procedural Skill", In D. Sleeman and L. Brown (Eds.), Intelligent Tutoring Systems. London: Academic Press, (1982).

[3] Fisher, Douglas, "Knowledge Acquisition Via Incremental Conceptual Clustering", Machine Learning, 2, 139 – 172, (1987).

[4] Falkenauer, Emmanuel, "Genetic Algorithms and grouping problems", John Wiley, New York, (1997).

[5] Rendell, L. "Genetic Plans and the Probabilistic Learning System: Synthesis and Results", Proceedings of the First International Conference on Genetic Algorithms and their Applications, (1985).

[6] Sison, R., Numao, M., & Shimura, M. "Multistrategy Discovery and Detection of Novice Programmer Errors", Machine Learning, 38, 157-180, (2000).

[7] Sleeman, D., Hirsh, H., Ellery, I., and Kim, I. "Extending Domain Theories: Two Case Studies in Student Modeling", Machine Learning, 5, 11-37, (1990).

AWETS: An Automatic Web-Based English Testing System

Zhao-Ming Gao
Department of Foreign Languages and Literatures
National Taiwan University
Taipei 106, TAIWAN
E-mail: zmgao@ccms.ntu.edu.tw

Test items are traditionally created by experts. While this approach has many advantages, it is laborious and time-consuming. Recent advance in corpus-based computational linguistics has shed new light on the feasibility of a computer-based language testing system capable of automatically generating items. This paper describes AWETS, an automatic web-based English testing system developed by the author's research team and used in his freshman English classes at National Taiwan University. AWETS automates test item generation, test delivery, scoring, and record keeping. It can generate random items for each testee in accordance with the input conditions of the test administrator. With AWETS, testers' jobs are reduced to inputting information such as a list of words and the time limit of each question. Besides being a useful tool for creating achievement tests in English vocabulary, AWETS can also generate proficiency tests based on a selected difficulty level without the need to input a word list. AWETS can be seen as a significant step toward future computer-based language testing system.

Keywords: **automatic generation of items, computer-based language testing, corpus-based computational linguistics, vocabulary testing**

1 Introduction

Test databank in current computer-based language testing systems is mostly created by human experts. This procedure is laborious and time-consuming. Moreover, since test databank is difficult to adapt, teachers using the systems have to spend a lot of time creating the tests for their own classes. To solve this problem, several researchers have suggested the feasibility of designing a tool to automatically generate items. For instance, [4] proposes creating a vocabulary test or exercise from a general corpus using a concordancer, and [5] suggests automatically generating CALL exercise from an electronic dictionary and a parsed corpus. Along the same line of research, we build AWETS, an automatic web-based English testing system that can greatly facilitate the creation of multiple choice vocabulary test. The system, designed with the central concern of adaptability, can generate multiple choice vocabulary test items in accordance with the conditions input by test administers. The system consists of three independent yet interrelated modules: the item generation module, the test delivery module, and the record keeping module.

2 The Item Generation Module

The system is developed based on a large collection of electronic texts and natural language processing tools such as a morphological analyzer and a part-of-speech tagger. The procedures of building the system are as follows.

1. Collection of a Text Database: We retrieve free electronic English texts from the internet primarily from Project Gutenburg and the Sinorama Magazine. Texts in Project Gutenburg are mainly literary works, while those in the Sinorama Magazine contain articles about the culture and events in Taiwan. To ensure that the retrieved texts are not too difficult for our learners, we only include works published after 1960.

The corpus size is about 0.2 million words.

2. Lemmatization: All the retrieved texts are processed by a morphological analyzer developed by University of Pennsylvania which changes regular and irregular inflections into their lemmas, i.e. basic forms (e.g. ran => run, happier => happy).
3. Frequency counts of lemmas: After lemmatization, frequency count of each lemma in the entire corpus is conducted.
4. Sorting of the frequency count of the lemmas in descending order:
5. Identification of the difficulty levels of each lemma: Three levels of difficulty are specified. They correspond to college entrance exams, TOEFL, and GRE. Each level has a range of adjustable values. At present, the range of these three values is stipulated as follows.

College Entrance Exam	Words which fall in the range of the most frequently occurring 3000 – 5000 lemmas
TOEFL	Words which fall in the range of the most frequently occurring 5001 – 7000 lemmas
GRE	Words which fall in the range of the most frequently occurring 7001 – 9000 lemmas

6. Tagging: Each text is processed by Eric Brill' s tagger which labels each word its part-of-speech information.
7. Indexing of each word: A database is created which records the documents and position in which a word occurs so that sentences containing a specified word can be retrieved in no time.

   Test administrators can choose the level of difficulty, the part-o f-speech of words, as well as the number of questions to be tested. Once the choices are made, the system will randomly retrieve sentences which meet the input conditions via the index. A subroutine then converts the retrieved sentences into multiple choice questions. The distracters of the questions are chosen from words of the same difficulty level as the target word. Figure 1 is the user interface for inputting conditions. Figure 2 is the automatically generated test items.

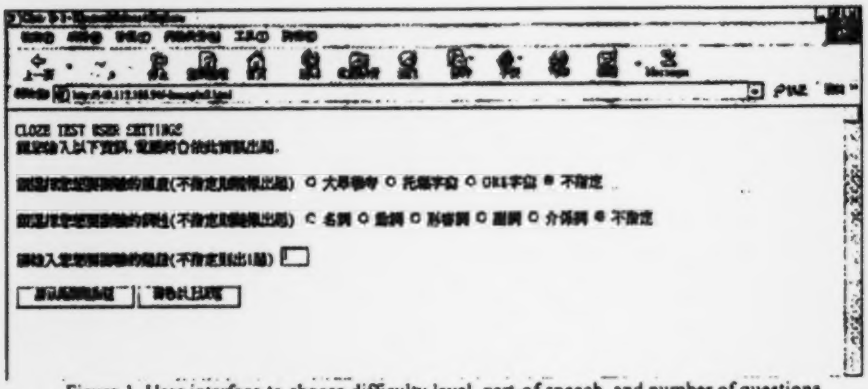


Figure 1. User interface to choose difficulty level, part-of-speech, and number of questions

BEST COPY AVAILABLE

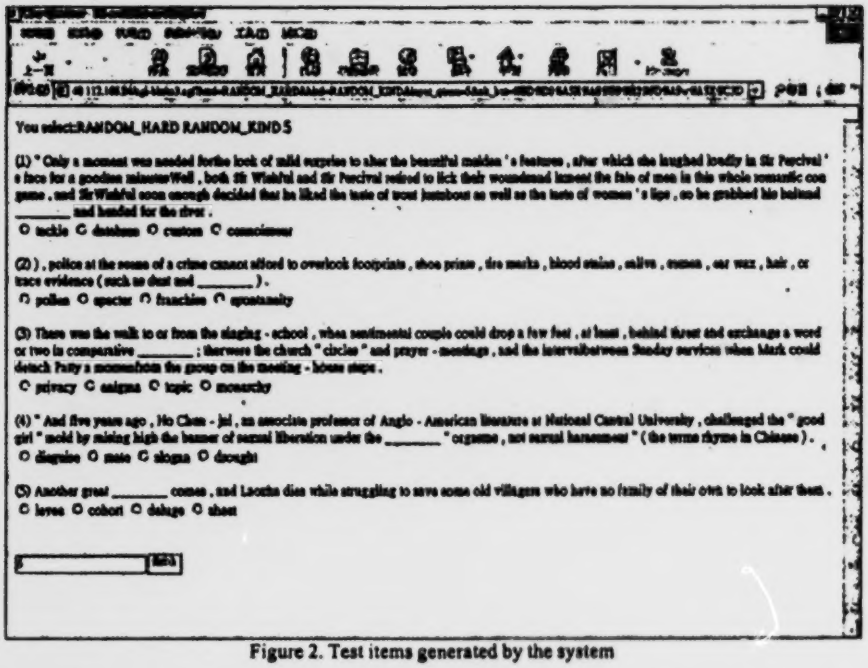


Figure 2. Test items generated by the system

As shown in Figure 2, the system is capable of generating individualized on-line vocabulary tests in the context of cloze tests based on the conditions input by a user. The system can thus be used as an excellent tool for self-paced vocabulary learning. If a learner wants to practice verbs at the TOEFL level, the system can create hundreds of such questions. As soon as he submits his answer, the system can check his answer and immediately present the correct answer to the user. Besides, if a test administer wants to change the difficulty level of the test, he can do it easily by changing the frequency range. To further facilitate the creation of vocabulary tests, the system also allows the test administer to decide which word should be tested. This is particularly useful for creating achievement tests. Once the tester inputs the words and the number of questions, the system can randomly generate multiple choice vocabulary tests in the context of cloze tests. Besides a corpus, AWETS also uses Wordnet, a lexical database developed at Princeton University, to generate items. It extracts the explanation of a lexical item and create multiple choice questions based on the item.

3 The Test Delivery Module

As described above, the item generation module can randomly create a specified number of questions in accordance with the input conditions by a test administer. To make test delivery more efficient, the test databank is created off-line. In other words, all the sentences meeting the input conditions are retrieved before the test starts. These sentences are converted into test items by a subroutine and then stored in the database. A subroutine then randomly retrieves a specified number of items from the databank and present them to the testees when the test starts. To ensure wide and unpredictable sampling, the subroutine is designed in such a way that no two tests are identical and no word will be tested twice in any test. The AWETS database also provides an interface (cf. Figure 3) for the test administer to input specification for the test. The interface allows the test administer to input the name of the test, the number of items, the time limit during which each question should be answered, and the number of times each testee can take the test. The test administer can further choose which classes and which words should be included in the test. After the test information is input by the test administer, testees proceed with the following procedures. They first input their user names and passwords. Before the real test begins, they are given 5 questions for practice. This procedure can help testees become familiar with the format of the questions. An interface and a test item such as Figure 4 is presented to the testees. As mentioned earlier, each question must be answered within a specified time limit. As soon as a question appears on the screen, the system begins to count down

BEST COPY AVAILABLE

the time left. The randomized questions and the time limit make cheating in the examinations much more difficult. Without these two functions, students might try to find answers fro m the person who sit next to them or from an on-line dictionary. The countdown device might also achieve a beneficial backwash, because testees need to speed up reading the question in order to finish the questions within the time limit.

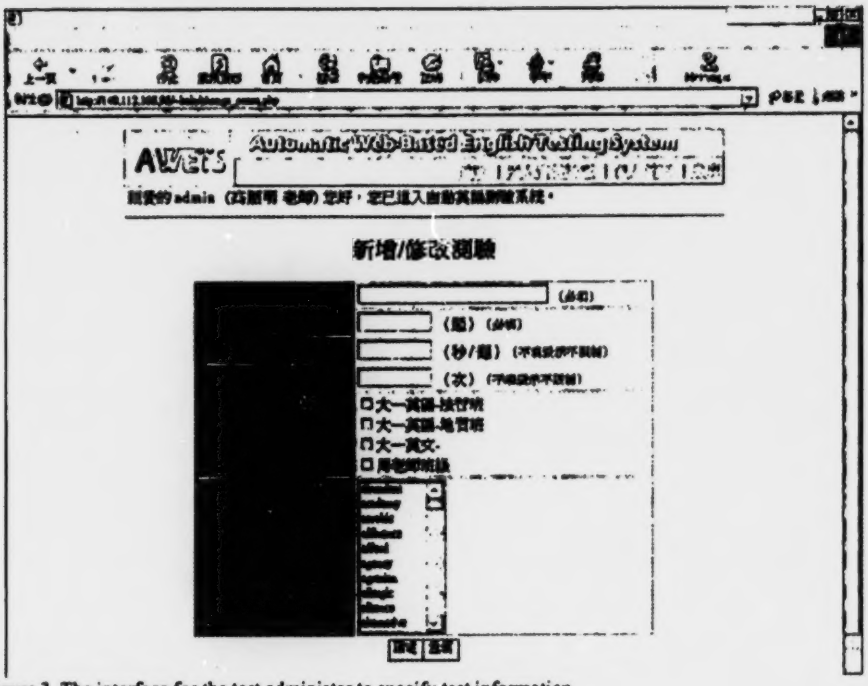


Figure 3. The interface for the test administer to specify test information

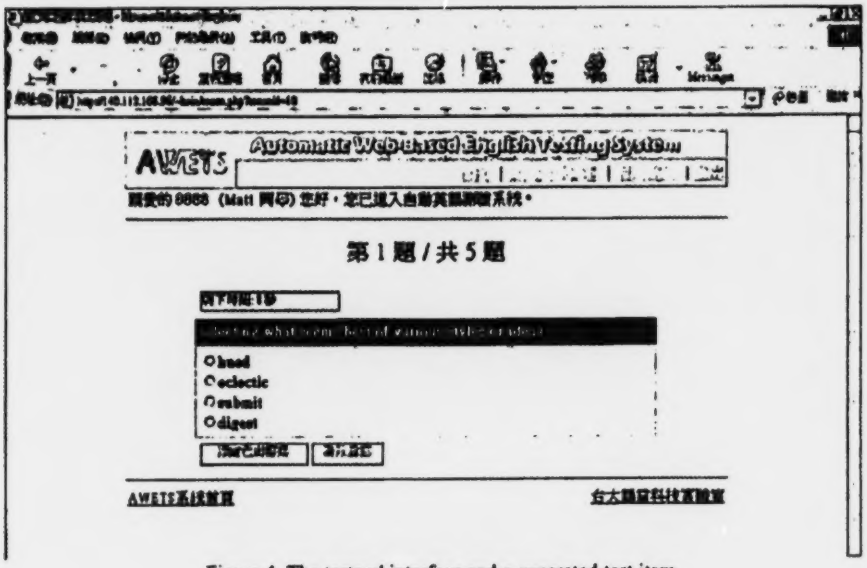


Figure 4. The testees' interface and a generated test item

1089 A

BEST COPY AVAILABLE

4 The Record Keeping Module

After each test, the system records the registration number, the name of the student, the test id number, the name of the test, as well as the student's score in each test. The database component allows teachers to query a student's record or the whole class's scores in an exam via the interface in figure 5.

57	lack	100.0000	2	查詢
b85306030	[illegible]	57.5000	2	查詢
b85302137	[illegible]	95.0000	2	查詢
b85302138	[illegible]	80.0000	1	查詢
b85303028	[illegible]	77.5000	2	查詢
b85305125	[illegible]	72.5000	2	查詢
b85305143	[illegible]	42.5000	2	查詢
b85305213	[illegible]	80.0000	2	查詢
b85501038	[illegible]	85.0000	2	查詢
b86701131	[illegible]	77.5000	2	查詢
b86701135	[illegible]	95.0000	2	查詢
b86701137	[illegible]	90.0000	2	查詢
b8870114	[illegible]	57.5000	2	查詢
b86701152	[illegible]	80.0000	2	查詢
b86701209	[illegible]	45.0000	2	查詢
b86701211	[illegible]	95.0000	2	查詢
b86701222	[illegible]	70.0000	2	查詢
b86701224	[illegible]	75.0000	2	查詢

Figure 5. The database interface for querying the whole class's scores in a test

The database component greatly facilitates the calculation of validity and reliability. When testees are given more than one set of test items in a given test, the correlation of the scores can be easily computed. The system also records all the questions and testees' responses. These data can be used to analyze testees' test-taking strategies. With this function, item analysis is possible although no test candidates have identical tests.

BEST COPY AVAILABLE

Figure 6. A student's responses to the test items

5 Some Problems of AWETS

Although AWETS performs relatively well, there are some limitations which prevent it from being a completely reliable testing instrument. First, the basic assumption that difficulty of words can be determined by frequency is challenged by some scholars, since there are some words common in everyday life but much less common in texts. Moreover, a word might have several meanings some of which are much more difficult than the others. The approach proposed in this paper cannot distinguish the difficulty of the different meanings of a word. Another question is whether there might be more than correct answer in generated test items. When AWETS automatically creates multiple choice questions, it randomly chooses distracters from the dictionary. Although the distracters rarely fit the context, it might happen that some of them are acceptable. Note that choosing distracters with different parts-of-speech from the target word does not solve the problem, because a word might be used in different parts-of-speech. It should also be admitted that although AWETS can create individualized tests, it lacks a rigid method to ensure equal difficulty for all testees. Another technical problem involved is that the part-of-speech tagging program and the program which identifies sentence boundary is not one hundred percent correct. This might result in undesirable test items. Even when sentence boundary is correctly identified, some sentences might not be appropriate in testing a learner when taken out of context. This is particularly true of short sentences. Long sentences, however, are not always unproblematic. In a vocabulary test, all the words in the sentence are meant to give the contextual clues except the target word. In other words, the target word should ideally be the most difficult word in the sentence. Consequently, if there is a word in the same sentence more difficult than the target word, the test item might not be appropriate. Questions like these all require more rigid methods than those adopted in current implementation of AWETS.

6 Conclusion and Future Research

In this paper, we introduce AWETS, a web-based system that can automatically create vocabulary tests and

BEST COPY AVAILABLE

adapt items according to the conditions input by test administers. AWETS greatly facilitates the creation of vocabulary tests and has fully automated procedures for item generation, test delivery, scoring, and record keeping. At present, the validity and reliability of the automatically generated test items are being investigated. Future research will focus on solving the problems noted in section 5 by using sense-tagged texts and more rigid methods to identify difficulty of words.

Acknowledgements: The author wishes to thank Miss Lin Gui-Guang, Miss Liang Jing-Xiou, Mr. Zhao Zheng-Ming, and Mr. Lin Zheng-Ru for helping implement AWETS. AWETS is supported in part by a grant from the Computing and Information Network Center at National Taiwan University for the promotion of asynchronous learning.

References

[1] Bulter, Jonathan. Cloze procedures and concordances: The advantages of discourse level authenticity in testing expectancy grammar. System 19, 1/2, pp. 29-38, (1991).

[2] Hughes, Arthur. Testing for Language Teachers. Cambridge University Press, (1989).

[3] Stevens, Vance. Classroom concordancing: Vocabulary materials derived from relevant authentic text. English for Specific Purposes Journal 10: 35-46, (1991).

[4] Wilson, Eve. The Automatic Generation of CALL Exercises form General Corpora. In Wichmann et al. (eds.) Teaching and Lanuage Corpora. Longman, pp. 116 – 130, (1997).

Case-Based Evaluating Assistant of Novice Programs

Hiroyoshi Watanabe, Masayuki Arai and Shigeo Takei
School of Science and Engineering, Teikyo University
Toyosatodai Utsunomiya-shi Tochigi, 320-8551 Japan
E-mail: {hiro,arai,takei}@ics.teikyo-u.ac.jp

This paper presents a method of implementing an evaluating assistant system that supports teachers' evaluation work of students' programs using case-based reasoning. The target evaluation tasks are to judge whether a student's program satisfies the requirements of the given problem and to give advice for the student's program. The case-based evaluating assistant system compares a program submitted by a student with evaluation cases in the case-base. If some case matches the program, the system applies the judgment and advice on the case to the program. We implemented a case-based evaluating assistant system for novice programs written in an assembly language based on the proposed method. The implemented system was utilized for actual classes and the results showed that the system reduced the teachers' evaluation work drastically.

Keywords: **program evaluation, programming classes, supporting teachers, case-based reasoning.**

1 Introduction

This paper describes a method of supporting teachers' evaluation work of students' programs. In programming education, programming exercise courses play an important role, because writing programs is indispensable to learning programming. In programming exercise classes, however, the teacher's loads of evaluation tend to be very heavy because the teacher has to read so many programs and reports. We aim to implement a computer system as an evaluating assistant that supports the teachers' evaluation work.

There are two approaches to the evaluation of students' programs. The first one is to diagnose programs and give advice by knowledge-based program recognition [1]-[3]. Most of the systems based on the approach require a huge amount of knowledge on bugs, and it would be difficult to constitute the systems practically. The second approach is to support teachers' evaluation work [4]. This approach may not necessarily aim at automating the evaluation work. It aims at implementing practical systems by limiting computers' evaluation work. We took the second approach.

We consider the program evaluation work as collaboration between teachers and computer systems and propose an evaluating assistant model of programs. We also propose a framework of the case-based evaluating assistant system.

2 Target Task and Evaluating Assistant

2.1 Task of Program Evaluation

The target evaluation tasks of a student's program are the following two tasks: (1) the first task is judging whether a student's program satisfies requirements of the given problem. When teachers set problems, they have educational intentions about what students should learn, namely concepts, algorithms, instructions and so on. Teachers read students' programs to see whether the educational intentions are achieved. Therefore, teachers accept a student's program when the program satisfies requirements of the given problem. The first task is defined on the assumption that students have to submit their programs over and over until their

programs are accepted. (2) The second task is giving written advice. Teachers give advice to students whether they accept a program or not: teachers give advice about the reasons why the program is rejected, and advice about bettering the program even if the program is accepted.

2.2 Evaluating Assistant of Programs

Figure 1 illustrates an evaluating assistant in the electronic submission environment of programs. The evaluating assistant pre-evaluates submitted programs and a teacher can refer to the results when he or she evaluates the programs. If the teacher trusts the evaluating assistant, the results from the assistant can be sent to students directly. Such an evaluating assistant is expected to save a teacher a lot of time and energy.

The output of the evaluating assistant consists of evaluation results, their reasons and the degree of confidence. The evaluation results include the judgment of acceptability (accept or reject) and written advice. The degree of confidence is one of surely, probably or unknown. When the degree of confidence is unknown, evaluation results and their reasons are not given.

The evaluation results of the assistant are required to be always correct when the degree of confidence is surely. If so, the results of the assistant with surely confidence can be sent to students directly, in other words, teachers can trust the evaluating assistant.

The evaluating assistant should have the capability to learn. The final results of the teacher's evaluation are available for the learning. If the assistant is capable of learning, almost the same programs as ones which the assistant has evaluated incorrectly, are expected to be evaluated correctly in the future.

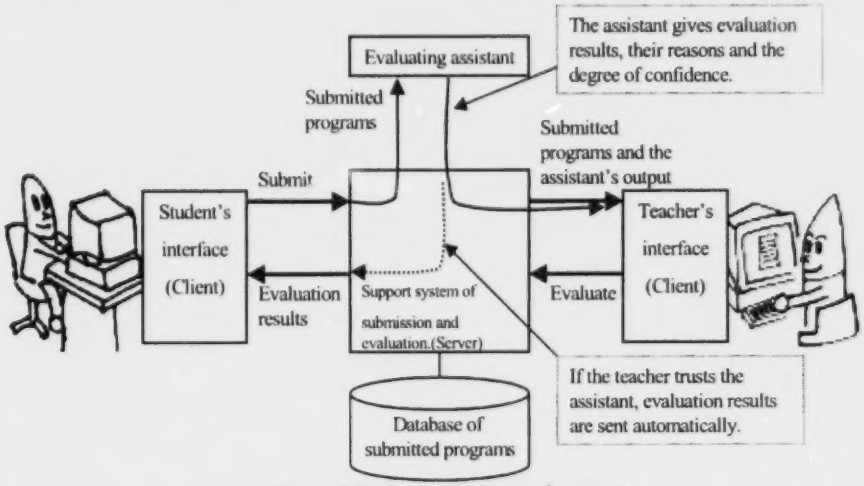


Figure 1 Evaluating assistant of programs

3 Case-based Evaluating Assistant

The case-based reasoning approach is one of the best approaches to implement an evaluating assistant described in Section 2.2. Case-based reasoning systems make use of stored past cases directly in solving newly presented problems [5]. The case-based evaluation of programs is defined as "if some evaluation case of a program whose implementation is the same as the newly given program, then the evaluation results on the case are applied to the given program".

3.1 Representation of Cases

A case for the case-based evaluating assistant consists of retrieval information, problem description, solution description and maintenance information.

(1) The retrieval information includes problem identification that the program is written for and features of the program. The features of the program depend on target programming languages. For example, numbers of if-statements, while-statements and other statements are available in the case of language C.
(2) The problem description in the domain of a program evaluation task is a program list itself. A program list should be represented as a normalized form [2], or a generalized form [6], because there are many variations of program lists for the same implementation.
(3) The solution description includes the judgment of acceptability and written advice.
(4) The maintenance information includes a teacher's name and the date of adding or updating the case.

3.2 Processes of Case-based Program Evaluation

The processes of case-based program evaluation are the following:
(1) Problem analysis: The retrieval information is extracted from a student's program list.
(2) Case retrieval: Cases are retrieved using information generated by analyzing a given program. Cases that have no possibility of matching the given program should be pruned here.
(3) Evaluating and selecting cases: Evaluating cases is the process of matching a given program against cases. The purpose of the process is to investigate whether the given program has the same implementation as the cases, or not. All candidates of cases are evaluated and the best match case is selected. The method of matching programs depends on the target programming languages.
(4) Applying and adapting cases: If there is a case that matches the given program, the judgment of acceptability on the case is applied to the given program. In addition, advice sentences on the case are available for the given program, although the sentences should be adapted for the given program. If no case matches the given program, the judgment and advice is not generated.

3.3 Case-base Maintenance

The maintenance of the case-base is performed using teacher's final evaluation results. One of the most important maintenance tasks is adding new cases when the evaluation results of the assistant are different from the teacher's. New cases are also added when the confidence of the evaluating assistant is not *surely*. More advanced maintenance, e.g., generalizing, specializing and forgetting cases [7], may be needed in order to refine the case-base.

4 The Evaluating Assistant System for Assembly Language Programs

Based on the proposed idea, we implemented a case-based evaluating assistant system for novice programs written in an assembly language [6]. The target assembly language is CASL which is adopted in examinations for information-technology engineers certified by the Japanese ministry of international trade and industry.

4.1 Implementations Depending on The Target Language

In this section, implementations depending on the target language CASL are described.
(1) Evaluating the program's action: Before the case-based program evaluation, the assistant system tests the action of a submitted program using prepared sample data. Only programs executed correctly are evaluated by case-based reasoning [6].
(2) Case representation: Although cases are represented in the form described in Section 3.1, no features except for a program ID are used for the retrieval information. A program list in a case is represented in CASL itself, or its generalized form that we defined [6].
(3) Case retrieval: The implemented system retrieves all cases whose problem ID is the same as a given program. That is to say, the system does not prune candidate cases.
(4) Case evaluation (program matching): The program matching process aims at making consistent correspondences of instructions, labels and registers between a case and a student's program [6]. If the following condition1 is met, the case matches the given program.

- **Condition 1**: All instructions of the case correspond to instructions of the given program, and all instructions that correspond to nothing do not affect to the program's action.
  Especially, if the following condition is satisfied, it is called a "perfect match":
- **Condition 2**: Instructions of the case and the given program correspond one-to-one and the differences of the order of corresponding instructions are trivial.

If the best match case meets condition2, *surely* is assigned as the degree of confidence. If the best match case meets condition1 but not condition2, *probably* is assigned. In the other cases, that is, when no case meets the condition 1, *unknown* is assigned.

4.2 Experimental Results

The implemented assistant system was utilized for actual classes of the CPU and assembly language course at our university in 1999. Seventy-three sophomore students in the department of computer science took this course. Problems presented in classes of the course are the following: (P1) select bigger of the two given integers, (P2) sum the given N integers, (P3) select the maximum of the given N integers, (P4) rotate N bits to the right and (P5) check the correspondence of "(" and ")".

Table 1summarizes results of using the assistant system. The following are found from Table 1:

- The values of (f) show that the implemented case-based assistant system achieves sufficiently high accuracy of judgments. Furthermore, the accuracy of the case-based assistant system satisfies the requirements described in Section 2.2, because it is a hundred percent in cases of *surely* confidence.
- The values of (g) show that the ratios of available advice without modifying are not as high as the accuracy of judgments, although it is fairly high.
- Because teachers do not need to evaluate the acceptability when the case-based assistant system outputs evaluation results with surely confidence, it is estimated that the system reduces the teachers' evaluation work by percentages shown as (h). In other words, by using the assistant system, the evaluation work of teachers is reduced by 60 to 90 percent depending on problems.

These results demonstrate that the case-based assistant system is very effectual in reducing teachers' evaluation work. Still, there is room for improvement in the capability to generate written advice.

Table 1 Evaluation data of the assistant system based on practical use in classes

	P1	P2	P3	P4	P5
(a)Cases saved in the case-base	15	10	29	34	38
(b)Submitted programs	119	119	140	156	157
(c)Programs rejected by checking their action	44	39	44	54	79
(d)Programs evaluated by the assistant system with *surely* confidence	62	72	72	67	46
(e)Programs evaluated by the assistant system with *probably* confidence	8	3	5	5	0
(f)Judgment accuracy of the assistant system (%)	100 (100)	100 (100)	97.4 (100)	100 (100)	100 (100)
(g)Ratio of available advice generated by the assistant system without modifying (%)	92.9 (100)	69.3 (72.2)	88.3 (90.3)	66.7 (64.2)	91.3 (91.3)
(h) $((d)/((b)-(c))\times 100$ (%)	92.7	90.0	75.0	65.7	59.0

( ) : values for programs evaluated by the assistant system with *surely* confidence only.

5 Conclusions

We have proposed a concept of a program evaluation assistant and a method of implementing the assistant by case-based reasoning. Based on the method, we implemented a system for a simple assembly language CASL and used it in actual classes; the results demonstrated that the system reduced teachers' evaluation work drastically. We plan to improve the modification functions of advice sentences (written advice) and the method of the case-base maintenance. This research was supported in part by the Japanese Ministry of Education Grant No.11680400 and No.12780293.

References

[1] Adam,A. and Laurent,J.P., "LAURA, A System to Debug Student Programs, Artificial Intelligence", vol.15, pp.75-122 (1980).

[2] Johnson,W.L., "Understanding and Debugging Novice Programs", Artificial Intelligence, vol.41, pp.51-97 (1990).

[3] Ueno,H., "Concepts and Methodologies for Knowledge-Based Program Understanding — The ALPUS's Approach", IEICE Trans. Inf. & Syst., vol.E78-D, no.2, pp.1108-1117 (1995).
[4] Konishi,T., Suyama,A. and Itoh,Y., "Evaluation of Novice Programs Based on Teacher's Intention", Proc. of ICCE95, pp.557-566 (1995).
[5] Kolodner,J. ," Case-Based Reasoning", Morgan Kaufmann Publishers,Inc. (1993).
[6] Watanabe,H., Arai,M. and Takei,S. , "Automated Evaluation of Novice Programs Written in Assembly Language, Proc. of ICCE99, vol.2, pp. 165 - 168 (1999).
[7] Watanabe,H., Okuda,K. and Yamazaki,K., "Methods for Adapting Case-bases to Environments", IEICE Trans. Inf. & Syst., vol.E82-D, no.10, pp.1393 - 1400, (1999).

CBR-TUTOR: A Case-Based Reasoning Approach to an Internet Agent-based Tutoring System

Rhodora L. Reyes and Raymund Sison
ccsrlr@ccs.dlsu.edu.ph, ccsrcs@ccs.dlsu.edu.ph
College of Computer Studies, De La Salle University, Professional Schools Inc.
Manila, Philippines

Providing individualized instruction is an important tutoring task. Different learners have different needs. This task becomes more important when dealing with learners on the web. This paper presents the CBR-TUTOR, an Internet-based tutoring agent system that uses case-based reasoning approach in providing adaptive instruction to its learners. Using CBR in the tutor model enables the tutor to reference from past experiences and identify which instructional strategies were successful given a similar situation or student characteristics. The CBR-TUTOR is designed as a distributed problem solving architecture where each agent performs decision-making tasks and cooperates to help improve the effectivity of the tutoring system.

Keywords: **Intelligent Tutoring Systems, Case-Based Reasoning, Web-based learning, Agents**

1 Introduction

"The Internet now provides a possible new dimension to information technology in education, not only in terms of potential as a vast information resource, but also in respect of interaction and knowledge construction between individuals" (Wood, 1999). Unfortunately, most of the learning systems and electronic textbooks accessible on the web lack the capabilities of individualized instruction and user-adapted learning support that are emergent features of Web-based Intelligent Tutoring Systems [10].In providing individualized instruction, it is important to diagnose the problems of individual learners and identify how to adapt instruction and remediation to the needs of the individual learner. The diagnosis of the learner often involves analysis of learner errors. This is the task of the student model component of an Intelligent Tutoring System (ITS). A student model is an approximate representation of a student' s knowledge about a particular domain, which accounts for the students' solutions to given problems [9]. The tutor model component of an ITS, on the other hand, uses the student model to determine how to provide instruction and remediation [6].

The tutor model must be able to recognize the similarity and differences in the needs of these learners. Different learners have different needs. The task becomes more important when dealing with students on the web. Therefore, Internet-based tutoring systems must be able to reference to past experience in order for it to know which approach will be appropriate given a situation (or case). However, no past situation is ever exactly the same as a new one and domain knowledge for instructional strategies is oftentimes incomplete. This makes the tutor model incapable of using the instructional method appropriate to the learner. It is therefore necessary to create a tutor model that has the capability to understand new situations in terms of old experiences and adapt an old solution to fit a new situation. Cased-Based Reasoning (CBR) suggests a model of reasoning that incorporates problem solving, understanding, and learning; and integrates all with memory processes. CBR can mean adapting old solutions to meet new demands, using old cases to critique new solutions or reasoning from precedents to interpret a new situation or create an equitable solution to a new problem. [5]. CBR cycle has four phases: *retrieving* the most similar case or cases, *reusing* the information and knowledge in the case to solve the problem, *revising* the proposed solution and *retaining* the parts of the experience that is likely to be useful for future problem solving [2].

Using CBR in the tutor model enables the tutor to reference from past experiences and identify which instructional strategies where successful given a similar situation or student characteristics. Existing

Case-based Intelligent Tutoring Systems use cases for teaching the learners the domain, that is, they use cases as pedagogy similar to the way exercises are used as strategy for teaching. Examples of such systems are Case-based Intelligent Tutoring Systems for operators of dynamic systems (CB-ITS) [3], Georgia Tech Case-Based Intelligent Tutoring Systems for Pilots (GT-CBITS) and Case-Based Reasoning Approach to Simulation-Based Intelligent Tutoring Systems for Tactical Action Officers (TAO ITS) [7]. However, none of these systems use CBR as an approach in helping the tutor identify similar experiences encountered when providing individualized instruction to the learners.

CBR-TUTOR is an Internet agent-based tutoring system that uses the CBR approach in providing adaptive instruction to its learners. It is designed as a distributed problem solving architecture where each agent performs decision-making tasks and *cooperates* to help improve the effectivity of the tutoring system. Cooperative agents are agents that are assigned to do specialized tasks to solve a common goal. Section 2 of this paper discusses the architecture of CBR-TUTOR followed by the discussions of its components in Section 3. Finally, the conclusion and future works will be presented.

2 CBR-Tutor Architecture

CBR-TUTOR is an Internet-based tutoring agent system that uses case-based reasoning (CBR) approach to determine how to provide individualized instruction to its learners. This section discusses the architecture of the CBR-TUTOR in terms of its components and their relationships.

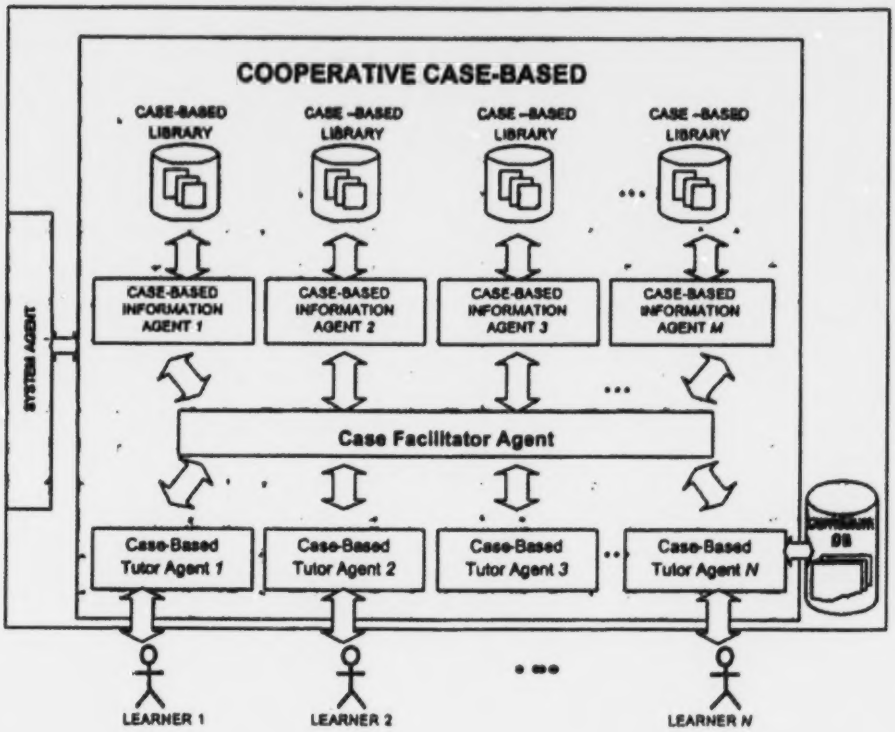
CBR-TUTOR is a distributed problem solving (DPS) system comprised of the system agent (SA), cooperative case-based module (CCBM) and the curriculum database (CDB). Figure 1 shows the architecture of CBR-TUTOR.

The SA serves as the registry module that contains the complete list of all agents initiated in the system. Whenever there is an unregistered learner (i.e., first time user of the system), the SA initializes the agent (or agents) that will be used for tutoring the learner and informs the CCBM about it. Whenever necessary, the SA also decides if there is a need to process the requests of creation of new agents in the system by CCBM.

The cooperative case-based module (CCBM) is the core component of the CBR-TUTOR. It is composed of cooperating agents designed for actual tutoring of the learners, retrieval, filtering, indexing and learning of cases, and facilitation of requests from different agents in the system. Its sub-components are case-based tutor agents (CTAs), case facilitator agent (CFA), case-based information agents (CIAs), and case-based libraries (CBLs). The CTAs are the actual tutors assigned to the learners while CIAs are agents whose tasks are to retrieve, filter, index and modify (or learn) cases in its CBL. A CBL contains the set of cases used in the system. Discussion of the CCBM components is discussed in detail at section 3.2.

Depending on the planned teaching activities, a CTA accesses the curriculum database (CDB) for content presentations. These presentations include the lessons, examples, elaboration, exercises, answers, definitions and descriptions.

Figure 1. The CBR-TUTOR Architecture



3 CBR-Tutor Components

The primary components of the CBR-TUTOR are its specially designed agents. These are COOPERATIVE CASE-BASED MODULE (CCBM) and SYSTEM AGENT (SA). This section discusses the detailed discussion of these components.

3.1 Cooperative Case-Based Module

The COOPERATIVE CASE-BASED MODULE (CCBM) is the heart of the CBR-TUTOR. It is composed of specialized agents that have specific decision-making task that cooperates to help provide individualized and adaptive instruction using the case-based reasoning approach. The major components of CCBM are CASE-BASED TUTOR AGENTS, CASE FACILITATOR AGENT, CASE-BASED INFORMATION AGENTS and CASE-BASED LIBRARIES, as illustrated in Figure 1.

3.1.1. Case-Based Tutor Agent

The CASE-BASED TUTOR AGENT (CTA) interacts directly with the learner. It creates a profile of its learner (i.e., learner type, lessons taken, performance, strategies applied, output from *external student modeling system*, etc.) and this information for evaluating the current scenario. (i.e., case). The CTA uses the case-based reasoning approach in planning for the teaching strategy to use, with the help of the other agents in CCBM.

The CTA has four components: INTERFACE, CASE-BASED MODULE, INSTRUCTIONAL PLANNER, and STUDENT KNOWLEDGE BASE, as shown in Figure 2.

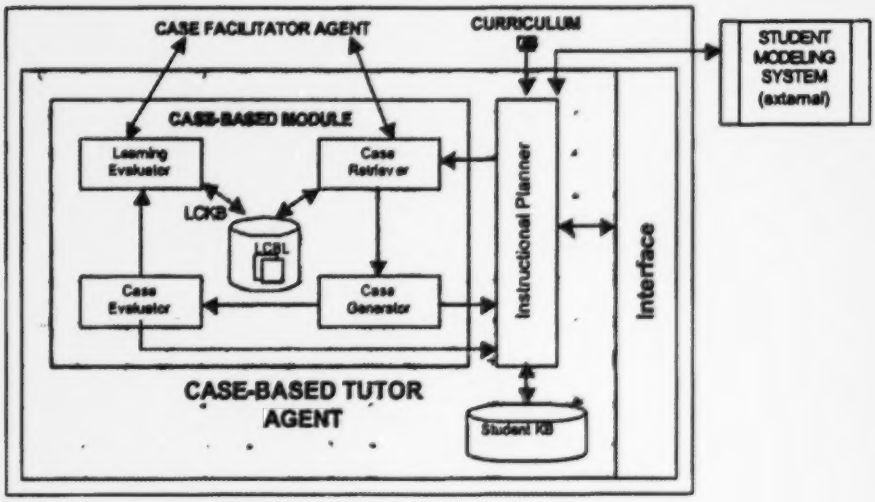


Figure 2. Components of a Case-Based Tutor Agent (CTA)

All communications between the CTA and the learner is done through the *interface*. The *interface* is designed as a *web-based interface* for simplicity and universal access. The system can be used through standard browsers.

The INSTRUCTIONAL PLANNER (IP) is the component of the CTA that assesses the current case (i.e., current teaching scenario), and communicates with the interface and the CASE-BASED MODULE (CBM). Based on the current case, the IP forwards its requests to the CBM for generation of helpful case (or cases). The proposed solution (i.e., result of the request) from the CBM is implemented by the IP. Implementation of the proposed solution requires the generation of content presentation. The IP does this by accessing the CURRICULUM DATABASE (CDB), which contains the lessons, exercises, examples, description, elaboration, answers and definitions.

The IP is also responsible for updating the STUDENT KNOWLEDGE BASE (SKB). The SKB contains information about the user including the name, password, identification number, and student type (i.e., low, medium high). It also contains the result of the diagnoses of the *external* student modeling system, lessons taken, and performance evaluation of the leaner.

The component of the CTA that uses the Case-Based Reasoning (CBR) approach is the CBM. The CBM's tasks are to retrieve useful case (or set of cases), propose a solution (i.e., teaching plan), test and evaluate the proposed solution, and if needed, learn a new case. The CBM keeps local copies of cases that are frequently used during the tutoring sessions and stores it in the LOCAL CASE-BASED LIBRARY (LCBL). CBM also has a CASE RETRIEVER module, which retrieves cases from the LCBL and/or requests for cases through the CASE FACILITATOR AGENT (CFA). The retrieval approach used by the CASE RETRIEVER is the same as the retrieval approach used by the CIA (discussed in section 3.2.3.). The CASE RETRIEVER, depending on its *certainty factor*, decides whether to request for case retrieval through the CFA or use only the retrieved cases from the LCKB. The *certainty factor* is a measure used to evaluate the appropriateness or availability of cases in the LCBL. If the CTA does not have enough cases to solve the current case, it makes a request to the CFA for retrieval of *good* cases. *Good cases* are those that have potential to make relevant prediction about the new case [4]. This means that cases retrieved either helps the CTA achieve a goal or warns about the possibility of a failure or point out an unforeseen problem [5].

The cases retrieved (or requested) by the CASE RETRIEVER is given to the CASE GENERATOR, which in turn checks which of the retrieved case matches exactly the retrieved case. In the event of finding an exact match, the CASE GENERATOR proposes a solution based on the retrieved case and forwards it to the IP for *reuse*. However, it is seldom that previous case matches the current case exactly. It is therefore necessary for the CASE GENERATOR to revise the retrieved case and propose a new solution. The *proposed new solution* is tested and, if needed, repaired by the CASE EVALUATOR until a *confirmed solution* has been achieved. The

BEST COPY AVAILABLE

confirmed solution is then forwarded to the IP for implementation. The CASE EVALUATOR also forwards the *confirmed solution* to the LEARNING EVALUATOR for possible learning of the new case. If there is a need to learn a new case, the LEARNING EVALUATOR updates the LCBL and informs the CASE RETRIEVER about the changes in the LCBL. The approach for learning a new case (i.e., case library update) used by the learning evaluator is the same as the approach used by the CIA (discussed in section 3.2.3.). The LEARNING EVALUATOR also informs the CFA that a new case has been learned.

3.1.2 CASE FACILITATOR AGENT

The case facilitator agent (CFA) serves as mediator between the case-based tutoring agents (CTAs) and the case-based information agents (CIAs). This means that the CFA performs matchmaking of services thatcan be provided by CIAs and requests made by CTAs. The CFA tracks all requests for retrieval of cases and monitors the updating (i.e., learning) of new cases. It receives requests from CTAs, sends these requests to the candidate CIA (or CIAs) and returns responses to the requesting CTAs. The CFA has two major components: service request module, and agent information manager (see Figure 3).

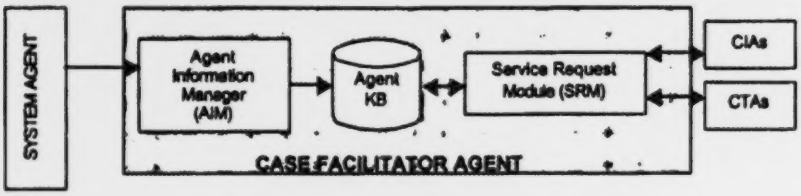


Figure 3. Components of the Case Facilitator Agent

The SERVICE REQUEST MODULE (SRM) supervises all requests from the CTAs. There are two types of requests: retrieval of cases and updating (learning) of new cases. Using the *knowledge* about the capabilities of the CIAs, the SRM performs matchmaking and assesses which CIAs are suitable to process the request. This knowledge includes the *indexing vocabulary*, *specialization* and *taxonomy of indexes* of each CIA. An *indexing vocabulary* is a set of relevant descriptors used to describe and index cases while *specialization* refers to the specific indexes being monitored by the CIA. The *taxonomy of indexes* contains information about the organizational structure of the indexes.

The SRM maps the capabilities of each CIAs to the requests and forwards the requests to the candidate CIAs. The SRM collects the result from all CIAs that responded to the request, checks and eliminates redundant cases before forwarding the result to the requesting CTA.

The AGENT INFORMATION MANAGER (AIM) monitors all the agents registered by the SYSTEM AGENT (SA) in the system. It has the knowledge of the *indexing vocabulary* and *specialization* of each CIA and the CTAs that have been registered. It also supervises the mapping and updating of the taxonomy of indexes. The knowledge about each agent and the taxonomy of indexes are used by the SRM to determine relationships, similarities and differences of the indexes of each CIA. This helps SRM in matchmaking the CTAs request and CIAs capability to process the request.

3.1.3 Case-Based Information Agent

The CASE-BASED INFORMATION AGENT (CIA) performs the tasks of retrieving cases, evaluating and filtering the retrieved cases in the CCBM. Each CIA has an associated CASE-BASED LIBRARY (CBL) for which they are responsible to maintain. Each CIA focuses on particular collection of features (i.e., dimensions) of the case. A *feature* is an attribute-value pair used in the description of the case [5]. This facilitates faster indexing, restructuring, searching and learning of cases. No two CIAs are exactly the same and despite similarities in their structure, they may return different results. A CBL of a CIA may contain cases that are similar to other CBLs (i.e., overlaps) or it may be totally different from the other CBLs .A CIA can also request the SYSTEM AGENT (SA) for *load reallocation* (i.e., creation of a new CIAs), if it is overloaded.

Retrieving Cases

Each CIA uses the combination of searching and matching when retrieving cases. The quality of the search algorithm is closely related to the quality of the organizational structure of the cases. The organizational structure of each CBL is designed, as a *flat library of cases* where cases are stored as simple lists (or array/files). All CIAs who were requested to retrieve cases use the *parallel retrieval approach*. In this approach, each candidate CIA will search for cases and forwards the result to the CFA (if there is any). The CFA will then be responsible for collecting and checking of results for redundancy.

Each CIA uses a SERIAL- SEARCH- PARTIAL- MATCH (SSPM) algorithm (outline shown in Table 1). Since each CIA *specializes* on specific *dimensions* (or set of features), it only searches a relatively small number of cases and searching is not expensive. A *dimension* collectively refers to all descriptive attributes of a case. In the SERIAL SEARCH algorithm, the entire CASE-BASED LIBRARY (CBL) maintained by the CIA is searched. This means that the accuracy of retrieval is a function only of how good the *matching functions* are. The matching function used by a CIA is the PARTIAL- MATCHING FUNCTION. In this approach, cases are indexed using observable features and derived features that capture partial similarities. A *combination of heuristic and numerical evaluation function* is used to compute for the matching and ranking of cases. The *heuristic function* filters cases that had mismatches in important features before comparing cases for their degree of similarity. To measure the degree of match of each pair, the Cognitive System' s (1992), evaluation function is adapted (see Equation 1).

$$\frac{\sum_{i=1}^{n} w_i (sim \ (f_i^{\,l}, f_i^{\,r})}{\sum_{i=1}^{n} w_i}$$

Where w_i is the weight of the importance of dimension (slot) *i*, *sim* is the similarity function for f_i^l and f_i^r primitives and are the values for the feature f_i in the input and retrieved cases, respectively.
The degree of match is represented as numerical values between 0 to 1. Closer matches have value closer to 1. Similarly, the similarity function with a value closer to 1 means that the features have high degree of similarity.

Equation 1: Evaluation Function

Table 1. Outline of SERIAL SEARCH- PARTIAL MATCHING ALGORITHM (SSPM)

1. For every case in memory, partially match input case:
   - Identify observable features and derived features
   - Compute for the degree of match by using the combination of heuristic and numerical evaluation function. The heuristics identifies the important criteria and then the numeric evaluation function is used for matching and ranking.
2. Return all the best case(s).

Learning Cases

Each candidate CIA decides whether the new case should be learned, and which information from the case to retain, in what form to retain it and how to index the case for later retrieval from similar problems. Learning is a natural consequence of using CBR. It learns by accumulating new cases and indexing the cases properly. A CIA learns basically by applying adaptation (or accumulating generalizations) to the cases and re-indexing of cases that are already in its CASE-BASED LIBRARY (CBL). Re-indexing is done when the case is recalled and it can not be used or it is used but results in failure. When a CIA learns a new case, it informs the CFA of the changes in its *indexing vocabulary* if there is any.

Indexing Cases

The indexing of a case indicates when a case should be retrieved. Cases are indexed based on the goal, solutions method and combinations of descriptors responsible for choice of particular solution. This type of indexing helps the CIA generate a case whenever there is a need to solutions to the current problem (e.g., what will be the strategy given the current case). Cases are indexed by CIAs by adapting the Universal Index Frame [8], which is a generally applicable descriptive vocabulary. UIF covers a broad range of domains about the interactions between agents and its goal.

Load Reallocation

Each CIA also has the capability to request the SA for a creation of a new CIA. When a CIA sees that it is already monitoring a large amount of indexes, using a *load factor*, the CIA can request the SA to divide the load by initializing a new CIA (or set of CIAs). A load is divided according to logical divisions and dimensions of the cases. A *load factor* is a measure of how many indexes a CIA can monitor without affecting the balance of the load of each CIA. The SA will then notify the CFA of the newly created CIA including the knowledge about it, and the changes in the knowledge about the requesting CIA.

3.1.4 Case-Based Library

The *CASE-BASED LIBRARY* (CBL) contains the set of stored cases. Cases represents specific knowledge tied to specific situations, it makes explicit how a task is carried out or how a piece of knowledge was applied or what particular strategies were used for tutoring the learners effectively. The CBL is designed as *flat library of cases* where cases are stored in a simple list. Since each CIA specialized on specific dimension of the case, the CBL is designed to be simple for faster accessing of cases.

Each case in the *CRC* has three major parts: *situation description, solution* and *result*. The *situation description* describes the goal (or set of goals), constraints on the goals, and other features of the problem situation. The *solution* part of the case contains the steps used to derive the solution (i.e., tutoring plan of action) and the justifications for decisions that were made. Alternative solutions and/or unacceptable solutions are also included in the *solution* part, if any. Finally, the *result* part of the case contains information about the success or failure of the solution, the explanation for failure or success, the repair strategy and the result of applying the repair.

3.2 System Agent

The SYSTEM AGENT (SA) contains the complete list of all agents initiated in the system. It verifies agent identities and provides their location in the network and transport addresses to the CASE FACILITATOR AGENT (CFA). It also stores additional information about the status of the agent and its type.

The SA communicates directly to the COOPERATIVE CASE-BASED MODULE (CCBM) and performs the following functions:

- Determines if the learner is an unregistered learner, initializes and assigns a CASE-BASED TUTOR AGENT (CTA) for the unregistered learner
- Processes requests from CASE-BASED TUTOR AGENTS(CIAs) for creation of a new CIA
- Monitors the complete list of agents (CTAs and CIAs) in the system and informs the CFA of the status (e.g., newly initialized) and information of these agents.

Aside from these functions, the SA is also responsible for all low-level interfaces. These includes access to the operating system or networking services, enforces access rights and privilege security, backs-up and archives pertinent information, and performs exception handling [1].

4 CONCLUSION

This paper presented the architecture of the CBR-TUTOR, an Internet agent-based tutoring system that uses the case-based reasoning approach in tutoring its learners. The architecture is designed such that it can be implemented for different domains (i.e., programming, problem solving, and others) and can be accessed through the Internet. The architecture differs from other internet-based tutoring systems because it utilizes the advantages of using previously experience cases to enhance the tutoring capability of the system. In addition, the CBR-TUTOR architecture is composed of specialized agents that performs the tutoring of learners, facilitation of requests, and filtering, retrieving and learning of new cases. All of these agents cooperate to achieve the goal of providing individualized and adaptive instruction to the learners. The use of agents in the design of this system is increases the effectivity of the tutor to provide adaptive instruction to its learners. Each of the tutoring agent focuses on the individual needs of its learners. Since the system is Internet-based, the use of agents can accommodate more users compared to non-agent-based systems. The other components of the system were also designed as agents because each of these components is autonomous and requires decision-making capability. Future work will focus on the implementation of

CBR-TUTOR in the domain of programming. Further research regarding the learning of cases where the system has the capability to do situation assessment where the reasoner elaborates a situation description to make the description fit the other case library descriptions will also be done.

References

[1] Abadia, L. (1999). A MultiAgent-Based Information Trading Floor Model for an Organizational Intranet.Graduate Thesis. Master of Science in Computer Science, College of Computer Studies, De La Salle University, Manila.

[2] Aamodt, A., Plaza, E. (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches. AI Communications. IOS Press, Vol. 7:1, pp. 39-59

[3] Chappell, A. and Mitchell, C. (1997). The Case-Based Intelligent Tutoring System: An Architecture for Developing and Maintaining Operators Expertise. Proceedings of the 1997 IEEE International Conference on System, Man, and Cybernetics. Orlando, Florida. http://www.chmsr.gatech.edu/publications/smc97/arc/abstract.html. (January 2000).

[4] Dingsoyr, T. (1998) Integration of Data Mining and Case-Based Reasoning. http:/www.idi.ntmu.no/ ~dingsoyr/ diploma/report.html. February 29, 2000.

[5] Kolodner, J. (1993). Case-Based Reasoning. Morgan Kaufmann Publishers, Inc.

[6] Reyes, R. (1999). Adaptive Web-Based Intelligent Tutoring System for C Programming. Proceeding of the 1999 International Conference in Computers in Education. Chiba, Japan.

[7] Row, R. (1995). A Case-based Reasoning Approach to Simulation-Based Intelligent Tutoring Systems and ITS Authoring. http:// www.navysbir.brtc.com/ SuccessStories/StottlerP3.html. (January 2000)

[8] Schank, R., and Osgood, R. 1990. A content theory of memory indexing. Northwester University, Institute for the Learning Sciences Technical Report no. 2.

[9] Sison, R . (2000). Multistrategy Discovery and Detection of Novice Programmer Errors. Machine Learning, 38, 157-180. Kluwer Academic Publishers, Netherlands.

[10] Weber, G. and Specht, M. (1997). User Modeling and Adaptive Navigation Support in WWW-based Tutoring Systems. ELM-ART II. http://www.psychologie.unitrier.de:8000/projects/ ELM/Papers/UM97-WEBER.html. (January 2000)

[11] Wood, T. Psychological Access and the Internet (199). Advanced Research in Computers and Communications in Education. G. Cummings et al. (eds.). IOS Press. Pp.973-980.

Controlling Problem Progression in Adaptive Testing

Roger E. Cooley & Sophiana Chua Abdullah
University of Kent at Canterbury
Computing Laboratory, University of Kent at Canterbury,
Canterbury, Kent CT2 7NF, The United Kingdom
Tel: +44-1227-823816
Fax: +44-1227-762811
Email: rec@ukc.ac.uk, sc34@ukc.ac.uk

Adaptive testing has, in recent years, been used as a student modelling technique in intelligent tutoring systems. One of the main issues has been to optimise the progression of problems posed as the student performs the adaptive test. Previous research has concentrated on finding a structure in a fixed collection of problems. This paper describes an algorithm for problem progression in adaptive testing. After describing current approaches to the progression problem, the paper discusses the role of expert emulation. It then describes a knowledge elicitation exercise, which resulted in a solution to the progression problem. Part of the knowledge elicitation process was supported by software based on constraint logic programming, clp(FD), and the paper concludes with an assessment of the prospects of developing an extended knowledge elicitation support system.

Keywords: **intelligent tutoring system, knowledge construction and navigation, adaptive testing, constraint logic programming**

1 Introduction

The major advantages of adaptive testing over fixed item testing are that a student's knowledge is explored thoroughly and efficiently, and with a minimum of redundancy. By asking an appropriate number of problems at appropriate levels of difficulty, adaptive testing neither bores by unnecessary repetition nor intimidates by posing a series of inappropriately difficult problems [1]. This makes adaptive testing attractive for student modelling in intelligent tutoring systems [2],[3].

This research was conducted in the context of providing remedial help in mathematics to a transient population of prisoners in a local prison. Here the students are studying courses such as City and Guilds (Key Skills), City and Guilds (Number Power) and for GCSE level examinations. Working with prisoners can face tutors with problems not normally encountered in more conventional settings. Unlike school students, the prisoners not only lack uniform prior knowledge in mathematics, but tend also to join or leave the prison at individual times. This makes the job of the human tutor difficult because of the need to assess the knowledge level of each prisoner before assigning them the appropriate level of one or more of the above courses and examination. Currently, fixed item testing is used as an assessment tool. This approach has a major disadvantage. Many prisoners are 'math anxious' and the use of fixed item testing may undermine their confidence and motivation in the subject. Adaptive testing avoids this danger by presenting problems at an appropriate level of difficulty.

One of the main issues in adaptive testing is the determination of an efficient progression from one problem to another. Previous proposals have included hard-wiring prerequisite relationships between knowledge items [3], and preparing an indexing framework for problems [4]. Section 2 of this paper reviews the major lines of research; and the paper then describes an approach to the progression problem based on the knowledge acquisition techniques used for expert systems. In doing so, it continues in the vein of Khuwaja & Patel's work [5]. The paper presents a rationale for this approach, describes briefly a semi-automated

method of eliciting syllabus content and characteristics, and then presents a progression technique elicited by standard techniques with an expert. It concludes with a discussion of the feasibility of automation in this area.

2 The Progression Problem

In a problem-solving environment, *problem progression* is concerned with the strategy in which the next problem is selected. In adaptive testing, this is usually based on the student's response to the current problem, as the process of selecting the next appropriate problem is crucial to the efficiency and precision of the whole student modelling process. Also, presenting *the right question at the right time* maintains the motivation of the student.

The structure of the domain, that is the way in which problems are related to one another, determines problem progression in adaptive testing; and the two significant and distinctive approaches to determining such structures are discussed in this section.

2.1 Item Response Theory

For adaptive testing systems which adopt the *Item Response Theory* or IRT [6], such as SIETTE [7] and CBAT-2 [8], the domain is made up of test items which are kept in an *item pool*. The construction of an item pool usually involves major empirical studies for content-balancing, to ensure no content area is over-tested or under-tested, and for item calibration. Each test item is associated with one or more of the following parameters – the *difficulty level, the discriminatory power and the guessing factor*. The *difficulty level* measures the difficulty level of a test item, the *discrimination power* describes how well the test item discriminates students of different proficiency, while the *guessing factor* is the probability that a student can answer the test item correctly by guessing.

Problem progression takes place like this. The adaptive test starts with an initial estimation of the student's proficiency, è. A *best* item or problem is selected. This is one which provides the most information about the student, and is calculated from the item's three parameters and current proficiency, è. An ideal item should have a difficulty level close to è, a high discriminatory power and a low guessing factor. A new proficiency, è', and its confidence level are calculated based on whether the student has answered the problem correctly or not, the old è, and the item parameters. The test continues until a stopping criterion is met, for example, when the confidence level of è' has reached a desired level.

2.2 Knowledge Space Theory

There are adaptive testing systems built on the theory of *knowledge spaces[9]*. Examples include a web-based, domain-independent system called RATH [10], a web-based system for the domain of mathematics called ALEKS [11], and a general purpose system for testing and training called ADASTRA [12].

Like the IRT-based systems, the domain is made up of test items of an academic discipline, each of which can be a problem or an equivalence class of problems that the student has to answer. The student's *knowledge state* is defined as the set of items in the domain that the student is capable of solving. For example, if a student has the knowledge state ***{a,b,d}***, this means that he can solve items ***a***, ***b*** and ***d***. Not all possible subsets of the domain are feasible knowledge states. Consider the example shown in [13]. In a domain of mathematics, if a student can solve a percentage problem, (item ***d*** say), then it can be inferred that the student can perform single-digit multiplication, (item ***a*** say), and thus any state that contains item ***d*** would also contain item ***a***. The collection of all feasible knowledge states is called the *knowledge structure*. The knowledge structure must also contain the *null state {}*, which corresponds to the student who cannot solve any item, and the *domain*, which corresponds to the student who can solve or master all items. When two subset of items are knowledge states in a knowledge structure, then their union is also a state. This means that the collection of states is *closed under union*. When a knowledge structure satisfy this condition, it is known as a *knowledge space*.

In practice, items for a domain are derived from instructional materials and systematic knowledge elicitation with teachers. This is also the case with establishing knowledge states where query procedures systematically elicit from human experts the prerequisite relationships between items [3], [14].

Once the domain is represented as a knowledge space, the adaptive testing strategy is then to locate as efficiently and as accurately as possible, a student's knowledge state. Problem progression becomes straightforward. For example, if a student has answered an item correctly (incorrectly), it can be inferred that he can (cannot) answer a prerequisite item and will thus not be asked to solve the latter.

2.3 Other Approaches

The domain can be represented as a *granularity hierarchy* [15] where items which represent a topic, subtopic or skill, are described at various grain sizes and connected together into a granularity hierarchy which allows focus shifts along either *aggregation* or *abstraction* dimensions. In this way, the ability to recognise student behaviour at varying grain sizes is important both for pedagogical and diagnostic reasons.

Other examples include an *indexing framework* for the adaptive arrangement of problems in the domain of mechanics [4], a problem-simplification approach [16], an optimisation expert system where both the knowledge structures of the student and the teacher are represented by structural graph, and problem progression is controlled by the relationship between the student's knowledge structure and that of the teacher's [17]. Evidence of a strong use of a student model in controlling problem progression can also be found in a system called TraumaCASE [18] which automatically generated clinical exercises of varying difficulty, and in the work of Beck, Stern & Woolf [19] who recorded information about a student using two factors – *acquisition* and *retention*. *Acquisition* records how well students learn new topics while *retention* measures how well a student remembers the material over time.

3 Knowledge Elicitation

The concern of the researchers discussed above is to exploit a structure of a syllabus to improve the efficiency of tests. The structure may either be revealed through elicitation, as was done by Dowling and her co-workers, or may be derived from a statistical analysis of student behaviour, (IRT), or it may be seen as being derived from the nature of the problem domain. Though there may be, from some given point of view, an optimal way of structuring a syllabus, the view adopted in this research is that it is a subjective matter to be determined by an expert teacher. Such a teacher might make use of informal statistical information, subject domain information as well as pedagogic information in determining a suitable structure. Studies of intelligent tutoring systems have shown that, as one would expect, it is difficult to transfer systems from one setting to another, because there is considerable cultural variation in both teaching and learning [20]. This provides the prime motive for investigating techniques based on expert emulation for the production of tests for local consumption.

Moreover, this is a natural extension of the *intelligent tutoring systems* endeavour, and it has an additional advantage. A lack of homogeneity amongst a student body can weaken the effectiveness of techniques based on population statistics; and the target body of students with which this paper has been concerned is, educationally, not very homogeneous.

4 Eliciting the Syllabus

There are several problems to be confronted when adopting an expert emulation approach to designing an adaptive test. They include the problems of finding suitable experts [21], selecting appropriate forms of knowledge representation and choosing appropriate methods of knowledge acquisition.

The approach to knowledge acquisition in the research described here is to separate the task of designing an adaptive test into the following sub-tasks:

- describing classes of problems,
- describing the skills used to solve problems,
- describing responses to problems,
- problem generation,
- problem progression based on student responses.

For the particular domain tackled, namely the arithmetic of elementary fraction addition, software has been developed to support the first four of these subtasks using Constraint Logic Programming, clp(FD), embedded in Prolog, [22]. This work has been described in a recent conference paper [23], and is briefly summarised here.

Clp(FD) is actively used by the knowledge engineer conducting knowledge acquisition interviews. The teacher, who is the target of the emulation, is not expected to write constraints, but is more than likely to take an interest in them. During discussions, which involve the production of example problems, the knowledge engineer enters the necessary constraints, or modifies existing constraints, to describe the particular class of problem under discussion. The set of constraints is then solved interactively to produce example problems. These form the basis of a discussion, and may lead to further rounds of discussion and modification.

The description of a class of problems is treated as a set of constraints. This consists of a set of variables, a statement of the domains of the variables, and a statement of the relational constraints that hold between the variables. For example, during an interview, the human tutor wanted to represent a class of problems, which involved the addition of two proper fractions with a common denominator of the form,

$$N1/D1 + N2/D2 = N/D$$

and he wanted to use single-digit integers.

This can be represented in clp(FD) as a code fragment:

```
domain([N1,D1,N2,D2],1,9),        % Single digit integers
N1 #<  D1,                        % First operand - proper fraction
N2 #<  D2,                        % Second operand - proper fraction
D1 #= D2.                         % A common denominator
```

The following is an example of the use of clp(FD) to describe skills. The *cancel fraction* skill can be represented in clp(FD) as:

```
% Simplify the fraction N/D into its lowest form to give X/Y
% Example:  63/81 gives 7/9
cancel(N,D,X,Y) :-
      domain([N,D,X,Y,F], 1,99),
      F*X #= N,
      F*Y #= D,
      maximize(labeling([], [F,X,Y]), F).
```

Here, variable F is the common factor to be cancelled. This is specified by the two relational constraints. The *maximize* predicate in the final line ensures that the largest value of F will be found.

5 Eliciting the Progression

The knowledge elicitation exercise involved approximately 20 hours of interviews spread over a period of three months. Conventional knowledge elicitation techniques, such as structured interviewing, task analysis and construct theory [24], were used.

Early interviews revealed the significance to the expert of the *skills* that students needed to exercise in order to solve particular problems. The following were identified:

a. Add equivalent fractions
b. Cancel fraction
c. Make proper
d. Find the lowest common multiple
e. Find equivalent fractions

The number of discrete skills required to solve a problem was considered as a measure of the difficulty of

the problem; and this measure was used to classify problems, and in so doing reveal a structure of the domain. This coincides with the findings of Beck, Stern & Woolf [19]. However, it is useful to note that this is only one of the many factors in measuring problem difficulty used by Lee [25], who identified, amongst others, the student's degree of familiarity with a particular type of problem.

In eliciting progression information, it is necessary to avoid the problem of combinatorial explosion. A *head on* approach requires the expert to provide a tree structure of sequences of problems indicating the appropriate *next* problem depending on the outcome of all previously asked problems. Such an approach is unattractive to both expert and knowledge engineer. Instead, an approach adopted was to attempt to uncover the underlying *algorithmic* strategy of the expert.

In general terms, the strategy of the expert is to test the students' abilities to exercise the identified skills at a particular level of difficulty. Failure to return a correct answer causes the questioning process to be resumed at a lower level of difficulty, that is, with problems requiring the demonstration of fewer skills. Whereas successful demonstration of all the identified skills causes the questioning process to be resumed with problems at a greater level of difficulty. The expert started with problems of middling difficulty and adopted a *binary chop* approach to selecting the next level. Within each level of difficulty, the selection of the *next* problem depended on the skills already demonstrated. Each available problem was scored using a set of weights, which favoured previously undemonstrated skills at that level. If the progression problem is viewed as a variant of state-space search, the expert's strategy has more in common with a *constrain-and-generate* paradigm [26], at a given level of difficulty, rather than a naïve *generate and test* approach. A schematic example of the use of this strategy is given below.

In a Prolog implementation of this strategy, a record of students' skills, demonstrated at each tested level of difficulty is recorded, and used to prepare a revision plan.

6 An Example

The human tutor first prepared the adaptive testing strategy for a domain of five skills described above. This is shown in Figure 1 for a domain of five skills.

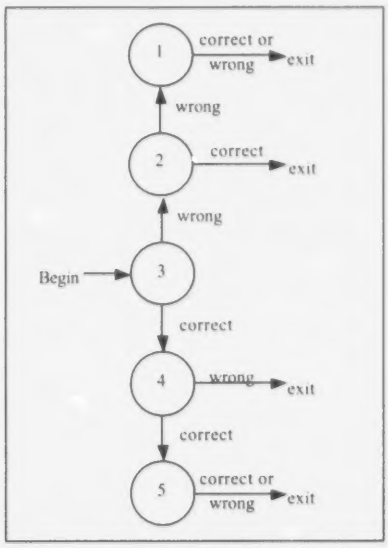


Figure 1: Human tutor's strategy in adaptive testing for a domain of 5 skills

In Figure 1, the adaptive test begins at node 3 which contains problems each of which can be solved by exactly three skills. If the student gets any problems wrong within that category, he moves onto node 2 which contains problems each of which can be solved by exactly two skills. If he gets all the problems correct within that category, he will exit the adaptive test. The rationalisation for this is described below.

If each of the skills were labelled as a,b,c,d,e, as in Section 5, then at node 3, there are $^5C_3$ that is 10 possible combinations of skills. For example, the combination [a,b,c] would involve a set of problems which each require all the skills **a**, **b** and **c** to be used. Skills **a**, **b** and **c** correspond to *add equivalent fractions, cancel fraction*, and, *make proper* respectively. However in practice, not all these combinations will be found in a valid problem type.

We introduced weights to each combination to enable the choice of the next best combination. We also imposed the following criteria for calculating the weight of each candidate set:

- If a skill has been not been asked yet, it carries a weight of 2
- If a skill has already been asked once, it carries a weight of 1
- If a skill has been asked more than once, it carries no weight
- Select the first set amongst the candidate set with the highest score

The following process shows how problems, each of which, require a combination of three skills are presented to the student.

a. Select [a,b,c] and scores are assigned to the other combinations, based on the above rules:

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5

b. Based on these weights, combination [a,d,e] becomes the next best choice and is thus chosen. The scores for the remaining combinations are recalculated.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3

c. Combination [b,c,d] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1

d. Combination [a,b,e] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1
3	-	0	*	0	0	0	0	0	0	0

e. As there are no more candidate sets, no more problems are presented.

The above example shows that out of the ten combinations, only problems of combinations [a,b,c], [a,d,e], [b,c,d] and [a,b,e] were chosen. As described previously, the human tutor would consider the student's previous performance and if any answers to problems were found to be wrong, he would assign problems at node 2 (see Figure 1). Conversely, if all the answers were found to be correct, he would assign problems at node 4 which require problems to be solved with exactly four skills.

The human tutor took the view that if a student has already tackled problems of three skills, whether he got them right or not, information gathered in packets of three skills need not necessarily apply to problems involving two skills. He considered that students may become anxious about problems which require more skills, and although some of the skills may well have been demonstrated in *easier* problems, the student may find it difficult to apply them in *harder* problems.

7 Conclusion

The paper describes the development of an adaptive test in the domain of elementary arithmetic, which required two styles of knowledge acquisition. The first is concerned with describing problems and skills, and it is computer-assisted; whereas the second is entirely manual and is concerned with the ordering, or progression, of problems to be posed to the subject of a test. However, based on this experience, work is currently underway to develop software to aid with eliciting details of progression. A valuable insight gained is that some degree of formalisation of the problem, as well as being convenient for the knowledge engineer, is also acceptable to the expert who helped with this work.

A possible significant difference between the research reported here and the work reviewed in Section 2 is that the approach to progression is not restricted to a fixed collection of problems. In view of Lee's findings [25], it would be inappropriate to enforce the equating of difficulty with the number of skills. Evidence encountered during the knowledge acquisition experience suggests that the sheer clerical complexity of mapping out sequences of problems, lead to some draconian simplification on the part of the expert. The task ahead, is to find an appropriate balance between convenience and efficiency.

References

[1] Vispoel, W. P., Rocklin, T. R., & Wang, T., "Individual differences and test administration procedures: a comparison of fixed-item, computerized-adaptive, and self-adapted testing", Applied Measurement in Education, 7, pp. 53-79, (1994).

[2] Collins, J. A., Greer, J. E., & Huang, S. X., "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 569-577, (1996).

[3] Dowling, C.E. & Kaluscha, R., "Prerequisite relationships for the adaptive assessment of knowledge", Proceedings of the Seventh World Conference on Artificial Intelligence in Education (AI-ED'95), Washington DC, USA, August 16-19, pp. 43-50, (1995).

[4] Hirashima, T., Niitsu, T., Hirose, K., Kashihara, A., & Toyoda, J., "An indexing framework for adaptive arrangement of mechanics problems for ITS", IEICE Transactions on Information and Systems, E77-D, pp. 19-26, (1994).

[5] Khuwaja, R. & Patel, V., "A model of tutoring: based on the behavior of effective human tutors", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 130-138, (1996).

[6] Wainer, H., "Computerized adaptive testing: a primer", NJ: Lawrence Erlbaum Associates, (1990).

[7] Rios, A., Millan, E., Trella, M., Perez-de-la-Cruz, J.L.,& Conejo, R., "Internet based evaluation system", Proceedings of the Ninth International Conference on Artificial Intelligence in Education (AI-ED'99), Le Mans, France, July 19-23, pp. 387-394, (1995).

[8] Huang, S. X., "A content-balanced adaptive testing algorithm for computer-based training systems", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 306-314, (1996).

[9] Doignon, J. P. & Falmagne, J. C., "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, 23, pp. 175-196, (1985).

[10] Hockemeyer, C. & Dietrich, A., "The adaptive tutoring RATH: a prototype", Proceedings of the International Workshop on Interactive Computer aided Learning (ICL'99), Villach, Austria, (1999).

[11] ALEKS 2000, http://www.aleks.com (accessed on August 15 2000).

[12] Dowling, C. E., Hockemeyer, C., & Ludwig, A. H., "Adaptive assessment and training using the neighbourhood of knowledge states", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 578-587, (1996).

[13] Villano, M., "Probabilistic student models - Bayesian belief networks and knowledge space theory", Proceedings of the Second International Conference on Intelligent Tutoring Systems (ITS'92), Montréal, Canada, June 10-12, pp. 491-498, (1992).

[14] Kambouri, M., Koppen, M., Villano, M., & Falmagne, J. C., "Knowledge assessment - tapping human expertise by the query routine", International Journal of Human-Computer Studies, 40, pp. 119-151, (1994).

[15] McCalla, G., Greer, J., Barrie, B., & Pospisil, P., "Granularity hierarchies", Computers & Mathematics with Applications, 23, pp. 363-375, (1992).

[16] Hirashima, T., Kashihara, A., & Toyoda, J., "Toward a learning environment allowing learner-directed problem practice - helping problem-solving by using problem simplification", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 466-314, (1996).

[17] Matsui, T., "Optimization method for selecting problems using the learner's model in intelligent adaptive instruction system", IEICE Transactions on Information and Systems, E80D, pp.196-205, (1997).

[18] Carberry, S. & Clarke, J. R., "Generating clinical exercises of varying difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 273-275, (1997).

[19] Beck, J., Stern, M., & Woolf, B. P., "Using the student model to control problem difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 277-289, (1997).

[20] Payne, S. J. & Squibb, H. R., "Algebra mal-rules and cognitive accounts of error", Cognitive Science, 14, pp. 445-481, (1990).

[21] Lightfoot, J. M., "Expert knowledge acquisition and the unwilling expert: a knowledge engineering perspective", Expert Systems, 16, pp. 141-147, (1999).

[22] Clp(FD) 2000, http://www.sics.se/isl/sicstus/docs/latest/html/sicstus.html#CLPFD (accessed on August 15 2000).

[23] Chua Abdullah, S. & Cooley, R. E., "Using constraints to develop and deliver adaptive tests", Proceedings of the Fourth International Conference on Computer Assisted Assessment (CAA), June 21-22, Loughborough University, UK, (2000).

[24] McGraw, K. L. & Harbison-Briggs, K., "Knowledge acquisition, principles and guidelines", NJ: Prentice-Hall, (1989).

[25] Lee, F. L., "Electronic Homework: an intelligent tutoring system in mathematics", PhD Thesis, The Chinese University of Hong Kong, (1996).

[26] Marriott, K. & Stuckey, P., "Programming with constraints: an introduction", Cambridge, MA: MIT Press, (1998).

Development of Intelligent Learning Support System with Large Knowledge Base

Katsuyuki SUGAYA and Setsuo OHSUGA
Department of Information and Computer Science, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, Tokyo 169-8555, JAPAN
E-mail: {sugaya, ohsuga}@ohsuga.info.waseda.ac.jp

The objective of this paper is to present framework for developing intelligent learning support system with large knowledge base. Recently, the need for effective learning support and training is mounting, especially in industry or engineering fields, which demand the learning of complex tasks and expertise knowledge. Intelligent learning support system is being employed for this purpose, thus creating a need for cost-effective means of developing learning support systems. In this study, intelligent learning support system is assumed as a part of the intelligent knowledge management support system. The factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, a new design of the system and learner modeling technique are discussed as well as a way of generating specific intelligent learning support system.

Keywords: **Intelligent System Design, Large Knowledge Base, Learner Model, Model-based Diagnosis, Knowledge Management**

1 Introduction

The purpose of this paper is to introduce a new framework for developing intelligent learning support system using large knowledge base. This system is a part of the intelligent systems that is developing to enable the expertise knowledge management.

In daily life, human has to interact with and reason about a large number of systems. This includes physical devices as well as non-physical systems. Also in professional work a growing number of people has to be trained in operating and designing large complex systems such as airplanes, nuclear power plants, and enterprises. Consequently, the goal of education or teaching may vary from inducing insight in the physical principles underlying the behavior of the device to teaching behavior analysis in the context of system design, operation, and maintenance. In addition, recently systems in the real world are becoming larger and more complicated. Rapid progress in science and technology has created a need for people who can solve complex problems and operate and maintain sophisticated equipment. In these situations, we, human beings, have to solve various types of problems using expertise in the large and complicated systems. Therefore the need for effective learning support or training is rising, given the increasing complexity of the workspace, especially in engineering or industrial fields.

Many computer assisted instruction techniques exist that can present instruction, and interact with students in a tutor-like fashion, individually, or in small groups [3]. The introduction of artificial intelligence technology and expert systems technology to computer assisted instruction systems gave rise to intelligent tutoring systems. In the intelligent tutoring system, for example, intelligent tutors that can model the learner's understanding of a topic and adapt the instruction accordingly [2]. Although intelligent tutoring systems research has been carried out for over 15 years, few tutoring systems have made the transition to the commercial market. Authors consider that some serious problems exist in the current methodology of developing intelligent tutoring systems. As an example, each system is developed independently, and tutoring expertise is hard-coded into individual systems. In particular, the problem of learner modeling technique exists as a basic issue. The system must have learner model that represents an estimate of the

learner current understanding of the domain knowledge to be used by tutor in order to give adaptive guidance and explanations to the learner. A number of learner modeling techniques have been developed [8]. However, not every model can be called complete expressing the learning condition of the learner. Hence, the motivation for this study comes from the need for effective intelligent tutoring systems, particularly development of more complete learner modeling technique.

For these problems like above we consider that the factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, authors present a new framework of the intelligent learning support system those enough practical conditions. Several concepts are included in this study; expert knowledge management with large knowledge base, knowledge sharing, knowledge processing, model-based learner diagnosis, etc.

2 Expert Knowledge Management using Knowledge Base System

In this section, we introduce briefly the key concept of our knowledge base system. Our research groups have tried to solve various problems by knowledge-centered intelligent system. The main concept is Multi-strata modelling scheme [5]. This modelling scheme is applied many intelligent systems, and these systems rewarded with good results, e.g. automatic programming system [1]. And we considered that Multi-strata model is strongly support the development of intelligent tutoring systems [6][7].

2.1 Intelligent System with Large Knowledge Base

At first, we discuss to apply large knowledge base for the architecture of intelligent learning support systems, which can generate learning support systems for a wide range of domain.

In these days, with the developing of science and technology, the systems which human manages with are enlarged and more complicated. In particular, it is too difficult to transmit expert knowledge from expert engineer to novice engineers. In the engineering field, even a large system developed by many expert engineers. When the system grows lager and more complex, the knowledge that is needed to build the system is more specialized and subdivided. In these situations, some serious problems are occurred. For instance, it is difficult to communicate between expert engineer and another fields' engineers or novice one. In other words, it is too more expertise to transmission of expert knowledge from human to humans. For this reason, the expert knowledge hiding is occurred in some engineering companies.

When the knowledge is specified and subdivided, in the situation like classroom, it is not appropriate to transmit the knowledge from expert engineer to novice one e.g. next generation engineers. Therefore, we propose the transmission of expert knowledge through the large knowledge base system (Fig.1).

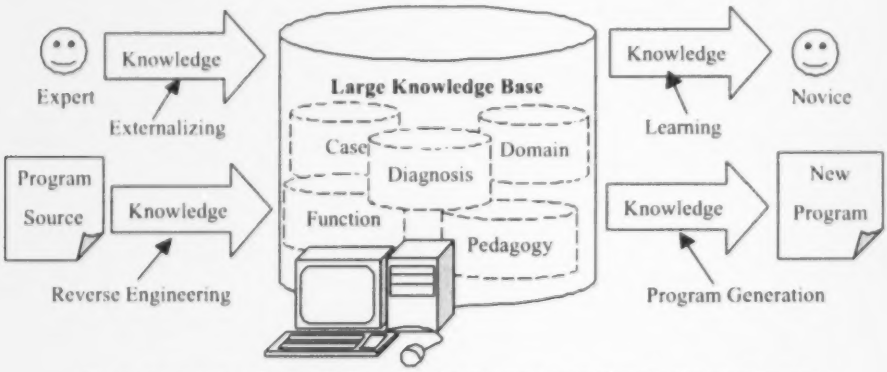


Fig.1: Knowledge Transmission using Intelligent Large Knowledge Base System

In this study, we consider that intelligent learning support system is a part of intelligent knowledge management support system. Moreover, we believe that knowledge management or learning support system is one of large and complex problem solving systems. The term problem is used here in a wide sense to mean what a person wishes to know or wants to do. There are various types of problems such as analysis,

design control, decision-making, planning, and teaching. Most of them are not well dealt with by conventional software method but require the system a capability to find a solution itself in a large space. Since the space is open, self-controlled exploration in the space is necessary. The system must be provided with the various methods to solve the different type of problems, each of which is represented by a specific knowledge chunk. Furthermore, a complex problem concerns different problem domains and since a problem requires domain specific knowledge, the system must be provided with a global knowledge base including the various type of domain knowledge.

In order to use knowledge effectively, the system must be able to extract only the necessary knowledge from the knowledge base referring to the type and the domain of the problem to be solved. For this purpose knowledge must be well structured. All used knowledge is accumulated in the large knowledge base (Fig. 1).

2.2 Necessity of Knowledge Processing Language

The whole of the problem solving process is from accepting external representation of problems to generating solutions. In order to represent problems in the system a processing language is necessary. The language has to meet two conditions: it has to be usable for representing problems; and it has to be processable by computer processor. In ordinary computers only the procedural language is used both for processing by the processor and for representing problems. The knowledge base system, on the other hand, introduces the second language to separate the above two aspects, as well as a conversion mechanism between them. The second language is a declarative knowledge representation language. The conversion either in the declarative forms or from the declarative to the procedural form is necessary. This is the inference. It can be implemented as a procedural program on conventional computers.

The specification for the second language must be decided so that it can represent these conditions. It had to be suited for representing predicate including data structure as argument and also for describing higher-level operation such as knowledge for selecting object knowledge. KAUS (Knowledge Acquisition and Utilization System) has been developed for the purpose by our research & development team.

3 Adaptability of Learning Support System

To meet the condition of adaptability, it is necessity to represent the learner's understanding of learning domain. In this section, we discuss a learner modeling method that is applied to diagnostic techniques in artificial intelligence.

3.1 Issues of Learner Model

The performance of intelligent learning support system depends largely on how well it knows why the learner fails to solve problems. Because of the sophisticated interaction requires information about the learner, the system has to maintain some kind of model of the learner. This model may include cases about what has been done before or information about what the learner is believed to know. The process of gathering information about the learner is mostly referred to as cognitive diagnosis. Ohlsson has given a widely accepted definition of cognitive diagnosis: "cognitive diagnosis is the process of inferring a person's cognitive state from his or her performance" [4]. We consider that the point of learner model is to represent knowledge state of learner, especially his/her fails to solve problem. To satisfy this requirement, we focus diagnosis techniques.

A diagnosis is defined in terms of one or more reasoning steps that the learner cannot have solved problem. A major advantage of this approach is that it can be based solely on a model of these correct reasoning steps; no knowledge is required about the specific misconceptions that learners may have about the domain of learning. Instead we model all primitive inferences that are required to arrive at the correct solution. In addition, our approach to diagnosis of learner behavior exploits results from model-based diagnosis as it is defined in the field of artificial intelligence.

3.2 Model-based Learner Diagnosis with Case Base

Model-based diagnosis is a prominent area within artificial intelligence and emerged in the last about 15 years. The technique of model-based reasoning has been widely researched and accepted as the principal

diagnosis in electronic circuit analysis, power station maintenance, medical diagnosis domains, etc. However, little emphasis has been put on its application to education or training system domain. The basic principle in model-based diagnosis is the description of system as a causal model. With the model at hand, the behavior predicated by the model is compared to the actually observed behavior. Since the predictions of the model are based on the assumption that the components work correctly, these assumptions may be partially dropped to accommodate for a detected behavior difference and thus diagnose faulty behavior.

However, there are some weaknesses in model-based diagnostic technique. The most serious weak point is the diagnosis time. It sometimes takes so much time to diagnosis. Therefore, we must be considering that it is necessary to model concerning the trade-off between the cost of a diagnosis time and its precision. Case-based reasoning, by contrast, excels in covering weak-theory domains, domains whose phenomena we do not yet understand well enough to record causality unambiguously. This feature allows case-based reasoning to be used in domains where model-based reasoning cannot be applied.

In the case-based reasoning, a reasoning engine remembers previous situations similar to the current one and uses them to help solve the new problem. However, case-based diagnostic technique has been criticized on many grounds. For example, that being specific to the system being diagnosed, they are non-constructive and that, having no analytic basis, the methods are restricted to specified faults and have a known level of competence. We think that the model-based diagnosis, being independent of the particular device descriptions, is intended to overcome these difficulties.

Therefore, we consider developing the approach of the model-based diagnosis system with case base. Model-based reasoning and case-based reasoning have the potential to complement each other quite well. However, no work has been done on specific issues of learner modeling using combine model-based reasoning with case-base. The outline of model-based learner diagnosis with case base is following. When the set of learner's behavior data input the diagnosis system, the diagnosis engine reasons the state of his/her knowledge consulting the diagnosis knowledge base include case base and object model base. The design of the model-based diagnosis system begins from describing the system as diagnosis object model. The system, which is a diagnosis object, is considered to be a set of domain models. The diagnosis object model that has knowledge of proper action, and the set of the behavior of learner as input value are given to a system. The first behavior of the system that received input is to seek whether there is a history about the same case in the case base. If the record to apply in the case is found, case base returns list of learner's knowledge, which should examine to diagnosis engine. Diagnosis engine does investigation about domain model of each record given to it, by comparing a simulation result in object model with the actual behavior of learner. Diagnosis process is finished if a trouble is recognized. When there was no record that complied with the input value in the case base, the process starts to use diagnosis domain object model. This domain object model has the hierarchical structure. A process begins from making the error model that one component in the extreme high class in the diagnosis object model is supposed to be out of order. The purpose of this process is to simulate using a made error model to examine whether the result of the simulation is the same as the behavior of learner. If there is no contradiction in the simulation result, the model-based reasoning is done again toward each domain knowledge model of the lower layer. In the same way, a diagnosis process is repeated until a trouble is recognized in knowledge component of the extreme lower layer. All process of diagnosis is knowledge processing by KAUS.

4 Discussion

The objective of this study was to develop a new intelligent learning support system, especially to focus two conditions; generality and adaptability. Authors in first propose the architecture of intelligent learning support system with large knowledge base to enough generality, which modeled by using multi-strata model. In second presented the model-based learner diagnosis to meet adaptability. All of the knowledge was represented by KAUS in intelligent learning support system that was assumed a part of the intelligent problem solving system. The issue of learner diagnosis is very important point to achieve adaptive instruction in intelligent learning support system. We proposed that fault diagnosis techniques be applied to infer the state of learner's knowledge. So we discussed the feature of diagnostic techniques, especially model-based reasoning with case base. Model-based reasoning appears to be a more promising technique than other knowledge-based methods because it can diagnose the faults that have not been pre-determined. Fails in learner's knowledge can be diagnosed automatically based on the models, which describe the correct behavior. However, because model-based approach reasons from the actual structure and function of knowledge, it is inefficient for some problems. Furthermore, obtaining domain models is sometimes either

difficult or too complicated, whereas most of the fails can be diagnosed based on past experience, which is very effective if the rule base or the case base is either comparatively small or well-indexed. A better solution is a hybrid approach integrating some of the diagnostic approaches. A case base will be provided to access the solutions to some fails diagnoses occurred previously, of which the domain models are unavailable. For some diagnoses, their solutions and contexts can also be stored in the case base for reuse later. Frequently occurring fails can be diagnosed efficiently even by a few of heuristic diagnostic rules. We believe that such a hybrid diagnostic approach will perform better than any of them does. In order to achieve this goal; we have considered the division of object model and problem type. On this part, it is necessary to carry out examination that will be more profound in future work.

References

[1] Aida, T. & Ohsuga, S., "Intelligent Systems Must Be Able to Make Programs Automatically for Assuring the Practicality", Lecture Note in Artificial Intelligence 1415, pp.47-56, (1998).

[2] Costa, E, New Directions for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1991).

[3] Mandl, H. & Lesgold, A, (eds.), Learning Issues for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1988).

[4] Ohlsson, S., "Some principles of intelligent tutoring", Instructional Science, Vol. 14, pp.293-326, (1986).

[5] Ohsuga,S., "Multi-Strata Modeling to Automate Problem Solving Including Human Activity", Proc.Sixth European-Japanese Seminar on Information Modeling and Knowledge Bases, (1996).

[6] Sugaya,K. & Ohsuga,S., "Design of Intelligent Education System using Multi-Strata Modeling Concept", Proc. The Sixth International Conference on Computers in Education, Vol.1, pp.305-311, (1998).

[7] Sugaya,K. & Ohsuga,S., "Framework for Developing Intelligent Tutoring System Using Multi-Strata Model", Advanced Research in Computers and Communications in Education, Vo.1, IOS Press, pp.832-835, (1999).

[8] Wenger,E., Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge, Morgan Kaufmann Publishers, Los Altos, California, (1987).

Educational Agents and the Social Construction of Knowledge: some issues and implications

Carolyn Dowling
Australian Catholic University
115 Victoria Parade, Fitzroy, Victoria 3065, AUSTRALIA
Phone: (61 + 3) 9241 4456
Fax: (61 + 3) 9241 4546
Email: c.dowling@patrick.acu.edu.au

The use of intelligent software agents within computer mediated learning environments is currently an important focus of research and development in both AI and educational contexts. Roles envisaged and implemented include those of tutor, of 'manager', of information seeker and of fellow learner. Each of these raises its own special challenges in relation both to the capabilities of the software and to our understandings in regard to the nature of the learning process. High on the list of factors currently believed to contribute to effective learning is social interaction in the service of knowledge construction. Within many electronic learning environments we are currently witnessing the emergence of a new participant in the social interactions that mediate learning. The substitution of computer programs possessed of varying degrees of intelligence, autonomy and 'personality', for certain dimensions of human presence within the computer based classroom raises a number of questions related to the processes through which knowledge is socially constructed, and to the qualities which are necessary to ensure successful participation in those processes. Through discussion of both theoretical perspectives and practical examples, this paper explores some of these issues.

Keywords: **AI in Education, Educational Agents, Intelligent Tutoring Systems, Interactive Learning Environments, Networked Social Learning, Teaching and Learning Process**

1 Introduction

Developments in computing and information technology in recent years have rapidly propelled the notion of intelligent software agents from concept to implementation. Today, whether or not we are always aware of them, they are an integral part of a growing number of computing environments. From the invisible armies of knowbots and related entities scurrying around the Net in the service of increasingly sophisticated search engines to the cheery little characters who pop up on our screens offering assistance with anything from formatting a date to constructing a complex multimedia presentation, or the 'personalities' with whom we interact in chat rooms in happy ignorance of their purely digital nature, intelligent agents are alive and well and are multiplying rapidly.

An early but still useful conception of a software agent is, "A character, enacted by the computer, who acts on behalf of the user in a virtual environment", useful in mediating " ... a relationship between the labyrinthine precision of computers and the fuzzy complexity of man [10, p. 355]. Later definitions tend to be expressed in more functional terms, such as, "An agent can be viewed as an object which has a goal and autonomously solves problems through interaction, such as collaboration, competition, negotiation and so on" [9]. This definition has some similarities with that offered by Maes [12] who defines an agent as:

"A computational system which:

- is long lived;

- has goals, sensors and effectors;
- decides autonomously which actions to take in the current situation to maximize progress towards its (time-varying) goals" [12, slide 5].

Summarising the writings of a number of researchers, Aroyo and Kommers [1, p. 237] identify four major characteristics of agents as being autonomy, responsiveness or reactiveness, pro-activeness and social ability. Other qualities frequently proposed, but not supported by all researchers or indeed by all users, include the ability to learn from experience and consequently to respond in flexible and possibly unforeseen ways to particular situations, and the possession of a believable 'character' or personality as a basis for social interaction.

It appears that a combination of factors has contributed to the current proliferation of software agents. Apart from the technical developments which have opened up the possibility of implementing what were previously largely theoretical conceptions, there is our very real need for assistance as we operate within computing environments characterised by rapid change, large quantities of extraordinarily complex information, and a lack of common organisational structures through which information may be accessed and managed. As Laurel predicted, there are now many situations in which, in the interests of efficiency, some form of 'intelligent' mediation is required between computer systems and the needs of users.

There are, of course, different forms that this mediation could have taken. The strong propensity for most users to accept assistance in the form of a more or less personified entity as largely unproblematic undoubtedly derives at least in part from the anthropomorphic elements implicit in most computer interfaces from the earliest days of computing. It can be strongly argued that a degree of personification has always been automatically and inevitably conferred as much by a program's use of language as a component of the interface as by our everyday understandings of the 'intelligence', albeit artificial, of computers. Intelligence and language use are, after all, key defining attributes of human beings.

Not only are we accustomed to interacting with computers as though they share with us a degree of 'humanity', but in a number of areas of activity we have been persuaded to value 'social' interaction particularly highly. Education is a good example, given the extent to which our current understandings of learning depend upon an acceptance of the belief that knowledge is to a large extent socially constructed. In the current drive to move teaching and learning online, the notion of agency in computing has found a strong ally and a vehicle for expansion. Unless the social interactions that mediate learning in face to face environments can be shown to have a digital equivalent, proponents of online courses will be forever 'on the back foot', with their products being regarded by most educators as second best. While courses incorporating the communications facilities of the Internet certainly go a considerable way in promoting interactions of various types between teacher and student and also between student and student, the possibility of using software agents to create an illusion of interpersonal interaction so convincing as to achieve pedagogical outcomes equivalent to those deriving from a relationship with another human being is extremely enticing to the designers of electronic learning environments.

2 Some examples of socially interactive pedagogical agents

Johnson [7] has proposed the following definition the role of a pedagogical agent as distinct from those designed for other purposes:

> "Pedagogical agents are autonomous agents that support human learning, by interacting with students in the context of interactive learning environments. They extend and improve upon previous work on intelligent tutoring systems in a number of ways. They adapt their behaviour to the dynamic state of the learning environment, taking advantage of learning opportunities as they arise. They can support collaborative learning as well as individualized learning, because multiple students and agents can interact in a shared environment. Given a suitably rich user interface, pedagogical agents are capable of a wide spectrum of instructionally effective interactions with students, including multimodal dialog. Animated pedagogical agents can promote student motivation and engagement, and engender affective as well as cognitive responses" [7, p. 13].

This is a comprehensive and optimistic vision, incorporating a number of possible roles for software agents within educational environments. Types of agents currently implemented in projects around the world include record keepers, information seekers, testers, facilitators of collaboration, tutors or instructors, fellow learners, and tutees. Of special interest in regard to this paper are those that contribute to the overtly social

dimensions of the learning environment. The last three listed most clearly fulfil this criterion.

2.1 Agents as instructors

There is a sense in which perceptions of the role of computers in the learning process have come full circle. Early models of the role of 'computer as tutor' in the form of drill and practice style of instructional software, generally based on Skinnerian principles and incorporating very limited interaction between user and computer, have long been rejected by most educators in favour of a range of other more acceptable guises including that of a learning tool, an information source, and a learning 'space'. With the development of agent technologies, as Johnson suggests, new possibilities now exist for incorporating computers within the learning environment in a range of socially interactive roles, including that of 'tutor', through modes of interaction more in keeping with current pedagogical theory.

It is commonly asserted that the presence of computers in classrooms has itself played a part in modifying the image of the teacher as the 'sage on the stage' in favour of a more collaborative model. Not surprisingly, these changing concepts are well reflected in many implementations of 'agent as teacher'. As Solomos and Avouris [18] write, for instance:

> "The user mental model of the system should be based on the metaphor of the "invited professor" rather than the "knowing everything own tutor". ... Our first findings confirm the observation that today's users, accustomed to hypertext-like interaction, are more likely to accept this collaborative teaching metaphor, according to which their tutoring system is viewed as an intelligent hypertext browser, offering links to other tutoring systems with the right content and at the right time" [18, p. 259].

The increasingly popular concept of the teacher as a facilitator of learning is also reflected in such statements as: "Each student working on the project will have an agent, operating in the background, watching progress, measuring it against the plan, and taking remedial action when necessary" [19, p. 362].

2.2 Agents as fellow learners

A style of agent of special significance in the context of socially constructivist theories of learning is the 'fellow learner', which to differing degrees might be presumed to include all participants within the learning environment. If agents are to gain widespread acceptance in the field of education, this is an important area for research and development. Since the 1980s Chan [2, 3] and colleagues have been working on a range of models of socially interactive agents for learning environments, perhaps the best known being the 'learning companion' – a software entity having limited knowledge of the domain in question, conceptualised as a fellow learner with whom the student may collaborate and even disagree. As in real life, some of these learning companions may be better informed than the student in the relevant domain of knowledge, while others may know less. Perhaps not surprisingly, in learning environments for younger students, animals are a popular choice of persona for such agents, as in this example of a networked learning environment for Taiwanese high school students, as described by Chan:

> "The Dalmation is having the same performance as the student. ... Another animal companion is Dragon, like one of those animal companions in Mulan, a Disney cartoon of this summer. This dragon will "learn" (mainly rote learning) from the student and also from other students on the Net and so may know more than the student. At certain point it'll stop learning and come back to teach the student. In a way, Dragon is protecting the student" [3].

An interesting development of this concept is presented by Sheremetov and Nunez [16, p. 310], who describe the function of a 'monitor agent' as being to modify the role, behaviour or expertise of learning companions from that of strong group leader to a weaker companion or even a passive observer, depending on its interpretation of the degree of guidance required by the learner.

2.3 Agents as pupils

We are all familiar with the common wisdom that we learn through teaching others. At the school level, many educators have long been familiar with the concept of the computer as 'tutee' through the use of the Logo programming language, in which 'teaching the turtle' was a familiar metaphor for the activity of programming. More recently, a number of researchers have explored the translation of this concept into electronic learning contexts where agents exist to be 'taught' by the student user, as in the example from Chan quoted above. A further example is described by Ju [8] who writes of a computer based peer tutoring

system employing two categories of agent – an 'expert', and a 'learner':

> "... students become active learners who are guided to learn by teaching a computer. After the students watch how the computer expert solves a set of linear equations [the program] helps the human student act as a teacher in order to learn more about the subject matter. At this time, the computer plays the role of a student ..." [8, p. 559].

3 Some issues for consideration

3.1 Multiple agents

Most agent based systems utilise a number of agents, many of them capable of a complex range of interactions with the student, with one another, and increasingly with agents associated with other programs. Their individual purposes derive from theoretical analyses of the component tasks and activities that are included in the larger scale pedagogical interactions of human beings. As educators, and indeed as students, we may simultaneously enact a range of roles within the educational environment. The apparently unitary activity of 'teaching' involves such elements as demonstrating, guiding, telling, questioning, explaining, testing, motivating, criticising – even learning! Many researchers consider that the electronic medium makes it feasible to identify and separate out these diverse functions. These can then be enacted through different configurations of agents working in relationships which ranging from collaboration to competition.

An example is the Multiple Agent Tutoring System (MATS) described by Solomos and Avouris:

> " MATS is a prototype that models a "one student-many teachers" learning situation. Each MATS agent represents a tutor, capable of teaching a distinct subject. All MATS tutors are also capable of collaborating with each other for solving learning difficulties that their students may have" [18, p. 243].

Strategies for most efficaciously combining the activities of multiple agents such as these necessitate a complex agent architecture, and understandably occupy a great deal of the research agenda in this area. Of interest in relation to their participation in the social construction of knowledge is the fact that one of the most common metaphors employed by a number of researchers and courseware designers is that of a 'society' of agents, a conception reminiscent of Minsky's *The Society of Mind* [14], Gardner's multiple intelligences [6] and other related theories of cognition and behaviour. In describing the different aspects of the design of their "multi-agent, computer-based interactive environment", for example, Costa and Perkusich [4, p. 196], drawing on the work of Franklin and Graesser [5] refer to their aggregation of agents quite specifically as a 'society'.

> "The society [of artificial tutoring agents] is an open multi-agent system made up of a collection of tutoring agents that co-operate among themselves to promote the learning of a certain human learner. This society is designed to be open and dynamic in the sense that it allows maintenance operations such as the entry and the exit of agents, besides eventual modifications in the knowledge and in the inference mechanisms of an agent. Each agent defines an expert tutor in some domain, having the necessary knowledge to solve problems in this domain. These agents are cognitive and possess properties like autonomy, goal-oriented, social ability" [4, pp. 197-198].

While on the one hand, the variety of functions of agents within a multi-agent environment must also be appreciated as an attempt to realise the type of rich user interface which Johnson suggests is necessary if the pedagogical interactions within electronic learning environments are to approximate to any degree to the face to face educational experience, some educators have concerns in regard to the assumptions underlying these practices. They argue that such developments are underpinned by a reductionist rather than a holistic understanding of the processes and relationships involved in teaching and learning. In separating out the different components of pedagogical interactions, are we enabling each part to be realised more effectively, or are we failing to acknowledge that the global act of human teaching may in fact be more than the sum of its component parts? It seems reasonable to suggest that firm judgments on issues such as this must await greater experience of the roles of agents within these learning contexts.

3.2 Personification

Another focus of debate concerns the degree to which personification is helpful in fostering fruitful pedagogical interaction between the human learner and software agents. This question clearly relates more

to the 'socially interactive' agents than to those fulfilling more tool-like functions, which arguably require far less in the way of 'personality'. As noted earlier in this paper, there are clear arguments for accepting that a degree of personification of computer interfaces is inevitable. As Shirk puts it:

> "Although there is some dispute among software critics concerning the advisability of having 'personalities' in computer programs, their presence seems unavoidable. Any time there is communication between a computer and a human, the information presented by the computer has a certain style, diction, and tone of voice which impact upon the human's attitude and response toward the software" [17, p. 320].

However the extent to which this should be deliberately fostered is less clear, although many feel intuitively that it should be an important element in the creation of an electronic learning environment characterised by interactions which can reasonably be described as 'social'.

An important aspect of the representation of 'character' or personality is visual appearance. Interestingly, both research and experience suggest that the relationship in the case of software agents is far from straightforward, and that a mismatch between realism in appearance and the apparent knowledge level of the agent can have a deleterious effect on credibility. The more visually realistic the representation, the higher the expectations of the user in relation to the appropriateness and 'intelligence' of utterances and actions. Agents that 'look' smart and 'act' or 'talk' dumb are poorly received by many users, who express a higher tolerance for the limitations of a 'character' more sketchily represented, for instance through cartoon-like graphics. As Masterton, writes, for instance, "A common problem with AI programs that interact with humans is that they must present themselves in a way that reflects their ability. Where there is a conflict between the ability of the system and the users' perception of that ability a breakdown occurs and users may either fail to exploit its full potential or become frustrated with its shortcomings" [13, p. 215]. He goes on to suggest the implementation of a degree of anthropomorphism intended to convey qualities such as friendliness and usefulness, without the implication of possession of full human capabilities [13, p. 211]. He describes the development and role of such an entity in the form of a VTA (Virtual Teaching Assistant) which is able to introduce topics and answer simple questions, the more complex types of exposition and interaction being left to the human teacher. In terms of a traditional scenario at university level, the VTA functions somewhat like a tutor or demonstrator as distinct from a lecturer. "In this way faculty is left free of the guiding and assisting issues of the course and is able to concentrate on more complex questions and higher level issues generated during the course" [13, p. 211].

Further instances of this principle are the examples of agents presented as animals discussed earlier in this paper. Our expectations in regard the cognitive skills of animals may well be more appropriate to the capabilities of software agents than are our experiences of human-to-human interactions.

3.3 Autonomy

Closely related to the 'intelligence' of software agents is the issue of autonomy, in particular the degree to which an agent should be furnished with pre-existing goals which might lead it to take particular action without instruction from the user, and even contrary to what the user might perceive as his or her interests and wishes. Exploring the implications of such entities existing and interacting within virtual reality environments, Loeffler [11], for instance, notes that the unpredictability resulting from significant autonomy might well result in agents who are less 'helpful' to us than we might hope or indeed expect. It is easy to slip from such considerations into the need for a contemporary version of Asimov's laws of robotics as conceived in fictional terms more than 30 years ago!

In educational contexts, the implications of autonomy, particularly in terms of control of and responsibility towards the learner, are potentially extremely complex and difficult to address without more exposure to these types of software, and indeed it is quite likely that such experience may cause community understandings in regard to appropriate relationships between the 'human' and the 'not human' in electronic contexts to develop and change over time. In the short term, current trends in educational thinking which favour giving more control and autonomy to the learner would appear to be more in line with the thinking of researchers such as Schneiderman who favour 'direct manipulation' over the development of interactive agents with a significant degree of independence of action. Where agents are involved, they may be programmed so as to exercise control over the learner on behalf of the creator of the learning environment, or they may be configured so as to be more sensitive to a user model, and more responsive to instruction from the user/student. In the latter instance, the agent would have a greater degree of responsibility to the needs and wishes of the learner, but this may not be in keeping with the pedagogical goals of the teacher.

Trust is another aspect of the teacher/learner relationship that is complicated by the degree of autonomy with which a pedagogical agent is endowed. To the extent that the programmer chooses to delegate certain functions and responsibilities to the agent, it is their problem, but it may also be an issue for students, particularly those with more insight into the nature of the agents with which they are interacting.

A further concern in regard to the autonomy of pedagogical agents relates to the issue of intervention in the learning process. Despite the finding of Aroyo and Commers [1] that pro-activity is a quality frequently sought after in agents, there is an important issue of balance to be addressed in relation to the educational process. It is well accepted that a high degree of unsought assistance whether from a human teacher or an excessively diligent and proactive agent can be quite detrimental, in particular to the metacognitive aspects of learning. Of course this is also an issue for teachers and learners in face to face educational contexts!

3.4 Level of participation in the social construction of knowledge

The belief that it is possible for agents to participate effectively in the social aspects of knowledge construction is central to the work of many theorists and researchers. Sheremetov and Nunez [16], for example, whose works derives overtly from the theoretical frameworks of Piaget and Vygotsky, argue that:
"The design of learning environments, virtual or not, aims to promote productive interactions. In this type of learning a student changes from being a passive information receiver to an active collaborator, interacting with the tutors and colleagues in the learning process. Learning does not only result from acquiring knowledge, solving problems or using tools, but also from interacting about these on-going activities with persons and agents"[16, p.305 – 306].

In relation to their specific project they write: "Our emphasis lies in the role of interactions in an artificial learning community as a group of real and artificial learners, tutors, and facilitators, working, supporting and learning from each other [16, p. 306]. But however personified and autonomous the software agent, can it really be said to participate fully in the social construction of knowledge? It has been argued quite extensively that even the most heavily personified of computer programs suffer from an intrinsic lack of ability to participate in the metacognitive aspects of learning. Pufall [15], for instance, expresses a strong belief that a computer program is unable at any level commensurate with human capacities to modify its own knowledge structures or cognitive processes, and so cannot be regarded as a co-constructor of knowledge in a meaningful sense. While this might well have been the case in relation to earlier computer based learning environments, can we continue to make the same claims with confidence today or in the future? The capacity of software to 'learn' and adapt to experience through the incorporation of new information, the appropriate modification of its representation of the context in which it functions (its 'world') and of its inference mechanisms, is undoubtedly increasing. One way of considering this question might be to look at it in terms of the type of distinction sometimes made between 'hard' and 'soft' notions of artificial intelligence. If our test of full participation depends on an understanding that the agent has 'learnt' in precisely the same way that the human has learnt, then we will have difficulty accepting the electronic entity as genuine co-constructor of knowledge. If, however, we make our claim on the grounds that it appears to the human learner that the agent has participated in the learning that has taken place, then perhaps we can at least tentatively admit such a piece of software to membership of the social milieu which has mediated the educational experience.

Conclusions

It is clear that developments in agent technology have created a range of new possibilities in terms of aligning computers more strongly with prevailing educational theories and philosophies. In considering the many issues which might be raised in relation to the nature and roles of pedagogical agents, there are three overarching questions. Firstly, do agents have the potential to enhance learning, or do they threaten to undermine those aspects of the educational enterprise that we most value? Secondly, to what extent might they assist in the replication of the social dimensions of face to face learning within online environments? Thirdly, do they go further than this, and create new possibilities in regard to the social mediation of learning? To the extent that visions such as those of Johnson [7] are able to be realised, we may be faced one day with the need to re-evaluate our attitudes regarding the relative merits of a human teacher and an electronic entity designed specifically for educational purposes. But while the rhetoric of developers often suggests an ideal surpassing the sometimes imperfect realities of human-to-human pedagogical interactions, the 'jury' of online learners and of educators is still out.

References

[1] Aroyo, L & Kommers, P., "Preface – Intelligent Agents for Educational Computer-Aided Systems", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[2] Chan, T.-W., "Learning companion systems, social learning systems, and the global social learning club", Journal of AI in Education 7 (2) (1996).

[3] Chan, T.-W. (1998), "The past, present, and future of educational agents", http://www.apc.src.ncu.edu.tw/apc/ppt_chan.html (accessed on February 3, 2000).

[4] Costa, E.deB. & Perkusich, A., "Designing a Multi-Agent Interactive Learning Environment", in Proceedings of International Conference on Computers in Education (ICCE '97), Kuching, Sarawak, Malaysia, December 2 – 6, pp. 196 – 203, (1997).

[5] Franklin, S. & Graesser, A., "Is it an Agent, or just a Program?: A Taxonomy for Autonomous Agents", Proceedings of the Third International Workshop on Agent Theories, Architectures and Languages, Berlin: Springer-Verlag (1996).

[6] Gardner, H., "Frames of mind: the theory of multiple intelligences", New York: Basic Books (1983).

[7] Johnson, W.L., "Pedagogical Agents", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp.13 – 22, (1998).

[8] Ju, Y. (1998), 'Development and formative evaluation of a computer-based peer tutoring system', Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 559 – 566, (1998).

[9] Kinoshita, T. & Sugawara, K., "Agent oriented computing", Tokyo: Soft Research Center (1995).

[10] Laurel, B., "Interface agents: metaphors with character", in Laurel, B. (ed.) The Art of Human-Computer Interface Design, Reading, Massachusetts: Addison-Wesley (1990).

[11] Loeffler, C.E., "Artificial Life of Agents", Proceedings of the IFIP World Conference on IT Tools, Canberra, Australia, September 2 – 6, pp. 48 – 55, (1996).

[12] Maes, P., "Software Agents Tutorial", http://www.media.mit.edu/people/pattie/CHI97 (1997), (accessed on March 18, 2000).

[13] Masterton, S., "Computer support for learners using intelligent educational agents: the way forward", Proceedings of, the Sixth International Conference on Computers in Education (ICCE '98), Beijing, China, October 14 – 17, pp. 211 - 219, (1998).

[14] Minsky, M., "The Society of Mind", London: Picador/Heinemann, (1985).

[15] Pufall, P., "Function in Piaget's system: some notes for constructors of microworlds", in Forman, G. & Pufall, P. (eds) (1988), "Constructivism in the Computer Age", Hillsdale, New Jersey: Lawrence Erlbaum Associates, (1988).

[16] Sheremetov, L. & Nunez, G., "Multi-Agent Framework for Virtual Learning Spaces", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[17] Shirk, H.N., "Technical writers as computer scientists: the challenges of online documentation", in Barrett, E. (ed.), "Text, Context and Hypertext: writing with and for the computer", Cambridge, Massachusetts: MIT Press (1988).

[18] Solomos, K & Avouris, N. (1999), "Learning from Multiple Collaborating Intelligent Tutors: An Agent-Based Approach", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

[19] Whatley, J., Staniford, G, Beer, M. &Scown, P. (1999), "Intelligent Agents to Support Students Working in Groups Online", Journal of Interactive Learning Research, Vol. 10, No. 3/4, pp. 235 – 243, (1999).

Generating interactive explanations by using both images and texts for Micro World

Kiyoshi Yoshikawa, Isamu Takahashi, Tatsuhiro Konishi and Yukihiro Itoh
Department of Computer Sciences, Shizuoka University
Johoku 3 - 5 - 1, Hamamatsu, Shizuoka, 432 - 8011, Japan
Tel: +81-53-478-1474 Fax: +81-53-478-1499
E-mail: {cs6098, i-takaha, konishi, itoh}@cs.inf.shizuoka.ac.jp

In this paper, we propose a method of constructing an intelligent Micro-World (MW) for high-school chemistry that accepts learners' questions and advises them whenever the learners are working in the MW. We also discuss the method generating explanations using both texts and images. At first, we argue on the interaction between a learner and such a system, and classify learner's typical demands and possible educational supports by the system. Next we show the ability necessary to deal with the demands, such as recognizing learners' plan, generating a plan to achieve a goal of an experiment, reproducing the state at any step of the change in MW, controlling the initiative of the interaction, and so on. Then we propose methods in order to realize the abilities. Moreover, we illustrate how to implement the abilities and introduce our prototype system.

Keywords: **Micro World, Interactive explanation, Mixed initiative**

1 Introduction

Micro-World (MW) has a problem that it is hard to support learners who are in impasse. We are developing an intelligent MW that supports the learners[1,2,4,5]. The domain subject of the MW is high-school chemistry. The MW has the following functions:

- Simulating changes in the world model of high-school chemistry.
- Recognizing the learner's plan by a sequence of his manipulations.
- Judging weather the learner is in impasse, by comparing the learner's plan with the standard plan that the MW generates. If the learner is in impasse, it assumes that the cause of the impasse might be lack of the knowledge necessary to perform the next manipulation which the learner should do.
- Giving the learner some advices by using texts. For example, the MW shows the knowledge which the learner doesn't understand, the manipulation that the learner should do next, and so on.
- Accepting learner's questions at any time when the learner is working in the MW and answering by using texts.

Our MW uses only texts in giving advices. In general, it is effective to explain something by using both texts and images. CINESPEAK [3] is one of the systems which can show explanations using both images and texts. It can generate a 3D animation and texts of explanation. It also can select appropriate camera shot corresponding to the contents of explanation. However, It can not generate explanations interactively.

We think it is necessary to avoid showing the texts and images prepared beforehand like video movies with some captions. The reason is that the explanation should be shown interactively. In other words, an educational system must not explain anything one-sidedly, because the condition of a learner is changing moment by moment while the system explains to the learner.

When an idea flashes upon a learner's mind during the explanation, the system must allow him to say his idea and respond to his remark. For example, when the system explains how to solve some problems in MW

to the learner who is in impasse, if the learner requires doing continuation of the problem solving process by himself, the system should prepare MW and let him continue solving the problem on MW. Similarly, if the learner requires changing some conditions of MW and explaining the method of solving the problem, the system should stop explaining, re-plan a new method to solve the problem with new conditions, and explain it.

In this paper, we extend the user interface of our MW in order to make it more effective. The first extension is that the MW uses not only texts but also images when it shows the learners advices or explanations. The second one is that the MW generates explanations interactively. Our extended system can explain manipulations that a learner performed in a MW and the manipulations necessary to achieve a given goal by using both texts and animations simultaneously. Moreover it can explain interactively according to the learner's demand.

In the next section, we discuss the ability necessary for the system that generate explanations interactively. In section 3 we show our basic approach to realize the abilities. In section 4 we illustrate how to implement the abilities, and we introduce our prototype system and show examples of its behavior.

2 Interactive method to explain

In order to generate explanations interactively, the system should have the following two functions.
- When a learner does not express his intention, the system must be able to lead his learning.
- The system must be able to deal with a learner's demand whenever the system aids learning (even when it is explaining something to him).

The former is out of range of this paper, because it is the topic concerning to the teaching strategy in the field of Intelligent Tutoring System (ITS). Therefore, We concentrate the latter.

Learners' demands and the method to deal with them depend on what kind of educational supports can be provided by the system. Therefore, we must clarify:
1. the educational supports and learners' demands.
2. what kinds of ability are necessary to deal with the demands.

2.1 Possible educational supports and learners' demands

We can classify states of the system into the following two types:
- The system gives a goal and the learner manipulates the MW on his own initiative.
- The system takes the initiative then it shows advice or explanations to the learner.

We discuss learner's demands and methods to deal with them on each state.

2.1.1 Supports and learners' demands when learner has initiative

We think the major demand on this state is to require an advice to resolve a learner's impasse. Therefore, we deal with only such type of demands as the first step of our research. In order to discuss how to deal with the demands, we classify causes of learners' impasse into the following two types.
(A):• A learner cannot understand the current state of MW.
(B):• A learner cannot decide what to do in the next step.

The system can satisfy the demand of the learner who is in impasse because of (A) by showing the following explanations:
- Explanation of a sequence of manipulations that the learner performed in the MW and the effect of each manipulation.
- Explanation of the state after each manipulation has performed.

The demand of the learner who is in impasse because of (B) can be satisfied by various ways. For example, the system identifies misunderstood or lacked knowledge and shows him the knowledge, the system explains on the similar case and lets him remind his experience, and so on. In this paper, we adopt the simplest way that the system shows the actions to be performed in the following steps. If we take the other way, we need to extend some functions to decide contents of explanations. However, the mechanism to control interactive generation of explanations is commonly reused.

As a result, the type of demands of the first state is only a demand to require some advice, and the type of explanations that the system generates is only an explanation of manipulations and the state after each one. In order to explain a manipulation and the state after it has been performed, the system generates animation showing how to perform the manipulation in the MW and texts explaining the effect of the manipulation.

2.1.2 Supports and learners' demands when the system has initiative

First, we discuss typical demands of learners who are in impasse because of (A) mentioned in the previous section. When the system explains to the learner a sequence of manipulations that the learner performed and the state after each manipulation by using animations and texts, the learner may demand that the system shows him a previous state again or a following state intermittently. In case that the learner finds his own mistakes while the system is explaining something to him, he may demand that the system stops explaining, prepares the initial environment, and lets him re-try solving his problem on the MW again. If the learner fails to resolve his impasse in spite of some explanations generated by the system, he may demand that the system shows him the whole correct process to achieve his goal on the MW.

Then, we imagine typical demands of learners who are in impasse because of (B). In this case, the system explains him the action to be performed in the following steps. The learner may demand that:
- the system shows him the previous/following states.
- the system stops explaining in order to let him do continuation of manipulations.
- he rewrites some conditions of his problem and the system explains how to solve the problem with new conditions.

We don't argue on all of above-mentioned demands, but only ones with which our system can deal, considering possible actions by our system. Such actions are as follows:
(1) Explaining the sequence of actions which learners have performed.
(2) Explaining the sequence of correct actions by which the given goal can be achieved.
(3) Setting an environment for experiment to let learners try achieving the goal free.

Table 1. Examples of typical demands by learners

Actions of the system		type of the demand and the scene where the learner input the demand
Action before the demand	Action after the demand	
(1)	(1)	The learner wants to see another action than one shown in the current explanation on the sequence of his previous actions.
(1)	(2)	The learner can understand what he has done, and wants to see what he should do next.
(1)	(3)	The learner finds the mistakes he has made, and wants to re-try the experiment.
(2)	(1)	The learner understands correct actions, and wants to compare it with what he did.
(2)	(2)	The learner wants to see another action than one shown in the current explanation on the sequence of correct actions.
(2)	(3)	The learner understands the correct actions, and wants to re-try the experiment.
(3)	(1)	The learner loses the current state in the process of achieving the goal of the experiment. He wants to confirm the actions which he has performed.
(3)	(2)	The learner loses the way to achieve the goal of the experiment. He wants to see the correct actions.
(3)	(3)	He finds he has failed to achieve the goal and wants to re-try the experiment.

Then we can classify the demands according to which actions are performed before/after accepting the demand. Combinations of the actions are 3*3= 9 types such as "when system doing (1), a demand is input, then it does (1)", "when it doing (1), a demand is input, then it begins to do (2)", and so on. Examples of the typical demand of each type are shown in Table 1.

2.2 Abilities necessary to deal with learners' demands

In this section, we discuss abilities necessary to deal with the learners' demands mentioned in 2.1. Basically, MW should have an ability to simulate changes in the MW according to learners' actions.
In addition, in order to deal with the demands mentioned in 2.1.1, the system should have the following abilities.

(a) Ability to recognize learners' plan from a sequence of his actions.

In order to explain what learners have done by not only listing up the actions, but also showing the meanings of the sequence of the actions, the system needs the ability.

(b) Ability to generate a plan to achieve a goal of an experiment.

In order to explain correct actions which learners should perform, the system has to be able to generate plan.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

The system had better be able to generate explanations using both texts and images. In order to generate visual explanations, the system should be able to operate MW in a similar way as learners do. In order to generate verbal explanations, the system should be able to generate texts from the result of planning or plan recognition.

In order to deal with the demands mentioned in 2.1.2, the abilities mentioned above are also necessary. In addition, the following abilities are needed.

(d) Ability to store the history of actions by learners or the system.

The ability is needed to do action (1) or (2) as a reaction of a demand in Table 1.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The ability is needed to do action (3) as a reaction of a demand in Table 1.

In addition, the following ability is necessary to realize mixed initiative. It is generally important to make interactive educational environment effective.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

3 Methods necessary to deal with learner's demand

The basic framework of the system as a MW can be seen in [5]. An extension in this paper is that the system becomes to have two individual environments: one is the environment for experiment used by learners, and the other is the environment for explanation. Our system operates the latter environment in its explanation. We add the latter environment in order to avoid that both a learner and the system try to operate a common one at the same time. The environment for experiment has an interface and functions to accept learner's actions, and reacts as soon as it accepts an action from a learner. On the other hand, the environment for explanation cannot accept manipulations from learners (though switches similar to the environment of experiment are displayed in its window, they are dummy).

We discuss how to equip such a framework of the system with the abilities mentioned in 2.2.

(a) Ability to recognize learners' plan from a sequence of his actions.

On this ability, please see our previous paper[illegible]

(b) Ability to generate a plan to achieve a goal of an experiment.

On this ability, please see our previous paper[illegible] too.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

Simulation in MW is performed by using symbolic knowledge representation. States at each step of

MW are also represented in a symbolic way. Manipulations by learners are also translated to symbolic representations. The control method of the simulator is event-driven: as soon as a manipulation is input to the simulator, the inference engine generates symbolic representation showing the next state of MW. The system draws the state of MW on the basis of the symbolic representation. Therefore, the system can simulate changes in the MW according to the generated or recognized plan, because the system can generate the input of the simulator represented symbolically from the plan.

In addition, because states of MW, manipulations to MW, and changes in MW are commonly represented in a symbolic way, the system can generate explanations in natural language on every fact in MW.

(d) Ability to store the history of actions by learners or the system.

It is easy to store such history because all of states of MW, manipulations to MW, and changes in MW are represented in a symbolic way. The system records only the initial state and a sequence of having performed actions as the history. The system can reproduce all states and changes by simulating the change in MW again on the basis of the history.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The system can reproduce any states in an explanation on learner's previous actions, by performing the manipulations stored as the history sequentially. On the other hand, it can also reproduce any states in the process when correct actions are performed, by performing the manipulations in the plan generated by itself. Thus, the system can set any states of an environment which learners can manipulate, by copying such reproduced states in the environment for explanation to the one for experiment.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

We adopt the following strategies for controlling the phases:

- Basically, a learner takes initiative, and he acts freely in MW.
- Turn over the phase to the other phase where the system takes initiative, as soon as the learner inputs a question or demands that the system explains something.
- If the system finds that the learner is in impasse, ask him whether he hopes to turn over the phase where the system takes initiative. And if he does, turn over it.
- Accept interruption by learners whenever the system generates explanations.
- Decide the next action of the system according to the interruption. For example, if the learner demands that the system sets the phase where the learner takes initiative, set a suitable state of the environment and let him experiment freely. If he inputs a demand for the system to explain other topic than the current topic, continue explanation on the requested topic.

4 Implementation

We designed a prototype system. Figure 1 shows outline of our system.

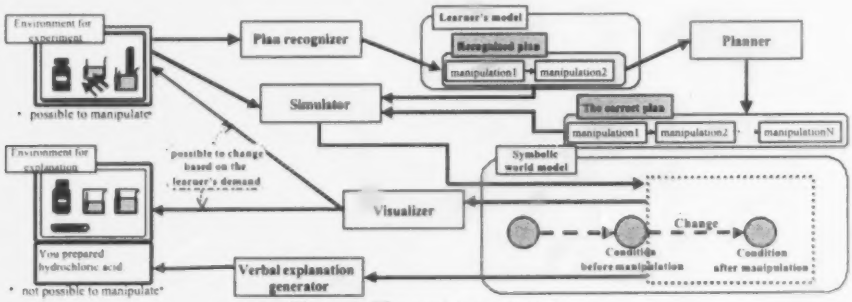


Figure 1: The prototype system

BEST COPY AVAILABLE

The system has *environment for experiment* and *environment for explanation*. The system sets a goal and a learner tries to achieve the goal by manipulating objects in *environment for experiment*. When the learner does an action in *environment for experiment*, the simulator reproduces a change in *symbolic world model*. Then the *visualizer* draws the state after the change in *environment for experiment*. At the same time, *the plan recognizer* monitors the learner's manipulations and recognizes his plan. When the learner becomes to be in impasse or requires some advice, *planner* generates a correct plan. Then the system visualizes environment for explanation, and starts explaining by using either recognized plan or the correct plan. In order to generate explanation, *simulator* reproduces states of the world model and *visualizer* visualizes the states in *environment for explanation*. Simultaneously *Verbal explanation generator* generates verbal explanation on the manipulation, the change, and the state.

The domain world model of this system is written by symbolic representation. In general, it is difficult to handle continuity of time and space by such representation. Therefore, our system handles time as a sequence of discrete segments of time. And it doesn't handle strict position of objects in the world, but only relative relations which can be represented by symbols, such as "chemical materials are in the same beaker". A change is also represented by symbols which shows the initial state, the actions causing the change, the changing state, and the state after the change. Most of the subjects in high-school chemistry can be handled in the above mentioned way.

This system is implemented by using Tcl/Tk and LISP (Kyoto Common LISP). This system can deal with the 5 subjects: method of preparing a solution of a certain molarity, acidic material, basic material, neutralization, and using indicator.

We show an example of the behavior of our system when a learner does an experiment of neutralization. Figure 2 shows a user interface for *environment for experiment*. In the environment, the learner prepares hydrochloric acid, prepares nitric acid, and sodium hydroxide, pours nitric acid into hydrochloric acid, prepares phenolphthalein, and mixes it into the mixed acid. Then he finds that he has not achieved his goal. In the case that he can't find the reason and inputs a demand for the system to explain his own actions, the system prepares an *environment for explanation* to start explaining the actions the learner has done. Figure 3 shows a user interface of *environment for explanation*. The interface has three windows: a window for displaying visual explanations and verbal explanations, a window showing a history of actions that have been taken place, and a window for inputting demands. In Figure 3, both visual and verbal explanations for the fourth action (marked in the list shown in the window for history). If the learner finds that he has made a mistake, and if he cannot find the correct way, he wants to demand that the system explains how to neutralize. He clicks on the button "*correct manipulation*" in the window for inputting demands. Then the system starts explaining the correct way (Figure 4). If he inputs a demand for the system to let him re-try the experiment, the system prepares *environment for experiment* and reproduces the state from which he wants to start experiment (Figure 5).

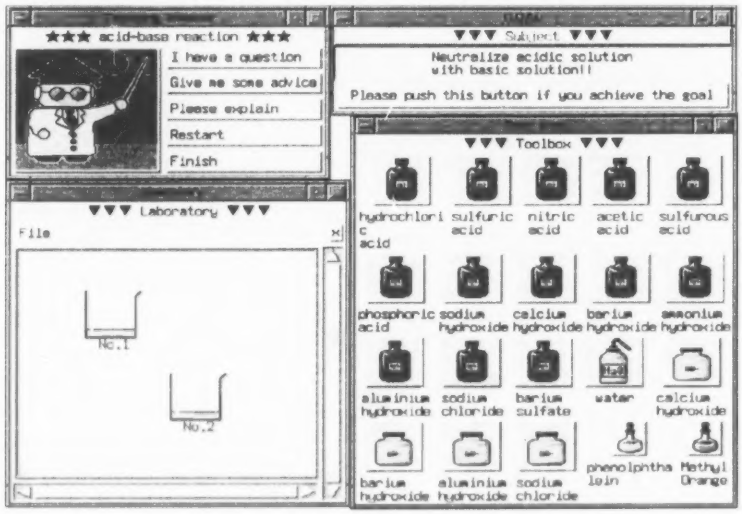


Figure 2: An example of environment for experiment

BEST COPY AVAILABLE

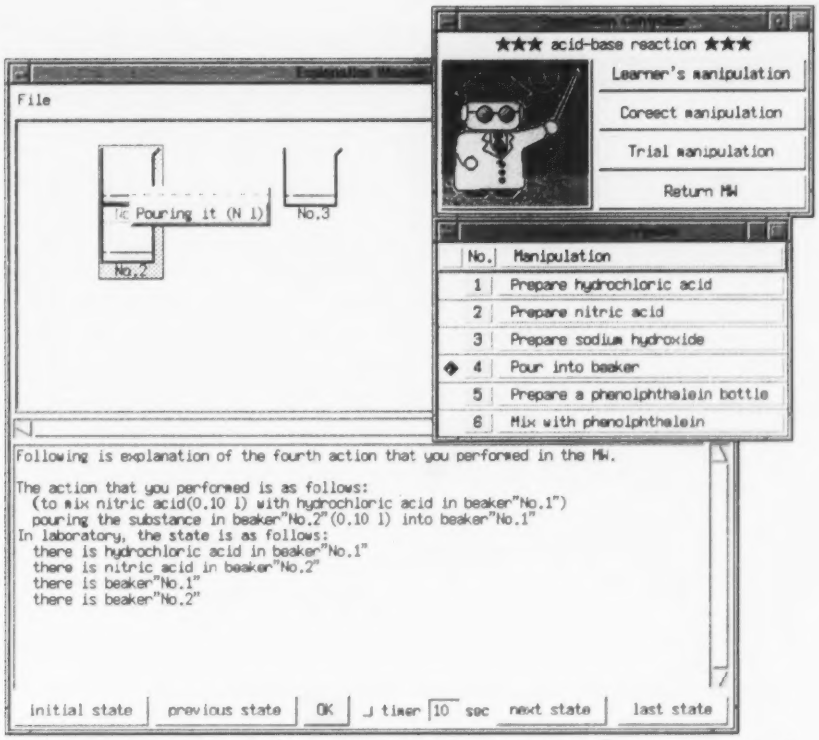


Figure 3: An example of environment for explanation (Explanations of a learner's actions)

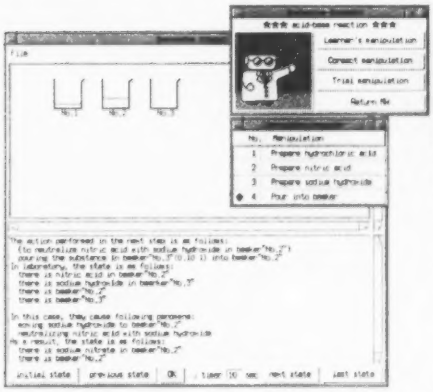


Figure 4: Explanations of corrects actions

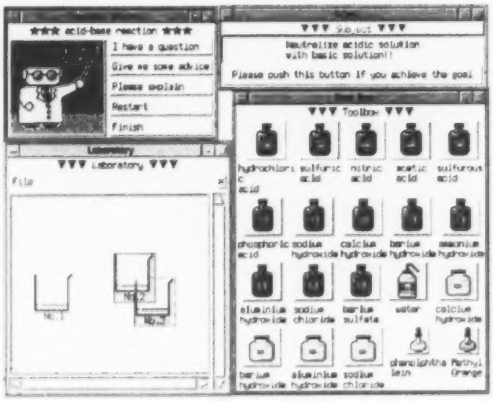


Figure 5: A reproduced environment for experiment

5 Conclusions

In this paper, we discuss a method constructing an intelligent and interactive MW generating explanations both images and texts. Our prototype system has relatively small domain knowledge base, so we have to make it larger in the future in order to increase subjects that our system can support.

When we will try to extend our system to handle other domains, the simulator underlying the system needs to deal with continuity of time and space. For example, if we deal with the field of electric circuit, the

BEST COPY AVAILABLE

simulator needs to handle topology. If we deal with the field of dynamics of physics, the simulator needs to handle coordinate system.

Our another future work is to evaluate the effectiveness of our system experimentally.

Acknowledgements

This research was supported in part by Grant-in-Aid for Encouragement of Young Scientists (12780125) from Japan Society for the Promotion of Science.

References

[1] Itoh,Y., Takahashi,I. and Konishi,T., "On Recognition of Student's Actions in ILE", Proceedings of the International Conference on Computers in Education(ICCE'95), Singapore, December5-8, pp.630-639,(1995)

[2] Itoh,Y., Takahashi,I. and Konishi,T., "On evaluating students' knowledge by observing their actions in ILE", Proceeding of Artificial Intelligence in Education(AI-ED'97), Kobe,Japan, August18-22, pp.595-597, (1997)

[3] Stuart G. Towns, Charles B. Callaway and James C. Lester, " Generating Coordinated Natural Language and 3D Animations for Complex Explanations", Proceedings of the Fifteenth National Conference on Artificial Intelligence (AAAI-98), Madison, Wisconsin, America, July 26-30, pp.112-119, (1998)

[4] Takahashi,I., Itoh,Y. and Konishi,T., "On a method to decide the order of knowledge shown as advice in ILE", Proceedings of the Sixth International Conference on Computers in Education (ICCE'98), Beijing, China, October 14-17, vol1, pp.373-380, (1998)

[5] Takahashi,I., Konishi,T. and Itoh,Y., "On a Framework of an Educational System which Acts both as ITS and Micro-World", Proceedings of the Seventh International Conference on Computers in Education (ICCE'99), Chiba, Japan, November 4-7, pp.954-957, (1999)

Intelligent Interactive Learning Environment: Design Issues

Siu-Cheung KONG* and Lam-For KWOK**
**Department of Information & Applied Technology, Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T.,Hong Kong. Email: sckong@ied.edu.hk*
***Department of Computer Science,City University of Hong Kong,Tat Chee Avenue, Kowloon, Hong Kong. Email: cslfkwok@cityu.edu.hk*

Interactive Learning Environment (ILE) provides interaction opportunities between learners and the virtual devices for productive learning. Intelligent ILE (IILE) provides quality feedback or authentic guidance to learners who need help in the ILE. This research aims to explore design implications of IILE by studying model of learner in the mathematics fraction domain. 169 primary four learners were invited to answer 10 open-ended questions on fraction addition and subtraction. A learner model on category of error and error pattern was formulated from the 423 erroneous responses. Results of the study indicated that researchers should study error patterns by understanding work of learners, distinguish careless mistakes from error patterns, and consider scaffolding support.

Keywords: **Intelligent Interactive Learning Environment, Learner Model**

1 INTRODUCTION

There are two categories of Learning Environment (LE): content-free and subject-specific [1]. A content-free LE allows participants and facilitators to formulate their own topics for discussion. Knowledge formulated from such interactions belongs to the learning community [2]. A subject-specific LE involves subject knowledge. Some subject-specific environments stress knowledge transfer like Intelligent Tutoring System (ITS) [3]. Other subject-specific environments such as Interactive Learning Environments (ILE), assisting learners to learn through exploration, put efforts on designing manipulative virtual learning devices [4]. No matter an LE is designed for knowledge transfer or knowledge formulation, subject matter of the learning domain should be carefully studied and incorporated in it [5].

1.1 Design Considerations of an ILE

The study of subject matters plays a crucial role in designing ILE involving knowledge exploration because learners are not obtaining knowledge directly from the ILE. Learners have to learn by analogy, that is, learners have to transfer knowledge from manipulating the manipulative virtual devices of the ILE to grasp the abstract concepts of the subject domain [4]. Expert teachers are skilful in predicting how learners will think and err [6]. This diagnostic ability is tied to an expert's special understanding of the subject and is undoubtedly derived from multiple opportunities to teach the same content [7]. This knowledge includes knowing which aspects of a topic are particularly difficult, what the common misconceptions are, and what representations are important for authentic learning. Shulman [8] termed this kind of knowledge as Pedagogical Content Knowledge (PCK). It is crucial to utilize teachers' expert knowledge, especially knowledge on representation for authentic learning, to design manipulative virtual devices of an ILE.

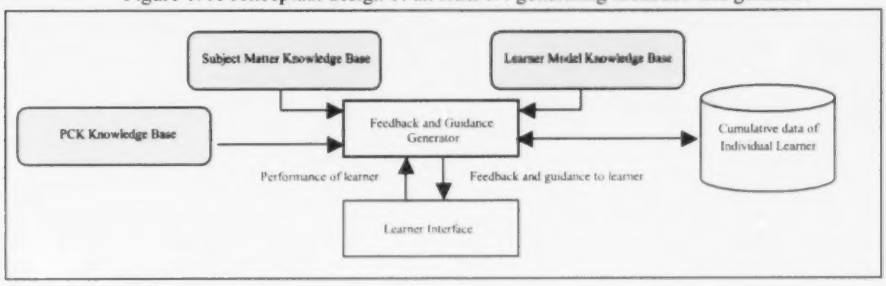
1.2 Design Considerations of an Intelligent ILE

An ILE may provide interaction opportunities between learners and the virtual devices for productive learning. Some learners may learn the subject matter well without the assistance of the virtual learning devices. Some learners may learn well with chances to interact with the interactive learning devices of the environment. However, some learners may need guidance to learn well in the ILE [9]. An Intelligent ILE (IILE) is an ILE that provide feedback or guidance to those learners who need such help in learning the subject domain. Those

learners who do not need help will not notice the existence of the auxiliary service. Learner model of learning in a subject domain may provide information about the behaviour of learners in learning the domain. Studying the learning model of learners may assist IILE designers to formulate design principles and obtain technical details such as formulating mal rules for understanding learning states of learners. A learner model thus may help to tailor-make an IILE for assisting various types of learners in learning the discipline. It is therefore important to study the learning model of learners in a specific subject domain for designing a useful and practical IILE to assist learners of various kinds in the learning process.

Three knowledge bases are therefore important for designing an IILE for learning subject-specific knowledge. They are the subject matter, the learner model of learning in the domain and the PCK of teachers in teaching the discipline. Subject matter knowledge base contains subject matter knowledge. It can provide subject matter advice and knowledge state of learners in the learning process. Learner model contains behaviour representations of learners. Learner model knowledge base may provide information about the learning state of learner. PCK knowledge base contains diverse guidance knowledge for different learning states of learners. It may provide learning advises based on PCK of experienced teachers of the subject domain who know how learners think and err in the discipline. Software agents will monitor the performance of learner in the learner interface. Software agents will determine proactive or reactive responses after a negotiation and communication process in the feedback and guidance generator. The negotiation will be a judgement of the knowledge state of the learner in the domain using both the learner model knowledge base and subject matter knowledge base of the IILE. Final decision will be an outcome after a consultation with the PCK knowledge base of the IILE and the cumulative data of an individual learner. The cumulative data records the historical learning states of each individual learner captured by the IILE. Figure 1 shows a conceptual design of an IILE for generating feedback and guidance.

Figure 1: A conceptual design of an IILE for generating feedback and guidance



1.3 Chosen Subject Domain

A review of literatures indicated that many learners have great difficulties in learning the concepts and procedural knowledge of mathematics fraction [10, 11, 12]. Streefland [11] further pointed out that the main cause of such difficulties is the inadequate and inappropriate teaching in the traditional approaches. As the teaching and learning of mathematics fraction is an internationally renowned difficult topic, it is considered as an appropriate exemplar to be investigated for automation.

2 AIM AND OBJECTIVES

The aim of this research is to study the knowledge of learners in a subject-specific domain and to investigate its implication for designing a subject-specific IILE. There are two specific objectives: (1) to understand the problems of learners in learning the topic; (2) to discuss design issues of an IILE. Such findings may inform the development of IILE for providing quality feedback and guidance to learners.

3 RESEARCH METHODOLOGY

A questionnaire for studying model of primary learners on learning fraction addition and subtraction was designed.

169 primary four learners from four different schools were invited to complete the questionnaire through their mathematics teachers. All learners had completed their learning of fraction addition and subtraction before the test. Learners were requested to do the questionnaire on individual basis in a mathematics lesson for about 35 minutes. No discussions were allowed. The answer sheets were not used for any form of assessment but returned to the researcher after the administration. All 169 answer sheets returned were used for data analysis.

4 RESULTS AND DISSCSSIONS

This section will report on the quantitative and qualitative analysis results of all errors responded by participants of the survey and will discuss their implications on designing an IILE. The learner model formulated contains two areas: (1) knowledge of learners on category of error; and (2) knowledge of learners on error patterns of the domain.

4.1 Knowledge of Learner on Category of Error

Nine categories of error were identified and summarized from the 423 incorrect responses. Though incorrect response of each question may contain more than one error, this study selected the primary source of error for classification. Results were summarized in table 1. Categories were organized in descending order of percentage that account for the errors. The summarized result may serve as an important reference in designing a learner model of LE for fraction learning. Among the nine categories, categories 1, 2 and 9 directly related to the subject matter and accounted for nearly forty percent of the erroneous work. Categories 3 and 8 were common types of error in any mathematics exercise. It is interesting to investigate whether learners in this age group would commit these types of error like doing subtraction for addition at a certain level of unconsciousness. The study reflected that these factors might account for another twenty percents of errors.

Table 1: Category of error summarized from the learner model of the study

	Category of Error	Percentage Accounted
1	Improper handling of mixed number in fraction operation	20.4%
2.	Insufficient procedural knowledge for evaluating fraction	14.7%
3.	Calculation or careless mistake	13.5%
4	Unable to set up correct expression for solving word problem	11.6%
5.	Incorrect strategy for evaluating expression	11.4%
6.	Unable to identify error pattern for erroneous work	10.9%
7.	Not responding to question or the piece of work unfinished	8.5%
8.	Conducting subtraction for addition and similarly addition for subtraction	5.5%
9.	Incorrect simplification of answer to the simplest fraction form	3.6%

Though categories 4 and 5 can be purposely avoided, they do play a role in mathematics learning. Setting up expression for solving problems in a scenario may help to test whether a learner has grasped the taught concept. Strategies of evaluating numerical expressions may help to detect whether a learner has knowledge on magnitude of operands and order of evaluation on operators in an expression. The deficiency of this knowledge accounted for twenty percents of errors detected in this study. Categories 6 and 7 accounted for the last twenty percent of learners' work that might not be understandable or remain unfinished. Those 10 percent of learners' work could not be identified for any error pattern reflected that even human teachers might be unable to understand open-ended pieces of work like evaluating mathematics expressions.

4.2 Knowledge of Learner on Error Patterns

This section will report on knowledge of learners with problems in working with fractions on addition and subtraction. After careful analysing error patterns of learners in evaluating and solving simple fraction addition and subtraction problems, two categories were summarized: (1) concrete error pattern; and (2) vague idea on working with fractions. The first category includes some concrete error patterns that can be abstracted into mal rules. The second category contains error patterns that cannot be easily summarized into mal rules but reflect vague ideas and incomplete working procedures of learners. One of the most famous mal rules on fraction addition can be named as "Add numerators and add denominators". Learner with poor knowledge on fraction addition will adopt knowledge of arithmetic addition by adding the numerators of fractions in the fraction expression to give the numerator of the resultant fraction and similarly adding the denominators of

fractions to give the denominator of the resultant fraction. There were four learners committing this type of error in this study. This rule might explain 3% of the errors. The second category of error pattern to be analysed involves high-level abstraction. The group of learners in this category showed no concrete error patterns. However, the pattern illustrated that these learners have some vague ideas of doing fraction addition and subtraction. Examples were illustrated in table 2.

Table 2 Vague ideas for evaluating fraction addition and subtraction expressions

	Error 1	Error 2
Learner 1 (3 score)	$\frac{3}{8}+\frac{1}{6}=\frac{9}{18}+\frac{9}{18}=\frac{18}{18}=1$	
Learner 2 (6 score)	$\frac{1}{2}+\frac{1}{3}=\frac{3}{10}-\frac{2}{10}=\frac{5}{10}=\frac{1}{2}$	
Learner 3 (0 score)	$\frac{1}{2}+\frac{1}{3}=\frac{1\times3}{2\times3}+\frac{1\times3}{3\times1}=\frac{3}{6}+\frac{2}{6}=\frac{6}{5}$	$\frac{3}{8}+\frac{1}{6}=\frac{3\times6}{8\times6}+\frac{1\times6}{3\times6}=\frac{54}{18}+\frac{3}{18}=\frac{12}{18}=\frac{6}{5}$

These erroneous presentations reflected that learners did have vague ideas about the working procedures on fraction addition. They need assistance to organize the disconnected nodes into a semantic net. Result of the studies indicated that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work.

Identify Careless Mistake

The learner model of this study reflected that twenty percent of errors were derived from calculation or careless mistakes. Careless mistakes in this study mean transcription errors or simple computational mistakes form one step to another. The feedback and guidance will be different if an error is identified as a careless one. An IILE should handle not only problems generated from subject matters but also general problems of learner like careless mistake. An authentic guidance should provide not only advices or actions that can assist learners to formulate conceptual understanding of the subject domain but also offer help to learners derived from general problems such as careless mistakes. An IILE should attempt to distinguish careless mistake from other error patterns like human teachers.

Scaffolding Support

The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help learner much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive learning support should be an arrangement of a sequence of situations for facilitating knowledge construction [12]. The role of a mathematics-learning environment will be to help learners to learn, especially those fundamental concepts in mathematics, but not to replace mathematics learning in the conventional manner. Therefore it is fundamental for such kind of learning environment to provide scaffolding support to learner when assistance is needed. Support should gradually withdraw so that learner can stand on its own after leaving the system. Therefore a fraction IILE should be designed like a blank sheet for learner to work with fraction. Feedback and guidance are only provided when it is needed. On the other hand, learner working in the IILE who does not need support will not notice the IILE in behind.

5 CONCLUSION

Studying the learning model of learners may assist IILE designers to formulate design principles and obtain details for understanding learning states of learners. The learner model of this study modelled behaviour of learners in two aspects: error category and error patterns. Nine categories of error were identified. Forty percent of errors were derived from inadequate knowledge of learners on subject matters. Twenty percent could be explained by careless mistakes. Twenty percent involved general mathematics knowledge. The final twenty percent of erroneous work were difficult to be classified or work was not completed. Learner model of the study reflected that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work. Result of

BEST COPY AVAILABLE

the study indicated that IILE needed to apply a strategy to identify careless mistake so that appropriate guidance to learners can be provided. The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive scaffolding support should be an arrangement of situations for facilitating knowledge construction. The future work of the study is to design ways and means to understand work of students, to devise strategy to distinguish careless mistake from other error patters, and to plan scenarios for assisting learners to learn by exploration in an IILE.

References

[1] Vosniadou, S., Corte, E.D., Glaser, R., & Mandl, H. (Eds.), "International perspectives on the design of technology-supported learning environments", Hillsdale, NJ: Lawrence Erlbaum, (1996).

[2] Duffy, T., & Jonassen, D. (Eds.), "Constructivism and the technology of instruction: A conversation", Hillsdale, NJ: Lawrence Erlbaum, (1992).

[3] Chan, T.W., "An introduction to intelligent computer assisted learning systems research and development", National Science Council Monthly, Vol. 23, No. 5, pp. 456-468, (1995).

[4] Akpinar, A., & Hartley, J.R., "Designing interactive learning environments", Journal of Computer Assisted Learning, Vol. 12, pp. 33-46, (1996).

[5] Wittmann, E.Ch., "Mathematics education as a 'design science' ", Mathematics education as a research domain: A search for identity, Dordrecht: Kluwer Academic Publishers, pp. 87-103, (1998).

[6] Berliner, D.C., "In pursuit of the expert pedagogue. Educational Researcher", Vol. 15, No. 7, pp. 5-13, (1986).

[7] Livingston, C., & Borko, H., "Expert-novice differences in teaching: A cognitive analysis and implications for teacher education", Journal of Teacher Education, Vol. 40, No. 4, pp. 36-42, (1989).

[8] Shulman, L.S., "Those who understand: Knowledge growth in teaching", Educational Researcher, Vol. 15, No. 2, pp. 4-14, (1986).

[9] Cheng, C.C., "Proactive guidance in computer-assisted language learning", Technical Report, LLL-T-24-95. Language Learning Laboratory, College of Liberal Arts and Sciences, University of Illinois, (1995).

[10] Behr, M.J., Harel, G., Post, T. & Lesh, R., "Rational number, ratio and proportion", Handbook of research on mathematics teaching and learning, New York: Macmillan, pp. 296-333, (1993).

[11] Streefland L., "Fractions in realistic mathematics education: A paradigm of developmental research", Dordrecht: Kluwer Academic Publishers, (1991).

[12] Ohlsson, S., "Knowledge requirements for teaching: The case of fractions", Teaching knowledge and intelligent tutoring, Norwood, NJ: Ablex Publishing Corporation, pp. 25-59, (1991).

Towards a Meta-Knowledge Agent: Creating the context for thoughtful instructional systems

Elspeth McKay
RMIT University, RMIT BUSINESS, School of Business Information Technology, GPO Box 2476V, Melbourne, Victoria 3001, Australia, elspeth@rmit.edu.au

This paper describes a creative approach to electronic courseware authoring. Many online learning systems adopt a generic framework in which cognitive modelling is difficult to achieve. A new CBT package called Cogniware is proposed to bridge this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive learning context. Learners are given the opportunity by this intelligent courseware to identify their cognitive style before embarking on the instructional material. Cogniware will use research findings on the interactive effect of cognitive style and instructional format on the acquisition of complex abstract programming concepts, involving spatial relations and logical reasoning [10], to direct the novice-learner to the instructional format that will best suit their cognitive style. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions.

Keywords: **Creative learning, educational agent, instructional design, interactive learning environments**

1 Introduction

Reliable mechanisms for courseware design, which provide beneficial flow-ons from research for the training and development sectors [10] are now available. Picking out the important instructional variables (learner's spatial ability, and method of delivery) for some types of instructional outcomes, progresses our ability to provide instructional environments for a broader range of novice-learners. These advancements give the learner a choice of information-transfer-agent, instructional format and instructional event conditions. Too often novice-learners are left to stumble their way through instructional material. We now have the means to deliver customised learning environments. Generic instructional formats often provide too much information, or too little. The meta-knowledge relating to an individual's likely perception of instructional strategies brings our courseware construction into the realm of being truly thoughtful instructional systems' development. In the past, there has been a traditional view that learners adopt a generic approach to make the learning of new abstract concepts meaningful. For instance, the intellectual skill associated with absorbing concepts should be included with the verbal information conveyed during instruction [20]. Cognitive processes involved in learning concepts, are generalization and discrimination [11]. For that reason, individuals generalise from a particular response to learning, to their overall learning experience. Learners look for common attributes that new concepts share with previously encountered ones [11]. However, while still assuming a generic learner cognitive profile, there is now some evidence relating to how an individual's initial mental construct might take the form of a graphical image [5]. That image could serve as a device for mental recognition if the actual object has been seen earlier. Furthermore, mental constructs include the perceptible and non-perceptible attributes of the concept and the cultural meaning given to the name of that concept.

However, there are few examples of research that make a connection between learning abstract computer-programming concepts and graphical-representation as an instructional strategy (see [8]; [9] & [10]. A colour

coding process to trace programming logic flow has been devised by Neufeld, Kusalik & Dobrohoczki [13]; and an interactive system, which traces the hidden activities of a computer-programming interpreter has been developed by Smith [18]. Courseware authoring involves the instructional designer in a complex pedagogical process. First, there must be some understanding of how learners deal with the learning content. Next, is the recognition of the interactive effect of an individual's knowledge processing and cognitive style. Finally, the designer needs to be aware of how the dynamics of the meta-knowledge processing (see Figure:1) impact on intelligent tutoring tools.

2 Dynamics of authoring an intelligent tutoring tool

The McKay [10] research has clearly identified the complexity of the meta-knowledge environment, and has outlined prospects for a customised learning shell. Progress is thus possible in linking research outcomes to actual learning contexts. The advent of computerized courseware dictates a need for innovative instructional strategies to articulate the visual (pictorial) approach to instruction. However, as this work has shown: not all individuals will cope effectively with a *graphical environment*

However, the observed interactive effect of the cognitive style construct [16] and instructional strategy, may be unique to the acquisition of programming concepts. Therefore, researchers/trainers will need to run an extensive pilot study programme to identify the interactive effects within their specific learning domain. In addition, the instructional material does not need to be limited to a textual/graphical comparison, but could be applied to any two or more instructional treatments of any kind. For instance, a structured versus exploratory strategy. Consequently, a special effort is required to reduce the measurable tension between the instructional mechanism (or dynamics of the tutor's view of the topic) and the actual instructional outcomes (or dynamics of the novice-learner's requirement for specific types of knowledge context). Figure:1 shows the interplay between learning and instruction.

Figure 1: Learning Process Dynamics

The Sternberg [19] approach was to concentrate on the basic information processes in analogical reasoning; while Dreyfus & Dreyfus [2] described stages of skill acquisition as five steps from novice to an expert: novice, advanced beginner, competence, proficiency, and expertise. Be that as it may, it was the sequencing of instruction that reflected the beneficial nature of meaningfulness to the act of learning [7]. Therefore, careful consideration needs to be given to the logical sequencing of instructional events to ensure participants are able to progress through the Dreyfus & Dreyfus skill acquisition steps. Intelligent tutoring systems seek to emulate the learning process, providing a novice-learner with a free fall approach to the pedagogy, or a feeling of being lost in hyperspace [4]. Many of the novice's failed attempts to construct the required domain knowledge are alleviated, when the courseware provides advance notification of the instructional content to promote the intended pedagogic framework. Thus the connection can be made between an individual's prior domain knowledge and their internal representation (Figure:1). This instructional device is called an advance organizer. It occasionally makes learning meaningful by relating new knowledge in a parallel fashion, to what is already known outside the content area [15].

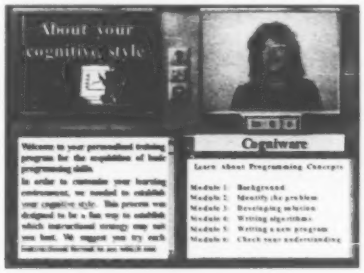
3 Taking a multi-sensory approach

Multi-sensory instruction can improve a student's capacity to learn effectively [1]. This instructional approach maximises the skills brought to the learning task, while minimising the experiences where their ineptitudes are emphasised. Nevertheless, this learning process is often overlooked in the literature, in terms of making new knowledge meaningful by relating to sensory events [17], or to actions already stored in a learner's experiential database (memory). This experiential (human) database is called a sensori-motor database [6]. Accessing this human database is probably the most important method we have for making new knowledge meaningful, during the early years of cognitive development [15]. An instructional strategy can tap into the power of an individual's sensori-motor database, with an innovative textual metaphor, for explaining conditional logic flow to a novice programmer. This textual metaphor describes a common event to support a reflective approach to acquiring the programming concept of conditional logic patterns, thereby encouraging a novice-learner to access their sensori-motor database, to implement a new concept. Experiential leverage for developing the procedural knowledge is gained through providing hands-on experience with example problems. There is a relationship between cognitive level and mental energy consumption in different learning activities [14]. Reading and listening are mentally and physically exhausting with dull and poorly designed material, thereby losing the reader's interest. Furthermore, there is another relationship between cognitive level and suggestive impact, for different kinds of instructional representations [9]. Therefore, designers should be conscious of this and strive to design their learning materials (text and pictures) in the most attractive, and relevant manner possible, so that novice learners are encouraged to process the content (message) on the highest possible cognitive level.

4 Cogniware

Following the premise that a multi-sensori approach is beneficial to learning. Cogniware has been developed using the Electronic Trainer authoring tool from Mindware Creative Inc. At present it consists of a front end module to determine the learner's cognitive style (the CSA [16]), and a choice of instruction method for the acquisition of programming concepts. Cogniware is multi-sensori in the sense that the instructional strategies on offer provide the learning material in a range of alternative instructional conditions. Figure:2 depicts a typical Cogniware screen interface with three instructional formats or separate viewing areas: graphical, textual, and voice. In addition there are cueing mechanisms for guided exploration, such as: directional icons, a learning module name tag, and an advance organizer screen.

Figure 2: Towards a Meta-Knowledge Agent



Cogniware provides the background material on different modes of learning in a textual description interface, while at the same time a voice description can be heard.

4.1 Choice of instructional format

Currently, Cogniware has three types of instructional format available: graphical, textual, and voice (see Figure:2), thereby providing the learner with the format which best suits their cognitive style. However, Cogniware is also flexible enough such that a learner can over-ride the default for the chosen format. Programming metaphors are used as expository instructional strategies. In so doing, they articulate the critical attributes of the concept-to-be-learned [12].

BEST COPY AVAILABLE

4.1.1 Textual

There are a number of ways in which we can aid the comprehension of the written word. To overcome one of the central difficulties associated with text processing, Cogniware provides the reader with the best possible means to select important information from the text [3]. Hotwords are included as pedagogical cues to navigate a novice-learner through a new concept. Text should not be considered as a flat structure, where all ideas are expressed with equal importance. The Cogniware text is therefore a highly structured communication tool, in which ideas are expressed hierarchically, where certain parts of the message can receive more attention than others. As a consequence, particular display techniques enable the reader to focus on the full context of the message by selecting the important issues without being overwhelmed by poorly structured text.

4.1.2 Graphical

Graphical metaphors used by Cogniware were chosen for their recognisable and distinguishing (or salient) features, to depict each programming concept to be learned. These visual metaphors serve to elicit prior experiential knowledge, enabling the learner to recognise the distinguishing features of the new concept, and to interpret the instructional context without specific prior learning.

4.1.3 Voice

The learner can view the video interface to hear a verbal description of the programming metaphors. Advice and reassurance is also provided to ensure maximum coverage of the multi-sensori platform. Voice directions for dealing with the CBT navigation are designed to reduce the cognitive effort required in dealing with the complexities of multi-media instruction. Reminders can be seen as a useful technique to keep the novice-learner on track. It is intended that demonstration video clips will be included in future releases of Cogniware to extend the multi-sensori capability.

5 Conclusions

Cogniware represents a creative approach to electronic courseware authoring. The sound instructional design foundation upon which this courseware is built, draws on the research conducted by Merrill's ID_2 team at Utah State University, USA, and recent research by McKay & Garner [9]. The latter research provided the experimental findings to link the important work on the Cognitive Styles Construct carried out at Birmingham University, UK , by Riding [16] with the effectiveness of various instructional formats. Cogniware was authored using The Electronic Trainer providing the ideal knowledge based framework for authoring electronic courseware. Online learning systems adopting a generic framework reveal that cognitive modelling is difficult to achieve. It is proposed that Cogniware bridges this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive rather than exclusive learning context. At the nexus of this CBT is the ability afforded to learners to identify their cognitive style before engaging with the multi-sensori instructional devices, allowing selection of an optimal instructional format. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions. Researchers can now provide a better understanding of the interactive effects of the cognitive style construct and instructional format on the acquisition of abstract concepts, involving spatial relations and logical reasoning [10].

Educational researchers are reminded to work towards ensuring their instruction works for people rather than ensuring their instruction works for the technology.

References

[1] Diana, E.M., & Webb, J.M. Using geographic maps in classrooms: The conjoint influence of individual differences and dual coding on learning facts. *Learning and Individual Differences*, 9(3), pp.195-214, (1997).

[2] Dreyfus, H.L., & Dreyfus, S.E. *Mind Over Machine: The power of human intuition and expertise in the era of the computer.* Free Press: New York, (1986).

[3] Jonassen, D.H., Hennon, R.J., Ondrusek, A., Samouilova, M., Spaulding, K.L., Yueh, P.-H., Nouri, V., DiRocco, M., & Birdwell, D. Certainty, determinism, and predictability in theories of instructional design: Lessons from science. *Educational Technology*, **37**(January-February), pp.27-34, (1997).

[4] Kashihara, A., Uji'i, H., & Toyoda, J. Reflection support for learning in hyperspace. *Educational Technology*, **39**(5), pp.19-25, (1999).

[5] Klausmeier, H.J. Concept learning and concept teaching. *Educational Psychologist*, **27(3)**(Fal), pp.267-286, (1992).

[6] Lindsay, P.H., & Norman, D.A. *Human Information Processing: An Introduction to Psychology.* (2nd ed.) Academic Press: New York, (1977).

[7] Mayer, R.E. The sequencing of instruction and the concept of assimilation-to-schema. *Instructional Science*, **6**, pp.369-388, (1977).

[8] McKay, E. Exploring the effect of graphical metaphors on the performance of learning computer programming concepts in adult learners: A pilot study. *Educational Psychology*, **19**(4), pp.471-487, (1999).

[9] McKay, E., & Garner, B.J. *The complexities of visual learning: Measuring cognitive skills performance.* Paper presented at the 7th International Conference on Computers in Education: New human abilities for the networked society, held 4-7 Nov, Japan. G.Cumming, P.Okamoto & L.Gomez (Eds.), IOS Press: Amstredam,Vol:1, pp. 208-215, (1999).

[10] McKay, E. *Instructional Strategies Integrating the Cognitive Style Construct: A Meta-Knowledge Processing Model (Contextual components that facilitate spatial/logical task performance):* Doctoral Dissertation in Computer Science and Information Systems: An investigation of instructional strategies that facilitate the learning of complex abstract programming concepts through visual representation, Faculty of Computing and Mathematics, Deakin University, Geelong Campus, Victoria. Australia, (2000).

[11] Merrill, M.D., Tennyson, R.D., & Posey, L.O. *Teaching Concepts: An instructional design guide.* (2nd ed.) Educational Technology Publications: New Jersey, (1992).

[12] Merrill, M.D. (1994). *Instructional Design Theory.* Educational Technology Publications: New Jersey.

[13] Neufeld, E., Kusalik, J., & Dobrohoczki, M. Visual metaphors for understanding logic program execution. *Graphics Interface* '97, pp.114-120, (1997).

[14] Pettersson, R. *Using digitial image elements to produce schematic pictures.* Paper presented at the 25th Annual Conference of the International Visual Literacy Association (held October 13-17): Visual literacy in the digital age: Selected readings, New York, (1993).

[15] Reigeluth, C.M. Meaningfulness and instruction: Relating what is being learned to what a student knows. *Instructional Science*, **12**, pp.197-218, (1983).

[16] Riding, R.J. *Cognitive Styles Analysis* : Birmingham Learning and Training Technology, (1991).

[17] Rosch, E. Principles of Cognition and Categorization. In E.Rosch & B.Lloyd (Eds.), *Cognition and Categorization.* Erlbaum: New Jersey, (1978).

[18] Smith, P. *The Development and Evaluation of a Glass-Box Interpreter for Teaching Novice Programmers.* Unpublished Doctor of Philosophy, Deakin, Victoria, Australia, (1998).

[19] Sternberg, R.J. Component processes in analogical reasoning. *Psychological Review*, **84**, pp.253-378, (1977).

[20] Tessmer, M., Wilson, B., & Driscoll, M. *A new model of concept teaching and learning.* Paper presented at the Annual meeting of the American Educational Research Association (March), California, (1989).

Modeling the Tutor Using Reinforcement Learning

Roberto S. Legaspi and Raymund C. Sison
College of Computer Studies,De La Salle University, Professional Schools, Inc.
Manila, Philippines
ccsrsl@ccs.dlsu.edu.ph, ccsrcs@ccs.dlsu.edu.ph

This paper is a work-in-progress research that describes a learning framework that would allow a tutoring agent to predict future effects of different tutoring tasks over a particular class of learners. The framework would also build a model of tutoring heuristics for the agent to use and update. Lastly, the framework enhances the adaptivity of the tutoring agent as it performs on-line, in real-time learning. These can be achieved by modeling the tutor of an ITS via reinforcement learning with the temporal difference method TD(0) as the central learning procedure.

Keywords: **reinforcement learning, temporal difference method, tutor modeling**

1 Introduction

For about two decades, the Intelligent Tutoring System (ITS) paradigm has dominated the field of AI and Education [3]. One reason for this is that the ITS formed the solution to the non-adaptive Computer-Aided Instruction Systems that cannot qualitatively model the knowledge of individual students. This limitation of CAI Systems led to their inadequate reasoning capacity and prevented the immediate remediation of students. As a computer-based tutor that models the student's knowledge, an ITS effectively provides individualized instruction and remediation. Machine learning (ML) has been used for student modeling [5] and background knowledge construction [6]. However, ML can also be used for improving tutoring strategies [1].

The tutor of an ITS determines the method of instruction and remediation[1] to be applied on a given situation. Some of the complex teaching tasks that the tutor is expected to do include reviewing a previously learned topic, reviewing a related though not yet learned topic, giving a problem to solve which can be new, the same, or related to something that was given previously with equal level of difficulty, giving hints or advice, and giving explanation of the processes involved. Should any tutor provide such instruction and remediation abilities, it should at least know the next teaching task that would effectively aid its learner. This functionality can be provided by modeling the tutor using *reinforcement learning* with the *temporal difference* method TD(0) as the central learning procedure.

Modeling the tutor as a learning agent has several advantages. The first is that it makes generalization of *teaching interaction sequences*[2] easier. This means that the tutoring agent can identify the best teaching interaction sequence over a particular student. The fact that no two students are completely the same shall not be disregarded. However, the scope of generalization shall be limited. Generalization of teaching interaction sequences shall only be done over a particular classification of students where differences in learning patterns can be finite and minimal. This would require a model of tutoring heuristics to be created and constantly updated by the agent as it learns from its own experience. As much as the agent can generalize teaching interactions, the second advantage is the agent's ability to customize teaching interactions among individual learners. The last advantage is the enhanced adaptivity of the tutoring agent as it performs on-line, in real-time learning.

---

[1] Throughout this paper, instruction and remediation tasks will be collectively called as *teaching tasks*.
[2] A *teaching interaction sequence* consists of teaching tasks carried out by the tutor and responses made by the student which complete an entire tutoring session.

The topics of the paper are presented as follows. The system architecture will be discussed in section two. It is then followed in section three by a description of a reinforcement learning framework using TD(0) core learning procedure. Section four presents a general snapshot of the system exhibiting reinforcement learning and updating a tutoring model. The paper concludes with section five.

2 Architecture

The general architecture that the paper proposes as approach in modeling the tutor is illustrated in Figure 1.

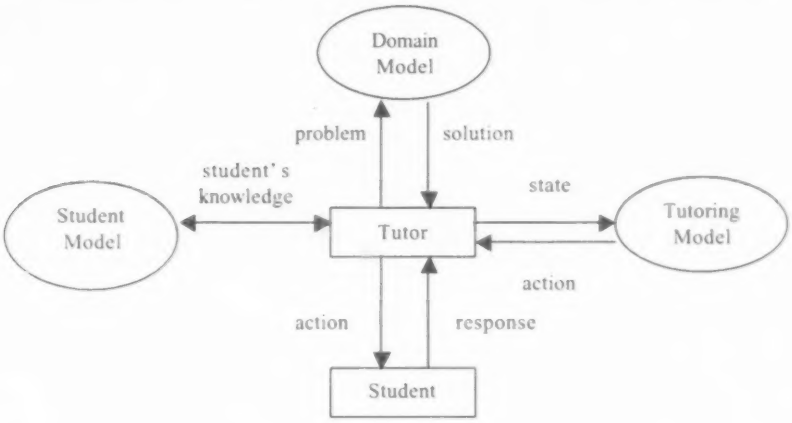


Figure 1. General Architecture to Model the Tutor

The *tutor* interacts with the *student* via the different teaching tasks (tutor's *actions*). The student's *response* to the tutor may range from pressing a key on the pad to giving complete solution to a problem. The *domain model* is a formal model of how the problems in the domain are to be solved. The *tutoring model* contains what the tutor has so far generated (or learned) as generalization of its teaching interaction sequences over the different student experiences. Any *state* would consist of the student's response to a presented teaching task, what the student knows so far (the *student's knowledge*), and the solutions to a given problem.

Once the tutor gets a clear picture of the current state, it consults the tutoring model to determine the next teaching task to be applied based on the given state. If there is no teaching task in the tutoring model that corresponds to the current state, then the tutor shall learn from experience through trial-and-error. At the end of an entire teaching interaction sequence (or tutoring session), the tutor updates the tutor model on any new sequence learned. Also at the end of an entire session, if the tutor realizes that the sequence of teaching tasks it assumed to be best for the student no longer applies, then it shifts to another sequence. For the tutor to generalize teaching interaction sequences over several students of a particular class, it shall constantly update the tutoring model.

The architecture also accounts for the peculiarities in behavior of the different students who will use it as learning happens while the student is interacting with the system. Teaching interaction sequences can be altered accordingly to individual students even on stochastic events.

3 Learning Framework

The architecture shall adopt reinforcement learning as its general learning framework with temporal difference method TD(0) as its central learning procedure. *Reinforcement learning* (RL) involves interaction between an active decision-making agent and its environment. All reinforcement learning agents have specific goals, can sense aspects of its environment, and can choose actions to influence their environment so as to achieve their goals despite the uncertainties in which they operate. Another characteristic of the RL

agent is that it can use its experience to improve its performance over time. In "unknown territories", a learning agent must be able to learn from experience through trial-and-error. Furthermore, for the learning agent, on-line performance is important. Literatures have covered both generally [2] and exhaustively [6] the issues of reinforcement learning.

In reinforcement learning, an agent generates an action in some state of its environment. The way an agent maps states to corresponding actions (or the way an agent behaves), is defined by a *policy*. Each time an action is performed, a feedback in the form of a numeric -valued reinforcement or *reward* (a negative reward is interpreted as a *penalty*) is given by the environment to the agent to indicate the desirability of the resulting state. The estimate of how good it is to perform an action in some state is given by a *value function* which is defined in terms of future rewards that can be expected. The goal of the learning agent is to maximize the expected rewards. It is important to note that a value function is dependent on the particular policy being implemented. Also, rewards are factual values computed by the environment via a reward function, while the value function generates an estimate made by the agent.

Given the architecture above, reinforcement learning can be integrated as follows. The student's response (student), his current knowledge (student model), and solutions to the problem (domain model) shall comprise the environment. Depending on the prevailing policy and given a state of the environment, the tutor model predicts the action (teaching task) to take and the resultant next state and its reward. The desirability of the next state is computed using the value function. The model contains several possible next actions and their corresponding next states and next rewards but produces only one of the possibilities. The tutor takes action and waits for the student's response. This sequence of state observation, model consultation, action taking, reward assignment and value computation is repeated many times until the goal is either achieved or not. The tutor receives a positive reward when the goal is reached. Otherwise, the tutor is negatively reinforced. In the case that the model has no provision for a given state (true most especially at the initial stages of building the model), then the tutor has to learn from experience via trial-and-error while estimating value functions. At the end of an entire teaching interaction sequence, learning is achieved in two ways. First, the tutor updates the tutor model for any newly learned sequence (generalization of teaching interaction sequences) which can be used in future sessions. Secondly, the tutor can determine whether a policy worked for the student or not based on the final reward attained by the sequence. If it does not work, then the tutor shall shift to a new policy. While the tutor is now a learning agent, it is interpreted to be a tutoring agent that learns teaching interaction sequences and generalizes them.

Clearly, the learning framework requires the tutor to learn from raw experience. Another equally important requirement is that the value function, which is just an estimate, must be close to the true value to really see the efficiency of performing an action on a given state and the desirability of being in the resulting state. There must be an efficient way to update the value function estimates until convergence to the true and correct value is guaranteed. To attain these requirements, the learning framework shall adopt temporal difference (TD) method, specifically TD(0), as the central learning procedure [6]. Though TD methods learn estimates in part on the basis of other estimates, it has been found that for any given fixed policy, it guarantees convergence to the correct value. Furthermore, TD methods are naturally implemented in an on-line, fully incremental fashion.

The TD(0) algorithm can be summarized as follows. Given a state s with a value function $V(s)$ under a policy π, TD(0) initializes $V(s)$ with an estimated value and takes action a given by π for s. After a has been taken, the agent observes the reward r, the next state s', and estimates $V(s')$. Updating on $V(s)$ is done via the computation $V(s) \leftarrow V(s) + \alpha[r + \gamma V(s') - V(s)]$ where α and γ are the learning and discount rates, respectively. Since the change in $V(s)$ to $V(s')$ now becomes a factual value, the equation brings $V(s)$ closer to its true value.

A system called ADVISOR [1] also trains an agent using RL with TD(0) as its mechanism. The agent takes its input from a model of a student population and derives a teaching policy that meets a specified educational goal. This is different from what this research would like to attain. The different teaching policies are kept by the tutor and feeds them (one at a time as needed) to the tutor model to determine the best teaching interaction sequence. At the end, what is derived is a generalization of the different teaching interaction sequences to meet the desired educational goal.

4 A General Snapshot of the System

The goal of the system's tutor is to keep teaching time to a minimum of 30 minutes while assuring a 90% mastery of the topic for the student. Giving it a reward of +1 each time it attains the goal reinforces the tutor. But a penalty of X-30 (where X is the total time to complete the teaching session) is given each time the tutor fails to attain the goal. It is assumed that the tutor will not stop (even if it exceeds the 30-minute mark) until the student gains 90% mastery of the subject matter. In such a case, the tutor receives a negative reward. The final outcome reward will tell the tutor if the policy produced a successful teaching interaction sequence or not. If it does, then the tutor continues to use that policy. Otherwise, it shifts to another policy.

Initially, the tutor model contains nothing yet. Given a policy that produced a teaching instruction sequence (review last topic, give an exercise and the student solves, explain the process, give hint and advice, give another exercise and the student solves, summarize session) that yielded the following value function estimates 0 0 0 0 0 +1. Using TD(0), the final values would be 0 0 0 0 +1 +1. The policy works in producing the correct sequence. The sequence is stored in the tutor model. As the policy prevails and the same sequence is used the next time around, then the values will become 0 0 0 +1 +1 +1. Continuously using the sequence leads to the convergence of value functions to the true values. The sequence may change (though the policy remains the same) if it no longer applies to a given state. The tutor has to learn once again from experience and come up with another training sequence and updates the model. The model contains not just the sequences that led to a success but including those that did not attain the goal.

Considering the case that the model has generalized over several situations, given a starting state, the model predicts the best teaching interaction sequence to apply on the student. Unfortunately, it did not work. The session went on to several more minutes beyond 30, and was completed with a penalty of −120. Using TD(0), the effect will cascade down through the sequence the moment it is used again. If the tutor gets into that sequence, it does not have to wait for the final outcome, using TD(0), the penalty cascaded already to some earlier state which the tutor immediately senses. At that point, the tutor abandons the sequence and changes policy.

5 Conclusion

Using reinforcement learning as the learning framework with TD(0) as the central learning procedure to model the tutor within the architecture that this paper proposes has perceived advantages over the traditional ITS. First, the tutor can provide teaching tasks that can be customized to an individual learner. Second, the system can update a tutoring model that generalizes teaching interaction sequences over several students of a particular classification. Lastly, teaching interactions are efficient as implemented in real-time.

As a future work, the learning framework can be extended to accommodate students from several different classifications.

References

[1] Beck, J., Wolf, B. & Beal, C., "ADVISOR: A machine learning architecture for intelligent tutor construction", To appear in the Proceedings of the Seventeenth National Conference on Artificial Intelligence, 2000.

[2] Kaelbing, L.P., Littman, M. & Moore, A., "Reinforcement Learning: A Survey", Journal of Artificial Intelligence, Research 4, pp. 237-285, 1996.

[3] Sandberg, J. & Andriessen, J., "Where is AI and how about Education?", Artificial Intelligence in Education, IOS Press, 1997.

[4] Sison, R., Numao, M. & Shimura, M., "Multistrategy Discovery and Detection of Novice Programmer Errors", Machine Learning, Vol. 38, pp. 157-180, 2000.

[5] Sison, R. & Shimura, M., "Student Modeling and Machine Learning", International Journal of Artificial Intelligence in Education, Vol. 9, No. 1-2, pp. 128-158, 1998.

[6] Sutton, B. & Barto, A., "Reinforcement Learning: An Introduction", MIT Press, Cambridge, MA., 1998.

Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language

Peter Schmidt
Department of Computer Science, University of Bonn
Römerstr. 164, 53117 Bonn, Germany
E-mail: peter@uran.informatik.uni-bonn.de

A restricted natural language is presented which is suitable for formulating mathematical proofs in the domain of calculus. A line of a proof according to the language consists of three parts: A marking, a proof statement, and a foundation of the statement. Foundations include among others the name of a theorem, the name of a concept, or a formula manipulation operation. It is demonstrated how mathematical proofs worded in that language may be automatically monitored and checked for correctness and completeness by a computer program. For that, techniques of the fields of theorem proving and of formula manipulation are applied; the lines of the original proof are transformed into a quantifier free form and checked line by line; an internal knowledge base of concepts and theorems allows for verifying proof statements which are founded by concept definitions or theorem applications. The described methods may be used in virtual or face-to-face universities for the purpose of proof exercises by students or for the purpose of automatically checking and scoring student proofs. The approach together with a medium-grained XML representation of concepts, theorems, and proofs may form the core of a learning environment which gives students the opportunity of an intensive interactive occupation with mathematical proofs.

Keywords: **Calculus Proofs, Verifying, Restricted Natural Language**

1 Introduction

Finding and constructing mathematical proofs are standard activities of persons who study mathematics or disciplines of science. For learning purposes, it would be desirable to have an interactive software system into which students could enter a mathematical proof in the usual way utilizing the natural language and the software system would monitor and verify the student's proof or provide help if needed.

From the side of the field of mechanical theorem proving, techniques and procedures are available to automatically prove theorems or check a given proof, if the theorem or the proof are worded in a formal language like first order logic or the quantifier free clause form (see e.g. [1], [5]). The main bottleneck to reach the above mentioned goal is the difficulty of processing and correctly understanding natural language input. As a solution to the problem or as a compromise we here suggest a restricted natural language to formulate proofs. The language results from an inquiry into mathematical proofs which occur in mathematical textbooks of the domain of calculus (see e.g. [8]). We chose the domain of calculus because of the importance of calculus for the edifice of mathematics and for many practical applications and because calculus belongs to the first fields which are studied at the universities.

Secondly, we discuss how proofs utilizing that restricted language may be automatically monitored and checked for correctness and completeness by a computer program. To monitor a proof, the proof is transformed into an internal form which includes the quantifier free notations of the occurring logical expressions. A proof is checked line after line like a human would do who tries to verify a given proof. The checking for correctness of the single statements relies on the techniques of the fields of theorem proving and of formula manipulation and of their combinations. Regarding the theorem proving techniques we utilize methods which are similar to the methods of Bledsoe, Boyer and Henneman to automatically prove limit theorems ([2],[3]).

Apart from providing opportunities of doing proof exercises, the described methods may be used in virtual or face-to-face universities for the purpose of automatically checking and scoring proofs of students.

Thirdly, we shortly discuss the extension of the approach to an extensive learning environment.

2 Mathematical Theorems and Proofs in the Domain of Calculus

The *subjects of calculus* include among others limits of sequences and functions, derivations of functions, determination of properties of functions, integrals, the study of special classes of functions, and many practical applications of theoretical results.

Proof methods used in calculus are multifarious and include direct proofs using the analytical definitions of concepts like limit, continuous or differentiable (epsilon-delta notation), inductive proofs, indirect proofs or proofs by counter-examples, or direct proofs utilizing chains of inferences of already proven theorems.

A large set of proofs in the domain of calculus follows a recurrent pattern. One characteristic of those proofs is the use of analytical definitions of the main concepts to establish the proof. A further characteristic of many proofs is that they employ formula manipulation methods as a central technique to establish the proof. Proofs often consist of a construction process. Those characteristics allow for monitoring proofs without a long chain of logical deductions.

3 A Restricted Natural Language to Formulate Proofs

The restricted language to word proofs is here informally described mostly by examples so that persons who are familiar with proofs of the domain of calculus can understand the scope of the various allowable statements. The language is not supposed to be exhaustive, but the current version of the language covers a large set of calculus theorems and proofs in textbooks and in collections of exercises.

The usual structure of a natural language proof in a textbook consists of a series of statements which are substantiated by one or more foundations. The statements may have a reference to other statements of the proof. The restricted language reflects that structure by dividing a proof into proof lines. Each proof line consists of up to three parts: a marking, a proof statement, and a foundation of the proof statement. By clearly separating the three parts of a proof line from each other, the variety of natural language wording reduces to a simple and easily comprehensible structure.

3.1 The wording of a proof

Basic elements of the language. There are a series of basic elements which may occur in a proof including numbers, variable names, function names, the universal quantifier (ALL), the existential quantifier (SOME), and the logical operators of negation (NOT) and of conjunction (AND). R denotes the real numbers. *Keywords* of the language generally consist of capital letters. *Intervals* play a central role in proofs and may be designated in the usual way, e.g. [a,b] for a closed interval of the real numbers, (a,b) for an open interval, or ALL x WITH |x-a|< delta for an interval with the point a in the middle of it. *Partitions of intervals* are often used in various contexts. They usually define end points and a list of intermediate points and fix the length or a maximum length of the resulting part intervals (see an example below). *Iterations* may be used in the usual way, e.g. i=0,...,n or j=1,2, ... to denote a finite or infinite sequence.

Proof statements. The current version of the language comprises the following proof statements which are described in the next paragraphs:

(1) Assignment statements. Assignment statements allow for defining new variables or functions. An assignment statement starts with the keyword LET. Examples are

LET delta = min(delta1,delta2),

where min denotes the minimum function and delta1 and delta2 are earlier defined variables, or

LET h(x) = f(x)+g(x) ALL x IN [a,b] , where the new function h(x) is defined, or

LET f : [a,b] -> R , where a function and its domains are defined.

(2) Choice statements. Choice statements describe a choice of an entity from a set of possibilities. A choice may e.g. refer to a number chosen from an interval or to a partition of an interval. A choice statement starts with the keyword CHOOSE. The format of such a statement depends on the choice situation. Simple examples are

CHOOSE eps > 0 or CHOOSE x IN [a,b].

An example which covers the choice of a partition of an interval is

CHOOSE PARTITION p OF [a,b] WITH $a=x_0 < x_1 < ... < x_n=b$ AND ($|x_i-x_{i-1}| <$ delta , i=1,...,n) ,

where [a,b] is an interval, x_i are points in the interval, and the mentioned restriction of the lengths of the intervals $[x_{i-1},x_i]$ holds.

(3) Relational statements. Relational statements, i.e. equations and inequalities, frequently occur in calculus proofs. The statements often include constraints on the appearing variables. Typical recurrent examples relate to analytical definitions of concepts and formula manipulation operations. An example which states the definition of continuity is: ALL eps > SOME delta >0 ALL x WITH |x-a| < delta: |f(x)-f(a)| < eps. Often a chain of equations and inequalities appears like ALL x IN [a,b]: |f(x)+g(x)| <= |f(x)| + |g(x)| <= M+N < INFINITY . Another simple example of a relational statement is eps/2 + eps/2 = eps , where eps is a given variable.

(4) Property statements. Property statements describe a property of an entity, e.g. the property of a function to be continuous in an interval. An example is: f IS continuous IN [a,b]. Other properties which often occur in calculus proofs are e.g. uniformly continuous, monotonously growing, or differentiable.

A series of **further statements** which often appear in a proof more or less drive or structure the proof.

(5) Proof type statements. A *proof type statement* characterizes how the proof is done, e.g. by finding a contradiction. The statement starts with the keyword PROOF TYPE and is followed by the name of a proof method from a list of proof methods, e.g.
by DIRECT, DIRECT_BY_DEFINITION, DIRECT_BY_A_CHAIN_OF_THEOREMS, INDIRECT, COUNTEREXAMPLE, SPECIALIZATION, COMPLETE_INDUCTION. The classification of the proof may be relevant regarding several aspects which are mentioned below. An example of a proof type statement is: PROOF TYPE INDIRECT.

(6) To prove statements. *To prove statements* are used to specify what must be or will be proven. There are two variants which may precede a statement: *to prove* or *sufficient to prove*. Here are examples: Let us assume that the conclusion of a theorem is: 'The function f(x) is bounded in an interval [a,b]'. Then the first line of a proof may be e.g. TO PROVE SOME m > 0 ALL x IN [a,b]: |f(x)| < m or the first line of the proof may be e.g.

SUFFICIENT TO PROVE ALL x IN [a,b]: |f(x)| < 1 . In the first case the keywords are followed by a statement which is equivalent to the conclusion of the theorem. And in the second case the keywords are followed by a statement from which the conclusion of the theorem may be inferred.

(7) Assume statements. *Assume statements* are mostly found in indirect proofs. They then state the negation of the statement of the theorem. The statement starts with the keyword ASSUME and there follows another statement. An example is ASSUME NOT [c] , where [c] denotes the marking of the conclusion of the theorem (see an example in Theorem 2 below).

(8) Contradiction statement. A *contradiction statement* states the contradiction of statements occurring in the proof. The statement starts with the keyword CONTRADICTION and its foundation contains the contradicting statements in one or the other way. An example is CONTRADICTION {[4],[6]}. The statement says that the statements marked by [4] and [6], respectively, are contradictory (see an example in Theorem 2 below).

(9) Anchor statements and **induction step statements.** *Anchor statements* and *induction step statements* serve the purpose to structure induction proofs. The statements start with the keywords ANCHOR and INDUCTION STEP, respectively. Examples are ANCHOR n = 1 and INDUCTION STEP n TO n+1.

(10) Proof finishing statement. The *proof finishing statement* consists of the keyword QED and states that the proof is assumed to be complete.

Markings. *Markings* serve the purpose to mark statements so that other parts of the proof may refer to the marked statement. The markings consist of letters and digits embraced by brackets, e.g. [A].

Foundations. A *foundation*, possibly together with other foundations, substantiates a proof statement. There are a couple of possibilities of denoting a foundation: A foundation may consist of the name of a theorem, of a formula manipulation operation, of a property of an object, or of a line number which denotes a logical line of the current proof or of the theorem. The foundation of a logical proof line is enclosed in curled brackets whereby the single foundations are enclosed in brackets and separated by commas, e.g. {[4], [5]}.

3.2 Examples of user proofs

The following examples illustrate the use of the language to formulate proofs. Note the more often occurring *double points,* e.g. one in the proof line which is marked by [2]. That double point is necessary for reasons of uniqueness to separate the prefix containing the quantified expressions from the inequality. An alternative would be to use an IF ... THEN ... statement. The foundations starting with the letters *fm* refer to formula manipulation operations, e.g. {[fm: rewriting]} in line [7]. The theorems are here not worded according to the language. A corresponding wording is necessary when the theorems and the proofs are automatically processed by a monitoring program.

Theorem 1 (Sum of continuous functions)
Let
[p1] f: R->R, g: R->R, a in R,
[p2] f is continuous at the point a
[p3] f is continuous at the point a
Then
[c] f+g is continuous at the point a

Proof:
[1] PROOF METHOD DIRECT_BY_DEFINITION
[2] TO PROVE
ALL eps > 0 SOME delta > 0 ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a) + g(a))|< eps {[c]}
[3] CHOOSE eps > 0
[4] SOME delta1 > 0 ALL x with |x-a| < delta1 : |f(x) - f(a)| < eps/2 {[p2]}
[5] SOME delta2 > 0 ALL x with |x-a| < delta2 : |g(x) - g(a)| < eps/2 {[p3]}
[6] LET delta = min(delta1,delta2)
[7] ALL x IN R : |(f(x)+g(x)) - (f(a) + g(a))| = |(f(x) - f(a)) + (g(x) - g(a))| {[fm: rewriting]}
<= |(f(x) - f(a)| + |g(x) - g(a)| {[fm: triangle inequality]}
[8] ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a)+g(a))| <= |(f(x)-f(a)| + |g(x)-g(a)| {[7]}
< eps/2 + eps/2 {[4], [5]}
= eps {[fm: simplification]}
[9] QED {[2],[8]}

Theorem 2 (Global Monotony)
Let
[p1] f: [a,b]->R is continuous
[p2] f' is differentiable in (a,b)
[p3] for all x in (a,b): f'(x) > 0
Then
[c] f is strictly monotonously growing in [a,b].

Proof:
[A] PROOF METHOD INDIRECT
[B] ASSUME NOT [c] {[A]}
[C] SOME x1 IN [a,b], SOME x2 IN [a,b] : x1 < x2 AND f(x1) >= f(x2) {[B]}
[D] (f(x2) - f(x1)) / (x2 - x1) <= 0 {[C]}
[E] SOME x0 IN (a,b) : f'(x0) = (f(x2) - f(x1)) / (x2 - x1) {[Mean-value theorem]}
> 0 {[p3]}
[F] CONTRADICTION {[D], [E]}
[G] QED

4 Monitoring and Checking User Proofs

A user may enter a proof of a given theorem utilizing the above described language. The natural language proof is then transformed into a quantifier free version. That version is suitable for applying techniques of theorem proving and of formula manipulation. Each step of the user proof is checked by one of several special procedures (see below). We will first discuss the quantifier free version of the above mentioned theorems. Then we will describe the special procedures in the context of checking the proof statements of Theorem 1 and of Theorem 2.

4.1 Quantifier Free Version of a Theorem and a Proof

To check a user proof the natural language proof is transformed into a quantifier free form. Generally, the known methods of the field of mechanical theorem proving apply to get a quantifier free version (see e.g. [1], [5]), but one has to take into account some particularities which result from the fact that the proof representation exceeds first order logic:
(i) The *choice statement* corresponds to a quantification. The identifier succeeding the element CHOOSE has to be treated as a universally quantified variable, if the constraint attached to the variable represents an interval. If the constraint represents an assignment, the variable corresponds to an existentially quantified variable. An example is: A statement "CHOOSE eps > 0" has to be treated as "ALL eps > 0".
(ii) The ranges (scopes) of the quantifiers are not explicitly given in the proof. They have to be determined according to the following rule: The range ends when another quantifier with the same variable name appears or with the last appearance of the variable name.

After having dealt with those exceptions one can apply the usual transformation procedures to the proof lines which contain quantifiers. The statements of the example proofs which contain quantifiers take the following forms (an 'a' or an apostrophe is here added to the markings of the original proof lines):

The quantifier free form of Theorem 1. Figure 1 essentially shows the quantifier free form of the proof of Theorem 1 according to the transformation procedure. We assume that the reader is in general familiar with that procedure and we only mention some modifications and specific aspects which relate to the example proof.

(i) According to the transformation procedure the quantified variable names must be replaced by unique names and the existentially quantified variables are replaced by Skolem functions. In the example, the variable *eps* of line [3] is renamed into *eps0*; *delta1* and *delta2* are replaced by the Skolem functions *d1(eps0)* and *d2(eps0)* which depend on *eps0*; *delta* of line [6] is renamed into *delta0* and defined as *min(d1(eps0),d2(eps0))*; the various variables *x* are not renamed here in the example because of readability.

(ii) The equations and inequalities are assigned a corresponding interval of validity. With that we follow the proceeding of Bledsoe et al. [2].

In addition to the quantifier free version, the monitoring program utilizes a table of the occurring objects, i.e. the functions, variables, constants, and their characteristic properties. We do not here mention further details.

```
[2a] |(f(x)+g(x)) -(f(a)+g(a))|< eps                          ; x IN ( a-delta , a+delta ),
[4a] |f(x) - f(a)| < eps0/2                                   ; x IN ( a-d1(eps0) , a+d1(eps0) ) ,
[5a] |g(x) - g(a)| < eps0/2                                   ; x IN ( a-d2(eps0) , a+d2(eps0) ) ,
[7a] |(f(x)+g(x)) -(f(a)+g(a)) |= |(f(x)-f(a))+(g(x)) -g(a)) | ; x IN R
     |(f(x)-f(a))+(g(x)) -g(a)) |<= |f(x)-f(a)|+|g(x) - g(a)|  ; x IN R
[8a] |(f(x)+g(x)) -(f(a)+g(a)) |<= |f(x)-f(a)|+|g(x)-g(a)|     ; x IN ( a-delta0 , a+delta0 )
     |f(x)-f(a)|+|g(x)-g(a)| < eps0/2 +eps0/2                  ; x IN ( a-delta0 , a+delta0 )
     eps0/2 +eps0/2 = eps0
```

Figure 1: Quantifier free version of the proof of Theorem 1

The quantifier free form of theorem 2. Figure 2 essentially shows the quantifier free form of the proof of Theorem 2. The quantities x0, x1, and x2 are existentially quantified.

```
[C'] f(x1) >= f(x2)  AND  x1 < x2
[D'] ( f(x2) - f(x1) ) / ( x2 - x1 ) <= 0
[E'] f'(x0) = ( f(x2) - f(x1) ) / ( x2 - x1 )
       (f(x2) - f(x1) ) / ( x2 - x1 ) > 0
```

Figure 2: Quantifier free version of the proof of Theorem 2

4.2 Checking a proof for correctness and completeness

The monitoring procedure of the user proof consists of checking one line of the proof after the other. The whole procedure of checking a proof falls into several special subprocedures which process the different kinds of proof statements. There are the following subprocedures which generally utilize the quantifier free versions of the original statements to process the original user statement:

PROCdef: checks the correspondence between a concept and its analytical definition
PROCfm: checks formula manipulation operations
PROClogic: checks logical manipulations
PROCassume: checks the different kinds of assume statements
PROCtoprove: checks whether the succeeding statement corresponds to the statement of the theorem
PROCtheorem: checks whether a theorem may be employed in a special situation
PROCcontradiction: checks contradicting statements
PROCqed: checks whether the theorem is in fact proven

We will describe some features of the procedures in the context of checking the example proofs and mention some more details which are not immediately related to the examples. It should be obvious that the subprocedures also apply to analogous proof steps of other theorems. With the description, we use the line markings of the original proofs (like [2] or [C]), and we do not additionally mention the corresponding line markings of the quantifier free versions (like [2a] or [C']), although the procedures actually utilize the transformed statements.

Checking Theorem 1.

Line [1] states the proof method as 'DIRECT_BY_DEFINITION'. That information will be used later when the 'QED' statement of line [9] occurs (see below).

Line [2] consists of a 'TO PROVE' statement and mentions the analytical definition of the continuity of the function f(x) + g(x) at the point a and as the foundation the conclusion *[c]* of the theorem. The subprocedure *PROCtoprove* uses the subprocedure *PROCdef* to verify that the user statement and the analytical definition of continuity correspond to each other. To check that statement, *PROCdef* uses an internally provided analytic definition of the concept of continuity. The user statement and the analytical definition are compared in the quantifier free form by a unification process. The user statement is regarded as correct when a unification is possible. *PROCtoprove* utilizes the foundation of the line [2] to establish the connection between the concept of continuity and the user definition. Line [2] is internally marked and used later when the 'QED' statement is processed (see below).

A 'TO PROVE' statement may also appear in a proof e.g. to state a lemma which will be used later in the proof. In that case no foundation would be needed and a connection to the conclusion of the theorem would not be established.

Statements which explicitly state the analytical definition of a concept or vice versa infer the concept from an analytical definition are frequently found in calculus proofs. They are all treated by the subprocedure *PROCdef* in a similar way.

Line [3] mentions the choice of an *eps* > 0. That statement corresponds to a universally quantified variable *ALL eps > 0.* The statement results in an entry into the table of the entities of the proof. No further operation happens.

The lines [4] and [5] reflect the analytical definitions of continuity of the functions f and g, respectively. The foundations {[p2]} and {[p3]} trigger the comparison with the definitions of the continuity of f and of g, respectively. The subprocedure *PROCdef* establishes the correctness of the user statements as in the case of line [2]. In order to deal with the *eps/2*, in contrast to the usual *eps* without any factor, a generalized version of continuity is used: *SOME M >0 ALL eps>0 SOME delta>0 ALL x WITH |x-a|<delta: |f(x)-f(a)| < M* eps*. A suitable factor of *eps* in the middle of the proof is often the key with continuity proofs to assure a neat < *eps* without a factor when the proof is finished. The reader will know that.

Line [6] defines the variable *delta* and its value by an expression. The statement results in an entry into the table of the entities of the proof. No further operation happens.

Line [7] gives rise to an equation and an inequality. According to the mentioned foundations, the subroutine *PROCfm* uses a simplification process to check the first equation and a *triangle inequality* subprocedure to check the second relation. Formula manipulation operations play a central role with proofs in the domain of calculus, so corresponding methods need to be available.

Line [8] divides into three relations. The first inequality is an immediate consequence of [7]. *PROCfm* checks their correspondence by standardizing the inequalities and by establishing that the interval mentioned in the line [8] is contained in the interval R of [7].

The second statement resulting from [8] establishes the statements of [4] and of [5] as foundations. *PROCfm* uses *evaluation heuristics* to handle the check of the correctness.

The third relation resulting from [8] only needs simplification which is also done by *PROCfm*.

Line [9] states that the theorem is proven. In the case of a *direct proof* one expects that the conclusion of the theorem will explicitly or implicitly occur as an inference within the proof, usually at the end of the proof. The subprocedure *PROCqed* processes the proof type of the line [1] and uses the preceding 'TO PROVE' statement which was already recognized as equivalent to the statement of the theorem to check whether the relation of the line [2] is fulfilled by the statement of line [8]. Therefore *PROCqed* uses *PROCfm* and a unification process is again employed. *PROCqed* recognizes that the proof is complete.

Checking Theorem 2.
Line [A] states the proof method as 'INDIRECT'. That information will be used later when the 'QED' statement of line [G] occurs (see below).

Line [B] mentions an 'ASSUME' statement which contains a negation of the conclusion of the theorem. The subprocedure *PROCassume* recognizes that one part of the contradiction, i.e. the part referring to the conclusion of the theorem, is established.

An 'ASSUME' statement may also be used to state something which will be proven later. That corresponds to an alternative use of the 'TO PROVE' statement.

The statement of line [C] is an immediate inference of the mentioned foundation [B]. The subprocedure *PROClogic* verifies that the statement of line [C] logically follows from the logical formula NOT [c] .

The statement of line [D] is an immediate consequence of its foundation [C]. *PROCfm* uses *evaluation heuristics* to handle the check for correctness.

Line [E] divides into two relations. The first relation consists of an application of the Mean-Value Theorem. The subprocedure *PROCtheorem* proves the correctness of the line by checking whether the premises of the mentioned theorem are fulfilled. *PROCtheorem* uses an internally provided version of the theorem. The second relation is an immediate consequence of the premise [p3] and checked by *PROCfm*.

Line [F] is founded by the statements of the lines [D] and [E]. The subprocedure *PROCcontradiction* uses *PROCfm* to check the contradiction.

Line [G] states that the proof is complete. In the case of an indirect proof one expects that a contradiction occurs and that one part of the contradiction is an inference of the negated conclusion of the theorem and the other part is a valid statement which was inferred. *PROCqed* processes the proof type of the line [A] and uses the preceding 'ASSUME' and 'CONTRADICTION' statements to verify that the proof is complete.

Error handling. In a *positive* case, a user proof can be recognized as correct and complete, that means that the occurring statements can be inferred using the corresponding foundations and that the sequence of statements actually proves the conclusion of the theorem. In a *negative* case, several types of light or severe errors may occur. From the perspective of a monitoring system which checks the various proof lines there may happen three cases in connection with each proof line:
(i) *The correct case*: The monitoring program can recognize that a statement can be inferred by using the given foundations. That positive case includes the possibility that a minor error occurred which can be clarified by a dialogue between the system and the user. The list of minor errors includes syntactical errors (e.g. regarding the language or any mathematical formula) or a lacking foundation which can be completed by the system. The completion may be possible e.g. in the case that the foundation of an obvious formula manipulation operation is missing or a reference to a preceding proof line is missing.

(ii) *The error case*: The monitoring program detects e.g. a logical error, an incorrect formula manipulation transformation, an unallowed application of a theorem, a premature 'QED' statement or no 'QED' statement. In that case the system can supply a hint to the user and the user gets the opportunity to correct the error.

The feedback in the case of multiple errors in a single statement depends on the way in which the errors are interconnected. Generally, the error possibilities are multifarious. Some multiple errors can be handled one after the other, e.g. when there are two errors in a formula. The hint that the formula is not correct may make the user rectify one error, so that only one is left.

Let us consider another example: A user enters the wrong name of the theorem which he applies and the application of the theorem is also wrong. The system would try to apply the mentioned theorem and two outcomes are possible: (a) The theorem cannot be applied or (b) the theorem can be applied. In the case of (a), a hint that the theorem is not applicable could help the user to recognize that he entered a wrong theorem name. In the case of (b), the system would state the conclusion of the theorem application. The user might then also recognize that the theorem name is wrong. In those cases the double error is reduced to one error.

(iii) *The unclear case*: The monitoring program cannot decide the correctness of a proof line. Various reasons may be responsible for that. One reason is that an important foundation is missing, e.g. a reference to the theorem which was used , so that the monitoring program cannot infer the user statement. Other reasons refer to the performance of the mentioned subprocedures: They may not be able to verify a correct statement or falsify a wrong statements in certain situations. Such a case suggests to expand the monitoring program.

5 Applications and Extensions and Pragmatics

The above described approach may be utilized for different purposes by different groups in educational institutions. Students have the opportunity to occupy themselves with mathematical proofs and do exercises which may be immediately checked for correctness and completeness.

On the other hand virtual or face-to-face universities may employ such methods in automatic on-line test systems. Proofs delivered by students could be automatically checked and scored. While students construct a proof the system might give hints in the case that foundations are missing, that there are syntactical errors, that the sequence of inferences is not complete, that a statement is just wrong, or that the student is lacking an idea how to prove the theorem. Dependent upon the amount of hints or help provided the software system might decrease the score gained.

The language as it was described above does not contain a set of symbols which are frequently used in theorems and proofs, as e.g the notation for limits, sequences, sums, integrals, or the faculty function. To integrate them one may use the notations of MathML [9]. A closer look at the proofs which are found in the text books of calculus suggests that a large set of the proofs can be worded using the above outlined language when one assumes that the usual mathematical symbols are available and some more extensions are done.

The described approach of verifying proofs demands an internal knowledge base of the concepts and theorems of calculus when proof statements are founded by concept definitions or theorem applications. Such a collection will sensibly use XML as a representation language (see e.g. [6]). See an XML representation of a theorem and of a proof on the website [7]. By utilizing that knowledge base an extensive learning environment which deals with mathematical proofs may be developed. Some aspects related to getting support with finding and constructing proofs are: One may retrieve theorems having the premises which may be used with the proof. One may retrieve a list of proof ideas of the domain and discover the one which may be useful in the current context. The roughly outlined approach to a learning environment stresses the personal proof finding and proof construction activity. A different approach to a learning environment in the field of mathematical proving relies on a general, interactive theorem prover [4].

It is obvious that one has to get used to entering a proof in the restricted natural language. An adequate interface may help to reduce the cognitive overload. Another option is to further develop the language, so that the proofs may be entered in a less restricted way and look more like textbook proofs. Such proofs might then be transformed into the restricted natural language. It is clear that the students would use such a verifying system only when the advantages outweigh the disadvantages. Some advantages are the confirmation of correctness and completeness or the detection of errors and the option of getting help.

6 Conclusions

A restricted natural language to formulate mathematical proofs in the domain of calculus was presented. It was demonstrated how mathematical proofs worded in that language can be transformed into an internal representation and checked for correctness and completeness. Some educational applications were mentioned. The extension to a learning environment was roughly outlined.

Our current prototype of verifying proofs includes an interface to enter natural language proofs, some procedures of theorem proving and an own formula manipulation system. The prototype will be further developed with respect to the methods and the knowledge bases.

References

[1] Bibel, W., "Automated Theorem Proving", Vieweg, Braunschweig, Germany, (1987).

[2] Bledsoe, W.W., Boyer, R.S., Henneman, W.H., "Computer proofs of limit theorems", Artificial Intelligence 3, pp. 27-60, (1972).

[3] Bledsoe, W.W., "Non-resolution Theorem proving", Artificial Intelligence 9, pp. 1-35, (1977).

[4] Buchberger, B., Jebelean, T., Vasaru, D., "Theorema: A System for Formal Scientific Training in Natural Language Presentation", Proceedings of the Tenth World Conference on Educational Multimedia and Hypermedia (ED-MEDIA/ ED-TELECOM 98), Freiburg, Germany, June 20-25, pp. 174-179, (1998).

[5] Chang, C.-L., Lee, R.C., "Symbolic Logic and Mechanical Theorem Proving", Academic Press, NY, (1973).

[6] Goldfarb, C.F., Prescod, P., "The XML Handbook", Prentice Hall PTR, Upper Saddle River,NJ, USA, (1998).

[7] XML representation of a theorem and of a proof, http://www.cs.uni-bonn.de/~peter/ICCE2000example.html

[8] Smith, K.T., "Primer of Modern Analysis", Springer Verlag, New York, (1983).

[9] Mathematical Markup Language (MathML) 1.01 Specification, http://www.w3.org/TR/REC-MathML.

Multimedia Intelligent Tutoring System for Context-Free Grammar

Rhodora L. Reyes, Carlo Paolo T. Galvey, Marie Christine D. Gocolay, Eden M. Ordona and Conrado del Rosario Ruiz
Software Technology Department, College of Computer Studies
De La Sane University, Manila
2401Taft Ave., Manila
Tel: (632) 5244402, (632) 5364278
Email: ccsrlr@dlsu.edu.ph

CFG-MINTS is a multimedia intelligent tutoring system that teaches context-free grammar. The tutor model of his ITS is composed of a set of teaching strategies and an algorithm that determines which teaching action to be deployed given the goals of the system and the current state of the student model. The student model uses the Constraint-Based Modeling (CBM) approach in diagnosing the learner. CBM reduces the complexity of student modeling by focusing on the difference of the student' s solution to the ideal solution only and the analysis is reduced to pattern matching. The assumption here is that there can be no correct solution of a problem that traverses a problem state, which violates the fundamental ideas, or concepts of the domain. The system also includes features for simulating the created context-free grammar to aid in teaching.

*The paper was not available by the date of printing.

Agents in a WWW System for Academic English Teaching

Alexandra Cristea and Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621; Fax: +81-424-89-6070
E-mail:alex@ai.is.uec.ac.jp

This paper describes our research on building a free, evolutionary, Internet-based, agent-based, long-distance teaching environment for academic English. Here we will describe some of the design aspects of the system prototype, focusing especially on the adaptive features and the agents of the system.

Keywords: **Distance Education, CALL, Agent Technology**

1 Introduction

As distances constantly grow smaller and the Internet links more and more remote parts of the world, English gradually becomes the lingua franca for information exchange. In the academic field, in research and development, where international cooperation is a must, English is used frequently. Academic English is International English. Although accents are more or less variable, the spoken, but mostly, the written academic language has still its rules and etiquette. Academics usually know some English and have a more or less wide English vocabulary. However, especially in Japan, but in other non-English speaking countries as well, there exists the phenomenon that, although a person can read academic papers in English, when it comes to writing a paper by oneself, or to make an academic presentation in English, serious problems appear. Therefore, we embed these necessary rules and etiquette in our teaching environment. The main aim of our system is to help academics exchange meaningful information with their peers, through a variety of information exchange ways: academic homepages, academic papers, academic presentations, etc. As far as we know, this type of English teaching system is new. Some English teaching environments on the Web appeared, but, as in [1] or [11], they have two main defects: they are not free, and/or they are not automatic, but based on real human teachers at the end of the line. Good on-line dictionaries [12], [8] and several collections of English on-line books [2] exist, but those can only act as auxiliary helpers during the English learning process. Our aim is to have a system capable to function autonomously, without human interference, as a virtual, long-distance classroom, embedding the necessary tutoring functions within a set of collaborating agents that will serve the student. The course is called 'MyEnglishTeacher', because of its evolutionary nature, of adapting over time to the needs and preferences of individual users. These needs can be expressed explicitly, or can be implicitly deduced by the system, represented by its agents. We are currently in the process of adding more AI-based intelligent adaptation capabilities. Users can find in our virtual classroom situational examples of academic life, presented as Multimedia, with Audio and/or Video presentations, Text explanations and pointers to the main patterns introduced with each lesson, exercises to test the user's understanding, moreover, adaptive correction, explanation and guidance of the user's mistakes. The general guidelines for this system were proposed by our course design researcher in [3] and elaborated by us in [6].

2 Background

Virtual environments in education and distance-learning systems are the recent trends in education worldwide. This trend is determined by the current spread of the Internet, as well as by a real demand for better, easy-to-access, and cheaper educational facilities. Therefore, universities everywhere respond to the academic demand for technological and pedagogical support in course preparation, by developing specialized software environments [5]. As bandwidths grow, the traditional text environments gradually switch to multimedia and Video-on-Demand (VOD) systems ([17]). The problems in the current language

education systems, as well as the motivation of our research, as pointed out by our language specialist team member and [15], can be resumed as follows: the lack of learning activities for checking learners' constructive understanding (requiring the learner not only to memorize, but also to summarize, generate, differentiate, or predict); the lack of a variety of problem-solving tasks to motivate students to think about their reading; the learning process does not enable learners to become active participants; in the current Computer Aided Language Learning (CALL) systems, learners cannot key-in the target language's sentences freely; lack of explanatory feedback (telling the user why); lack of exercises related to the learner's individual characteristics; lack of considerations about the effectiveness of different physical attributes of the presentations, on the students' learning; lack of analysis of the interaction between learner and learning environment, with special focus on assimilation and accommodation. These problems could not be solved by traditional systems, mostly due to their lack of adaptability, or in other words, intelligence. In [19], it is stated: "there is the need to endow these systems with the ability to adapt and learn, that is, to self-improve their future performance". The objective of this research is to help learners achieve academic reading and writing ability. The course is intended for students whose starting English level is intermediate and upper-intermediate, who have some vocabulary of English, but not much practice in using it. The tutoring strategy used is to give the reader insight into his or her implicit or explicit learning strategies. The methodology applied is the communicative teaching approach, allowing communication and interaction between student and tutoring system, via agents. The interactive reading strategies applied and yet to apply include bottom-up theory, top-down theory, and schemata theory. The topics and stories used are mainly passages from textbooks, journals, reference works, conference proceedings, and academic papers, in other words, real-life academic products.

3 System features and modules

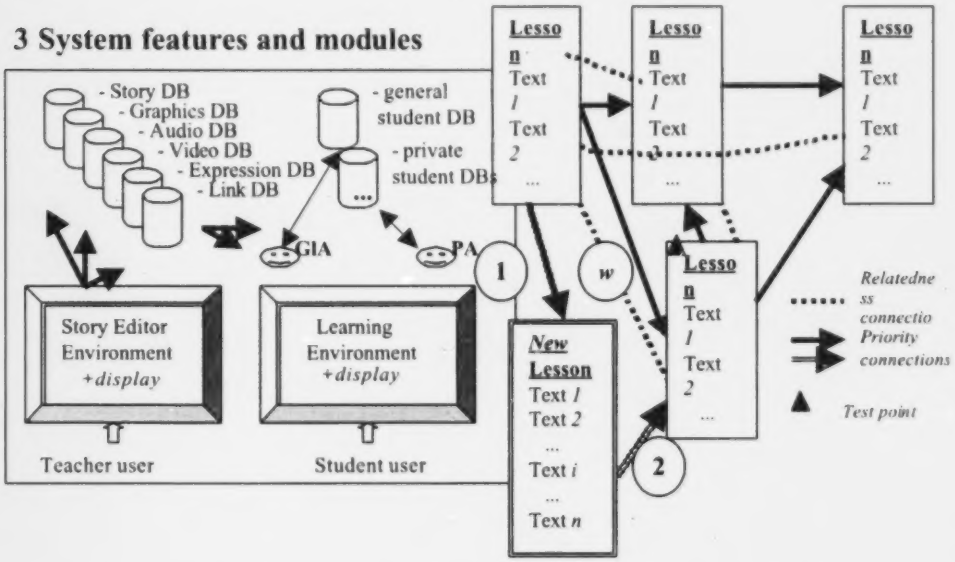


Fig. 1: The system modules and their interaction

Fig. 2: The subject link database

The system offers two interfaces, one for the teacher/tutor user, for course-authoring purposes, and the other one for the student user, who is supposed to learn. The information exchange from tutor to system contains input of lessons, texts, links between them, etc., but also asking for help in editing. The data from the tutor is stored in six different structured databases, including a library of expressions that appear in the text, a VOD database, a background image database, an audio database of listening examples, a full text database and a link database. The information exchange with the student is more complex. It contains usage of the presented materials, implicit or explicit advice, the student's advice requests, queries, searches, gathering of data on the student by the two agents, the Global Agent (GIA) and the Personal Agent (PA). Each of these agents has its own database on the student(s). The GIA stores general features on students, and the PA stores the private features of each student. User modeling follows many patterns, and has many applications. [7] proposes a fuzzy-based, stereotype collecting user model for hypermedia navigation. [18] elaborates on the Human Plausible Theory. ([4]) provides intelligent help for determining the cause of errors in software usage.

[14] has shown how prior belief (belief bias) can influence the correctness of judgment of the human users). Other authors, like [10] have studied the relation between achievement goals, study strategies and exam performance. A realistic user model has to take into consideration the influences a system can achieve on the user, in order to allow an easy interpretation of the current state, as well as an easy and clear implementation of the user model.

4 The Authoring System Module (Story Editor)

Our most important goal is to design a meaningful, evolutionary feedback for the user. In order to build such a

system, an authoring tool is necessary for flexibility purposes: our colleagues researching the optimal material for academic English teaching should be able to add or delete freely the available resources. In a way, they are also clients/users, and should be restricted to build a courseware, which conforms to the capabilities of the system. In the following, these restrictions and their purposes are explained. These restrictions are necessary instruments for the two system agents to work with, as will be shown later in this paper.

Texts: Each video/audio recording has to have a corresponding TEXT (of dialog, etc.). For each text, it is analyzed if video is necessary, or if audio suffices, as audio requires less memory space and allows a more compact storage and a speedy retrieval. Each TEXT also has (beside of main text, etc.), the following attributes: a short title, keywords, explanation, patterns to learn, conclusion, and finally, exercises. Titles and keywords are naturally used for search and retrieval, but the explanation and conclusion files can be also used for the same purpose, as will be explained later on.

Lessons: One or more TEXTs (with video or not) make up a LESSON. Each LESSON also has (beside of texts, etc.) the following attributes: title, keywords, explanation, conclusion, combined exercises (generated automatically or not). Next, a text or a lesson will be referred as 'SUBJECT'.

Priority and Relatedness Connections: When introducing one or more subjects, the teacher has to specify the Priority Connections, i.e., to show the required learning order, with a directed graph (arrows). When there is no order, subjects will have the same priority, and build a set. The teacher (courseware author) should also add connections between related SUBJECTS, with indirect links. This means, the teacher has to add Relatedness Connections between subjects, for which no specific learning order is required, but which are related. These relations are useful, e.g., during tests: if one of the subjects is considered known, the other one should be also tested. The main differences between the priority connections and the relatedness connections is that the first ones are directional, weightless connections, whereas the latter are non-directional, weighted connections. After these priorities and links are set, the system will then automatically add more links via keyword matching, from explicit keyword files and keyword search within subjects. Priorities among the texts of a lesson are set implicitly according to the order of the texts, but can be modified, if necessary. The teacher / multimedia courseware author can decide if it is more meaningful to connect individual texts, or entire lessons, for each lesson. The way a new lesson is introduced, by asking the teacher to set at least the previous and the following lesson in the lesson priority flow, is shown in figure 2 (steps 1,2). As can be noticed from figure 2, priority connections, with no respective relatedness connection, can exist. This can happen when, e.g., common course design knowledge dictates that respective priority, but the learning contents of the lessons are quite different. These kinds of priorities are optimal student learning strategy related connections, not similar contents connections. These priorities help the system to place the current subject in the global subject map. Final priorities will be set by the system according to findings (teacher's input, keyword matching). This final result can be shown to the teacher or not, depending on the options under which the system is running. We are currently testing if it is wise to allow the teacher to have add/modify/delete rights. The final graph is used for the student, and it can be shown to the student upon request, serving as a map guide.

Numbering: SUBJECTS are numbered automatically in the order of their creation. Teachers are prohibited to use numbering. This is because otherwise, every time new material is brought, the numbering should be changed according to the new order of priorities. TEXTs are automatically numbered inside a lesson, and are referred from outside with two numbers: the LESSON number and the text number.

Test Points: The teacher should mark TEST POINTS (figure 2), at which it is necessary to pass a test in order to proceed (these tests can be at any SUBJECT level).

5 Student models and agents

The system gradually builds two evolutionary student models: a global student model (GS) and an individual student model (IS), managed by two intelligent agents: the personal agent (PA) and the global agent (GlA).

The reason for doing so is that some features, which are common to all students, can be captured in the GS. However, many studies have shown [17] that personalized environments and especially, personalized tutors, have a better chance of transferring the knowledge information from tutor to student. This is true even in the more general sense of a tutor and student, where the tutor can be man or machine, and the student likewise. In this work, we mean by agent a "computer system situated in some environment", "capable of autonomous action", "in the sense that the system should be able to act without the direct intervention of humans", "and should have control over its own actions and internal state" [13]. These agents' intelligence is expressed by the fact that each agent "is capable of flexible autonomous action in order to meet its design objectives", and that it is "responsive" (it perceives its environment), "proactive" (opportunistic, goal-directed), "social" (able to interact) [13], and of an "anticipatory" nature (having a model of itself and the environment, and the capability to pre-adapt itself according to these models) [9]. Next, the raw data stored for the two student models, the GS and IS, is presented.

The GS: The GS contains the global student features: the common mistakes; favorite pages, lessons, texts, videos, audios, grading of tests' difficulty (according to how many students do each test well or not); search patterns introduced, subjects accessed afterwards: if many IS use the same order, than they are recorded in the GS.

The IS: The IS contains the personal student features: the last page accessed; grades for all tests taken, mistakes and their frequency; if the student takes the test again and succeeds, his/her last grade is deleted, but his/her previous mistakes are collected for future tests; the order of access of texts inside each lesson; order of access of lessons (this can be guide to other students: "when another student was in your situation, he/she chose..."); frequency of accessing texts/ lessons/ videos/ audios, etc. - for guidance and current state check; search patterns introduced, subjects accessed afterwards (to link patterns with new subjects that the system didn't link before).

The PA: The role of the personal agent is to manage the information gathered on the user, and to extract from this information useful user guidance material. Each step taken by the user inside the environment is stored, and compared with both what was proposed to the user, as well as with what the user was expected to do (from the PA's point of view). The differences between previous expectation and current state are exploited, in order to be used for new guidance generation. Beside of analyzing the own user and extracting knowledge from the data on him/her, the PA is able to request information from the GIA, about, for instance, what other users chose to do in a similar situation to the current one of the PA's own user. Furthermore, the PA can contact other PA's with similar profiles (after a matchmaking process), and obtain similar information as from the GIA, only with more specificity. The PA can decide to turn to another PA if the information from the GIA is insufficient for a decision about the current support method. The PA decides, every time a user enters the system, what material should be studied during that particular session, and generates a corresponding list. Therefore, the course index is dynamic, not static. To this material, the PA will add or subtract, according to the interaction with the user during the session. According to [16], the PA is therefore an interface agent ("a computer program to provide assistance to a user dealing with a particular computer application" – in this case, a learning environment). However, the PA's job description is a little wider than this, as can be seen also in the following.

The GIA: The global agent averages information from several users, to obtain a general student model. The deductions of the global agent are bound to be non-specific. The GIA is necessary, because otherwise, the system will not profit from the fact that different users interacted with the system, and each new interaction can smoothen the path for following users. The GIA is to be referred before the PA starts looking for information from other PAs, process that can be more time-consuming. Therefore, the role of the GIA is to offer to the PAs condensed information, in an easily accessible, swiftly loadable form. From this description, it is clear that the GIA is subordinate to the PA (from the student user's point of view). The GIA cannot directly contact the student user – unless the PA explicitly requests it. If the GIA considers that its intervention is required, it still has to ask for permission from the PA. In this way, the generation of confusing advice is avoided.

From the described interactions between agents and databases, and between the agents themselves, it is clear that the agents of the system work in two ways. The first way is based on the embedded rule/knowledge systems, which try to foresee, prevent and solve conflicting situations. The second way is as evolutionary, learning objects, which can adaptively change their representation of the subject space, by creating and deleting links and changing weights. A next step in the system's agents design will be focused on adaptive problem, quiz and test generation. In short, this design is made necessary by the fact that a student, after failing to pass a test, has to be presented, after some more learning is done, with a new test, of similar difficulty and contents. As it is difficult for the teachers to generate as many tests as would be necessary for such repeated situations, this task is to be passed to the system's agents. A very important task of each of the agents is also to keep the consistency of the subject link database. The agents inform the teacher(s) if some subjects form loops (determined by the priority connections set by the teacher(s)), if some subjects become inaccessible; if a teacher is not available, they make corrections by themselves, and decide from the student (s) feedback about the appropriateness of those changes.

6 Conclusions

We have proposed in this paper an Evolutionary, Web-based, Academic English Teaching Environment, called "MyEnglishTeacher". Moreover, we have described the rationale, the design and implementation and the modules of our system: an authoring environment for the teacher user(s), which is generating the lessons, and a learning environment for the student user(s). We have further on presented each of these modules in more details. The learning environment is based on two intelligent agents, interacting with each other and the student user, in order to guide the student through a new course for academic English, which is under development in our laboratory. We have also explained in which sense our agents evolve and present intelligence. Our agents build and modify student models with the help of a double graph: a non-weighted, directional priority graph, and a weighted, non-directional, relatedness graph. In addition, we have explained how, from the authoring system courseware design requirements, we enforce the generation of structured content databases, to serve as a basis to the rule/knowledge bases, which will be used and added to by the two agents. We believe that with our system we are addressing more than one current need: the need of an English tutor for academics, which should also be easily accessible – i.e., on-line –, free, adaptive and user-friendly.

References

[1] Aspera PrivaTeacher, http://www.privateacher.com/

[2] Bartleby.com, Great books on-line, http://www.bartleby.com/

[3] Cristea et al,. (1999) "The Theoretical Framework for CALL Courseware Development", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 723-726.

[4] Collins, A. and Michalski, R. (1989) "The logic of plausible reasoning: A core theory", Cognitive Science, Vol. 13, 1-49.

[5] Collis, B. (1999) "Design, Development and Implementation of a WWW-Based Course-Support System", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 11-18.

[6] Cristea et al, (2000) "An Intelligent language teaching tool for the Web", Proc. of ISSEI 2000, Bergen, Norway.

[7] Di Lascio, L., Fischetti, E. and Gisolfi, A. (1999) "A Fuzzy-Based Approach to Stereotype Selection in Hypermedia", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 285-320.

[8] Dictionary, http://www.dictionary.com/

[9] Ekdahl, B., Astor, E. and Davidsson, P. (1995) "Towards Anticipatory Agents", Woolridge, M., Jennings, N.R. (Eds.), Theories, Architectures, and Languages, Lecture Notes in Artificial Intelligence, Springer Verlag, 191-202.

[10] Elliot, A.J., McGregor, H.A. and Gable, S. (1999) "Achievement Goals, Study Strategies, and Exam Performance: A Mediator Analysis", Journal of Educational Psychology, Vol. 91, No.3, 549-563.

[11] EnglishLearner, http://www.englishlearner.com

[12] Jeffrey's Japanese-English ó English-Japanese on-line dictionary. http://enterprise.dsi.crc.ca/cgi-bin/j-e/jis/dict

[13] Jennings, N.R. and Wooldridge, M. (1998) "Applications of Intelligent Agents", Agent Technology Foundations, Applications, and Markets, Springer-Verlag.

[14] Sa, W.C., West, R.F. and Stanovich, K.E. (1999) "The Domain Specificity and Generality of Belief Bias; Searching for a Generalizable Critical Thinking Skill", Journal of Educational Psychology, Vol. 91, No.3, 497-510.

[15] Levy, M. (1997) "Computer-Assisted Language Learning", Oxford Claredon Press.

[16] Maes, P. et al. (1993) "Learning Interface Agents", Proc. of the 11th Nat. Conf. AAAI, MIT/AAAI Press.

[17] Tomek, I. (1999) "Virtual Environments in Education", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 3-10.

[18] Virvou, M., Du Boulay, B. (1999) "Human Plausible Reasoning for Intelligent Help", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 321-275.

[19] Weiss, G. And Sen, S. (Eds.) (1996) "Adaptation and Learning in Multi-Agent Systems", Springer Verlag, Lecture Notes in Artificial Intelligence, Vol. 1042.

Navigation Script for the World Wide Web

Sachio Hirokawa*, Kengo Nishino and Daisuke Nagano*****
** Computing and Communications Center, Kyushu University,*
**E-mail: hirokawa@cc.kyushu-u.ac.jp*
*** *** Graduate School of Information Science and Electrical Engineering, Kyushu University*
***E-mail: Kengo.Nishino@ma3.seikyou.ne.jp*
****E-mail: nagano@matu.cc.kyushu-u.ac.jp*

In the World Wide Web, there is rich material for education. We propose a language to navigate students through the educational material on WWW. Navigation script makers can describe a tour with sequential, parallel and selective controls. It supports multiple Threads where videc and audio accompany a browsing window. The language is described with XML and implemented in Java. So, the system can be used as an applet and as an application.

Keywords: **Hypermedia navigation ; Web graph ; XML ; JAVA**

1 Introduction

In the World Wide Web, there is rich material for education. For example, many university teachers give the contents of their lectures as their homepages. This paper describes a system which utilizes internet resources as educational material and makes them into an organized tour. The tour is described in a script language and an interpreter program navigates students through the material on WWW. Students are navigated automatically and interactively while they browse html-files and listen to and watch continuous multimedia.

We need to collect necessary pages from web resources containing a lot of garbage in order to make lists of URLs for our educational purpose. It is important to have students understand the relation between the collected pages and grasp the whole view of the field. When they do not understand the relation, or when they forget how they arrived the page, they feel that they got ``lost in webspace". There is a proposal of using web graphs as imaginary map of WWW[3]. A web graph is a directed graph whose nodes are URLs and whose edges are links between URLs. The web graph is more intuitive than just a list of URLs. But a web graph is nothing but a static representation of WWW. There is no mechanism how to lead students with material on the graph. There is no dynamic process to navigate them. We propose a script language that describes the navigation of WWW.

Maps are useful for navigation of real world and for navigation of WWW. For example, the page of Mapion http://mapion.co.jp/ shows geographic maps of towns. Besides, ``car navigation systems" based on GPS are becoming popular. RWML[5] and NVML[6] are proposal to combine the geographic map and the information on WWW. NVML describes the driving course, distance, time and supplies messages and images for specified points. When the car passes the point, a message and a image will appear according to a signal from GPS. The main concern of these researches is in geographic maps and navigation in real world. The maps we consider are imaginary maps of internet resources. Our goal is to design a language to describe a tour of WWW and to implement an interpreter of the language.

Ariadne[4] is a system of WWW navigation. It has a browser window and a separate window of tour. A user views the map of the tour and can proceed forward, backward and can choose if there are branches on the tour. But user needs to control every step of navigation. Our system supports both interactive and automated navigation. Another feature of our system which lacks in Ariadne is the parallel navigation. In our system, while a user is watching a browser window, another navigation thread can play audio data.

WebOFDAV[1] is a visualization system of web graph. When a user is traversing a series of URLs, the system draws the local graph of visited pages. The graph changes dynamically following the user. WebOFDAV is useful to tell where we are on WWW and powerful to get rid of the problem of lost in webspace. But the graph is used only for an aid for browsing and no navigation route is provided.

The rest of paper is organized as follows. The section 2 analyses the basic feature of navigation of WWW. The section 3 describes the navigation script using XML and explains the visualization of the scripts. The section 4 introduces a virtual machine with two stacks, which enables forward and backward navigation. The section 5 summarizes the paper.

2 Navigation Script

The most important feature of the navigation system is to guide the user around web pages in specified order. Therefore, we adapt sequentiality into navigation language. And to make the contents of html-files easier to understand, we need to combine audio, video, and images together with the usual browsing window. We introduce parallelism. To increase the variation of the navigation depending on each visitor, we add selection mechanism in the language. We design the language as a structured programming language with sequential, parallel and selective controls. The basic navigation units are multimedia data specified as URLs.

We chose XML as the description language of the navigation for simplicity and extendability. As implementation language we chose Java. We use ``XML Parser for Java"[2] for XML parser,and ``JMF"[7] for multimedia data. We describe the language as the following DTD (Document Type Definition).

```
<!ELEMENT statement (simple|sequential|parallel|select)>
<!ELEMENT simple (message)>
<!ATTLIST simple kind CDATA #REQUIRED
   target_name CDATA #REQUIRED
   play_time CDATA #REQUIRED
   delay_time CDATA #REQUIRED>
<!ELEMENT message (#PCDATA)>
<!ELEMENT sequential (simple|sequential|parallel|select)*>
<!ELEMENT parallel (simple|sequential|parallel|select)*>
<!ELEMENT select (selector)+>
<!ELEMENT selector (simple|sequential|parallel|select)>
<!ATTLIST selector selectname CDATA #REQUIRED>
```

Each tag and parameters have the following meaning.

- <statement>: This tag represents the root of navigation tour. It may contain subtours as children. There are four kinds of tours,<simple>,<sequential>,<parallel> and <select>.
- <simple>: This is the basic unit of the navigation. It contains a few lines of messages to describe the contents of the web page. It has the attributes of kind, target name, play time and delay time. Target name specifies the URL of the data. The kind describes the kind of multimedia data. Play time is the duration time and delay time is the time to wait before play.
- <sequential>: It may contain subtours of the kind <simple>, <sequential >, <parallel> and <select>. Subtours are followed consecutively.
- <parallel>: It may contain subtours of the kind <simple>, <sequential>, <parallel> and <select>. Subtours are activated in parallel.
- <select>: This tag causes a pause of the system. User can choose the navigation selectively from the given subtours. Those subtours are provided as children with the tag <selector>.
- <selector>: It may contain a subtour of the kind <simple>, <sequential>, <parallel> and <select>. It has the selectname as an attribute, which is used in the select menu.

3 Navigation Window, Control Panel and Browsing Window

Fig 1 is a screenshot of the system, which has a browser window, a quicktime movie screen, the controller screen and the window of navigation script.

We chose the representation with nested boxes for the visualization of navigation script instead conventional DOM-tree of XML nodes for several reasons. The most important feature of the navigation is the flow of time. To visualize this, we draw the subtours of a sequential tour from left to right. In Fig 1, time goes horizontally from left to right. Parallel tours and visualization of selection are placed vertically. The difference is that each subtour of the selection has its name, specified with its selectname, and the order in the choice. For example, if a selection has three choices, the second subtour is displayed as "2/3 selectname".

Visualization of navigation script is not only for static view. It has a control panel and user can go forward and backward along the navigation. When a node is displayed on the browser window, the node in the navigation window is highlighted. So, the user has always global view of the navigation.

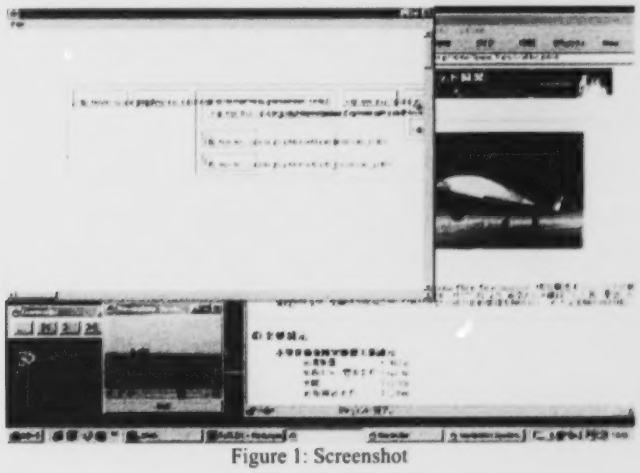


Figure 1: Screenshot

4 Interpreter of Navigation Script

Navigation is performed according to the kind of statement. Parallel statement opens a new browser window and a different thread performs the navigation in parallel.

The interpreter has two modes, the fully automatic mode and the interactive mode. Basically, the interpreter displays the specified html-files on the browser window. It displays the html-file on the screen for "play time" and changes to the next screen. When the user wants to see in detail, he can make a pause. He can go backward as well. The controller interacts with the user. The functions of the controller are "pause", "play", "forward", "backward", "rewind" and "stop". The "play" and "pause" toggles the mode. The "forward" and "backward" are for interactive mode. The browser screen moves one step in the sequential statement. This control is different to the controllers of multimedia players for the continuous media.

To realize forward/backward control in the navigation, we use two stacks of statements in the interpreter. The first stack "do"contains the list of statements to follow. The second stack "done" contains the list of statements already performed. The interpreter is realized by a transition of states depending on the top of the two stacks.

4.1 Forward Transition

Due to the limit of space, we only explain the forward transition concerning to parallel statement. If a parallel statement contains substatements, the interpreter creates n-1 threads which begin execution with "done" stack empty and whose "do" stack contains the substatements. For example, a parallel statement "<parallel>a b c</parallel>" creates two new threads(Fig 2).

BEST COPY AVAILABLE

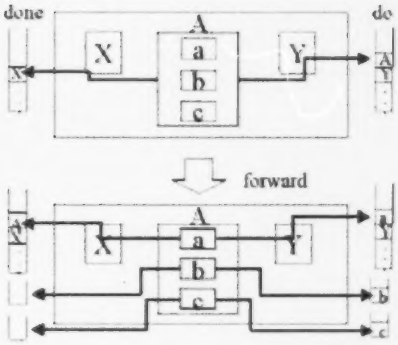


Figure 2: Forward Transition for Parallel Statement

4.2 Backward Transition

In the backward transition, the interpreter pops the statement at the top of ``done" stack and pushes it on "do" stack. If it is a sequential statement, then all the substatements are poped out of the "do" stack. A situation, where the "done" stack is empty, occurs only after a forward transition of a parallel statement. To go backward from such a situation, we need to delete such threads activated by the parallel statement.

5 Conclusions

We proposed a language for the navigation of WWW and described its implementation. The material of a navigation tour is web pages and multimedia data on WWW. The navigation script is defined as DTD of XML. Anyone can create a dynamic navigation from a static list of URLs. The language supports multimedia data and provides sequential, parallel and selective constructs of the tour.

References

[1] M. L. Huang, P. Eades, R. F. Cohen, ``WebOFDAV -navigating and visualizing the Web on-line with animated context swapping", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 638-642, (1998).

[2] IBM, ``XML Parser for Java", http://www.alphaWorks.ibm.com/tech/xml4j/(accessed on August 9,2000).

[3] D. Ikeda, T. Taguchi, S. Hirokawa, ``Developing a Knowledge Network of URLs", Proceedings of Discovery Science '99', Springer Lecture Notes in Artificial Intelligence Vol. 1721, 328-329, (1999).

[4] J. John, A.T. Jensen, K. Geronbak, ``Ariadne:a Java-based guided tour sys-tem for the World Wide Web", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 131-139, (1998).

[5] RWML Working Group, ``Road Web Markup Language (RWML) Draft Ver.0.71a (in Japanese)", http://www2.ceri.go.jp/its-win/RWML/RWML-071.html (accessed on August 9,2000), (1999).

[6] M. Sekiguchi, K. Takayama, H. Naito, Y. Maeda, H. Horai, M. Toriumi, "NaVigation Markup Language (NVML)", submission to the World WideWeb Consortium, http://www.w3.org/TR/NVML(accessed on August 9,2000), (1999).

[7] Sun Microsystems, ``Java Media Framework", http://java.sun.com/products/java-media/jmf/2.0/index.html (accessed on August 9,2000).

Organization of the introductory and motivational stage of activity in a computer tutoring system

Gennadiy Atanov and Vladimir Laktiushin
Donetsk Institute of Social Education; DISO, Donetsk, 83000, Ukraine;
E-mail: atanov@dongu.donetsk.ua

1 The activity approach in education

From the point of view of modern didactics, the final aim of instruction is not gaining knowledge but forming the way of acting being realized via skills [3]. It may be only done in the process of activity, namely learning activity. In this sense, any instructional process represents guidance, operative management of learning activity. It is management that is mechanism of teaching but not passing knowledge. Learning activity is a product of teaching because it is the aim of teaching. Knowledge is necessary, so far as the way of acting is worked out by means of operating with knowledge. On the other hand, knowledge is formed only in the process of activity []. Thus content of teaching includes subject to mastering and knowledge on which based this activity. From the point of view of organization, activity has three stages: 1) of introductory and motivation, 2) of operation and cognition, 3) of control and estimation.

An action is a unit of activity. The way of acting is a system of operations that provides solving of problems of a definite kind. The way of acting has three functional parts: (1) orientating one that provides preparation the student to activity; (2) executive one providing transformation of the objects of activity; (3) control one that provides check-up of rightness solving the problems and comparison the factual products of activity with desired ones, that is, the aim of activity [2].

Many authors of computer technologies attribute them to the ones based on activity (learning by doing) only because of work specificity with a computer but not because they realize principles of the theory of activity. In accordance with it, projecting a computer tutoring system means, first of all, projecting learning activity, not knowledge. Knowledge is projected after actions. Only on determining actions, it is possible to pick out knowledge providing formation of these actions.

Development of activity my be schematically represented in the following way: *need – motive – aim – subaims – problems – subproblems – actions – operations – product.* The introductory and motivation stage of activity, especially for learning activity, is the most important one because it is the initial stage of activity. It is called to settle questions of "lead-in" of students in activity, their adaptation to future activity, that is, questions of orienting and motivation.

In the orientating part of the way of acting, they pick out two components (Mashbits, 1988). The first one – general orienting – provides picking out those properties and qualities of the objects of activity that are essential for their transformation. The second one – orienting for the executive part – provides working out a plan of activity. Only the executive part of the way of acting providing immediate transformation of the objects is the direct product of the traditional teaching. There is the only way to do this – solving problems.

2 Organization of the introductory and motivational stage

The introductory and motivational stage plays an important psycnological and didactical role in teaching in general; while using a computer, its role increases repeatedly. Nevertheless, to meet a tutoring system in which due attention would spare to this stage is a very rare thing. We organized it in tutoring systems in physics [1]. The tasks of the introductory and motivational are realization and understanding by the students: 1) aims and problems of the system; 2) physical character of processes and phenomena, as well as principles of operation of the installations that are the subjects of the system's activity; (3) knowledge necessary to

reach the aim put the system. According to the theory of activity, it is operating with this knowledge that leads to forming first skills necessary for solving a particular problem and then the way of acting in aggregate.

The approach of problems that is realized in our systems is based on solving a separate problem whose complication increases that of problems being solved usually. This approach is more preferable from the point of view of activity. Firstly, it allows easily and effective organize learning activity and, secondly, it gains essentially in motivation as presupposes achievement of a practically significant aim. In many systems, this aim is even submitted in their titles, for example, "Hit the Target", "Rescue the Friends", "Render Harmless of the mine", "Determine the material". It is a very effective means to increase motivation, as the student becomes a subject of activity, the main acting person of the events expanded. Various methods of realization of this stage are used, for example, mimicking processes and phenomena, "assembling" installations from their separate parts, discussion their purposes and peculiarities of operating the installations, test tasks of the closed and open types, ones for accordance and ones for correct sequence.

Let us consider as an example systems "Internal Combustion Engine". The aim of it is determination of power and efficiency of an engine in accordance with its constructive parameters. As one can see, the title of this system does not promote increase of motivation because of the lack of the personal orientation. This is achieved by another method. A list of cars with demonstration of their outward appearance is offered to students. Students choose a car that they like and then carry out calculations for the engine of their own car.

Let us describe in what way a test task for accordance is realized in these systems. A "dumb" scheme of an installation without pointers of its component parts is shown on the screen. A list of its component part is placed next to it. Activity of students consists in the following. Separate elements of the scheme are pointed sequentially by chance, and students have to put for each element of the scheme corresponding one of the list. If the title of the pointed component part is determined correctly, another element is pointed, and so on. The determined parts acquire their numbers, and as the result, the "dumb" scheme is transformed into a "live" one. In such a way an orienting support of activity is created.

Further development of the introductory and motivation stage in the system above proceeds in the following way. The system demonstrates work of the engine during a whole cycle with replacement of the piston, opening and closing the exhaust and inlet valves, ignition of a air and gas mixture. Students may start such a demonstration several times independently. Now students see interaction of the component parts of the engine already well known to them, now they unit in their consciousness not simply mechanically but functionally reflecting physics of the processes occurring in the engine.

Subsequent deepening of orienting passes by discussion of what students have seen. It is very convenient to use the so-called active prompts with this purpose. Active prompt is built as a test task of the open type. It represents a phrase, in which a keyword is missed; this word has to be entered by students. If students do not know it, they may address to the system for help, and it will show this word on the screen. In order to keep the students' active position, the system offer the same active prompt repeatedly, and students must enter this already well known word themselves. Examples of active prompts are phrases: "The inlet valve is open when the piston goes down(wards)", "The spark springs up when the piston is at the upper extreme position" (the missed words are in italic). The main thing here consists in not completeness of these tasks but in importance of ascertaining these (and other) facts for forming the orienting base of the future activity.

The elements of the introductory and motivational stage are distributed throughout a system, their task is to prepare students to performing subsequent separate actions. If, for example, there is a necessity of using some formula, it is very convenient to remind it by a test task of the closed type. Students are offered several formulas, and they have to choose the necessary one. If students make mistakes, a short dialogue should be organized so that students could understand the nature of the mistakes. Then the task should be given again, the search of the answer becoming more sensitive. And the answer will be obtained without fail.

If the development of an action demands using exact wording (of laws, principles, theorems, definitions of concepts, and so on), it is expediently to employ a test task for the correct sequence. In the chosen wording, all the words are missed by chance (this does the system), and the task of students consists in that the words must be arranged correctly with the help of the mouse. It is a very creative and constructive work, it thrills, in the first place, because the sense appears little by little. Everyone can reach the sense even if he/she is not familiar with it at all.

References

1. Atanov, G.A., Kandrashin,G.V., Laktiushin,V.V. Computer Tutoring Systems for Science Education Based on the Activity Approach. New Media and Telematic Technologies for Education in Eastern European Countries. Eds. P.Kommers, A.Dovgiallo, V.Petrushin, P.Brusilovsky. Enshede: Tvente University Press. Pp. 75-79. (1997)
2. Gal' perin, P.Ya. Psychology of Thinking and Doctrine about Step by Step Forming Mental Actions. Moscow. (1966) (in Russian).
3. Mashbits,E. Psychological and Pedagogical Problems of Computating in Education. Moscow, Pedagogika (1988) (in Russian).

The Application of Uncertainty Reasoning for an Intelligent Tutoring System

Hown-Wen Chen*, Teran Wu and Dong-Yih Bau
Institute of Information Management, Da-Yeh University
112, Shan-Jeau Rd., Da-Tsuen, Chang-Hwa, Taiwan
Email :hwchen@aries.dyu.edu.tw

The activity of test and evaluation is an important part of Computer-Assisted Instruction systems. In most systems, 「absolutely learned」 and 「absolutely unfamiliar」are often used to represent the status of a student in learning a novice concept. However, for each target concept, there are usually more than one related sub-concepts with different degrees of importance. Thus, it is quite difficult to instruct each individual student effectively according to his learning status in those conventional systems. A hybrid technology of fuzzy theory and uncertainty reasoning are thus used in the research. The proposed intelligent tutoring system was designed to illustrate: 1.automatically tracking and analyzing the current learning status of a pupil, especially detecting the formation of learning barriers or misconceptions; 2. autonomously leading pupils to visit assisted learning path and thus proposing tutorials to make the learning of students more effectively. 3.linguistically explaining the implicit behavior of a pupil during the whole learning process. In addition, the mathematical course of teaching Pythagoream Theorem was used as the content of our test-bed. A simulation by hand and positive feedbacks from teachers of junior high schools illustrate the reasonableness and applicability of the proposed tutoring system.

Keywords: **Pythagoream Theorem, Fuzzy Logic, Uncertainty Reasoning, Intelligent Tutoring System**

1 Introduction

Researches about Intelligent Computer Aided Instruction (ICAI) have incrementally grown since 1970, for example, standard intelligent tutoring systems [1], or participants in virtual environments [2], or a virtual instructor in a training environment [3]. However, as known, the effectiveness of education would depend on the local culture. But, there are few intelligent tutoring systems focusing on Taiwanese students have been reported. CORAL [4] was designed as an interface system, without any artificial intelligence module of teachers' expertise, to provide a long-distance collative learning environment of virtual learning. As discussed in lots of tutoring systems, the most challenging issue is how to evaluate and diagnose the learning of students. Tests are a typical and popular method of evaluation. Taking the GRE as an example, people have taken the test through computers since 1992. The IBM co. and Arthur Anderson Co. have begun to work on the development of a computerized testing system. Such systems, which change the form of tests from conventional paper-to-pencil to on-line, are proliferating rapidly. For ICAI, it becomes more popular that the evaluation of pupils' learning should not be simply classified as「absolutely learned」and「absolutely unfamiliar」. In addition, ways of leading each individual pupil to enjoy an efficient learning experience is also pursued. In the research, we proposed an intelligent tutoring system which can afford the most appropriate tutorials to each pupil according to his learning status and thus can prevent pupils to trap into a misconception too long.

2 The Organization of Tutorials and Maintaining Principles

Before implementing our tutoring system, some special issues and adopted techniques must be introduced.

Those topics include the organization of tutorials, a way of representing pupil's learning status, and the detection of any formed misconception.

2.1 The Construction of a Hierarchical Concept Tree

In general, tutorials would be organized as a tree hierarchy of curriculum in the order of chapter, section, sub-section, paragraph, etc. Since learning a complicate concept must depend on the success of learning all its related sub-concepts, the kind of structure cannot be claimed to be suitable for both learners and instructors. That is, too few containment or precedence information about curriculum is available. Thus, learning concepts and related tutorials are re-arranged as a hierarchical conceptual tree of containment here. According to literatures [5] and interviews with teachers of junior high schools, the concepts related to learning Pythagoream Theorem for native pupils can be analyzed and constructed as Figure 1. In the tree, the learning of any parent conceptual node must follow after at least one of its children nodes.

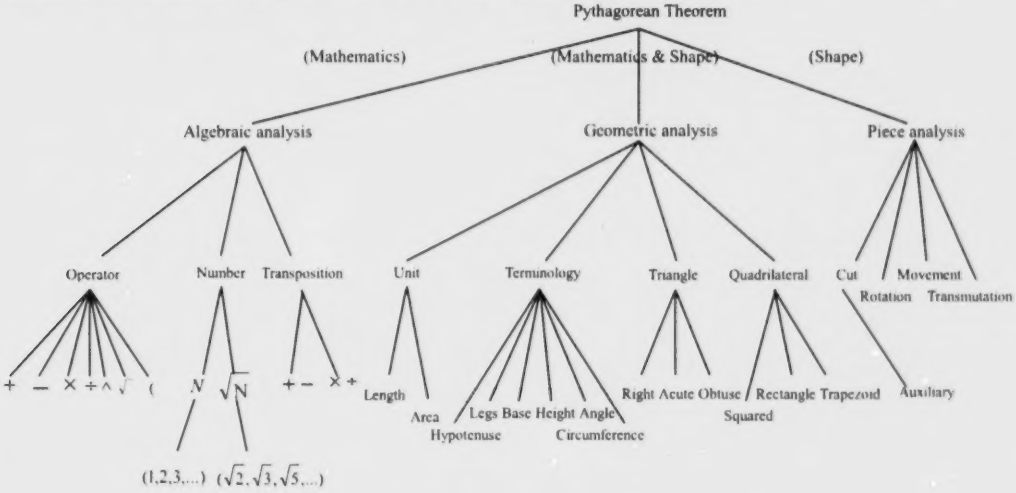


Figure 1. A hierarchical concept tree of Pythagorean Theorem

2.2 The Setting of Node Weights within the Hierarchical Concept Tree

To express the corresponding degree of importance, an integer is assigned to each testing question related to individual concept [5]. However, it is still a heavy burden even for an expert to quantitatively assess the extent. Besides, the estimated grade of importance is too subjective in general. In our system, the influence of each node on learning its parent node is defined through fuzzy theory as follows:

Step 1: Some teachers in junior high schools are asked to evaluate the relevance of nodes related to their parent node in the hierarchical concept tree.

Step 2: Fuzzy theory is included to quantify teachers' opinions in the designed questionnaire obtained in step 1. Five possible values for linguistic variables are used. Note magnitudes 0.0 and 1.0 are not adopted in the memberships because of product operations and symmetry.

Step 3: Murray's or Ishihawa's Max-Min method is used to fuzzily integrate those multiple expertise. After that, a defuzzification process to evaluate the mass centroid of fuzzy numbers is applied. The weights of nodes within the hierarchical concept tree are thus settled as shown in Figure 1.

2.3 The Maintenance of Belief Parameters

To increasing the expression power of the proposed system above "absolutely known" and "absolutely unfamiliar", a belief parameter m and another updating parameter λ described in Dempster-Shafer Theorem [6] are applied here to assess the familiarity degree of a pupil to a particular learning concept within the hierarchical concept tree. To describe the meaning of the updating parameters λ and θ ($\theta=1-\lambda$), two cases must be taken in account:

Case 1: <u>Making a correct answer</u>

λ and θ can be used to denote the belief degree of promoting to a higher level and of staying on the same level within the conceptual hierarchy, respectively.

Case 2: Making a wrong answer

λ and θ can be used to denote the belief degree of degrading to a lower level and of staying on the same level within the conceptual hierarchy, respectively.

As to defining the updating rules of the belief parameter m, a general sub-tree structure is considered. In the tree, a node f has three children nodes labeled as a, b, c, and the interconnection links are labeled as W_{af}, W_{bf}, W_{cf}

Case 1: *Making a correct answer in the test for the conceptual node a*

A promotion within the conceptual hierarchy must be activated. The belief parameters of the two relevant nodes a and f are thus modified as

$$m_f^t = (W_{af} \bullet \lambda) + m_f^{t-1}$$
$$m_a^t = (W_{af} \bullet \theta) + m_a^{t-1} \qquad \textbf{(eqn. 1)}$$

m_f^t, m_a^t : the magnitudes of belief after promotion

m_f^{t-1}, m_a^{t-1} : the magnitudes of belief before promotion

W_{af} : the weight of link between nodes **a** and **f**

Case 2: Making a wrong answer in the test for the conceptual node **f**

A degradation within the conceptual hierarchy must be activated. The belief parameters of the four relevant nodes, **f** and its children nodes **a, b, c,** are thus modified as

$$m_f^t = (\theta) + m_f^{t-1}$$
$$m_a^t = [\ W_{af} \bullet \lambda \bullet (1 - m_a^{t-1})\ ] + m_a^{t-1}$$
$$m_b^t = [\ W_{bf} \bullet \lambda \bullet (1 - m_b^{t-1})\ ] + m_b^{t-1} \qquad \textbf{(eqn. 2)}$$
$$m_c^t = [\ W_{cf} \bullet \lambda \bullet (1 - m_c^{t-1})\ ] + m_c^{t-1}$$

Case 3: If a correct answer is made in the topmost conceptual node, it is impossible to promote anymore. However, the belief of the topmost conceptual node is still updated with eqn. 1.

Case 4: If a wrong answer is made in the lowest conceptual node, it is impossible to degrade and the belief of the node is updated with eqn. 2.

2.4 The Strategy of Instruction

Several principles have been applied in the proposed system:

The instruction and assessment examination would only take place in the conceptual node with the largest belief. However, all assessment tests for its children nodes with weights larger than a pre-chosen threshold must be answered correctly. If the mentioned condition is not satisfied, the focus of instruction and assessment would be transferred to one of its children nodes instead.

According to Dempster-Shapfer Theorem, the procedure of normalization must be applied after each updating of belief.

There is an implicit relationship between the magnitudes of weights and belief parameter λ. To avoid the learning process to be not in progress, according to eqn. 2, the magnitude of belief updating in any child node (a) must be larger than that of parent node (f). Thus,

$$W \bullet \lambda \bullet (1) > 1 - \lambda$$
$$\Rightarrow \lambda > \frac{1}{(1 + w)} \text{ for all possible w}$$

2.5 The Analysis of Learning Traces and Detection of Misconceptions

Two kinds of traversal information would be recorded during the learning process: the weighted correct rate of answering testing questions for each conceptual node, and the traversal path of all visiting nodes.

First, the weighted correct rate can be used to indicate the current comprehension degree of a concept during the learning progresses. As known, the status near to the ending of learning should be emphasized. In other words, a pupil would be regarded as having been familiar with the concept if he can finally pass the

corresponding test independent of times of previous failures. To simulate the phenomenon, three kinds of information must be kept: the number of making wrong answers W, the number of making contiguous correct answers after the last wrong answer C, and the total number of answering T. The weighted correct rate is defined as 1-W / [(T-W-C)+W+2*C], i.e., 1-W/(T+C). The interpretation of the weighted correct rate would be based on fuzzy expression in our system.

Another important issue is the way of detecting the formation of a misconception. A misconception may be caused by some blind spots of learning and thus always makes the learning process trap into a loop. A good diagnosis module of a tutoring system must have such kind of detection capability and could inform the other tutorial guidance module to show some appropriate auxiliary tutorials. If the test of each child node has passed, i.e., the learner has traversed and correctly answer all questions related to the concepts of all children nodes, the conceptual node is marked as P (Passed). If a learner cannot pass the test of a conceptual node and all its children nodes satisfy one of the following two conditions, then the learner is identified as trapping in a misconception corresponding to the conceptual node. The two conditions are <i>the child node has been marked as P; or <ii>the weighted correct rate is absolutely 1 (100%).

3 The Development and Design of Our System

Based on those described ideas, a prototype tutoring system comprising a testing and evaluation module has been developed and demonstrated. Microsoft Visual FoxPro 6.0 is used under the platform of Microsoft Windows 98. There are four modules included in our system shown in Figure 2.

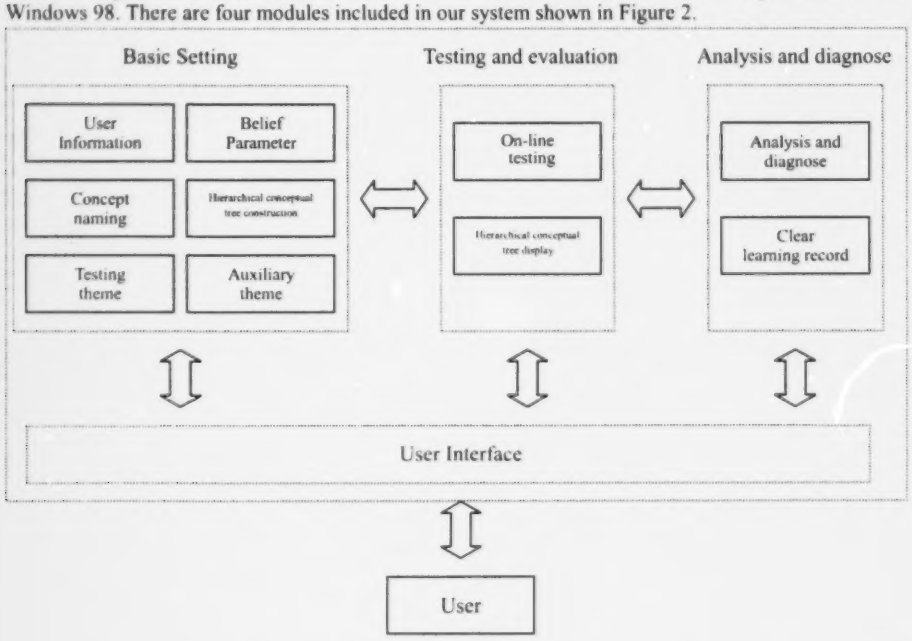


Figure 2. The architecture of the tutoring system

4 Conclusion and Future Work

In the research, techniques of fuzzy theory and uncertainty reasoning are applied to create a novel tutoring system. As demonstrated, the proposed tutoring system shows an excellent capability to present proper tutorials to guide pupils, precisely evaluates their learning status, and then shows auxiliary teaching materials to prevent pupils from trapping in any formed misconception. Finally, the traversal of learning would be analyzed and interpreted by fuzzy expressions.

Besides, some issues are worthy of deeper investigations through the study:

1. Some adaptive techniques of machine learning, e.g., genetic algorithm and artificial neural networks, should be applied to help instructors to automatically choose or tune parameters used in the tutoring system.
2. More applications about the proposed system should be examined to show its portability.

Acknowledgement

This study is supported by National Science Council of R.O.C. under contract number NSC88-2520-S-212-003

References

[1] Anderson, J.R,"Cognitive modeling and intelligent tutoring", *Artificial Intelligence*. 42, pp.7-49, (1990).
[2] Pimentel, K. and Teixeira, K, "Virtual Reality: Through thenewlooking glass", Blue Ridge Summit, PA: Windcrest/McGraw-Hill, (1994).
[3] Rickel, J. and Johnson W. L, "Pedagogical agents for immersive training environments", Proc. of the 1st International Conf. on Autonomous agents, New York, (1997)..
[4] Chien Chou and Chuen-Tsai Sun, "The design and implementation of a cooperative distance learning environment: The CORAL experience", Education Technology and Media, 26, pp. 13-21, April, (1997).
[5] C. S. Hsu, H. F. Dou and G. J. Huang, "The application of concept inheritance in learning diagnosis system", Proc. of ICCAI'98, pp. 602-609, (1998).
[6] Shafer, G., "Mathematical Theory of Evidence ", Princeton University Press , Princeton , New Jersey ,(1976).

The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS

Tsunenori Mine Akira Suganuma Takayoshi Shoudai
Graduate School of Information Science and Electrical Engineering, Kyushu University
6-1 Kasuga-kouen, Kasuga, 816-8580 JAPAN
E-mail:{ mine@is, suga@is, shoudai@i }.kyushu-u.ac.jp

Abstract

Many Internet technologies enable us to hold lectures with Web contents and even develop new lecture methods using the technologies. This paper proposes AEGIS (Automatic Exercise Generator based on the Intelligence of Students) that generates exercises of various levels according to each student's achievement level, marks his/her answers and returns them to him/her. In order to realize this feedback mechanism, we currently restrict the question-types which are generated to the following three types: multiple-choice question, fill-the-gap question, and error-correcting question. All question-types can be generated from the same tagged document. The aim of this system is to help the students understand the lecture with exploiting preexisting electronic documents.

Keywords: Artificial Intelligence in Education, Web-Based Learning, Exercise Generator

1 Introduction

As the Internet has come into wide use, WWW environments provide lots of opportunities to various fields. In the educational domain, Web data are being exploited as useful materials. We have been developing Web-based self-teaching systems and building the tools for helping students understand their subjects[1, 2, 3, 4].

We are currently focusing on the automatic student's achievement level evaluator that generates an exercise from tagged documents, presents it to students and marks their answer automatically. We call the system AEGIS (Automatic Exercise Generator based on the Intelligence of Students)[6, 7].

Creating exercises which are suitable for students is not easy. When we try to make some exercises for them in classes, we have to take at least their achievement level into considerations. The well-considered exercises are useful not only to measure the achievement level of students but also to improve their performance. It is not easy task for any teacher to make exercises of various difficulties according to their achievement level. Besides, it is very important to mark the students' answers and return the marked results to them for keeping their learning enthusiasms. This task becomes harder in proportion to the number of the students in a class[5].

This paper discusses AEGIS, which generates the three question-types from the same tagged data. Guessing the achievement level of each student from his/her trial history, AEGIS selects the most suitable question-type and exercise for him/her according to not only his/her achievement level but also the difficulty of the tagged data. After marking his/her answer, AEGIS returns it to him/her with its explanation.

The aim of this system is to exploit pre-existing electronic documents, in particular, our on-line documents shown at our Web site (http://cl.is.kyushu-u.ac.jp/Literacy) and to help students understand their lecture whose materials are set up as Web data so that they even at home can try exercises using AEGIS through the Internet.

The rest of this paper is constructed as follows: Section 2 shows related works to discuss the difference from AEGIS. Section 3 describes question-types that AEGIS deals with, considering both view points of students(answerers) and teachers(questioners) and Section 4 describes the exercise generating process by AEGIS. Section 5 shows the overview of AEGIS.

2 Related Works

A lot of automatic quiz generators have been proposed so far. Browning et. al. proposed Tutorial Mark-up Language(TML in short) to generate questions automatically[8, 9]. TML has a couple of tags to specify a question, a multiple-choice and a message. It requires a correct answer in a multiple-choice tag to mark a student's answer to the question. Carbone et. al. proposed CADAL Quiz[10], which generates a multiple-choice quiz from a question database. After marking a student's answer, CADAL Quiz returns the result to him/her and tutors. Both of them restrict the question type only to a multiple-choice quiz. On the other hand, ClassBuilder[11] generates many kinds of quizzes and grades a student's answer. However, all of them do not mention any effect of making the difficulty level of question-type change according to the students' achievement level. In order to improve their performance and keep their enthusiasm to challenge the quiz for a long time, it is indispensable to consider their performance level for generating their exercise. This point is the difference from other systems. AEGIS makes use of pre-existing electronic documents so as to embed tags into them, generates exercises automatically with tagged documents according to students' achievment levels, and reestimates both their levels and the difficulty level of the generated question through marking their answers.

3 Question-Types

There can be several types of a question in every subject. Since our aim is to get a computer generate an exercise and mark student's answer to it, we thus restrict to the following three question-types: multiple-choice question, fill-the-gap question, and error-correcting question.

Multiple-choice question. Students choose the correct answer from a given candidate list.

Example. Complete the sentence. Choose your answer from the following list.

Data structures need to be studied _____ order to understand the algorithms.

(1) an (2) in (3) on (4) at (5) by

Fill-the-Gap question. Students try to fill in the blank of a given sentence with the correct answer without any help.

Example. Fill in the blank with the right word.

Data structures need to be studied _____ order to understand the algorithms.

Error-correcting question. Students have to find the wrong expression in a given sentence and correct it.

Example. Right or wrong? Correct the sentence if it is wrong.

Data structures need to be studied an order to understand the algorithms.

All of these question-types can be constructed from a sentence by replacing one or more consecutive words with a blank or a wrong expression. We call the region replaced *hidden region*. We note that these three question-types have different difficulties even if they are constructed from the same *hidden region*. Figure 1 shows the tagged data to be used for generating the above three types of questions.

```
⟨QUESTION SUBJECT="idioms"⟩
Data structures need to be studied ⟨DEL CAND="an,on,at,by"⟩ in ⟨/DEL⟩ order to understand the algorithms.
⟨/QUESTION⟩
```

Figure 1: The tagged data to generate three question-types shown in Section 3

Students' View Point

Every multiple-choice question has surely the correct answer in its candidate list and contains the information that leads students to the correct answer. They can therefore make their choice with confidence from the list. In the case of a fill-the-gap question, they have to fill in the blank by themselves with their convinced answer without any information about the answer. Comparing both question-types, we can say

that a fill-the-gap question is more difficult than a multiple-choice one. In the case of an error-correcting question, it forces them to determine whether or not there is an error in the question sentences and to correct it if it is found. An error-correcting question gives no information leading them to its correct answer, and the wrong expression in the sentences is not clear for students. We can therefore say that an error-correcting question is the most difficult one for students among those question-types.

Teachers' View Point

Once teachers set a *hidden region*, the efforts that are required to make with the three question-types are similar. The process for making exercises is as follows: in the case of a fill-the-gap question, the teachers have nothing to do. There is no information that they have to add to the exercise paper. We can say that a fill-the-gap question is the easiest one which is made among these three question-types. In the case of an error-correcting question, teachers have to think of at least one wrong expression which can be replaced with the *hidden region*. In the case of a multiple-choice question, they have to prepare several distractors to construct a candidate list. We can say that a multiple-choice question requires more information than an error-correcting one. From their points of view, a fill-the-gap question is consequently the easiest one which is made, and an error-correcting question is easier than a multiple-choice one.

4 Automatic Exercise Generating

4.1 Exercise Generating Process

The exercise generating process from teaching documents is summarized as follows:

1. Setting a *hidden region*: teachers make clear their intention why they want to ask the question to their students, that is, they consider which of the *hidden regions* is the most suitable for their intention.

2. Selecting a paragraph or sentence(s) from teaching documents: the sentences before and after *hidden regions* are often of importance to ask their students the unique answer of the question. We call the paragraph or sentence(s) a *question region*. A *question region* may have more than one *hidden region*.

3. Constructing a candidate list: a multiple-choice question requires a couple of distractors to set up a list of answer candidates. Any distractor should be natural so as to be added to the list. This list depends on the teacher's intention.

These three steps are deeply related to the teachers' intentions. It is not easy to extract such intentions automatically from the teaching documents. AEGIS system thus deals with tagged documents that already have the information such as *hidden regions* and candidate lists.

4.2 Necessary Information for Generating Exercises

In order to embed the above three kinds of information into the teaching documents, we define the following three tags: QUESTION, DEL, and LABEL.

QUESTION surrounds a *question region*, that is, the statements between ⟨QUESTION⟩ and ⟨/QUESTION⟩ are a *question region*. In the region, there can possibly be some expressions that are related to a *hidden region*. They can be good hints to lead students to the correct answer.

SUBJECT is the unique attribute of QUESTION. Its value stands for the subject or topic of *question region*.

DEL indicates a *hidden region*, which is the word(s) or sentence(s) between ⟨DEL⟩ and ⟨/DEL⟩.

A fill-the-gap question can be generated only by replacing the *hidden region* with a blank.

CAND is one of DEL's attributes. It is used to specify a candidate list.

LABEL has an attribute NAME that specifies a dependency relation with a *hidden region*. The sentence/s surrounded by LABEL tags is/are presented as a reference for the answer of a question, which will be generated with the DEL tag whose REF's value is the same as that of the NAME of the LABEL.

⟨QUESTION SUBJECT="W_S"⟩ *question region* ⟨/QUESTION⟩		
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
⟨DEL CAND="CANDIDATE" LEVEL="PAIR" GROUP="ID" REF="ID"⟩ *hidden region* ⟨/DEL⟩		
CANDIDATE	::=	W_S | W_S,CANDIDATE
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
PAIR	::=	LOW,HIGH
LOW	::=	an integer between 1 and 10
HIGH	::=	an integer between 1 and 10
ID	::=	keyword
⟨LABEL NAME="ID"⟩ sentences ⟨/LABEL⟩		
ID	::=	keyword

Figure 2: Tags for exercise generations

4.3 Necessary Information for Adjusting Difficulty Level of Question

The additional three attributes of DEL, which contain the information on the difficulty of solving the exercise, are LEVEL, GROUP, and REF. They specify the difficulty of each *hidden region*, and the connections to other *hidden region*.

LEVEL specifies the difficulty of the exercise to be generated from a *hidden region* itself. The value of this attribute is a pair of integers between 1 and 10. These integers specify the lowest and highest achievement level of the students who can try the exercise. AEGIS system determines whether or not the *hidden region* is worth being transformed into the exercise by comparing the student's achievement level from the both values of LEVEL.

GROUP specifies the dependency relation between *hidden regions* and holds the uniqueness of the correct answer. This GROUP is used to adjust the exercise level. If we want to generate more difficult exercises, all the *hidden regions* that have the same values in GROUP are replaced with blanks or wrong expressions at the same time. On the other hand, for generating easier ones, some of the *hidden regions* in the group are not transformed because those regions help students answer the question as hints.

REF specifies the dependency relation between a *hidden region* and other expressions than the *hidden region*. Both the region and expressions are specified with LABEL. If a *hidden region* is connected to an expression, the value of REF in the *hidden region* is the same as that of NAME in the expression with LABEL.

5 AEGIS system

5.1 Overview of AEGIS

The AEGIS system consists of three databases: *Exercise DB* (**EDB** in short), *User Profile DB* (**UPDB** in short) and *Level Management DB* (**LMDB** in short), and three main database managers: *Exercise Generator* (**EG** in short), *Answer Evaluator* (**AE** in short) and *Level Manager* (**LM** in short). The overview of AEGIS is shown in Fig. 3.

Teaching documents with the tags are compiled into the **EDB** and **LMDB**. All of the *question regions* are indexed sequentially and each *hidden region* is labeled with its own subindex of the index of each *question region*. The level of a *hidden region*, which is deeply related to the level of the question to be generated from the *hidden region*, is stored in the **LMDB** together with the index of the *hidden region*. The level of each *hidden region* in **LMDB** is reexamined regularly. **UPDB** keeps students' trial histories with their current achievement level.

EG and **AE** make communications with the users (students) through Web browsers after being invoked through CGI (Common Gateway Interface).

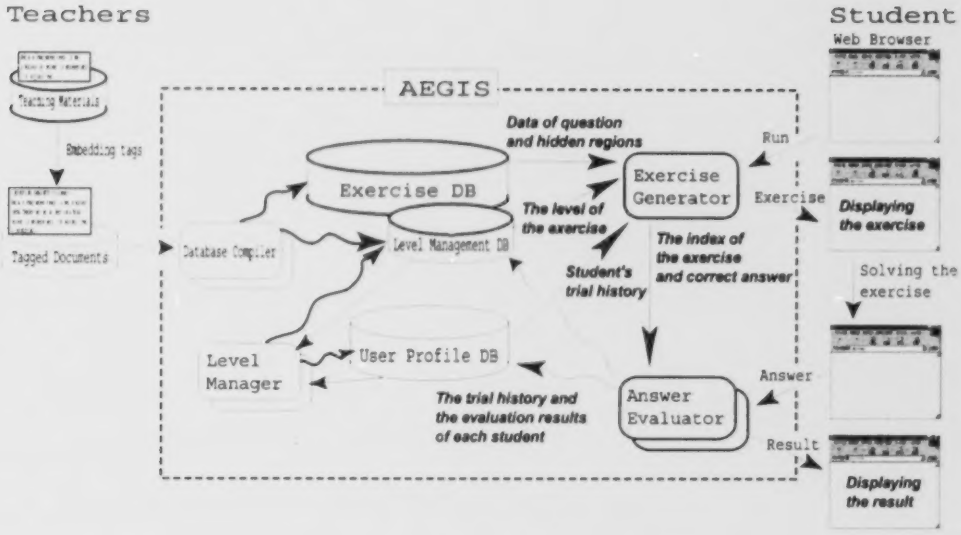


Figure 3: Overview of AEGIS

5.2 Exercise Generator(EG)

The exercise request from a student invokes **EG**. The **EG** searches the most suitable *hidden region* in **EDB** with looking over both the student's profile stored in **UPDB** and the level of the *hidden region* stored in **LMDB**, and determines the question-type of the *hidden region*. As mentioned in section 3, every question level has a relation to the question-type. **EG**'s decision process of the question-type thus employs the following strategy: If the student's achievement level is closer to the lowest number in LEVEL of the *hidden region*, **EG** selects a multiple-choice question as the question-type with high probability. On the other hand, if it is closer to the highest number in the LEVEL attribute, **EG** selects an error-correcting one.

Once **EG** determines the question-type of the *hidden region*, it is not difficult to generate the question. This is because the *hidden region* represents the correct answer of the question which is generated and teachers have already given the list of distracts explicitly with CAND attribute. Now, let's see how **EG** works when it generates the three kinds of questions:

- *Multiple-choice question*: **EG** randomly constructs one possible list for the multiple choice with both the correct answer and some distracts and outputs a question, which is generated by replacing the *hidden region* with a blank, with the list.
- *Fill-the-Gap question*: **EG** outputs a question which is generated only by replacing the *hidden region* with a blank.
- *Error-correcting question*: **EG** outputs a question which is generated by replacing the *hidden region* with one of the wrong answers specified in the CAND attribute.

Figure 4 shows an example of teaching documents with the tags. It is a piece of the teaching documents in the elementary course of Computer Literacy at our university. This course is taken by all first and second year students, about 2,300 students[5]. The teacher's intention in the example document is to teach how to use multiply and divide operations. Figure 5 shows the three question-types which are generated from the document.

5.3 Answer Evaluator(AE)

After outputting a question to the student, **EG** sends the following three kinds of information to ask **AE** to mark his/her answer: the index of a *hidden region*, the question-type, and the correct answer. After

BEST COPY AVAILABLE

In the previous section, we learned a program for adding two integers and showing the answer on the display. In the similar way, for all basic arithmetic operations including addition, subtraction, multiplication, and division, we can make a Pascal program in the following way.
(QUESTION SUBJECT="arithmetic operations")
This program computes the multiplication and division for two input integers and shows the answer.

```
program enzan;
var x,y:integer;
   seki,shou:integer;
begin
   write('Input two integers : ');
   readln(x,y);
   seki:=(DEL CAND="x,xy,x×y,x mul y" LEVEL="1,5")x*y(/DEL);
   shou:=(DEL CAND="x/y,x÷y,xdivy,x mod y" LEVEL="1,5")x div y(/DEL);
   writeln('Seki:',seki);
   writeln('Shou:',shou)
end
```

(/QUESTION)
The 7th statement multiplies x by y, and the 8th statement divides x by y. We note that the answer of "div" is an integer.

Figure 4: Example of teaching documents with the tags

(a) Multiple-Choice (b) Fill-the-Gap (c) Error-Correcti

Figure 5: Three questions generated from the document in Figure 4

marking his/her answer by matching with the correct answer, **AE** shows him/her the marked result and stores it with the index of the *hidden region* and the question-type into the **UPDB**.

5.4 Level Manager(LM)

Although the initial value of the level of each *hidden region* is specified by teachers, it continues to move up and down according to the students' achievement levels, which will change as time goes by. The supplement manager **LM** processes their achievement levels statistically, computes the revised level of each *hidden region*, and stores it into the **LMDB**. **LM** increases the difficulty level of a question if a student whose level is greater than the level of question answers it wrongly, and decreases if a student whose level is less than the level of question answers it correctly. The new difficulty level of a question is consequently determined as shown in Fig.6.

After updating **LMDB**, **LM** updates the student's achievement level according to the difficulty levels of all questions he/she correctly answered.

Now, we show the formal definition of calculating both the achievement level of a student and the difficulty level of a question. Let $s_{i,t}$ and $q_{j,t}$ be the achievement level of student S_i and the difficulty level of question Q_j at time t respectively, where $1 \leq s_{i,t} \leq 10$,$1 \leq q_{j,t} \leq 10$. $s_{i,t}$ is recursively calculated with $q_{j,t}$ at stated periods and vice versa. They are defined as follows:

BEST COPY AVAILABLE

$$s_{i,t} = \begin{cases} 1 & \text{if } m_{s_i,t} = 0 \\ \frac{1}{m_{s_i,t}} \sum_{j=1}^{m_{s_i,t}} q_{j,t} \cdot \delta_{i,j} & \text{otherwise} \end{cases} \qquad \delta_{i,j} = \begin{cases} 1 & \text{if } S_i \text{ answered } Q_j \text{ correctly} \\ 0 & \text{otherwise} \end{cases}$$

$$q_{j,t} = \begin{cases} q_{j,t-1} + \frac{\sum_{i=1}^{m_{q_j,T}} |s_{i,\tau \in T} - q_{j,t-1}| \xi_{i,j}}{\sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}|} & \text{if } \sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}| \neq 0 \\ q_{j,t-1} & \text{otherwise} \end{cases}$$

$$\xi_{i,j} = \begin{cases} -1 & s_{i,\tau} \text{ is less than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ correctly} \\ 1 & s_{i,\tau} \text{ is greater than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ wrongly} \\ 0 & \text{Otherwise} \end{cases}$$

Where $m_{s_i,t}$ stands for the number of questions that S_i tried by t and τ is the latest time such that S_i tried to answer Q_j and $t-1 < \tau \leq t$. T is the set of τ. $m_{q_j,T}$ stands for the total number of students who tried Q_j in T. $q_{j,0}$, which is the initial difficulty level of the question Q_j, is given with the attribute $LEVEL$ of DEL tag by teachers.

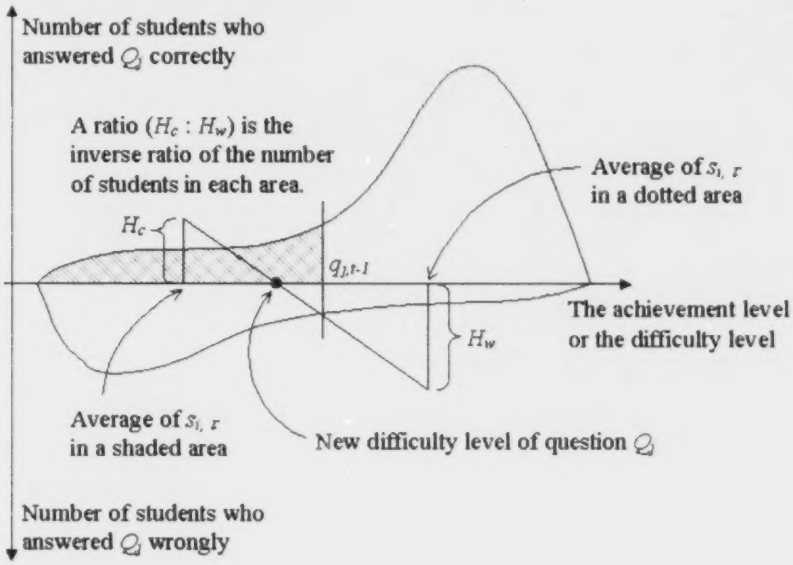


Figure 6: Renewing Difficulty level of Question based on Student's Achievement Level

6 Conclusions

We discussed our new Web-aided system AEGIS. The system is currently implemented in Perl scripts and CGI. We have a plan to evaluate this system by applying it to the real courses of Computer Literacy, which are taken by more than 2300 students at our university. We hope it will work fine as an educational tool for every student and help him/her to understand his/her subjects if teachers can make tags in their teaching documents. Also, we plan to implement a tagging tool and an algorithm to generate another kind of exercise that allows more than one correct answers.

Acknowledgments

We thank Dr. Teruko Mitamura at Carnegie Mellon University for her helpful comments to improve this paper.

This research was partly supported by the Grant for Special Academic Research P&P from Kyushu University and the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Encouragement of Young Scientists(A), No. 11780281, 2000.

References

[1] H. Sato, T. Mine, T. Shoudai, H. Arimura, S. Hirokawa: On web visualizing how programs run for teaching 2300 students. In *Proc. Int. Conf. on Computers in Education, ICCE'97*, pages 952–954, 1997.

[2] T. Mine, D. Nagano, K. Baba, T. Shoudai, S. Hirokawa: On-web visualizing a mechanism of a single chip computer for computer literacy courses. In *Proc. Int. Conf. on Computers in Education, ICCE'98*, volume 2, pages 496–499, 1998.

[3] R. Fujimoto, A. Suganuma, T. Mine: Development of a classroom management system on the web. In *Proc. Int. Conf. on Computers in Education, ICCE'99*, volume 2, pages 756–759, 1999.

[4] R. Fujimoto, Y. Tsutsumi, A. Suganuma: Cacce: Computer aided cooperative classroom environment. In *World Conference on Educational Multimedia, Hypermedia & Telecommunications*, page 1686, 1999.

[5] S. Hirokawa, T. Miyahara, T. Mine, T. Shoudai, M. Mori: Teaching 2300 students with www – practice and experience at kyushu university. In *Proc. ERI'96*, pages 59–63, 1996.

[6] T. Shoudai, A. Suganuma, T. Mine: AEGIS: Automatic Exercise Generator with Tagged Documents based on the Intelligence of the Students, Joint Conference on Knowledge-Based Software Engineering, to appear. JCKBSE2000, Brno, Czech Republic, 2000

[7] T. Mine, T. Shoudai, A. Suganuma: Automatic Exercise Generator with Tagged Documents

Considering Learner's Performance Proceedings of WebNet2000, San Antonio, Texas, to appear as a short paper, 2000

[8] P. Browning, J. Williams, D. Brickley, H. Missou: Question Delivery over the Web using TML http://www.ilrt.bris.ac.uk/netquest/liveserver/qbanks/demos/paul/lboro/ohp1.html, CAA, 1997

[9] P. Browning: TUTORIAL MARKUP LANGUAGE - A CBA SYSTEM http://www.soton.ac.uk/~ukgec/workshop/5-cba/minutes.htm#TUTORIAL, 1998.

[10] A. Carbone, P. Schendzielorz: A Web-Based Quiz Generator for Use in Tutorials and Assessment Global J. of Engng. Educ., Vol.I, No.3, 1997 http://www.eng.monash.edu.au/usicee/gjee/vol1no3/paper20.htm.

[11] ClassBuilder GradeBook And Exam Creation Software: http://www.classbuilder.com/

Traversing the Case Graphs A Computer Model for Developing Case-based Learning Systems

Isaac P.W. Fung & R. H. Kemp
Institute of Information Sciences and Technology
Massey University
Palmerston North, New Zealand
Fax: +64-6-3502259
P.W.Fung@massey.ac.nz; R.Kemp@massey.ac.nz

This paper presents an extended theory for representing cases in a case-based physics learning environment. There are two issues with which developers of case-based tutoring systems often contend: one is assessing and retrieving similar cases from the case library; the second one is delivering the case contents to the students. Whilst an earlier paper has addressed the former issue, this paper focuses on the latter by defining a computational mechanism that is used for delivering the case content. The mechanism is developed by defining a procedural semantics on the case graph which incorporates the dynamic modelling capability of petri nets. A case is initially opaque to the student. During case interaction, however, it will be made transparent gradually by engaging the students with problem-solving activities. The activities are modelled using the notions of marking places and firing transitions, where places and transitions represent case variables and operations, respectively. The idea is illustrated with an example of providing guidance to students solving problems in the domain of Newtonian mechanics.

Keywords: **Artificial Intelligence, Conceptual Graphs, Intelligent Tutoring Systems, Case-based Reasoning**

1 Introduction

This paper presents an extended theory of representing problem-solving cases proposed in [5] for the purpose of modelling instructional activities between the cases and the learners within the context of case-based tutoring systems (CBTS) [11]. In response to the classic criticisms [12] leveled at the first-generation of computer-assisted learning software that frequently have to go back to inflexible, pre-compiled problem solutions, CBTS is very attractive for several reasons. Two of them are particularly appealing to us. From an instructional perspective, students are highly influenced by past examples (i.e. real cases) to guide their problem-solving activities [1] or completing cognitive tasks [8]. Our project sponsor demands that the final system should faithfully reflect what students actually do when completing their homework. It is, therefore, our aim to ground our system design at the outset on sound psychological findings about pupils' learning behaviours. Secondly, from a technical viewpoint, case-based adaptation techniques are powerful in adapting interface components to the user's need [14].

Individual learner's needs, style and progress do differ substantially. Case-based reasoning technology [7] endows the system with the capability of inferring what is considered 'best' for the students by referring to their past learning histories. [5] proposed the use of conceptual graphs (CG) [13] for representing tutorial cases. While this method elegantly tackles the issue of assessing case similarity, how the case graphs are built remains a 'black-box'. The case users have no way to inspect the internal processes for constructing the graph. To ensure

the cases are useful in tutorial contexts, the knowledge components of the cases need to be 'available' to the students. What we mean by 'available' is making the case solution transparent, i.e. the system is capable of justifying each problem-solving step being shown to the students in terms of the underlying physical principles.

The procedural semantics defined on case graphs which forms the core contents of this paper, provides a way of making the solution procedures explicit to the students. The idea is to synthesize a CG and the actor graph defined in [13] into one single global graph instead of treating them separately. The resulting structure is a tripartite graph that has three types of nodes: concept nodes, symbolic relation nodes and mathematical relation nodes. The mathematical relation nodes are for handling mathematical calculations in the domain of Newtonian mechanics, the targeted subject domain of our project These calculations are important in many science and engineering applications. In making the synthesis, two important ontological commitments were made. Firstly, human cognitive functions in studying a concrete case are viewed as a process of constructing graphs. Relevant concept nodes are created and linked to each other via some appropriate relation nodes (whether symbolic or mathematical). A case represented by the graph consists of sets of concept nodes and relation nodes, but to what extent the students understand the case contents remains unknown until some observable actions are seen. Secondly, the process of building the graph is based on the notion of concept node marking. Initially, the sets of nodes in a case are all opaque to the users because they are not yet marked. The set of nodes representing the initially given physical quantities are marked first. Each problem-solving step is viewed as generation of new graph nodes, but they are implemented as the nodes states change from unmarked to marked. To mark a set of nodes, the mathematical relation nodes (or operators) which link the marked and the unmarked nodes have to be fired. The procedures of solving the problem are defined as the firing sequence for marking the target concept nodes. The subgraph associated with a particular fired node represents the semantics of the knowledge behind its firing.

2 Formal Definition of the Case Constituents

We represent a typical case abstractly by a directed graph which is composed of

* Three disjoint sets of vertices C, R *and* R_m (i.e. $C \cap R = \varnothing$; $C \cap R_m = \varnothing$; $R \cap R_m = \varnothing$ and $C \cap R \cap R_m = \varnothing$) where C represents the set of concept nodes; R represents the set of symbolic relation nodes; and R_m represents the set of mathematical relation nodes.
* A set of directed arcs E such that $E \subseteq (C \times R) \cup (R \times C)$. Each arc $e \in E$ connects a concept $c \in C$ to a symbolic relation $r \in R$ or vice versa.
* A set of directed arcs E_m such that $E_m \subseteq (C \times R_m) \cup (R_m \times C)$. Each arc $e_m \in E_m$ connects a concept $c \in C$ to a mathematical relation $r_m \in R_m$ or vice versa.

Shown in Figure 1 is an example case graph where

$C = \{c_1, c_2, c_3, c_4, c_5, c_6\}$;
$R = \{r_1, r_2, r_3, r_4\}$;
$R_m = \{r_{m1}, r_{m2}, r_{m3}, r_{m4}\}$;
$E = \{(c_1, r_1), (r_1, c_2), (c_3, r_2), (c_4, r_2), (r_2, c_2), (c_5, r_4), (r_4, c_2), (c_6, r_3), (r_3, c_1)\}$; and
$E_m = \{(c_1, r_{m1}), (r_{m1}, c_2), (c_2, r_{m2}), (c_2, r_{m3}), (c_5, r_{m3}), (r_{m2}, c_3), (r_{m3}, c_4), (c_3, r_{m4}), (c_4, r_{m4}), (r_{m4}, c_6)\}$.

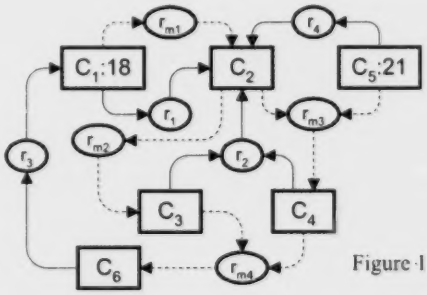


Figure 1

* For every $r_m \in R_m$, there exist an input set $I_r(r_m)$ and an output set $O_r(r_m)$ such that

$I_r(r_m) = \{ c \in C \mid (c, r_m) \in E_m\}$; (c, r_m) is called the input arc of r_m, and c is called the input concept of r_m; and
$O_r(r_m) = \{ c \in C \mid (r_m, c) \in E_m\}$; (r_m, c) is called the output arc of r_m, and c is called the output concept of r_m.

For example, the input/output set of the node r_{m3} in Figure 1 are $I_r(r_{m3}) = \{c_2, c_5\}$ and $O_r(r_{m3}) = \{c_4\}$ respectively.

* For every $c \in C$, it is defined as *marked* if it is being instantiated to a specific individual. In Figure 1, c_1 and c_5 are marked whereas the others are non-marked.
* The marking μ of a graph G can be represented by a *n-vector*: $\mu = (\mu_1, \mu_2, \ldots, \mu_n)$, where each $\mu_i \in (T, F)$. For example, the graph in Figure 1 has the marking $\mu = (T, F, F, F, T, F)$.
* A mathematical relation node $r_m \in R_m$ is *enabled* whenever each concept $c \in I_r(r_m)$ is marked. In Figure 1, only r_{m1} is enabled at that marking.

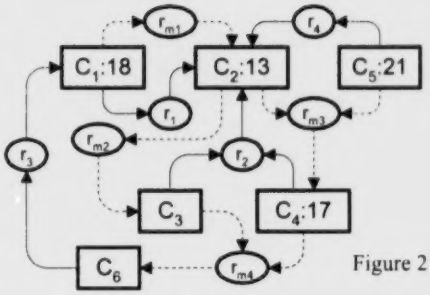


Figure 2

* When a mathematical relation node is enabled, it can be fired at any time and every time a mathematical relation is fired, every $c \in O_r(r_m)$ will be marked[1].
* For every $c \in O_r(r'_m)$, where r'_m is the fired mathematical relation, the content of c is evaluated according to the formulas inscripted in the respective $r'_m \in I_c(c)$.
* Supposing the formulas inscripted in r_{m1} is $c_1 = c_2 + 5$ and r_{m3} is $(c_2 + c_5) / 2$, the firing of r_{m1} will mark c_2 which enables r_{m3} because c_5 has already been marked. If r_{m3} is fired later, a new marking (shown in Figure 2) will be formed and become $\mu = (T, T, F, T, T, F)$.

3 Representing Mechanics Problem-solving Cases

In our application domain, Newtonian mechanics, two categories of physical entities are identified with respect to the cases we use for tutoring: *physical objects* and *physics concepts*. Both are represented, however, as rectangular-shaped concept nodes. In each case, a number of physical objects are involved, such as a block, a car, a plane, a spring, etc., but they are normally described abstractly just as a physical object. Various meaningful relations obtain between the objects, which essentially represent the physical configuration between them. For instance, it makes sense to represent the 'rest_on' relation that holds between a block and a plane whenever the block is on the plane. Other meaningful relationships are: 'above', 'contact_with', 'moves_on', and so forth. There are attributes, intrinsic and motion-related, of the physical objects which refer to one object only. For example, 'acceleration'(a motion-related attribute) and 'mass' (an intrinsic attribute) applies to a single physical object on its own. In representing a physical situation, there are some other domain-related ideas such as external force or friction, which characterize the case being described. All these concepts are categorized as physics concepts as they are used to describe the state of the world depicted by the case. Figure 3 shows a typical case adopted from a standard physics textbook.

Two blocks A & B are resting on a frictionless horizontal plane as shown. If an external force of 10N is acting on A, what is the acceleration of the blocks and the force of contact between them? (The masses of A and B are 3kg and 7kg respectively).

[1] The notion of marking and firing is borrowed from the petri nets formalism [9]

Solution: Apply Newton's 2nd Law on A&B

$$\begin{aligned}
\text{Net Force}_{A\&B} &= \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \\
\text{External Force}_{A\&B} &= \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \\
10 &= (3 + 7)\ \text{Acceleration}_{A\&B} \\
\text{Acceleration}_{A\&B} &= 1\ \text{m/s}^2
\end{aligned}$$

Apply Newton's 2nd Law on A

$$\begin{aligned}
\text{Net Force}_{A} &= \text{Mass}_{A} \times \text{Acceleration}_{A} \\
\text{External Force}_{A} + \text{Contact Force}_{A} &= \text{Mass}_{A} \times \text{Acceleration}_{A} \\
10 + \text{Contact Force}_{A} &= 3 \times 1 \\
\text{Contact Force}_{A} &= -7\text{N}
\end{aligned}$$

Apply Newton's 2nd Law on B

$$\begin{aligned}
\text{Net Force}_{B} &= \text{Mass}_{B} \times \text{Acceleration}_{B} \\
\text{Contact Force}_{B} &= \text{Mass}_{B} \times \text{Acceleration}_{B} \\
\text{Contact Force}_{B} &= 7 \times 1 \\
\text{Contact Force}_{B} &= 7\ \text{N}
\end{aligned}$$

Figure 3: A typical Newtonian mechanics case and its solution

As the complete graph representing the case occupies too much space, the whole graph is divided into several subgraphs. To illustrate the idea, three representative subgraphs are shown in Figure 4, 5 and 6. The subgraph in Figure 4 represents the physical objects involved in the case and their relationships. The (component) nodes encodes the part-whole relationship between the whole system A&B and its constituents A and B. The tuple [Blocks: A&B] → (component) → [Block: B] depicts the block labelled as 'B' as part of the whole system labelled as 'A&B'. The other relation nodes essentially represent the spatial relationships between the objects.

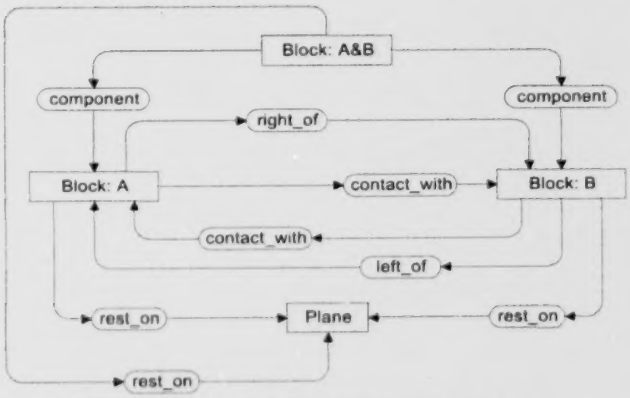


Figure 4: The subgraph showing the physical objects involved in the case and their relationship

The subgraph shown in Figure 5 concerns the attributes, both intrinsic and motion-relationed, of block A and other relevant physical concepts centred around it. The absurd type [T] as the agent of the Net_Force_A and External_Force_A indicates it is something that is of no relevance to us. In Figure 6, those concept types that participate in some sort of mathematical relations are shown. Note that most of the arcs in Figure 6 are dotted indicating they are different from the usual symbolic relations.

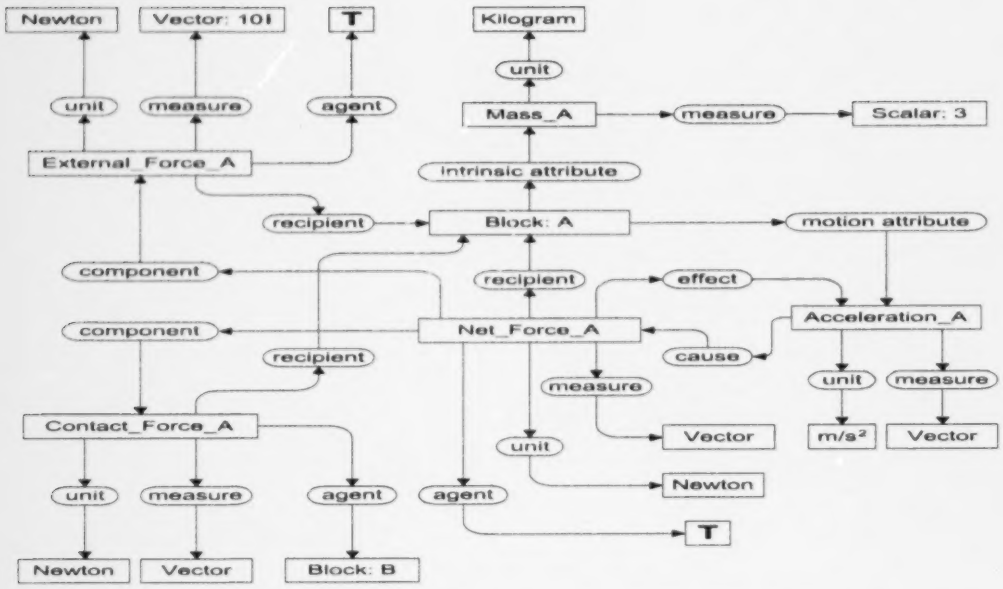


Figure 5: Subgraph showing the attributes of block A and other relevant physical concepts.

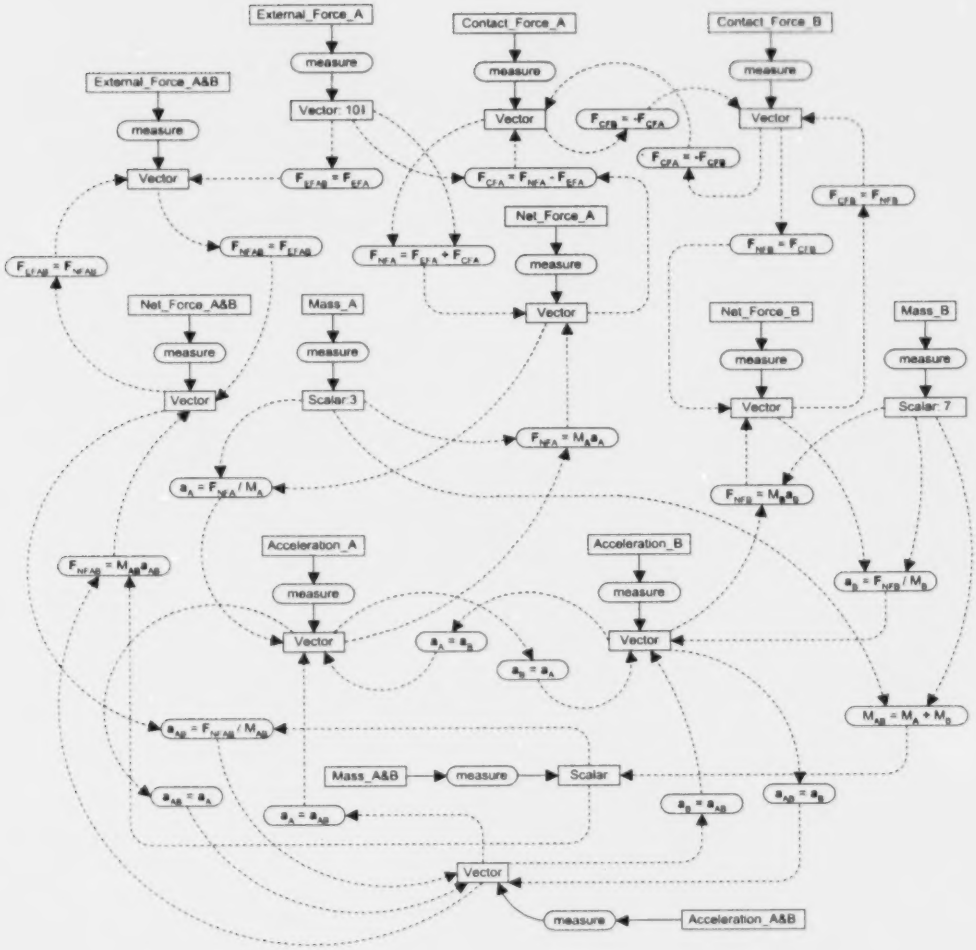


Figure 6: Subgraph showing the mathematical relationships between the relevant concept types

4 Modelling Variables Instantiation as Node Marking

Once a case has been encoded with the formalism, problem-solving activities can be modelled. When given a problem to tackle, the students will generally be asked for a new value from a set of given data. This is modelled as marking the concept nodes such as C_1 and C_5 in Figure 1. The goal is to get the concept node C_6 marked. At the initial marking, only r_{m1} is enabled and therefore any attempt to trigger other mathematical operations is not allowed and, thereby, invites tutorial intervention. The whole process of creating successive markings can be illustrated with a search tree (see Figure 7). The tree

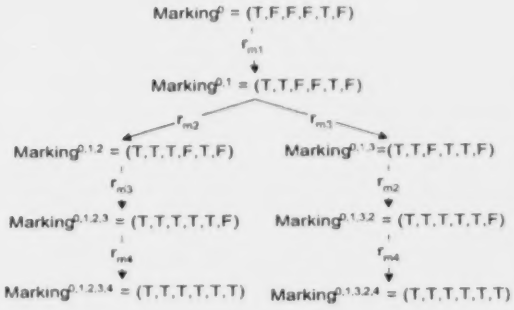


Figure 7

indicates the student can gain access to a large solution space for him/her to explore but in the mean time the tutor can keep track of what can/cannot be done.

5 CLASP: A Case-based Learning Assistant System in Physics

A system called CLASP, has been developed to implement the idea. At the current stage of development two types of activities associated with examples have been identified: providing solutions for studying, and exercises with answers; hence the modes of interaction in the CLASP prototype are also designed around these two themes. When the users issue a request (in terms of the problem description of their own problems) the system will search through its whole case library and provide them cases which match their request. The style of presenting the case will follow the user's wishes, but only two modes of interaction (solution studying and guided-problem-solving) are available. This is to reflect the common way of using examples in physics textbooks. In the study mode, the system presents the whole case (i.e. both the problem and solution statements) for the user to study. This looks like an electronic reference book and the student may browse through the relevant cases. In the guided-problem-solving mode, the system only presents the problem situation to the users, but appropriate system guidance will be provided in solving the problems. The schematic architecture of CLASP is shown in Figure 8. The students interact with the system with the support of the back-end knowledge base.

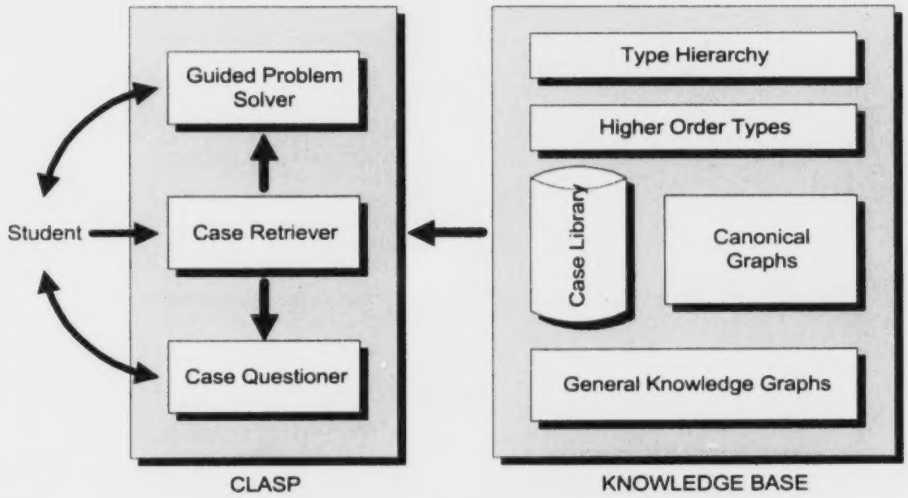


Figure 8: Schematic description of the CLASP architecture

Problem-solving in CLASP is modelled as a graph search. When a problem situation, such as the one shown in Figure 3, is encountered, the initial data are represented as concept nodes being instantiated to specific values and they are displayed to students on the working pad (Figure 9). Now the problem-solver can start tackling the problem by searching through the graph and seeing what additional information can be inferred from the initial given data. For the system to perform the tasks, the expertise has already been encoded in the case graphs, therefore the next step to be taken is searching the graph to find out which operators can be fired. The inferred steps may be unfolded or kept hidden for a while as a hint to advise the student. The intelligence of the system's problem-solving ability comes from its inference engine, being implemented by different graph search methods.

Problem Space	System's Comments:
External_Force_A: 10N Mass_A: 3 kg Mass_B: 7 kg	Initial Conditions: M_A = 3kg; M_B = 7kg; and External Force $_A$ = 10N.

Figure 9: The working pad and the corresponding system responds

The explanatory capability of the system comes from the matching of the input-operator-output nodes with the consequences of the general knowledge graphs. Whenever an operator is fired, the associated nodes will be matched against the consequences of the general knowledge graphs. If one is found, and it should be, then that particular graph will be tagged. If the student requests a justification of the step taken, the system can explain the graph in general terms. For example, the firing of an algebraic summation operator on the values of masses of two physical objects will match the consequence of the general knowledge graph in Figure 8 so the whole graph can be retrieved for explanation (Figure 10). The working pad, showing the problem space, and the explanation combinations supply the integration of what and why the step happened and the whole process becomes transparent to the student.

Problem Space	System's Comments:
External_Force_A: 10N Mass_A: 3 kg Mass_B: 7 kg 1 Mass_A&B: 10 kg	Step 1: For a system comprising two components, the mass of the whole system is evaluated by the algebraic sum of the masses of their individual components. $M_{A\&B} = M_A + M_B$

Figure 10: The working pad and the corresponding system responds

6 Conclusions

Case-based reasoning (CBR) is a versatile AI technology and can been found in many industrial applications [2] but its potential in training and education is still not fully explored. The work reported here may serves to strengthen the position of CBR in developing instructional systems.

The contribution of the paper to the endeavour of computer-assisted learning is twofold. Firstly, technically, a formal framework for representing cases for learning purposes has been developed. Its formal basis provides a solid foundation for developing robust computer-based instructional systems. With this methodology, the developers only have to concentrate their effort on collecting and encoding the cases. The rest (generating relevant instructional activities from the cases) will be taken care of by the system. This approach offers another advantage for rendering the cases amenable to further analysis. This may be used for providing tool to verify the case-base for internal consistency. Secondly, educationally, our approach paves the way for systematic educational software engineering because it is built on the needs of users, not the technical skills of the developers. Often, educational software developers have adopted a technically-driven design philosophy. Such systems run the risk of losing sight of what is actually happening in the real learning setting.

Our approach avoids the temptation of jumping onto the hi-tech bandwagon but, instead, concentrates firstly on what the students really need. The reason we developed a case-based learning system was not due to the existence of the technology and trying to find what role the technology can play in learning. Rather, we choose

to develop a case-based approach to learning because students do learn from referring to past cases. This principle we consider crucial in determining if the final system proves itself useful to our students. Other features of the system have not been described due to space limitation. They include generating different categories of questions from a case graph [6] to promote self-explanation from the students. The model proposed in this paper can also perform qualitative reasoning [4], and causal order between system variables can be represented succinctly.

References

[1] Anderson, J.R. et al., "Learning to Program in LISP", Cognitive Science, Vol. 8, pp.87-129, (1984).

[2] Bergmann, R. et al., "Developing Industrial Case-based Reasoning Applications", Springer-Verlag, (1999).

[3] Fung, P.W., "Designing an Intelligent Case-based Learning Environment with Conceptual Graphs", PhD Thesis, Dept. of Computation, UMIST, England, (1996).

[4] Fung, P.W., "Generating Qualitative Predictive Problems in a Case-based Physics Tutor" In B. du Boulary & R. Mizoguchi (Eds.) Artificial Intelligence in Education: Frontiers in Artificial Intelligence and Applications Vol. 39, Ohmsha: IOS Press, (1997).

[5] Fung, P.W. & Adam, A., "Conceptual Graphs for Similarity Measurement in a Case-based Physics Problem Solver" In Proceedings of AI-ED 95 – World Conference on Artificial Intelligence in Education. Washington D.C, (1995).

[6] Fung, P.W. & Adam, A., "Questioning Students on the Contents of Example Solutions" In Proceedings of European Conference on Artificial Intelligence in Education, Lisbon, (1996).

[7] Kolodner, J. "Case-Based Reasoning" San Mateo, CA: Morgan Kaufmann Publishers, (1993).

[8] LeFevre, J.A. & Dixon, P., "Do Written Instruction need Examples?" Cognition and Instruction, Vol.3, pp.1-30, (1986).

[9] Peterson, J.L., "Petri Net Theory and the Modeling of Systems." Englewood Cliffs. NJ: Prentice-Hall Inc. (1981).

[10] Sanders, K.E., Kettler, B.P. & Hendler, J.A. "The Case for Graph-Structured Representations" In D.B. Leake & E. Plaza (Eds.) Case-based Reasoning Research and Development. Lecture Notes in Artificial Intelligence, Vol. 1266, pp. 245-54, Springer-Verlag, (1997).

[11] Schank, R.C., "Case-based Teaching: Four experiences in Educational Software Design." Report No.7, The Institute of Learning Sciences, Northwestern University, (1991).

[12] Self, J., "Student Models in Computer-aided Instruction." International Journal of Man-Machine Studies, Vol. 6, pp. 261-76, (1974)

[13] Sowa, J., "Conceptual Structures: Information Processing in Mind and Machine" Reading, MA: Addison-Wesley, (1984).

[14] Specht, M. & Weber, G., "Episodic Adaptation in Learning Environments" In Proceedings of the European Conference on Artificial Intelligence in Education, Lisbon, pp.171-176, (1996).

Use of abstraction levels in the design of intelligent tutoring systems

Ruddy Lelouche
Département d'informatique
UNIVERSITÉ LAVAL Québec G1K 7P4 CANADA
Tel.: (+1-418) 656 2131, ext. 2597 Fax: (+1-418) 656 2324
e-mail: lelouche@ift.ulaval.ca

In problem-solving domains (mathematics, physics, engineering, and most "exact science" disciplines), the knowledge to be acquired by the student is twofold: the knowledge describing the domain itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an educational system in such a domain encompasses three knowledge types: the domain knowledge and the problem-solving knowledge, i.e. the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process. In this paper, we show how these three knowledge types can be modelled, how they should interact with one another in order to fulfil the system educational purpose, and above all how abstraction levels can shed a uniformizing light on the system operation and make it more user-friendly. We thus hope to bring some contribution to the general and important problem of finding a generic architecture to intelligent educational systems.

Keywords: **Intelligent tutoring systems, Abstraction, Complexity, System Design**.

1 Introduction

Teaching is a very complex process in itself. Teaching strategies and activities vary considerably: by the role and autonomy they give to the learner, by the type of interactions they trigger with him/her, by the evaluations they enable, by the relationships they make between theory and practice, etc. From that last perspective, teachable domains can be classified according to the type of knowledge to be acquired by the student: "know", "know-how", and "know-how-to-be". Examples of such domain types are respectively: anatomy or a language grammar, the skill to solve a mathematical or medical problem, and the capability to adapt to one's environment or to deal with personal relationships. We are more particularly interested in the second type.

Moreover, almost all teachable domains vary in complexity, from simple basics to relatively complex problems to solve or situations to deal with. Thus, a student should learn and master the basics of such a domain before being taught wider notions. And when a human tutor detects errors or misunderstandings, s/he usually draws the student's attention on a small subset of the involved knowledge, so that s/he may correct his/her errors and/or misunderstandings, focusing either on a given set of the domain knowledge or on the scope of knowledge involved by a given problem.

Problem-solving (PS) domains are the ones in which we are interested here. In such a domain, the knowledge to be acquired by the student is twofold: the domain knowledge itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an education-oriented system in such a domain, which we here call a PS-ITS, must encompass three knowledge types: the domain knowledge and the problem-solving knowledge, constituting the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process.

This paper has two goals: to present each of the three types of knowledge involved in a PS-ITS, and for each type of knowledge, to show how abstraction and complexity levels appear and how we think it is possible to deal with them.

To do so, we present in section 2 our domain knowledge modelling and how we exemplify it in a few PS domains . Next, in section 3, we focus on the advantage of separating the problem-solving knowledge from the domain knowledge in a PS-ITS, and we present some problem-solving activities in various domains. In section 4, we briefly describe some principles of tutoring knowledge modelling in a PS-ITS. In each of these three sections, we show how to use abstraction and complexity levels, exemplifying them in a few typical domains.

Finally, section 5 presents the educational interests of using abstraction and complexity levels when modelling the three types of knowledge involved in a PS-ITS.

2 Domain knowledge

In order to describe the domain knowledge, we first present its characteristics in a general PS-ITS (section 2.1). We then show how we model it in a few PS domains (section 2.2), and how such an approach lets us introduce the notions of abstraction and complexity levels (section 2.3).

2.1 General

The first type of knowledge involved in every ITS, the *domain knowledge* (DK), contains all theoretical and factual aspects of the knowledge to be taught to the student. Although its specific structure can be varied, it typically may include concepts, entities, and relations about the domain [Brodie & al., 1984], object classes and instances [Kim & Lochovsky, 1989], possible use restrictions, facts, rules, [Kowalski, 1979; Clocksin & Mellish, 1981], semantic or associative networks [Findler, 1979; Sowa, 1984], etc.

The main system activities centred on this knowledge type are:

- providing the student with theoretical presentations and explanations about the various knowledge elements and their relationships in the teaching domain;
- providing the other modules of the ITS, i.e. problem-solving and tutoring, with the necessary background of domain knowledge that they need.

2.2 Application to a few domains

In the particular domain of **cost engineering**, Lelouche and Morin [1997; Morin, 1998] represent this type of knowledge with concepts, relations, and a special case of relations modelled as concepts, the factors.

Concepts can be basic entities like investment, interest, investment duration, present and future values, compounding, compounding period, interest rate, annuity, etc.

Concepts are linked to one another by various types of *relations*: either usual knowledge-representation relations, like *subclass of*, *element of*, *sort of*, etc., or numerical relations represented by formulæ. Such a formula is:

$$F = P \times (1 + i)^n \tag{1}$$

which, given the present value P of an investment over n periods at interest rate i, computes the corresponding future value F of that investment.

A formula such as (1) can be rewritten as:

$$F = P \times \Phi_{PF,i,n} \text{ where } \Phi_{PF,i,n} = (1 + i)^n \tag{2}$$

$$P = F \times \Phi_{FP,i,n} \text{ where } \Phi_{FP,i,n} = (1 + i)^{-n} \tag{3}$$

thus introducing the *factors* $\Phi_{PF,i,n}$ and $\Phi_{FP,i,n}$. Factors allow us to separate their definition (rightmost equalities above, a quantitative aspect) from their possible uses in the application domain (leftmost equalities, a qualitative aspect).

Similarly, the factor $\Phi_{AP,i,n}$ converts a series of identical annual amounts A into a unique present value P:

$$P = A \times \Phi_{AP,i,n} \text{ where } \Phi_{AP,i,n} = \frac{(1+i)^n - 1}{i\,(1+i)^n} \tag{4}$$

Actually, $\Phi_{AP,i,n}$ is a sum of Φ_{FP} factors (see details below). The factor $\Phi_{PA,i,n}$ does the reverse process:

$$A = P \times \Phi_{PA,i,n} \text{ where } \Phi_{PA,i,n} = \frac{i\,(1+i)^n}{(1+i)^n - 1} \tag{5}$$

There exist other factors converting gradient and geometrical series of amounts into a present or future value; such factors are also computed as a sum of $\Phi_{FP,i,n}$ factors.

In **geometry**, *concepts* are basic elements like point, line, segment, and later more elaborate elements like angle, then square, rectangle, circle, ellipse, polygon, solid, polyhedra, etc. Examples of *relations* between concepts are adjacency (of segments or angles), parallelism (of lines or line segments), complementarity (of angles), etc. Upper-level, more abstract concepts are then defined using lower-level ones, as well as relations between these lower-level concepts (e.g. a triangle is a set of three segments adjacent pairwise).

In **mechanical physics**, we similarly introduce *concepts* like time, distance, velocity, acceleration, mass, force, and later angle, angular velocity, angular acceleration, moment of inertia, torque, etc. We also introduce *relations* like the one defining velocity as the variation in distance per unit of time, or the one stating that the acceleration a is proportional to the force F that is applied. Introducing a generalization from linear to rotational movement, another relation defines angular velocity as the angle variation per time unit, and another one states

that the angular acceleration α of a solid body is proportional to the torque τ that is applied to it. More precisely, we have:

for a linear movement $F = M \times a$ where M = total mass of the body (6)

and for a rotational movement $\tau = I \times \alpha$ where $I = \sum (m \times r^2)$ (7)

Equation (6) expresses Newton's second law. In equation (7), I is the moment of inertia and is expressed in terms of the mass m of each of its particles and of its distance r to the rotation axis. Obviously M in equation (6) and I in equation (7) play the role of factors as in cost engineering.

Although formulæ like (2-7) related to factors essentially involve quantitative aspects, the similarities and differences between them, and the circumstances regulating the use of either one, are of a deeply qualitative ground. In **cost engineering**, if the *value* of factors is indeed calculated from two or three numerical parameters, the *context* in which they are defined depends on whether we have to timewise move a unique amount or a series of amounts, identical or not, or conversely to compute an equivalent annual amount, etc. In fact, this context corresponds to the type of conditions that govern the investment, or *investment conditions type*, without respect to the amounts and durations involved, and is thus essentially qualitative. Similarly, in **physics**, the proportionality between force and linear acceleration, or between torque and angular acceleration, expresses a qualitative relationship. Only if the need arises, the exact relationship can be expressed by using the actual mass M in formula (6) or the result of the computation of the moment of inertia I in formula (7), which in the general case involves a simple or double integral. Indeed, did not the use of qualitative reasoning originate with qualitative physics?

2.3 Towards the notions of abstraction and complexity levels

In most PS-domains, abstraction most obviously appears in the *definition of the domain concepts* themselves, like we showed in all three domains above.

If *factors* are used in the domain, it also appears that every factor introduces an additional intermediate abstraction level between the concepts implied in the equation defining it. For example, in the case of formula (1), or equivalently formulæ (2) and (3) in **cost engineering**, or in the case of formula (6) and (7) in **physics**, we have (see figure 1):

- at the bottom of the hierarchy, basic concepts "making technicalities explicit" if necessary: the interest rate and the number of periods in cost engineering, the distribution of mass within the body volume in physics ;
- above them, concepts more fundamentally related to the problem being solved, namely in cost engineering the present and future values of the investment, and in physics the force and acceleration, or the torque and angular acceleration;
- between these two levels, an intermediate level created by the introduction of the factor (Φ_{FP}, Φ_{PF}, M, or I).

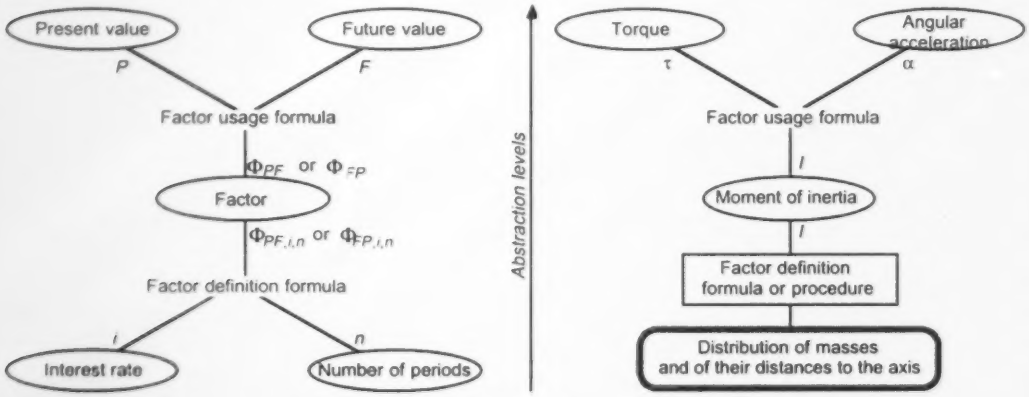


Figure 1 — Representation of a factor as a concept.

That intermediate status of the factor, originally just an intermediate variable in computations [see formulæ (2) and (3) or (6) and (7)], makes it appear as a pedagogically oriented concept, which clearly separates

- the computational, quantitative aspect of the factor definition,
- from the practical, qualitative aspect of the factor usage in a domain problem.

This follows the theory [Lenat & al., 1979; Malec, 1989] according to which the use of multiple *abstraction levels* eases the modelling process and simplifies inferences which may be made on the domain concepts.

Most interestingly, our scaffolding approach can be made more general, at least in certain domains, where we may present and use higher-level factors built upon these first ones. Indeed, in cost engineering, "above" Φ_{FP} and

Φ_{PF}, the factors used to express the present and future values of a series of identical amounts (and vice versa) are a first way to generalize this concept hierarchy. For example, the Φ_{AP} factor is indeed a sum of Φ_{FP} factors:

$$\Phi_{AP,i,n} = \sum_{k=1}^{n} \Phi_{FP,i,k} = \sum_{k=1}^{n} (1+i)^{-k} = \frac{(1+i)^n - 1}{i\,(1+i)^n}$$

where the last expression results from computing the geometrical series shown. This example constitutes a proof of (4), but also and mainly shows that the Φ_{AP} factor is at a higher level than Φ_{FP}. Note that this refers to a *complexity level* rather than an abstraction level, since it is due to the way the Φ_{AP} factor is defined and computed. Similarly, the moment of inertia of a complex body can be (and often is) computed as the sum of elementary moments of inertia, and therefore is at a higher complexity level.

3 Problem-solving knowledge

In order to describe the problem-solving knowledge, we now present the general characteristics regarding problem-solving knowledge modelling in a PS-ITS (section 3.1). As we did in section 2, we then examplify our model in the cost-engineering and physics domains (section 3.2).

3.1 General

The second type of knowledge is specific to PS-domains [Ganeshan & al., 2000; Gertner & VanLehn, 2000], henceforth to PS-ITSs. We call it *problem-solving knowledge* (PSK). It contains all inferential processes used to solve a problem resulting from the instantiation of a practical situation based on the domain knowledge [Kowalski, 1979; Patel & Kinshuk, 1997]. In other words, in order to be able to solve a problem, the problem-solving knowledge needs a theoretical background, which is found in the domain knowledge. The processes stored in PSK may be represented in various ways, using any or all of: logic [Kowalski, 1979], procedural networks [Brown & Burton, 1978], semantic networks with procedural attachments, (augmented) transition networks, production rules [Goldstein, 1979; Anderson & Reiser, 1985], etc.

The main system activities centred on this knowledge type are:
- providing the inferential tools for problem solving, by the system or by a student;
- providing the inferential tools for coaching a student in a problem-solving session.

The main advantage of separating the problem-solving knowledge from the domain knowledge is that it emphasizes the distinction between the domain itself and the skills used to solve a practical problem in that domain, thus simplifying the learning process. That knowledge separation into DK and PSK is common to all PS-domains; this is why we believe that PS-ITSs, which are aimed at helping the student to learn how to solve problems, should display the same knowledge separation.

Besides, following [Lelouche & Morin, 1997], we can use — we believe in a novel way — that separation between DK and PSK to define four *generic operating modes* in a PS-ITS, based on the type of knowledge involved (DK or PSK), and on who "generates" that knowledge (the system or the student).
- In *domain-presentation mode*, the student asks the system some information about a domain theoretical element, and the system reacts by transferring to the student the required information or knowledge. The knowledge involved in this category is always DK, system-generated.
- In *demonstration mode*, the student asks the system to solve a practical problem or to coach him/her while s/he solves a problem. In the first case, the problem typically comes from the student him/herself, whereas in the latter one the problem typically comes from the tutoring system. In either case, the main level of knowledge involved is PSK, system-generated.
- In *domain-assessment mode*, the system prompts the student to develop a domain element, and the student thus expresses his/her understanding of that element. If judged necessary, the system may then intervene to correct that understanding. The knowledge involved in this mode is essentially DK, student-generated.
- Finally, in *exercising mode*, the system prompts the student to solve a practical problem. The student then solves it step by step, showing what s/he understands of the involved problem-solving knowledge and of the associated domain knowledge. If necessary, the system may decide to intervene in order to help him/her reach his/her goal or to correct it. The knowledge involved in this mode is naturally PSK, student-generated.

3.2 Application to a few domains

Several problem-solving activities are domain-independent, like:
1. identify and instantiate the given problem data;
2. identify and instantiate the expected result(s);
3. apply a formula;
4. apply a theorem.

Every PS-domain also has its own domain-dependent activities. For example, in **cost engineering**, we have:

5. draw a temporal diagram to represent the relevant events;
6. compare amounts located at the same date;
7. compare amounts located at different dates;
8. add amounts situated at the same date;
9. add amounts situated at different dates;
10. choose a reference date;
11. move an amount from one date to another;
12. collapse a series of periodic amounts into one single amount;
13. explode an amount into a series of periodic amounts.

Similarly, in the subset of **mechanical physics** refered to above, some activities would be:

14. compute a torque;
15. compute an angular acceleration;
16. compute a moment of inertia.

In many cases, a PS activity can be rephrased into, restated as, a different one, of a lower *abstraction level*, because more immediate, more down-to-earth, closer to the problem to be solved. For example, in **mechanical physics**, assuming that the torque and the moment of inertia of a given solid body are known (either given or previously computed), the activity "compute the angular acceleration" (activity 15) would be expressed as, or translated into "apply formula (7)", an instance of the lower-level activity 3. A PS physics tutor is presented in [Gertner & VanLehn, 2000].

Sometimes, a PS task may also be divided into smaller ones, letting us use again the notion of *complexity levels* in these tasks. For example, in **cost engineering**, comparing two amounts situated at different dates implies:

- first, choosing a reference date at which to make the comparison;
- then, moving either (or both) amount(s) from its (their) present date(s) to the reference date;
- finally, comparing the amounts, now both located at the same reference date.

These subactivities (of types 10, 11, and 6 respectively in the sample list above) thus appear to be of a lower complexity level than the initial one (of type 7). However, it is interesting to note that, although activity 7 turns out to be more complex than activity 6 (the latter is part of the former), both are stated using the same *abstraction level*.

It may also happen that some lower-level activities can *only* appear as components of a higher-level one. For example, still in **cost engineering**, the activity "drawing a temporal diagram" (type 5 above) implies the following tasks, which can only be accomplished as part of that activity (hence their identification in this paper from 5a to 5d):

5a. draw a timeline to encompass all periods implied by the problem data;
5b. draw arrows representing the amounts involved in the problem data;
5c. if necessary, split an amount (or each amount in a series) to simplify the computations;
5d. qualitatively draw a special arrow to represent the expected result of the computations to be made.

In that case, activity 5 is both of a higher complexity level and of a higher abstraction level than any of its subactivities.

4 Tutoring knowledge

We now briefly present the *tutoring knowledge* (TK) in order to help the reader to better apprehend the relationships of that knowledge with DK and PSK. This third type of knowledge contains all tutoring processes enclosed in the ITS. It is not directly related to the teaching domain or to problem solving, but is there to help the student understand, assimilate, and master the knowledge included in DK and PSK [Gagné & al., 1992; Gagné & Trudel, 1996].

The main system activities using TK are:

- ordering and formatting the topics to be presented to the student;
- monitoring a tutoring session, i.e., triggering the various tutoring processes according to the system tutoring goal and the student's actions; such monitoring may imply giving explanations, asking questions, changing to another type of interaction, etc.;
- in a PS-domain, while the student is solving an exercise, monitoring the student's PS activities: understanding and assessing these activities, giving advice to correct or optimize them, giving hints or partly solving the exercise at hand (as required by the student or by the tutoring module), etc.;
- continuously analysing the student's progress in order to improve the efficiency of the tutoring process.

The advantage of separating the tutoring knowledge from the knowledge of the domain to be taught has been emphasized long ago [Goldstein, 1977; Sleeman & Brown, 1982; Clancey, 1986; Wenger, 1987], and lies in the reusability of TK in various domains. In the case of PS-domains, the domain to be taught clearly encompasses both DK and PSK; indeed, the term "domain knowledge" applies to DK if referring to the knowledge type, and to DK + PSK if referring to the knowledge to be acquired. Therefore, as shown in the introduction, in a PS-ITS, knowledge ends up being separated into three categories rather than two.

We believe that the tutoring processes are triggered by *tutoring goals* which depend on the current educational setting and learning context. The role of tutoring goals has been discussed in several works, some of the most recent ones dealing with task and instruction ontologies [Mizoguchi, 1999]. In the current state of our research, our assumption is the following: the underlying hierarchy or hierarchies governing the way tutoring processes interact with one another is not related to these processes *per se*, but rather to the *current goal* to be attained when they are invoked. The current goal varies during the session, depending on the student's actions or difficulties, following a dynamically built abstraction-based hierarchy. If our assumption turns out to hold, then the *dynamic structure of educational goals and subgoals* — which itself depends on the student's desires or abilities, the main underlying objective of the tutoring system, the student's state (e.g. of tiredness, etc.) and performance, etc. — will determine the succession of tutoring processes activated and tutoring interactions taking place. To our knowledge, the use of abstraction levels to induce a dynamic hierarchy of tutoring goals is new, as is the assumption that such a hierarchy will play a major role in activating the various tutoring processes and student–system interactions. Learning goals have been used by Towle [2000], but only for educational simulations, not for tutoring processes in general.

5 Educational interests of abstraction and complexity levels

In the above sections, we have sketched a complexity– and abstraction–level approach to help model the three types of knowledge involved in a PS-ITS. In this section, after clarifying these notions in section 5.1, we present the educational interests of our model. Sections 5.2 to 5.4 focus on the type of knowledge respectively presented in sections 2 to 4. Section 5.5 summarizes that discussion with some overall pedagogical interests of our approach.

5.1 An informal definition of abstraction and complexity levels

In the first three sections, we only refered to abstraction and complexity levels. Here, we try to define these notions better and in a more generally applicable way. Both notions are based on the common notion of *refinement*, but differ in how the refinement is made: in a general way, abstraction is based on, or refers to, *expressiveness* or *scope*, whereas complexity is based on, or refers to, the *number of components*.

For *concepts*, taking geometry as an example, a polygon has a higher abstraction level than a triangle or a square, because the number of sides in a polygon is indefinite, but a lower abstraction level than a set of segments, because these segments in a polygon are forced to be pairwise adjacent; a square has a higher complexity level than a triangle, because it has more sides, and also because there are constraints (re. size and angles) between these sides. In cost engineering, we saw that the factors Φ_{FP} and Φ_{AP} are expressed at the same abstraction level, although Φ_{AP} has a higher complexity level, because of the way it is defined and computed. A similar distinction between abstraction levels and complexity levels holds for the *relations* they express.

For *problem-solving activities*, we have similar distinctions, as shown in section 3.2 with several examples.

Finally, the same holds for *tutoring processes*, or student–system interactions. For instance, the ITS task of tutoring a student while s/he is solving a problem will turn out to be of a higher complexity level if the student encounters more difficulties, although the abstraction level of this process does not depend on the particular student being tutored or on the particular problem being solved. On the other hand, reacting to a student request for hint, or for explanation, is of a lower abstraction level than the previous one; however, there again, the complexity of that task will depend on the specific student request (some simply formulated questions may have quite complex answers!), and will eventually depend also on the way the student is or is not satisfied with the initial system response.

Such level-based distinctions have also been made, for example, by Mizoguchi [1999]. Note that, although the statement "A has a higher abstraction level than B" is clear and may be true, we think that the number of abstraction levels between A and B is not defined, because that number would depend on the modelling effected; for the same reason, it would be even more meaningless to try to assign a numeric value to these levels.

5.2 Domain modelling

The definition of concepts from the simplest to the most complex induces a long-time known *presentation order* for the subject matter. Similarly and in addition, the factor hierarchy described in section 2 for cost

engineering lets us derive an *order for the presentation of factors* to the student, from the lowest (simplest) level up to the highest, i.e. with increasing understanding complexity. That does not imply that such an order is unique, or even the best (e.g. a student's personal interests might make another order more motivating for him/her), but it is justified by our model. This presentation order may itself induce, like for domain concepts, a possible *order for prerequisites*; e.g., if a student experiments difficulties to deal with Φ_{AP}, has s/he well mastered Φ_{FP}, a conceptually simpler factor?

Moreover, the factor-induced intermediate abstraction levels will permit the ITS to exhibit a *sharper modelling of conceptual errors*. For example, the source of an understanding error concerning one of the two relations in equation (2) or (3) or (7) (see also figure 1) is much easier to identify using the corresponding factor, either as a definition error or as a usage error, than an error concerning the global equation (1), where the definition and application relationships are not made explicit, and therefore are impossible to distinguish. Similarly, an error using a Φ_{AP} factor may be diagnosed as possibly resulting from an insufficient mastery of the simpler factor Φ_{FP} as concept (which in turn will be diagnosed as related either to its definition, or to its usage). Similarly in physics, if the student stumbles on concepts like angular acceleration or moment of inertia, has s/he mastered the simpler although similar concepts of acceleration or mass?

Abstraction and complexity levels on domain elements (concepts and relations, possibly including factors) can then be used to introduce various abstraction levels of explanations. Such explanations can then be tailored to the student's questions, and adapted to the reminders possibly needed by the student.

5.3 Problem-solving modelling

The problem-solving activities briefly presented in section 3 naturally display abstraction and complexity levels. Indeed, a standard problem can usually be divided, possibly in more than one way, into major steps, which can then be split into simpler substeps. As explained in 5.1, each subactivity in that case may be either simpler (lower complexity level) or more concrete (lower abstraction level) than the original one, or both.

In a first development stage, these abstraction and complexity hierarchies, both for domain elements and for problems to be solved, can ease the *definition of exercise types* to be implemented into the ITS, and can ease the tutor module task of *choosing the exercise type* to challenge the student with. Later, once that basic system is operational, the same hierarchies can help develop an automatic *exercise generator* dealing with the domain elements to be mastered by the student. That approach will then help the student to acquire a better critical mind about the relative importance of *problem-solving* knowledge vs. *domain* knowledge.

As for domain elements, abstraction and complexity levels can be used to introduce various types of *explanations* about the problem to be solved, varying both in abstraction (focus level, terms used, references made) and in complexity (quantity of details, possible references to the problem substeps). Moreover, our approach will lead the student to focus specifically on the *activities* for which s/he needs more tutoring, with the abstraction and complexity levels appropriate to his/her individual case.

5.4 Tutoring modelling

Functioning mode		Domain-presentation mode	Demonstration mode	Domain-assessment mode	Exercising mode
Main type of knowledge involved		Domain knowledge	Problem-solving knowledge	Domain knowledge	Problem-solving knowledge
Student's main goal		To learn (acquire or improve knowledge)		To assess his/her learning	
Direction of the knowledge transfer		System → Student		Student → System	
Typical interaction	Trigger (start)	The student asks the system... some information about a domain theoretical element	to solve a practical problem or to coach him/her in problem solving	The system prompts the student... to develop a domain element	to solve a practical problem
	Knowledge exchange	The system presents... the requested element	a possible solution to the requested problem	The student presents his/her view of... the requested element	a possible solution to the given problem
	Result (closure)	The student expresses his/her understanding... of the element	of the problem solution	The system assesses the student's answers, and possibly corrects them	

Table 2 — Characteristics of the four typical operating modes of a problem-solving ITS.

As presented in section 3.1, the distinction between DK and PSK leads to the natural definition of four operating modes. Their main characteristics are recalled in Table 2.

The successive tutoring goals aimed at by the system (see section 4) are likely to result in a chain of recursive calls of the tutoring processes invoked. This recursivity will or will not be direct, depending on the tutoring interaction types being chained: the system might decide to temporarily change between interaction types, e.g. to respond to the student's actions or requests. However, the potential length of this chain is only apparent: because of the abstraction hierarchy of tutoring goals, each newly invoked process will be called with a *narrower scope* and/or a *lower complexity*, which eliminates the risk of "forgetting" the initial tutoring goal or of running into an infinite loop.

More generally, tutoring the student may take the form of explanations, guidance, hinting, or even partially solving the exercise on which the student is currently working. The level at which these will be conducted will depend on the current tutoring goal (see section 4). We think our approach is close to that of VanLehn and his colleagues [2000], although they focused their attention on fading and deepening (a particular result of the tutoring interactions) rather than on the current pedagogical goal (the cause for these interactions).

5.5 Overall interests of these abstraction and complexity levels

Abstraction levels are certainly not new. What we think is new is to use them in a systematic way to shed a uniformizing light on the ITS design and operation, and to make it more user-friendly once implemented.

First, they may help to give a better tailoring to the system tutorial interventions to fulfil the student's needs and the system tutoring goals, thus improving its conviviality and efficiency.

Then, all the capabilities presented above should result in smoother, more "natural", human-like interactions with the student. This improved ability to reproduce a human teacher's behaviour contributes again to make the system more user-friendly, and more likely to be used by the student.

Finally, although that aspect is not in the scope of this paper, our refinement of the three types of knowledge as described in sections 2 to 4 paves the way to the conception and the implementation of a structured error model, and eventually of a structured student model.

6 Conclusion

This presentation of a possible knowledge structure for PS-domains, which emphasizes the separation between domain knowledge and problem-solving knowledge, shows how a general functioning theory of such an ITS — namely the four operating modes described in sections 3.1 and 5.4 — can naturally be derived.

Moreover, the abstraction and complexity levels highlighted throughout this paper can be used as a common guideline to help finding an appropriate representation for each one of the three knowledge type, and thus can help creating more efficient ITSs. More generally, this guideline can shed a uniformizing light on the system design, although it has never been used in a systematic way in the design or implementation of an ITS.

We thus hope to bring some contribution to the general and important problem of finding a generic architecture for intelligent tutoring systems.

References

[1] Anderson John R.: *Cognitive Modelling and Intelligent Tutoring*. Washington, DC: National Science Foundation (1986).

[2] Anderson John R. & B. J. Reiser: "The LISP Tutor". *Byte* **10**, no. 4, p. 159-175 (1985).

[3] Brodie Michael L., John Mylopoulos & Joachim W. Schmidt, eds.: *On Conceptual Modelling, Perspectives from Artificial Intelligence, Databases, and Programming Languages*. New York: Springer Verlag (1984).

[4] Brown John S. & Richard R. Burton: "Diagnostic models for procedural bugs in mathematical skills". *Cognitive Science* **2**, p. 155-192 (1978).

[5] Clancey W. J.: "Qualitative student models". *Annual Review of Computer Science* **1**, p. 381-450 (1986).

[6] Clocksin William F. & Christopher S. Mellish: *Programming in Prolog*. Berlin: Springer-Verlag (1981).

[7] Findler Nicholas V., ed.: *Associative Networks*. Orlando, FL: Academic Press (1979).

[8] Frasson Claude, Gilles Gauthier & Alan Lesgold, eds.: *Intelligent Tutoring Systems*, Proc. of the *3rd International Conference, ITS'96*, Montréal (Canada), 12-14 June 1996. LNCS 1086, Berlin: Springer (1996).

[9] Gagné Denis & André Trudel: "A highly flexible student-driven architecture for computer-based instruction". [Frasson & al., 1996], p. 66-74 (1996).

[10] Gagné Robert M., Leslie J. Briggs & Walter W. Wager: *Principles of Instructional Design*, fourth edition (1st edition published in 1974). Orlando, FL: Harcourt Brace Jovanovich (1992).

[11] Ganeshan R., W.L. Johnson, E. Shaw & B.P. Wood: "Tutoring diagnostic problem solving". In [Gauthier & al., 2000], p. 33-42 (2000).

[12] Gertner A.S. & K. VanLehn: "ANDES: a coached problem-solving environment for physics". In [Gauthier & al., 2000], p. 133-142 (2000).

[13] Goldstein Ira P.: *The Computer as Coach: an Athletic Paradigm for Intellectual Education*. AI Memo 389, AI Laboratory. Boston, MA: Massachusetts Institute of Technology (1977).

[14] Goldstein Ira P.: "The genetic epistemology of rule systems". *International Journal of Man-Machine Studies*, Vol. 1, No. 1, p. 51-77 (1979).

[15] Gauthier Gilles, Claude Frasson & Kurt VanLehn, eds.: *Intelligent Tutoring Systems*, Proc. of the *5th International Conference*, Montréal (Canada), 19-23 June 2000. LNCS 1839, Berlin: Springer (2000).

[16] Kim Won & Frederick H. Lochovsky, eds.: *Object-Oriented Concepts, Databases, and Applications*. ACM Press, Reading, MA: Addison-Wesley Publ. (1989).

[17] Kowalski R.: *Logic for Problem Solving*. Berlin: North-Holland (1979).

[18] Lelouche Ruddy & Jean-François Morin: "Introduction of pedagogical concepts in domain modelling for an ITS". *European Journal of Engineering Education*, Vol. 23, No. 2, p. 255-271 (June 1998).

[19] Lelouche R. & J.-F. Morin: "Knowledge types and tutoring interactions in an ITS in a problem-solving domain". *FLAIRS 1997, Proc. of the 10th International FLorida Artificial Intelligence Research Symposium*, Daytona Beach (Florida, U.S.A.), 10-14 May 1997, p. 62-66 (1997).

[20] Lenat D., F. Hayes-Roth & P. Klahr: *Cognitive Economy*. Working Paper HPP-79-15, Stanford Heuristic Programming Project, 46 pages. Stanford, CA: Stanford University (June 1979).

[21] Malec J.: " Knowledge elicitation during dynamic scene description ". *ACM–SIGART Newsletter: special issue on knowledge acquisition*, No. 108, p. 162-163 (April 1989).

[22] Mizoguchi Riichiro: "Ontology-awareness for intelligent instructional systems". Invited talk *Advanced Research in Computers and Communications in Education, Volume 1* (G. Cumming, T. Okamoto & L. Gomez, eds.), Proceedings of the *7th International Conference on Computers in Education, ICCE 99*, Chiba (Japan), 4-7 November 1999. Amsterdam, Netherlands: IOS Press, p. 45-52 (1999).

[23] Morin J.-F.: *Conception of an intelligent tutoring system in cost engineering: knowledge representation, pedagogical interactions, and system operation*. Master Thesis, Département d'Informatique. Québec, Canada: Université Laval (1998).

[24] Patel Ashok & Kinshuk: "Intelligent tutoring tools in a computer-integrated learning environment for introductory numeric disciplines". *Innovations in Education and Training International*, Vol. 34, No. 3, p. 200-207 (1997).

[25] Sleeman D. H. & John Seely Brown, eds. : *Intelligent Tutoring Systems*. London: Academic Press (1982).

[26] Sowa John F.: *Conceptual Structures*. Reading, MA: Addison-Wesley (1984).

[27] Towle B.: "Using student task and learning goals to drive the construction of an authoring tool for educational simulations". In [Gauthier & al., 2000], p. 173-181 (2000).

[28] VanLehn K., R. Freedman, P. Jordan, C. Murray, R. Osan, M. Ringenberg, C. Rosé, K. Schulze, R. Shelby, D. Treacy, A. Weinstein & M. Wintersgill: "Fading and deepening: the next steps for ANDES and other model-tracing tutors". In [Gauthier & al., 2000], p. 474-483 (2000).

[29] Wenger, Étienne: *Artificial Intelligence and Tutoring Systems*. Los Altos, CA: Morgan Kaufmann (1987).

Using Decision Networks for Adaptive Tutoring

Peng-Kiat Pek* and Kim-Leng Poh**
** Singapore Polytechnic*
500 Dover Road, Singapore 139651
E-mail: baiychen@magix.com.sg
*** National University of Singapore*
10 Kent Ridge Crescent, Singapore 119260
E-mail: isepohkl@nus.edu.sg

This paper reports a research project that uses dynamic decision networks in providing teacher with information on students' misconceptions and students with online tutoring. A set of Bayesian networks models the conditional dependencies between learning objectives and goals which are associated with the curriculum. Student's responses to test items are recorded and transformed as evidence into a relevant Bayesian network to compute his likely state of knowledge mastery. The personalized Bayesian network is then converted into a dynamic decision network by adding utility and decision nodes. Tutoring policy is followed through and necessary responses from the student are solicited using additional test items. The student Bayesian network is updated when new evidence arrives, and is again converted to a decision network to determine the next tutoring policy. This process is repeated until the pre-requisites are achieved. The results generated by the system and future directions are discussed.

Keywords: **Adaptive Tutoring, Decision Network, Student Model, Tutoring Strategy**

1 Introduction

Tutoring of students is an ill-structured problem that is characterized by:
(a) Uncertainty of student's knowledge mastery.
(b) Preferences, judgements, intuition, and experience of teacher.
(c) Criteria for decisions are occasionally in conflict, and highly dependent on the teacher's perception.
(d) Decisions must be achieved in limited time.
(e) The student's mental states evolve rapidly.

This study attempts to address these issues by using an intelligent *decision-theoretic* approach. The framework of this research has contributed to the development of an intelligent decision support system called *iTutor*, for tutoring Engineering Mechanics at Singapore Polytechnic.

Probabilistic or Bayesian networks [9] and decision analysis [5] have shown to be capable of solving many real-world problems involving reasoning and decision marketing under uncertainty. Bayes's nets allow for efficient reasoning and inference about combination of uncertain evidence. Student modeling with Bayes's nets for intelligent tutoring had achieved successes, see for example in [16], [11], and [2]. The differences in these works lie mainly in the choice of variables and granularity of the models.

In Villano's Knowledge Space Theory, the basic unit of knowledge is an *item* (in the form of a question). The student's knowledge state is defined as the collection of items that the student is capable of answering. The collection of all feasible states is called the *knowledge structure*, and it is connected by the *learning path*. By incorporating uncertainty at each node, the knowledge space can be transformed into a Bayes's net. The Bayes's net then constitutes a student model where probabilistic reasoning can be performed when evidence is available. Reye on the other hand, uses pre-requisite relationship of domain knowledge and *dynamic belief network* for modeling student's mastery of a topic. Finally, Conati and Vanlehn make use of teacher's

solution(s) as the ideal model to track student's faulty knowledge as the student solves a problem.

Our work here differs from others in that we construct relevant Bayes's nets by modeling learning objectives (**L**), evidence (**V**) from student responses, application of knowledge to different situations (**C**), and learning goal (**G**). A decision network [3] is then formed by adding decision and utility nodes to the Bayes's net. As it is computationally intractable to track student's solution in real time, we use sequential decisions to generate tutoring strategy that anticipates students' responses.

This paper is organized as follows: Section 2 provides an overview of the conceptual framework for the decision theoretic intelligent tutoring system called *iTutor*. The transformation of student's responses to evidence is discussed in Section 3. Section 4 illustrates how the student model is constructed from a set of Bayes's nets, while Section 5 presents the tutoring strategy model using two-step look-ahead decision network. The results of a typical *iTutor* session are illustrated in Section 6. It emphasizes the automation of decision network construction and shows that when student's responses are available, the system is able to diagnose student's misconceptions and to provide adaptive tutoring using the generated strategy. Finally, we conclude by discussing future directions.

2 Framework of Adaptive Tutoring

Figure 1 shows the essential components of adaptive tutoring in *iTutor*.

The ***Evidence Model*** converts the student response (x_{ijk}) to item i into evidence of knowledge mastery for a relevant learning objective (v_{jk}).

The ***Student Model*** consists of a set of Bayes's nets with nodes that are either Evidence, Case, Learning Objective, or Goal. These nodes are initialized with prior information from the teacher's judgement and theoretical probability models. The student model can be subsequently updated to reflect a student's knowledge mastery when evidence is available.

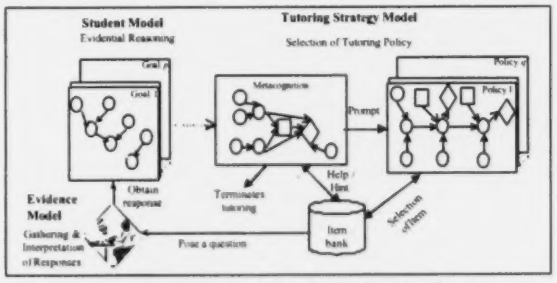


Figure 1: Inferencing Kernel of Adaptive Tutoring

The ***Tutoring Strategy Model*** uses decision-theoretic approach to select *satisfying* [14] learning objectives for tutoring student. The metacognition sub-module determines the appropriate tutor's action: providing more help or hint, prompting another question, or stop the tutoring session. Dynamic Decision Network (DDN) provides approximate solutions for partially observable Markov decision problems, where the degree of approximation depends on the amount of look-ahead. If the decision is to obtain evidence of mastery on a learning objective, an item of difficulty b_i that matches the student's ability θ_j will be selected. Student's response is collected, evaluated, and transformed into evidence at the relevant nodes in the student model. The *chance* nodes in DDN are updated and a decision policy is generated. In this way, the system is able to adapt tutoring to the needs of the student and achieve the objectives of the curriculum.

3 Evidence Model

The student's responses are processed in the evidence model. Let V_{jk} be the evidence node that indicates the student's (j) mastery state of learning objective k. Let X be the set of responses and $x_{ijk} \in X_{ik} \subseteq X$ be the response to item i which tests the kth learning objective, then

$$\Pr(v_{jk} \mid x_{ijk}) \propto \Pr(v_{jk}) \prod_i \Pr(x_{ijk} \mid v_{jk})$$

where $\Pr(v_{jk})$ is the prior probability which can be obtained statistically from past data. $\Pr(x_{ijk} \mid v_{jk})$ is the likelihood of correct-answer score. An example of the likelihood function is $\delta_k \exp(-b_i v_{jk})$ where δ_k is the importance of knowing learning objective k so as to answer item i correctly and b_i is the difficulty index for item i.

4 The Student Model

BEST COPY AVAILABLE

The Student Model consists of a set of Bayes's nets, and each Bayes's net models the student' s mastery of a key concept (*goal*). In Section 4.1, the structure of the student model is defined. The construction of Bayes's net and the conditional probability assignment are discussed in Section 4.2. Instantiation of an evidence node activates a message passing process in the Bayes's net. This process results in the updating of marginal probabilities at the nodes. Most commercial software for developing probabilistic network possesses efficient algorithm [1] for implementing the message passing process.

4.1 Semantics of the Student Model

The Student Model is a directed acyclic graph (DAG) that represents a joint probability distribution of a key concept and several learning objectives. A node represents the learning objective as a random variable, and an arc represents possible probabilistic relevance or dependency between the variables. When there is no arc linking two nodes, it indicates probabilistic independence between the variables. In this study, the variables are classified into four types Evidence, Case, Learning Objective, and Goal as shown in Figure 2.

Symbol	Name	Function
N_v	Evidence Node	It contains knowledge states based on student' s response.
N_C	Case Node	It contains knowledge states that reflect ability to apply knowledge in different situations (cases).
N_L	Learning Objective Node	It contains knowledge states of key learning objectives (defined in the syllabus).
N_G	Goal Node	The concept student is expected to know. Each Bayes' s net must have at least one Goal node.

Figure 2: Types of Nodes in Student Model

More formally, a student model in *iTutor* is a DAG $\mathfrak{I} = (N, \psi)$ where $N = N_v \cup N_L \cup N_C \cup N_G$ are the nodes such that N_v is a set of evidence nodes, N_L is a set of learning objective nodes, N_C is a set of case nodes, and N_G is a set of goal nodes.

$\psi = \psi_{pL} \cup \psi_{pC} \cup \psi_{pG}$ are the arcs such that $\psi_{pL} \subseteq N \times N_L$ are arcs into learning objective nodes, $\psi_{pC} \subseteq N_v \times N_C$ are arcs from evidence nodes to case nodes, and $\psi_{pG} \subseteq (N_L \cup N_G) \times N_G$ are arcs from learning objective or goal nodes to the goal nodes.

Notice that evidence nodes have no parent node and only evidence nodes could be the parents of case nodes. Goal nodes are always sink nodes and they have parents that are either learning objective nodes or goal nodes. This signifies that mastery of a concept (goal node) is dependent on the mastery of learning objective(s) and/or pre-requisites (other goal nodes).

4.2 Construction of a Bayes's Net

Figure 3 shows a Bayes's net on mastery of a hypothetical concept (*goal*) "XYZ". Each node has three knowledge states: *non-mastery*, *partial-mastery*, and *mastery*. The granularity of Bayes's net depends on the number of nodes and its states. However, as the granularity becomes finer, the number of entries in the conditional probability table grows exponentially.

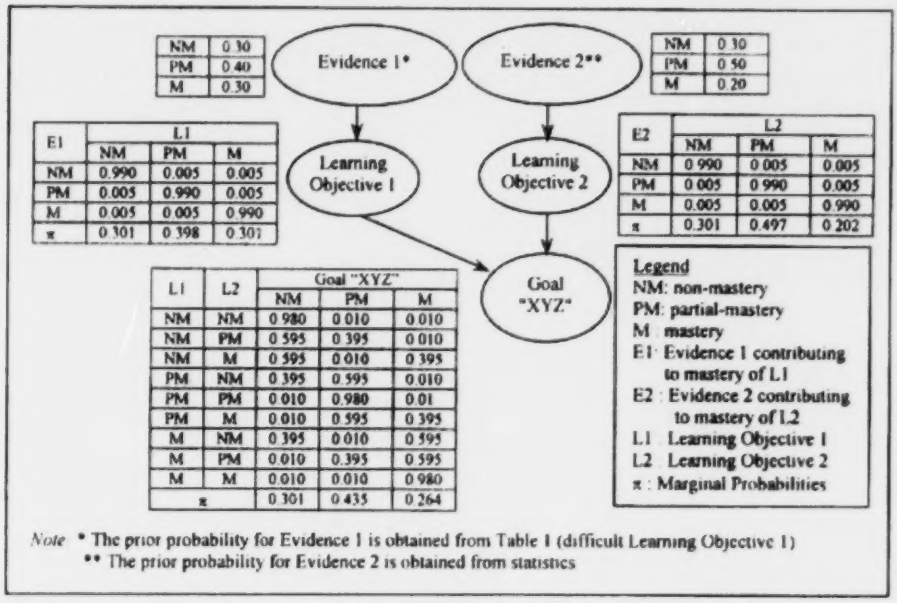
Table 1 Category of Difficulty in Mastering the Learning Objective

	Probability values		
Category	NM	PM	M
very easy	0.001	0.009	0.99
easy	0.01	0.09	0.90
fairly easy	0.05	0.15	0.80
Neutral	0.10	0.20	0.70
fairly difficult	0.20	0.30	0.50
difficult	0.30	0.40	0.30
very difficult	0.40	0.50	0.10

Values at the root nodes are known as *prior* probabilities while that at other nodes are *conditional* probabilities. To use the probabilistic network the random variables must be initialized with prior probability values. These values may be based on teacher's belief or past statistics. An intuitive method is to generate a probability table based on seven-category of the difficulty of learning objectives (see Table 1). These probability values are to be input as the prior probability of the related evidence. The teacher also has the flexibility to amend the values based on their belief and context of usage. On the other hand, the probability values can be obtained from statistics of previous tests/examinations. A simple procedure for the use of past statistics is:

a) Assigned learning objectives to each question;

b) Enter student's responses (in terms of percentage) for the questions that she has answered;
c) Compute the average number of students (in percentage) for each mastery category: 040 (non-masterystate), 40-70 (partial-mastery state), and 70-100 (mastery state).



NM	0.30
PM	0.40
M	0.30

NM	0.30
PM	0.50
M	0.20

E1	L1		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.398	0.301

E2	L2		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.497	0.202

L1	L2	Goal "XYZ"		
		NM	PM	M
NM	NM	0.980	0.010	0.010
NM	PM	0.595	0.395	0.010
NM	M	0.595	0.010	0.395
PM	NM	0.395	0.595	0.010
PM	PM	0.010	0.980	0.01
PM	M	0.010	0.595	0.395
M	NM	0.395	0.010	0.595
M	PM	0.010	0.395	0.595
M	M	0.010	0.010	0.980
π		0.301	0.435	0.264

Note * The prior probability for Evidence 1 is obtained from Table 1 (difficult Learning Objective 1)
** The prior probability for Evidence 2 is obtained from statistics

If a probability distribution function is able to describe the statistics, it can be used. In Figure 3, the values Pr(E2=non-mastery) = 0.30, Pr(E2=partial-mastery) = 0.50, and Pr(E2=mastery) = 0.20 are obtained from statistical data for this particular evidence. It is acceptable for another person to assign different probability values so long as it is consistent with the probability axioms [12]. Since the decision theory approach is normative rather than descriptive, it is able to explain the actions of the decision-maker.

For any node n_q, the conditional probability required to specify the Bayes's net is computed based on the relative importance (*weights*) of the parent nodes $pa(n_q)$ to itself.
If the state of n_q and $\mathrm{pa}(n_q)$ is the same, then $\Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} (w_{pq} - (c-1)\kappa)$

$$\text{else } \Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} \kappa \qquad (1)$$

where c *is the number of states and* $0 \le w_{pq} \le 1$.

κ is a constant and a measure of uncertainty such as careless errors, lucky guesses, changes in the student knowledge state due to learning and forgetting, and patterns of student responses unanticipated by the designer of the student model. The weights w_{pq} are either assessed based on the teacher's subjective judgment or past students' responses to closely related items.

Referring to Figure 3, since Learning_Objective_1 is dependent only on Evidence_1, $w_1 = 1$. Let Learning_Objective_1 has greater influence on mastery of goal "XYZ" than Learning_Objective_2, $w_{1g} = 0.6$, and $w_{2g} = 0.4$. Assigning $\kappa = 0.005$, the conditional probability tables can be computed using equation (1).

5 Tutoring Strategy

When a student logon to *iTutor*, the system automatically searches his ability index from the database. The

BEST COPY AVAILABLE

ability index is either computed from the tests taken previously by the students, or from her knowledge states in the student model (see Section 5.1). Human tutors consider the student's emotional state in deciding how to respond. Similarly in *iTutor*, the system considers factors such as response time, response pattern, student knowledge structure to determine tutoring actions: give more hint, help, ask another question, or stop the tutoring session. If the decision is to prompt another item, a learning objective and an appropriate item will be selected to coach her (see Section 5.2). Section 5.3 discussed the generation of tutoring strategy based on student's response.

5.1 Mapping of Knowledge State to Student Ability

Let the student's ability be $\theta_j = (\theta_{j1}, \theta_{j2}, .. \theta_{jm}, .. \theta_{jp})$. A function $f: v_{jm} \rightarrow \theta_m$ where v_{jm} is the evidence at the goal node (g) of mth Bayes's net. An example of such function is:

$$\theta_{jm} = \begin{cases} N(1.5, 0.6) & v_{jm} \geq 0.7 \\ N(0.5, 1) & 0.4 < v_{jm} < 0.7 \\ N(-1, 1.2) & v_{jm} \leq 0.4 \end{cases}$$

where $N(\mu, \sigma)$ denotes a *normal* distribution with mean μ and standard deviation σ

The computed ability index is then used to categorize (Advance, Intermediate, or Beginner) the student. An appropriate learning objective is selected based on the heuristic shown in Table 2. Value assignment is used to compute the path length of Bayes's net and is used as preference for tutoring policy generation. They are as follow:

$$\begin{aligned} &\text{value}(G) = 0 \text{ for } G \in \{\text{Goal nodes}\} \text{ and } \text{ch}(G) = \phi \\ &\text{value}(\text{ch}(N)) = 0 \text{ if } \text{ch}(N) = \phi \\ &\text{value}(N) = \text{value}(\text{ch}(N)) + 1 \text{ for node } N \\ &\text{where } \text{ch}(N) \text{ is the child node of } N \end{aligned} \quad (2)$$

Table 2 Search Heuristic for Identifying Learning Objective for Coaching

Category	Identification of first Learning Objective for tutoring
Advance	25% of pathLength*
Intermediate	50% of pathLength
Beginner	75% of pathLength
New#	50% of pathLength ($\lceil$pathLength/2$\rceil$)

Note:
- * pathLength denotes max(value(N)) $\forall N \in$ Bayes's net.
  The value(N) assignment is stated in equation 2
- \# The category *New* refers to students who login to the system the first time

5.2 Item Selection

Each item is tagged with an index (b_i) that estimates the minimum ability to answer it correctly with 0.5 probability. The items are assumed to be independent and the index obtained through statistic of past students' attempts or assigned using teacher's belief. Subsequent update of item difficulty index may be performed through item response theory [4] such as Rasch model [10].
From the set of items related to a learning objective, an item i is selected based on: $\theta_j - b_i < \varepsilon$ where ε is a

Table 3 Utility of Various Outcomes

Condition / Expression	Preference
Decision: Stop	
$S(N)$ = "M" & value(N) = 0	1
$S(N)$ = "N" & value(N) = 0	0
k = number of $N_k \in \{(N_k, S_k)\}$ with same S_k	$1 - k/5$
number of tries, n, for the same learning objective	$1 - n/5$
Decision: Ask item on same N	
$S(N)$ = "M"	0
$S(N)$ = "N"	1
$S(N)$ = "P"	$\left(1 - \frac{\text{value(N)}}{\text{pathLength}}\right) \times \eta$ where η is a constant
Decision: Ask item on ch(N)	
$S(N)$ = "M"	1
$S(N)$ = "N"	0
$\gamma = \max(\Pr(S(\text{ch}(N)) = \text{"M"} \mid x = 1) - \Pr(S(\text{ch}(N)) = \text{"N"} \mid x = 0)$	
Decision: Ask item on pa(N)	
$S(N)$ = "M"	0
$S(N)$ = "N"	1
$\gamma = \max(\Pr(S(\text{pa}(N)) = \text{"M"} \mid x = 1) - \Pr(S(\text{pa}(N)) = \text{"N"} \mid x = 0))$	

Remarks: $S(N)$ denotes the knowledge state of node N
ch(N) denotes child node of node N

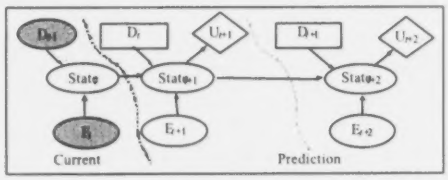


Figure 4: Dynamic Decision Network

Table 4 Utility Values for Item Difficulty Level Selection

Current Knowledge State ($State_i$)	Current Response (E_i)	Next Question Typ (D_{i+1})		
		Easy	Ave.	Diff
Non-Mastery	Correct	-0.2	1	0
	Wrong	0.4	-0.2	-0.4
Partial Mastery	Correct	-0.4	0.2	1
	Wrong	0.4	1	-0.2
Mastery	Correct	-0.4	-0.2	-0.2
	Wrong	-0.2	0.2	-0.2

BEST COPY AVAILABLE

pre-defined small value. This ensures selected item is challenging and likely to be solved by the student. Teacher's solution will be displayed upon student's request so that she can learn from her mistake. This strategy assumes student's ability is dynamic and can be raised to higher levels through self-paced computer-aided tutoring.

5.3 Tutoring Policy Generation

To bring the probabilistic network one step closer to being a useful *intelligent tutoring system*, automated decision-making capability has been added. When asked to provide a tutoring policy for the student, the system generates a course of action based on her current mastery states. The tutoring policy aims to use a series of items with differing difficulty to determine more precisely her mastery of specific learning objectives. Items are categorized into *easy*, *average* and *difficult*. In this project, a two-step look-ahead dynamic decision network is recommended so as to compromise between the need to invoke policy generation routine for a decision and the long computing time to generate policy with many decisions.

Define a Bayes's net with nodes N,
E_t be the evidence at time t,
$Bel(N)$ be a vector of probabilities (updated over time),
d_t be the decision at time t, and
α be the normalization constant.

Prediction 1: $Bel^*(N_{t+1}) \leftarrow \sum_{N_t} Pr(N_{t+1} \mid N_t, d_t) Bel(N_t)$

Estimation 1: $Bel(N_{t+1}) \leftarrow \alpha Pr(E_{t+1} \mid N_{t+1}) Bel^*(N_{t+1})$

Prediction 2: $Bel^*(N_{t+2}) \leftarrow \sum_{N_{t+1}} Pr(N_{t+2} \mid N_{t+1}, d_{t+1}) Bel(N_{t+1})$

Estimation 2: $Bel(N_{t+2}) \leftarrow \alpha Pr(E_{t+2} \mid N_{t+2}) Bel^*(N_{t+2})$

Expected Utility: $\sum_{N_t} Bel(N_t) \max_{d_t} \sum_{N_{t+1}} Pr(N_{t+1} \mid N_t, d_t) \times \max_{d_{t+1}} \sum_{N_{t+2}} Pr(N_{t+2} \mid N_t, d_t, N_{t+1}, d_{t+1}) \times U(N_t, d_t, N_{t+1}, d_{t+1}, N_{t+2})$

Figure 5: Prediction-estimation Process

Figure 4 shows a dynamic decision network (DDN) used in this study. In addition to the decision nodes for current and future time steps, the DDN also contains the previous decision, D_{t-1}, as an evidence node. When the evidence for state t arrives, the probability distributions of $State_t$ are updated [1] using the prediction-estimation process (see Figure 5). After the initial prediction of probabilities (Bel*), $State_{t+1}$ estimates the new belief based on projected evidence [13]. This process repeats for $State_{t+2}$. Eventually, the expected utility is evaluated by a sequence of summations and maximizations. Tables 3 and 4 show the utility functions for node U_{t+2}. Selecting the outcomes with maximum expected utility value constitute the tutoring policy.

6 An Illustration

6.1 Construction of a Decision Network

In this project, the construction of all probabilistic networks is performed using Netica API [7]. A module leader enters the learning objectives and the weights of the key concept *Forces* using Microsoft Access [6]. The probabilistic values shown in Figure 6 are entered based on past examination results. By clicking the button "Model Construction", a Bayes's net (see Figure 7) and a decision network (see Figure 8) on "Forces"

Figure 6: A Snapshot on Data Entry for Model Construction

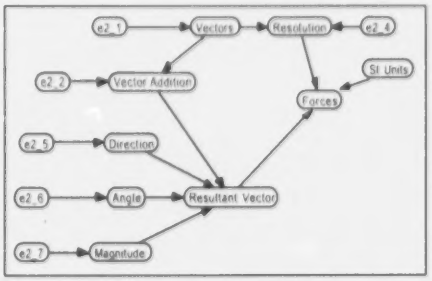


Figure 7: Bayes's Net on *Forces*

BEST COPY AVAILABLE

will be created. Teachers who are familiar with Netica application [8] can use the generated Bayes's net to perform *what-if* analysis. For example, a teacher may want to determine the likely student's improvement if he provides remedial instructions on "Resolutions of Vectors". He can do so by instantiating the evidence node *e2_4* to "Mastery" state, and observe the probability of mastery in the goal node labeled *Forces*.

6.2 Diagnosis of a Student's Misconceptions

The items to be presented to the students are coded by the teacher using Scientific Notebook [15]. With *iTutor*, the teacher is able to monitor student's progress through the database management tool. Figure 9a shows a snapshot of a student who had answered item "Force_001" correctly and partially correct for item "Force_004". The teacher can track a student's mastery states by clicking the "Advice" button. The system transforms the responses to evidence, and instantiates the evidence nodes in the Bayes's net as shown in Figure 9b. The posterior mastery states are displayed (see Figure 9c). The output also provides the teacher information on specific learning objectives to tutor. In addition, he can also examine the detailed strategy by clicking the "Tutorial Strategy" button. This action causes the generation of a decision network (see Figure 9d). Figure 9e shows items to be posed to the student if she continues with the online tutorial. At any stage, the teacher may intervene by providing personal coaching.

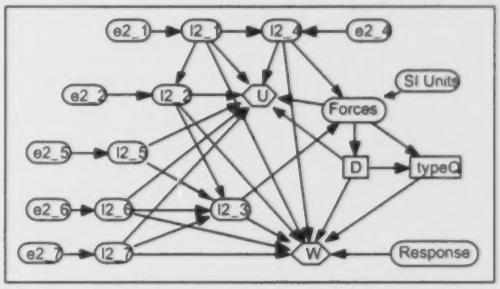


Figure 8: Decision Network on *Forces*

7 Conclusions

Presently, the students' knowledge states remain unchanged until additional evidence is available. The system also uses a constant learning rate for all students. One future direction is to include additional parameters to model student forgetting and learning rates. Another area is to provide a user interface for teachers not familiar with Netica application to perform *what-if* analysis. In this way, the teacher will be able to focus on student's issues rather than to learn another software tool. The next future direction is to include probability functions other than *Normal* distribution. This is essential when the ability distribution of student cohort is not symmetric.

A significant result of this project is the use of Bayesian networks to generate sound probabilistic inferences. Another contribution is the automation of decision networks construction. The recommended strategy is used in adaptive tutoring. With *iTutor*, teacher is able to monitor the student's progress and yet had time for lesson preparation and coaching of weaker students. In addition, the teacher has accessed to the student's knowledge states and actions taken by *iTutor* at every stage of the tutoring process. Moreover, it enables students to have tutorials customized to their needs.

References

[1] Castillo, E., Gutiérrez, J. M., & Hadi, A.S., "Expert Systems and probabilistic network Models", Springer-Verlag, (1997).

[2] Conati C. & Vanlehn K., "Teaching meta-cognitive skills: Implementation and evaluation of a tutoring system to guide self-explanation while learning from examples", Proceedings of AIED '99, 9th World Conference of Artificial Intelligence and Education, Le Man, France, (1999).

[3] Deam, T. L. & Wellman, M. P., "Planning and Control", Morgan Kaufmann, San Mateo, California, (1991).

[4] Hambleton, R.K., Swaminathan, H., & Rogers, H. J., "Fundamentals of Item Response Theory", Sage Publications, Inc, (1991).

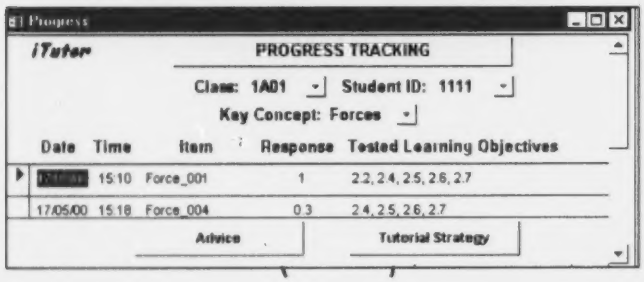
[5] Howard, R.A. & Matheson, J.E. "Readings on the Principles and Applications of Decision Analysis", Menlo Park, California: Strategic Decisions Group, (1983).

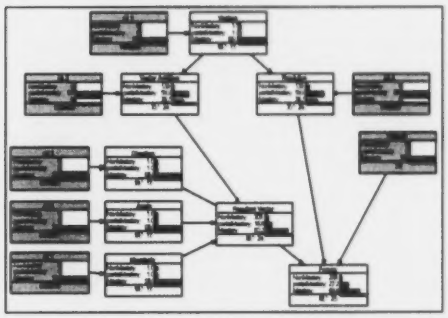
[6] Litwin, P., Getz, K., & Gilbert, M. , "Access 97 Developer's Handbook", 3d edition, Sybex Inc, (1997).

[7] Norsys, "Netica API Programmer's Library Reference Manual", version 1.06, Norsys Software Corp., (1999)

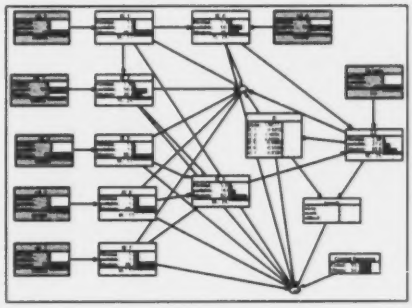
[8] Norsys, "Netica Application Reference Manual", version 1.12, Norsys Software Corp., (1999).
[9] Pearl, J., "Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference", Morgan Kaufmann Publishers, Inc, (1988).
[10] Rasch, G., "Probabilistic Models for Some Intelligence and Attainment Tests", Danish Institute for Educational Research, (1960).
[11] Reye, J., "A belief Net Backbone for Student Modeling, Proceedings of Intelligent tutoring Systems", Third International Conference, ITS ' 96, Springer-Verlag, (1996).
[12] Ross, S., "A First Course in Probability", Prentice-Hall International, Inc., 5th edition, (1998).
[13] Russell, S. & Norvig, P. , "Artificial Intelligence: A Modern Approach", Prentice Hall, (1995).
[14] Simon H.A., "The New Science of Management Decisions", New York: Harper & Row, (1960).
[15] TCI Software Research, "Scientific Notebook version 3.00 Build 939", Brooks / Cole Publishing Company, (1998).
[16] Villano, M., "Probabilistic Student Models: Bayesian Belief Networks and Knowledge Space Theory", Proceedings of Intelligent Tutoring Systems: Second International Conference, ITS '92, Springer-Verlag, (1992)

(a) User interface for teacher to track student's progress





(b) Bayes's net running as background process (transparent to user)



(d) Dynamic decision network running as background process (transparent to user)

Student ID: 1111

The student's mastery states are :

Learning Objective		NonMastery	Partial	Mastery	Value
l2_1	Vectors	0.010	0.010	0.980	93.75
l2_2	Vector Addition	0.014	0.599	0.387	69.87
l2_5	Direction	0.010	0.010	0.980	93.75
l2_6	Angle	0.010	0.010	0.980	93.75
l2_7	Magnitude	0.010	0.010	0.980	93.75
l2_3	Resultant Vector	0.030	0.168	0.802	85.71
l2_4	Resolution	0.014	0.599	0.387	69.87
g1	SI Units	0.000	0.000	1.000	95.00
g2	Forces	0.030	0.272	0.698	81.59

The expected score for this key concept Forces is 81.59.

Based on the knowledge states, you may want to provide coaching in Vector Addition, and Resolution.

(c) Output of student's mastery states

Student ID: 1111
With regard to the key concept Forces, the course of action is :

```
select average item from l2_2 (Force_002)
 if response is correct then
    select difficult item from l2_2 (Force_012)
    if response is correct then
          select average item from l2_4 (Force_013)
    else
          select average item from l2_2 (Force_021)
 else
    select easy item from l2_2  (Force_003)
    if response is correct then
          select average item from l2_2 (Force_017)
    else
          select easy item from l2_2 (Force_006)
```

(e) Output of tutoring strategy

Figure 9: Overview of an *iTutor* Session

BEST COPY AVAILABLE

ICCE / ICCAI 2000

Learning Societies in the New Millennium : Creativity, Caring & Commitments

Proceedings

Content

Full & Short Papers (Interactive Learning Environments)

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)
A Constructivist Virtual Physics Laboratory
A Distributed Backbone System for Community-Based Collaborative Virtual Universities
A Java-based Interactive Learning System of Junior High School Level Geometry
A Learning Environment for Problem Posing in Simple Arithmetical Word Problems
A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics : Through a Practice of Three Junior High Schools
A Web-based Interactive Exercise System for Learning Mathematical Functions
An experiment of situated learning on college students
An Environment for Learning by Design : In the Case of Learning of Search Algorithms
An Implementation of Campus Distance Learning System Using Multicast
An Interactive Game System to Stimulate Word Associations
An on-line ITS for elementary algebra
Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching
Construct in-service Training Web Site for School Teachers
Constructing a real-time CAD learning system based on OpenGL in Web-based environment
Design for Interactivity
Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments
Developing an Effective Web-Based Learning Environment for Overseas Chinese Education
Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology
Development of Cross-cultural Communication System and Web-based Japanese Education
DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment
EDASEQ - A log-file analysis program for assessing navigation processes
Evaluation of the Web-Based Learning System

Generating interactive explanations by using both images and texts for Micro World

Gold Peach Web Community 2000: A Research on Developing Web Based Interactive Learning Environment

Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships

Internet Video on Demand System of Classroom Teaching Cases

Learner Control in Technology-mediated Learning within a Constructivist Model

Learning Algorithm Design Through Interactive Simulation

Learning Digital Logic Design by Concept Mapping

Learning with Computer Mediated Communication in Remote Offcampus Cross-Cultural Contexts:Bridging the Information Gap

MathCAL's Diagnostic Sub-System

Meta-Knowledge Agent: Creates the context for thoughful instructional systems.

Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

Networked Constructive CAI System Putting Emphasis on Communication and Discussion - An Example of Proportion-concept in Mathematics of Elementary School

Real-Time Handwriting Communication Systems for Distance Education and Collaborative Learning

Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Students' thinking processes when learning with computer-assisted mass lectures

The Application of Scaffording Theory on the Elemental School Acid -Basic Chemistry Web

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

The externalization support system of self-explanation for learning problem-solving process

The Good, the Bad, the Ugly or Interactive Learning Environments

The Impact of Learning Style on Group Cooperative Learning

The usability aspects of an universal brockerage and delivery system for the Pan-European higher education

Virtual Inhabited 3D Worlds and Internet Based Learning Environments

Web Speaking: A Language Learning System in the Web

WWW-Supported Environments for Learning and Teaching Statistics

▲ HOME

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)

Stephen C F Chan*, Andy Wai, Jean Chow & Vincent T Y Ng
Dept. of Computing, Hong Kong Polytechnic Univ., Hong Kong
*csschan@comp.polyu.edu.hk

A web-based Computer-aided learning system for 3D - Surface Development Module (C3D-SD) has been developed for teaching the appreciation of 3D geometric shapes by unfolding the surface boundary of a solid object into a planar 2D pattern. The problem is similar to the problem of surface development in technical drawing and highly related to the reverse problem of folding a 2D shape into a 3D object, with practical applications in sheet metal work, pattern making, and packaging design. C3D-SD makes extensive use of animation, interactive control by the student, and quizzes to present the material and to engage the students. It makes use of the solid modeling library SML to create 3D solid shapes by Boolean combinations (union, intersection and difference) of primitive shapes, and Java3D for rendering and animation. It includes a Packaging Design Module which builds on the Surface Development module by automatically adding flippers and minimizing the rectangle enclosing the unfolded pattern. This system is the second installment of a series of CAL systems for Three-dimensional Geometry that the authors have been developing.

Keywords: **3D geometry, surface development, animation**

1 Introduction

Surface development is an important technique in design. Generally it involves unrolling a curved surface into a planar 2D pattern. Theoretically speaking only certain classes of surfaces are "developable" [Carmo 1976]. If, however (as is the case in many computer graphics systems), curved surfaces are approximated by sets of planar facets, then all curved surfaces can be unfolded into 2D planar shapes, although they may appear to be "unnatural" or "ugly". A related problem is the unfolding of the planar faces bounding a facetted solid object into a planar 2D shape. The inverse of the problem is folding a planar 2D shape into a 3D object, e.g., folded the card-board boxes for hamburgers in fast-food restaurants. These techniques have practical applications in sheet metal work, pattern making, packaging and package design, etc. [Giesecke et al 1997] This paper describes the development of a Web-based computer-aided learning system for teaching the appreciation of surface development/unfolding based on a polygonal representation of solid objects. It is a part of a series of Web-based tools for teaching 3D geometry that our group has been developing. A previous project focussed on sectioning and interactions between some primitive solid shapes was reported in [Chan et al 1999].

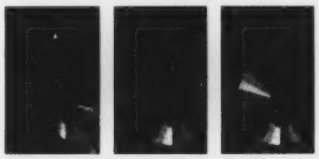
Traditional teaching materials on these topics were mainly text based. Better materials have graphics or charts in addition to plain texts. In presenting descriptive topics, this approach is adequate. However, in teaching three-dimension geometry, the two-dimensional and static presentation style is obviously not enough. The use of videos can be effective to some extend but it is still one-way communication and not interactive. A more effective alternative is to use real solid objects to help students visualize 3D shapes. But some objects are difficult to be made, and it is impossible for teachers and students to change the size, scale, shape or appearance of the object quickly.

In contrast to the limitation of 2D materials, videos and real 3D objects, a virtual environment can be a better approach in presenting certain 3D geometry problems. A virtual environment is a computer-generated environment in which 3D or even the forth dimension (time) can be presented through animation. Within the virtual environment, one can change the size, scale, shape or appearance of the virtual object interactively. To have a clearer look, one can zoom into the object. To see the inner structure, one can set part of the object

to be transparent. And geometry can be animated by transforming the object over time. And of course, an interactive teaching approach is much better than one way communication in enhancing student understanding. Finally, for purposes of accessibility and distribution, the Web is the ideal environment. These considerations drove the development of this project.

2 Overview of C3D-SD

The main problem tackled by C3D-SD is surface development, as illustrated below in Figure 1. In (a) is shown a solid cone shaped object with the top cut off at an oblique angle. In (b) the surface of the cone is in the middle of being unfolded. In (c) the unfolding is complete. Note that we had tried to keep the unfolded 2D shape connected. As a result, the curved conical surface itself became disconnected (actually connected through a single vertex). It is not difficult to see that it is possible to unfold the surface while keeping the curved conical surface connected.



(a) (b) (c)

Figure 1. Surface development in action.

C3D-SD is organized into three types of activities:

1. Tutorials - Students are guided through demonstrations, including: matching 3D solids to unfolded shapes, animations of unfolding (e.g., of the conical object in Figure 1), animations of folding 2D patterns into 3D solids, adding flippers to unfolded 2D patterns for fastening, reducing the size of the rectangle bounding the unfolded pattern, etc.
2. Free-form exercises - Students are allowed to explore the teaching material on their own. They are provided with numerous opportunities to interact with the teaching material, e.g., creating complex 3D solids by combining primitive shapes, selecting view points, putting different textures on objects, controlling the animation process, etc. The problems are similar to those presented in tutorials. But many more shapes are available for students to experiment with, for self-guided exploration and exercise.
3. Tests - Students can test their understanding of the material through multiple-choice tests. They are asked, e.g., to match an unfolded 2D shape with the solid object, such as illustrated below in Figure 2. If so desired, they can turn to the free-form exercises to explore the test shapes that they have problems with.

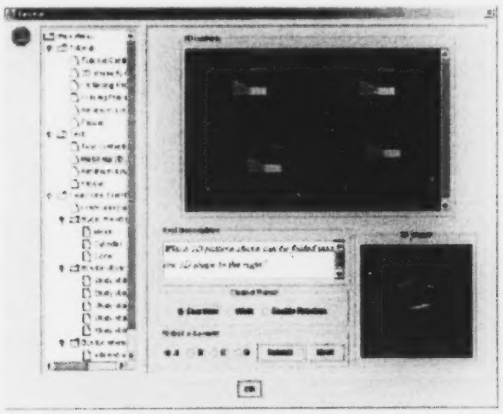


Figure 2. Sample multiple choice question.

The three types of activities are chosen for the following reasons. The tutorials provide core contents to be imparted to the students. The free form exercises allow the students to explore the subject on their own.

BEST COPY AVAILABLE

Different students with different backgrounds and learning styles benefit from different learning activities, hence both guided and sef-guided types of activities are provided. Finally, tests are developed to gauge the students' grasp of the material. It is expected that C3D-SD can be integrated with an intelligent tutoring system to provide a learning experience more tailored-made for the individual students.
C3D-SD focuses on five types of problems:

1. Matching 3D solid shapes with the corresponding unfolded 2D patterns.
2. Unfolding the surface boundary of a facetted solid and developing curved surfaces.
3. Folding 2D patterns into 3D solid shapes.
4. Simple packaging design: Adding flippers to the unfolded 2D pattern for fastening.
5. Simple packaging design: minimizing the rectangle bounding the unfolded 2D pattern.

3 The 3D Solid Design Module

Java was chosen to develop this system as it is a web-oriented development language and only a Java-enabled Web browser (e.g. Netscape, Microsoft Internet Explorer) is needed to access the Web pages without installing other plug-ins. However, it is difficult to build 3D applications using only the core Java classes. A Java-based high-level programming library, Solid Modeling Library (SML) [Chan et al 1998] is used in C3D-SD for designing 3D solid objects. SML supports the building of 3D solid objects through a set of atomic functions called Euler operators. These functions allow the incremental manipulation of Boundary Representation (B-rep) models, while processing the underlying well-formed data structure. It also supports the creation of solid primitives (block, cylinder, cone, sphere, torus) and Boolean operations (union, intersection, and difference) on solids and transformations (translation, rotation) of solid objects for easy creation of complex 3D solid shapes. For example, a hollow pipe can be created by the differencing (subtracting) a smaller cylinder from a larger cylinder. SML uses a hierarchical half-edge data structure that stores rich information about a solid model [Mantyla 1988], including solid-to-face, face-to-face, face-to-edge, edge-to-edge, edge-to-vertex, and vertex-to-vertex information. The data structure used in SML to represent the surface boundary of solid objects is illustrated in Figure 3.

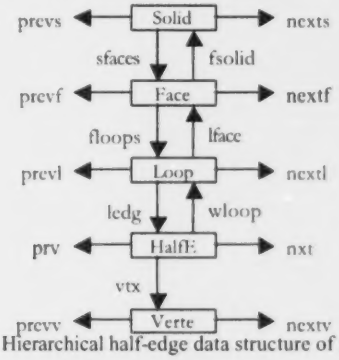


Figure 3. Hierarchical half-edge data structure of SML.

4 Surface Development

The process of surface development or unfolding is illustrated in Figure 4 using a cube as an example. Each face of the cube is coloured differently for easy identification. One might imagine that the unfolding starts by holding the bottom (red) face of the cube fixed to the horizontal plane, and rotating the rest of the cube about the edge linking the red face with the green face until the green face is in the same plane as the red face. This is followed by the blue face, then the yellow, then the light blue, ..., and finally the purple, until all faces lie in the horizontal plane.

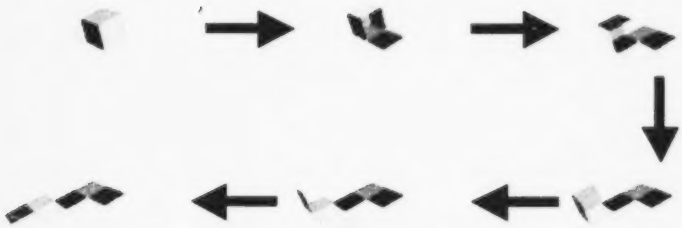


Figure 4. Unfolding a cube.

Sun Microsystems provides the Java3D application programming interface (API) which can be used to develop three-dimensional graphics applications and applets. It gives developers high-level constructs for creating and manipulating polygon-based 3D geometry and for constructing the structures used in rendering that geometry [Sowizral et al 1998, Sun 2000, Brown & Peterson 1999]. It is an object-oriented API, which can be used to construct individual graphics elements as separate objects and connect them together into a tree-like structure called the scene graph. It contains a complete description of the entire scene including the geometric data, attribute information and viewing information needed to render the scene from a particular point of view. Java3D provides a simple and flexible mechanism for representing and rendering scenes with lighting effect but it does not provide high-level construct for creating complicated solid object models. Hence SML was used to create the 3D solids which are subsequently converted into Java3D for rendering and animation.

4.1 Conversion from Solid (in SML) to Surface (in Java3D)

Each face object in SML is converted into a Java3D geometry object by using the information on the vertices of the face. As a result a SML solid object is converted into a group of Java3D geometry objects, each representing a face as illustrated in Figure 5. However, the data structures used to represent objects in Java3D and SML are different, and a conversion process is required to integrate the two systems to take advantage of their respective strengths to produce a more complete solution.

The displayable object in Java 3D is implemented by the Shape3D class. The Geometry and Appearance objects make up a Shape3D object. The Appearance objects controls the outlook of an object, e.g. color, material, etc. The Geometry object contains the vertexes information. We choose triangle as the basic shape in forming a geometry object because it contains the minimum number of vertexes that can form a plane. So that any face shape can be formed by the combination of triangles.

The conversion of an object represented in SML to one represented in Java3D involves 4 steps. Recall that each face in a SML Solid is converted into a Geometry object in Java3D.

1. Find the number of faces in the SML Solid object.
2. For each face, find the number of vertexes and the coordinates of each vertex.
3. Group three vertexes into a triangular strip.
4. Combine all triangular strips to form a Geometry object in Java3D.
5. Each Geometry object will result in a Shape3D object.
6. Group all Shape3D objects to form the representation of the solid in Java3D.

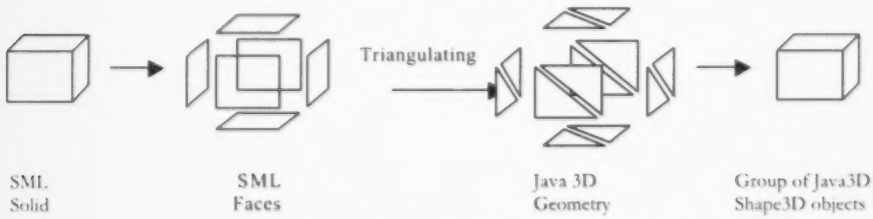


Figure 5. Converting an object from SML into Java3D.

4.2 Unfolding Path

In order to "develop" a surface approximated by a set of polygons, or to unfold the boundary of a solid, one needs to determine a connected path traversing all the faces one at a time. The path for unfolding can be

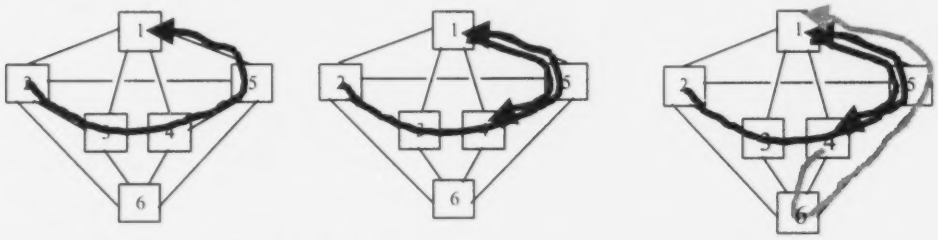
1. specified manually by the student,
2. pre-set in CAL-SD manually by the teacher, or
3. determined automatically by CAD-SD.

Automatic determination of the path for unfolding involves two steps:

- Determine the connectivity between the faces, e.g., in the form of a **graph** whose nodes are the faces, and an edge links a pair of neighbouring faces, and
- Traverse the graph to find the desired connected **path**(s) that visits each face one at a time and each face only once.

As the data structure of SML stores rich information of the complete solid, the connectivity relationships between faces can be easily derived. To derive the path(s) of traversing all faces one and only one at a time is a version of the traveling salesperson problem [Johnsonbaugh 1996]. It is a problem that is known to be hard (computationally expensive) for arbitrary graphs. In our system prototype, we chose to use exhaustive search because of its simple implementation. In future versions we may try to find a more efficient algorithm. In the default version of the algorithm, we simply try to find a solution (any solution) using the well-known **backtrack** algorithm. Firstly, pick up a face arbitrarily. Then, traverse to one of its neighbors. Repeat this process until all the faces have been visited. When a dead-end occurs, it will back track one or more steps to find another possible way (Figure 6). Dead-end means arriving at a face with no un-visited neighbours, while there are still un-visited faces remaining in the graph.

The algorithms implemented in C3D-SD so far traverse the faces of an object in a linear sequence, i.e., the unfolded faces form a linear chain of planar polygons. There are other alternatives, e.g., unfolding in two directions at the same time, resulting a Y shaped chain of polygons, etc. In future versions of the system, we will implement other unfolding algorithms.



(a) Dead-end occurs when traversing 2 ⇨ 3 ⇨ 4 ⇨ 5 ⇨ 1

(b) Backtracking from dead-end to face 4 to find another possible path

(c) Path 2 ⇨ 3 ⇨ 4 ⇨ 6 ⇨ 5 ⇨ 1 is one of the possible paths traversing all the faces one and only one time

Figure 6. Finding a possible path for unfolding the faces of a solid.

4.3 Heuristics for Developing Smooth Surfaces

In SML and in Java3D, as in many computer graphics systems, a curved surface (e.g. conical, cylindrical, etc.) is approximated by a set of planar polygons. If we choose a face' s neighbor in an arbitrary way, a solid may be unfolded into an "ugly" or "unnatural" shape because the set of polygons used to approximate a smooth surface my or may not be unfolded (smoothly) in an appropriate sequence. The left side of Figure 7 shows a cylinder approximated by a total of 22 plane faces (20 for the curved surface and 2 for the top and bottom faces). If we unfold the cylinder arbitrarily, for example, following the path 1-2-3- ..-21-22, may result in the patter in the middle. One of the polygons in the set used to approximate the curved cylindrical surface is disconnected from the other polygons in the set.

We observe, however, that in the set of polygons approximating a smooth curved surface, each polygon shares at least one edge with another polygon in the set, and the included angle between the two polygons is very close to, but just slightly less than, 180 degrees. Taking account of the Smooth Surface Heuristics discussed above, we can try to select the neighbor making the largest angle with the current face, instead of selecting an arbitrary one. Applying this heuristic to the unfolding of the cylindrical solid will result in the developed surface to the right.

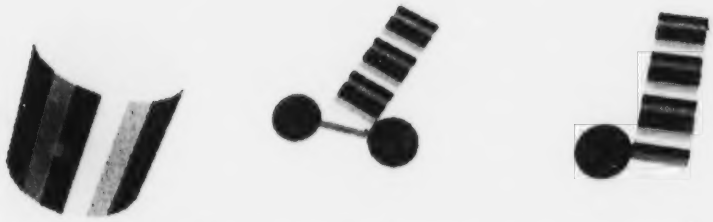


Figure 7. Arbitrarily unfolding the cylinder to the left may result in the pattern in the middle, and applying smooth surface heuristics will result in the pattern to the right.

5 Partially Automated Packaging Design

The design of packaging such as the rectangular boxes used to hold hamburgers at fast food restaurants involves the design of the 2D patterns that can be folded into such boxes. Similar problems exist in sheet metal work and other areas. The surface development/unfolding algorithm discussed above can be used to partially automate such designs.

5.1 Addition of "Flippers"

In addition, one also need to add "flippers" to some of the faces. Flippers are extended faces for putting glue or stickers in order to fasten two faces together when folding the planar 2D shape into a 3D solid shape. We have developed a simple algorithm to determine which edges of the faces of a solid model need to have flippers added. As flippers are used in connecting neighbouring faces, basically, all edges around a face need flippers except:

1. Edges that have been used as axes of rotation during the process of unfolding, i.e., edges between consecutive faces in the connected path for unfolding. (in Figure 8)
2. Edges for which flippers have already created on the opposite face (in Figure 8)

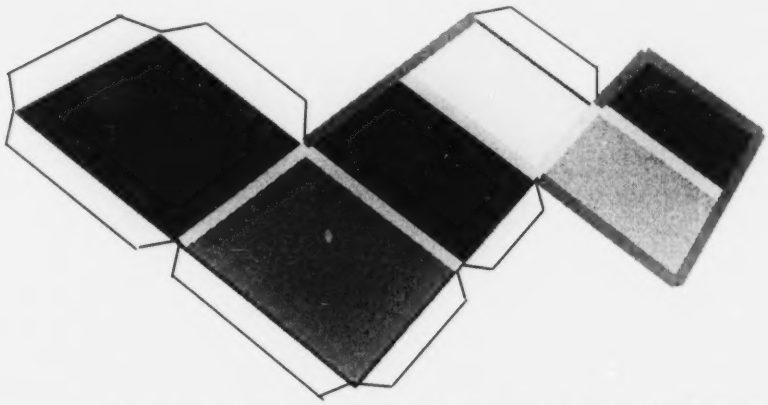


Figure 8. Creation of "flippers" in partially-automated design of packaging.

5.2 Minimizing Bounding Rectangle

The unfolding of 3D shapes are often constrained by certain requirements. For example, in the design of

packaging or sheet metal work, the unfolded shape may be the pattern to be cut out of a rectangular sheet, to be folded into the solid shape. In such cases it is desirable to reduce the amount of wastage by making the rectangular sheet required as small as possible. This translates into a requirement to minimize the area of the smallest rectangle enclosing the unfolded planar shape, as illustrated in Figure 9. Smallest rectangle enclosing the unfolded 2D shape. Such constraints may not be easy to satisfy absolutely. However, it is often enough to find a reasonable but not necessarily the perfect solution. In the case of determining a minimum bounding rectangle, it may be sufficient to find a local but not the absolute minimum. A local minimum can be determined by backtracking a few steps from the solution found to determine the set of related solutions and choose the one with the smallest bounding rectangle.

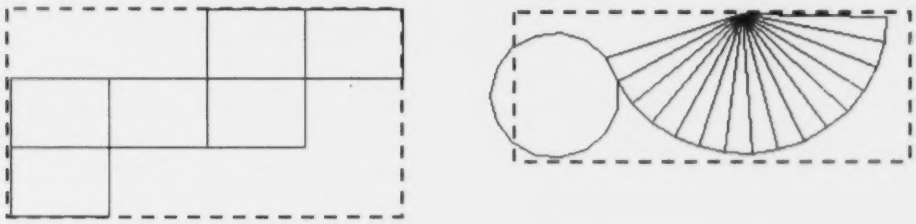


Figure 9. Smallest rectangle enclosing the unfolded 2D shape.

5.3 Some Examples Used in CAD-SD

Many examples of realistic solid shapes have been built into CAD-SD for illustrating and teaching surface development. Figure 10, Figure 11, and Figure 12 show the results of unfolding some common solid shapes, with "flippers" added automatically. For simple solid shapes it is fairly easy to deduce from the unfolded 2D patterns what the original 3D solid shapes are. Some of these are given to the students as exercises.

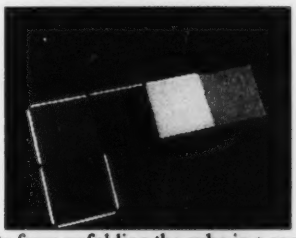


Figure 10. The 2D shape that results from unfolding the cube in a sequence different from that shown in Figure 8. Creation of "flippers" in partially-automated design of packaging., also with flippers added.

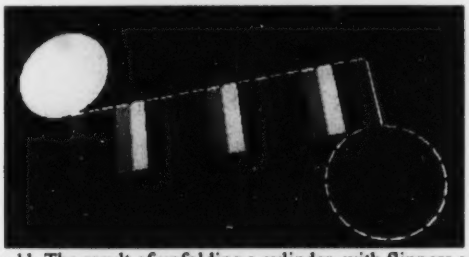


Figure 11. The result of unfolding a cylinder, with flippers added.

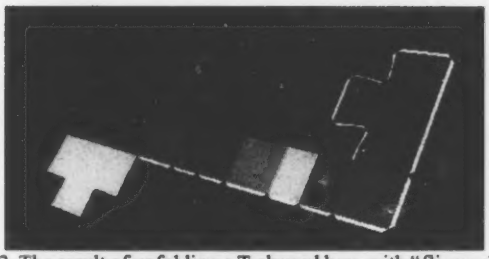


Figure 12. **The result of unfolding a T-shaped box, with "flippers"** added.

6 Conslusion

Using the SML solid modeling system and Java3D surface modeling and rendering system, we have successfully developed the basic structures of a CAL system that makes use of 3D modeling, animation, and interactivity to teach the appreciation of certain class of 3D shapes through surface development and unfolding. We have also shown how the unfolding algorithm can be used to partially automate the design of the 2D patterns used in certain sheet metal work and packaging design problems, by also automating the addition of flippers for attaching neighbouring faces, and reducing the rectangular sheet from which the planar (unfolded) patterns are to be cut out. Based on these basic functions, a comprehensive set of teaching materials can be developed to greatly enhance the degree and interactivity and effectiveness in the teaching of the appreciation of 3D geometry.

Acknowledgement

The work reported in this paper was partially supported by Hong Kong UGC/RGC/CERG grant PolyU 5102/97E.

References

[Brown & Peterson 1999] Brown, Kirk & Peterson, Daniel. *Ready-to-Run Java 3D*, Wiley, 1999.

[Carmo 1976] M P do Carmo. *Differential Geometry of Curves and Surfaces*. Prentice-Hall, 1976.

[Chan et al 1998] Chan, S., Ng, V., and Au, A.. "A Solid Modeling Library for the World-Wide Web", *Computer Networks and ISDN Systems*, Vol. 30, Issue 20-21, Nov. 1998, pp. 1853 – 1863.

[Chan et al 1999] Chan, Stephen, Lui, Kin Ming, Ng, Vincent & Chui, Raymond. "A Java-based Computer-Aided Learning System for 3D Geometry", *Proceedings, The 7th International Conference on Computers in Education*, Volume 1, November 4 – 7, 1999, Chiba, Japan, pp. 1010 - 1017.

[Giesecke et al 1997] Frederick E. Giesecke, Alva Mitchell / Henry Cecil Spencer, Ivan Leroy Hill / John Thomas Dygdon /James E. Novak with Shawna Lockhart. Technical Drawing, Tenth edition (p.626 - 640): Prentice Hall 1997.

[Johnsonbaugh 1996] Richard Johnsonbaugh. Discrete Mathematics, fourth edition (p.304 – 309, p.331 – 336): Prentice Hall

[Mantyla 1988] Martti Mantyla. An Introduction to Solid Modeling (p.161 – 174): Computer Science Press 1988

[Sowizralet al 1998] Henry Sowizral, Kevin Rushforth & Michael Deering. The *Java 3D API Specification*, Addison Wesley, 1998.

[Sun 2000] Sun Microsystems, Inc. *Java 3D 1.1 API Specification*, http://java.sun.com/products/java-media/3D/index.html, 14 April, 2000.

A Constructivist Virtual Physics Laboratory

Fu-Kwun Hwang
Dept. of Physics, National Taiwan Normal University
#88, Sec. 4, Ting-Chou Road, Taipei, Taiwan 116
Tel: +886-2-29346620
Fax: +886-2-29326408
E-mail:hwang@phy03.phy.ntnu.edu.tw

A virtual Physics Laboratory with 60+ physics java applets was established for student to play and enjoy learning physics (http://www.phy.ntnu.edu.tw/java/). Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher around the world already design worksheets incorporate with our java applets in their day-to-day instruction. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply their physics to everyday life. It can be operated as different kinds of modes, such as studying individually, study cooperatively and having lessons collectively etc. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

Keywords: **Java Animation, Virtual Laboratory, Computer Assisted Learning.**

1 Introduction

Many have predicted that the Internet, particularly the World Wide Web, will transform education. As more schools adopt the internet and more teachers and students become increasingly interested in the web-based activities, the need for easy-to-use and meaningful web learning environments has increased dramatically. At the same time, education research has shown that the learning style and student-centered learning are important to meaningful learning . Learning becomes an active process of discovery and participation base on self-motivation rather than on more passive acquaintance of facts and rules [8]. Current and emerging technological advances in information and communication technology make it possible to develop interactive learning environment to support new ways of learning. The most promising technologies are based on virtual machines, meta-languages, and open Internet standards. Although the Internet lowers the barriers to authoring and distribution of educational software, its ability to deliver active content may, in the long run, be more significant. Interactive learning environments are having an increasing role in teaching and learning, and are likely to play an important role in the future [10]. In particular, those tools that encourage/enhance discovery, creativity, and thinking are very much needed.

One of the most exciting developments is the integration of interactive software into web-based courses using the Java programming language. Many physics teachers and students recognized benefits of using the WWW to enhance teaching and learning, while they were using our Virtual Physics Laboratory (VPL). We have developed more than 60 physics related java applets, which become the core of VPL. Java animations developed at our site offer many advantages for the integration in our didactic concepts: All of our java animations visualize the effects and parameters of the related physics concepts or phenomena. It provides

user to manipulate all necessary parameters in a very intuitive and interactive way. Through modifying these parameters in java animation, students get a much better understanding of the underlying physics and mathematics aspects. Our tools are easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The most important implication of choosing a web-based technology is the way it facilitates sharing. We have received tremendous email feedbacks from physics teachers, parents and students all over the world. Many teachers developed their own worksheets in cooperated with our java applets, and used it in their classroom. Due to the slow connection over the Internet and many requests from educators, our VPL contents were distributed as mirror sites at more than 35 educational institutions around the world.

2 The Learning Process

Traditional approaches to education promote subject-based learning, which encourage teachers to focus on covering materials and students to adopt surface learning which fail to integrate knowledge [3]. When the television was invented half century ago, many had predicted that the television would transform the education. Some people thought if the best teacher were lectured on TV, all the students would be educated under the best environment. We have learned the lesson, teaching and learning is not delivery process between teacher and students. It appears that "learning consists of the growth of additional neural connections stimulated by the passage of electrical current along nerve cells (neurons) and enhanced by chemicals (neurotransmitters) discharged into the gaps (synapses) between neighboring cells" [11,12]. People learn differently and know things differently because they take different pathways on different occasions; which related to the context, their previous experiences, and their physical and emotional state. Not all pathways are accessed in the same way. However, as a particular pathway is re-used, additional connections are built which strengthen the linkages. Some of these mental pathways become so worn that the mind seeks to use these easy routes to arrive at an understanding. In many case, learning means making new pathways, adjusting pathways or removing pathways among memories that become "known" as incorrect. Learning is a personal activity and the function of a teacher is to help student create interaction between subject under studied and student's cognition structure.

The rapid advancement of the Internet, particularly the development and prolific expansion of the WWW, enable educators to create multimedia teaching resources and interactive instructional strategies which can be delivered to any students without regard to time, place, or computer platform. However, the medium of delivery is not the sufficient condition for learning. Education research informs us that technological advances do not necessarily lead to improve learning. Nothing happens until the learning is actively engaged. For today's technology to have a long lasting impact on science education, it will need to base more on successful pedagogy than on the latest compilers, hardware, or algorithms.

Interactive engagement (abbreviated IE) teaching methods take many different formats [2]. All of them, however, force the student to play a much more active role in the learning process, increase the amount of interaction with fellow students and instructors, and emphasize conceptual understanding as well as quantitative problem-solving. Hale's study [1] compared IE methods, with traditional lecture methods at variety institutions, and showed a significant, across the-board improvement in students' conceptual understanding in IE classes. The most dramatic differences are seen in the area of conceptual understanding. The interactive capabilities of WWW-based instructional strategies can be employed to better match how we teach with how we know students learn.

3 Virtual Physics Laboratory: Enjoyable place to play and learn physics

Game playing is a self-motivated and rewarding activity. An enjoyable computer game is found to be player centered, and it must enhance discovery. Learning should be a self-motivated and rewarding activity, too. Can we make learning as motivated and rewarding activity as computer game playing? This was the initial spark for the VPL project, to develop an enjoyable interactive learning environment helping learners to make sense of physics.

Research on animation can be organized according to the purpose of the animation. In general, instructional graphics satisfy five purposes: they are cosmetic, motivation, attention getting, presentation, and practice [7]. Cosmetic and motivation are in the affective domain, while the others are in the cognitive domain.

1. Graphics used for cosmetic purposes are used to "dress up" the text. Unfortunately, learning does not take place directly as a result of cosmetic graphics. Rieber notes, "At their best, cosmetic graphics help maintain student interest. At their worst, cosmetic graphics distract student attention from other important material."
2. Graphics used for motivational purposes, appealing to the viewer's attitudes. It's important for learner to see material as exciting and relevant. Although learners may be motivated by novel graphics, they may also become saturated as they are inundated with such visuals. As a result, motivating visuals can quickly lose their instructional impact.
3. Graphics used to gain attention. Their primary difference from motivational graphics is that they are not designed to influence the attitude of the viewer but rather to focus the viewer's attention. Attention-gaining graphics may directly influence students' learning, thus it is classified according to the cognition domain of learning. A good example is our "Thin Lens Animator"[13] that shows the images of an object in front of a lens as user click and drags the object across the screen.
4. Graphics used for presentation. For instance, our "Pendulum Animation"[14] is not only present a dynamic visual, but also present data. The data is observed to change as the animation is running. Therefore, the learner can make a connection between the state of the data and the state of the animation.
5. Graphics used for practice activities. This purpose is especially suited to interactive computer simulation where learner receives feedback based on his or her input. For example: Users can type in the base frequency and modify different components of higher order frequency with mouse to create new sound wave and hear it instantly in "Fourier Synthesis"[15].

Our Java applets can be used for all the aforementioned purposes. Most of all, we focus more on students' cognition development. The created java applets aim at invite students to develop deeper, more connected understanding of physics concepts. Seeking connections in contrast to the conventional model of learner as receiving information and of instruction as providing information, in short, to promote conceptual change. According to Rieber, there are two prerequisites for animation to have positive effect on learning outcomes: (1) there must be a need for external visualization (2) learning of the described phenomenon must require an understanding of how an object's properties change with time or position. Rieberb recommends, "Animation should be incorporated only when its attributes are congruent to the learning task". That is, the animation may not be an advantage over a static image in all case. We have designed our java applets according to the recommendation. Many physics concepts especially those involve spatial and time variance, such as stationary wave, Doppler effect[16], and so on, are difficult to express clearly in words or in pictures on the blackboard. By means of our animated java applets, drawing or demonstrations, teacher can cut down the lecture time in class and enable students to understand physics concepts more effectively.

Examples 1:Traffic light system (html page 6k, java class files 27k)[17]

Situation: "Would you like to engineer the traffic light system for a one-way street that consists of several lanes along which rush-hour traffic flows? How would you time the onset of green lights at the various intersections? How to apply what you have learned in kinematics to promote the traffic flow? This java applet let you play with it and find out your answer." All the relevant information is provided for students to find out the answer. This is an authentic situation; the underline principle was used in many cities to control the one-way traffic lights. Each moving square in Figure 1 represents a car, its color indicates whether the car is accelerating, moving with constant velocity, or stopped. The height of each blue circle gives information about the velocity of the corresponding vehicle. User can adjust the timing between green light, yellow light and red light, change time delay between successive intersections, ... etc. It is a kinematics problem for high school students related to topics in constant motion and motion under constant acceleration. Students can work in-group, discuss with each other, propose solutions, explain the reasons of their predictions, use physics concepts to analyze and synthesis the answer, and run the animation to compare and find out the answer. Many students find it is a fun game to play and they gain deeper understanding of related physics concepts at the same time.

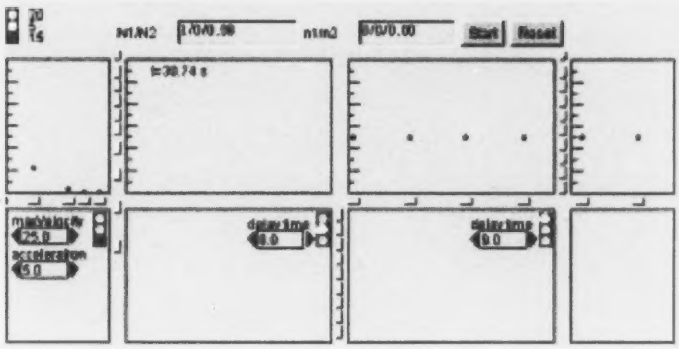


Figure 1: Screen shot of Traffic Light System java simulation

Example 2: Measure your Reaction time (html page 6k, java class files 20k)[18]

Situation: "You are driving on the high way and listening to the music you like most. Suddenly, you see the brake light of the car in front of you just turned on. You will try to hit the brake and slow down your car. But, there is a small time delay before you really do that--- your reaction time. During that period of time, your car is still moving at the same HIGH speed! If you do not want something VERY BAD happened, what is the minimum distance between your car and the one just before yours?" This is a very dangerous situation in real life. However, students can try out such experiments with our java animation safely.

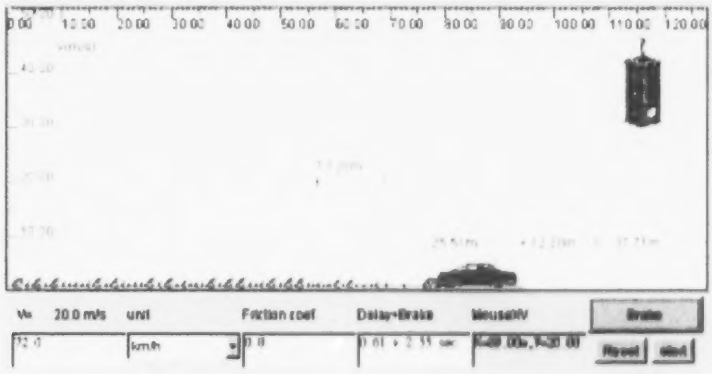


Figure 2: Screen shot of Reaction Time Measurement java animation.

As shown in Figure 2, when the user clicks the button to start the animation, the car will move from left to right at preset constant velocity. The streetlight will turn from green to yellow, and then turn to red light at random selected time. User needs to click the "Brake" button when the red light is on. Those small dots were generated at run time; its height shows velocity of the car at the same horizontal position. Users can move the mouse within the area to find out corresponding value for each dot. Figure 2 indicates the vehicle is moving at 20m/s (72km/hr), arrives at the first red bar when the red light turn to red, and user click the "Brake" button after the car runs 12.2 meter more (the second red bar position). So the reaction time for the user is measured to be 0.61s for this case. It also shows car running at 20m/s need 25.51 m (or 2.55s) to fully stop after driver hit the brake. (Assuming the friction coefficient between the road and the tire of the vehicle is 0.8, which is a typical value for auto tires on dry concrete.) Users can measure their reaction time with this simple java applet, and find out the safe distance to keep when they are driving on the high way. This java applet also reminds users that the braking distance for the vehicle is proportional to the square of the velocity. When you change speed of your car from 80km/hr to 100km/hr, the braking distance increased by a factor of $(100/80)^2 = (1.25)^2 = 1.56$ (velocity increased by a factor of 1.25). Such requirement is a law governs by nature. May be you can miss the speed ticket if the police is not there; however, car accident will happen if not enough distance were reserved for the corresponding speed. This is a very important lesson need to be

BEST COPY AVAILABLE

learned; it can save people's life.

Most of the functions provided by our java applets are operated with mouse click and drag, ease to use and intuitive. Sound, colors and good animated drawings can attract learners' attention and sharpen their ability of thinking. Many more examples can be found at our VPL. Interaction between the student and the learning materials is essential. For different learning tasks different interactivities are appropriate. The design of java applets focused on promoting students' integrated understanding of physics concepts through the use of carefully designed curriculum. We want to generate sequences of stimuli that can be used either to activate a person's existing mental models or initiate the development of new ones. To enable student to connect new ideas to their existing knowledge, making bridge to connect their own piece of information. Our approach is remarkably different from typical novice strategies where students attempt to mathematically analyze a problem before qualitatively describing it (an approach often called "plug-and-chug" and characterized by the lack of conceptual though during the problem-solving process [9]). Requiring student to consider problems qualitatively has been shown to have a positive influence on students' problem solving skills and conceptual understanding [5,6].

In physics, information about a physics system were represented in many different ways: using words, equations, graphs, diagrams, table of numbers, contour maps, vector plots, and so on. Many students have considerable difficulty, not only with creating these representations but also in seeing how they express information about the system and how they are related to each other. Our VPL can help student conquer their learning difficulty. With so many feedbacks from teachers, parents and students all over the world, we found

1. Applets in VPL can help students make sense of translation among representation: Showing animations of a dynamic system and move the relevant information to a coordinated graph, diagram, or plot can, when used in conjunction with an appropriate lesson, significantly help students develop skills in using different representations to help them make sense of the physics. For examples: "Superposition principle of wave", "Simple harmonic motion" and "Transverse Wave and Longitudinal Wave" java applets.
2. Applets in VPL can help students understand equations and physical relations among measurements. Many students treat equations as if they were only a way to calculate a variable or determine a number as a solution. Physical equations represent relationships between various observations and measurements. We know how the nature operates from those relations. For examples: " Spring Force and Simple Harmonic Motion", "Thin Lens" and "Double Slit (interference) " java applets.
3. Applets in VPL can help students build mental model of physical systems: In some cases, students don't have the experience or imagination to put together what they are reading in the texts and hearing from the lectures into a coherent, sensible picture. They memorize bits and pieces, but because these pieces are not linked into consistent, self-supporting structure, they forget or confuse the parts. Visions of interacting objects having qualities and measurable properties. Producing visualizations that display these characteristics can help students create these mental models. For examples: "The location of an supersonic airplane", "Moving point source (Doppler effect/Shock wave)" and "Propagation of electromagnetic wave".
4. Applets in VPL can give students engaging, hand-on, active learning experiences. Students learn much more effectively when they have control on their own learning. Having animations that students can use to explore phenomenon on their own, can produce more effective learning experiences. For examples: "Reaction time and car accident ", "The electronic multimeter" and " Projectile/Satellite Orbits" java applets.
5. Applets in VPL can serve as a sketchpad on which students can explain and describe their understanding to each other. Educational research shows it is valuable to have students explain what they are thinking, both to themselves and to each other. Two or three students working together to answer questions with a simulation can produce a powerful learning environment. For examples: "Physics of rainbow", "Billiards and Physics" and "Mixing colored light beams/paint pigments" java applets.

4 Future work

When learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animations. Teacher can provide hints or demonstrations in the classroom and find out how the learner operated with the java animation. However, VPL is designed for web access, which allows students' direct access without teacher's guidance. All of our java applets are client-based simulations. We see the needs to establish communication between client and server. We will extend their function to support client-

server communication: to control and synchronize animation running on several machines, to exchange data between distributed applets. Besides, it can be used to monitor how the remote user operated with our java applets, identify when they encounter difficulty for research purpose and provide assistance at the same time. Therefore, our java applets can be used as stand-alone learning tools or as shared animations to support cooperate learning over the net.

5 Conclusions

Many web sites are aimed at providing information while we focus on interactive animations to assist student construct his/her own physics concepts. The VPL offers possibilities to concentrate on student-centered approach for learning. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher already design worksheets incorporate with our java applets in their day-to-day instruction. We welcome lectures to translate our web pages into their own languages and share with us. All the labels and texts used in the java applets can be easily changed to local characters with any web page editor. This provides many users at different countries to use our java applets for their teaching and learning. Our VPL can be used as a teaching tool during the lecture or as assignments for the students to play and enjoy learning physics. It can be used in different ways, such as studying individually, study cooperatively and having lessons collectively etc. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply physics to their everyday life. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

References

[1] Hale, M. E., Oakey, J. R., Shaw, E. L., & Burns, J., "Using Computer Animation in Science Testing", Computer in the Schools, 2, 83-90. (1985)

[2] Heller, P., Keith, R., & Anderson, S. "Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving," American Journal of Physics, 60, 627-636 (1992)

[3] Margetson, D. Current Educational Reform and the significance of problem-based Learning studies in Higher Education, 19, 1, 5-19 (1994)

[4] Novak 1999, G., Patterson, E., Gavrin, A., and Christian, W., Just-in-Tie Blending Active Learning with Web technology, (Prentice Hall, Upper Saddle River, NJ 1999)

[5] Larkin, J. H., McDermott, J., Simon, D. P., and Simon, H. A., "Expert and Novice Performance in solving Physics Problems" Science, 208, 1342-1355.

[6] Leonard, W. J., Dufresne, R. J., and Mestre, J. P., "Using Qualitative Problem Solving Strategies to Highlight the Role of Conceptual Knowledge in Solving Problesm" Amercian Journal of Physics, 64, 1495-1503 (1996)

[7] Rieber, L., Computer, Graphics, and Learning (Brown & Benchmark, Madison WI 1994)

[8] Sfard, A., On two metaphors for learning and dangers of choosing just one. Educational Research, 27 (2), 4-12 (1998)

[9] Titus, A., "Integrating Video and Animation with Physics Problem solving Exercises on the World Wide Web", Ph. D. dissertation. North Carolina State University: Raleigh, NC. (1998)

[10] Wasson, b., Advanced educational technologies: The learning environment. Computers in Human Behavior, 13 (4), 571-594 (1997)

[11] Creating the Future, http://www.newhorizons.org/crfut_perkins.html, David Perkins: Mindware and the Metacurriculum (Accessed on May 20, 2000).

[12] Turn on the Lights!, http://www.cefpi.com/issue/issue5.html,Using what we know about the brain and learning to design learning environments (Accessed on May 20, 2000).

[13] Thin Lens Animator, http://www.phy.ntnu.edu.tw/java/Lens/thinLens.html (Accessed on May 20, 2000).

[14] Pendulum java applet, http://www.phy.ntnu.edu.tw/java/Pendulum/Pendulum.html (Accessed on July 31, 2000).

[15] Fourier Synthesis, http://www.phy.ntnu.edu.tw/java/sound/sound.html (Accessed on July 31, 2000).

[16] Doppler Effect and Shock Wave, http://www.phy.ntnu.edu.tw/java/Doppler/Doppler.html (Accessed on July 31, 2000).
[17] Traffic Light System, http://www.phy.ntnu.edu.tw/java/trafficControl/trafficControl.html (Accessed on July 31, 2000).
[18] Reaction Time, http://www.phy.ntnu.edu.tw/Reaction/reactionTime.html (Accessed on July 31, 2000).

A Distributed Backbone System for Community-Based Collaborative Virtual Universities

Qun Jin *, Jingde Cheng **, Hiroaki Ogata * and Yoneo Yano *****
** School of Computer Science and Engineering, University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan E-mail: jinqun@u-aizu.ac.jp*
*** Department of Information and Computer Sciences, Saitama University, Urawa, 338-8570 Japan E-mail: cheng@ics.saitama-u.ac.jp*
**** Department of Information Science and Intelligent Systems, Tokushima University, Tokushima, 770-8506 Japan E-mail: {ogata, yano}@is.tokushima-u.ac.jp*

In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge

delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

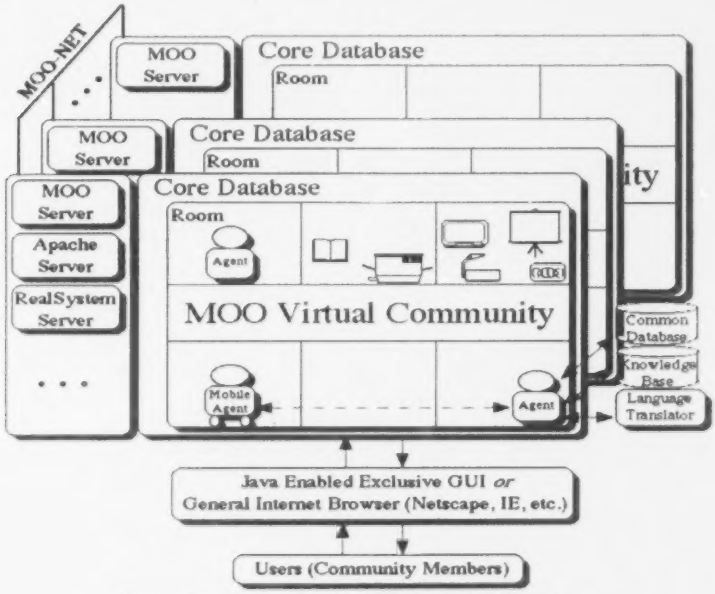


Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

BEST COPY AVAILABLE

To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by ``*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a

special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

Acknowledgments

This work has been partly supported by 1998--1999 and 2000-2002 Japanese Ministry of Education Grant-in-Aid for Scientific Research Contract Nos. 10780195 and 12558012, 1999 HITOCC Research Grant No. 99-12, 1999 University of Aizu Research Grants Nos. R-9-1, P-17 and P-22, and 2000 University of Aizu Research Grants Nos. R-9-2, P-9 and G-25. The authors wish to express their gratitude.

References

[1] R. Chellappa, A. Barua and A.B. Whinston, "An Electronic Infrastructure for a Virtual University," Commun. ACM, Vol.40, No.9, 1997, pp.56-58, (1997).

[2] L. Harasim, "A Framework for Online Learning: The Virtual-U," IEEE Computer, Vol.32, No.9, pp.44-49, (1999).

[3] P. Wallace, The Psychology of the Internet, Cambridge University Press, (1999).

[4] L. Lau, Distance Learning Technologies: Issues, Trends and Opportunities, Idea Group Publishing, (2000).

[5] Q. Jin and Y. Yano, "Design Issues and Experiences from Having Lessons in Text-Based Social Virtual Environments," Proc. IEEE/SMC'97, pp.1418-1423, (1997).

[6] Q. Jin, "A Framework for Community-Based Collaborative Virtual Universities," Proc. ICCE'99 Tutorial and Workshop, pp.70-74, (1999).

[7] Q. Jin, "Collaborative Virtual Environments for Information Exchange and Knowledge Organization," Journal of Three Dimensional Images, Vol.13, No.3, pp.54-58, (1999).

[8] P. Curtis, LambdaMOO Programmer's Manual, Version 1.8.0p5, 1996.

[9] A. Wilson, MOO-net Overview, available at URL http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/overview.html (accessed on August 15, 2000).

A Java-based Interactive Learning System of Junior High School Level Geometry

Yu-Ru Chen*, Tzyy-Leng Allen Horng, and Don-lin Yang***
**Department of Information Engineering*
***Department of Applied Mathematics*
Feng Chia University
100, WenHwa Rd, Seatwen, Taichung, Taiwan407
**Tel: +886-4-4517250 ext. 3743*
***Tel: +886-4-4517250 ext. 5126*
**Fax: +886-4-4516101*
***Fax: +886-4-4510801*
**E-mail:dlyang@fcu.edu..tw*
***E-mail:tlhorng@math.fcu.edu.tw*

In this paper we propose a Java-based CAI system that provides a learning-by-doing environment with hands-on exercise and instant interaction capabilities on the World Wide Web. Our current topics of interest is the Euclidean geometry for junior high school students. To design the system, we adopt the theory of concept map to construct teaching and learning materials. We are currently testing the system and has observed that it does significantly help students in learning geometry.

Keywords: **CAI, concept map, Euclidean geometry, Java applet**

1 Introduction

As computer science and Internet technology make speedy progress at every moment, computer aided instruction (CAI) plays an important role in our life, especially in future education for global citizens at every corner of the world. Many researches focus on the web-CAI, but there are some drawbacks in these systems:

(1) Some of these systems simply use graphs or animations and text to describe the meanings of the teaching materials. Although this way of displaying is more lively than the traditional textbooks, the learners still need to stare at the screen uncomfortably to read the text thoroughly to understand its meanings. Besides, some subjects such as mathematics need to be learned by practicing with examples.
Plain text reading is just not enough.

(2) Most multimedia web-CAI systems requires high bandwidth, which is still a problem for the current internet infrastructure. Long waiting time for response will definitely degrade the effect of learning no matter how well designed the web-CAI system is.

To demonstrate our ability of conquering the above problems, we have developed a web-CAI system in Chinese (http://www.math.fcu.edu.tw/~tlhorng/geometry) for teaching and learning junior-high-school Euclidean geometry (named just geometry in the following context). Students can have great fun in learning on our system owing to its highly interactive and experiment-oriented features. Besides, the system is designed all using small-size Java applets, and is therefore robust enough to tolerate the usual congestion on the internet.

The rest of the paper is organized as follows: Section 2 introduces our design theories such as the concept maptheory and dynamic geometry method; Section 3 shows the implementation and Section 4 summarizes the whole work and some future enhancement.

2 Theories behind our design

First we employ the concept map theory to plan the curriculum and then apply dynamic geometry method to design the curriculum to be highly interactive, problem-oriented and, most importantly, interesting. In this way, the learners are encouraged to learn by playing with those Java applets, and to construct their knowledge system by concept map theory.

2.1 Concept map theory

In order for learners to make a meaningful learning, Ausubel present a meaningful learning theory [1]. The idea in this theory is that whenever to learn a new concept or a new knowledge it must base on the prior experience. Ausubel's theory considers that the relation between the new concept and learner's prior knowledge plays an important role in the meaningful learning. Whenever the new knowledge, learners' prior concept, and proposition framework are successfully joined, learning is created. In other words, learners can make a meaningful learning by utilizing learners' prior concept to link the new concept to organize the whole knowledge. Novak further presents a concept mapping method for the purpose of verifying Ausubel's theory [1]. Concept map is composed of propositions. Every proposition contains two concept nodes and a relation link between them. In a concept map, concepts are represented in a hierarchical way. A general or summarized concept is put in an upper hierarchy, and a specific or particular concept is put in a lower one. A graph describing the integration of concepts from the lower levels to higher ones and the relation linking among them is called concept map that can represent a knowledge structure effectively.

2.2 Dynamic geometry method

To teach or learn geometry effectively, we usually have the following two aspects in mind [2]: knowledge developing (the deductive method), and knowledge acquiring (the generalizing method).

Both are equally important. However, most of the current geometry curriculum in junior high school has been emphasizing on how to prove a geometric problem by the deductive way, and frequently ignoring how to the generalize a geometry concept by experiments and observation. Our web-CAI system present the curriculum in both ways and particularly emphasizes the latter one.

3 Implementation

In our web-CAI system, the whole curriculum is problem-oriented, and each geometric problem, besides its proof, is designed to be explored by experimentation which is implemented by Java applets. Java applet is selected owing to its full-featured library for designing internet applications and its platform-independent portability [3-5]. The code was written by JDK 1.1 and is entirely in Pure Java™.

3.1 Drawing the concept map

There are four steps to draw the concept map: 1. concept seeking, 2. concept categorization, 3. concept hierarchy, 4. concept relation.

Concept seeking: First list all important concepts to be taught. A concept is the foundation unit stored in the human brain, although everyone may store a same thing by concepts in his own different way. That is why everyone may response differently when seeing or hearing an identical event at the same time. This individual opinion of everybody is called the concept.

Concept categorization: After seeking for concepts, this step is to divide concepts into two parts: event and target. Taking circle as an example in our geometry curriculum, we can list twelve relevant important concepts as categorized in table 3.1

Concept hierarchy: After categorizing the concepts, we further place them into a hierarchy. As mentioned above, a more general concept will be put in a upper level, while a more specific one in a lower level. Figure 3.1 is the hierarchy chart of Table 3.1.

Concept relation: After putting all concepts in a hierarchy, we further denotes those relations among concepts to form a complete concept map. Following the above, the circle's concept map is shown in Figure 3.1.

Event	Target
line	relationship between a circle and a line
chord	relationship between a chord and the diameter
chord and center	relationships between a chord and its distance to center
central angle	relationship between a central angle and a chord
arc	relationship between a chord and a arc
circumferential angle	relationship between a arc and a circumferential angle
tangent	two tangents from an external point to a circle are equal in length
quadrilateral	the opposing angles of a quadrilateral inscribed in a circle is complementary
triangle	three bisectors are concurrent in a triangle
incenter	Distances of the incenter to the three sides of a triangle are equal
two circles	relationship between two circles
two circles and tangent	tow circle' s common tangent

Table 3.1. Concept categorization

3.2 Composing the plan for teaching materials

By the concept map, we can further propose the teaching materials and write down these ideas into a table called the plan of teaching materials. Following the above, Table 3.2 shows a small part of the plan: the relative locations of two circles and their common tangent.

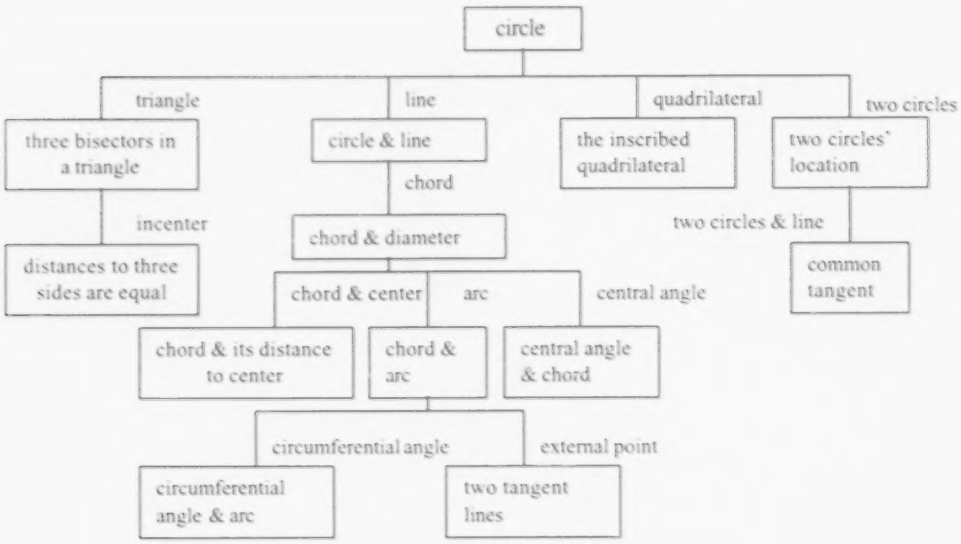


Figure 3.1 Circle' s concept map.

Page	Consist Concept
Circles' locations	There are six kinds of relations for two circles judging from their locations: separated internally, separated externally, tangential internally, tangential externally, intersecting and coincident.
Common tangent	Two circles on a plane can have the following common tangents according to their relative locations: When the two circles are separated externally, there are two external common tangents and two internal ones. When the two circles are tangential externally, there are two external common tangents but one internal one. When the two circles intersect at two points, there are two external common tangents and no internal one. When the two circles are tangential internally, there is only one external common tangents and no internal one. When the two circles are separated internally, there is neither an external common tangent nor an internal one.

Table 3.2 A part of the plan of teaching materials

3.3 Displaying the teaching materials by Java applet

Taking the common tangent of two circles as an example, we display this part of teaching materials by the

BEST COPY AVAILABLE

Java applet shown in Figure 3.2 (a)-(c). This Java applet is designed that the learner can play around by dragging any center (shown as red dots) of the two circles which will change the distance between these two centers. From the movement, the learner can observe various kinds of common tangents happening for the two circles. If we show it alternatively by some static graph or animation, the learner would have problem catching its meaning effectively.

3.4 The examination module

Besides those Java applets for displaying teaching materials, our web-CAI system also provides an examination module for on-line testing. Through this module, teachers can edit test problems and grade students' answers, and students can take tests and look up for their grades all on our web-CAI system. Four individual applets, in charge of problem editing, examination, grading, and grade looking-up, consist of this examination module. Figure 3.3 particularly shows the problem-editing part, in which teachers can edit a test problem and draw the illustration related to it. Also, all the test problems can be saved in a database server driven by JDBC• Java Database Connectivity. JDBC is a Java-standard SQL database access interface [6]. It provides access to varieties of databases. After teacher edit the examination questions, the students can take the exam on our web-CAI system. On that, students can write down the answers and draw some auxiliary lines on the illustration which may be required for proving a geometric theory or just to help them solve the problem. Teachers can then grade and comment the students' answers, and the students can look up for the grades and teacher's comment later all on our web-CAI system.

4 Conclusions and future work

We have developed a web-CAI system that provides an interactive learning and testing environment on Web. In this way, the learner can learn more effectively than other multimedia-CAI systems. Currently we have chosen Euclidean geometry in junior high school as an example, and plan to extend to other science subjects, the physics and chemistry in the future. Besides, we keep modifying the GUI in our system to be more friendly and interesting. We also plan to choose a junior high school to test our system and evaluate its performance.

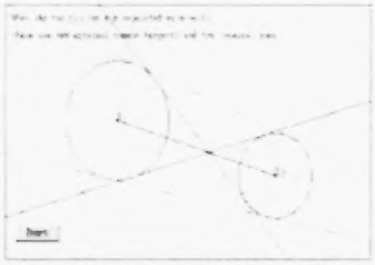


Figure 3.2 (a) A scene of the Java applet of two circles' common tangents. Red points are subject to dragging.

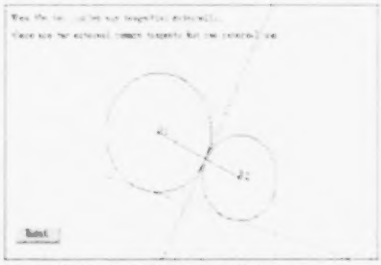


Figure 3.2 (b) Another scene following Figure 3.2 (a).Red points are subject to dragging.

Figure 3.2 (c) Another scene following Figure 3.2 (b). Red points are subject to dragging.

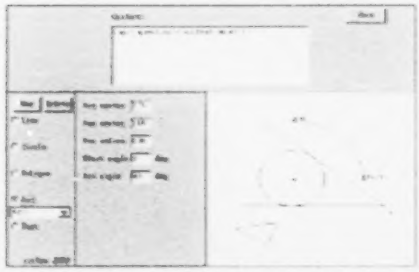


Figure 3.3 Test problem editing part of the examination module.

BEST COPY AVAILABLE

References

[1] The concept mapping homepage, http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm

[2] Mathematics resources center, National Normal Taiwan University, http://mathsup.math.ntnu.edu.tw/.

[3] Knudsen, "Java 2D Graphics' ', O' Reilly, Cambridge, Massachusetts, (1999).

[4] Arnold and Gosling, "The Java programming language' ', Addison-Wesley, Reading, Massachusetts, (1998).

[5] Deitel and Deitel, "Java : how to program' ', Prentice Hall, Upper Saddle River, New Jersey, (1997).

[6] Reese, "Database Programming With JDBC and Java' ', O' Reilly, Cambridge, Massachusetts, (1997).

A Learning Environment for Problem Posing in Simple Arithmetical Word Problems

Akira Nakano, Naoki Murakami, Tsukasa Hirashima and Akira Takeuchi
Kyushu Institute of Technology Department of Artificial Intelligence
680-4 Kawazu, Iizuka 820-8502, Japan
E-mail : nakano@minnie.ai.kyutech.ac.jp

Several researchers indicate that to pose arithmetical word problems is an important way to learn arithmetic. However, the problem posing practice actually is not popular. In this paper, we describe an Intelligent Learning Environment which realizes the problem posing practice. In the problem posing practice, the learners pose problems by using the tools provided by the ILE. The ILE has a facility to diagnose the problems posed by the learners. By using the result of the diagnosis, the ILE indicates whether the problems are correct or not, helps the learner to correct the wrong problems, and provides the next step of problem posing. We used the ILE in three different situations for evaluation. The subjects were elementary school teachers and elementary school students. We also report the results of the evaluation. In the ILE, the interface was implemented in Java, and the diagnosis module was implemented in Prolog. So it can be used on World Wide Web. The current environment deals with simple arithmetical word problems.

Keywords: **intelligent learning environment, problem posing, intelligent tutoring system, interactive education, World Wide Web**

1 Introduction

The main purpose of the practice to solve arithmetical word problems is to make learners recognize the relations between concepts and numerical relations, and master to use the relations. Although the problem solving practice is the most popular way, it is not the only way. Several researchers indicate that to pose arithmetical word problems is also effective. However, the problem posing practice actually is not popular.

The main reason is that the problem posing practice is strongly required teachers to deal with each learner individually in comparison with the practice of problem solving. We aim to realize computer-based learning environments for the problem posing practice [1]. For the problem solving practice, many ILEs are developed so far [2-6]. However, there are few ILEs for the problem posing practice until now.

This paper describes an Intelligent Learning Environment for the problem posing practice for simple arithmetical word problems that can be solved by the addition of one time or the subtraction of one time. The main characteristic of the ILE is the function to diagnose the posed problems. By using the results, the ILE indicates errors in the posed problems and suggests that the next step of problem posing.

Interface of the ILE was implemented in Java, and the diagnosis module was implemented in Prolog. Therefore, if only users have a computer connected to Internet with a popular internet browser, they can use the ILE through WWW: E-mail: nakano@minnie.ai.kyutech.ac.jp http://www.minnie.ai.kyutech.ac.jp/~nakano/problem-posing.shtml (currently Japanese only).

In this paper, the first, the necessity of problem posing and an Intelligent Learning Environment for it are described. Then, interface and diagnosis module of the ILE are explained. The results of preliminary evaluation of the ILE are also reported.

2 Background

2.1 The necessity of an ILE for problem posing

Several researches about problem posing of arithmetical word problems suggested that problem posing was important to learn arithmetic, for example, analysis and investigation about the task of problem posing [7,8], investigation about effect of the problem posing practice [9], investigation in the problem posing practice at arithmetic class [10,11]. Besides, the Curriculum and Evaluation Standards for School Mathematics (in USA, 1989), and Professional Standards for Teaching Mathematics (in USA, 1991) also indicated that it was important for learners to experience to pose problems.

However, the practice actually is not popular in arithmetic class in comparison with problem solving practice. In the practice of problem solving, every problem has an answer and one or a few solution methods. Therefore, the teachers can easily judge the results of problem solving by learners. Then when the answer is wrong, to tell the correct answer or the solution method is not meaningless.

In contrast with problem solving practice, to prepare every correct problem in the problem posing practice is very difficult. Besides, the correct problem that a learner is trying to pose, after depends on the wrong problem posed by the learner. Therefore, the teachers have to examine each problem whether the problem is correct or not, and where of the problem is wrong.

Based on this consideration, we believe that to realize an ILE for problem posing with problem diagnosis function is the promising way to make learning by problem posing popular.

2.2 The problem posing dealt in the ILE

Silver has noted that the term "problem posing" is generally applied to three quite distinct forms of mathematical cognitive activity [12]. They classified three types of problem posing: (1) presolution posing, in which one generates original problems from a presented stimulus situation, (2) within-solution posing, in which one reformulates a problem as it is being solved, and (3) postsolution posing, in which one modifies the goals or conditions of an already solved problem to generate new problems. The problem posing deal in our ILE is (2) within-solution posing. In the ILE, because, in the ILE, first, a learner decides a calculation formula to solve the problem, and next, he/she is trying to pose problem solved by the calculation.

Currently, the LIE can deal with only Change-Problem[13]. In Change-Problem, the quantity in the initial situation is changed to the quantity in the final situation by the change action. The Change-Problem usually consists of three sentences: the first sentence describes the initial situation, the second sentence describes the change action, and the third sentence describes the final situation. Therefore, we prepare a "problem template" that composed of three single sentence templates. By filling in the blanks of three single sentence templates, the problem is completed.

In the ILE, the template of Chang-Problem is composed of the tree single sentence templates that describe: initial situation, change action, and final situation, respectively. The initial situation has the four information: "owner", "object", "number", and "unit". This means that "owner" has "object" and the number of "object" is "number", then, the unit of the number is "unit". The change action has the five information: "actor", "object", "number", "unit", "action". Several actions, for example, "take" has two more information: "from" and "to". The final situation has the four information: "owner", "object", "number", and "unit".

3 ILE for problem posing

3.1 Configuration of the ILE

The current version of the ILE consists of clients and server shown in Figure 1. A client is an interface of the ILE. The interface provides learners the tools to pose problems and gives them guidance to promote problem posing. Inter face is explained in more details in this section 3.2.

The server has two modules: the one is Problem Diagnosis Module and the other is Advice Generator. First, the ILE receives the posed problem, and diagnoses it in Problem Diagnosis Module. Next, in Advice Generator, the ILE generates advice for each learner by using the result of diagnosis. These are explained in

more details in this section 3.3.

Because the ILE deals with several learners by one server, the ILE manages ID, PW, and Learner Model in Private Information Manager.

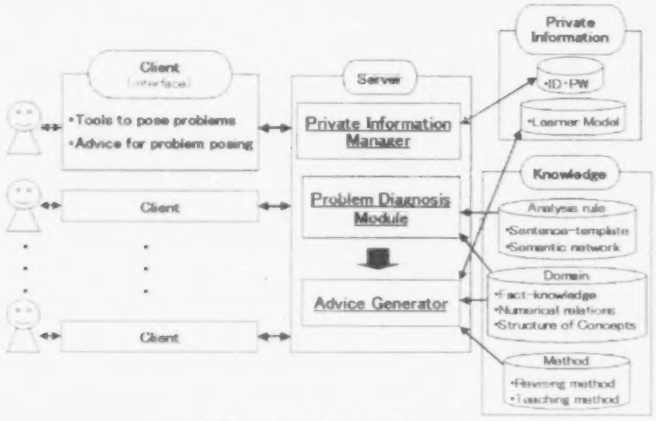


Figure 1: The frame of the ILE

3.2 Interface

Figure 2 shows the interface of the ILE. Current interface deals with only Japanese. In Figure 2, Japanese was translated into English for this paper. The parts of the interface are expressed as follows.

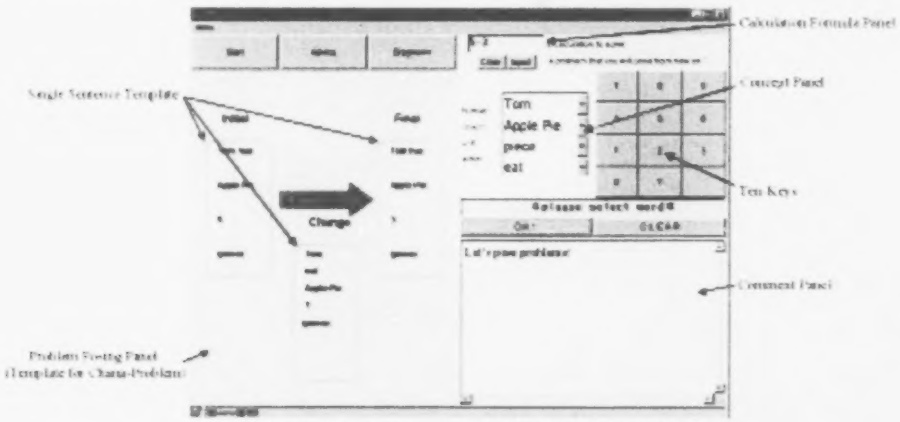


Figure 2: the prototype Interface (English version)

• Calculation Formula Panel

In this panel, a learner gives calculation formula. The learner poses problems which can be solved by this calculation formula.

• Concept Panel

This panel provides concepts to fill in blanks of sentences (three single sentences templates). The concepts that are provided in the Concept Panel are classified in the five categories: "human", "object", "unit", "action", "number".

• Ten-key

BEST COPY AVAILABLE

Numerical values are put into blanks of sentences with Ten-key.

• Problem Posing Panel

In the current version, this panel provides the template of Change-Problem. The ILE asks a learner to fill in blanks of sentences. In the order of the blanks, the ILE gives questions. By answering the questions, the blanks are filled in. Here, the learner has to select concepts from Concept Panel. By using Figure 3, posing a sentence of initial situation in Chang-Problem is explained. The left side of the figure shows questions.

For example, the initial situation in Chang-Problem is composed of four elements: "owner", "object", "number" and "unit". So, the ILE asks the learner "Who has?", "What the person has?", "How many?", "What is unit?". The learner also should decide what number is the answer by selecting the question mark in Ten-key.

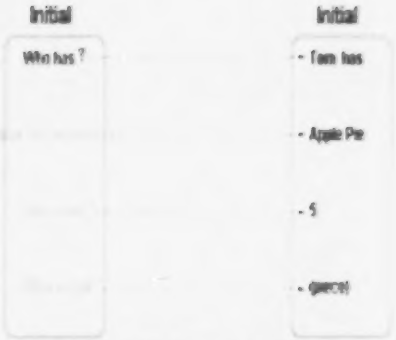


Figure 3: An example of posing sentence by using Single Sentence Template

The right side of the figure shows an example which the learner answered the questions. The result shows "Tom has 5 pieces of Apple Pies".

By answering the all questions, learners pose problems For example, Figure 2 shows the correct problem in Problem Posing Panel: the initial situation is "Tom has 5 pieces of Apple Pies", the change action is "Tom eats the 3 pieces of Apple Pies", and the final situation is "How many pieces of Apple Pies does Tom have?".

• Comment Panel

This panel shows advice and suggestion massages that are generated based on the diagnosis of the posed problems.

3.3 Problem posing in the ILE

A learner poses a problem by the following process.

(1). Giving a calculation formula

First, the learner gives a calculation formula. The calculation formula consists in three elements. That is, two operands and an operator. Because the calculation formula is the way to get the answer of the problem, we call it solution.

The solution can be applied to several numerical relations. For examples, if the learner assigned "5-3" to the solution, the solution can be applied to the following four numerical relations: (a) "5-3=X", (b) "5-X=3", (c) "3+X=5", (d) "X+3=5" (the current version of the ILE only handles natural numbers). Here, numerical relation (a) means the answer is the number in the final situation, numerical relation (b) and (c) mean the answer is the number in the change action, and numerical relation (d) means the answer is the number in the Initial situation.

(2). Selecting concepts from Concept Panel and combining them with the template of Change-Problem

The template has several blanks, and the ILE asks the learner to pose a problem by filling the blanks with the concepts. Then, if the learner selected a concept from the set of wrong concepts, the ILE can give the learner feedback, which suggested that the concept is wrong.

(3). Request to diagnose a problem

When the learner clicks the "diagnosis button", the problem is sent to the server and is diagnosed.

(4). Revising the wrong problem by using the suggestion given in the Comment Panel

When the posed problem is wrong, the learner receives feedback that indicates an error at Comment Panel.

The ILE generates the message by using the result of the diagnosis.

(5). Posing the new problem by using the suggestion

When the learner posed the correct problem, the learner receives feedback which is suggests to pose the new type of problems.

3.4 Problem Diagnosis Module and Advice Generator

BEST COPY AVAILABLE

Problem Diagnosis Module and Advice Generator are functions of the server in the ILE. Problem Diagnosis Module diagnoses problems sent by the client, and Advice Generator generates messages that are provided for each learner.

The ILE, first, diagnoses a single sentence and then diagnoses the problem composed of three sentences, and compares the solution given by a learner with the problem posed by the learner. In the first step, the module has knowledge about acceptable sentences (initial situation, change action, final situation). We call each sentence "basic relation", and the knowledge "single sentence schema". The single sentence schema checks each basic relation to find the errors in a sentence.

In the second step, the relation among the sentences is diagnosed. The module has the knowledge about acceptable relations among basic relations. We call the knowledge "problem schema". The problem schema checks the numerical relation between the sentences to find the wrong sentence in the problem.

In the third step, the relation between the solution and the problem is diagnosed.

In the following section, the diagnosis process is explained. Then, the feedback made by the diagnosis result is presented.

3.4.1 Diagnosis of the posed problems

Diagnosis of the posed problems is carried out in three steps: the first step is the diagnosis of a single sentence. The second step is the diagnosis of the problem composed of three sentences. The third step is the diagnosis of the relation between the problem and the solution.

(1). Diagnosis of a single sentence

In this diagnosis, two types of errors are detected: (1-a) errors in the relation between object and action, and (1-b) errors in the relation between object and number. Here, Mismatch of blanks (that is, object blank or action blank and so on) and concepts is already checked in the interface.

An example of (1-a) is a sentence that "Tom eats his 2 sheets of postcards." "Tom has 5 cups of apple pies" is an example of (1-b). These errors are detected by checking with sentence schema in that the acceptable relations between object and action or object and number are described.

(2). Diagnosis of problem

In this diagnosis, three types of errors are detected: (2-a) errors in the final situation, (2-b) errors in the change action and (2-c) no relation errors. (2-a) means that the initial situation can be changed by the change action, but cannot be changed to the final situation. (2-b) means that the initial situation can be changed to the final situation, but cannot be changed by the change action. (2-c) means that the initial situation cannot be changed by the change action and to the final situation. These errors are detected by comparing by problem schema in that the acceptable relations among the situations and the change action are described.

An example of (2-a) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats Tom's 3 pieces of apple pies" and "how many pieces of lemon pies does Tom have?" An example of (2-b) is the problem composed of the following three sentences: "Tom has 5 pieces of apple pies", "Nancy eats her 3 pieces of apple pies, and "how many pieces of apple pies does Tom have?"

(3). Diagnosis of the relation between the problem and the solution

The diagnosis module can generate an equation from the problem. In this diagnosis, first, the module solves the equation. Then the calculation to derive the answer is compared with the calculation posed by the learner as the solution. When the two calculations do not correspond, an error in the relation between the problem and the solution is detected.

3.4.2 Feedback for the client

(1). Indication of an error

If the diagnosis module finds an error, the ILE indicates it. Even if the problem includes several errors, the

ILE indicates the error detected first.

(2). Suggestion of the next step of problem posing

The ILE suggests the next step of problem posing when the posed problem is the correct one. In the diagnosis, the module diagnoses not only whether the problem is correct or not, but also what concepts, actions or equations are used in the problem. Based on the results, the ILE can suggest more difficult problem posing by specifying concepts or an equation type to be allowed to use in problem posing.

4 Preliminary evaluations

A prototype of the ILE has been already developed. We used it in three different situation for evaluation, as follows: (1) Use by teachers of the elementary school, (2) Use by students of elementary school in arithmetic classes, (3) Use by students of elementary school outside the class.

In (1), we asked the teachers to evaluate the ILE from the viewpoint of teaching. Then, two of them permitted us to use the ILE in their arithmetic class. So, we had two opportunities to evaluate the ILE in the second situation. In (2), we asked the students of elementary school to pose arithmetical word problems with the ILE in two arithmetic classes. In the trial, although we collected the answers for our questionnaires, we failed to record logs of problem posing. Therefore, we could not get the data about the number of posed problems, and the students behave for feedback from the ILE. In (3), we gathered several students again, and asked them to use the ILE out of class. Here, the students used the ILE for the first time.

In this section, we report these results.

4.1 Use by the teachers of the elementary school

To evaluate a learning environment, the evaluation by teachers is important. We asked five teachers of elementary school to use the ILE. After they posed several problems by using this ILE, we asked them several questions. The questions are as follows: (1) How do you evaluate the effect of problem posing to learn arithmetic? (2) How do you evaluate the way of problem posing used in the ILE? (3) How do you evaluate the interface? (4) How do you evaluate the indications for the errors in posed problems? (5) How do you evaluate the advises to suggest the next step of problem posing? Table 1 shows the results.

Table 1: Evaluation of the teachers

	Good	So-so	Bad
(1)	5	0	0
(2)	3	2	0
(3)	2	3	0
(4)	4	1	0
(5)	5	0	0

Table 1-(1) means that all teachers think to learn arithmetic by using problem posing is effective. Table 1-(2) suggests that the ILE realizes an useful environment for learning by problem posing. Two teachers out of three teachers who answered "Good" to the question (2), gave us opportunities to use the ILE in classes. A few teachers also indicated that the limitation of concepts that were allowed to use in problem posing should be revised. This is one of our future works. In Table 1-(3), three teachers answered "So-so". The result means that the interface is not always easy to use. In Table 1-(4), four teachers answered "Good". The result suggests that the indications for the errors in the posed problem are acceptable. However, several teachers also indicated that the sentences of the indications may be difficult for elementary students. In Table 1-(5), the all teachers answered "Good". This result means that the teachers think the suggestions to make learners progress the next step of problem posing adequately support learning by problem posing.

4.2 Use by the students of elementary school in arithmetic classes

We used the ILE in two classes: the one was composed of 25 students in third grade and the other was composed of 30 students in fifth grade. In each class, 15 minutes were used to explain the use of the ILE, and 20 minutes were used for the problem posing practice with the ILE. In this problem posing practice, students were two people one set, and they operated one personal computer with two. Then two assistants assisted them to operate the ILE in the experiments.

Table 2: Evaluation of the

		Yes	No Answer	No
Third -grad	(1)	22	0	2
	(2)	22	0	2
Fifth-grad	(1)	27	2	1
	(2)	25	4	1

We asked two questions after the problem posing practice: (1) Are you interested in problem posing by using this ILE? (2) Do you want to pose more problems by using this ILE? The result is shown in Table 2.

The results suggested that most students were interested in problem posing with the ILE. But we were not able to get enough data to confirm that the students pose problem well.

4.3 Use by the students of elementary school outside the class

Subjects were one student of fourth-grade, and threes students of sixth-grade in elementary school. In the experiment, we used 15 minutes in the demonstration of this ILE, and 25 minutes in the problem posing practice. The results were as follows. In Table 3, *Diagnosis* indicates the number of time of request to diagnose.

Table 3: Logs of the problem posing

Diagnosis	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
i	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**
ii	**α-C**	**α-C**	**β-W**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**		
iii	**α-C**	**α-C**	**β-C**							
iv	**α-C**	**β-C**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-W**	**γ-C**	

α: A±B=X, **β**: A±X=C, **γ**: X±B=C (A,B,C are numerical values. X is a variable)

C: Correct, **W**: Wrong

In Table 3, equations named by Greek (α , β , γ) specify the type of problem posed by subject. "A" is the number in the initial situation, "B" is the number of the change action, and "C" is the number in the final situation. "X" is the number that is derived by the solution. In the α type, the answer is in the final situation. So this type of problem is the easiest one. In the β type, the answer is in the change action. In the γ type, the answer is in the initial situation. In this order, problems become difficult. The ILE can judge not only "C (correct)" or "W (wrong)", but also the type of problem whenever the student requests the diagnosis.

In Table 3, three subjects (i, ii, iv) tried to pose the problems of the all types, and subject-iii tried to pose the two types of the problems. The subject-i posed the wrong problem of the γ type on the 3rd request to diagnose in the practice. And the subject was repeating to revise it in seven times. As a result, the subject posed the correct problem of the γ type in the 10th trial. And the subject-ii posed the wrong problem of the β type on the 3rd request to diagnose in the practice, then the subject posed the correct problem of the β type in the 4th trial. And the subject-iv posed the wrong problem of the γ type on the 3rd request to diagnose, then the subject posed the correct problem of the γ type in the 9th trial, too. But, the subject-ii gave up to correct the wrong problem of the γ type, although s/he was repeating to revise the wrong problem in three times. The results suggest that the feedback is effective to forward the learner to revise the wrong problem.

In the current ILE, if a learner corrected the problem, the ILE suggests the next step of problem posing. The first step is problem of the α type. the second step is problem of the β type. and the third step is problem of the γ type. In Table 3, all subjects follow the suggestion. In the results, when a learner posed a correct problem, the learner can not poses only the same type of problem again, but also other types of problem by using the feedback. This suggests that the feedback is also effective to advance the next step of problem posing.
Conclusions

5 Conclusion

In this paper, we described ILE for problem posing in simple arithmetical word problems. The ILE provides the template to pose Change-Problem in current version. And the ILE can diagnose the problem that learners fill blanks of the template with several concepts, values, and question mark. Besides, the ILE can support

each learners by using the results of diagnosis. We used the ILE in three different situations for evaluation. In the results, we consider that this research provides basis functions to realize the problem posing practice by ILE about simple arithmetical word problems.

In future work, we will refine functions in the ILE. For example, in the ILE, we will deal with not only Change-Problem, but also the other types of problems. And we will develop a function in which teachers can customize concepts provided for their students in their problem posing practice, because teachers hope to use concepts which are popular in their classroom. Then, we will evaluate the ILE again in order to investigate about the effect to learn arithmetic.

References

[1] Nakano・A.・T.Hirashima・A.Takeuchi・"Problem-Making Practice to Master Solution-Methods in Intelligent Learning Environment・" Proc of ICCE'99・pp891-898・1999.

[2] Barr,A., Beard, M., Atkinson, R.C., "The Computer as a Tutorial Laboratory: the Stanford BIP Project". Int.J. Man-Machine Studies, Vol.8, pp.567-596, 1976

[3] MaCalla, G.I. "The Search for Adaptability, Flexibility, and Individualization:Approaches to Curriculum in Intelligent Tutoring ILEs", In Jones, M. and Winne P.H.(Eds.), Adaptive Learning Environment: Foundation and Frontiers, Springer-Verlag, pp.91-122, 1990

[4] Hirashima, T., A.Kashihara, J.Toyoda : "Toward a Learning Environment Allowing Learner-Directed Problem Practice". Proc. of ITS'96 Lecture Notes in Computer Science 1086, pp.466-474,1996

[5] Hirashima, T., A.Kashihara, J.Toyoda : "Providing Problem Explanation for ITS", Proc. of ITS'92 Lecture Notes in Computer Science 608, pp.76-83, 1992

[6] Hirashima, T., T.Kohno, A.Kashihara, J.Toyoda : "Development of Support Facilities for Arithmetical Word Problem Exercises in Intelligent Tutoring ILE". Electronics and Communications in Japan, pp.22-33, 1992

[7] Silver・E.A.・Mamona,J.・"Posing Mathematical Problems:An Exploratory Study・" Journal of Research in Mathematics Education・vol.27・No.3, pp293-309・1996.

[8] Lyn D. English・"Children's Problem Posing Within Formal and Informal Contexts・" Journal of Research in Mathematics Education・vol.29・No.1, pp83-106・1998.

[9] Ellerton, N. F., "Children's made up mathematics problems: A new perspective on talented mathematicians," Educational Studies in Mathematics, 17, pp261-271, 1986.

[10] Silverman, F. L., Winograd, K., Strohauer, D. "Student-generated story problems. Arithmetic Teacher," 39, pp6-12, 19992.

[11] Silver・E.A.・Cai,J.・"An Analysis of Arithmetic Problem Posing by Middle School Students・" Journal of Research in Mathematics Education・vol.27・No.5, pp521-539・1996.

[12] Silver, E.A, "On mathematical problem posing. For the Learning of Mathematics," 14(1), 19-28

[13] Kintsch, W., Greeno, J.G., "Understanding and Solving Word Arithmetic Problems," Psychological Review, vol.92, No.1, pp109-129, 1985.

A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics :Through a Practice of Three Junior High Schools

Masahiro NAGAI*, Yasuyuki OKABE, Jyunichiro NAGATA*** and Kanji AKAHORI***

**Tokyo Institute of Technology, Graduate School of Decision Science and Technology, Dept. of Human System Science 2-12-1,O-okayama,Meguroku-ku,Tokyo,152-8552,Japan Tel.+81-3-5734-3233 nagai@math.e.chiba-u.ac.jp, akahori@ak.cradle.titech.ac.jp*

***Sumiyoshi School Attached to Department of Human Development,Kobe University 5-11-1,Sumiyoshiyamate,Higashinada-ku,Kobe,658-0063,Japan Tel.+81-78-811-0232 yokabe@kobe-u.ac.jp*

****Junior High School attached to Department of Education,Chiba University 1-33,Yayoicyo,Inage-ku,Chiba,263,Japan Tel.+81-43-290-2493 nagata@jr.chiba-u.ac.jp*

The topic of Internet for educational purposes is currently hotly pursued but there are still not many observations on the effectiveness of it in school mathematics. In this paper, we discuss the findings of Web-based collaborative learning in school mathematics conducted with three junior high school in Japan, March 2000. Students performed asynchronous collaborative learning using bulletin-board type database installed in a Web server set at the Koshikawa laboratory in Chiba University. Students solved several mathematical problems presented on a Web page while discussing with other students in the database. In classes using the Internet, 3 or more methods of the problem solving emerged in the database as compared with a traditional class, and students could study many mathematical views and conceptions as a result of it. Moreover, a research of the student's opinions after the lessons indicated that students wanted to hear the other students' ideas and views and have collaborative learning, breaking down the traditional concept of the classroom wall barrier.

Keywords: **Web, Bulletin Board, Collaboration, School Mathematics**

1 The background and intention of this research

It is now believed that mathematical knowledge is created through collaborative learning, rather than something individual. This is based on social constructivism in recent years. And teachers have come to accept their new position of an advisor to the students as shown by Vygotsky's "Zone of proximal development".

Through using a distributed network such as the Internet, its very features are effectively utilized and allows the externalization of the student's knowledge. These knowledge can then be shared and this learning method is in accordance with the present idea of how learning occurs[4]. Thus, we have researched on web-based collaborative learning on school mathematics from 1998 focusing on this point[1][2]. With Web-based collaborative learning, it efficiently and effectively overcomes whatever physical differences the students may have and thus widely used for science and social studies lessons.

In mathematics, objectivity is the rule and therefore, there is no need for students to be able to express regional difference clearly and there are not many investigations into web-based collaborative learning of school mathematics. In this paper, we describe the qualities and reasons for conducting Internet based

collaborative learning of school mathematics. We also describe the results of the questionnaire distributed to the students after the lesson.

2 The method of collaborative learning

In this research, we used the "bulletin board[1]" system that can be downloaded free from the Web site. As shown in Fig.1, the discussion progresses by entering in one's idea and posing questions to the others' idea or opinion. Students build their knowledge positively and share them in this process. The discussion is displayed by a tree structure whereby a reply to a question or comment is indicated with a new line, separated from the previous note with a slight space. Each new reply is so indicated, forming a tree structure. The symbol[2] is given to each utterance so that the kind of utterance may be understood. This database was installed in the Web server "Topo" at Koshikawa laboratory, Faculty of Education, Chiba University, and linked to the web page that we refer to as "The Page of Mathematics Teaching-Materials Research[3]". Students used this system for its school mathematicsFig.3. Fig.2 shows the notes which students have entered. Students study, choosing between the two screens, i.e. Fig.1 and Fig.2.

Fig. 1

Fig. 2

3 The outline

The Web-based collaborative learning was performed as follows.

O Student participants

Nagaura Junior High School, 1st grade 2 class

Sumiyoshi Junior High School, 1st grade 3 class

Junior High School attached to Chiba University, 1st grade 3 class

O Term March 2000

O Instruction plan

Each junior high school had a 2 hours lesson.

The 1st hour …Students read the problem and produce their own ideas.
And, they enter in their questions and opinions.

The 2nd hour…Students read the others input and enter in their ideas.
And they continue the discussion.

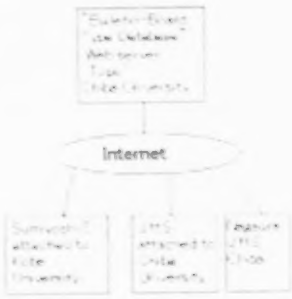


Fig. 3

3.1 Problems given to students

[1] raib-g 2.04 (wakatiai program)

[2] Question="質問"・My Theory="私　考　", etc.

[3] The author's page. http://www2.ak.cradle.titech.ac.jp/nagai/math_room/math.asp

The Grant-in-Aid for Educational Research, Chiba Prefecture(1997), and the Grant-in-Aid for Scientific Research, Japan Society for the Promotion of Science(Encouragement Research B, subject numbers 10913006,1998 and 11913005,1999) are granted to this page.

BEST COPY AVAILABLE

The two following problems were shown on the Web page at the beginning of the collaborative learning. Students solved the problem given to them with instructions from the teacher.

○**Problem1**
This year is A.D. 2000. Let's make the following formulas.
(1) The answer is set to 2000, using all the number of 1,2,3,4,～,19, and 20 at least once.
(2) Each number can be used only once.
(3) You may change the sequence of numbers.

○**Problem 2**
How to find, among a set of twelve balls, one which is lighter than any of the other equally-weighted eleven? You have only three chances to use a pair of balances. (Please also consider the reasons and enter it in.)

3.2 The student's activity

First, students read the given problem and create their questions and ideas about the problem. Next, they access the database and enter their notes. They read the others' writing, and if something attracts them, they will write a reply. The activity was performed over 2 hours and problem solving was carried out. A questionnaire shows that students participated in this collaborative learning positively. The teacher's role is only to support the computer operations of the students or problem solving when needed. In the beginning, although there were many students who took time in deciding what to enter or how to operate the database, they got used to it gradually.

4 Analysis and consideration of the collaborative learning

These were two problems and the students solved either one or the other collaboratively. Three junior high schools tackled the problem using the Web-based collaborative learning for 2 hours. Another class was asked to solve the problems not using the Web-based collaborative learning method i.e. traditional method. We describe the difference in the learning produced from the difference between these two methods of instruction. We also analyzed the results of the questionnaire.

4.1 Regarding problem 1

With problem 1, students find as many formula as they can whose answer is 2000 using all the integers from 1 to 20. In the collaborative learning using the Web, students invented 14 kinds of the following methods.

Formulas obtained from the collaboration using the Web (14 methods)

1. 20×10×5×2+(1+3-4)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
2. 20÷10×(19-9)×(18-8)×(17-7)×(16-6)÷(15-5)×(14-4)÷(13-3)×(12-2)÷(11-1)=2000
3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000
4. (3+5+7+8+11+12+13+14+15+16+17+18+19)×(6-2-4)+20×10×(9+1)=2000
5. 10×20×5×2-(9+6)+(8+7)-15÷3+(1+4)-(11+19)+(12+18)-(13+17)+(14+16)=2000
6. (19-18+17-16+15-14+13-12+11-9+8-7+6-5+4-3+2-1)×10×20=2000
7. 20×10×(1+2+3+4)+(13-6-7)×(5+8+9+11+12+14+15+16+17+18+19)=2000
8. 20×10×5×2+(4-3-1)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
9. (1+3+7+9)÷2×(20+15+5)÷4×(6+14+12+8+11+19+13+17)÷10×(18-16)=2000
10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
11. {1+2+3+4+6+7+8+9+10+11+14+16+17+18+19-(5+12+13+15)}×20=2000
12. 20×10×2×5÷1×(19+17+16+7+9+3+15-4-6-8-11-12-13-14-18)=2000
13. (1+2+3+4)×10×20+5+6+7-18+8+9-17+16+13-14-15=2000
14. {(11-1)+(12-2)+(13-3)+(14-4)+(15-5)-(16-6)-(17-7)-(18-8)-(19-9)}×10×20=2000

Next, in the traditional class, only four kinds of formulas appeared.

Formulas obtained by the ordinary class (4 methods)

3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000

10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
15. (11-1)×10×20+12-2-4-6+8-3-5+16-7-9+14+15+19-13-17-18=2000
16. (2×3+4+5+6+7+8+9+10-11+12+13+14+15-16+17-18+19)×20÷1=2000

4.2 Regarding problem 2

With problem 2, students find the lighter weight out of 12, using only a pair of balances and within 3 steps. The following four methods of solving the problem appeared in the collaborative learning using the Web. The notation shows how to divide the 12 weights first. For example, "4 4 4" means to divide the 12 weights into three groups containing four weights in each group first.

◇The first division found in the collaboration using the Web

(6 6) (4 4 4)
(3 3 3 3)(5 5 2)

◇The first division found in the traditional class

(6 6) (4 4 4)
(3 3 3 3) (5 5 2) (2 2 4 4)

As shown above, four kinds of methods appeared in the collaboration using the Web and five appeared in the traditional class.

4.3 Analysis and consideration of the data

In problem 2, the variety of methods for solving the problem did not differ much between the Web-based collaboration and the traditional class. However, in problem 1, the number of methods on collaborative learning using the Web was 3 or more times as compared with the traditional class(Exact Probability Test, $p<.05$). For mathematics problems with limited answers, there is not much difference seen between the two methods of instruction. On the contrary, for problems with many possible answer, students achieve better results when they can do the problem solving with the other students through the Web. We definitely believe that the students are able to solve problems by referring to the other student's notes. This can be seen from the student's interaction. For problem 1, five formulas generally represented as "0 × m+2000(m is an integer)" were produced in the collaborative learning using the Web. This is the formula not produced from the traditional class. We consider that the students become aware of this general formula by referring to the others formulas, and they utilize this general formula to solve the problem. Moreover, the students are also influenced by notes such as those below.

First, 20 ×(4+6) ×(19-9) etc. is calculated, and it is made 2000. Then, it will be set to 2000 if the number which remains is set to 0. Example 20 ×(4+6) ×(19-9)+(18-17+16-15+14-13+12-11+10-8-5-1) ×(2+3) =2000.

2000/03/14 Tuesday 09:25 [9]

Although the formula of this student's example lacks a necessary "7", it is considered that the explanation which means 0×m+2000 was very helpful. This can be read also in the following response to the note " ".

This is a good idea. Every number which is multiplied with 0 is 0. 2000/03/16 Thursday 11:12 [93]

Such examples show that there were some students who didn't only enter their formula, but the strategy as well, and it be ne a support to other students.

As mentioned above, in collaborative learning using the Web, since the others idea remains on record and can always be referred to, students could utilize this and solve the problem. Problem 1 is asking for many possible formulas whose answers are 2000. That is, we claim that collaborative learning using the Web is effective especially with problems which demand exemplification. And students were able to access many mathematical views and conceptions. This appears also in the result of the questionnaire shown as "Many students' ideas can be known. 49 persons." and "Various methods and ideas which are easy to understand can be known. 36 persons.", and it turns out that the student's incentive and understanding can be improved. These educational effects are obtained by the realization of collaborative learning using the Web, and cannot be obtained in the class which is traditional. We emphasize that the effectiveness of the collaboration using the Internet on school mathematics is demonstrated.

5 Conclusion

In this paper, we referred to the educational effect and influence of the collaboration of three junior high schools using the Web. As we have shown, it has been indicated that students can utilize many mathematical knowledge and conceptions when we use the Web with due consideration given to the type of problems the teacher thinks can extract the most out of the students. This shows that collaborative learning using the Web is useful to train various views and ways of thinking currently emphasized by the Ministry of Education in Japan and National Council of Teachers of Mathematics(NCTM)[3],U.S.A. We emphasize that the database on the Web is effective as an environment where students can tackle open-ended problems in mathematics.Considerations for the future include the improvement of the student's computing skills, the improvement of the system with regards to numerical expressions and careful selection of the kinds of mathematical problems to be given to the students. After all, according to a questionnaire, since it is indicated that 70 percent or more of students are supporting collaborative learning using the Web from various reasons, we want to continue the research wholeheartedly from its educational perspective.

Acknowledgement

We express our sincere thanks to Miss. Cheong. Meng. Mei and the following institution for assistance.
A part of this research is selected as a supporting plan in the Voluntary-Plan of the 100-School Networking Project (Phase II ,1998) and the School-Plan of the E square project (1999) of the Center for Educational Computing.

References

[1]Masahiro NAGAI and Hiroaki KOSHIKAWA . "A Development of Collaborative Learning on School Mathematics Using the Web I" The Mathematics Education Paper Publication Meeting 31, Japan Society of Mathematical Education. 1998 . pp.283-288

[2]Masahiro NAGAI, Yasuyuki OKABE, Junichiro NAGATA, Hiroaki KOSHIKAWA, Tadashi TAKAHASHI, Kanji AKAHORI . "A Design of the Environment Supporting Collaborative Learning on School Mathematics Using the Distribution Network" . The Plenary Session of TSG6(Distance Learning in Mathematics Education) ICME9 at Japan, August 2nd 2000.

[3]NCTM . "Curriculum and Evaluation Standards for School Mathematics" . 1989

[4]Yutaka SAEKI . "New Computer and Education" . Iwanami Pocketbook .1997

[5]Matthew B.Miles, A.Michael Huberman . "Qualitative Data Analysis" . SAGE Publications . 1994

A Web-based Interactive Exercise System for Learning Mathematical Functions

Takayoshi Yoshioka, Yuzo Higuchi and Hitoshi Nishizawa
Toyota National College of Technology
2-1 Eisei-cho, Toyota, 471-8525, JAPAN
Tel: +81-565-36-5852, 5849, Fax: +81-565-36-5925
E-mail: {yoshioka, nisizawa}@toyota-ct.ac.jp

1 Introduction

Although exercises are important in learning fundamental mathematics, it is not easy to provide an appropriate exercise for every student in a class because the understanding level and the calculating skill of the student usually differs widely. Computer systems storing problems for the exercises and learning histories of the students might help the situation. The system should also have some intelligence in evaluating students' answers for making it closer to the written exercises and going beyond the multiple choice questions [1].

CAS and graphic calculators have some intelligence in a way. They calculate or operate mathematical expressions symbolically, show the graphs of functions immediately. But the use of them does not always help the students to understand the mathematical concepts or the meanings of the operations [2]. They might become black boxes that hide not only the detailed process of the calculation but also the mathematical ideas lying behind them.

The authors have been developing a Web-based interactive exercise system since 1996 and have been using it as a supporting tool for teaching mathematics to our students [3]. The purpose of developing the exercise system is to change the roles of the students and the CAS. We want the students to think or guess in their exercises and the CAS to assist them for giving some meaningful hints for solving problems by themselves.

2 Interactive Exercise System

The exercise system described in this paper consists of networked computers for students and a WWW server collaborating with a database and a CAS, MATHEMATICA™ as the evaluation engine [4], which allows the students wide variety of mathematical expressions for their inputs. An evaluation is done by MATHEMATICA™ according to the rules described in custom evaluation functions coded with MATHEMATICA™ language [5]. It evaluates the students' inputs symbolically and returns more meaningful comments than correct or not. More detailed description of the structure of the system and some examples of the interactive exercises implemented on it have already been reported [3, 5].

The system, however, needs shorter response time for the exercise of expressing the mathematical function of a given graph. The exercise shows a student a graph of a function, asking to express the function as a mathematical expression (Fig. 1).

It gives the student several input fields for typing his/her expressions in. The expressions are sent to the server and compared with the answer symbolically by MATHEMATICA™. If one of the expression is equal to the answer, a simple comment "right expression" is returned to the student.

If no expressions are equal to the answer, comments describing the difference between the expressions and the answer are returned instead. A graphic image showing both the answer in blue color and the last expression in red color is also displayed, which helps the student to realize the difference visually. Every evaluation gives some hints toward the right expression, which allow the student to learn from his/her

mistakes.

3 Processing Time for the Evaluations

The new exercise needed more evaluation time than the other exercises when Macintosh was used as the server machine. Although the new exercise itself is most popular among the students, the long waiting time hindered it's regular usage. Technically, the biggest difference of the exercise from the others is that MATHEMATICA™ creates a new graphic file dynamically every time at the evaluation and the file is embedded into the HTML for the exercise page. The long waiting time was caused by the process of creating the graphic file.

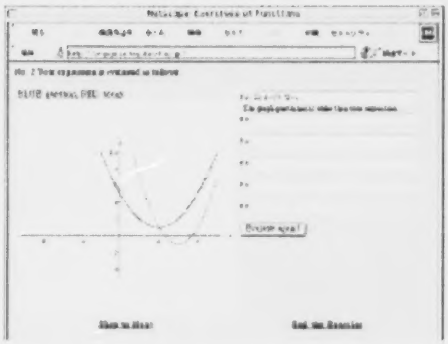


Fig.1 A student' s Web-page after the evaluation

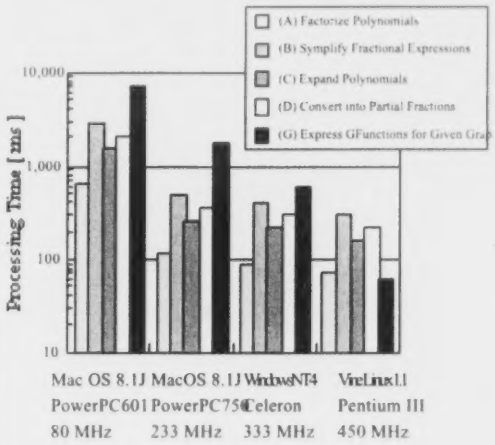


Fig.2 CPUs' processing time for the evaluations

We compared the CPU's processing time needed when MATHEMATICA™ evaluates expressions according to the rules described in the evaluation functions for the system (Fig. 2). There are four exercises of; (A) factorizing a polynomial, (B) simplifying a fractional expression, (C) expanding a polynomial, and (D) converting into partial fractional expressions, each of which needs only symbolic evaluation, and an exercise of expressing the function for given a graph (G) which lets the system create a new graphic file adding to the symbolic evaluation. The measurement was done using several server machines running different operating systems, i.e. Macintosh OS, WindowsNT, and Linux. Although the server machines used to run those operating systems are different in the type of CPU and the clock speed, we thought that the clock frequency of the CPU becomes a rough measure of the performance of a server, which consist of hardware and an operating system.

When we use Macintosh OS or WindowsNT for the operating system of the server, the evaluation of "expressing the function for a given graph" takes more processing time than the other exercises which does not create any graphic files. The processing time decreases with the clock frequency of the CPU and the exercise (G) consumes the longest processing time. If we select a PC running Linux as the server, the tendency is reversed. The evaluation which creates a graphic file becomes the shortest process on the sever while the processing time for the other exercises have same tendency. If we compare the Linux machine (450 MHz) with the WindowsNT machine (333 MHz), the processing time is 1/10 for the exercise (G) while it is 1/1.38 in the exercise (D), and the clock frequency of the CPU is 1.35. Changing the operating system for the server must be the most cost-effective improvement for the response when we put the exercise (G) into wider use.

4 Conclusions

A Web-based interactive exercise system has been extended to serve a new exercise of expressing the function for a given graph. MATHEMATICA™, a CAS used in the system as the evaluation engine, has far

better performance on Linux than on Macintosh OS or WindowsNT for the new evaluation when it creates a new graphic file. The increased performance will make the exercise to be used regularly.

References

1) Pitcher, N., Goldfinch, J., Beevers, C., "Computer base assessment: beyond multiple choice", Proceedings of ICTMT4, P31 (1999).
2) Hong, Y. Y. & Thomas, M., "Super-Calculators and Mathematics Examinations", Proceedings of ICCE'99, vol.2, pp483-490 (1999).
3) Hypermedia Learning Environment, http://orange.ee.toyota-ct.ac.jp/defaultE.html (accessed on July 25, 2000).
4) Miyaji, C., "Network Programming with Mathematica" (in Japanese), Iwanami shoten (1998).
5) Nishizawa, H., Saito, H., Pohjolainen, S., "Evaluation Methods of Mathematical Expressions in On-line Exercises on Expanding Polynomials and Simplifying Rational Expressions", Proceedings of ICTMT4, P52 (1999).

An experiment of situated learning on college students

Fonchu Kuo*, Hin-chung Wong, Gin-Fon N. Ju***, P.M. Chen*, T.W. Lin*, Shu-Hui Liu** and Hsiao-Chiao Hung****

**Department of Computer Science, Soochow University, Taipei, Taiwan, R.O.C., P. O. Box 14-135, Taipei, Taiwan*

E-mail: kfc@cis.scu.edu.tw

***Department of Microbiology, Soochow University, Taipei, Taiwan, R.O.C. No. 70, Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

wonghc@mail.scu.edu.tw

****Department of Psychology, Soochow University, Taipei, Taiwan, R.O.C., No. 70,Lin-shi Road, Shi-lin Area, Taipei, Taiwan*

gju@cis.scu.edu.tw

Several experiments of situated instruction have been done in elementary school. We conduct the inaugural experiment on college students. A group of 44 students who are taking food microbiology course involved in this experiment. We designed a science fiction named "Save the Taiwan", which is a story regarding a Microbiology technician handles a disease crisis. A student can learn how to deal with the crisis and solve the problem of an infectious disease when he uses this CAI software. The evaluation practice consists of four dimensions, subject domain demands, instructional demand, user interface demand, and pragmatic demands. The result of evaluation shows notable effect on college students.

Keywords: **situated learning, evaluation of CAI, Microbiology**

1 Introduction

The advantage of traditional instruction is that the knowledge that students learned can be "stiff knowledge". The stiff knowledge can not be smoothly applied to solve the actual problem in a real environment (Brown, 1989). Situated cognition bases on the theory that the learning should be constructed at real situation. Only when the learner derive the knowledge from the real situation then he realizes the real meaning of the learned knowledge and cherish the value of knowledge and take it as the tool for solving the problem. (Cognition and Technology Group at Vanderbilt, 1990)

There was experiment on elementary school student (Tsu, 1997). The experiment was focus on learning simple mathematics calculating. We conduct the experiment on college student, trying to find out if situated learning can be succeed on the domain of higher education. The students of Department of Microbiology have to take laboratory classes during the period of 4 years college. They always have the problem of how and where to apply what they have learned in the class. The instructive goals of laboratory class are diverse. Lazarowitz & Tamir (1992) believe that learning is a process of construction. Despite of learning the laboratory skill, oral discussion between instructor and students should be part of the learning process. In addition, a more inexpensive and more efficient instruction method, such as computer aided instruction or simulations, should be adapted in the class. Anchored situated instruction adapts computer technology to implement situated cognition theory. (Cognition and Technology Group at Vanderbilt,1990) In our software, we develop a pseudo but can be real situation, embedded the learning materials in the circumstances. Through the interaction between user and CAI software, learner can then practice the process of collecting and filtering information as well as the methods to solve the problem.

2 Design features of our approach

The script was written and designed by a professor of Department of Microbiology. We adopt several principles in our design.

1. Provide vivid circumstance. Multimedia allows us to design a vivid environment, so that the situation can avoid over-simplified and lack of context. (Yang, 1995). Multimedia also provides plentiful visual symbols, e.g. video images, graphic charts, sound as well as text to make the play more fun and close to real environment.

2. To hide useful information in the story, a learner may have trouble to transfer what he has learned to different situation if he was teaching in a simplified or provided obvious cue environment. Whereas, a learner can learn to justify what information can be useful and what information is not useful for solving the problem in a simulated situation.

3. To randomize the plot of the story, the learner can memorialize the plot if he has experienced in using this CAI software. This can then cause the learning process in vain. We use Random function in our design; one of the bacteria was picked randomly and then, in turn, develop different story.

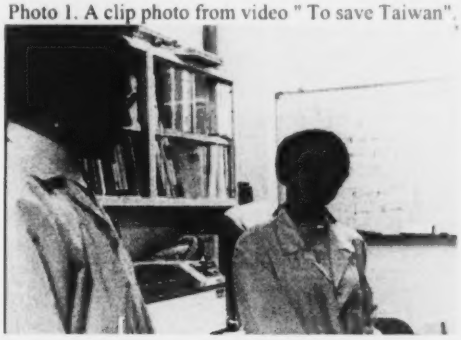
4. To have productive result, there may be only one answer or solution in a traditional instruction. However, in a real environment, there may be more than one solution to solve the problem. They may be pros and cons from one to one, but they may all workable. We do not provide firm answer to user instead, we provide an open-ended environment for user to construct his own path and solution.

3 The story

3.1 Outline of the story

There is a food mediated infectious disease occurs in a small town that locates at the seashore of Taiwan island. Within a few days, this infectious disease has spread to nearby counties and caused many cases of death. Tai-shang (see photo 1), the leading actor, a technician of the local public health administration office, is responsible for finding out the etiologic agent of the disease. In the story, Tai-shang is facing many challenges like the ones in real life. His girl friend, professor and colleagues are all in the plot and interactive with him. After the accident happened, he had faced the pressure from his superior, public media, even from a local councilor. He must acts like a detective who searches the cue and a scientist who seeks for the truth of problem. Finally, with the encouragement of his college instructor, Ta-shang successfully finishes his task.

Photo 1. A clip photo from video " To save Taiwan".



3.2 Goal of learning

a. Cognitive aspect

• a. Assessment of identifying the virus, fatal virus can not be classified from appearance. Thus, the learner

has to make a judgement base on the information gathered from the plot and then decide how to proceed the process of bacteria identification.

- b• Learning of the skills of bacteria identification, there are skills, e.g. Stain, biochemical test, can be practiced.
- c• Usage of bacteria identification index table, after the preliminary result of biochemical test, the learner needs to learn to use bacteria identification index table for final judgement.

b• Attitude • •

- a• Right attitude of science work, through playing the role in the game, the learner can identify the spirit of scientific work, diligence and concentration, as the attitude of being a scientist.
- b• Social caring, since the story has a local background, we hope the learner can improve the caring of local society by solving the problem for local society.

4 Evaluation of our experiment

There are four criteria of the evaluation of the designated software. The criteria is based on the character the teaching subject, human learning theories, and research on user interfaces• Kuittinen, 1998• • The criteria consist of four types of requirements: subject domain, instructional, user interface design and pragmatic matters. We invited two batches of domain experts, the faculties of Department of Microbiology and industry professionals to evaluate subject domain. They focused on examining if the concept and methods of this domain are generally applied in our software, which means they checked the relevancy to instructional aims. The group of 20 experts showed their positive opinion at the following chart.• Table 1• •The instructional demand is a student-centered approach. We divide a group of 44 college students who are taking food microbiology into two groups. The 22 randomly selected members of test team used our software for average 6 hours in a period of a week. A cognitive examination was taken after one week. The result shows that the test team has better performance in cognitive aspect. Table2• The interactivity, display elements and connections between them are examined as the criteria of user interface. We use questionnaire to test team and found out that the team members show satisfaction of the user interface.• Table 3• As the pragmatic criteria, the hardware and software requirements are evaluated to see if a specific and /or expensive equipment or environment is required to use the software. Our software can be used in a common Microsoft Windows environment plus Pentium compatible personal computer. A learner can run our software either at computer room in campus or at his own PC.

Table 1. The result of experts poll

	number	Min	Max	Average	standard deviation	variance
Can the instructional goal of " assessment of identifying pathogenic bacteria " be reached?	12	3	4	3.67	0.49	0.242
Can the instructional goal of " learning the identification methods " be reached?	12	2	5	4.00	0.74	0.545
Can the instructional goal of " usage of diagnostic table for the identification bacteria " be reached?	12	2	5	4.08	0.79	0.629
Can the instructional goal of " influence on right scientific attitude " be reached?	12	2	4	3.58	0.79	0.629
Can the instructional goal of " influence on social caring" be reached?	12	2	4	3.25	0.87	0.750
Does the content of software cover" common foodborne pathogenic bacteria and their characteristics"?	12	2	5	3.92	0.79	0.629
Does the content of software cover" procedures of identification of pathogenic bacteria"	12	4	5	4.33	0.49	0.242
Does the content of software cover" knowledge for assessment of methods used in bacterial identification"	12	2	5	4.17	0.83	0.697

Table 2. Evaluation on the cognitive improvement of the software

Item		n	Average	SD	F-value	df	t-value
Score of Midterm examination	Control group	23	61.96	6.92	2.54	42	-0.34
	Exp. group	21	62.90	11.03			
Semester score	Control group	23	80.09	9.66	1.00	42	1.59
	Exp. group	21	75.48	9.65			
Cognitive Examination	Control group	23	29.74	6.11	1.09	42	-3.14**
	Exp. group	21	41.29	6.98			
Situated Questions	Control group	23	3.57	2.64	1.04	42	-3.73**
	Exp. group	21	6.57	2.69			
Questions on Microbiological Skill	Control group	23	26.17	5.07	1.08	42	-5.47**
	Exp. group	21	34.71	5.28			

Table 3. Evaluation of user interface of the software

	number	Min	Max	average	standard deviation	variance
I do not need tutoring before I use this software	21	2	5	3.95	0.92	0.848
I can easily know how to jump to next screen	21	1	5	3.76	1.18	1.390
I can exit the software anytime, anywhere.	21	2	5	4.52	0.93	0.862
I do not have the situation that I can not proceed because that I did not memorize the previous information while I use this software.	21	2	5	4.19	0.87	0.762
It's easy to modify my answer before I press the "confirm" bottom	21	2	5	4.10	0.94	0.890
I can receive the system feedback anytime when I use the software.	21	2	5	3.90	0.77	0.590
The system feedback is clear enough and no need to be explained.	21	2	5	3.81	0.81	0.662
I can use the software without reading the user's manual in ahead	21	2	5	4.19	0.87	0.762
I think the execution speed is proper to me.	21	2	5	3.95	0.80	0.648
I can handle the execution speed of my own.	21	2	5	3.81	0.75	0.562
I am satisfied the quality of the video.	21	1	5	3.29	1.01	1.014
I can use the software without knowing how to operate Window NT	20	3	5	4.55	0.60	0.366
Total score	21	39	55	47.81	4.12	16.962

5 Conclusions

We completed situated learning software "To save Taiwan" which attract the user to learn the microbiology knowledge and skills. This interactive software provides multimedia and random plots, which enable user to play the role in the story. It can also served as the tool to convey the right scientific attitude and social caring to learners.

The evaluation of this study showed promising results. It is possible and valuable to adapt situated learning to other disciplines in higher education. A disciplinary can construct the learning process on a situated

environment. By using the multimedia software, a learner can learn knowledge as well as the attitude in a near true story. He can then realize the meaning of the knowledge and identify himself with what he has learned and then applied to real environment.

References

- 1. Hsu, H.Y. "Design of anchored instruction" Audio-Visual Instruction bimonthly. 37(1), page14-24, (1995)
- 2. Yang, C. H. "The situated instruction theory and hypermedia learning environment". Instruction technology and media. August, 1995. page41-48. (1995)
- 3. Brown, J. S.Collins, A., & Duguid, P., " Situated cognition and the culture of learning", Educational Researcher, 18,32-41. (1989)
- 4. Cognition and Technology Group at Vanderbilt., "Anchored instruction and its relationship to situated cognition ", Educational Researcher, 19,P2-10, (1990)
- 5. Lazarowitz, R., and P. Tamir.. "Research on using laboratory instruction in science. In: Handbook of research on science teaching and learning". Ed. By D.L. Gabel. P. 94-127. MacMillan Publishing Company, New York., (1992)
- 6. Kuittinen, M. "Criteria for evaluating CAI applications", Computer & Education 31, 1-16, (1998)
- 7. Winn, William,"Instructional design and situated learning: Paradox or partnership?" Educational Technology 33(3), page 16-21,(1993)

An Environment for Learning by Design
- In the Case of Learning of Search Algorithm -

Tsukasa HIRASHIMA, Hidenori IKEMATSU, Mayt Kalayar, Akira TAKEUCHI
Kyushu Institute of Technology, Department of Artificial Intelligence
680-4, Kawazu, Iizuka, 820-8502, JAPAN
TEL: +81-948-29-7618, FAX: +81-948-29-7601
tsukasa@ai.kyutech.ac.jp

This paper described a learning environment for search algorithms. In the learning environment, learners can build search algorithms by combining several parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. In the diagnosis, errors in the algorithms are detected. By using the results of this diagnosis, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms. We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising.

Keywords: **Learning by design, Error diagnosis, Search algorithm**

1 Introduction

An effective way to learn procedural knowledge in depth is to make learners apply it to various cases. However, although the learners may master how to use the procedure through the experience, it is not enough to answer the question "what the procedure is". Several investigations [1-4] suggested that "learning by design" is a promising way to promote the learner's understanding about "what that is". For example, in order to understand a machine in depth, assembling it from its smaller parts is the best way. In the case of the understanding of procedure, to build up the procedure by trial and error is useful in order to understand it.

This paper reports about a learning environment for learning by design, targeting basic search algorithms taught in an introduction to artificial intelligence lecture, that is, depth-first search, breadth-first search and three heuristics searches (best-first, minimum consuming cost, and A algorithm). In the lecture, usually, the procedure of each search algorithm is taught and learners carry out the searches following the procedures by hand. Some of them understand the meaning of the algorithms through the practice, but some of them only memorize the procedures. Our environment provides several parts of the search algorithm as icons. Learners can assemble them by direct manipulation in the environment. The environment interprets the assembled parts as a search algorithm and diagnoses it, for example, as to whether it falls into the loop or not. Then, the environment gives feedback for the algorithm to revise it or to try to build the next one. The tree structures that are generated as the results of the searches following the algorithms are also presented to the learners. These feedbacks are necessary to realize learning by design effectively.

In this paper, first, the model of the search algorithm that is the basis of the design of this environment is described. Then, the configuration and functions of the learning environment are explained. The preliminary evaluation of the environment is also reported.

2 Interactive Learning Environment of Search Algorithms

Figure 1 shows the configuration of the ILE. It is composed of the interface and reasoning module. In the interface, learners design and build search algorithms, and receive feedback from the system. In the

reasoning module, the algorithms are diagnosed and feedback messages for them are generated. The interface is implemented in Java as a client and the reasoning module is implemented in Prolog as a server. Therefore, the ILE can be used on the Internet.

In this section, first, the model of search algorithms used in the ILE is described. The modeling is indispensable for designing the interface for algorithm building and in order to diagnose algorithms. Then, the interface where learners can build the search algorithms by direct manipulation is presented. The diagnosis of the algorithms and the feedback generated based on the results of the diagnosis are also explained.

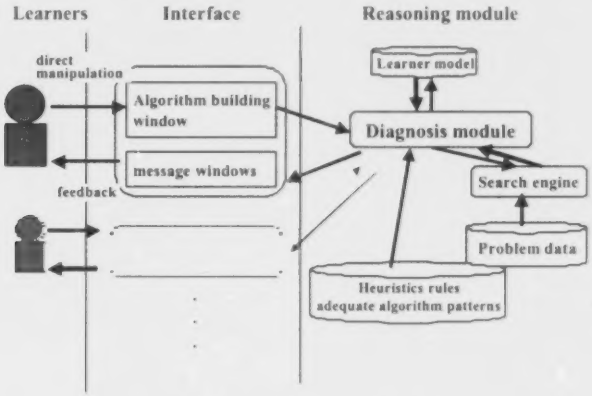


Figure 1. Configuration of the ILE

2.1 A Model of Search Algorithm

Search algorithms taught in the introductory lecture of artificial intelligence share the same procedure as follows. Here, both "Open" and "Closed" are lists composed of search nodes.

1) The start node is put into Open.
2) If "Open == []" then "the end of the search is in failure".
3) Pick up one node at the head of Open (the node is called *n*)
4) If "*n* == goal" then "the end of the search is in successful".
5) Generate child nodes from *n*.
6) Put the child nodes into Open.
7) Put *n* into Closed.
8) Return to Step-2.

The differences between the search algorithms are characterized by the operation of Step 6. For example, depth-first search is characterized as the algorithm in which the child nodes are put into the head of Open in Step 6. Breadth-first search is characterized as the algorithm in which the child nodes are put into the tail of Open in Step 6. In heuristics searches, the way to sort Open is an essential characteristic. In addition, for every algorithm, the method of selection of child nodes to put into Open is also an element that characterizes the search algorithms.

In our system, search algorithms are characterized by the combination of the following three list operations used in Step 6: "selection," "connection" and "sort." There are two types of selection operations: the first is "to select nodes that are not included in a list," and the other is "to select nodes that are not included in a list or are lower in cost than the same node in the list." Connection also has two types. The first is "to put nodes into the head of a list" and the other is "to put nodes into the tail of a list." The referred list is usually Open. We prepared three types of sorts: "to sort in the order of the consumed cost (minimum consumed cost search)," "to sort in the order of predicted cost (best-first search) " and "to sort in the order of the total of the consumed and predicted cost (A algorithm)."

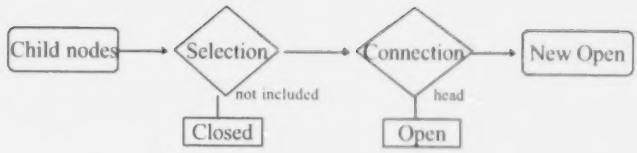


Figure 2. An example of the model of Search Algorithm

Figure 2 shows an example of a search algorithm built by the operations. The lozenge is the operation, and the rectangle is the list. The parameter that indicates "referred cost" or "head or tail" to specify the operator is presented at the bottom right of the lozenge. Therefore, Figure 2 means that "the child nodes that are not included in Closed are put into the head of Open." This is a kind of depth-first search that prunes using Closed.

Every part described above is necessary to build the search algorithms taught in the introductory lecture to artificial intelligence. In order to make learners understand search algorithms more deeply, our ILE provides an environment where learners can build search algorithms freely, and can receive feedback for the algorithms. In the following section, the ILE designed based on the model of search algorithms is described.

2.2 Building Search Algorithms

The interface for building search algorithms is shown in Figure 3 (currently, the interface is written in Japanese. Explanations in Figure 3 are translated to English for this paper. Japanese version is shown in [5]). Learners

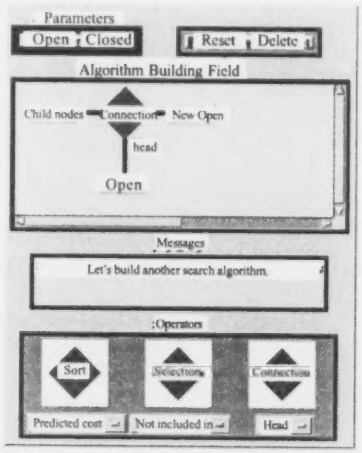
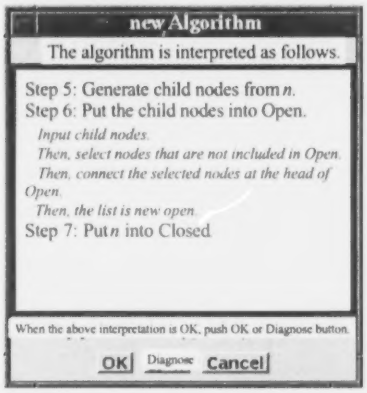


Figure 3. The Algorithm Building Field.

build search algorithms in the "building field" by assembling parts provided in the interface. At the bottom of the Interface, three operators are provided in the lozenges. The parameters specifying the operators are selected from the menu under the lozenges. The reference lists of the operators are selected from the box at the upper left. All manipulation in the interface can be done with a mouse. The algorithm in the building field is a depth-first search without having pruned.

Learners can confirm the algorithm built by themselves in two ways: a written explanation and a trace of the

search tree. The explanation is generated by interpreting the operations in order of sequence in the building field. Figure 4 is the explanation of the algorithm shown in Figure 3. A search tree is generated by showing the trace results in a search space. The search spaces are provided as mazes in the environment. Figure 5 is an example of search tree that is the results of the search for the maze shown in the right in the figure.



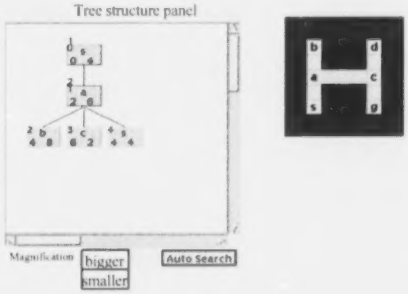


Figure 4. An Example of Explanation an Algorithm. Figure 5. An example of search tree.

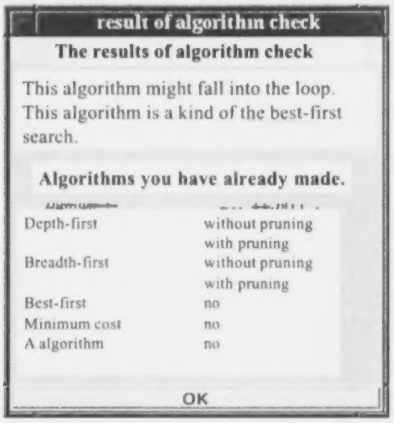


Figure 6. An Example of the Results of Problem Diagnosis.

Learners can also ask the system to diagnose the algorithms built in the building field. The reasoning module has both the adequate combinations of operations and heuristics rules to criticize the algorithms that are not adequate. By using the adequate combinations, the adequate algorithms can be detected. By using the heuristics rules, the errors in the inadequate algorithms are detected. If no errors are detected by the heuristics rules, the reasoning modules can not judge the type of the errors. The heuristics rules are prepared from the following three points of view: the kind of algorithm, redundancies in the algorithm and the covering of the search space. An example of messages generated from the results of the diagnosis is shown in Figure 6. In the following section, the diagnosis of the search algorithms is described.

2.3 Diagnosis of Search Algorithms

In the reasoning module, the algorithms are diagnosed using heuristics rules. The heuristics rules of each viewpoint are shown in this section.

2.3.1 Type of Algorithm

The algorithms built by the learners are categorized by the following heuristics rules.

* When, after child nodes are put into the head of Open, either any nodes are not put into the head of Open or Open is not sorted, the algorithm is categorized as depth-first search.
* When, after child nodes are put into the tail of Open, either any nodes are not put into the tail of Open or Open is not sorted, the algorithm is categorized as breadth-first search.
* When, after child nodes are put into Open, Open is finally sorted in the order of consumed cost, the algorithm is categorized as minimum consumed cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of predicted cost, the algorithm is categorized as predicted cost search.
* When, after child nodes are put into Open, Open is finally sorted in the order of the total of consumed cost and predicted cost, the algorithm is categorized as A algorithm.

When the algorithm has no characteristics checked by the above rules, the kind of algorithm cannot be specified.

2.3.2 Redundancy of Algorithm

When the algorithms include the following operators, the diagnosis module judges that the operators are redundant in the algorithms.

* The same operators are used continuously.
* When several operators of sort are used, only the operator of sort used at the end has meaning.
* After using the connecting operator with a list as the parameter, the execution of the selection operation with the same list as the parameter results in deleting the added nodes.

2.3.3 Covering of the Search Space

Several search algorithms that can be built by learners can not find goals that exist in a search space. The reasoning module diagnoses whether or not the algorithm can cover the search space, by using the following heuristics rules.

* When several child nodes which might imply goals are not put into Open, the algorithm might fail to reach the goal included in the search space.
* When the algorithm that isn't categorized as breadth-first, minimum consuming cost or A algorithm doesn't include the selection operator with Closed as the parameter, the algorithm falls into the loop.

2.4 Feedback based on the Diagnosis

Based on the results of the above diagnosis with heuristics rules, the messages to criticize the algorithm are provided in the interface. Figure 7 shows an example of the messages. When the type of an algorithm is judged, the type is indicated. When the algorithm includes the redundant operators, the operators and the explanation of the redundancies depending on each heuristics rule are provided. When the algorithm might not cover the search space because several child nodes fail to be input into Open, the explanation prepared for the heuristics rule is shown. When the algorithm might fall into the loop, the possibility of falling into the loop is indicated.

When the algorithm includes a pruning operation, the fact is also indicated. In the interface shown in Figure 7, to motivate learners to build the next algorithms, the algorithms the learner has made correctly and hasn't made yet are shown.

3 Preliminary Evaluation

For a preliminary evaluation of the learning environment, we gathered thirty college students and asked them to use the learning environment. Those who were in the second grade or in the third grade have already taken the lecture of artificial intelligence. Their participation was voluntary. Before the experiment, we explained how to operate the environment for ten minutes. Then, we asked them to build search algorithms in the learning environment for an hour.

In the experiment, we recorded the following data: (1) the number of algorithms built by the learners, (2) the number of adequate algorithms, (3) the number of inadequate algorithms that could be diagnosed with heuristics rules, (4) the number of inadequate algorithms that couldn't be diagnosed, and (5) the number of types of the adequate algorithms the learner made. The results are shown in Table 1. After the experiment, we asked four questions: (a) Are you interested in the system? (b) Is the system easy for you to use? (c) Would you like to use the system more? (d) Do you understand the search algorithms better than before? The results are shown in Table 2.

Table 1. The results of the students algorithm building.

Student number	(1)The total number of algorithms	(2)Adequate algorithms	(3)Inadequate algorithms (be diagnosed)	(4)Inadequate algorithms (not be diagnosed)	(5)the type of the algorithms
No.1	26	11	15	0	5
No.2	24	10	6	8	5
No.3	16	10	6	0	5
No.4	38	17	13	8	5
No.5	44	13	20	11	5
No.6	48	10	26	12	5
No.7	21	8	8	5	3
No.8	26	15	9	2	5
No.9	23	14	4	5	5
No.10	16	5	6	5	1
No.11	43	24	11	8	5
No.12	20	8	12	0	5
No.13	16	9	7	0	5
	361	154	143	64	

Table 2 . The Results of Questions.

	Yes	Maybe yes	No	No answer
Qusetion-a	10	3	0	0
Question-b	1	7	5	0
Question-c	7	5	0	1
Question-d	3	3	4	3

In Table 1, the total number of algorithms the learners made was 361, that is, 27.8 per student. The total number of adequate algorithms was 154, that is, 43 % of the algorithms. The total number of inadequate algorithms was 207 (57%). The number of diagnosed errors by heuristics rules was 143. This means that the system could detect the errors in 69 % of the inadequate algorithms. Among thirteen students, eleven students made every type of algorithm.

In Table 2, the results of Question-a and –c suggest that most of the students had interest in the learning environment. The result of Question-b indicates that the interface is not easy for the students to use. For Question-d, four students answered "no", and three students didn't judge, that is, more than half the students didn't think they gained a deeper understanding by using the learning environment.

Students made many algorithms in the experiment and they answered that the learning environment was interesting. In addition most of them could make every type of algorithm. These results suggest that the learning environment is promising. The answers for Question-b mean we should improve the interface. In Question-d, Six students thought they got deeper understanding by using the environment, but seven students didn't think so. When we gathered students, we told them that we would ask them to use a learning environment for search algorithms. Therefore, most of the students participating in the experiment might have confidence about their understanding of search algorithms. This is one reason for the result for Question-4.

As for the results, the experiment suggests that the learning environment is promising to be used in the real world, but the effect couldn' t be confirmed clearly.

4 Conclusions

This paper described a learning environment for learning by design in the case of search algorithms. In the learning environment, learners can build search algorithms by combining parts by direct manipulation. Then, the environment diagnoses the algorithms in order to give feedback about the algorithms. First, the environment judges whether or not the algorithms are adequate. When the algorithms aren' t adequate, they are diagnosed using heuristics rules. The heuristics rules detect errors in the algorithms. By using the results of this diagnoses, the environment can give messages to help the learners revise their algorithms or to motivate them to build the next type of algorithms.

We have already implemented the learning environment. As a preliminary evaluation of the environment, we asked 13 students to use the environment, and gathered several types of data. As a result, the experiment suggests that the learning environment is promising to be used in the real world and that is promising, but the effect couldn' t be confirmed clearly. In the next step, we will use the learning environment in class and evaluate it in a real learning context.

References

(1) S.Papert: Mindstorms, Basic Books, Inc(1980).

(2) G.Fisher, K.Nakakoji: Empowering Designers with Integrated Design Environments, Proc. of the First International Conference on Artificial Intelligence in Design, pp105-117(1991).

(3) A.Repenning: Programming Substrates to Create Interactive Learning Environments, Interactive Learning Environments, Vol.4, No.1, pp.45-74(1994).

(4) E.Soloway, M.Guzdial, K.Hay: Learner-Centered Design: The Challenge for HCI In The 21st Century Interactions,Vol.1, No.2, pp.36-48(1994).

(5) H.Ikematsu, Myat, T.Hirashima, A.Takeuchi: Interactive Learning Environment for Search Algorithm, Proc. of Research Meeting of Kyushu Division of Information Processing Society of Japan, 3A-5, pp.101-108(2000)(in Japanese).

An Implementation of Campus Distance Learning System Using Multicast

Jiang Dongxing, Tao Chaoquan, Fang Guowei, Shen Peihua
Computer and Information Management Center of Tsinghua University
Qinghuayuan No.1, Beijing 100084, P.R.China
Tel: +86-10-62772150, Fax: +86-10-62782728, E-mail: jdx@cic.tsinghua.edu.cn

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The Campus Distance Learning System is an important way to solve the problem. This paper starts with an examination of some existing solutions, and then introduces the primary-secondary model multimedia network teaching system designed by researchers in the Computer & Information Management Center of Tsinghua University. The system is composed of three parts: the primary classroom system, the secondary classroom system, and the courseware management system. It fulfills real-time interactive teaching and learning, and multipoint communication, and at the same time records the teaching materials as courseware. The paper focuses on the constituents, structure and characteristics of the system, and expounds in detail the implement technology based on multicast. In the end, the paper points out some problems calling for further consideration.

Keywords: **Network distance learning; primary-secondary model; multicast**

1 Introduction

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The traditional resolution was videoing and then broadcasting through CATV. This used to play an important part in television education, but it can not support the interaction between the teacher and the students, and the information that is limited by TV is not sufficient for lectures. With the network becoming more and more popular, network education instead of CATV is being received by more and more people. Many companies and universities have developed different network distance learning systems, the following are several famous systems.

Remote Education System of VTEL: This system is an application of the VTEL videoconference system in education. It adopts a complete set of software and hardware developed by VTEL and can implement mulitpoint bi-directional interactive network education.

IP/TV of CISCO: IP/TV is software developed by Cisco company, supporting video on demand and video broadcast. It adopts the client/server model and is mainly used for transferring high quality video, audio and data via computer networks. The system supports three ways of video transferring: live, on-demand and scheduled.

Multimedia Distance Education System of SATCOM: This system includes a program courseware generation system and a courseware on demand system.

2 Primary-Secondary Model Multimedia Network Teaching System

2.1 System Constituents

The primary-secondary model multimedia network teaching system is composed of three parts: the primary classroom system, the secondary classroom system and the courseware management system (See figure 1).

The primary classroom is where the teacher stays. In this classroom, the video and slide of the lecture are recorded synchronously. The video and slide information is broadcast live through multicast, and at the same time the information is stored in the courseware library for asynchronous use.

The secondary classroom is the classroom without the teacher, maybe a remote classroom. Students in this classroom can join the lecture by registering and playing the composite stream courseware synchronously with the primary classroom.

The courseware management system provides the directory service, user register management, asynchronous courseware on demand, and other management functions of the coureware library.

The free terminal can join the lecture from anywhere of the campus network through registering. It can also play courseware on demand from the courseware management system.

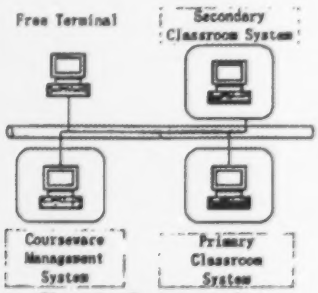


Figure 1 System constituents

2.2 System Structure

Figure 2 shows the structure of the primary-secondary model multimedia network teaching system. Its subsystems are as follows:

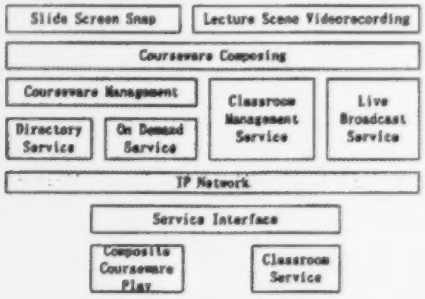


Figure 2 System structure

- Courseware synthesizing: The courseware synthesizing is the kernel subsystem of the primary classroom system. In this procedure, both the basic materials of the courseware – lecture scene videorecording and slide screen snaps are compressed into the composite courseware with synchronous timestamp. Afterwards, the courseware is stored into disks and multicast at the same time by the system.
- Lecture management service: The lecture management service is anther important subsystem of the primary classroom system, its main functions being registering new courseware in the courseware management system, requesting for the multicast address, configuring the multicast scope and lecture management.
- Directory Service: This is the kernel function of the lecture management system. It provides lectures and courseware lists and user management.
- On-demand Service and Live Broadcast Service: On-demand service is an asynchronous courseware service provided by the courseware management system while live broadcast service is a synchronous

service provided by the lecture management system. Both of them provide composite stream courseware to the user, the former using unicast and the latter using multicast.

- Lecture Service: This is an interactive supporting system provided by the secondary classroom system. With it students in the secondary classroom can participate in the discussion. The means of interaction may be keyboard typing, and speaking with a microphone.

2.3 System Characteristics

The main characteristics of the primary-secondary model multimedia network teaching system are the following:

1) It uses two streams to play the teacher's videorecording and slide screen snaps, and the quality of the slide screen snaps is the same as that of the slides in the primary classroom.
2) The lecture scene is kept in the archives in real time, and can be replayed at any time.
3) The teacher can discuss with students in remote classrooms through videoconference, and they can write on the same electronic white board.
4) The audience can have interlocution with the lecturer by text typing.

3 Implementing the System with Multicast

3.1 The Multicast Technology

By keeping routers informed about multicast hosts, multicast datagrams can traverse an internetwork and reach many hosts simultaneously. The ability to traverse an internetwork and reach an unlimited number of "member" hosts simultaneously without affecting others adversely is the linchpin of multicast. A Class D IP address in the range from 224.0.0.0 to 239.255.255.255 is a "multicast address." Each is also known as a "host group address," since datagrams with a multicast destination address can be received by all hosts that have joined the group that an address represents. Figure 3 shows the datagrams spreading abroad.

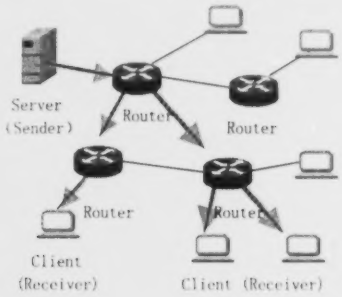


Figure 3 Datagrams sent only to hosts in a group

The mechanisms incorporated into WinSock 2 for utilizing multicast capabilities can be summarized as follows:

- Three attribute bits in the WSAPROTOCOL_INFO struct, which are used by **WSAEnumProtocols()** to discover whether multicast communications are supported for a given protocol;
- Four flags defined for the *dwFlags* parameter of **WSASocket();**
- One function, **WSAJoinLeaf()**, for adding leaf nodes into a multicast session;
- Two **WSAIoctl()** command codes for controlling multicast loopback and the scope of multicast transmissions (SIO_MULTICAST_SCOPE and SIO_MULTIPOINT _LOOPBACK).

We can benefit from using multicast to implement network teaching system, which can be described as the following:

1) Because the member of a multicast group is dynamic, and no authority is requested, the terminal can join or quit a group at any time;
2) All hosts belonging to a multicast group have a clear physics network topology;
3) All users in one subnetwork that join the same multicast group share the same stream over network, and this can greatly lighten the network load.

3.2 System Implementation

In the practical system, we adopt the combinative way of multicast and unicast: using multicast to broadcast information from the primary classroom, and using unicast to implement the interaction between the primary classroom and the secondary classroom. Figure 4 shows the structure of the practical system in detail.

The primary classroom system is composed of a server, a teacher's PC, a video recorder, two overhead projectors and an electronic white board. The teacher's PC is used to play slide of the lecture, and it projects the slide to the electronic white board. If the teacher writes something on the electronic white board, the teacher's PC will capture the written information and combine it with the slide. At the same time, the teacher's PC compresses the slide/written information and sends it to the server. The server takes charge recording the video/audio information, receiving the slide/written information from the teacher's PC, and broadcasting the information with multicast. At the same time, the server stores all information into special type file, which is the composite courseware.

The full function secondary classroom is made up of a server, a video recorder, two overhead projectors and an electronic white board. The server receives the video/audio and slide/written information from the primary classroom, and projects the video information on the white wall, the slide/written information on the electronic white board.

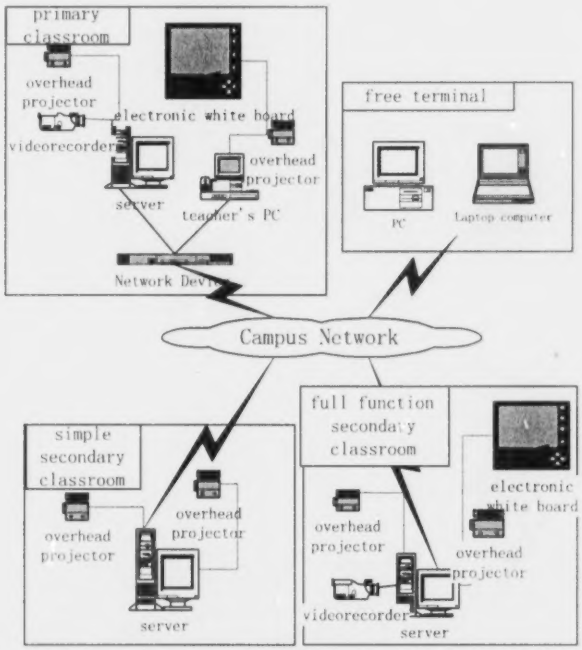


Figure 4 The topology of the primary-secondary model multimedia network teaching system

The simple secondary classroom is made up of a server and two overhead projectors. The server receives the video/audio and slide/written information from the primary classroom, and projects the information on the white wall separately.

The free terminal may be any PC connected to the network. It receives the video/audio and slide/written information from the primary classroom and displays it in different windows.

The teacher in the primary classroom and the students in the secondary classroom can discuss with each other. This is implemented with unicast. During the discussion, the server in the secondary classroom records the information of the students and sends it to the server of the primary classroom. The server of the primary classroom receives this information and projects it on the white wall. If students in the secondary classroom write something on the electronic white board, the servers will transmit the written information,

which will be shown on the electronic white board of the primary classroom at the same time.

4 Conclusions

In our experiments, we use lossless a compression algorithm and the slide screen snaps can be compressed to 1%~2%, it means that the slide screen snaps will take up 100~200Kbps bandwidth. In another side, the video information can be compressed into 128Kbps by MPEG-4 and all the information of this system can be fit in a 384Kbps channel. This system is available for long distance learning and of course for campus distance learning.

The primary-secondary model multimedia network teaching system has built a virtual network classroom system. It will play an important role in making better use of teaching resources and improving teaching efficiency.

References

[1] Jiang Dongxing, Lin Ehua, "Windows Sockets Network Programming", Tsinghua Univ. Press, (1999).

[2] Colin Perkins and Jon Crowcroft, "Real-Time Audio and Video Transmission of IEEE GLOBECOM'96 over the Internet", IEEE Communications Magazine, pp.30-33, (1997).

[3] Victor O. K. Li , Wanjun Liao, "Distributed Multimedia Systems", Proceedings of the IEEE, (1997).

[4] Song Yunxian, "The present and future of network education", Multimedia World, (1997).

An Interactive Game System to Stimulate Word Associations

Naoko Niitsu*, Takeyuki Kojima, Bipin Indurkhya, Yoshiyuki Kotani
Tokyo University of Agriculture and Technology
Department of Computer Science, Tokyo, Japan
**E-mail : naoko@fairy.ei.tuat.ac.jp*

We present here an interactive game system designed to stimulate user's knowledge associations between words. The system is based on a word-association television game called "Himitsu no Tsunagari". This game uses two different words and an association word. Each player is given a word, and must guess the other word and the association word to win the game. Our system allows person-to-person matches and person-to-computer matches. We believe that our system stimulates the users' creativity and their ability to form associations. Our system also acquires knowledge of word associations from game records. As more and more games are played, the system's knowledge of associations grows, and so does its ability to compete with the user.

Keywords: **Educational game, Interactive learning, Knowledge acquisition, Word association.**

1 Introduction

Many games have been designed to enhance various human abilities. Saeki [8] has pointed out that educational software needs to motivate learners in order to attract and retain their attention. If only its appearance is attractive, learners tire of the software soon. One approach developed in our lab to motivate children is the "Instruction Assisted Computer" (IAC) paradigm [4]. In this paradigm, the system is given a passive role and the children are put in the driver's seat. The result is that the familiar roles of teacher and pupil are reversed, and it is the children who end up 'teaching' the computer. To date we have successfully developed and studied several different systems using this paradigm [3][6][8].

Associations between words and concepts form a major dimension of human knowledge. Stimulating these associations can greatly influence concept formation and increase one's problem-solving skill [1][9]. Models based on association networks have been used for vocabulary acquisition [5] [7], and many association word-games have been developed [2].

In this paper, we describe a system to play an association game called 'Himitsu no tsunagari'. This game requires the player to think of several concepts at once and look for associations between them. We believe that this stimulates various associations inherent in the user's knowledge. Our system allows a user to play with another user (on the web, so that two users do not have to be in the same place), or with the computer. It also has a knowledge acquisition module, which analyzes the associations created in each game. These associations are added to the system's knowledge base, and result in a gradual improvement in the system's performance. In the rest of this paper we describe our system and the results of our initial experiments.

2 A Brief Introduction to Himitsu no Tsunagari

Himitsu no Tsunagari is a television game show in Japan. It is an association game using two different words (called 'keys') and another word that is associated with both keys (called a 'link'). There are two teams and a judge. Behind each team, a key is hidden (see Figure 1), so that each team can see the opponents' key, but not their own. Neither team can see the link. The goal of the game is to find their own key and the link. Each team takes turn guessing answers based on the visible key and the past guesses of the other team. The judge provides an evaluation of each guess ('correct', 'close', etc.). For example, in the second row in Table

1, Team B can infer that their key is something "yellow" from Team A's previous answer.

The associations between the keys and the link are not limited to those semantic or conceptual, but can be of any kind. For example, in Japanese "Niji" serves as a link between the keys "14 o' clock" and "rainbow" because both keys are homonyms of "Niji".

3 Design and Implementation of the system

Here we describe the interactive system for the Himitsu no Tsunagari game. We first describe the goals of our system. Then we explain the rules of the computer game, which are a little different from those of the TV game. Thirdly we present an outline of our system and discuss the relations among various modules. Fourthly, we describe the reasoning and knowledge acquisition modules in more detail. Finally, we describe the interface of our system.

Table 1. Flow of a game (Topic : keys - banana and strawberry, association - fruit)

Team	Visible key	Answer (Key)	Answer (Association)
A	Banana	Sunflower	Yellow
B	Strawberry	Lemon	Sour
A	Banana	Grapefruit	Fruit
B	Strawberry	Pineapple	Fruit
A	Banana	Raspberry	Fruit
B	Strawberry	Banana	Fruit

3.1 Design goals of the System

In order to allow many people to play and enjoy our system, we set the following design goals:

- The game can be played on the Web.
- The computer can be one of the players.
- The system has an easy-to-use interface.

3.2 The rules of the computer game

We clarified and added some rules to the TV game rules, as explained below.

- The game is played with two players and one judge
- At the beginning of a game, each player is given a key and the judge is given both keys and the link.
- The judge evaluates each guess as 'correct', 'near miss, 'incorrect', or 'strange'.
- Each player is allowed 90 seconds for making a guess.
- The game is finished when the judge declares the guesses of the key and the link as correct.

3.3 Overview of the system

The structure of our system is shown in Figure 1. There are five modules in it: game server, user interface, knowledge acquisition, reasoning module (making guesses), and knowledge database. The game server is responsible for sending the keys and the link to the players and the judge, and for passing messages (guesses and evaluations) between the players and the judge. The words used in the game and their associations are saved in the knowledge

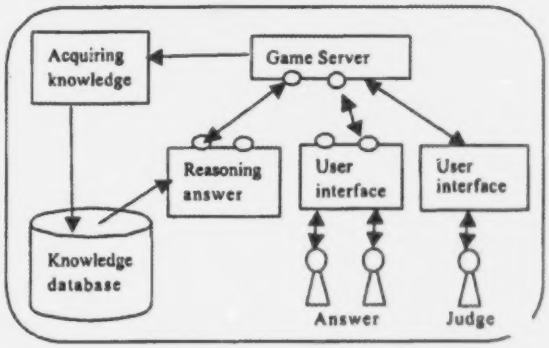


Figure 1. Structure of the system

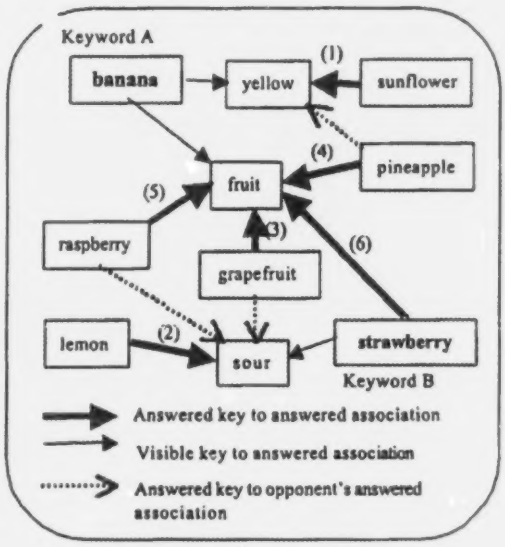


Figure 2. Association network from a game.

database. This knowledge is used to make guesses when the computer is one of the players.

3.4 Acquiring and Reusing Knowledge

We describe here our approach to acquiring knowledge about word associations from past games, and using this knowledge to make guesses in subsequent games.

3.4.1 Knowledge acquisition from past games

From the record of a game we can make an association network (Figure 2). It is difficult to say from the record which guesses of the opponent were useful for a player in making his or her own guesses. For example, when the opponent's guess seems quite unrelated to the visible key, a player may just disregard it. However, we assume that the link and the key in each player's guess are associated. We also assume that the link in each player's guess is associated with the key visible to that player. So we add <guessed-key, guessed-link> (➡) and <visible-key, guessed-link> (⟶) to our set of associations in the knowledge base. We call each of these pairs an "association pair", and the network created by all the association pairs an "association net".

3.4.2 Reasoning Module: Guessing the key and the link

As mentioned above, we assume that the link guessed by a player is associated with the visible key and the guessed key. For this guess we make two assumptions: the guessed link is correct or incorrect, and the guessed link has something to do with the hidden key. For example, if the opponent guessed "the key is 'apple' and the link is 'red'", and it was judged incorrect, a player can infer that the opponent's visible key (and the player's hidden key) is associated with red and the correct link is not "red". From these two pieces of information we can search for plausible answers in the association net (Figure 3). Every time the opponent makes a guess, the computer searches the association net and adds a certain weight to each plausible association pair. When it is the computer's turn to make a guess, it selects the association pair with the highest weight.

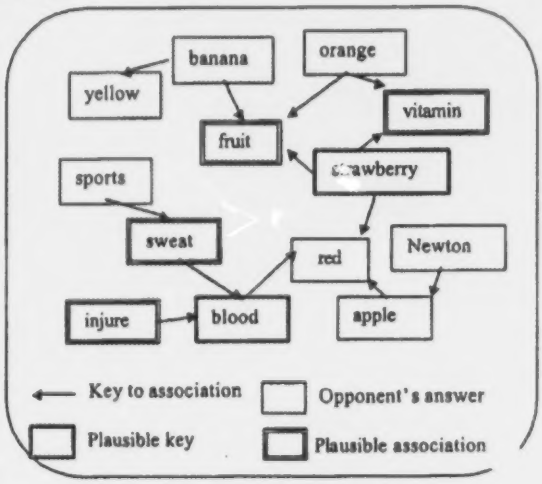


Figure 3. How to search for plausible answers

3.5 Interface

There are two displays, one for the judge and one for the players. They differ only in the input area. The player-interface displays the visible key and the history of the game (the player's guesses, the opponent's guesses, and the judge's evaluations), and has areas for entering the guessed link and key. The judge-interface is similar except for the input area. Instead, it has eight buttons (four each for the key and the link) at the bottom of the screen to evaluate the players' guesses. There is a time limit of 90 seconds, after which an answer is sent automatically.

4 Experiment

We tested our system with 10 undergraduate students in the Computer Science Department. In the beginning, we explained how to play the game with various topics and a sample game. Then subjects were matched to a computer to play the game using ten topics for two hours. Assistants judged the games. Subjects sometimes thought deeply and sometimes seemed to hit upon an idea quickly. We acquired about 1,400 answers. Here is a result of one game (see Table 2).

After playing the system, we let the subjects explain from which words they guessed the answers. We used their explanations to determine from how many words an answer was guessed • we call this the 'base-words number'. For example, "wiener" was guessed from "coffee" and "hotdog", so the base-words number is 2. The average base-words number was 1.4. This result shows that users try to consider more than one word in playing this game.

Table 2. An example, "Wiener & Twins". Both concepts also called "sohseiji" in Japanese

Turn	visible key	Key	Association
Computer	Wiener	American	Coffee
Sujject	Twins	Haliwood	Shuwalzneger
Computer	Wiener	Ketchup	Hotdog
Sujject	Twins	No	No
Computer	Wiener	Salami	Sausage
Sujject	Twins	Wiener	Sausage

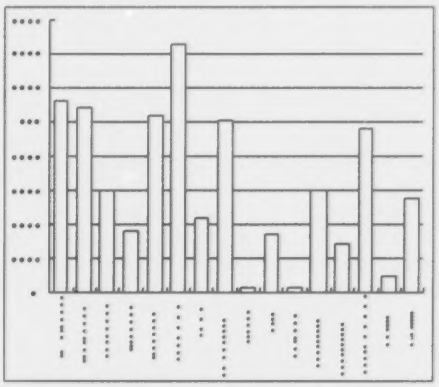
Some subjects tended not to answer within 90 seconds. Such subjects were found to have a higher base-words number than those who answered in time.

We categorized the associations into 16 groups (Graph 2), most of them from Togawa's classification. Superior, inferior, instance, synonym, same, emotion (<magic, muse>), character (<apple, red>), character2 (<Wright, airplane>), component (<sausage, pork>), inclusion (<apple, pineapple>), junction (<sun, flower>), place/time, phonic, verb, target (<knife, apple>), ellipsis (<wolf, liar>wolf boy lies a lot). Synonym was the most frequently guessed category. Ellipsis association represented 5% of the guesses. We think that playing with the system stimulates many kinds of associations.

We also gave a questionnaire after playing the game. In spite of its free answer form, most players answered that they enjoyed thinking and the moment of hitting upon an idea.

5 Conclusion

We described an interactive system using the Himitsu no Tsunagari game. In this game a user can play against either other users or a computer player. The computer uses the knowledge acquired from past games. It improved itself by acquiring knowledge from game records. Users tried to answer using associations to 1.4 words on average and in various categories. In addition, they said they enjoyed thinking about the answers in the experiment. We believe our system stimulates users' ability of associating words. Since many games were played, the computer acquired sufficient knowledge to compete well against users.



Graph 2 Categories of associations

References

[1] Entwisle, D.R., "Word associations of young children", John Hopkins Press, Baltimore, 1966.

[2] Kanasugi, T., & Matsuzawa, K., "The world of word-play", SIG-LSE-9903-S-4, 1999. (Special Interest Group on Language Sense processing Engineering of Japanese Society for Artificial Intelligence.)

[3] Kitajima, K., Nakagane, H., Inui, N., Kotani, Y., & Nishimura, H., "Knowledge acquisition oriented education system using a crossword puzzle", Proceedings of 54th National Conference of IPSJ, Vol. 4, pp. 299-300, 1997.

[4] Kotani, Y., "IAC – An education tool based on the paradigm 'the user is the teacher'", Proceedings of 'New Methods of Computer Usage in Education' Symposium, pp. 49-53, 1989.

[5] Meara, P.M., "Network structures and vocabulary acquisition in a foreign language", in P. Arnaud & H. Bejoint (eds.) "Vocabulary and applied linguistics", Macmillan, London, 1992.

[6] Otomo, A., Inui, N., Nose, T., Indurkhya, B., & Kotani, Y. "A building-block playing system using circles and squares to promote creativity in children", Proceedings of ICCE' 99, pp. 542-549, 1999.

[7] Rapaport, W.J., & Ehrlich, K., "A computational theory of vocabulary acquisition," in L. Iwanska & S.C. Shapiro (eds.) "Natural language processing and knowledge representation: Language for knowledge and knowledge for language", AAAI Press, Menlo Park (CA), pp. 347-375, 2000.

[8] Saeki, A. "The new computer and education", Iwanami books, Tokyo, 1997.

[9] Schwartz F., & Rouse R.O., "The activation and recovery of associations", International Universities Press, New York , 1961.

An on-line ITS for elementary algebra

Li Yi-Ping*, Chan Kan-Kan**

University of Macau
P.O.Box 3001, Macau
Tel: 853-3974323
Fax: 861095
*fstypl@umac.mo , **fedrc@umac.mo

The objective of this research is to reinforce the concepts and procedures of elementary algebra that students learn in junior schools. Students react to teacher's instructions in various way. However, in a traditional class, the ratio of teacher to student is still too great. The question of how to help all the students with limited number of teachers arises. This paper describes how to achieve the above objective with the help of an intelligent tutoring system. It discusses the design outline and the system architecture of the proposed system. The tutor tracks student's performance and uses this information to provide most suitable instruction to each student dynamically.

Keywords: **Web-based learning environment, intelligent tutoring system, elementary algebra**

1. Introduction

In a class of forty students, it is hard for teachers serving every student's questions within a class of forty minutes. Teachers teach students concepts and methods or techniques to solve problems in group. Then related exercises are given to students to practice at home. Students who have no doubts in class might cope with the exercise and learn well while some might not master the technique that teacher has taught. They always frustrate when they cannot solve the problem. In this situation, some advice from teacher is very helpful in their learning process. However, teachers are not always available while they need help. Also teachers might not be able to answer many students' doubts at the same time. This research is conducted with the aim of using computers to support the knowledge acquisition process that is adjusted to the capabilities of individual student. Students just need to have a web browser to connect to school network and would get assistance right away.

Many existing CAI applications do help a bit in students' learning process but they do not consider the background knowledge of students. This means that they might provide inappropriate feedback to students which in turn affects student's progress in learning. In order to overcome this situation, research has been investigated on intelligent tutoring system which includes functions for guiding students towards proper knowledge acquisition, according to observation of the student's problem-solving process and identification of the causes of student error.

We first depict the learning environment of our system in section 2and then the overall architecture of our system is mentioned with detail description of main components of ITS in section 3. The final section concludes our work.

2. Learning Environment of on-line ITS for elementary algebra

ITS for elementary algebra is designed as a problem solving environment to be used in class. Therefore we assume that student is familiar with the basic concepts of elementary algebra and know the ways to factorize a polynomial. Students use the system as a tool at home or during class practice. Since the condition that students

use it lacks teacher's support, an interactive problem support should be built into the system. With this feature, students might get help on steps of problem solving where he has difficulty.

In order to access the on-line tutoring system, a student just needs a web browser and types the address where the system locates. An instance of the system will be created in student's computer in the form of ActiveX control. Although it might argue that there is great network delay in loading the system in student's computer, interactivity and userfrindliness deserve a short delay. In fact, in a local environment, the network traffic is not so congested. Therefore this is not a real problem. Instead, students can use it as if any Windows program and do not have to worry about its maintenance or compatibility issues. The control serves as a communicator betweent the system and the student. It transfers student's action to the system and returns the reponse of the tutor to the student.

Every student has his own session during the learning process. When a student enters the system with his user name and ID, a model of student performance is created or opened to set his learning environment. ITS selects a problem according to student's level for him to work or waits for the student to enter a problem which he has doubts. In both situations, the student solves it with the guidance of the tutor in a step-by-step way. The system keeps track of every step of the student in background. If nothing goes wrong, it remains quiet otherwise it prompts student's error. His problem solving procedure is kept in the system for future reference.

3. Overview of on-line ITS for elementary algebra

Our system follows the standard architecture of client-server model. The system resides on the server side. The basic components of the learning system are the domain module, pedagogical module, student modeler and the interface.

The domain expert module consists of two main programs. One is a problem solver which is capable of solving problems in its knowledge base. The other one is question generator that creates new problems according to the instruction of pedagogical module. In order to achieve its mission, the knowledge base is composed of both rules and cases. The expert model is capable of solving general problems by the rules coded in its module. As for miscellaneous problems, they are indexed as cases with problem characteristics and solving techniques so that the domain expert knows how to retrieve the relevant solving technique with the detected problem features.

The domain that we have chosen is factorization of algebraic polynomial for students in elementary classes. Given a polynomial, factorization is to express an integral polynomial as a product of prime polynomial. Therefore a polynomial is not completely factored unless each factor is either a monomial or a prime integral polynomial. Generally, there are 4 basic methods to factorize an algebraic formula. They are: (1) obtaining the common factor (2) using identities (3) cross-method and (4) divide the polynomial into groups and then simplify groups to find factors.

The pedagogical goal is to let junior students master the methods to factorize a polynomial smoothly. Students are taught the basic method to factorize an algebraic formula. However, they always get lost in the actual application to find the factors of a given formula. Therefore, we have organized the pedagogical knowledge by constructing groups of problems according to the level of difficulty, problem characteristics and solving technique. Within each level, there are pre-requisite question types which a student must understand before a certain question type will be generated. Figure 1 shows part of the relation among question types. There are several groups having polynomial problems as bellows:

- Problems, which just need one method to solve. They are polynomial with common factors, problems that satisfies the characteristics of perfect square: $(a\pm b)^2 = a^2\pm 2ab+b^2$, difference of 2 squares: $a^2-b^2=(a+b)(a-b)$, sum or difference of 2 cubes: $a^3\pm b^3 = (a\pm b)(a^2\mp ab+b^2)$, or perfect cube: $(a\pm b)^3 = a^3\pm 3a^2b+3ab^2\pm b^3$ and problems of trinomials with a degree of 2 i.e. $x^2+(a+b)x+ab = (x+a)(x+b)$
- Problems that need 2 methods to solve are posed, for example: ab^2-4a. There are a few combination of solving techniques like common factor with standard equation, common factor with cross method or cross method with standard equation.
- Problems with more than 4 terms that need to be divided into groups of terms before they can be solved by the general methods.
- Problems that require special techniques to solve like adding terms, splitting terms etc.

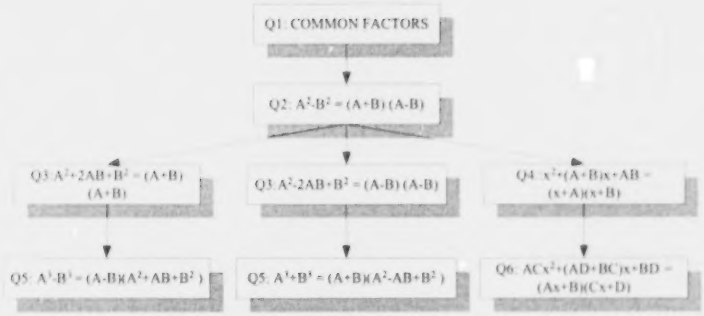


Figure 1. Part of the pedagogical knowledge

A student modeler tries to understand the mental state of a student so as to provide a more accurate estimation of individualized instruction. The task of building a student model is extremely difficult as the amount of information to capture is huge. Although it has been pointed out that this task is intractable[1], an incomplete student model is still very useful in the process of tutoring [2] [3].

The student modeler evaluates the solution of the student and the ways he factorizes the polynomial with respect to the one solved by domain expert. Although the solution path for a given problem of a student might be different from that of domain expert, the student's solution is still correct if it answers to the problem. In our case, if all the factors that the student found are irreducible, his answer is correct. The tutor would suggest him another way to solve the problem if it is found that his solution path is different. In this way, students are guided to know that there is always another way or a better method to solve a problem. Referred to table 1, student is asked to factorize a problem $4a^2-16b^2$, the second column shows the ways that he solves the problem. The student answers the question correctly and his student model is updated accordingly. Although his problem solving procedure differs from the sample, this would not affect his student model. Only the tutor would suggest him its way for the student as reference.

Problem: $4a^2-16b^2$			
Student	Reason	Tutor	Reason
$=(2a-4b)(2a+4b)$	$a^2-b^2=(a+b)(a-b)$	$=4(a^2-4b^2)$	Common factor
$=2(a-2b)2(a+2b)$	Common factor	$=4(a+2b)(a-2b)$	$a^2-b^2=(a+b)(a-b)$
$=4(a-2b)(a+2b)$	Multiply numbers		

Table 1. Procedure that the student and the tutor solves a problem.

The student model in ITS for elementary algebra contains a general information about the student, history of student's performance such as previously solved problem, information about the usage of factorization techniques and what kind of problems he is able to solve according to the pedagogical knowledge. All these information is important to allow students to receive more instruction and perform more problem-solving questions in areas in which they are relatively weak. An array of integer is used to keep the system's belief of student's mastery of a certain skill.

The interface of our system shown in Figure 2 is designed to be user friendly. It is divided into 3 main regions: upper part shows "Check answer" and "New problem" buttons; lower part is the area where the tutor provides feedback. The student interacts with the system mainly at the left side of middle part of interface. He may enter a question by himself or the system might generate one based on his experience. A list of actions is listed for him to explore the problem solving technique. He may select an action to tell the system how he would solve the problem. Every action selected would be given an appropriate feedback to the student. In this way, he might discover what is the consequence of selecting an action. An input area is allocated for the student to enter auxiliary data needed for his selected action. When the answer button is clicked, the student's solution is evaluated and his student model is updated accordingly.

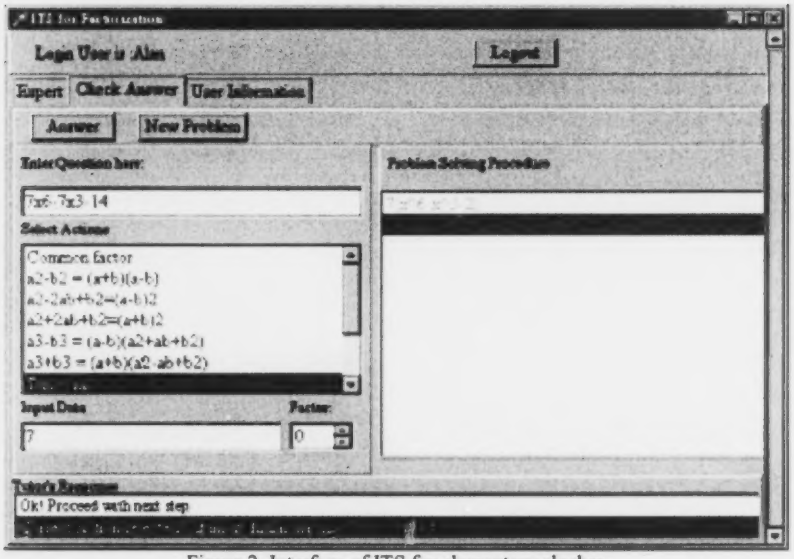


Figure 2. Interface of ITS for elementary algebra

3.1 Evaluation

In our experiments to simulate the problem solving procedure of students using the system, we found that it follows the overall design. It is able to provide individualized instruction, appropriate feedback and model student's performance. For major types of the factorization problem in junior school, the tutor is able to solve and guide the students. However, there are also questions that it fails to solve and guide. There are also cases that the available action for students to use in the problem solving process is not enough.

4. Conclusion

In this paper we have described an on-line intelligent system with interactive problem solving support and curriculum sequencing. A prototype system designed with some learning theory is implemented. The system helps students to reinforce the factorization technique. Our intention of building this system is to increase the learning progress of students and it shows to be a successful tool according to informal evaluation

Since the success of an ITS depends greatly on the student model, we are planning to improve our system with a more accurate student model in the near future. The user interface will be reconstructed to improve the interactivity between users and the system. The implemented domain knowledge is quite limited in this stage and we are developing larger domain knowledge.

Reference

[1] Self J., "Bypassing the intractable problem of student modeling", Intelligent tutoring system: at the Crossroads of Artificial Intelligence and Education, (1990).

[2] Self J., "Formal Approaches to Student Modeling", Student Modeling: The key to individualized knowledge-based instruction, (1994).

[3] Woolf B.P. and Murray T., "Using Machine Learning to advise a student model", Student Modeling: The key to individualized knowledge-based instruction, (1994).

BEST COPY AVAILABLE

Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching

Chao-Fu Hong, En-Yih Jean, Pei-Chin Wu, Chien-Miing Lia and Tsai-Hsia Wu*
**Aletheia University, Nei-Li High School*
cfhong@email.au.edu.tw
No. 32 Chen-Li Str. Tamsui City Taiwan ROC
TEL:886-2-26212121-5536

At recently year the research of teaching method are trending to request the student for active learning, to avoid the student to learn the stuff knowledge. Therefore the number of researchers in the constructivism and cooperative learning etc fields are many. Even now how to estimate the student's learning attitude belong an active type, is a big problem. In our research, we recur to the simple method, adopt the discovery teaching. Because under the discovery teaching, the student does not only use his ground knowledge, but also need face the problem's stimulation and bring the solution. This method can mostly saturate the today's teaching trend. But how to analyze the student's learning obstacle area and supply the explanation to help him cross over the learning barrier is a net bottle in the discovery teaching. In this paper, connect the concept graph and the gray decision-making to issue the gray analyzing method of learning obstacle. This method has a flexible ability to point out the area of learning obstacle, it also can infer the student inbuilt concept or relationship on his knowledge structure. Finally, according to the expert's experiments rule to clearly distinguish the core of problem. Then the system obeys the inferring rules to bring the explanation and the similar question to stimulate the student to build his whole knowledge. This learning cycle will continue until the student completely finishes his learning.

Keywords: **Discovery Teaching• Gray Theory• Concept Graph• OO**

1 gray relational concept graph

a. The design of cognitive structure

Induct the student to learn the material, not only implant him a located knowledge, but also hope he can actively learn or construct the knowledge. Therefore, our system want to stimulate the student, and hope he use his langue or letter to descript his thinking. It like he uses his symbols to review the content and build his cognitive structure. Therefore in our system, our chapter designing does not like traditional, we use the proposition to build concept graph.

Table 1 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1					
Node 2					
Node 3					
Node 4					
Node 5					

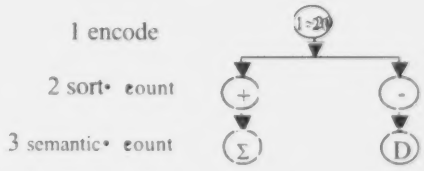


Fig. 1 Concept Garph

b. Relational concept graph

From the cognitive structure graph we can understand that the relation be assembled by node linking to other node, of course each relation also has its particular mean. And in our system the question is based on proposition, then accord with the problem' s subject the expert can distribute the weight to each node and each relation. These data can be consisted a matrix, and we call this matrix as the conceptual relationship matrix.

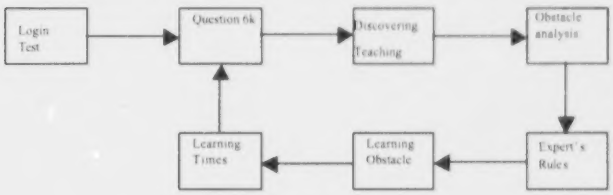


Fig. 2 System graph

As Fig.2, when the student log into the system, the system will give him some questions are selected from the question database. After the student transmit his answers to system, the system will start to analyze his learning obstacles. Of course, the student' s does not have much time for studying, the system hardly collect the enough data for analyzing by statistical recursive method. Because the statistical recursive has some limited: large data, the data distribution must like normal and the variants cannot too many. Consequently, the only way we can elect to adopt the gray theory to reduce the analyzing data. This matrix is called the gray relational conceptual matrix.

2 Gray relational learning obstacles analysis

The gray decision making system is meaning that the system includes some gray element (uncertainty or incomplete factor). In general case, the decision making space X is constituted by event sets S• {Sij} and efficiency sets R..

After the student interact with system, the system can collect his data to assemble the gray relationship' s matrix. The analysis method explains as following.

Table 2 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	0.5	0.5
Node 5	0	0	0	0.2	0.8

Table 3 the gray relationship' s matrix

relation node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	1	1
Node 5	0	0	0	0.2/0.8	1

1. According to the Grey formulate, can translate table 2 to table 3. The system can calculate each node' s average weight, and according these values to arrange their ranking.

Table 4

Node 1	Node 2	Node 3	Node 4	Node 5
0	0	0	1.25/2	2/2

2. If the nodes weight higher than the threshold value 0.3, the system can find the weight at node 4 and 5 are higher than 0.3, the system define these nodes are the learning obstacle nodes.
3. At the same time, according to the relation' s matrix (table 2), the relation 4-5 is 1 higher than • •cut (0.3) is the relation of learning obstacle.
4. According to the expert' s rules decide expanding or reducing the learning obstacle area.
   Use the aforementioned logic the system can reduce the relation 5-4 and relation 4-5 to infer the learning obstacle area is node 5

3 Conclusion

On the teaching the most afraid thing is to induct him learning the inert knowledge. Therefore, in all teachings methods the discovery teaching is the only one can avoid this problem that is why we adopt the discovery teaching to develop our system. But how to break through the discovery teaching' s net bottle, our issue are: integrate the concept graph and gray decision-making system to develop the gray analyzing method, and use it to discover the student' s learning obstacle. This analyzing has an ability to point out the learning obstacle area, and enhance the inferring ability to find the student' s learning obstacles or the incompletely knowledge, then pass through the expert' s rules, the crossing analysis method can find the problem kernel. Then system rely on this result to elect the problem saving content, let the student can learn it again and rebuild his knowledge structure until he can construct the whole knowledge.

Reference

[1] Chao-Fu Hong[a], Yueh-Mei Chen[b*], Yi-Chung Liu[a], Tsai-Hsia Wu[a] :Discuss 3D cognitive graph and meaningful learning,ICCE99.

Construct in-service Training Web Site for School Teachers

Jia-Rong Jerome Wen* and Wen-Chin Chen**
**jerome@nknucc.nknu.edu.tw*
***timmy@icemail.nknu.edu.tw*

1 Introduction

Information technology grows rapidly recently. People use Internet to obtain many kinds of information. The Internet has become the most important path in cyber world. In the last five years, using the Internet to carry out distance learning, especially for teachers' in-service training, changes the style of education.

To actualize the policy which was to build an lifelong-learning education environment, Ministry of Education delegated National Kaohsiung Normal University (NKNU) to manage Asynchronous Distance Learning class for high school teachers in Oct, 1999.

2 Construct Asynchronous Distance Learning Web page

Generally speaking, teachers have to control the instructive materials, activities, learning process and evaluation. Every instruction system must include all of the three factors as following:

2.1 Instructive materials and activity designing

If we just put the materials onto web site, they look like electronic books on Internet. It is helpless for students. Therefore, when designing the contents of curriculum, we make it in "practicing" orientation. Activities make teacher and students interact with each other and avoid students to feel humdrum or like reading an electronic book.

2.2 Evaluation

When students finish learning a chapter, we give them an formative evaluation to verify whether students master the thesis or not. If students pass the formative evaluation, they can continue the curriculum. If not, they have to go back and learn it again until they pass the formative evaluation. The system would give some feedback to students, they would know which part of contents they don't understand yet. Then, we always hold an examination when finishing the curriculum, the summative evaluation. (Figure-1)

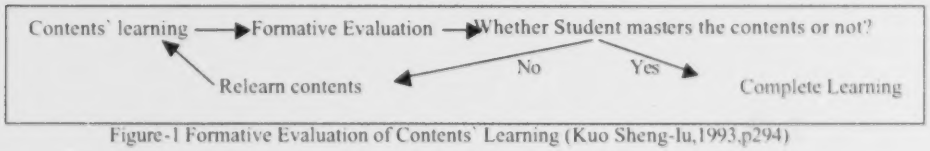


Figure-1 Formative Evaluation of Contents' Learning (Kuo Sheng-lu,1993,p294)

2.3 Learning process

Instead of quantification of examination, we should care about the reflection from students after instruction and learning. Grades cannot decide students' learning efficiency. During designing the materials, we considered every details of students' learning process. These include

- counts in connection
- counts in joining the forum
- contents what student discuss
- chatting situation between teacher and students

- Homework – students work hard or not
- Chapter evaluation (formative evaluation)
- teachers and students communicate by email

All items can be saved into database so that we can estimate student' s behavior in learning.

3 Concepts on designing curriculum

We design several activities and strategies. The activities will make students concentrate on the contents. we consider about the strategies as following:

3.1 Homework:

We assign homework after students finish learning every chapter. They can evaluate themselves through homework to know how much they learn and review contents again.

3.2 Operative Orientation:

In the homework, they have to work some operation by computer, such as computer game.

3.3 Self-determination:

Self-determination means that students have to study by themselves and plan study schedule by themselves.

3.4 Interactive :

We define interaction into two ways : one direction and two direction (Table-1).

	One direction	Two direction
Asynchronous	Announcement FAQ	On-Line Forum
Synchronous		Chat Room

One direction: teacher to student
Two direction: teacher and student

Table-1 Interactive model

3.5 User Interface• •

What users feel about it is very important in internet environment. Hyperlink always be mazes for a novice in the internet. Trying to solve user interface problem , we use several ways as following :

3.5.1 Frame• cut web pages into several frame to reduce confusing

3.5.2 Tree menu• from the reaction of students , the tree menu is easy to access the pages

3.5.3 Learning Path• guideline for students on the web

References

[1] Fred Jevons."Distance Education and Campus-Based Education : Parity of Esteem", New South Wales, Australia : Peter Smith and Mavis Kelly. (1987)

[2] Kuo Sheng-lu(1993). "The Evaluation of Psychology and Education", Chin-Hua , 7th Edition., (1993).

[3] Lisa Neal(1998). "Distance Learning". ACM(http://www.acm.org)(accessed on May 15,2000).

[4] Mei-Sheng Chao, "The Impact of a Systems Approach on Interactive Distance Teaching: The Development of the ATM Video Network System at National Chung-cheng University", ETR&D, Vol 47. No 2. pp. 112-117(1998).

[5] Sun Chuen-tzai, Chu Ching-hao, & Shiu Idi, "The research of constructing hypermedia teaching material", Information and Education• vol. 67• pp 13-25(1998).

[6] Wang Chien-Shin, " Web-based network system for instructive management", Information and Education, Vol. 67• pp 3-12(1998)

[7] Wen Jia-rong, "The research on present Statement and Requirements of junior-high-school Information Education", Information and Education, Vol. 51, pp17-26(1996)

[8] Wen Jia-rong, Wu Ming-lung , "Information Education Theories and Applications in New Age ", Song Kang ,1st Edition.(1999).

[9] Han Shan-ming, "Information Education Fundamental Construction – Speed", Information and Education, Vol. 68, pp14-16 (1998)

Constructing a Real-Time CAD Learning System Based on OpenGL in Web-Based Environment

Wen-Chai Song*, Shih-Ching Ou*,Song-Rong Shiau**
**Department of Electrical Engineering, National Central University, Taiwan*
***Department of Electrical Engineering, National Taipei University of Technology, Taiwan*
4F,NO.184-1,Kee-Kin 1st Road,An Lo District, 204, Keelung ,Taiwan
Tel:+886-2-24325455
Fax:+886-2-24324075
E-mail:songchen@ms10.hinet.net

The purpose of this paper is to apply network technology to make the design of Web-based learning graphics systems for user. Several issues will be addressed in this paper such as the development of an Integrated Interactive Graphics System (IIGS) for a better design environment. In this paper, we attempted to develop a web-based graphics learning system by Bézier, B-spline and NURBS algorithms. The purpose of the research was to increase the effect of Computer-Aided Design (CAD) in network .The other advantages is that network browser is the common platform in internet and intranet, the graphics system can be portable cross different operating system, as like windows 98,linux..etc. In fact, the graphics learning system have attempted to be shared the resource each other.

Keyword: **OpenGL, VRML, NURBS, CAD/CAM, CAI, Curves, Surfaces**

1 Introduction

As the Internet has improved in the last ten years, web-based graphics learning has become very important in Internet. In recent year, the distance learning by Internet has been established and developed in Computer-Assisted Instruction (CAI) system. In this paper, the user can design and learning sculpture curves and surfaces on a personal computer by the interactive way. The graphics system has friendly interface in operating process.

OpenGL is a software interface that allows the programmer to create 2D and 3D graphics images. OpenGL are both a standard API and the implementation of API. In other words, OpenGL is a set of functions which have the same syntax and which act the same way on every platform, even though different vendors have written the actual subroutines, which implemented the API standard.

Graphics programming concepts underlie the function of OpenGL. These concepts are easy for the average application programmer to understand and use. OpenGL is independent of the hardware, operating, and windowing systems in use. Using OpenGL to make a program is easier than using API to do. API is integrated into a windowing system, since learning how to program a windowing system is often quite complicated.

2 Curve Modeling

Curve methods are usually included in different courses such as geometric modeling, CAD/CAM, computer-aided geometric design (CAGD), computer graphics, etc. In teaching this material, it is essential that students have an access to computer graphics facilities. Practical experiences help them to understand the dry theory. There are many books concerning curve and surface modeling and each of them considers

this subject in a different way (with some modifications). Users are confused, especially beginners. The next weakness of method representations is in lack of comparative means. Learning can be more effective if different methods are studied simultaneously on the same data by changing control parameters.

This field is developing very quickly and therefore researchers need also an effective comparative tool for their new improved approaches or methods. For these reasons, a program package for modeling and analysis of parametric curve methods called CM ("Curves Modeling") has been constructed. It is written in OpenGL. Not only 2D but also 3D curves are considered. Three various methods are incorporated in CM in the first menu level. Including all menu levels, there are ten methods or their modifications. In the interpolation methods, a curve passes through all control points, in the approximation methods, however, a curve passes only near to control points.

Figure 1. The Curve modeling interface

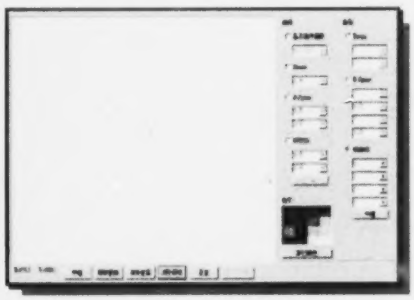


Figure 2. The Surface-modeling interface

A curve is compounded of small curves called curve segments and is determined by an equation in parametrical form (parameter u). In the knot vector for u (Uknot), there are parameter values for segment boundaries.

3 The Bézier, B-spline and NURBS Curves Algorithms.(extract)

NURBS curves:

A pth-degree NURBS curve is defined by

$$C(u) = \frac{\sum_{i=0}^{n} N_{i,p}(u) w_i P_i}{\sum_{i=0}^{n} N_{i,p}(u) w_i} \quad a \le u \le b \tag{12}$$

Where the {Pi} are the control points (forming a control polygon), the {Wi} are the weights, and the {Ni,p(u)}are the pth-degree B-spline basis functions defined on the non-periodic (and non-uniform) knot vector.

$$U = \left\{ \underbrace{a,\ldots,a}_{p+1}, u_{p+1},\ldots,u_{m-p-1}, \underbrace{b,\ldots,b}_{p+1} \right\} \tag{13}$$

4 Surfaces Modeling

In the computer graphics, a surface is usually generated by a surface representation method on a control net (linked control points in a 3D space). Methods for surface representation are divided in two major groups: approximation and interpolation methods. At the interpolation methods, a surface passes through all control points, at the approximation methods , however, a surface passes only near to control points. A surface is compounded of small surfaces, called patches, presented by two families of isoparametric curves.

A program package for modeling and analysis of parametric surface methods called SM ("Surfaces

Modeling") has been constructed .A surface is determined by an equation in parametrical form (parameters u and v). We speak about u and v directions (parametrical view) or about direction X and direction Y respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parameter values u and v for patch boundaries.

5 The Bézier, B-spline and NURBS Surfaces Algorithms.(extract)

NURBS surfaces:

A NURBS surface of degree p in the u direction and degree q in the v direction is a bivariate vector-valued piecewise rational function of the form

$$S(u,v)=\frac{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}P_{i,j}}{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}} \qquad 0\le u,v\le 1 \tag{14}$$

The $\{P_{i,j}\}$ from a bi-directional control net ,the $\{W_{i,j}\}$ are the weights ,and the $\{N_{i,p}(u)\}$ and $\{N_{j,q}(v)\}$ are the non-rational B-spline basis functions defined on the knot vectors

6 The structure of the graphics learning system:

(1)System operating process and interface:
(2) Graphics algorithms:

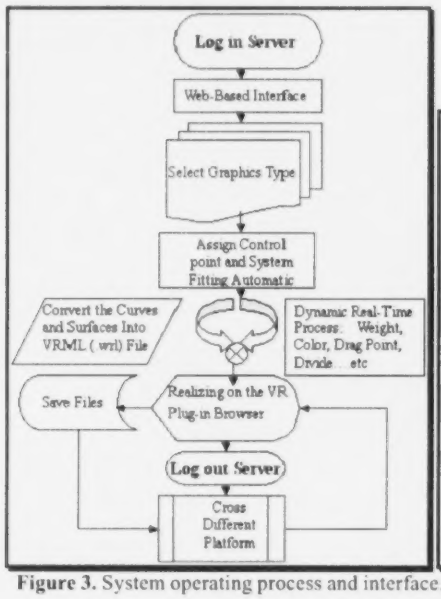


Figure 3. System operating process and interface.

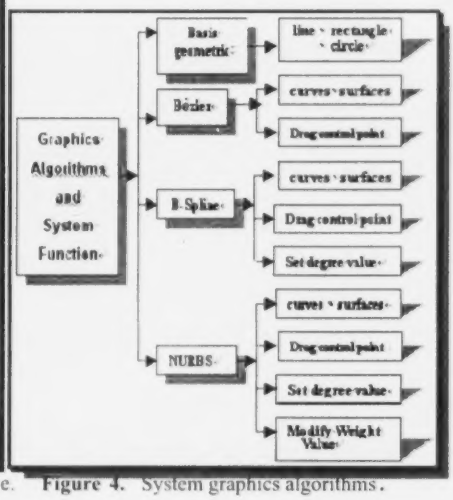


Figure 4. System graphics algorithms.

7 Brief Overview of OpenGL

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. OpenGL have the following obvious benefits:

(1) Reliable and portable
(2) Scalable

BEST COPY AVAILABLE

(3) Easy to use

VR as a Training Tool

Virtual Reality training can dramatically reduce the cost of delivering training by decreasing learning time for student and instructors.

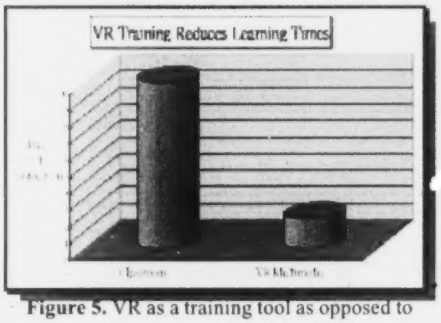


Figure 5. VR as a training tool as opposed to Classroom techniques (RTI)

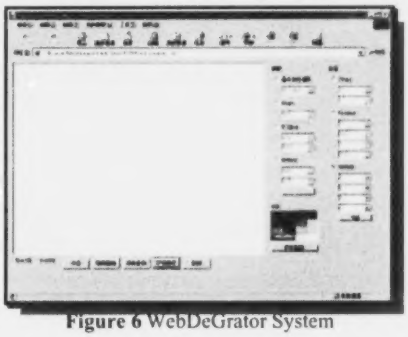


Figure 6 WebDeGrator System

8 Implementation and Example:

(1)The Integrated graphics Learning real-time system:
(2)Drawing NURBS curves and Covert Curves into VRML 3D Type:

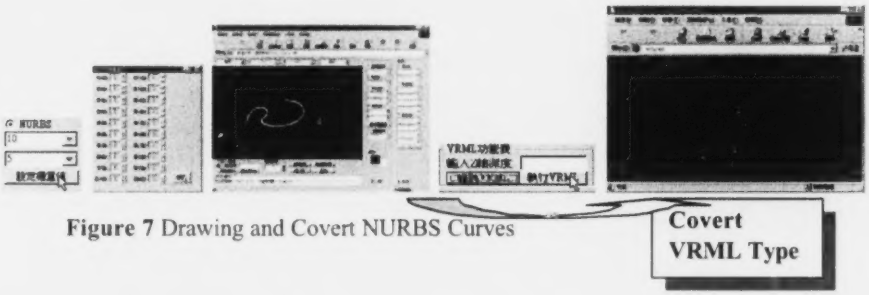


Figure 7 Drawing and Covert NURBS Curves

9 Experiment results:

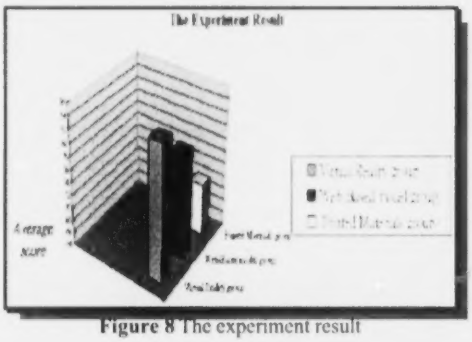


Figure 8 The experiment result

While the differences between the groups were significantly different, the virtual reality group performed is best; the Web-based model group is better than the printed materials group.

10 Conclusion:

The paper describes a new technology that we have established a VR-Based real-time graphics system. In summary, the system offers the following contributions:

1. To accomplish an Integrated Graphics Learning Real-time System
2. To share the resources in network.
3. To establish a computer network assisted learning system.
4. To explore and compare these algorithms of the sculpture curves and surfaces.
5. To integrate VRML with web–based learning system and realize 3D graphics on VR environment

11 Acknowledgments:

We would like to thank the anonymous reviewers for their invaluable and constructive comments that help to improve this paper. This research is working by the Automatic & CAD laboratory under Department of Electrical Engineering National Central University, Taiwan.

12 References:

[1] Ainge D. J., "Upper primary students constructing and exploring three dimensional shapes: a comparison of virtual reality with card nets", J. Educationai Computing Research, 14(4), pp 45-369.1996.

[2] Bricken, M. A, "Description of the Human Interface Technology Laboratoryí s Virtual Worlds". Technical Report, Human Interface Technology Laboratory, U. of Washington, Seattle: 1990

[3] Christine Youngblut.."Educational Uses of Virtual Reality Technology". Institute for Defense Analyses. 1998

[4] Clark, R.E. "Reconsidering Research on Learning from Media". Review of Educational Research, winter, Vol. 53, No. 4, pp. 445-459, 1983

[5] Flanagan, D.: "Java in Nutshell, A desktop quick reference - Java 1.1", Second edition, O'Reilly, 1997.

[6] GERALD, "NURBS from Projective Geometry to Practical Use". FARIN,1999.

[7] Les Piegl. & Wayne Tiller." The NURBS Book". .Springer, 1997

[8] Manetta and R. Blade in "Glossary of Virtual Reality Terminology" in the International Journal of Virtual, 1998

3 Design Issues

3.1 Screen design

Interactive media places users in a one-on-one relationship with a program that can be as intimate, or more intimate than, a face-to-face exchange [22]. For that reason, it is the task of educational multimedia producers to transform that relationship into a successful learning experience. In a user-controlled environment that enables students to turn off the program whenever they want, screen design becomes essential to maintaining learner motivation. Effective screen design allows for maximum learning from the materials while providing the learner with appropriate control of the learning process [16]. This could be compared to the teacher's role at the beginning of a traditional classroom setting. An effective screen design sets the stage for meaningful 'deep learning' to take place and motivates the student to stay engaged. The signs of a poorly designed screen are cluttered displays, complex and tedious procedures, inadequate command languages, inconsistent sequences of action and insufficient informative feedback [20]. Such designs can lead to anxiety, poor performance and dissatisfaction with the program. Some researchers recommend limiting the amount of text on screen to three lines in order to prevent information overload [4]. Users are most effectively able to concentrate on the multimedia material when the screen is made user-friendly with consistent commands and positioning of buttons. The importance of the screen design is corroborated by a number of researchers [21], [1]; [23]; [8].

The choices for screen design are endless, but the two basic extremes are simple and complex. There are both advantages and disadvantages for either consideration. The primary advantage of keeping the screen 'simple and uncluttered' is that it is less likely that users will suffer from immediate sensory 'overload.' As Stemler points out, multimedia instruction packages can become "nightmares when designers try to dump anything and everything into a single program simply because the capability is there" [21]. Most researchers agree with this approach [17]; [18]; [19].

In many cases, a thoughtfully designed complex interface will hold the user's attention longer. The use of a metaphor is one way of integrating a number of complex features with a simple visual structure and provides users with a sense of place, familiarity and ease of use. Within VLU, the metaphor of campus buildings is employed to distinguish between the four sections of the program: Grammar, Listening, Vocabulary and Writing. This metaphor is also useful for selection of the three levels of difficulty within the program. After diagnosis, the users take an elevator to the appropriate level of the unit they are working in.

3.2 Navigation

Unlike passive approaches to education, in student-centered learning, users navigate the path of their own learning. Because of this, the navigation design of a program determines the level of interactivity users will experience. There is a delicate balance between giving enough sense of direction to avoid anxiety, without over-directing users. It is important for users to always know where they are going. Too much freedom may result in students reviewing material or completing tasks that are not relevant to their purpose. According to the findings of Laurillard, learners working on interactive media lacking a clear narrative structure will display learning behavior that is generally unfocused and inconclusive. Learner control, one of the key benefits of interactive media, thus becomes pedagogically disadvantageous if it results in mere absence of structure [14]. While the users should be provided with sufficient choice through hypermedia links, there needs to be a balance between jumping around and sticking to one task [5]. According to Wild and Quinn, the ideal combination is "scaffolded reflection", that is, navigation that encourages thinking without losing the focus of the instruction [24].

There are several possibilities for how users access materials: sequentially, semi-directed, free choice or through pathways. Each of these methods can be designed to have extreme linear order or extreme non-linear order where users have little or no chance of deviating from a predetermined sequence. Thus,

package possibilities can range from strict, prescribed, sequential learning to complete freedom of choice. An alternative is a semi-directed program, allowing for the possibility of choice within certain situations.

Users can be given the option of skipping ahead only when a task is finished or they can be allowed to skip ahead at any time. Common procedure is to have the exit function or menu function available to users at all times. This implies that the navigation has minimal travelling; that is, express pathways so users arrive at their desired destination as fast as possible with little or no redundancy. In contrast, users may not be given the option of skipping at all but can only exit when a particular task/topic/section/unit is finished. Kristof & Satran suggest that users should not have multiple paths to any particular location because this causes confusion [11].

In VLU, users can chose to skip ahead to sub-topics at any time, yet are required to select the Main Menu to do so. Thus, while students can jump around to any building or level, they automatically enter a linear sequence once they have chosen a particular lesson (unless they click on the Main Menu, which is available at all times). This is particularly true for the Grammar section, where skipping ahead may mean missing important grammatical rules and explanations. In this section, students choosing to skip ahead will hear a friendly reminder from the animated host: "You are not advised to go to this task at this stage". Users are then given the option of proceeding anyway, or returning to the previous section.

3.3 User Feedback

Within the interactive format, the educational value of a program is directly linked to the style and quality of user feedback. The users can receive either immediate or delayed feedback to responses or actions. Immediate feedback lets the users have only one attempt at providing correct information, or making a decision. Delayed feedback, in contrast, allows the users to have a longer learning experience, an experience which requires completion of one or more steps before the users receive any feedback.

Feedback can also range from: i) individualized feedback which is based upon individual choice and performance, ii) to a more general response which addresses content considerations, iii) to a type of scoring (percentage, grade, written comments). Personal feedback can be created to address users by name and either make suggestions or critique decisions made. In VLU, the computer greets users by name as they enter the program. Because most users tend to respond positively to being addressed individually, this is usually seen as a positive option [9].

3.4 Testing

Users can also be tested before, during, or after using a package. The test that precedes the work done in the package can be used as a diagnostic tool for the user. By diagnosing weaknesses or strengths, students can be directed to enter the program at an appropriate level of difficulty. Considerations on the nature of the test include whether or not the test should be timed, whether students should be able to choose the subject matter of the test and how long the test should be. The answer to these questions will depend upon the type of material being tested. Analytic material probably requires no time limit, whereas non-analytic material may need to be timed. A secondary consideration would be how many times a user can take a specific test. How often should tests in general be given? Once per unit? One test per section or per topic?

If testing is used, diagnosis will be more reliable if several tests have been taken; therefore, a bank of tests is useful. It follows then that each test must accurately assess the skills being tested and all tests must be equal in difficulty. The generation of tests can be accomplished by having a single bank of questions with the computer randomly selecting the questions. This will ensure that users do not duplicate test materials.

Testing within VLU is an option provided to users once they have entered one of the campus buildings. The test length varies according to each section, but averages about 15 minutes per unit. For example, upon entering the Listening Test area, users are presented with a pop-up menu that asks them to select a test in

their area of interest: Environment, English, Politics and Business or Social Issues. In this way, students are able to control their learning experience and are not penalized for a lack of knowledge in a particular area.

3.5 Scoring

Another question designers will need to address is what kind of report users will receive after completing a test or set of tasks. Does the program require written comments, percentage grades, or is a simple pass/fail more appropriate? Reporting can be automatic after each task, or the report can be accessed upon request. One extreme is for there to be no access to scores until the entire unit/section/package is completed; the other is for automatic reporting to occur whenever a task is completed. The feedback or report can be a numerical or graphic representation. There can be results posted on the screen, or they can be printed, or even saved to a disk. Another design possibility is to have a progress report after users have used the program for a specified period of time. The progress report can incorporate individual feedback or re-direction to an easier or more difficult level. Teachers may also want to have a network reporting option that automatically sends them the students' reports [9].

Within VLU, users are provided with a percentage grade for each task as well as an overall grade for the section completed. This provides users with a clear indication of their areas of weakness, whether it be in specific grammatical structures, writing topic sentences, listening for key words or creating compound nouns. A rating of "good", "average" or "poor" is also given, with 80 percent or higher being good, 79 to 50 as average and below 49 as poor. With this method of reporting, users are oriented within the tri-level system of the program and provided with goals for motivating improvement.

Conclusions

As multimedia producers, our goal is to harness the power of emerging technologies to achieve our educational objectives. With proper planning and design implementation, producers can not only simulate the classroom setting, but enhance it - and thus contribute to an overall rise in the level of educational standards. As Kozma points out, our ability to take full advantage of new technologies depends on the creativity of designers and our understanding of the relationship between these capabilities and learning [10]. This becomes especially important as computer-based multimedia becomes a ubiquitous aspect to learning at all levels [12]; [2]; [7].

This paper has discussed some of the issues involved in designing interactive courseware, with an emphasis on the Higher Education environment. The authors have attempted to use the experience of VLU to identify some of the key challenges involved in the various stages of multimedia design: development environment, design, user feedback and piloting. One of the greatest challenges involved in multimedia design is integrating the freedom-of-choice that makes interactivity what it is, without straying too far away from the sensible guidance necessary for any valuable educational endeavor. Designers are being challenged to create a learning environment that combines learner controlled browsing within a system-encouraged structure. As demonstrated in VLU, this bipolar dynamic is evident in almost every stage of the production process - from navigation to taskwriting to the integration of audio and visual effects. Every interactive learning production has its own set of problems and challenges, which is perhaps what makes multimedia design such an exciting and creative field to be working in. The lessons gained from VLU will continue to improve the program as it is exposed to more users and teachers, and as the development team generate new ideas for a revised version. It is hoped that these insights will contribute to the growing source of knowledge on multimedia design and ultimately lead to better products for students.

References

[1] Boyle, Tom. "*Design for multimedia learning*". London: Prentice Hall, (1997).

[2] Falk, D. & Carlson, H. "Multimedia in Higher Education: A practical guide to new tools for interactive teaching and learning", Medford, NJ: Learned Information, (1995).

[3] Gatlin-Watts, R., Arn, J. & Kordsmeier, W., "Multimedia as an instructional tool: Perceptions of college department chairs". Education Vol 120, No.1, pp. 190-196, (1999).

[4] Hannafin, M.J. & Rieber, L.P. "Psychological foundations of instructional design for emerging computer-based instructional technologies: Part II", Educational Technology Research and Development, Vol 37, *No.*2, pp. 102-114, (1989).

[5] Hanson-Smith, E., "Why multimedia?" CAELL Journal Vol 7, No. 3, pp. 35-36, (1996-1997).

[6] Hedberg, J, Harper, B., Brown, C. & Corderoy, R., "Exploring user interfaces to improve learning outcome", In Beattie, K., McNaught, C., & Wills, S. (Editors) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 15-29, (1994).

[7] Heinich, R., Molenda, M., Russell, J., & Smaldino, S., "Instructional Media and Technologies for Learning", Englewood Cliff, NJ: Prentice Hall, 5th Edition, (1996).

[8] Ivers, K. & Barron, A. "Multimedia projects in education: designing, producing, and assessing", Englewood, CO: Libraries Unlimited, (1998).

[9] Klassen, J. and Milton, P., "Decision-Making in the Pre-production Stages of Developing an Interactive Multimedia Package", In Bradbeer, R. (Editor), Current Practice in Multimedia Education, Hong Kong: City University of Hong Kong Press, pp. 19-32, (1999).

[10] Kozma, R. "Learning with Media", Review of Educational Research, Vol 61, No. 2, pp. 179-211, (1991).

[11] Kristof, R., and Satran, A., "Interactivity by Design: Creating and Communicating with New Media", Mountain View, CA: Adobe Press, (1995).

[12] Lamb, A.C., "Multimedia and the teaching-learning process in higher education", In Albright, M.J. & Graf, D.L. (Editors) Teaching in the Information Age: The Role of Educational Technology, San Francisco: Jossey-Bass Publishers, pp. 33-42, (1992).

[13] Laurel, B. (Ed.) "The Art of Human-Computer Interface Design", Reading, MA: Addison-Wesley, (1990).

[14] Laurillard, D., "Multimedia and the learner's experience of narrative", Computers & Education, Vol 31, pp. 229-242, (1998).

[15] Liu, M, Jones, C. & Hemstreet, S., " Interactive multimedia design and production processes", Journal of Research on Computing in Education, Vol 30, No. 3, pp. 254-280, (1998).

[16] Milheim, C.L. & Lavix, C., "Screen Design for Computer-Based Training and Interactive Video: Practical Suggestions and Overall Guidelines", Performance and Instruction, Vol 31, No.5, pp. 13-21, (1992).

[17] Orr, K.L., Golas, K.C., & Yao, K., "Storyboard development for interactive multimedia training", Journal of Interactive Instruction Development, Winter, pp. 18-31, (1994).

[18] Overbaugh, R.C., "Research-based guidelines for computer-based instruction development" Journal of Research on Computing in Education, Vol 27, No. 1, pp. 29-47, (1994).

[19] Rambally, G.K. & Rambally, R.S., "Human factors in CAI design", Computers and Education, Vol 11, No. 2, pp. 149-153, (1987).

[20] Schneiderman, B. "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Reading, MA: Addison-Wesley, 2nd Edition, (1992).

[21] Stemler, L., "Educational Characteristics of Multimedia: A Literature Review", Journal of Educational Multimedia and Hypermedia, Vol 6, No. 3/4, pp. 339-359, (1997).

[22] Utvich, M., "Instructional Design: People and the Art of Interactive", Multimedia Producer, Vol 1, No. 9, pp. 1-5. www.kipinet.com. (1995).

[23] Vaughan, T., "Multimedia: making it work", Berkeley: Osborne McGraw-Hill, 4th Edition, (1998).

[24] Wild, M. & Quinn, C., "Implications of educational theory for the design of instructional multimedia", British Journal of Educational Technology, Vol 29, No. 1, 73-82, (1998)

[25] Wills, S. & Swart, R., "The book is dead, long live the book: Designing interactive publications", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 83-92, (1994).

[26] Woolsey, K. "Multimedia Opportunities", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 93 -98, (1994).

Designing for Interactivity

Johanna Klassen*, Douglas R. Vogel, and Emily Moody*****
**CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* pdklasse@cityu.edu.hk
***IS Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* isdoug@is.cityu.edu.hk
**** CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* Emily_Moody@hotmail.com

In education, 'interactivity' is the catalyst that has transformed the traditional classroom setting into an active media environment. Yet the standards for interactivity within education are by no means clear. Educators and multimedia designers are confronted with many questions concerning the effectiveness of interactive courseware as a learning tool. In this paper, the authors draw on their experience of producing the interactive courseware package *Virtual Language University*, an interactive multimedia package for language learning that has over 3,500 interactive tasks. Specific topics in the paper include screen design, navigation, effective task writing, choices in the type of user feedback, scoring and testing. Attention is given to decision-making procedures that deepen understanding, promote interactivity and encourage self-direction.

Keywords: **interactivity, multimedia, courseware design**

1 Introduction

In education, interactivity has transformed the traditional classroom setting into an active media environment. As Laurel indicates, interactivity is a necessary component for learning to take place. Learners only learn how to learn when they are actively and continually involved in the learning process [13]. Yet the standards for interactivity within education today are by no means clear. Educators and multimedia designers are confronted with questions concerning the effectiveness of interactive courseware as a learning tool, such as: how multimedia can be successfully integrated into the classroom, what level of interaction should be included, and which programs are most suitable. As this new area of learning evolves, those involved in interactive learning are discovering that developing material according to a multimedia interface is simply not enough [25]; [26]; [5]; [3]. Courseware designers are being challenged like never before to produce material that deepens understanding, promotes interactivity and encourages self-direction.

In this paper, the authors draw on their experience of producing an interactive courseware package to discuss the primary areas involved in designing a multimedia program in a Higher Education institution. A review of multimedia production discourse will be used to connect the discussion to broader issues within educational technology and interactive learning. Attention will be given to the decision-making procedures that add to an enhanced level of interactivity within computer-assisted learning.

2 Development Environment

2.1 Virtual Language University (VLU)

Virtual Language University (VLU) is an interactive learning program developed at the City University of Hong Kong. The courseware consists of four CD-ROMs and aims to provide a self-directed learning tool for students and academic staff interested in improving their English skills. The two-year long project was

funded by the Teaching Development Grant of the University Grants Committee. The development team that was responsible for creating the program was an eclectic international mix, consisting of a project manager, three computer programmers, a graphic artist, two scriptwriters and several student helpers. This team worked closely during every stage of the production, including the conceptual phase of brain-storming and scriptwriting, and the production phase of computer programming, video recording, and graphic design. The program was completed after an extensive review and piloting process that took several months.

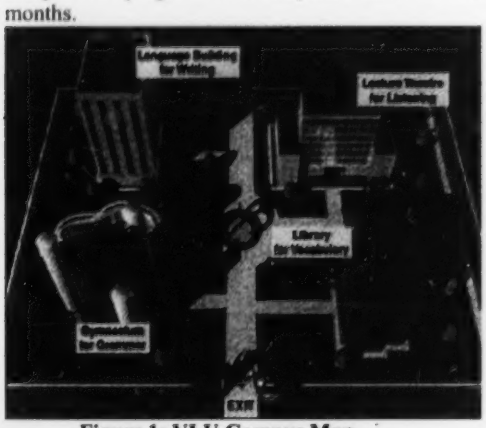


Figure 1: VLU Campus Map

Figure 2: VLU Lobby

Upon entering VLU, users are introduced to four units: Listening, Writing, Vocabulary and Grammar, metaphorically represented as four separate buildings in a virtual university campus (See Figure 1). The animated host, a friendly Dr. Einstein, provides first time users with a tour of the campus and explains how the program works. Once the users have selected a building (or unit) to work in, they are given a test and provided with feedback on weaknesses before being directed to the appropriate level: 1, 2, or 3, with 1 being the easiest (See Figure 2). For example, the Listening Unit consists of five multimedia lectures from University professors, which include video, graphics, sound and about 40 tasks per lecture. Users can control the forward, back and replay buttons of the lecture, and in this way monitor their own pace and approach in a "learner controlled" environment [5]. Within the Writing Unit, a video tutorial by an actual English teacher guides the students through complex writing structures, pausing for interactive tasks along the way. The other sections, Grammar and Vocabulary, provide ample practice for users to improve their proficiency in grammar usage and to expand their vocabulary. In total, there are over 3,500 interactive tasks in the program, all of which are programmed to give immediate or delayed feedback and a percentage score after each task. Users can also access their last two scores, as this information is automatically stored in the computer.

2.2 Project Development

Developing a multimedia product calls for a collaborative effort from various team members drawing from different backgrounds. The team usually includes a project manager (who is often the instructional designer), a subject-matter expert, scriptwriters, computer programmers, graphic artists, a videographer, an audiographer and administrative support [2]; [15]. The success of an interactive learning product depends very much on the ability of the team to work together; "As multimedia development demands the cooperation of many highly skilled and talented individuals, division of responsibilities, smooth communication, and strong commitment to the objectives of the project are essential to make a project successful" [15]. Depending on the size of the team, one person may take on several roles throughout the course of a project, or roles may overlap - as was the case for the production of VLU.

The project manager addresses the conceptualization stage [[9] and plans the instructional design. This involves a critical look at the educational needs, the interface design and a proposal for the delivery

content. The project manager will identify the instructional goal of the program, which should define, in general, what the program intends to achieve [2]. At the same time, s/he will determine the learning characteristics important to the design, such as the level of instruction, language, age and culture of the end users. The project manager is also responsible for outlining the schedule for the project and may facilitate a liaison with external specialists. S/he coordinates the efforts of the team, encourages positive interpersonal communications, and ensures that team members stay on track and complete their part by specified deadlines [2]; [15].

The scriptwriter works with the project manager to develop the content and design of the final product. S/he is responsible for selecting appropriate media, writing tasks, creating storyboards as well as developing ideas for graphics. Together, the project manager and scriptwriter construct the skeleton for the project, which is then brought to life by the programmers and graphic artists. The early phase is probably the most important stage of the production - and, if done properly, can save hours of time in unnecessary programming and tedious revisions.

Once the programmers and graphic artists have the scripts in hand, they can proceed with the production phase. They may use a number of authoring programs, systems or languages to implement the suggestions of the scriptwriter and project manager [2]. The graphic artist designs the program's graphics and animation, working closely with the scriptwriter to ensure everyone is thinking in the same direction. The videographer collects and digitizes video and photo images and the audiographer records the necessary sound elements. In the case of VLU, university professors were videotaped professionally. Academic lectures were given on different topics, such as "Exploring the Internet", "Organizational Behavior" or the "Poetry of Cavafy". The scripts for the lectures were first written by the professors and then transformed into an interactive format by the scriptwriter and project manager. The professors also acted as the subject-experts of the team, providing specialized feedback during the piloting of the program.

2.3 Scriptwriting

The key to good interactive multi-media packages is the nature and level of interaction between the users and the application. The level of interactivity is directly related to the successful creation of appropriately placed tasks that range in nature and content. During the scriptwriting stage, decisions concerning the number and type of tasks, the style of feedback, the sequence of questions, the different levels of tasks and the type of scoring are made. The decisions should first be organized into an outline form to give a broader perspective and to ensure there is an appropriate distribution among all the categories. It is also important for scriptwriters to maintain consistency throughout the scripts with the use of identical terminology, predictable sequences and the same command language.

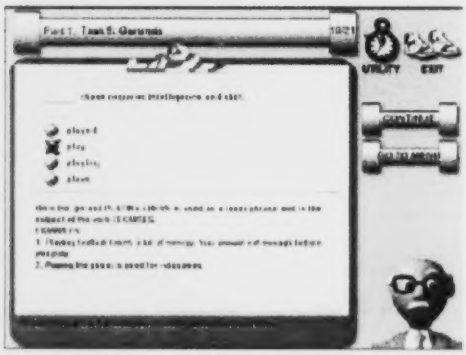


Figure 3: Grammar

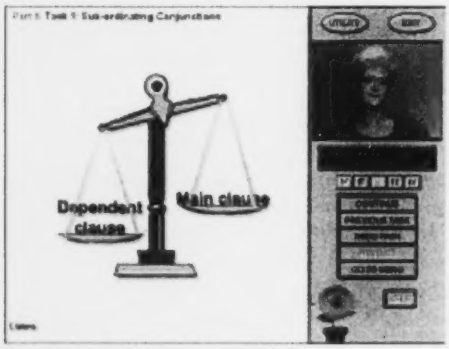


Figure 4: Writing

BEST COPY AVAILABLE

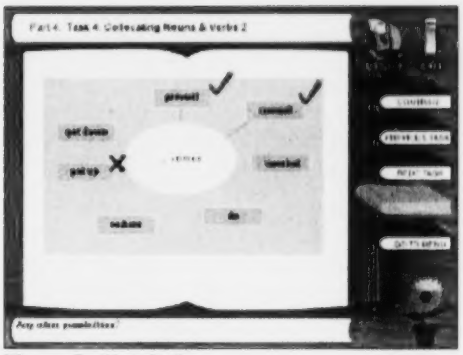


Figure 5: Vocabulary

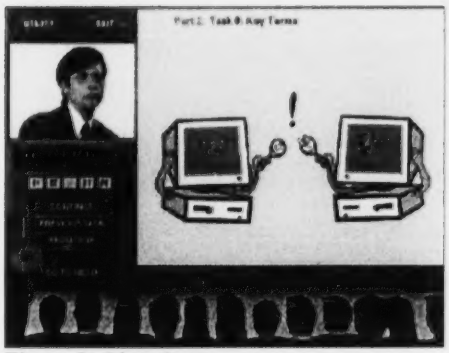


Figure 6: Listening

In VLU, tasks were written according to the instructional aim of each of the four units (See Figures 3-6). The main types of tasks that were used include click, drag, notepad writing and multiple choice. Multiple choice and click are the easiest to construct, both for the scriptwriter and programmer, but should be combined with other task types to ensure maximum interactivity. Each task is designed according to the learning objective of the unit. For example, in the Listening Unit, tasks are diagnosed as vocabulary, main ideas, key words, summary, predictions or inferences. When choosing the frequency and placement of tasks, Orr, Golas & Yao [17] advise including an option for an interactive task every three of four screens, or once every minute. Yet designers should avoid a strict adherence to any formula for interactivity, as it depends entirely on the content, style and complexity of the material being presented. "You cannot gauge the amount of active involvement in a technology product by the number of mouse clicks, and ..similarly, one cannot assess learning by overall level of activity" [26].

The binary structure of the computer makes the process of task-writing an interesting and difficult endeavor. The scriptwriter is faced with the challenge of creating insightful, thought provoking tasks that elicit predictable, quantifiable responses. Where a teacher may be able to judge the validity of a multiple range of answers, a computer cannot. It is therefore up to the scriptwriter to predict all of the potential responses, a challenge especially for tasks that allow users to type responses in an open-ended format. During the piloting of VLU, for instance, it was observed that certain open-ended questions caused frustration among students who believed their answer to be correct - and if judged by a real-life teacher, may well have been. It is for this reason that questions with vague, complex or multiple responses must be constructed with great care.

How, then, can multimedia tasks be written without oversimplifying multifaceted and in-depth subject matter? This has been one of the leading criticisms of multimedia development as it expands to cover the more concept-based material within higher education. Users may get an unwarranted sense of having mastered a complex subject after correctly answering a complete set of computerized quizzes and close-ended questions [14]. One method of avoiding such a compartmentalization of information is allowing students to write down their own opinions on a profound subject matter using a computerized notepad. In VLU, this non-graded task is used to elicit predictions of what the lecture could entail, or personal opinions that the student may have. In this way, students are encouraged to contribute their own ideas and thus are able to build confidence in their analytical skills. The producers of the interactive multimedia package *Investigating Lake Iluka* argue that the notepad facilitates cognitive self-management by allowing students "to collect and manage information from a variety of different sources" [6]. This is substantiated by Laurillard [14], whose case study found that students appreciated "being forced, or perhaps enabled, to consider and develop their own analysis first, before seeing what the expert has written".

Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology

LO Ting Kau*, AU Wing Kee, and YIP Wai Ming*****
The Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T., Hong Kong
*E-mail: * tklo@ied.edu.hk, ** wkau@ied.edu.hk, *** wmyip@ied.edu.hk*

Design and Technology (D&T) as a school subject aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society. Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. This article discusses the ways that IT can be made relevant to the learning and teaching of D&T and in teacher education. It then describes the development of an ongoing project[#] which aims at developing an IT-immersion environment to enhance learning and teaching of D&T at a teacher education institution in Hong Kong. The setting up of this information-rich, collaborative learning environment is to complement "traditional" lab-based approach to learning and teaching of Computer Aided Design (CAD) and Computer Aided Manufacture (CAM).

Keywords: **IT-immersion, Learning Environment, Design and Technology, Teacher Education**

1 Introduction

Design and Technology (D&T) as a school subject "aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society." [3] Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. [5] IT is also being regarded as an effective tool for learning and teaching D&T in two main areas, namely:

- ***IT as a tool.*** IT can support many aspects of designing and making in D&T. For example, information processing and presentation, modelling, computer-aided design and manufacturing, control and communication.
- ***IT as a source of knowledge.*** Here, IT is being regarded as a source of knowledge to learn about materials, equipment, designing and manufacturing. This encompasses CD-ROM information systems, and the use of local or online databases accessible over the Internet. [2] [6]

2 IT in Education Policy in Hong Kong

The Hong Kong Special Administrative Region (HKSAR) Government launched its IT in Education Policy in 1998. [1] [5] According to this policy, Hong Kong teachers will be required to reach different levels of IT Competency in Education over the next few years; and IT-supported instruction will become one of the essential instructional strategies in future. Consequently, teacher education institutions in Hong Kong will be

---

[#] The project entitled "Development of an IT-immersion Environment to Enhance the Teaching and Learning of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)" is supported by the Teaching Development Grant (TDG) administrated by the HKIEd, which is granted by the University Grants Committee (UGC), Hong Kong.

required to integrate in their pre-service programmes IT competency elements such as producing courseware, applying the skills of computer-aided instruction, and using various electronic networks for peer support and collaborative learning.

3 The Project

The following sections describes an ongoing project which aims at developing an IT-immersion environment to enhance learning and teaching in D&T at the Hong Kong Institute of Education (HKIEd), the major provider of D&T teacher education in the territory. This project is a response to the HKSAR Government's urge for the integration of IT to enhance the effectiveness of learning and teaching in teacher education institutions. [1][5] The initial target group of the project is student teachers undertaking D&T at the Institute. This target group will continually widen and might eventually include practising teachers in D&T and other technology-related subjects in Hong Kong secondary schools.
The project aims to:

- develop an IT-immersion learning environment for student teachers majoring in D&T, especially focused on areas of CAD and CAM;
- develop appropriate courseware for the enhancement of learning and teaching of basic and selected topics on CAD and CAM;
- develop an appropriate web-interface for students and staff to enhance face-to-face classroom interactions;
- enable students to appreciate modern techniques of product design and prototype making through the use of CAD and CAM technologies.

4 IT-immersion Learning Environment for D&T

Davies [4] suggests that an ideal learning environment for D&T is one where the learners have maximum autonomy and are working on self-directed projects and teachers are constantly assessing with pupils where they are and where they need to go. The IT-immersion learning environment under discussion utilises some of the attributes and resources of Web-based learning and adopts a constructivist approach to create a meaningful learning environment where learning is fostered and supported. This IT-immersion environment, we believe, would facilitates greater interaction between the teacher and students, and students and students; assist D&T student teachers transit to the new mode of learning and teaching, and enable them to develop habits of life-long learning. To effect the paradigm shift from a largely teacher-centred approach to a more interactive and learner-centred approach, it is important that D&T student teachers appreciate the need for the change and are receptive to the challenge of taking up their new role as a learning facilitator in future.

Key features of the IT-immersion environment include:

- ***Learner-centred, time and space independent learning***. With the use of Web-based instructional materials, students are allowed to progress at their own pace and at any time and space.
- ***Changing Roles of Teachers and Students***. In the IT-immersion environment, the role of the teacher changes from knowledge provider to that of facilitator and guide. Conversely, students are no longer passive learners. They become participants, collaborators in the creation of knowledge and meaning.
- ***Self-directed Learning***. One increasingly important competency in the future society will be "self-directed learning". In the IT-immersion environment, students continually learn to use IT tools for the accessing, processing, and transformation of information into new knowledge.
- ***Just-in-time Learning***. "Just-in-time learning" [7] implies a high level of individualisation and self-direction in the learning process. Each student learns just what he/she needs at the time when he/she needs it. This is a radical diversion in the instructional delivery system from place-based and time-fixed group instruction to one that is fully under learner-control.
- ***Individual differences accommodated***. Learning is a complex process that takes place as an interaction between learners and their environment. The interactive multimedia and hypermedia capabilities of Web-based and CD-ROM based instructional materials would enable student control over timing and pacing and provide interactivity and active learning.
- ***Collaborative / Cooperative Learning***. Collaborative learning in this IT-immersion environment regards that both teachers and students be active participants in the learning process. The Web, for

instance, presents an especially good environment for asynchronous collaboration in which students work together but not necessarily at the same time. This IT-rich environment also provides ground for cooperative learning that students and teachers interact together in order to accomplish a specific goal or develop an end product which is content specific. For instance, an ad-hoc group of students, teachers, and perhaps outside experts, can come together for a particular task or design project. The group splits into distributed design teams to tackle design challenges. The design teams interact over the computer network, working cooperatively and drawing on different expertise. The design is shared over the network, evaluated, and combined into an integrated artefact or system.

It is perhaps worthwhile pointing out that in an IT-immersion learning environment, IT is still considered as a supportive tool. Its introduction supplements, and indeed may change the "traditional" learning and teaching approaches in D&T. However, it is not intended to and will not replace traditional teaching altogether. For one reason, D&T is intrinsically an action-based subject. Engagement with designing and making requires students to be active cognitively and physically. Besides, lab-based activities serve a variety of different purposes that would be unlikely replaced by other means [8], for example: (a) first hand experience of using a variety of materials, equipment and processes safely; (b) actually realise high quality products, test them and evaluate them in use; and (c) face-to-face interaction among peers and the tutor.

5 Basic Components

The IT-immersion environment comprises two major components, namely: (a) the physical component, and (b) the virtual component (Figure 1).

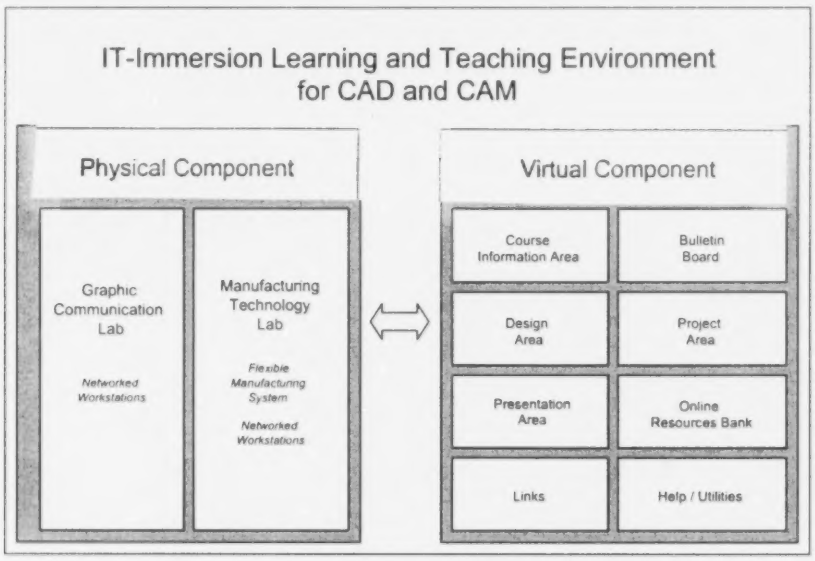


Figure 1. Major Components in the IT-immersion Learning and Teaching Environment.

The ***Physical Component*** includes facilities installed in the two labs at the HKIEd for CAD and CAM:

- ***Manufacturing Technology Lab***: A Flexible Manufacturing System (CNC Lathe, CNC Mill, and Robot), a CNC micro-router, 15 networked PC workstations, video-conferencing systems, appropriate software and peripherals, etc.
- ***Graphic Communication Lab***: 21 networked PC workstations, video-conferencing systems, digital camera, appropriate software and peripherals, etc.

The ***Virtual Component*** of the IT-immersion environment include:

- ***Course Information Area*** - for students to gain access to course-specific information such as course outlines, schedules, course materials, assignments and other course-related information.
- ***Bulletin Board*** - for teachers and students to post up announcements.
- ***Design Area*** - for supporting both synchronous communication (e.g. real-time interactive chat, used to brainstorm with teachers or peers) and asynchronous communication (e.g. e-mails) to facilitate design activities. For example, students can "talk" online and discuss their design ideas via video-conferencing and/or Internet technologies with peers, teachers or experts outside the campus who can provide them with suggestion for improvement on the design. Digital cameras can be used to record the development of models/products and to present design ideas.
- ***Project Area*** that houses students' individual and collaborative design projects. A Data Bank will be set up for students to store their design works. The Data Bank will become a central design database, accessible by all members of each of the design and manufacturing teams to ensure that all team members are working with identical information.
- ***Presentation Area*** - for students to present their projects and showcase their design work beyond the classroom and to a wider audience.
- ***Online Resource Bank*** - for teachers to upload and retrieve interactive instructional and reference materials.
- ***Internet links*** - to support teachers and students using the Internet to locate professional materials and content resources in D&T and other related disciplines.
- ***Help / Utilities.***

6 IT-enhanced Activities and Learning Experiences

In the IT-immersion environment, student teachers are provided with the opportunities to use IT to explore, develop, model, communicate and realise their design ideas in a variety of ways. As such, IT becomes an integrated and natural part of their study in D&T. More specifically, to take as an example, video conferencing technology can be used as an effective medium for developing new ways of learning and teaching D&T and introducing teachers and students to various aspects of information, communications and design technologies. Using the latest information and communications technology provides the opportunity for expertise and resources to be made available to pre-service and practising D&T teachers off-campus from the HKIEd. Via video conferencing systems or the Internet, they can work collaboratively together on concurrent design projects, discuss problems and jointly solve them, and exchange ideas and information.

In brief, working in an IT-immersion environment would help D&T student teachers to understand how to become discerning users of available hardware and software. This in turn, would help them to understand what IT can and will do to enhance their future pupils' learning in D&T.

7 Conclusion

This paper discussed the potential of an IT-immersion approach to provide D&T student teachers with a richer, more meaningful education relevant for the future workplace and learning environments. It is also suggested that this IT-immersion approach can be used in a mixed-mode manner to support traditional lab-based approach to learning and teaching CAD and CAM. This adjunct or mixed-mode seems appropriate for a wide range of learning and teaching activities in D&T where real world experience and face-to-face interaction are essential. By using a mixture of traditional and IT-immersion instructional methods and tools, the learner can experience recent technology development and its impacts on learning. The point is to find out the right balance.

The project is still at its developmental stage, the effectiveness of the IT-immersion approach to learning and teaching D&T has yet to stand the test of time. However, the experience so far suggests that the project will be a success and will bring substantial benefits to both teaching staff and students.

References

[5] Au, W. K., Kong, S. C., Leung, K. P., Ng, M.W. & Pun, S. W., "Level of Information Technology Competency, Core Course Elements and Assessment Tool for Teacher Training in IT in Education: The Final Report", Hong Kong: Education Department, HKSAR, (1999).

[4] Barlow, J., "Computers in Technology Education", in J. Williams & A. Williams (Eds.), "Technology Education for Teachers", pp. 136-179, South Melbourne: Macmillan Education Australia, (1996).

[1] Curriculum Development Council (CDC), "Syllabus for Secondary Schools: Design & Technology (Secondary 1-3)", Hong Kong: CDC, (1999).

[6] Davies, L., "Virtually There! The Millennium", The Journal of Design and Technology Education, Vol. 4, No.1, pp. 61-64, (1999).

[2] Education and Manpower Bureau (EMB), "Information Technology for Learning in a New Era: Five-Year Strategy 1998/99 to 2002/03", Hong Kong: Education and Manpower Bureau, (1998).

[3] National Association of Advisers & Inspectors in Design and Technology (NAAIDT), "Enhancing Design and Technology through the Use of IT", Wellesbourne: The Design and Technology Association (DATA), (1995).

[7] Romiszowski, A., "Web-Based Distance Learning and Teaching: Revolutionary Invention or Reaction to Necessity? ", in B. Khan. (Ed.), Web-based instruction, pp. 25-37, Englewood Cliffs, NJ: Educational Technology Publications, (1997).

[8] Wankat, P. & Oreovicz, F., "Teaching Engineering", New York: McGraw-Hill, (1993).

Development of Cross-Cultural Communication System and Web-based Japanese Education

Lumi Tatsuta, Yaeko Nakanishi , Masayuki Ohnishi, Atsuo Iguchi* ,
Giichi Tomizawa and Kimiko Gunji*****
**Dokkyo University(Japan) • •*
***Science University of Tokyo(Japan)*
****University of Illinois(UA)*
1-1 Gakuen-cho Soka, Saitama Japna 340-0042
tatsuta@dokkyo.ac.jp

In 1998 we presented a framework and system construction of "Images of Japan," a learning system of the Japanese culture and language in Beijing, China. In this paper, we discuss the results of our initial evaluation of its framework and system based on personal feedback from students and on the responses to the survey carried out in the form of questionnaires. Even though the overall assessment was positive, we have received a few suggestions for improvement. We are now working on the implementation of improvements, some of which we also introduce here.

Keywords: **Cross-Cultural Communication, Japanese Education, Communication Tool**

1 Introduction

"Images of Japan" was constructed to develop an effective network-based learning environment of cross-cultural communication: disseminating information on Japanese culture and providing opportunities to learn Japanese. In order to encourage active participation and to keep the users motivated to share their knowledge and develop a deeper understanding which they could not achieve alone, we have had Japanese students and non-Japanese students select items which they want to introduce or they want to know. More than 300 items have been collected. The data also reveal that there is a wide gap in their perception of Japanese culture, particularly between Japanese and non-Japanese students. We expected that this perceptional gap between the Japanese and foreign students would serve to facilitate cooperative and collaborative learning and sharing of knowledge among the users and to lead to their active participation in the program.

2 The Framework of the System and its Evaluation

Users can jump from the top page to any pages by clicking the icons installed in the index. Since this courseware is primarily constructed to show the diversity of Japanese society and to encourage Japanese and non-Japanese students to think about Japanese culture and to share opinions and ideas with each other, the pages of Classification and Collaboration are the central parts of this framework. Over 300 cultural items are presented in the Classification page. In the Collaboration page, "Bulletin Board," "E-mail," and "Voting," devices are installed. The "Bulletin Board" serves not only to link together Japanese students and non-Japanese students giving them opportunities to chat or exchange information, but also to provide data to evaluate the effectiveness of this collaborative learning program.

In the "Voting" users are encouraged to vote for the items in which they are interested. Users can also add new items of their own choice in the existing page. The ranking is continuously updated so that users can feel a sense of participation and maintain their interest. In addition to "Bulletin Board" and "Voting,"

"Questionnaire Page" was later added to obtain direct opinions from the users and to evaluate how much collaboration and development of knowledge has been achieved. The Questionnaire basically consists of multiple-choice questions. As evaluation based on these means should be carried out through a long span of time, however, we have decided to perform an experimental assessment in the form of a questionnaire in the meantime. The number of responses collected was 63 in total (51 Japanese and 12 non-Japanese students.) Questions focus on the following themes; (1) the overall framework, (2) information on the Japanese cultural items, and (3) the Japanese language learning program.

3 Results of the Questionnaire on the Overall Framework

In the evaluation of the overall framework, the following issues were addressed. The responses turned out basically positive.

Table.1

	Good	bad
Accessibility of items	78%	22%
Layout	92%	8%
Linking	98%	2%

Table.2

	very good	good	not good	bad
Size of the letter and presentation	12%	80%	6%	2%
Screen presentation	12%	80%	8%	0%
Control of Screen	8%	80%	10%	2%

Table.3

	Very interesting	Interesting	Not interesting
Photo picture	8%	78%	16%
Illustration	14%	53%	33%
Animation	20%	68%	12%

With regard to question of "Accessibility of items," however, 22% of the students responded negatively. The reasons could be multifold. The list of cultural items could be too numerous for participants to screen them thoroughly. The instructions on how to use the page might have been inadequate. A few students might not be able to plug in the page. Also, a minor technical problem might be present. However, the quantity of photos, illustrations, animations and sound is controlled so that users will not find them overwhelming. In any case, improving the accessibility is one of the issues that requires further study. On the other hand, we feel that the number and wide variety of cultural items, which might look overwhelming to some viewers, is in fact an important advantage. At the moment each one of those items is categorized into sixteen major subjects, and the users have to select one of the major subject first to reach the page of each item. How to arrange topics so that the users will find them easy to access is an issue to be studied as well.

4 Japanese Cultural Items

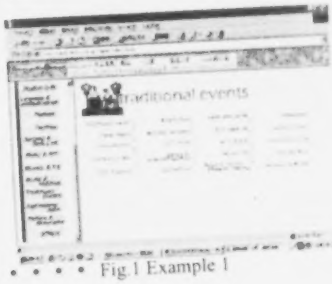


Fig.1 Example 1

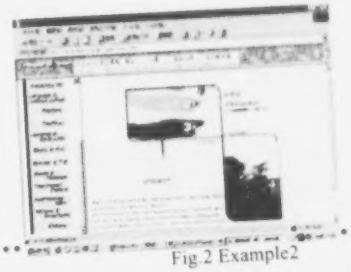


Fig.2 Example2

BEST COPY AVAILABLE

The above are examples of a cultural page. Each item basically consists of two pieces of visual information either in the form of photos , illustrations or animations, followed by the comments or brief information given by the students who participated in the original survey are given. In the survey, the following four questions were asked. As shown in the figures, their responses turned out less positive than those on the "Overall Framework".

(1) Could you understand the ways young students grasp Japanese culture?

Japanese students	Yes 76%	No • 24%
Non-Japanese students	Yes 100%	No 0%

(2) What do you think of this home page on Japanese culture introduced by students?

Japanese students	Useful 55%	Not useful 6%	Interesting 31%	No Answer 8%i
Non-Japanese students	Useful75%	Not useful 0%	Interesting 25%	No answer 0%

(3) After having read these pages, have your ideas towards Japanese culture changed?

Japanese students	Yes 37%	No 63%
Non-Japanese students	Yes 100%	No 0%

(4) Do you want to exchange your ideas with others on the "Bulletin Board?"

Japanese students	Yes 71%	No 29%
Non-Japanese students	Yes 100%	No 0%

The reason for the negative response is in part due to lack of sufficient information on each item. Particularly, the responses from Japanese students are much less positive than those from foreign students. On the other hand, written responses from foreign students were quite favorable: saying, e.g.,

"This is a fascinating resource to learn more about Japanese culture," "I think the items introduced here are very thorough, everything from traditional to modern culture." This wide difference in the response between Japanese and non-Japanese students is basically due to the fact that those non-Japanese students are the ones who are already interested in Japanese culture and willing to learn more, while most of the Japanese students are not necessarily interested in Japanese culture, or the items presented here are not enticing but too familiar to them. The objective reasons for the negative reactions should be sought for, too. It is also evident that we have to improve the Japanese Cultural Page so as to encourage students to share their knowledge and opinions actively and enhance their cross-cultural communication skills.

5 Improvements

In order to ensure that students will use our program as a source of information about Japanese culture and as a tool for cross-cultural communication, we have to make it more attractive for them. As a first step, we are now working on a construction of a "Discussion Room.," where two groups of students, Japanese and non-Japanese, exchange their ideas, feelings, and opinions on a series of scenes excerpted from Japanese movies (one is "Funeral" and the other is "Shall We Dance?") These two movies not only reflect ways of thinking of Japanese people but also its conventions of daily life and will serve as an interesting source of cross-cultural communication. Another group of students is assigned to discuss "Bushidoo vis-a-vis Knighthood," and the fourth group of students should discuss a topic of their own choice. We expect that through these activities the students will experience both satisfaction and frustration in communicating with other people of different cultural backgrounds. The conversations recorded in the Discussion Room are being accumulated and will be analyzed as a source of studying cross cultural communication.

As for the Japanese language Program, we could not obtain sufficient feedback from the foreign students The language program was made for intermediate students. However, since the number of foreign students who have reached intermediate level Japanese in this first experimental evaluation was limited, we could not obtain concrete comments or reactions on the program. At the time when we constructed the language program, we could not provide appropriate audio information nor video due to the problem of network speed. Since this problem has been solved, however, we are now not only adding sound to the original program but also constructing a new listening comprehension page. The listening comprehension is geared to basic level students. By doing so, a more active use of this program will be expected. It will be also used in class starting this October and the feedback from the students will be duly analyzed and be used for further improvements.

6 Future Plans

The results of the initial experimental evaluation have suggested that this home page could be a good source of information on Japanese culture. However, they also have revealed that some changes in the framework as well as in the content of the cultural and language pages should be made in the near future. Some of those changes are now being made as mentioned above. The program also needs to expand to include the participation of other universities, particularly those which they have a Japanese language program or course on Japanese culture. After implementing further improvements and having obtained a sufficient number of responses, we will reevaluate the home page.

References

[1]Barthel, Alex(1998)"The user of computer technology in the teaching of speaking touniversity students" Proceedings of ICCE98 Global Education on the Net Japanese Learning System: hhtp://www2.ak.cradle.titech.ac/jp/japanese

[2]Murphy, Kare L.(1998) "A Constructivist Look at Interaction and Collaboration via Computer Conferencing" International Jl. of Educational Telecommunications 4 (2/3)

[3]Nakanishi,Y. (1999) "On Evaluation of a Collaborative Learning System for Japanese and Japanese Culture" Dokkyo University International Center

[4]Ogata, Hiroaki & Yano, Yoko(1998) "Knowledge Awareness: Bridging learners in a CollaborativeLearning Environment" International Jl. of Educational Telecommunications 4(2/3)

[5]Tatsuta, Rumi, et.al (1998)• "Images of Japan" -- "Collaborative Learning System for Japanese and Japanese Culture" Proceedings of ICCE98 Global Education on the Net Japanese Learning System

[6]Tatsuta, Rumi, et.al (1998) "Development of a collaboration system on Internet in order to enhance t he understanding of Japanese Culture" Dokkyo University Studies of Economics Nol68

[7]Y. Nakanishi, L.Tatsuta, et.al (1999)• "On Experimantal Evaluation of a Collaborative Learning System for Japanese and Japanese Culture" Advanced Research in Computers and Communications in Education

DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment

Ying-Dar Lin, Wen-Chun Sun, Chien Chou, Huan-Yun Wei
Department of Computer and Information Science
National Chiao Tung University
Hsinchu, Taiwan
Tel: +886-3-5712121-56667
Fax: +886-3-5712121-59263
E-mail: ydlin@cis.nctu.edu.tw

With the rapid growth of both computer technology and the Internet, conventional models of testing are gradually being replaced by CAT (Computer Assisted Testing) systems. However, the major problem in most CAT systems is the difficulty in refreshing and supplying test items. This paper presents a novel network CAT system, DIYexamer (Do-It-Yourself Examer). It has three features that differentiate it from existing CAT systems: student DIY items, item-bank sharing, and automatic assessment of item discriminability. DIYexamer accepts test items contributed form teachers as well as students, and allows limited item sharing between item-banks possibly maintained by different organizations. An algorithm is applied dynamically to assess the discriminability of items in item-banks in order to filter out less qualified contributions, hereby assuring the quality of stored items while scaling up the size of item-banks.

Keywords: **computer assisted testing, test evaluation, test acquisition, discriminability, distant learning**

1 Intorduction

With the continuing development of computer technology and the Internet, educators now have new alternatives for creating, storing, accessing, distributing and sharing learning as well as testing materials. Should testing be performed on or learned from computers, and then a computer can best assess the work, Bugbee (1996)[1]. Hence, assessing the learning achievements and attitudes of students via computers or networks becomes a challenging task for many educators and researchers.

A. Computer-assisted Testing Categories

Computer-assisted Testing (CAT) or Computer-based Testing (CBT), the use of computers for testing purposes, has a history spanning more than twenty years. The documented advantages of computer administered testing include reductions of testing time, an increase in test security, provision of instant scoring, and an individualized adaptive testing environment [2][3][4][5]. As listed in Table 1, three categories of CAT are currently employed: standalone packages, test centers and networked systems.

TABLE 1: Categories of CAT

	Network support	Item generator	Random item selection	Item source	Item quality assessment	Item-bank sharing	Test result analysis
Standalone package	No	Built in item-bank	Yes	Fixed	No	No	Yes
Test center	Yes	Expert	Yes	Limited	Yes	No	Yes
Networked system	Yes	Built in item-bank	Yes	Fixed	No	No	Yes

1) Standalone package: This type of computer software package is typically stored on disks or CD-ROMs. Some packages have built-in item-banks, while others require teachers to input test items. These CAT packages generally do not have network capabilities.
2) Test center: The test centers or lab services require dedicated computer terminals for testing purposes. Students are required to complete the computer-based tests at the centers. Well-known applications of this type of service are Graduate Record Examinations (GRE) and Graduate Management Admission Test (GMAT), as provided by Educational Testing Services (ETS) [6].
3) Networked system: This enables students to perform an examination through an Internet connection. Concurrent testing of multiple users, automatic score calculation, and automatic test result analysis are supported by a networked system. The major advantages of networked systems are the convenience of examinations and test result calculation. However, the major flaws are the limitation of the amount of items and no item discriminability assessment.

B. Problem Statement

Regardless of which CAT system is employed, a critical issue in developing CAT is the construction of a test item-bank. Traditionally, asking teachers and content experts to submit items generates the item-bank. Three major drawbacks of the traditional method can be observed:
1) Limitation of item amount: Teachers and content experts tend to have similar views on the test subject. That is, in a given field vital subject matter might be confined. Therefore, although more teachers and content experts are invited to contribute test items, the total number of distinct items remains low.
2) Passive learning attitude: Students are conventionally excluded from the creation of tests. In a typical computer-assisted testing system, teachers generate tests, the system presents test sheets and students then complete the tests. That is, within the system of testing, they play a passive role, and are not afforded the opportunity to conduct "meta-learning" or "meta-analysis."
3) No guarantee on item quality: Permitting students to generate tests may be a possible solution to the aforementioned problems. However, this raises a new problem: quality assurance and ensuring that the tests are worth storing and used for further tests. Even when the whole item-bank is contributed by teachers and content experts, ways to dynamically assess and filter test items are needed.

The rest of this paper is organized as follows. The three distinct features of DIYexamer are introduced in section 2. Section 3 describes how the DIYexamer was implemented and its functionalities for administrators, teachers, and students. The discriminability calculation formula is then presented in section 4. Finally, the accuracy of discriminability discretion of DIYexamer and conventional methodology are compared through a real-life test in section 5.

2 The Diyexamer Solution

The DIYexamer[7] is a Web-based multi-server system that allows students to contribute test items, and provides an effective means of verifying the discriminability of these items. Three main ideas are as below:

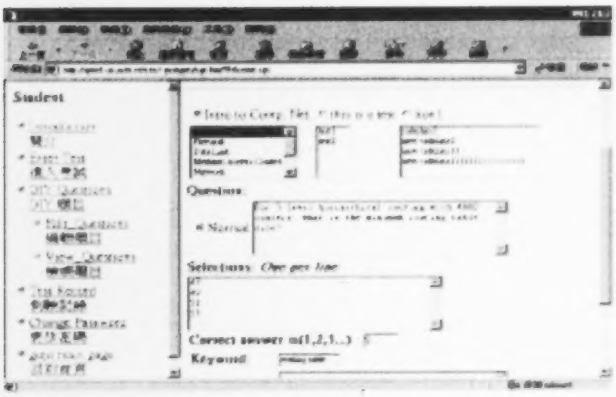


Fig 1: Students generate items into the item-bank

1) Item DIY by students: DIYexamer allows students to generate test items into the item-banks online as Fig 1. Teachers can query these items generated by students as Fig 2. In addition to rapidly increasing the total number of items in an item-bank, this feature also encourages students to develop *meta-learning*, i.e. *creative learning*. In order to submit tests, students must thoroughly study the learning materials, develop higher-level overviews of the materials, and practice cognitive and creative thinking.

Fig 2: Student DIY items as queried by teachers

Fig 3: Average item discriminabilities of item-banks

2) Assessment of item discriminability: DIYexamer provides an item-discriminability assessment method to ensure the quality of the stored items. In addition to ensuring the internal consistency of existing test items, this method also continuously and dynamically screens additional new items in the item-bank. Fig 3 shows the average item discriminabilities of several item-banks.
3) Item-bank sharing: DIYexamer, a scalable multi-server system, connects many item-banks stored in different servers. Therefore, via the Internet, more items can be accessed and shared. The sharing is limited and controlled in a sense that a server issues a request, describing the criteria of a test item it requests, to another server. A server does not open up its item-bank for unlimited access.

Additional advantages have been identified and include the facts that since DIYexamer provides a real-time on-demand generation of test-sheet function, cheating is avoided. Also, DIYexamer provides an item cross-analysis function to which the degree of difficulty for each test as well as the entire test base can be accurately measured.

BEST COPY AVAILABLE

3 Diyexamer System Implementation

A. DIYexamer Network Architecture

DIYexamer is a WBT (WWW-Based Testing) system. An important feature is the sharing of item-bank via network connections. According to Fig 4, several DIYexamer servers form a *scalable test union*. Therefore, each server can access other servers and thus achieve item-bank sharing. A remote server can also join the test union to share additional test-bank resources, and leave the test union without affecting other servers.

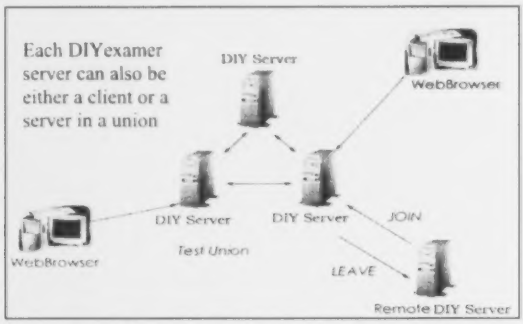


Fig 4: Network Structure of DIYexamer

B. Internal System Model

The internal architecture of DIYexamer (Fig 5) is divided into three layers. Interface layer is responsible for providing web interface for users. Test Profile Layer (TPL) selects items to form a test sheet, computes scores, and calculates the discriminability of selected test items. Test base Sharing Layer (TSL) accesses both local and remote databases via a network. Three functions of TSL are listed in Table 2:

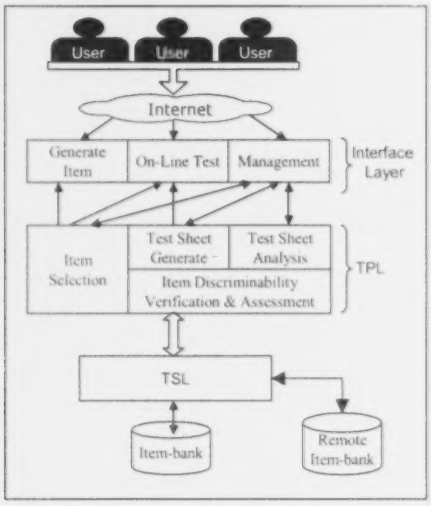


Fig 5: Structure of DIYexamer

TABLE 2: Functions of TSL

Function	Description
Add new items	New items and corresponding answers are categorized to specific chapters and stored in the local item-bank.
Access local item-bank	Accessing local while generating test sheets and calculating discriminability.
Connect to remote item-bank	Item-bank sharing through a connection to a remote item-bank.

Environments and development tools used to construct DIYexamer are listed in Table 3. Perl is used to write CGI programs to create user interface as homepage. Apache, an open source web server software, is responsible for front-end. The back-end, item-bank, is handled by Postgres.

TABLE 3: Environments and development tools

Function	Tools
HTTP Server	Apache 1.3.3 [8]
Programming Tools	Perl 5.003 [9] · CGI.pm-2.56 [10] · Gd.pn-1.14[11]
DBMS	Postgresql 6.5.3 [12]
O.S.	Red Hat Linux release 6.1[13]

C. Functionalities for administrators, teachers and students

DIYexamer provides a web interface for users to remotely control and operate the system. Three types of users are supported: administrators, teachers, and students. Corresponding functionalities are listed in Table 4.

TABLE 4: Functionalities for different users

	Administrator	Teacher	Student
System and Database	• Examine system status • Join a test union • Leave a test union • Create personal accounts • Create group accounts • Modify accounts • Modify item-bank • Redact course division • Backup database	• React course division	
Item production		• Create tests sheet • Select test items • Edit test items • Read test items	• Edit test items • Read test items
Test	• Network Invigilate	• Input scores of homework	• On-line test
Analysis	• Analyze tests • Analyze test items	• Analyze tests • Analyze test items • Analyze subjects and divisions	• Analyze tests
Inquiry		• Inquire tests • Inquire test items generated by students • Inquire students scores	• Inquire personal scores

4 Discriminability Assessment Of Diyexamer

A. Method of Traditional Discriminability Assessment

A criterion against which the quality of test items is judged is the assessment of discriminability. An item is regarded as with high discriminability when competent students correctly answered it, while less competent students incorrectly answered it, and vice versa. When computing item discriminability, those students with relatively high and relatively low scores are taken as samples. Those students whose scores fall in middle range not

considered. Next, item discriminability is computed according to the performance of these sampled students when answering each item.

In the traditional discriminability assessment method[14], those in the top 30% and the bottom 30% rank groups are chosen as samples. The top 30% scorers are defined as "high-rank group (H)", while the bottom 30% scorers are defined as "low-rank group (L)". The formula for calculating the discriminability of an item is as follows:

$$\text{Discriminability} = \frac{\text{The number of students in H that answered correctly}}{\text{The number of students in H}} - \frac{\text{The number of students in L that answered correctly}}{\text{The number of students in L}}$$

In the traditional method, two major drawbacks can be observed. The first one has something to do with whether the 30% is in terms of *count of students* or *range of scores*. The sampled students fall in the top 30% and the bottom 30% rank groups, i.e. in terms of *counts*. However, it is possible that these scores differ only slightly from the average score especially when scores are not wide-spread distributed, where many scorers should not be considered in computing the discriminability. Second, the effect on discriminability assessment by each student in either group is assumed to be the same. However, those students that received different scores have different degrees of tendency to correctly or incorrectly answer an item. For example, a sampled student who received 97 points should have higher referential value than a sampled student who received 80 points.

B. Method for DIYexamer's Discriminability Assessment

When selecting sample students, only those whose scores have large gap with the average score should be considered. Accordingly, those with the top 30%, in terms of range, scores are defined as "high-score group (H')", while those with the bottom 30% scores are defined as "low-score group (L')".

To show the different criteria and effects of choosing samples in the traditional method and DIYexamer method, Fig.6 depicts the score distribution in a test. In this example, the highest score is 92, the lowest score is 34, and the average score is 69. The "high rank score group" and the "low rank score group" are chosen according to these two methods. Take student X as an example, the score of X is 66, which differs only 3 points from the average score. The associated information of X should have little, if not none, referential value in computing item discriminability. However, X is chosen as a sample in the high rank group in the traditional method. This fallacy results from using rank group, in terms of count, as the criterion of choosing samples. In DIYexamer, X is not chosen since score group, in terms of range, rather than rank group is used. Only those with large gap with the average score are chosen as samples.

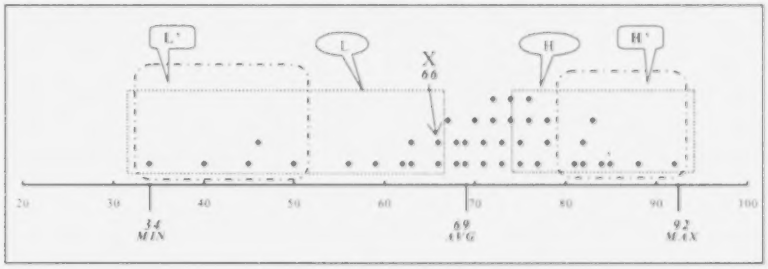


Fig 6: Comparison of samples taken in the traditional method and DIYexamer method

For different samples to have different impacts on discriminability, a referential value with respect to an item is generated for each student selected as a sample. We first define the item discriminability as the average of all associated referential values, as shown below:

$$\text{Discriminability} = \frac{\text{Sum of the referential values of sampled students}}{\text{Number of sampled students}}$$

Since the referential values depend on students' scores, the referential values are computed according to the ratio of correct and incorrect answers of the sampled students. The ratios of correct and incorrect answers are defined as follows:

$$\text{Ratio of correct answer} = \frac{\text{Number of items answered correctly}}{\text{Number of items on the test}}$$

$$\text{Ratio of incorrect answer} = \frac{\text{Number of items answered incorrectly}}{\text{Number of items on the test}}$$

TABLE 5: Principle to compute the referential value of a student with respect to an item

Student	Answer	Item discriminability	Referential value to compute discriminability
Competent (With high ratio of correct answer)	Correct	High	Ratio of correct answer
	Incorrect	Low	Ratio of incorrect answer
Less competent (With low ratio of correct answer)	Correct	Low	Ratio of correct answer
	Incorrect	High	Ratio of incorrect answer

According to Table 5, the referential value of a student correctly answered an item is the ratio of correct answer of the student. Alternately, the referential value of a student incorrectly answered an item is the ratio of incorrect answer of the student. This policy comes from the fact that an item should have increased discriminability if correctly answered by a competent student, while rendering decreased discriminability if correctly answered by a less competent student. In this way, a competent student contributes large referential value to a correctly answered item and small referential value to an incorrectly answered item, and vice versa.

C. Algorithm for DIYexamer's Discriminability Assessment

The test result of a student is used if the score falls in either the high or the low score group. A referential value is computed for each item the student answered. The discriminability of an item is the average of all of the associated referential values.

To calculate for each item, information must be recorded in the database. First, the highest and the lowest scores (i.e. Gmax and Gmin) of all students who answered the question item are recorded to calculate Gh and Gl. Gh and Gl are used as thresholds to determine whether a student is eligible to affect the rating of an item. Second, the number of students with referential values (i.e. n) and the sum of referential values (i.e. Accumulator) are recorded. The calculation formula and the corresponding definition of used parameters are listed below. Algorithm of DIYexamer's discriminability assessment summarized in Fig 7.

Accumulator: sum of referential values
n: number of students with referential value
T: number of correctly answered questions in this test
F: number of incorrectly answered questions in this test
Gmax: highest score of all students answered this question
Gmin: lowest score of all students answered this question
Gh: high threshold for ratio of correct answer
Gl: low threshold for ratio of incorrect answer
Ans: A Boolean variable indicates whether a student correctly or incorrectly answered the question

```
if((T/(T+F)>Gh) or (T/(T+F)<Gl))
{
 if (T/(T+F)>Gmax)
   Gmax = T/(T+F)
 else(T/(T+F)<Gmin)
   Gmin = T/(T+F)
 Gh = Gmax-(Gmax-Gmin)*30%;
 Gl = Gmin+(Gmax-Gmin)*30%;
 n = n+1;
 if (Ans==Correct)
   Accumulator = Accumulator + T/(T+F);
 else (Ans==Wrong)
   Accumulator = Accumulator + F/(T+F);
 Discrimination = Accumulator /n;
}
```

Fig 7: Discriminability assessment algorithm

5 Evaluation Of The Discriminability Assessment In Diyexamer

The fairness and performance of DIYexamer was evaluated. We conducted an experiment where 10 students took the test on-line using DIYexamer with 10 items. Table 6 summarizes the test results. Fig 8 shows the score distribution of the experiment. Discriminability for each item is computed using both the traditional method and the DIYexamer method. However, the discriminability originally falls between -1 to 1 using the traditional method, while falling between 0 to 1 using the DIYexamer method. To compare these two methods, both two ranges of discriminability are then normalized to 0 to 10, as shown in Fig 9.

According to Fig 9, the item discriminability differs in these two methods because the samples taken are different. The low-score group consists of student 1, 2, and 3 by the traditional method, while only 1 and 2 by the DIYexamer method. In this case, student 3 got 4 points, which differs from the average score (i.e. 5.2 points) by only 1.2 points. Since student 3 should have little, if not none, impact on the assessment of discriminability, student 3 is in fact not a proper sample.

Observe that, in Table 6, student 1 who is a less competent student and has incorrectly answered all items except item 1, and student 10 who is a very competent student and has incorrectly answered item 1. Thus, item 1 can be concluded as of low discriminability. Comparing the assessment results in these two methods, the computed item discriminability of item 1 is very low in the DIYexamer method but not as low in the traditional method.

Comparing item 3 and item 1 in Table 6, item 3 should have higher discriminability than item 1 because competent students tend to answer item 3 correctly and less competent students tend to answer item 3 incorrectly, which is not true for item 1. However, item 3 and item 1 have the same discriminability, i.e. 5, by the traditional method. In this case, the actual discriminability is more accurately reflected in the DIYexamer method than in the traditional method.

TABLE 6: Result of the test experiment

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Number of correct answers(score)
student1	1 (correct)	0 (incorrect)	0	0	0	0	0	0	0	0	1
student2	1	0	0	1	0	0	0	0	0	0	2
student3	0	1	1	0	1	0	0	1	0	0	4
student4	1	1	0	1	0	0	0	1	0	1	5
student5	0	1	0	1	0	0	1	1	0	1	5
student6	1	1	1	0	0	1	0	1	1	0	6
student7	0	1	1	1	1	0	0	1	1	0	6

student8	1	0	0	1	1	1	1	0	1	1	7
student9	1	0	0	0	1	1	1	1	1	1	7
student10	0	1	1	1	1	1	1	1	1	1	9

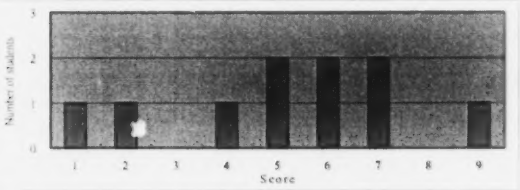


Fig 8: Score distribution of the test experiment

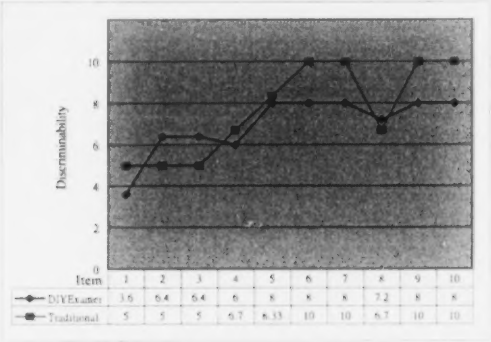


Fig 9: Comparison of item discriminability

6 Conclustion

This paper has presented a novel architecture for a networked CAT system, DIYexamer. It supports item DIY by students, item-bank sharing, and item discriminability assessment.

For discriminability assessment, new calculation formula were proposed. When compared with the traditional assessment scheme, the main difference is that the top and the bottom 30% of the *score* group, in terms of *range of scores* were selected rather than the *rank* group, in terms of *count of students*. Thus, item discriminability is more accurately reflected particularly when the tested students have close scores.

Item-bank sharing and item DIY by students has increased both the *amount* and the *variety* of questions in item-banks. Item DIY by students promotes *creative learning* within students, while automatic discriminability assessment assures better quality than traditional CAT systems.

A questionnaire was used to survey subjective attitudes of students about DIYexamer. As shown in Table 7, the outcome revealed that most students were interested in item DIY.

TABLE 7: DIYexamer questionnaire results: percentage and the number of students in parentheses of each question

Question	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Item DIY is interesting.	12.3 (7)	43.9 (25)	21.1 (12)	15.8 (9)	7.0 (4)
Item DIY is fanciful.	19.5 (10)	49.1 (28)	21.1 (12)	10.5 (6)	1.8 (1)
I am curious about the testing result of my DIY item.	26.3 (15)	59.6 (34)	10.5 (6)	3.5 (2)	0.0 (0)
I learned a lot when creating items.	12.3 (7)	47.4 (27)	22.8 (13)	17.5 (10)	0.0 (0)
I am curious about the teacher's opinion about my DIY item.	22.8 (13)	50.9 (29)	22.8 (13)	1.8 (1)	1.8 (1)
I am curious about other students' opinions about my DIY item.	15.8 (9)	56.1 (32)	21.1 (12)	7.0 (4)	0.0 (0)
I studied harder to prepare item DIY.	10.5 (6)	54.4 (31)	21.1 (12)	14.0 (8)	0.0 (0)
Judging the difficulties of my DIY items is easy.	40.4 (23)	38.6 (22)	14.0 (8)	7.0 (4)	0.0 (0)
Judging the fitness of my DIY items is difficult.	36.8 (21)	49.1 (28)	8.8 (5)	5.3 (3)	0.0 (0)
Item DIY by students comes from the laziness of teachers.	7.0 (4)	12.3 (7)	43.9 (25)	33.3 (19)	3.5 (2)
If possible, I hope such item DIY mode through the whole course can replace conventional testing.	1.8 (1)	10.5 (6)	35.1 (20)	38.6 (22)	14.0 (8)

Items generated by students are easier than by the teacher.	7.0 (4)	36.8 (21)	28.1 (16)	24.6 (14)	3.5 (2)
I knew more about the testing material after item DIY procedure.	8.8 (5)	50.9 (29)	22.8 (13)	15.8 (9)	1.8 (1)

The technique proposed herein is useful in general tuition not only to improve the quality of test items and fairness; but also to save time from generating questions and computing scores. We recommend that DIYexamer be popularized to schools.

ACKNOWLEDGEMENT

The authors would like to thank Tsung-shun Wu, Yi-Neng Lin, Chih-Hsuan Tseng, and Ding-Li Wang for the prototyping works of DIYexamer.

REFERENCE

[1] C. Bugbee, "The equivalence of paper-and-pencil and computer-based testing," J. of Research on Computing in Education, vol. 28, no. 3, pp. 282-299, (1996).
[2] C. V. Bunderson, D. K. Inouye, and J. B. Olsen, "The four generations of computerized educational measurement," in Educational measurement (3rd ed.), R. L. Linn, Ed. New York: American Council on Education—Macmillan, pp 367-407, (1989).
[3] S. L.Wise and B. S. Plake, "Research on the effects of administering tests via computers," Educational Measurement: Issues and Practice, vol. 8, no. 3, pp. 5-10, (1989).
[4] A. C. Bugbee, Examination on Demand: Findings in Ten Years of Testing by Computers 1982-1991. Edina, MN: TRO Learning, (1992).
[5] Load, F. M., Applications of Item Response Theory to Practical Testing Problems. Erlbaum, Hillsdale, NJ ,(1980).
[6] "Educational Testing Services Network", http://www.ets.org (accessed on Augest 22, 2000).
[7] "DIYexamer system", http://speed.cis.nctu.edu.tw/~diy (accessed on Augest 22, 2000).
[8] "Apache HTTP Server Project", http://www.apache.org/apache/ (accessed on Augest 22, 2000).
[9] "The Perl Language homepage", http://perl.com/ (accessed on Augest 22, 2000).
[10] L. Stein, "CGI.pm-a Perl5 CGI Library", Version 2.31, 2/9/1997, http://www-genome.wi.mit.edu/ftp/pub/software/WWW/cgi_docs.html (accessed on Augest 22, 2000).
[11] "GD.pm-Interface to Gd Graphics Library", Version 1.14, http:// www-genome.wi.mit.edu/ftp/pub/software/WWW/GD.html (accessed on Augest 22, 2000).
[12] "The Postgres95 homepage", http://s2k-ftp.cs.berkeley.edu:8000/postgres/ (accessed on Augest 22, 2000).
[13] "Red Hat Inc.,", http://www.redhat.com/ (accessed on Augest 22, 2000).
[14] Jacobs. L. C. and Chase, C. I., Developing and Using Tests Effectively: A Guide for Faculty. Jossey-Bass, San Francisco, CA ,(1992).

EDASEQ – A log file analysis program for assessing navigation processes

Helmut M. Niegemann
Institute for Media and Communications, Ilmenau Technical University, P.O. Box 100565, 98684 Ilmenau (Germany). Email: helmut@niegemann.de

Research on the effects of hypermedia learning environments often suffers from a lack of systematic control of learning conditions, especially the sequencing of the content. While available tools for logfile analysis are confined to delivering frequencies and other figures, the tool to be presented (EDASEQ: Exploratory Data Analysis for Sequential Data) was developed to facilitate the analysis of the navigation paths of single learners as well as "average" paths of a group of learners. Because standard statistical procedures for handling sequential data are not suitable here, the tool is primarily founded on graphical methods. Navigation processes are represented by transition matrices, and with additional visualizations and trajectories. Apart from descriptive portrayals, the tool also allows for categorizing empirically found navigation patterns on the basis of theoretically defined prototypical patterns. Furthermore, it is possible to compare the patterns of single learners or groups. Results can be used to better explain the effects of self-regulated learning in hypermedia learning environments. Without knowing variables like sequencing, time-on-task, or the number and configuration of examples studied by learners, it is hardly possible to interpret the impact of external learning conditions on the learning outcomes.

Keywords: **learning processes, navigation, hypermedia, methodology, tool**

1 Introduction

A fundamental problem of research on self-regulated learning is the possible variation of learners' behaviors, especially regarding variables like the sequence of content, the time spent with studying different parts of subject matter, the number and arrangement of examples and exercises: Have they really worked through all the relevant information? How many examples were chosen, with what methods of representation and in what combinations? How many exercises were worked through, and to what result, resp. with mistakes of what kind? How long were the learners occupied with what contents? This is valid for every type of research on self-regulated learning, but especially for learning with hypermedia. Even with the same context conditions, quantitatively and qualitatively completely different courses of learning are possible and thus, in consequence, very different results. Even when the learner activities displayed are described exactly, there are differences with respect to the quality of the elaborative treatment; the external conditions of the learning processes, however, are principally controllable. Unfortunately, standard statistical procedures are not suitable to represent an "average path" in an educational hypermedia system: Mean times spent on looking to specific pages or mean frequencies of visits are often not sufficient to explain differences in learning outcomes.

2 Aims of the development of EDASEQ[1]

For the description and categorization of such processes there thus remain graph theoretical procedures. There were already attempts at implementing these some time ago; the best known is probably Flanders' (1970) procedure for the analysis of teaching (cf. also Canter, Rivers & Storrs, 1985). For the treatment and

[1] Supported by the Deutsche Forschungsgemeinschaft (German Research Foundation), grant Az. Ho 649/9-1,2,3).

evaluation of data on the basis of graph theoretical cor
is relatively simple to use. It was therefore an aim of th
six year research project on case-based hypermedia le
a procedure allowing recorded data of learning process
about which allows those processes to be analyzed e
becomes possible, c) records of several processes can
possible between (1) single records of processes, i
individual process and an aggregated one, in order to l
typical route taken in their group, (3) two aggregated
treatment resp. marginal conditions using experimenta
prototype process that is produced artificially, in orde
within the framework of defined deviations, or to te
processes, it should also be possible to extract simple
screen pages, specific transition frequencies, length of

3 Forms of representation

In order to represent hypermedia navigation processes,
equivalent codes: transition matrices on the one hand
conspicuous characteristics in the graphical representa
of indices. Since both forms of representation are prac
special feature of well designed hypermedia learning
given in such a way that learners have the choice of e
deeper into the subject at any chosen place, or of combi
then deepening their knowledge. In order to determ
appropriate structuring of knowledge in the medium
elaboration" and the "variance of elaboration" have be
every hypermedia occurrence, which is all the higher, t
specific subject. If, for instance, the highest level with t
on the subject "inference statistics" or "descriptive stati
the subject "log-linear models" would have, for examp
values of all screen pages visited could then give
"elaboration" of the material; the measurement is c
analogously. Not least, characteristics of the chronologi

4 Realization

As the first step towards a reduction of process data in
problem" - in compliance with the demands - a software
enables processes to be transferred rapidly into transiti
the consultation of specific pieces of information and of
ascertained. The learning programs developed in this
learners need up to five hours to complete the given tas
single entries, each consisting of the time (in seconds a
screen page. Log-files existing as ASCII text files are
the simultaneous treatment of a larger amount of record
form of transition matrices can furthermore be compa
reduce data one can also stipulate that transitions whic
should be ignored.

5 Examples of process representation

The following representations are based on fictitious da
of representing certain processes, in order to determ
perceptible. Apart from this the size of these records was
to be given. shows the evaluation as regards the frequen

graph theoretical considerations there is, however, as yet no method which therefore an aim of the development of methods within the framework of a based hypermedia learning environments in vocational training to develop ta of learning processes to be so prepared that a) a data reduction is brought ses to be analyzed exploratively, b) a categorization of typical processes everal processes can be aggregated and finally d). Comparisons are made ords of processes, in order to see differences and similarities, (2) an ated one, in order to be able to study deviations of single learners from the , (3) two aggregated processes, in order to compare groups under different ns using experimental designs, (4) a single or an aggregate process with a d artificially, in order to categorize processes of one or several prototypes l deviations, or to test hypotheses. Apart from the characteristics of the ble to extract simple statistics: e.g. frequency of the calling up of specific requencies, length of stay etc.

tion

navigation processes, there are first of all two different but mathematically ices on the one hand and aligned graphs on the other. Whilst one can see e graphical representation, the matrix representation allows the calculation epresentation are practicable, both should be taken into consideration. One hypermedia learning systems is a structured presentation of knowledge s have the choice of either informing themselves superficially or of going sen place, or of combining both courses of action: first gaining an overview, e. In order to determine the extent of the "deepening" - assuming an ledge in the medium -, two characteristic values, the mean "depth of f elaboration" have been developed. The depth of elaboration is a rating for ich is all the higher, the deeper the corresponding screen page goes into a he highest level with the index number 1 is the term "statistics", then pages s" or "descriptive statistics" would have the index number 2 and a page on vould have, for example, the index number 5. The arithmetic mean of the ted could then give an indication of the extent of the "deepening" or he measurement is completed by the elaboration variance ascertained stics of the chronological process should be portrayable.

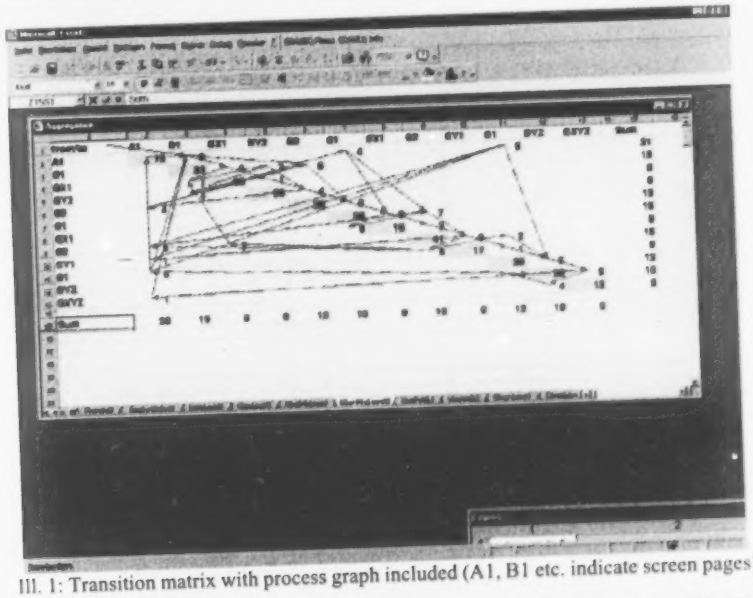
ion of process data in the Mannheim research project "Case-based learning e demands - a software-technical evaluation procedure was developed. This ed rapidly into transition matrices, so that firstly the simple frequencies of s of information and of the transitions between offers of information can be ms developed in this project each encompass approx. 150 screen pages; complete the given tasks and corresponding records comprise 3000 - 5000 the time (in seconds after midnight) and the designation of the respective s ASCII text files are downloaded and converted into MS Excel files. For rger amount of records it is also possible to stack them. Process data in the furthermore be compared to each other and also aggregated. In order to e that transitions which are more seldom than a specified threshold value

s representations and indices

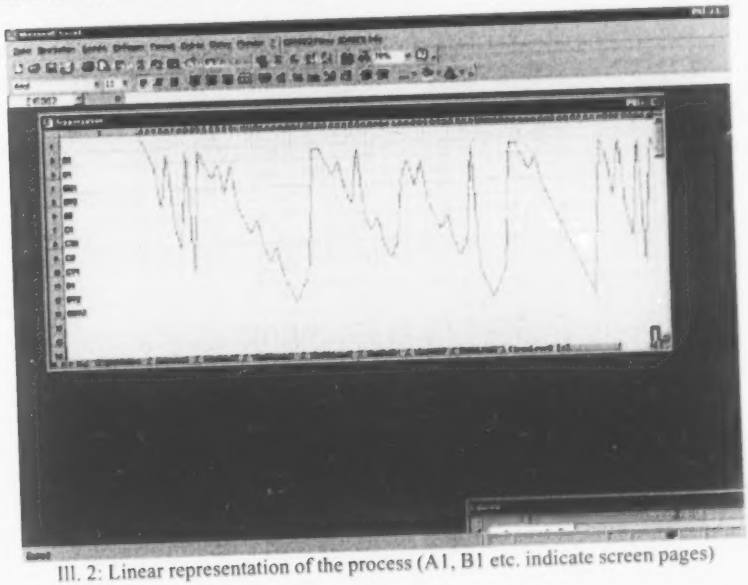
e based on fictitious data; i.e. records were produced with the specific aim es, in order to determine whether the corresponding characteristics are ize of these records was to be restricted, in order to enable a written account as regards the frequency with which single screen pages were called up, as

well as the length of the stay there (absolute in seconds and relative to the complete time needed). Ills. 1 shows a transition matrix with aligned graphs of the process included (option). One alternative graphical representation ("chronological") is given in Ill. 2. Here, above all, recourses to previous steps are clearly to be seen: the test person would, in this case, have chosen a strategy whereby he/she began by choosing page B1 on the higher level, "deepening" from there straight to BX1, going back to B1, choosing another "deepening" (BY2) etc. The values in the main diagonal indicate how many time units the learner has here stayed on each separate page.

In a third, more concise representation of the process every node (page, screen, chapter etc.) is represented by one cell and the navigation process is shown by arrows between the cells. Analyzing aggregated data, the thickness of the arrows indicates the frequency of the transitions between two nodes. So, a sequence of thick arrows represent a "modal path", i.e. a path used by many users. (Ill. 3)

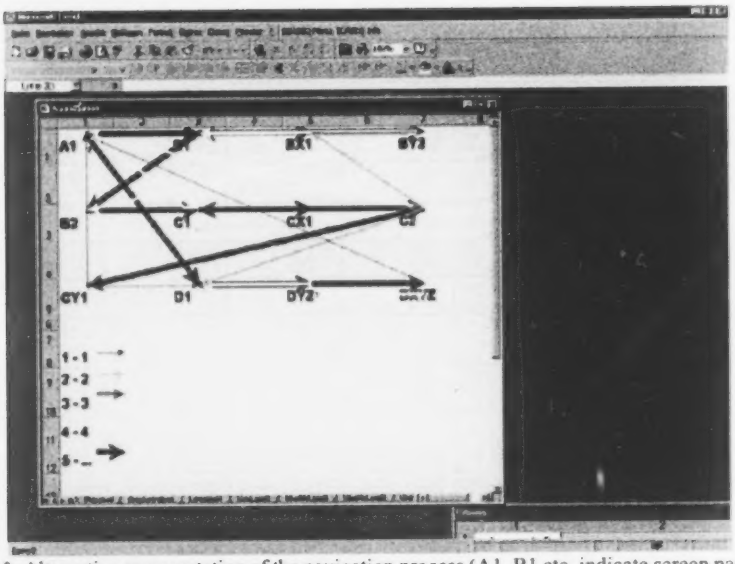


Ill. 1: Transition matrix with process graph included (A1, B1 etc. indicate screen pages)



Ill. 2: Linear representation of the process (A1, B1 etc. indicate screen pages)

BEST COPY AVAILABLE



Ill. 3: Alternative representation of the navigation process (A1, B1 etc. indicate screen pages)

6 Conclusion

The procedure which has been developed is first of all explorative, i.e. data are so prepared and represented that they allow categorizations and comparisons, thus offering a basis for the forming of hypotheses. Very extensive record files, in particular, are reduced. Although the procedure for the analysis of records on navigation was developed in hypertext, resp. hypermedia systems, it is also suitable for the treatment and analysis of data on the observation of teaching or other courses of communication.

References

[1] Bishir, J. W. & Drewes, D. W. (1970). Mathematics in the behavioral and social sciences. New York: Harcourt, Brace & World.

[2] Canter, D., Rivers, R. & Storrs, G. (1985). Characterizing user navigation through complex data structures. Behaviour and Information Technology, 4, no. 2, 93-102.

[3] Clarke, J. & Holton, D. A. (1994). Graphentheorie. Grundlagen und Anwendungen. Spektrum: Heidelberg

[4] Flanders, N. (1970). Analyzing teaching behavior. Addison-Wesley: Reading.

[5] Olson, G. M., Herbsleb,J. D., & Rueter, H. H. (1994). Characterizing the Sequential Structure of Interactive Behaviors Through Statistical and Grammatical Techniques. Human-Computer Interaction, 9, pp. 427-472

[6] Sanderson, P. M. & Fisher, C. (1994). Exploratory Sequential Data Analysis: Foundation. Human-Computer Interaction, 9, pp. 251-317

BEST COPY AVAILABLE

Generating interactive explanations by using both images and texts for Micro World

Kiyoshi Yoshikawa, Isamu Takahashi, Tatsuhiro Konishi and Yukihiro Itoh
Department of Computer Sciences, Shizuoka University
Johoku 3 - 5 - 1, Hamamatsu, Shizuoka, 432 - 8011, Japan
Tel: +81-53-478-1474 Fax: +81-53-478-1499
E-mail: {cs6098, i-takaha, konishi, itoh}@cs.inf.shizuoka.ac.jp

In this paper, we propose a method of constructing an intelligent Micro-World (MW) for high-school chemistry that accepts learners' questions and advises them whenever the learners are working in the MW. We also discuss the method generating explanations using both texts and images. At first, we argue on the interaction between a learner and such a system, and classify learner's typical demands and possible educational supports by the system. Next we show the ability necessary to deal with the demands, such as recognizing learners' plan, generating a plan to achieve a goal of an experiment, reproducing the state at any step of the change in MW, controlling the initiative of the interaction, and so on. Then we propose methods in order to realize the abilities. Moreover, we illustrate how to implement the abilities and introduce our prototype system.

Keywords: **Micro World, Interactive explanation, Mixed initiative**

1 Introduction

Micro-World (MW) has a problem that it is hard to support learners who are in impasse. We are developing an intelligent MW that supports the learners[1,2,4,5]. The domain subject of the MW is high-school chemistry. The MW has the following functions:

- Simulating changes in the world model of high-school chemistry.
- Recognizing the learner's plan by a sequence of his manipulations.
- Judging weather the learner is in impasse, by comparing the learner's plan with the standard plan that the MW generates. If the learner is in impasse, it assumes that the cause of the impasse might be lack of the knowledge necessary to perform the next manipulation which the learner should do.
- Giving the learner some advices by using texts. For example, the MW shows the knowledge which the learner doesn't understand, the manipulation that the learner should do next, and so on.
- Accepting learner's questions at any time when the learner is working in the MW and answering by using texts.

Our MW uses only texts in giving advices. In general, it is effective to explain something by using both texts and images. CINESPEAK [3] is one of the systems which can show explanations using both images and texts. It can generate a 3D animation and texts of explanation. It also can select appropriate camera shot corresponding to the contents of explanation. However, It can not generate explanations interactively.

We think it is necessary to avoid showing the texts and images prepared beforehand like video movies with some captions. The reason is that the explanation should be shown interactively. In other words, an educational system must not explain anything one-sidedly, because the condition of a learner is changing moment by moment while the system explains to the learner.

When an idea flashes upon a learner's mind during the explanation, the system must allow him to say his idea and respond to his remark. For example, when the system explains how to solve some problems in MW

to the learner who is in impasse, if the learner requires doing continuation of the problem solving process by himself, the system should prepare MW and let him continue solving the problem on MW. Similarly, if the learner requires changing some conditions of MW and explaining the method of solving the problem, the system should stop explaining, re-plan a new method to solve the problem with new conditions, and explain it.

In this paper, we extend the user interface of our MW in order to make it more effective. The first extension is that the MW uses not only texts but also images when it shows the learners advices or explanations. The second one is that the MW generates explanations interactively. Our extended system can explain manipulations that a learner performed in a MW and the manipulations necessary to achieve a given goal by using both texts and animations simultaneously. Moreover it can explain interactively according to the learner's demand.

In the next section, we discuss the ability necessary for the system that generate explanations interactively. In section 3 we show our basic approach to realize the abilities. In section 4 we illustrate how to implement the abilities, and we introduce our prototype system and show examples of its behavior.

2 Interactive method to explain

In order to generate explanations interactively, the system should have the following two functions.
- When a learner does not express his intention, the system must be able to lead his learning.
- The system must be able to deal with a learner's demand whenever the system aids learning (even when it is explaining something to him).

The former is out of range of this paper, because it is the topic concerning to the teaching strategy in the field of Intelligent Tutoring System (ITS). Therefore, We concentrate the latter.

Learners' demands and the method to deal with them depend on what kind of educational supports can be provided by the system. Therefore, we must clarify:
1. the educational supports and learners' demands.
2. what kinds of ability are necessary to deal with the demands.

2.1 Possible educational supports and learners' demands

We can classify states of the system into the following two types:
- The system gives a goal and the learner manipulates the MW on his own initiative.
- The system takes the initiative then it shows advice or explanations to the learner.

We discuss learner's demands and methods to deal with them on each state.

2.1.1 Supports and learners' demands when learner has initiative

We think the major demand on this state is to require an advice to resolve a learner's impasse. Therefore, we deal with only such type of demands as the first step of our research. In order to discuss how to deal with the demands, we classify causes of learners' impasse into the following two types.
(A):• A learner cannot understand the current state of MW.
(B):• A learner cannot decide what to do in the next step.

The system can satisfy the demand of the learner who is in impasse because of (A) by showing the following explanations:
- Explanation of a sequence of manipulations that the learner performed in the MW and the effect of each manipulation.
- Explanation of the state after each manipulation has performed.

The demand of the learner who is in impasse because of (B) can be satisfied by various ways. For example, the system identifies misunderstood or lacked knowledge and shows him the knowledge, the system explains on the similar case and lets him remind his experience, and so on. In this paper, we adopt the simplest way that the system shows the actions to be performed in the following steps. If we take the other way, we need to extend some functions to decide contents of explanations. However, the mechanism to control interactive generation of explanations is commonly reused.

As a result, the type of demands of the first state is only a demand to require some advice, and the type of explanations that the system generates is only an explanation of manipulations and the state after each one. In order to explain a manipulation and the state after it has been performed, the system generates animation showing how to perform the manipulation in the MW and texts explaining the effect of the manipulation.

2.1.2 Supports and learners' demands when the system has initiative

First, we discuss typical demands of learners who are in impasse because of (A) mentioned in the previous section. When the system explains to the learner a sequence of manipulations that the learner performed and the state after each manipulation by using animations and texts, the learner may demand that the system shows him a previous state again or a following state intermittently. In case that the learner finds his own mistakes while the system is explaining something to him, he may demand that the system stops explaining, prepares the initial environment, and lets him re-try solving his problem on the MW again. If the learner fails to resolve his impasse in spite of some explanations generated by the system, he may demand that the system shows him the whole correct process to achieve his goal on the MW.

Then, we imagine typical demands of learners who are in impasse because of (B). In this case, the system explains him the action to be performed in the following steps. The learner may demand that:
- the system shows him the previous/following states.
- the system stops explaining in order to let him do continuation of manipulations.
- he rewrites some conditions of his problem and the system explains how to solve the problem with new conditions.

We don't argue on all of above-mentioned demands, but only ones with which our system can deal, considering possible actions by our system. Such actions are as follows:
(1) Explaining the sequence of actions which learners have performed.
(2) Explaining the sequence of correct actions by which the given goal can be achieved.
(3) Setting an environment for experiment to let learners try achieving the goal free.

Table 1. Examples of typical demands by learners

Actions of the system		type of the demand and the scene where the learner input the demand
Action before the demand	Action after the demand	
(1)	(1)	The learner wants to see another action than one shown in the current explanation on the sequence of his previous actions.
(1)	(2)	The learner can understand what he has done, and wants to see what he should do next.
(1)	(3)	The learner finds the mistakes he has made, and wants to re-try the experiment.
(2)	(1)	The learner understands correct actions, and wants to compare it with what he did.
(2)	(2)	The learner wants to see another action than one shown in the current explanation on the sequence of correct actions.
(2)	(3)	The learner understands the correct actions, and wants to re-try the experiment.
(3)	(1)	The learner loses the current state in the process of achieving the goal of the experiment. He wants to confirm the actions which he has performed.
(3)	(2)	The learner loses the way to achieve the goal of the experiment. He wants to see the correct actions.
(3)	(3)	He finds he has failed to achieve the goal and wants to re-try the experiment.

Then we can classify the demands according to which actions are performed before/after accepting the demand. Combinations of the actions are 3*3= 9 types such as "when system doing (1), a demand is input, then it does (1)", "when it doing (1), a demand is input, then it begins to do (2)", and so on. Examples of the typical demand of each type are shown in Table 1.

2.2 Abilities necessary to deal with learners' demands

In this section, we discuss abilities necessary to deal with the learners' demands mentioned in 2.1. Basically, MW should have an ability to simulate changes in the MW according to learners' actions.
In addition, in order to deal with the demands mentioned in 2.1.1, the system should have the following abilities.

(a) Ability to recognize learners' plan from a sequence of his actions.

In order to explain what learners have done by not only listing up the actions, but also showing the meanings of the sequence of the actions, the system needs the ability.

(b) Ability to generate a plan to achieve a goal of an experiment.

In order to explain correct actions which learners should perform, the system has to be able to generate plan.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

The system had better be able to generate explanations using both texts and images. In order to generate visual explanations, the system should be able to operate MW in a similar way as learners do. In order to generate verbal explanations, the system should be able to generate texts from the result of planning or plan recognition.

In order to deal with the demands mentioned in 2.1.2, the abilities mentioned above are also necessary. In addition, the following abilities are needed.

(d) Ability to store the history of actions by learners or the system.

The ability is needed to do action (1) or (2) as a reaction of a demand in Table 1.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The ability is needed to do action (3) as a reaction of a demand in Table 1.

In addition, the following ability is necessary to realize mixed initiative. It is generally important to make interactive educational environment effective.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

3 Methods necessary to deal with learner's demand

The basic framework of the system as a MW can be seen in [5]. An extension in this paper is that the system becomes to have two individual environments: one is the environment for experiment used by learners, and the other is the environment for explanation. Our system operates the latter environment in its explanation. We add the latter environment in order to avoid that both a learner and the system try to operate a common one at the same time. The environment for experiment has an interface and functions to accept learner's actions, and reacts as soon as it accepts an action from a learner. On the other hand, the environment for explanation cannot accept manipulations from learners (though switches similar to the environment of experiment are displayed in its window, they are dummy).

We discuss how to equip such a framework of the system with the abilities mentioned in 2.2.

(a) Ability to recognize learners' plan from a sequence of his actions.

On this ability, please see our previous paper[4, 7].

(b) Ability to generate a plan to achieve a goal of an experiment.

On this ability, please see our previous paper[4, 7] too.

(c) Ability to simulate changes in the MW according to the plan generated or recognized by itself, and ability to generate verbal explanations showing what actions has been done or what actions should be going to be done.

Simulation in MW is performed by using symbolic knowledge representation. States at each step of

MW are also represented in a symbolic way. Manipulations by learners are also translated to symbolic representations. The control method of the simulator is event-driven: as soon as a manipulation is input to the simulator, the inference engine generates symbolic representation showing the next state of MW. The system draws the state of MW on the basis of the symbolic representation. Therefore, the system can simulate changes in the MW according to the generated or recognized plan, because the system can generate the input of the simulator represented symbolically from the plan.

In addition, because states of MW, manipulations to MW, and changes in MW are commonly represented in a symbolic way, the system can generate explanations in natural language on every fact in MW.

(d) Ability to store the history of actions by learners or the system.

It is easy to store such history because all of states of MW, manipulations to MW, and changes in MW are represented in a symbolic way. The system records only the initial state and a sequence of having performed actions as the history. The system can reproduce all states and changes by simulating the change in MW again on the basis of the history.

(e) Ability to reproduce the state at any step of the change in MW and allow learners to manipulate the MW.

The system can reproduce any states in an explanation on learner's previous actions, by performing the manipulations stored as the history sequentially. On the other hand, it can also reproduce any states in the process when correct actions are performed, by performing the manipulations in the plan generated by itself. Thus, the system can set any states of an environment which learners can manipulate, by copying such reproduced states in the environment for explanation to the one for experiment.

(f) Ability to control the two phases: a phase where a learner takes initiative by actions to achieve the goal, and a phase where the system takes initiative by generating explanations.

We adopt the following strategies for controlling the phases:

- Basically, a learner takes initiative, and he acts freely in MW.
- Turn over the phase to the other phase where the system takes initiative, as soon as the learner inputs a question or demands that the system explains something.
- If the system finds that the learner is in impasse, ask him whether he hopes to turn over the phase where the system takes initiative. And if he does, turn over it.
- Accept interruption by learners whenever the system generates explanations.
- Decide the next action of the system according to the interruption. For example, if the learner demands that the system sets the phase where the learner takes initiative, set a suitable state of the environment and let him experiment freely. If he inputs a demand for the system to explain other topic than the current topic, continue explanation on the requested topic.

4 Implementation

We designed a prototype system. Figure 1 shows outline of our system.

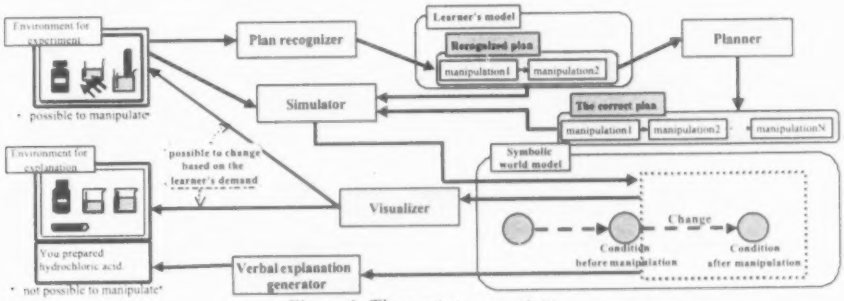


Figure 1: The prototype system

BEST COPY AVAILABLE

The system has *environment for experiment* and *environment for explanation*. The system sets a goal and a learner tries to achieve the goal by manipulating objects in *environment for experiment*. When the learner does an action in *environment for experiment*, the simulator reproduces a change in *symbolic world model*. Then the *visualizer* draws the state after the change in *environment for experiment*. At the same time, *the plan recognizer* monitors the learner's manipulations and recognizes his plan. When the learner becomes to be in impasse or requires some advice, *planner* generates a correct plan. Then the system visualizes environment for explanation, and starts explaining by using either recognized plan or the correct plan. In order to generate explanation, *simulator* reproduces states of the world model and *visualizer* visualizes the states in *environment for explanation*. Simultaneously *Verbal explanation generator* generates verbal explanation on the manipulation, the change, and the state.

The domain world model of this system is written by symbolic representation. In general, it is difficult to handle continuity of time and space by such representation. Therefore, our system handles time as a sequence of discrete segments of time. And it doesn't handle strict position of objects in the world, but only relative relations which can be represented by symbols, such as "chemical materials are in the same beaker". A change is also represented by symbols which shows the initial state, the actions causing the change, the changing state, and the state after the change. Most of the subjects in high-school chemistry can be handled in the above mentioned way.

This system is implemented by using Tcl/Tk and LISP (Kyoto Common LISP). This system can deal with the 5 subjects: method of preparing a solution of a certain molarity, acidic material, basic material, neutralization, and using indicator.

We show an example of the behavior of our system when a learner does an experiment of neutralization. Figure 2 shows a user interface for *environment for experiment*. In the environment, the learner prepares hydrochloric acid, prepares nitric acid, and sodium hydroxide, pours nitric acid into hydrochloric acid, prepares phenolphthalein, and mixes it into the mixed acid. Then he finds that he has not achieved his goal. In the case that he can't find the reason and inputs a demand for the system to explain his own actions, the system prepares an *environment for explanation* to start explaining the actions the learner has done. Figure 3 shows a user interface of *environment for explanation*. The interface has three windows: a window for displaying visual explanations and verbal explanations, a window showing a history of actions that have been taken place, and a window for inputting demands. In Figure 3, both visual and verbal explanations for the fourth action (marked in the list shown in the window for history). If the learner finds that he has made a mistake, and if he cannot find the correct way, he wants to demand that the system explains how to neutralize. He clicks on the button "*correct manipulation*" in the window for inputting demands. Then the system starts explaining the correct way (Figure 4). If he inputs a demand for the system to let him re-try the experiment, the system prepares *environment for experiment* and reproduces the state from which he wants to start experiment (Figure 5).

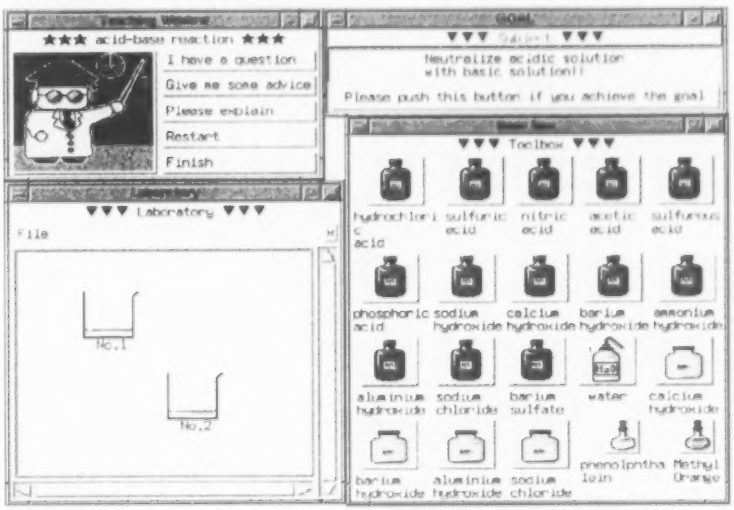


Figure 2: An example of environment for experiment

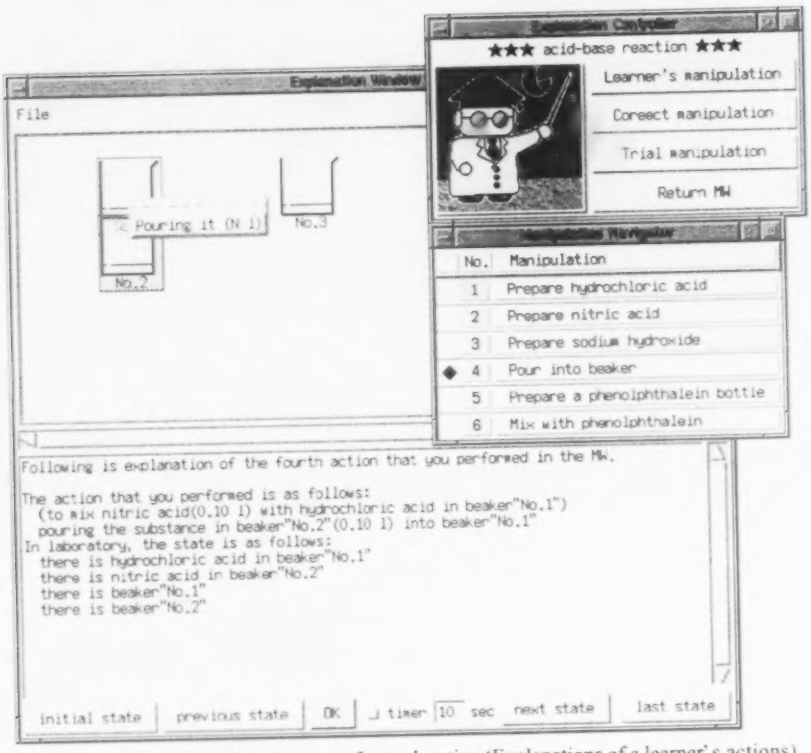


Figure 3: An example of environment for explanation (Explanations of a learner's actions)

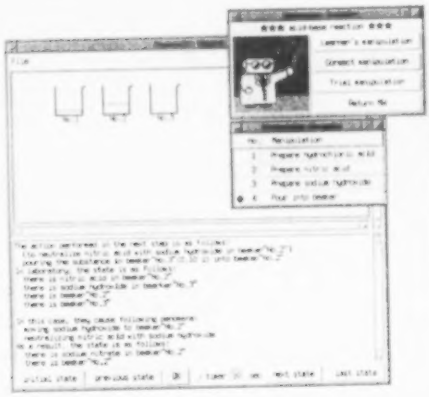


Figure 4: Explanations of corrects actions

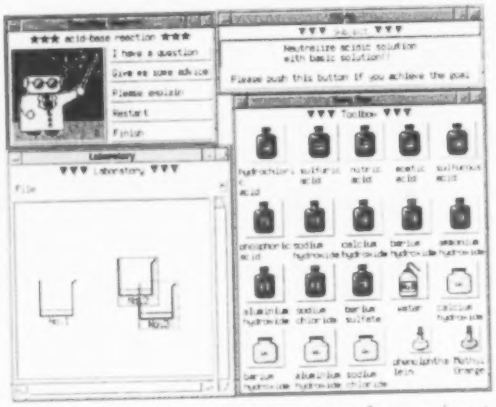


Figure 5: A reproduced environment for experiment

5 Conclusions

In this paper, we discuss a method constructing an intelligent and interactive MW generating explanations both images and texts. Our prototype system has relatively small domain knowledge base, so we have to make it larger in the future in order to increase subjects that our system can support.

When we will try to extend our system to handle other domains, the simulator underlying the system needs to deal with continuity of time and space. For example, if we deal with the field of electric circuit, the

BEST COPY AVAILABLE

simulator needs to handle topology. If we deal with the field of dynamics of physics, the simulator needs to handle coordinate system.

Our another future work is to evaluate the effectiveness of our system experimentally.

Acknowledgements

This research was supported in part by Grant-in-Aid for Encouragement of Young Scientists (12780125) from Japan Society for the Promotion of Science.

References

[1] Itoh,Y., Takahashi,I. and Konishi,T., "On Recognition of Student's Actions in ILE", Proceedings of the International Conference on Computers in Education(ICCE'95), Singapore, December5-8, pp.630-639,(1995)

[2] Itoh,Y., Takahashi,I. and Konishi,T., "On evaluating students' knowledge by observing their actions in ILE", Proceeding of Artificial Intelligence in Education(AI-ED'97), Kobe,Japan, August18-22, pp.595-597, (1997)

[3] Stuart G. Towns, Charles B. Callaway and James C. Lester, " Generating Coordinated Natural Language and 3D Animations for Complex Explanations", Proceedings of the Fifteenth National Conference on Artificial Intelligence (AAAI-98), Madison, Wisconsin, America, July 26-30, pp.112-119, (1998)

[4] Takahashi,I., Itoh,Y. and Konishi,T., "On a method to decide the order of knowledge shown as advice in ILE", Proceedings of the Sixth International Conference on Computers in Education (ICCE'98), Beijing, China, October 14-17, vol1, pp.373-380, (1998)

[5] Takahashi,I., Konishi,T. and Itoh,Y., "On a Framework of an Educational System which Acts both as ITS and Micro-World", Proceedings of the Seventh International Conference on Computers in Education (ICCE'99), Chiba, Japan, November 4-7, pp.954-957, (1999)

Gold Peach Web Community 2000: A Research on Developing Web-Based Interactive Learning Environment

Wu, Tung-Xiung*; Yui-Liang Chen**
Dept. of Information Management, Shih Hsin University
#1, lane 17, Mu-Cha Rd. Sect. 1, Taipei, 116, Taiwan, ROC
**Email: txwu@cc.shu.edu.tw*
***Email: ychen@cc.shu.edu.tw*

This series research was based on the progressive concepts of web community, cultural and cultivation features to develop an interactive learning environment for children. The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface has been developed and tested. There were four functions in this community: total Web-Based CAI, interactive learning navigation, collaborative learning classroom, and community management.

Keywords: **Web-Based Learning, Interactive Learning Environments, Web Community, Culture and Cultivation**

1 Introduction

This series research attempted to access the specific objectives as follows:
Developing an interactive learning platfomm 'Gold Peach' for children based on the fundamental ideas of 'web community'.

Initiating the 'cultural' and 'cultivation' features on designing web environment.
Conducting a field study on focus groups to testify the usability of 'Gold Peach'. Two pretest groups have been done. A well-designed quasi experiment including 3 primary schools is still under going.

The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface that had been developed and tested.

2 Literature Review and Problems Defining

2.1 Web Community

Web community was a progressive and extended concept from 'network-based learning community' that was introduced by Lave ea al. (1991)' s 'situated learning' and modified by Qiou (1996).

The components of network-based learning community were:
The organization of community: There were hardware, tools, and members. The community could be in an open or a closed form.

The learning activity: Lave et al. (1991) indicated it should have legitimate peripheral participation (LPP). Such participations included access, communication, learn to talk, collaborative learning and knowledge sharing.
The learning material: There were both existing material that was prepared in the learning database and

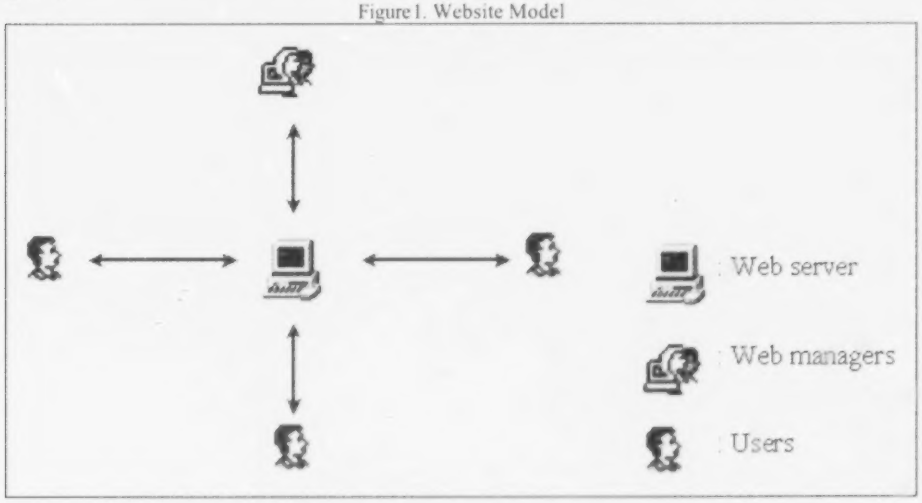
ongoing knowledge that was shaped by the collaborative learning processes.

The moderation: Lave et al. (1991) did not point out any leader in the community while Qiou (1996) advocated the necessary role of 'moderator' who would be the teacher to the other users (students). However, Kearsley (1997)'s idea could be noted here. He emphasized an online teacher is to coordinate the learning direction more than to dominant dogmatism.

After examining the literature above, the author suggested there should be the fifth element: 'the integrated interaction model'.

In general, the conceptual modes of websites interaction could be described as 'radiation model' (see Figure 1):

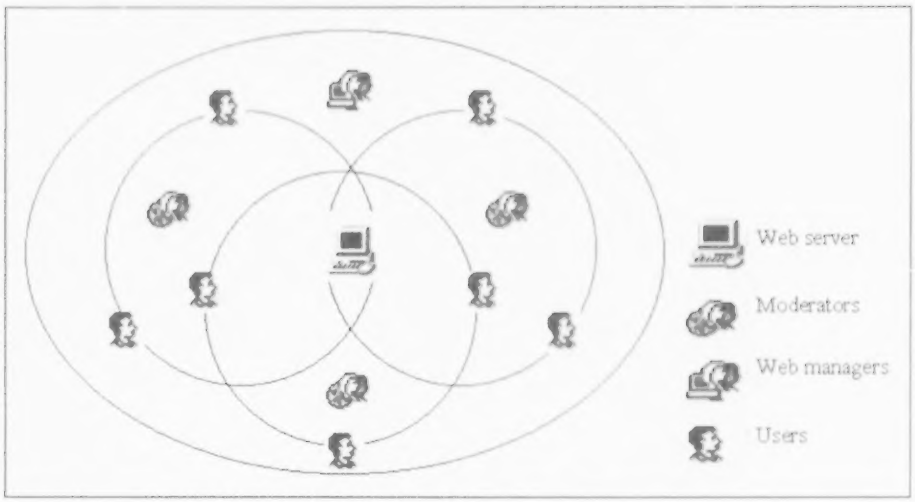
Figure 1. Website Model



The website manager has a 'one to multiple' interaction with users through internet. The website manager will provide all web function, service content and all learning activities.

n practice, it is impossible to prepare complete and sophisticated learning material, achievement test, and all peripheral participation by a single manager or few individuals. It reflects the facts that a lot of existing learning websites that are lacking of updating or content depth.

Figure 2. Web Community Model



Therefore, the author brought a new ' web community model' as Figure 2.

This model designed two different interactions: systems functions and information contents. The website manager would only take the former responsibility. The information contents would be divided into more sub communities or interest groups that would be coordinated by external moderators. It was expected that there would be some interlaced area between groups, thus it would be linked as an integrated community. Group moderators did not have to worry about the web techniques; they could be concentrated to develop the learning behavioral interaction for users.

2.2 Culture

Internet makes the earth smaller, brings the world into a village. When we are celebrating the international boundary is falling down; do we regret that the pluralistic colors are also vanishing?

Though there are millions web sites, we have found the inevitable trend that the web characters grow similar faces, wear same uniforms, their interactions are more and more following consistent pattern. We cannot tell which web site is from a certain corner of which continent.

It worried him when the author called for a seminar of designing a new web with his college students. When we needed an innocent leading actress, there was only Snow White left in students' mind; when we made up a worrier model, the Black Knight came out; when we set up exploring plots, they were thinking of Star Trek. They ignored or forgot there are plenty of symbols and scientific fictional stories in Chinese history and mysteries. The young generation is losing its heritage of cultural imagination. (Wu, 1997)

The author suggested that we should remind web designers to consider ' cultural feature ' to be an essential factor for designing web. It would be not interesting, if there were no cultural differences in the cyber world. (Wu, 1998; Wu et al. 1999)

2.3 Cultivation

Media' s form (or environment) is as well as content may produce cultivation effect to children, according to Gerbner et al. (1979)' s series work concerning Media Sociology perspective. This idea may come from a long tradition of ' The Medium is the Message' (McLuhan, 1966). It argued that media itself would affect audience' s recognition, attitudes, and even behavior.

There were rich studies and documents on ' TV cultivation theories' in 1970s and 1980s. (Anderson, 1980; Hughes, 1980) Scholars advocated that there are heavy effects influencing children by television. They also

found television would build up a 'media reality' which is far different from the 'real reality'. 'TV children syndrome' was discovered and considered a serious problem.

However, there was still a positive angle to this effect. We could conclude that although media might distort one's behavioral development, while it also might inspire one's mental potential especially in his/her childhood.

WWW is the most powerful media next to television. When we reviewed the lessons from television, the author wanted to suggest that developing web is not only defining a mechanism but also initiating an organism that might cause cultivation between community members.

The effect of cultivation could be operationalized and explored by users' behavioral changes after their experiencing the new media's form and environment. Therefore, the web community also needs a two-way feedback system to collect, measure, and interpret data that real users' innovation behavior, if there is any.

2.4 Current Learning Webs

The author thoroughly investigated ten significant current learning webs in Taiwan to understand if they also noticed the above three concepts. The observation could be summarized as:

Table 1.

	Web Community	Culture	Cultivation
Yes	2	0	1
No	8	10	9

Most of learning webs were in radiation model, one way teaching, and without any culture consideration. This fact explained the emerging need and encouraged the author to develop an integrated web learning community environment.

3 Methodology

As an application research, four methods were employed:
1. Literature reviews.
2. Depth interviewing with experts whose major is in children education.
3. Web systems analysis and design. Four requirements had been defined, they were:
-Total Web-Based CAI: including structural learning materials, systematic learning achievement tests, scores database, users demographic database, parameters base, and analysis tools.
-Interactive learning navigation: guiding users how to solve problems with internet resources instead of telling them the answers.
-Collaborative classroom: creating an online virtue space for the moderator and users to allocate assignments, talk over problems, display output, and share knowledge.
-Community management: verifying the applications for moderators, recognizing the rights of them, providing tools and interfaces for moderators to prepare learning materials, tests, and other collaborative activities.
4. Field study on focus group: two primary schools, one in Gi-Lung City and the other in Tau-Yuan County, had been selected as focus group, interaction and users' feed back had been analyzed for further rigid experiments.

4 Results

4.1 Community Environment and User Interface

The web was named 'Gold Peach Web Community'. Gold Peach is a magic fruit in West Holy Mother's garden based on Chinese ancient legend. You could navigate the cloud and explore unknown world after eating the Peach. The sprit of scientific fiction is as keen as modern imagination.

Since Gold Peach also appears in the famous Chinese classic fiction ' The story of the venture tour to West' , we adopted and inherited the background, characters and plots from the story to create the cyber environment of the web as Figure3.

After logging in the community, the child users could play roles as Magic Monkey, Pig, Sandman, Dragon Horse or other genius etc. They could follow Master Monk to break in 81 forbidden area that were controlled by different monsters and demons. They could steal Gold Peach to surf the WWW to find out the answers for their questions. Or, they might join one of parties in Flower Island where they could chat or work out a task together.

Figure3. Gold Peach Entrance

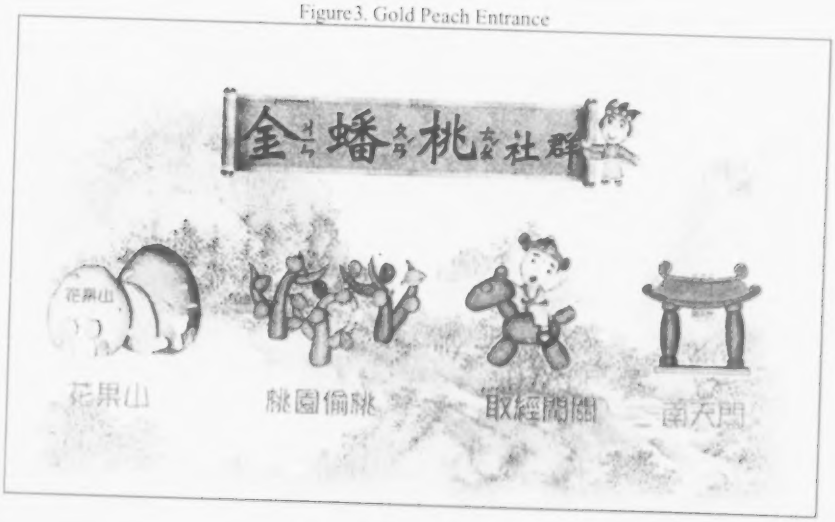


Figure4. Design Process

4.2 Interactive Learning Design Process

The moderator (teacher or expert) users could apply to be god or goddess in South Heaven Palace. After verification procedure, they would be authorized to be in charge a specific interest group to develop the learning interaction with child users.

With a easy, step-wise, and flexible tool (see
Figure4), they could plan their syllabus and learning units. It was easy to reorganize and modify chapters and sections.

There were multiple functions to support moderators to arrange test. They could use either closed-ended or open-ended questions, single option or multiple choices. They also wanted to design some hints for the users who did not pass the test. They could set links to the internet resources where buried the treasure of answers.

They could also direct a virtue seminar or assign a fieldwork. All participants could exchange their idea or experiences upon moderators' requests.

All closed-ended questions in tests would be graded automatically while moderators would mark the open-ended questions.

The users scores and evaluations would be computed and organized in database. A parameter framework would be derived from a certain amount of accumulative data later on. In the same time, a report of user's learning achievement would be prepared for use's parents through web connection. Parents also could reply their comments to the moderators.

5 Conclusions and Discussions

BEST COPY AVAILABLE

5.1 Web Community: A progressive idea for learning environment

Web Community could be considered as a progressive idea for learning environment. It improved traditional one-way teaching and display and realized total peripheral participation and interaction.

The specification of ' Gold Peach Web Community' could be summarized as the following:
Developing interactive learning platform and environment where all community members could learn, solve problems, and share knowledge.

Consolidating learning contents that were combined primary schools' curricula with internet resources and information.

Reviewing and categorizing current information and webs that are suitable and interesting for children.

5.2 Culture: A deficiency, excess and integration trace

Three generations of the user interface were developed during last a few years. It revealed the introspection on seeking the cultural feature of web design.

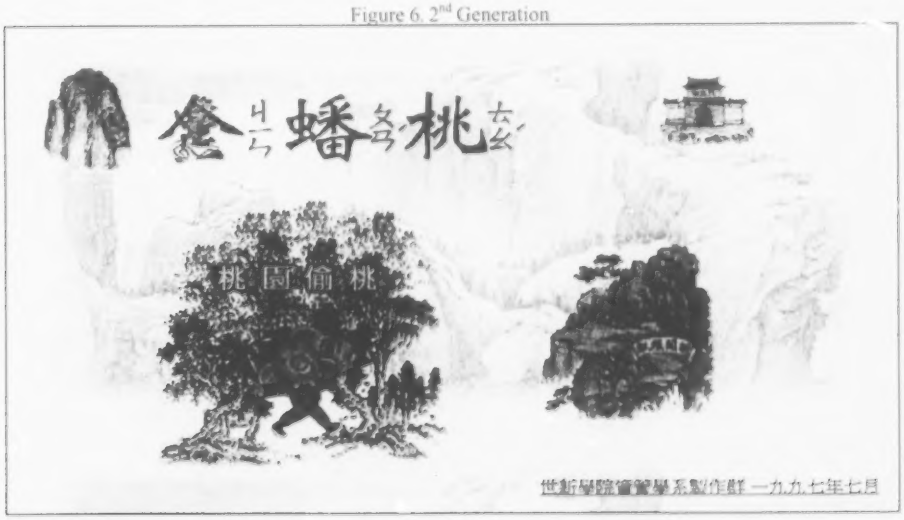
Though the ' culture requirement' was highlighted according to the web developing strategy for the 1st generation, the implement was relatively unsuccessful. The artists in the project team were still lost in the long term Westernized training. The leading role, Magic Monkey, was cute, but lack of originality. The presentation of icons and background were inevitably under European shadow. (See Figure5)

Figure5. 1st Generation

The effort on discovering lost tradition inspired the using of Chinese ink and calligraphy art to stylize the home page for the 2nd generation. The cultural specification was distinguished, however, the black-and-white idea was too abstract to attract children' s attention. (See Figure 6)

We did not find a balance between cultural skill and modern technique until the 3rd generation. We inherit the 3-D model of Chinese flour idol and the styling interest of folk drama to cerate cyber characters. The objects in the background were Chinese materials with modern simplified geometric outlines. The real culture should be a living idea that contented historic and current context. (See Figure3)

Figure 6. 2nd Generation



5.3 Cultivation: A ferment attempt

The result of this research 'Gold Peach Community' was expected to guide a new direction and a new method for children to develop their abilities of learning and problem solving under silent and positive cultivation.

The effort to discover the cultivation effect was still under ferment period. However, this research

BEST COPY AVAILABLE

investigated and accomplished some feedback mechanisms in the systems. They could detect and reveal possible cultivation effects by comparing users learning behaviors and achievement. Since cultivation is more likely a time series effect than a sudden change, the author suggests a large scaled and longitudinal experiment on this issue in the future studies.

References

[1]Anderson, James A. (1980); The Theoretical Lineage of Critical Viewing Curricula; Journal of Communication; Vol.30, No.: 64-70

[2]Hiltz, S. R.; Teaching in a Virtual classroom; Proceedings of the 5th International Conference on CAI;Taipei: NSC; invited paper; 1995

[3]Kearsley, G.; A Guide to Online Education; http://gwis.circ.gwu.edu/~etl/online. html; 1997

[4]Lave, J. & E. Wenger; Situated Learning: Legitimate Peripheral Participation; London: Cambridge Univ. Press; 1991

[5]McLuhan, Marshall(1966); Understanding Media: The Extensions of Man; NY: McGraw-Hill; Ch.1

[6]Gerbner, George, Larry Gross, Michael Morgan and Nancy Signorielli(1979); Television Viewing and Fear of Victimization: Specification or Spuriousness; Annenberg, Penn.: The Annenberg School of Communications, Univ. of Penn.

[7]Hughes, Michael; (1980); The Fruits of Cultivation Analysis: A Reexamination of Some Effects of Television Watching; Public Opinion Quarterly; 46: 287-302

[8]Qiou, Guei-Fa; (1996); Situated Learning Concept and Computer Assisted Learning; Taipei: National Normal Univ. Press

[9]Wu, Tung-Xiung and Yui-Liang Chen; (1999) Cultural and Cultivation Features on Web Designing: A Case Study of Gold Peach Community; In Bullinger, Hans-Jorg and Jurgen Ziegler (eds.) Human-Computer Interaction: Communication, Cooperation, and Application Design; Mahwah, N.J.: Lawrence Erlbaum Associates; Vol. 2, p:66-70

[10]Wu, Tung-Xiung; (1998); Gold Peach Web Community: A Research and Production Project; Taipei: Project of NSC: NSC-87-2515-S-128-001-CH

[11]Wu, Tung-Xiung; (1997); A Research on 'Educational function' and 'Cultural Specifications' of Internet Services; Shih Hsin Journal; No. 6:115-27

Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships[1]

Fu-Yun Yu
Graduate Institute of Education
National Cheng-Kung University
No. 1, Ta-Hseuh Rd., 701, Tainan, Taiwan, R. O. C.
Tel: +886-6-275-7575 ext. 66225
Fax: +886-6-276-6563
E-mail: fuyun@mail.ncku.edu.tw

The effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, was explored in this study. More specifically, the effects of e-mail utilization in classrooms on student attitudes toward the instructor, the class and interpersonal relationships were the focus of the study. In total, sixty-eight prospect teachers enrolled in "Computers in Education" course participated in the study for a whole semester. Results from the study provided substantial evidence supporting e-mail's facilitative effects on student attitudes toward the instructor, the class as a whole, and other classmates.

Keywords: **Attitudes toward the class, Computer literacy instruction, E-mail, Interpersonal-relationships.**

1 Introduction

With unique characteristics like faster and asynchronous communications, greater flexibility for participant time management, improved receiver control and use of the message, and cost savings, etc. electronic mail (hereinafter named e-mail) is becoming more and more common in contemporary organizations [8, 12, 22, 24, 31, 33, 36]. In views of many of its advantageous features over conventional communication modes, e-mail has presented itself as a promising instructional and learning tool since its advertent.

Despite its potential value in variant educational settings, substantial evidence has come mostly from studies done in the areas of communication, literature and language learning [1-6, 9-21, 23, 25-30, 32]. For instance, Marttunen & Laurinen (1998) using e-mail as a forum for argumentation and debate supported the idea of incorporating the media for critical thinking and argumentation skills [19]. Whipp (1999) integrating e-mail discussion activity in an undergraduate methods course found that e-mail activity promoted reflection and joint interpretations of field experiences among participants [32].

Studies focusing on intercultural communications further stressed the multicultural learning opportunities e-mail engendered. For example, Cohen & Miyake's 1986 study showed that joint participation in the e-mail interaction across cultures could encourage multilingualism and awareness to other cultures [4]. Results from Ma's study (1993) indicated that students participating in the international e-mail communication tended to be more open of sharing information that provided them with subject and cultural knowledge [18]. Ruhe's endeavor (1998) in creating classroom e-mail exchanges among college

[1] The study was partly supported by National Science Council of the Republic of China (NSC 89-2413-H-006-008)

preparatory English-as-a-Secondary students scattering around different continents again demonstrated that e-mail could be effective in teaching intercultural awareness [23]. Numerous scholars, on the other hand, focused on exploring and actualizing e-mail's educational potential for the teaching of writing and composition [1-3, 5-6, 10-11, 16, 25-30].

Though e-mail, as an instructional aid, has been claimed to provide students with greater access to faculty and peers, the impacts of e-mail systems on student attitudes toward the instructor, the class as a whole as well as interpersonal relationships severely fall short of empirical research basis at the present time. Thus, the present study focused on determining the value of e-mail communication in enhancing participant affect and social gains. The major purpose of the present study was to investigate the effectiveness of e-mail, one of the most accessible, convenient, and easy to use computer-mediated communications, on student learning outcomes. By incorporating e-mail into the instructional process, and inviting on-line communications both between and among instructors and students throughout the semester, the researcher expected to observe the differential effect e-mail has on student attitudes toward the instructor, the class and their classmates.

2 Methods

2.1 Participants and learning context

Two classes of students from "Computers in Education" course (N=68) participated in the study. The course was offered in 1999 semester year under a teacher preparation program in a National university in Southern Taiwan. The course was introductory and selective, aiming to strengthen prospect teachers' computer competency. Student self-introduction held at the first class session revealed that most students possessed only fundamental computer skills, had limited exposure to computer-mediated communication, and had not experienced e-mail utilization within class in the past. Additionally, as the course was offered during the Fall semester, most students were new to each other and had not taken the instructor's class before.

The study was conducted in a university computer laboratory with fifty computers designed for individual student learning. A Classroom Broadcast System was installed to network student workstations in the computer lab to further facilitate teaching and learning. During each class session, the instructor would give an overview of today's topics, explain and demonstrate the procedures involved in operating different computer applications and functions, which were interspersed with student hands-on practice. E-mail together with basic operation systems, word-processing, spreadsheet, computer-generated presentation using PowerPoint, and web-surfing techniques were taught by the same instructor in a one-semester two-credit course.

Two performance-type posttests were designed to assess student skills on operation systems, e-mail, word-processing and spreadsheet. A group-based final project of any topics of student choice was used for web-surfing and PowerPoint skills assessment.

2.2 Experimental design and treatment conditions

As most participants from both classes possessed fundamental computer skills and were acquainted to neither each other nor the instructor, a posttest-only experimental design was adopted in the study. To examine the potential effects of incorporating e-mail systems in a classroom setting, two participating classes were randomly assigned to different treatment conditions, namely, the e-mail utilization condition and the traditional condition. Prior to the commencement of the study, students were required to obtain a university e-mail account. A 2-hour class session was designated for e-mail instruction and practice. Procedures for sending, receiving, reading, responding, forwarding, printing, and deleting mails as well as e-mail features like address-book and attachment were explained, demonstrated and practiced in the class.

To examine the effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, all instructional components and procedures were kept essentially the same except the way in which supplementary materials were disseminated to students and student assignments were handed in. In the e-mail utilization condition, instructors send out supplementary materials including weekly course outlines, additional reading materials, announcements, and computer-related news updates (e.g., newest computer virus) via e-mails at least two

days ahead of meeting time. Moreover, students were requested to hand in all their assignments/reports electronically and were encouraged to use it for future correspondence with the instructor, their teammates, and other classmates. As e-mail was treated as a supplementary channel to the class, no compulsory measures were taken to force students to use e-mail except those mentioned. Nevertheless, students were strongly encouraged by the instructor to log in the system at least once a week to check mails and print out any materials they deem useful. As mentioned previously, a group-based project gearing toward integrating Internet resources for any instructional topics of group choice was designed as the second evaluation component of the class, students were encouraged to take advantages of e-mail systems to communicate with their self-chosen teammates along the way. By opening up on-line communications both between and among instructors and students throughout the semester, the cultivation of elevated attitudes toward classmates, the instructor and the class was postulated.

In the traditional group, on the other hand, students would receive essentially the same supplementary materials in class and would hand in assignments directly to instructor, only that they were in hardcopy format. In other words, after the instruction on e-mail systems and functions, the instructor did not intentionally integrate e-mail utilization into the instructional process to further promote computer use. One last thing, performance-type posttests on e-mail ascertained that students in both treatment conditions mastered the skills.

2.3 Measures

A post-session self-report questionnaire administered individually at the last session of the class was used to collect data pertaining to the effects of integrating e-mail on student attitudes and interpersonal relationships. The 9-item "Class Evaluation" developed by the university was used for the measurement of student attitudes toward the instructor and the class as a whole. Sample items included, "the instructor was prepared and the instructional content was appropriate; the instructor was available to discuss academic matters with students both in and out of class and could explain things in a clear fashion; the instructor's attitude toward teaching was diligent, and the instructor was responsible and punctual." The 13-item "Perceptions Toward Teammates Scale," developed by Yu (1996-97), was used to test the hypothesis relevant to student perception toward their teammates [34]. Sample items included, "I am willing to work with my teammates again next time; I liked my teammates." Finally, the 11-item "Perceptions Toward Other Classmates Scale," developed by Yu (1996-97), was included to test the hypothesis relevant to student perceptual impressions of other classmates. Sample items included, "Other classmates helped me greatly with respect to my learning; other classmates were friendly." The internal consistency reliability (coefficient alpha) for student perceptions toward their teammates and other classmates was .92 and .86, respectively.

Each statement on the questionnaire was rated on a five-part discrete scale, with corresponding verbal descriptions ranging from "strongly disagree" through "disagree," "no-opinion/average," "agree," to "strongly agree." Each response received a weight of 1, 2, 3, 4, or 5, respectively. To counteract possible response-set tendencies, both positive and negative statements were included. Scoring on the negative statements was reversed so that negative and positive responses could be summed and averaged with higher scores reflecting more positive attitudes.

3 Results and discussion

Data were analyzed using the analysis of variance technique on student attitudes toward the instructor/class, their own teammates and other classmates. A .05 level of significance was adopted for use in this study. The means and standard deviation (SD) values for each of the dependent variables were listed in Table 1.

Results from t-tests showed significant differences between the two treatment conditions in student attitudes toward the instructor/class, $F(1, 66) = 2.898$, $p < .01$, and student attitudes toward other classmates, $F(1, 66) = 2.033$, $p < .05$. However, data analysis did not show significant differences between the two treatment conditions in student perception toward their own teammates, $F(1, 66) = 1.476$, $p > .05$. The results further showed that subjects in the e-mail utilization condition tended to rate the instructor/class and other classmates more positively than those in the traditional group.

Table 1: Descriptive Statistics of Different Treatment Conditions on Subject Attitudes Toward the Instructor/Class, Their Teammates, and Other Classmates

	Integrating E-mail Group (N=35) M (SD)	Traditional Group (N=33) M (SD)
Attitudes Toward the Instructor/Class	43.3605 (2.8042)	41.0303 (3.7800)
Perception Toward Their Teammates	57.7940 (6.2625)	55.3747 (7.3470)
Perception Toward Other Classmates	45.1944 (5.4867)	42.7273 (4.4880)

Data from after-session debriefings with participating students combined with sample e-mails both sent and received by students supported the idea of integrating e-mail systems into the learning process. While some students did take advantages of e-mail systems to ask academic-related questions (e.g., procedures for a specific application functions not covered in class, deadline for assignments, etc.) and/or send social greetings during holidays, the majority of e-mails transmitted were forwarding mails of variant topics ranging from health-related issues to jokes, novels and updated news in the technology world, etc. Many students pointed out that e-mail's distinct features like forwarding and address-book immensely facilitated interaction and information sharing among classmates and the instructor. Most students developed the habit of logging in the systems to retrieve e-mails along the way. Through increased interactions among the participants via receiving a wide array of articles and useful information forwarded from classmates and the instructor, mutual understanding, acceptance and bonding thus fostered. Thus, it was reasonably why students in e-mail conditions tended to view the instructor as better prepared, easier to locate, and other classmates as friendlier and more helpful.

Though the non-significant results in student attitude toward their own teammates was somewhat surprising at first, a closer look at e-mail use pattern among teammates shed some light onto the issue. E-mail was introduced into the learning environment in an attempt to facilitate group interaction within team-members; however, students in the e-mail treatment group rarely used this channel for online discussion and primarily as a last resort for scheduling purpose with their own teammates. As most group members sat closer to each other during the class and arranged meeting time for final project discussion right after class sessions, they didn't find e-mail especially useful in that aspect. As students did not use the technology for inner group communication except under very extreme situations, the fact that e-mail's integration into the learning environment did not significantly influence subjects' attitudes toward their teammates was understandable.

4 Conclusions

This study focused on examining whether incorporating e-mail into computer literacy classroom settings could positively influence student attitudes and interpersonal relationships. Results indicated that student attitudes toward the instructor/class and other classmates were positively influenced by this approach. The obtained results provided empirical evidence supporting the usefulness of e-mail as an aid for promoting out-of-classroom contacts of various types among faculty members and classmates, which, one way or the other, contributed to more positive attitudes.

Though e-mail might provide students with greater access to faculty and peers and seemed to enrich teacher/student interpersonal relationships in the present study, a word of suggestions for avant-courier was rendered. For e-mail to be effective as an alternative option for further two-way communication between teachers and students, all essential elements must be present. First, the important role "feedback" played during the process. Many students stressed that their willingness to continue having out-of-classroom contacts with instructors via e-mail was determined by the presence of the instructors' response in return. As Zaremba (1997) clearly pointed out "Without feedback, e-mail is likely to be less effective than it potentially could be. The quality of communication may be a function of the timeliness of feedback provided by the recipient." [35]. To create a bond of communication with students via e-mail, timeliness of feedback provided by the recipient would be an important task all participants need to attend to.

Secondly, for electronic communication to take effects, accessibility of essential hardware and software must be in place [22]. Some students mentioned specifically during the interview that limited access to computer hardware and network seriously prevented them from taking a full advantage of e-mail as a unique

communication tool. To ensure ongoing communications among participants electronically, interested implementers cannot ignore measures overcoming equipment and facility shortage.

Finally, opportunities for training and familiarization of the system for all parties would certainly facilitate the integration process. Extra time, care and possibly some incentives may be needed not only to get students accustomed to on-line message exchanges but also to have students appreciate e-mails' advantages especially during initial exchanges. Only when all the essential components as mentioned were in place, many of the potential impacts e-mail could have on the instructional settings like liberation of traditional roles associated with different parties, and humanitarian learning environments for all individuals would thus be actualized.

References

[1] Allen, M., "E-mail in the writing class: Promoting student communication", Paper Presented at the Annual Meeting of the Teachers of English to Speakers of Other Languages, ERIC No. 394 348, (1995).

[2] Bard, D., "Literacy practices in extra-academic conversations: Quilting bees via e-mail", ERIC NO: ED 422569, (1998).

[3] Chen, G. M., "The effect of e-mail debate as a teaching tool: a pilot study", Paper presented at the Annual Convention of Speech Communication Association, New Orleans, Louisiana, November, (1994).

[4] Cohen, M. & Miyake, N., "A worldwide intercultural network: Exploring electronic massaging for instruction", Instructional Science, Vol. 13, pp. 257-273, (1986).

[5] Coogan, D., "Tutoring, a new way to do new work", Computers and Composition,Vol. 2, No. 2, pp. 171-181, (1995).

[6] Dowden, R. & Humphries, S., "Using e-mail in computer assisted freshman composition and rhetoric", T.H.E Journal, Vol. 24, No. 10, pp. 74-75, (1997).

[7] Dreher, H. V., "Telecommunications for Learning", Englewood Cliffs, NJ: Prentice Hall, pp. 44-46, (1991).

[8] D'Souza, P. M., "Electronic mail in academic settings: a multipurpose communication tool", Educational Technology, Vol. 32, No. 3, pp. 22-25, (1992).

[9] Durost, D. D & Hutchinson, S. L., "Keypals--e-mail leads to new friends", Dimensions of Early Childhood, Vol. 25, No. 4, pp.17-22, (1997).

[10] Grosz-Gluckman, V., "A look at the use of electronic mail (e-mail) as a learning tool in the writing skills of adult LEP Female Students", ERIC NO.: 416720, (1997).

[11] Hawisher, G. E. & Selfe, C. L., "The rhetoric of technology and electronic writing class", College Composition and Communication, Vol. 42, pp. 55-65, (1991).

[12] Holliday, L., "Challenging questions about e-mail for language learning", ESL Magazine, Vol. 2, No. 2, pp. 14-15, (1999).

[13] Kroonenberg, N., "Developing communicative and thinking skills via electronic mail", TESOL Journal, Vol. 4, No. 2, pp. 24-27, (1994/1995).

[14] Leh, A. S., "Electronic mail in foreign language learning: communication and culture", Proceedings of Selected Research and Development Presentations at the 1997 National Convention of the Association for Educational Communications and Technology, ERIC No. 409 851, (1997).

[15] Liang, T., "Cooperative learning on the Internet: The intercultural E-mail connection", Proceedings of the Fifth International Symposium on English Teaching, pp. 233-242, The Crane Publishing Co., (1996).

[16] Liaw, M-L., "Communication strategies used by freshman English students in e-mail writing", Proceedings of the Fifth International Symposium on English Teaching, The Crane Publishing Co., pp. 211-222, (1996).

[17] Lunde, K. R., "Using electronic mail as a medium for foreign language study and instruction", CALICO Journal, Vol. 7, pp. 68-78, (1990).

[18] Ma, R., "Computer-mediated conversation as a new dimension of intercultural communication between college students in Taiwan and USA", Paper presented at the International Conference of Chinese Communication Research and Education, Taipei, Taiwan, June, (1993).

[19] Marttunen, M. & Laurinen, L., "Learning of argumentation in face-to-face and e-mail environments", ERIC NO.: 422791, (1996).

[20] Rankin, W., "Increasing the communicative competence of foreign language students through the LF

Internet Video on Demand System of Classroom Teaching Cases

- Building "RAPSODY": An Intelligent Media-Oriented Remote Educational System for Self-Learning Support -

Hisayoshi INOUE and Toshio OKAMOTO
Graduate School of Information Systems
The University of Electro-Communications
1-5-1 Chofugaoka, Chofu-City, Tokyo, 182-8585 JAPAN
TEL: +81-424-43-5623
E-mail: {ino,okamoto}@ai.is.uec.ac.jp

Our study aims to accumulate information for teachers, about established teaching methodologies and techniques. For the purpose of our study, we construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education". In this paper, we describe the details of our video searching system, the design of the database tables, and we show an example of system operation.

Keywords: **Information Education, Teacher Education, Distance Learning, VOD, Rapsody**

1 Introduction

In now-a-days advanced information society, the demands about teachers' competence are high and diverse. Concretely, teachers are required to posses on one hand curriculum development ability, learning environment design ability, group learning, individual learning, simultaneous learning, and on the other hand the previous abilities should be supported by class practice ability, observation and evaluation ability, and last but not least, the ability to connect the textbook's world and the real world. .

It is difficult to raise and form this complex set of abilities, with the help of only the presently available education and training methodology for teachers. Therefore, the necessity emerged [1] to examine the feasibility of a new systematic approach, for supporting the teachers' literacy progress, by building on their natural talents/ and abilities, and expanding these to reach the required width and breadth.

The information technology science is offering the tools for the development of an environment supporting the teachers' endowment progress. The knowledge concerning the teachers' education contents and methods is stored as multimedia information, in the form of pictures, videos and sound tracks. Moreover, by using the network environment, it is possible to make use of all resources over the net, without any constraints or restrictions of time and/or geographical location.

With this goal in mind, we are researching the development of an integrative distance education training system for supporting teachers' self-training, called RAPSODY (Remote and Adaptive System of Oriented Dynamic Teaching/Learning) . Up to now, the availability of video records and guidance plans about lessons was limited to education training centers or universities, etc. The present research intends to make the information on educational activities and practices public, and aims at joint usage and re-usage of teachers' self-learning and self-training methodologies and tools. Concretely, we develop a retrieval system based on dialogue patterns, by using a database of lesson videos.In order to jointly use the information in the distributed environment, or to be able to re-use it, we implemented a Video On Demand (VOD) system. The (teacher) user can control/manage the specification and stop/suspension of

the regeneration point for the distributed VOD.

The main purpose of our research is therefore to propose a distance-learning environment on the Internet, for improving the teachers' practical abilities. In this paper, we describe the video on demand system developed until now, the indexing method of the classroom teaching movie example database, the system's functions and the system's evaluation.

2 The outline of the system

2.1 The structure of the system

Fig. 1 shows the structure of the search system. The system is built of the following three parts:

- Web browser;
- Lesson video example database;
- Video distribution server.

The web browser has the role of the user interface. The search/retrieval mechanism searches the lesson example video database via three types of relational database files.

The video distribution server stores the lesson scenes' videos. The video distribution server performs the VOD function at the users' requests. The search functions performed for the user are of the following two types.

- Keyword Search
- Feature Oriented Search

The Keyword Search (fig. 1,) takes place as explained below.

a-1) The user designates the search conditions.
b-1) The search mechanism compares the search conditions input by the user, with the available class example video database.
c-1) The search mechanism extracts the record(s) matching the searching conditions.
d-1) The result is displayed as the search result.

The Feature Oriented Search process (fig. 1,) is done as shown in the following.

a-2) The system dialogue mechanism enquires about the video characteristics/features desired by the user.
b-2) The user can answer to the system's enquiry vaguely [2].
c-2) The decision making table (showed later on in table 6), obtained from the user, is the basis for the evaluation of the specific search conditions. The gathered search conditions are passed over to the search mechanism of the database.
d-2) The database search mechanism compares the search conditions resulting from the evaluation with the lesson example videos contained in the database.
e-2) This result is displayed as the search result.

The search result is formatted as an URL list that is shown to the user. These URLs perform the function of linking the search result and the actual videos on the VOD server. The (teacher) user chooses the URL that s/he wants to refer (Fig. 1,).When the URL is chosen, the VOD client software, embedded via the Web browser plug-in, starts, and the video playback begins.

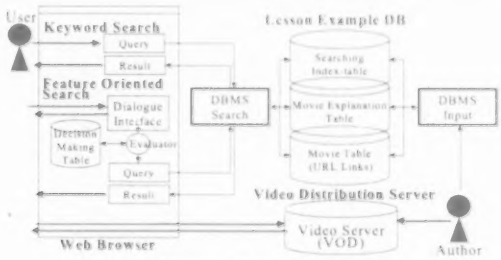


Figure 2 Sstem Organization

3. Database structure

3.1 Lesson (unit) database

The following three relational database files define the video lesson database.

- Searching Index File
- Movie Explanation File
- Movie File

In the following, we will explain in detail each database file type.

3.2 Searching Index File

The Searching Index File results from the comparison of the video database with the search items. The search items are organized in items for the Keyword Search and items for the Feature Oriented Search. In table 1, we show the Searching Index File for the Keyword Search, and in table 2, the Searching Index File for the Feature Oriented Search.

For the Keyword Search, the search conditions are given directly by the user. The Searching Index File slots are "lesson name (unit)", "learning contents (subunit)", "used information equipment/machinery/device(s)", "used tool(s) application(s)" and "class viewpoint".

In the Feature Oriented Search, the system generates the search conditions, based on the information obtained from the user. The Searching Index File (Feature Oriented Search) employs comparison of the extracted search conditions and the database, depending on the dialogue with the user. The slots of the Searching Index File for the Feature Oriented Search mechanism are "teacher activity " and "student activity ".

Table 1 Searching Index File (Keyword Search)

index frame database basic search key

record fields	value type
ID (primary key)	*numerical value type*
lesson name (unit)	*text type (menu selection)*
learning contents (subunit)	*text type (menu selection)*
used information equipment/ machinery/ device(s)	*text type (menu selection)*
used tool(s) application(s)	*text type (menu selection)*
class viewpoint	*text type (menu selection)*

Table 2 Searching Index File (Feature Oriented Search)

index frame database feature search key

record fields	value type
ID (primary key)	*numerical value type*
teacher activity	*text type (menu selection)*
student activity	*text type (menu selection)*

3.3 Movie Explanation File

Table 3 shows the contents of the Movie Explanation File, regarding the movie features. When the user is about to commence the lesson, the points, which need his/her attention, are explained via the contents of the Movie Explanation File. These explanations are used when displaying the search results.

Table 3 movie explanation file

movie feature description video feature information)

record fields	value type
camera angle	*text type (menu selection)*
equipment existence	*text type (menu selection)*
equipment usage	*text type (menu selection)*
number of teachers	*text type (menu selection)*
teachers' movements	*text type (menu selection)*
existence learning supporter(s)	*text type (menu selection)*

number of students	*text type (menu selection)*
students' movements	*text type (menu selection)*
existence of a central student	*text type (menu selection)*

The explanation information in the Movie Explanation File (table 4) resumes the lesson scenes compiled by the video registrants, and the information on how the checkpoints, necessary for the lesson, were estimated. The slot of table 4 called "teacher's aim", corresponds, for instance, to the classification 8 presented later on in table 7.The "checkpoints 1 to 3" express the free description of the image, from the points of view shown below.

Checkpoint 1 the movie preconditions to be considered;
Checkpoint 2 what should be extracted/ understood from the current movie;
Checkpoint 3 the necessary forecast of the movie's following development.

Table explanation file

4 movie
movie explanation database

record fields	value type
ID (primary key)	*numerical value type*
teacher's aim	*text type (menu selection)*
checkpoint 1	*text type (item description · within 100 characters)*
checkpoint 2	*text type (item description · within 100 characters)*
checkpoint 3	*text type (item description · within 100 characters)*

3.4 Movie File

Table 5 shows the Movie File. The Movie File contains pointers to the real videos. The VOD server houses the real videos. Table 5 contains the Movie File slots called "thumbnail picture (still picture)", "previous movie", "movie URL (movie file name)", and "next movie".

Table 5 movie file

movie database

record fields	value type
ID (primary key)	*numerical value type*
thumbnail picture (still picture)	*text type (still movie file name)*
previous movie	*text type (URL type input)*
movie URL (movie file name)	*text type (URL type input)*
next movie	*text type (URL type input)*

For the discrete movie time-series {P(t)}, the following relationship exists:
$[P(t-1),P(t),P(t+1)]$ = [previous movie, movie URL, next movie];$P(t=0)$ ={still picture};where t is the time.

4 The system's behavior

Figure 2 shows the search conditions input interface (for Keyword Search). Figure 3 shows the search result display interface. After the (teacher) user specifies the conditions for the desired video search via the search conditions input interface, the search starts. The result of this is displayed in the search result display interface [3] [4]. This interface shows the value of the slots called " still picture", "lesson contents (subunit)", "teacher's aim", "checkpoints", "teachers' activity" and "students' activity". The "still picture" can be seen in figure 3 (). Next to being a significant snapshot of the lesson video, the still picture has also the role of a pointer to the real video (a link to the VOD video file), so describes the URL (figure 3,). By clicking on the still picture, the video starts (figure 3,). The "teacher's aim" (fig. 3,) and "checkpoints" (fig. 3,) are, as mentioned before, the most important information for image explanation. The figure also presents the (teacher) user with help/support information about other items and record fields.

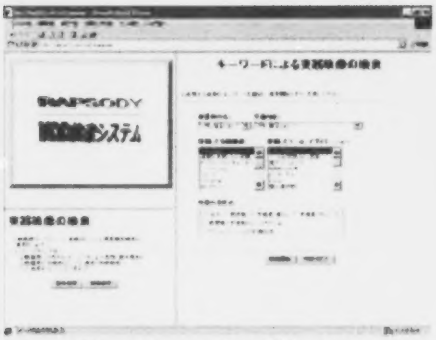


Figure 2 search conditions input picture

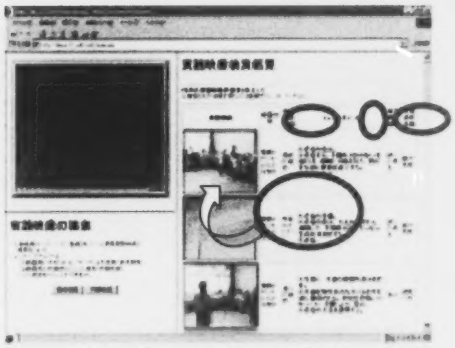


Figure 3 search result display picture

5 Conclusions

We construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education".We have presented in this paper the summary of the video search VOD system we have developed, moreover, we have shown the database organization and the system's behavior.As for the future tasks and research, we are planning to investigate about building a flexible key for the video search mechanism. We are studying at present the dialogue mechanism, with the immediate goal of using the search result's negative feedback information to the user's request, to serve as a new search key.

References

[1] Okamoto, T. (research representative/delegate) : "1998. Advanced Information Society; synthetic research on the contents, system and form of teachers' education – midway report", 1997, 9 year research funds foundation of the Ministry of Education, A)(1)09308004 stage report.

[2] Stain, A, Gulla, J.A, Muller, A. and Thiel, U.: "Conversational Interaction for Semantic Access to Multimedia Information", Intelligent Multimedia Information Retrieval, pp. 399-421, MIT Press, 1997.

[3] Noguchi, H.: "Data representation and management in image databases", IPSJ, Vol.33, No.5, pp. 457-465, 1992

Learner Control in Technology-mediated Learning within a Constructivist Model

Manuela Perez and Jun H. Jo
School of Information Technology
Faculty of Engineering and Information Technology
Griffith University, Gold Coast, QLD, Australia
PMB 50 – Gold Coast Mail Centre
QLD 9726 – Australia
Tel: + 61 7 5594 8266
Fax: + 61 7 5594 8066
E-mail: M.Perez@gu.edu.au and J.Jo@gu.edu.au

This paper explores current strategies on learner control within a technology-mediated learning environment, with a special emphasis on constructivism as the underlying learning theory. An adaptive learning model, based on constructivism is presented. The model addresses the issues of learner control and its implementation within a technology-mediated learning environment. The model's major components: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module are outlined and analysed. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible. We propose a system that is dynamic and merges the capacity to deliver educational material with the ability to analyse learners performance, based on navigational patterns and results, and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

Keywords: **Learner Control, Technology-mediated Learning, Constructivism, Technology-mediated Adaptive Learning Model.**

1 Introduction

Technology has impacted greatly on education. Since the introduction of technology, new delivery methods, as well as new challenges, have emerged. One of the most important delivery methods introduced has been flexible delivery or flexible learning as it is now preferably called. Flexible learning is learning that can be achieved at your own pace and independently of time and place. Several technology-mediated approaches, for example, Web Based Instruction (WBI) and Competency Based Instruction (CBI), have been used to provide the flexibility required to deliver flexible learning.

Technology-mediated learning is versatile. It can be used as the only means to deliver education or as an aid to traditional up-front teaching. Although technology has been embraced by education, there are areas of concern over its use, or more precisely, over its misuse. Areas of concern include: access to the medium, measurement of students learning, testing the validity of the Internet as an instructional medium and the cost of producing technology-based learning materials (Rickard, 1999; Eckert *et al.*, 1997). Selwyn (1996) points out that the Internet can become a trap for both teachers and students as it can go from the '*tool to the toy*' in education if its use is not properly guided and monitored. Phillips (1980) also expresses concern about the quality of on-line materials on the Internet. In spite of these issues the proliferation of courses designed and developed for a technology-mediated environment continues to increase.

This paper explores current trends on technology-mediated learning environments with an especial emphasis on learner control. The paper also proposes an adaptive learning model based on constructivism. The model addresses the issue of learner control and its implementation within a technology-mediated learning environment.

2 Technology and learning control

A technology-mediated environment offers the learner a number of choices and alternatives that were inconceivable in a traditional educational setting. Traditional education, both on-campus and distance learning, is highly structured, teacher centred, mostly one-way communication and directed to passive learners. In contrast, technology-mediated learning, within a constructivist approach, can be learner centred, unstructured to suit the learner's individual learning needs and context-based. It also allows the learner to take control of the learning process, promotes social discourse and collaboration and contributes to the personal growth of the learner.

2.1 Learner Control in Technology-mediated Learning

The definition of *learner control* often appears to be elusive. In its broadest sense, learner control refers to the level of self-determination that the learner has in making decisions about his/her learning (Doherty, 1998). Learner control is often being addressed in combination with other factors. For example, learner control and attitude towards the technology-based system used (Ivanoff and Clarke, 1996; Mitra, 1997) and learner control and epistemic beliefs (Jacobson, *et al.*, 1996). Learner control, within the scope of this paper, refers to the degree of autonomy that learners have in organising, pacing, sequencing and using the available learning resources. That is, the ability and power of adapting the technology-mediated environment to suit their individual specific learning needs. Control over their learning direction and pace is made possible by the many alternatives and choices that a technology-mediated learning system offers the learner (Bagui, 1998). The level of control that the learner needs to exert over the learning environment is not constant over time. Learners will engage in different levels of control depending on their individual learning style (Rasmusen and Davidson-Shivers, 1998), prior knowledge of the material or related material (Fitzgerald and Semrau, 1998), attitude towards information technology (Ivanoff and Clarke, 1996; Mitra, 1997) and past experience, initiative, intellectual and social maturity, metacognitive proficiency, and insights (Ewing *et al.*, 1998).

2.2 The role of the teacher in Technology-mediated Learning

Frank Wydra anticipated a learning environment in which the teacher's role focus changed from delivering instruction to designing the instruction (Wydra, 1980). By the hand of technology we may transform the teacher from the "*sage on stage*" to the "*guide at the side*" (Andrews, 1997). Within a technology-mediated learning environment, the educator's role, far from becoming redundant, metamorphoses into a more challenging and active one. The educator becomes the leader, designer and manager of the learning environment (Doherty, 1998). Other vital functions are initiating the learning process; supporting, encouraging and motivating the learner and mediating between the learner, the technology and the resources (*Ewing et al., 1998*).

The new role of the teacher, in technology-mediated learning, is a very demanding one. *Ewing et al.*, (1998) emphasise the great deal of effort that goes into planning and preparing technology-mediated learning materials and environments. The design and development of multimedia teaching material, especially for distance education, is a time-consuming process. For one hour of CBT software approximately 200 hours of development time are required (Kawalek, 1995). The educator's role does not stop after the planning, designing and preparation of the technology-based materials. It must also facilitate the learning, monitor learners' progress and evaluate the performance of the system, the learners' and his/her own in order to further improve the system. "*The need for the teacher does not go away*" in a technology-mediated environment with emphasis on learner control (Andrews, 1997).

3 Constructivism

The introduction of technology-mediated learning has called for a revision of learning strategies.

Constructivism is gaining momentum and has been heralded as the most appropriate learning theory for the technological classroom. Constructivism was introduced by Piaget's and Vygotsky's learning theories. Piaget's learning theory involves two cognitive stages: assimilation and accommodation (West *et al.*, 1991). During the assimilation stage the learner attempts to fit the environment with existing mental schemata. The accommodation stage is reached when the learner is confronted with a new experience, for which no schemata exists, or one exists but does not conform to the new experience. As a result, equilibrium occurs when, through an alternate process of assimilation and accommodation, the learner achieves cognitive stability. Externally in-coming experiences find a corresponding mental schemata and the learner is aware of this fact. In order to achieve high-level cognition the learner must be aware that learning has indeed occurred. Otherwise, learning will stop at the behaviourist level where it is ascertained by an external party, usually the teacher, or in the case of a technology-mediated environment by a computer program.

Vygotsky's learning theory differs from Piaget's in that he sees learning taking place within a social and cultural context. He argues that social interaction affects the way the learner sees the world. That is, it contributes to the way the learner constructs his/her schemata. Therefore, the quality of the learning will be determined by the quality of the social interactions or what Vygotsky terms *zone of proximal development* (Oliver, *et al.*, 1997).

In a learning environment the cultural and social interactions translate to interactions between teachers and peers. Within this collaborative learning environment the teacher becomes the facilitator of learning. The facilitator's role should be to design, promote and guide the learning but not to enforce it as learning is an individual process. Knowledge in this environment is socially constructed and has no absolute value but a socially agreed value.

4 The proposed learning model

The aim of the proposed model is to offer an adaptive learning system that caters for different types of learners and learning styles with an especial emphasis on learner control. The proposed model operates within a constructivist approach to learning (Ewing, *et al.*,) based on the following points:

1. **All learners are different**
2. **Learning is individual to each learner**
3. **A learner can learn at different speed levels in different situations**
4. **A learner can engage in different learning strategies simultaneously**
5. **Learners learn best with a context**
6. **Learners construct and re-construct knowledge as they seek to understand and explain their environment**

4.1 Proposed model learning variables and controls

The concepts of learner individuality and learner control are essential to constructivism. Table 1 below depicts the main variables involved in the proposed model in relation to learning control and learners' choices and options.

VARIABLES	CONTROLS	
	INSTRUCTOR	LEARNER
Learning Objectives	Overall	
Amount of information provided	Overall	
Amount of information used **Addition/removal of material**		Desirable
Material appearance and mode		Desirable
Pacing, time	(When necessary)	Desirable
Sequencing	(When necessary)	Desirable
Place, location		Desirable
Monitoring learners' individual progress	Overall	
Interaction and collaboration	Shared	Shared
Assessment	Overall	

Table 1. Control Variables and Controllers

The term ***desirable***, rather than ***overall***, is used in the learner control column because the proposed model's aim is to empower learners not to force them to take control. For example, a learner that possesses prior knowledge of a topic is more likely to exercise control over his/her learning than a novice learner is. The second is more likely to follow a linear approach to learning until he/she too acquires prior knowledge.

Learning objectives

Learning objectives within the model are explicit, clearly specified and achievable. The acquisition of non-anticipated learning objectives is possible within the system, especially, when the learner accesses more information that is required to complete a task. This is a positive feature of the model as far as the specified learning objectives have been reached.

Amount of information provided and used

The system contains all the information necessary to achieve the specified learning objectives or provides references to acquire it. However, the learner controls the amount of information that is actually used. A learner can discard a particular learning material piece in favour of another, which has been acquired from external sources, just because is easier to understand or is visually more appealing. Learners' performance can be improved by designing materials that can be adapted to satisfy different learning styles (Rasmussen and Davidson-Shivers, 1998).

Learning material appearance and mode

A genuinely adaptive technology-mediated learning system must allow learners to customise the appearance and mode of the material displayed. This may include: changing background and text colours and choosing between text, graphics, audio and video modes.

Pacing and timing

The learner has the autonomy of pacing his/her learning and scheduling his/her study time. However, in some instances this has to fit within the general time-frame allocated to the course or subject. The designer controls the general time-frame, if one exists.

Sequencing

Learning materials must be accessed in the order that most benefits the learners' learning style. The model is able to cope with the demands of linear as well as non-linear approaches to learning. Figure 1 displays an example of the progression or navigation path of a learner who prefers to be guided by the system. '*Learner 1*' uses all the material provided and in the order provided until she encounters difficulties and seeks the help of an instructor or other learners. Then, revises the previous lesson and again continues with the linear path provided. In contrast, '*Learner 2*' feels confident enough to discard material provided and adds material from external sources. Both learners achieve the corresponding learning objectives through the use of different learning strategies. Beginners often benefit from having a structured learning path (Eaton, 1996). A graphical representation or map of the entire unit or lesson must be made available to the learners to guide their navigation decisions (Barba, 1993).

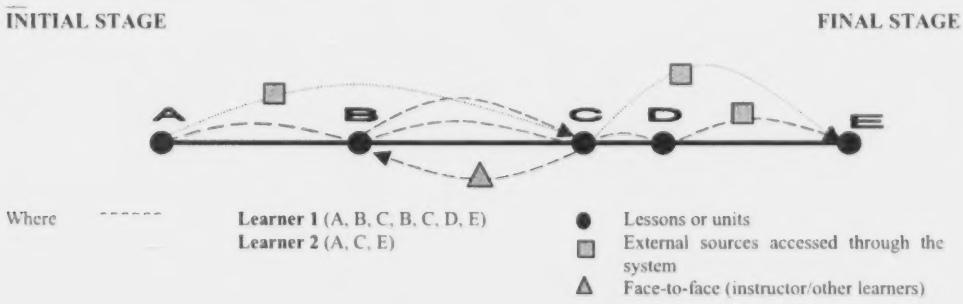


Figure 1. Learning Sequence Patterns – Linear and Non-linear

Learners must be free to use forward and backward navigation through the system as long as it does not compromise the learning itself. For example, if the completion of a task is the pre-requisite for another,

allowing the learner to move onto a task for which a pre-requisite has not been completed might result in a waste of time and unnecessary added frustration for the learner. For example, moving into algebra without knowing how to multiply.

Place and location
Technology-mediated learning offers the possibility of accessing and using learning materials at different locations. Using the proposed model, learners can now study at home, at appropriately equipped learning centres or at traditional classrooms.

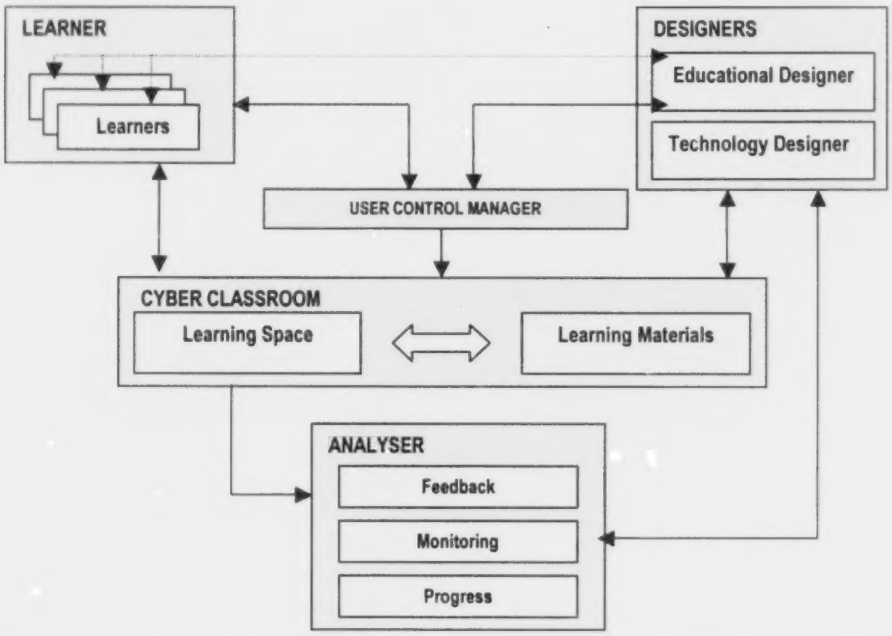
Monitoring learners' individual progress
Instructors are in control of monitoring the learners' individual progress. Based on the analysis of the learners' performance instructors can either guide or advise the learners through different strategies or modify the system.

Interaction and collaboration
The system must provide the capabilities to allow learners to interact with each other and with their instructors. This communication may occur, for example, through e-mail, and on-line forums. Physical, or face-to-face, communication is also a part of the model.

Assessment
Assessment is designed and administered by the instructor. This is to evaluate the students' learning performance and to provide feedback both to the educator and to the students.

4.2 Technology-mediated Adaptive Learning Model

The proposed model, the Technology-mediated Adaptive Learning (TAL) model, is composed of five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and Analyser module, Figure 2.



Where → Technology-mediated communication (web browsing, down/uploading, email, forum, database updates, ...)
⇢ Physical communication

Figure 2. The Technology-mediated Adaptive Learning (TAL) Model

4.2.1 Learner Module

The learner module comprises the learner group. Learners interact with the TAL system through the Learning Space. Communication with instructors and other learners occurs within the Learning Space or physically, as indicated by the dotted line in Figure 2.

4.2.2 Designers Module

The designers' module can be composed of an educator, instructional designer, multimedia designer and technicians. This module is concerned with three main areas: the educational design, multimedia design, and computer and Internet technology. The educational designer is in charge of designing quality learning materials within a constructivist approach. This includes being aware of the subject matter as well as the pedagogical theory in use. The multimedia designer and the instructional designer help the educator to appropriately formulate the teaching materials for CBI or WBI. The technology designer provides the means to make the learning materials available to the learner group through a technology-mediated environment. Good skills and tools for multimedia authoring and technical services are required in this module, which may cause production cost issues.

4.2.3 User Control Manager Module

The User Control Manager allows the learner to customise the learning space. Through this module the learner can select the display mode to suit his/her own learning needs and preferences, for example, text, graphics, audio or video mode. Pacing and sequencing of the learning material can also be controlled from this module.

4.2.4 Cyber Classroom Module

The Cyber Classroom module is composed of two sub-modules: Learning Space and Learning Materials module. The Learning Space is where the learning is delivered. This is generally a kind of display unit, such as a personal computer or a network terminal screen. It may also include equipment for sound and video. It must be easy to interact with and be self-explanatory. Within the Learning Space the learner has the option of accessing learning materials provided by the educator, such as lecture notes, or external resources such as Internet sites or libraries

4.2.5 Analyser Module

The purpose of the analyser module is three-fold. First, it gathers statistics on the performance and progress of learners. Second, it records learners' perceptions about the learning material presented and about the overall working of the system (learner feedback). Finally, it monitors and records students' navigation patterns into a database. These will provide an indication of the learners' preferred learning styles. This information can be used to provide advice for the learner and to improve the system (Chavero *et al.*, 1998) by evaluating the existing materials and options and formulating new ones. The optimal implementation of the system will be to incorporate an Intelligence module to automatically generate and administer changes, based on the information within the database.

The TAL model is being implemented in a couple of different programming languages and database tools.

5 Reviewing learner control, constructivism and the TAL model

5.1 The TAL Model and Learner Control

The main objective of the model is to provide a technology-mediated learning system able to support learner control within a constructivist approach. The learner control variables, identified in Table 1, have been built into the model. Learning objectives, amount of information provided, monitoring of learners individual progress and assessment are overall controlled by the instructor, while the amount of information used/added/removed, material appearance and mode, pacing, timing, sequencing, place and location are potentially controlled by the learners. Interaction and collaboration can be initiated by either party as the need arises.

5.2 The TAL model and Constructivism

The underlying pedagogical theory governing the TAL model is based on constructivism, and specifically on the constructivist elements represented in the table below. The model addresses all elements, however, its concrete effectiveness will only be determined after development and implementation, in practice.

TAL Constructivist Approach Checklist	
EXPECTED CONSTRUCTIVIST ELEMENTS	**TAL MODEL**
• All learners are different	The model allows for learner differences in needs, learning styles, and skills.
• Learning is individual to each learner	Learners can customise the learning materials to suit their learning styles and needs through the User Control Module.
• A learner can learn at different speed levels in different situations	Learners can control pacing and sequencing of learning materials.
• A learner can engage in different learning strategies simultaneously	Learners can engage in linear and non-linear strategies. Also they can learn independently and/or seek collaboration.
• Learners learn best within a context.	Learning materials (provided by the TAL model) are always presented within a context.
• Learners construct and re-construct knowledge as they seek to understand and explain their environments	This feature is intended within the model but only after implementation will it be ascertained.

Table 2. TAL Constructivist Approach Checklist

6 Conclusion

This paper has addressed current educational trends on learner control within technology-mediated learning environments. The roles of the learner and the teacher have been reviewed and analysed in the light of technology-mediated environments.

The TAL model, based on constructivism, was presented, and its major functions were explained. The model includes five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model presented, empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible.

From the designers point of view the model is a dynamic system that merges the capacity to deliver educational material with the ability to analyse learners performance (based on navigational patters and results) and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

References

[1] Andrews, E.A., A non-euclidean view of teaching, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[2] Bagui, S., Reasons for increased learning using multimedia, *Journal of Educational Multimedia and Hypermedia*, **7**(1), 3-18, (1998).

[3] Barba, R.H., The effects of embedding an instructional map in hypermedia courseware, *Journal of Research in Computing and Education*. **25** (4), 405-412, (1993).

[4] Chavero, J., Carrasco, J., Rossell M.A. and Vega, J.M., A graphical tool for analysing navigation through educational hypermedia, *Journal of Educational Multimedia and Hypermedia*. **7**(1), 33-49, (1998) .

[5] Doherty, P.B., Learner control in asynchronous learning environments, *ALN Magazine*, **2**(2), (1998). URL:http://www.aln.org/alnweb/magazine/vol2_issue2/doherty.htm.

[6] Eaton. M., Interactive features for HTML-based tutorials in distance learning programs, *AusWeb96*, (1996). URL:http://elmo.scu.edu.au/sponsored/ausweb96/educn/eaton/paper.html

[7] Eckert, A., Geyer, W. and Effeldberg, W., A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[8] Ewing, J.M., Dowling, J.D. and Coutts, N., Learning using the World Wide Web: A collaborative learning event, *Journal of Educational Hypermedia*, **8**(1), 3-22, (1998).

[9] Fitzgerald, G.E. and Semrau, L.P., The effects of learner differences on usage patterns and learning outcomes with hypermedia case studies, *Journal of Educational Multimedia and Hypermedia*, **7**(1), (1998).

[10] Ivanoff, G. and Clarke, J., The use of the world wide web for teaching: things to consider before putting materials on-line, *Australian Communication Conference: Teaching Communications Skills in a Technological Era*, Monash University, Australia, (1996).

[11] Jaconson, M.J., Maouri, C., Mishra, P. and Kolar, C., Learning with hypertext learning environments: theory, design and research, *Journal of Educational Multimedia and Hypermedia*, 5(3/4), 239-281, (1996).

[12] Kawalek, J., in (Eckert, A., Geyer, W. and Effeldberg, W. (1997). A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada), (1995).

[13] Mitra, A., Categories of computer use and their relation with attitude toward computers, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Alberta, Canada, June, (1997).

[14] Oliver, R. and Omari, A. and Herrington, J., Exploring student interactions in collaborative world wide web learning environments, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[15] Phillips, R., What research says about learning on the Internet, *in* C. McBeath, C. McCoughlin and R. Atkinson (*eds.*), *Planning for Progress, Partnership and Profit, Proceedings EdTech '98*, Australian Society for Educational Technology, Perth, (1998).
URL:*http://cleo.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/p/phillips.html.*

[16] Rasmusen, K.L. and Davidson-Shivers, G.V., Hypermedia and learning styles: can performance be influenced? *Journal of Educational Multimedia and Hypermedia*, 7(4), 291-308, (199[illegible]

[17] Rickard, W., Technology, education, and the changing nature of resistance, *EDUCAUSE, Educom Review*, Vol. 34 (1), 42-45, USA, (1999).

[18] Selwyn, N., The Internet and schools: An uneasy alliance? *Compute-Ed*, Vol 4, (1998).
URL: *http://www.edication.uts.edu.au/projects/comped/Vol4/selwyn.html.*

[19] West, C. K., Farmer, J.A. and Wolff, P.M., Introduction to Cognitive Science and instructional design, *Instructional design: implications from a Cognitive Science*, pp.3-27, Allyn and Bacon, Sydney, (1991).

[20] Wydra, F.T., Learner controlled instruction, *Englewood Cliffs, Educational Technology Publications*, New Jersey, (1980).

Learning algorithm design through interactive simulation

Hoi-kau Yuen
Department of Curriculum Studies
The University of Hong Kong
Pokfulam Road, Hong Kong SAR, China
Fax: +(852) 2858 5649
Tel: +(852) 2859 2540
Email: hkyuen@hkucc.hku.hk

The teaching of algorithm design is a subject of great difficulty, however, its value has not been addressed in the curriculum of computer studies in secondary schools. The aim of this paper is twofold: to describe the method and design principles of developing the Traffic Light System Simulator (TLSS) and to discuss a learning example of using TLSS. The TLSS is a learner-centred simulation tool for learning algorithm design. It provides a daily life problem in a learning environment. In solving the problem, students are encouraged to think and construct their own possible solutions. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

Keywords: **programming, algorithm, simulation, learner-centred**

1 Introduction

"Algorithmics is the spirit of computing" advocated by Harel [4]. Computer programming mainly consists of three activities - problems identification, analysis; algorithm design to tackle problems; and algorithm representation in a computer coded language [16]. Algorithm is usually defined as a method, procedure, recipe or step-by-step process for doing a job, or a finite sequence of unambiguous, executable steps that will ultimately terminate if followed, in which "unambiguous" means at each step the action to be performed next must be uniquely determined by the instruction and the data available at that time. Yet algorithm design is usually more challenging and problems-bounded as it involves solving continuous problems during execution [16]. To design an algorithm is to find a step-by-step procedure for locating a clue for errors [5]. This design activity entails an exceedingly diverse activity and involves complex cognitive processes. Difficulties in discovering algorithms are prevalent in the learning of computer programming.

The teaching of algorithm design is a subject of great difficulty, its value, however, has not been addressed in the curriculum of computer studies in secondary schools. Algorithm design has been revealed as an activity that demands abstraction, analysis, and synthesis abilities from students [3]. Therefore, the learning of algorithm design contributes not only to the teaching of computer programming, but also the cognitive development of students [17]. This paper attempts to address the importance of algorithm design in computer programming by examining the development of the Traffic Light System Simulator (TLSS), a learner-centred simulation program for learning algorithm design.

The TLSS, comprising simulation, animation, sound, text, graphics and video, aims to stimulate learners' interaction and initiative by simulating the actual algorithm design activities in learning process. As the word "interaction" indicates n its compounded use with multimedia. Interactive multimedia enables learners' communications, exchanges and involvement. Effective use of interactive multimedia enhances learning motivation and retention. Multimedia also provides an authentic environment which is relevant to daily life. The aim of this paper is twofold: to describe the method and design principles of the TLSS development and to discuss a learning example of using TLSS.

2 The Development of TLSS

In the development of the TLSS, the prototyping paradigm was adopted. Prototyping is a process allowing the developer to create a model of software that will be completed in the future. Like all approaches in software development, prototyping begins with requirements gathering [12]. However, Marques i Gralles [8] opines that the "development of an educational program always begins with an initial idea which seems to have the potential for enhancing particular teaching and learning processes". In other words, the development of TLSS, backed by Marques i Gralles' initial concept, has been supported by basic principles. The present model's principles are to apply the learner-centred approach as well as to nest with the understanding of teaching and learning algorithm design in secondary schools [18]. Grounded theory [3], which is a methodology for the systematic generation of conceptual models from qualitative data, was used to collect and analyse information from the interviews of teachers and students [20] during requirements analysis.

The label "grounded theory" means "the discovery of theory from data" [3]. Grounded theory is an approach of the handling of qualitative data and of the formulation of theoretical propositions in social sciences, and this methodology has been used successfully for conceptual analysis in a number of information system development projects [11].

Strauss [15] presents a "concept-indicator model" to direct the conceptual coding of a set of empirical indicators. It is a possible operation of concept formation from qualitative data. Indicators are labels for actual data, such as behavioral actions and events, observed or described in documents and in the words of interviewees or informants. By constant comparison of indicators to indicators and their related data or documents, the researcher is forced into confronting differences, and degrees of consistency of meaning among indicators. This generates an underlying uniformity, which in turn results in coded categories, coded relations, definitions and properties of categories and relations, and theoretical concepts.

In order to develop a system "grounded" from the teaching and learning of teachers and students, twelve teachers and ten students from various schools were interviewed. The following issues were addressed in the interviews: (1) to identify the difficulties of teaching and learning of algorithm design in secondary schools, (2) to examine the needs, skills, and interests of students in the learning of algorithm design, and (3) to identify a series of problems conducive for learners' further exploration and motivation. Data were analysed using the constant comparative method in grounded theory.

The following is a brief summary of some major findings supporting the TLSS development: (1) algorithm design is too abstract to some students, (2) students are lack of logical thinking skills, (3) some teachers think that learning algorithm design is very important, (4) some teachers think that algorithm design can be learned naturally, (5) students' existing mental model is an important factor of learning algorithm design, (6) most students cannot decompose problem into sub-problems, (7) there is a lack of teaching material in algorithm design, and (8) the curriculum is not related to daily life.

The results also reveal that teachers use either teacher-dominated method or subject-centred method. Teachers with teacher-dominated method "are serving the immediate needs of the dependent, authority centred, linear thinking students" [9]. Teachers in this case direct students' learning through a straightforward lecture of textbook and presentation. Teachers who teach with subject-centred method "are providing more information and use a greater variety of presentation method" [9]. The responsibility for learning is on students, while the teacher primarily provides opportunities for learning to take place. Most teachers adopt this subject-centred method. They teach with metaphors, examples, pictures or games. Apart from textbooks, they also prepare notes, laboratory sheets, and supplementary exercises as teaching materials.

The discovery method of instruction for teaching computer programming is one of the major focuses in educational computing research [14], and discovery learning occurs when a learner is motivated to act and allowed to formulate and test questions or answers [7]. A number of studies suggest to connect computer programming with logic, truth tables, switching circuits, gating symbols, flow charts, pseudocode and visual simulation enhance the teaching and learning of computer programming in secondary schools [1]. Other studies indicate that algorithm animation seems to be a useful tool for teaching algorithm [6].

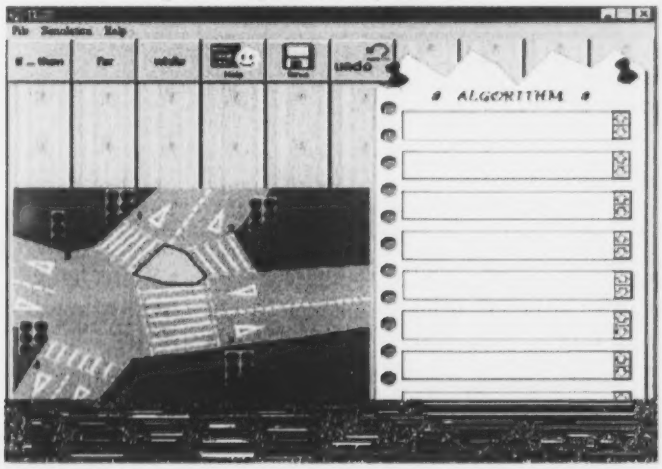
Further to these observations, this paper focuses on the learner-centred approach which facilitates active, multi-functional, inspirational, and situated educational experiences. The basic principles of learner-centred

approach can be summarised as: (1) problem-driven rather than structured analysis of the curriculum content; (2) attending to learners' needs, skills and interests; and (3) learning on a constructivist approach.

3 The TLSS Simulation

The TLSS embraces two distinct features. First, the system provides students with an authentic multimedia context that will motivate students to learn and explore [19]. The system allows continuous feedback and challenge to stimulate students to decompose the challenge, thus keeping students continue learning activities [13]. Second, students might benefit from actively constructing the algorithm than passively watching the algorithm. The system supplies a visualised simulation and an animated environment which students are actively immerse in creating, exploring, testing, and understanding their implemented algorithms.

Figure 1: "Algorithm" components of TLSS

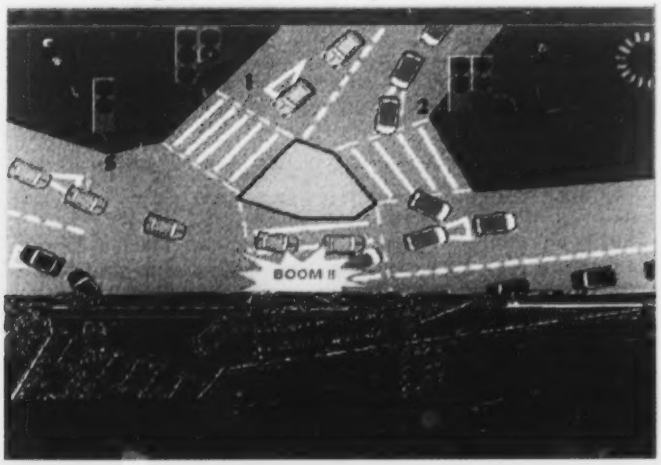


The TLSS provides a dynamic model of a traffic light system with simulated roads, traffic lights, vehicles, pedestrians and various traffic situations. It allows students to present and test their algorithm of controlling a traffic light system in animation. The system also represents students' algorithm in Pascal programming language to reinforce programming language learning.

The TLSS consists of two major components namely, "algorithm" and "simulation". In the "algorithm" component, users are asked to design an algorithm using "while", "for" and "if-then" to control five sets of traffic lights at a junction (Figure 1). Students are expected to begin by simple guided situations on resolving two traffic lights. Each "if-then" will be contained in statement 1 and 2 of a set of algorithm design. Implanting "if-then" statements may be relatively simple and direct for most students. Other components, "for" and "while", targeted at coupling the algorithm with variables and validity, complicates the activity. From the outset of the compilation, students will be given no explanation of the set, "if-then", "for/while", but be guided on a step-by-step traffic light simulated situations to generate in them understanding of the syntax. Students will use each set of algorithm, represented as statements ensuring the smooth running of traffic lights, to assign the colour of traffic lights and its time span. Incorrect input of algorithm or a change of the idea can be rectified by pushing the "undo" button. The "save" button enables students to retain their exercises. After compiling the algorithm, students can proceed to the "simulation" component by pushing the simulated button for execution of their design. Evolved will be an animated environment. Since the aim of the designed algorithm is to ensure the safety of pedestrians and vehicles, correctly compiled algorithm yields smooth running of traffic while incorrect algorithm gives rise to accidents. Accidents are categorised into car crash and car bumping into pedestrians. Figure 2 is a graphical presentation of a car accident in the simulation.

BEST COPY AVAILABLE

Figure 2: "Simulation" components of TLSS



If an accident occurs, users may return to the "algorithm" component to re-compile another possible algorithm and test it again. The activity allows students unlimited trials of designs and implementation. Because solutions to every situations are totally dependent on the success of the algorithm design, students' problems solving, engagement in critical thinking to reach for the success stage are crusts of the TLSS.

4 Shirley: A Learning Example

A preliminary version of the TLSS has been developed, and a group of secondary 5 students (Grade 11) with average academic ability were asked to use the TLSS for learning algorithm design and computer programming. The process of using the TLSS was observed. Because of the volume of data generated, the case of only one student, Shirley, was reported and discussed in this paper.

A sequential activity comprising a series of exercises to guide students to the final operation of all five lights is assigned (see Appendix). Each student, engrossing in the learner-centred approach, will freely discover problems and solutions on their own. Also, as featured in the approach, questions will dominate the exercise so that students can actively engross in the revelation of questions. Students are encouraged to try out patterns so as to simulate the "debugging" process of programming environment. Emphasis of the exercise will not only be the success of compilation, but on the process of compilation. The process of compiling a simulated TLSS demonstrates ways of how students can plan, debug and execute a computer programme.

Shirley, who has completed one-year programming learning practice in her secondary 4 (Grade 10) studies, started the activity by following the assignment instruction. She operated the TLSS and set the simulation off by pushing the button at the very first instance. By observing the simulated junction, Shirley tried to locate directions for the movement of cars and the operating sequence of traffic lights but of no avail. Shirley found that all traffic lights, cars and pedestrians were not working and in stand-by mode. Simulation could not be executed because algorithm was not compiled.

Having finished observation, Shirley returned to the menu and tried to familiarise herself with the available syntax of the simulation. She tried put the "If..Then" onto one of the boxes and observed the pattern of its appearance. The representation of "If..Then" as conditions to be fulfilled was acknowledged. Double-clicking the "statement 1" box, Shirley realised it was the first condition for the first part of the algorithm and the "statement 2" box was ignored. Returning to the assignment instruction, Shirley began to work on how she could survive for 20 seconds if lights 1 and 2 were simultaneously working. Without a second thought, Shirley inserted "red" and "20 seconds" for light 1 and the same for light 2. Two "If..Then" statements appeared after hitting the "OK" button. A simulated environment was followed where all pedestrians crossed the road at ease. Some pedestrians were standing on the traffic island. Shirley considered that it was due to some pedestrians were heading to light 3 area so they kept waiting on the island. The assignment question on the difference of the situation between the reality and the simulated

environment also reinforced Shirley's belief that some pedestrians were on different directions. Shirley failed to recognise the time of traffic light was determinant in affecting pedestrians' continuation of crossing the road. That misunderstanding gave rise to recurrent traffic accidents in other activities which required much longer time.

Having triumphed on the first part of the exercise, Shirley tried to make a car crash as required. For convenience, Shirley followed instructions strictly. She produced "light 2" as "red" for "20 seconds" and "light 5", "red", "20 seconds". A first car crash was experienced. It was too quick a crash and Shirley missed out the sequence, details and picture. Shirley could not answer the first question of how long it took for the first collision. Shirley decided to study and read carefully questions provided by instructions before finding out solutions. By returning again two times to the simulation, Shirley concluded that the crash took place after 8 seconds of execution. In order to remove the accident, Shirley had to find out a workable algorithm. Shirley tried to visualise the traffic pattern in her mind but was not successful. She then realised it was because the most important element of vehicles direction was not recorded. Pens and paper were ready before Shirley returned to the simulation again. She then looked for patterns of the traffic and pictured it onto the paper. She devised that light 2 should stay red long enough to allow light 5 cars to run. Although unsure about the result, she kept light 5 as red for 20 seconds and light 2, red, 40 seconds. The result was successful and Shirley proceeded to the third part of the exercise.

The third activity requested Shirley to run the car more than once. Suggestions on using "For" button was put forward. On devising "for i = 1 to n", Shirley did not understand the function of "n". No hints were given. She did not know where to put the "for" trunk at the infant stage. After several unsuccessful hits of trying to make the equation (e.g. "i" equals "10" and "n" equals "9"), Shirley took an hour break. Shirley returned and read carefully the instruction again. She decided to insert "for i = 1 to 5" and retained the previous lights 2 and 5. A first success was experienced. She concluded that "if" functioned as an executable command while "for" predicted the number of execution of the "if" command.

The fourth activity demanded Shirley to keep cars running forever. Shirley did not understand what was meant by the "for-loop" inside the "while-loop" as delineated in the activity. She tried to put the "If..Then" statements first, and then the "while-loop", the "for-loop". Consecutive errors led Shirley back to study questions carefully again. She devised the sequence of the "for-loop", the "while-loop" and the "If. Then" statements. Working out the sequence, Shirley realised that the "while" statement should always remain "True" because it kept the "If..Then" to continue for "n" times. The "If" just started the programme and "while" was a continuation command.

The fifth activity asked why car accidents occurred. The activity required Light 3 as red for 10 seconds while light 4, green 14 seconds. An alternative could be light 5 as green for 16 seconds. Shirley selected the first combination (light 3 as red for 10 seconds and light 4 as green 15 seconds) but a car accident occurred. After trying out a couple of combinations, Shirley shifted to the diagram she drew before. She worked out the flow of cars, wrote down seconds next to each light. She went back to four previous activities to devise solutions. She attended to her negligence of the importance of time element in activity 1. She finally could not contribute colours and time to lights as she could not work out the transition time of lights passing through red to green. Shirley believed there should be intermission for red-yellow and yellow lights. She recorded every combination and observed its execution. Shirley then tried to perform a monitor system by checking the time for accidents taking place like the guidance referred by activity 2. After almost 20 combinations, Shirley referred back to the question and decided to remove the "for-loop" and the "while-loop". No traffic accident occurred because there was no repetition of car flow. Shirley, however, was not satisfied with the result because reality traffic required continuous flow of cars. She tried to learn from experience in activity 2 that one light's stopping time should be longer than the other's flowing time. After almost 30 trial and errors, Shirley reached the conclusion that emphasis should be on the transition lights. Finally, Shirley gave up algorithms without reaching successful traits. The last activity requested the smooth running of cars by operating all traffic lights. Shirley did not proceed to this stage and the assignment was handed in.

5 Discussion

In the observation, we found that students using the TLSS were encouraged to participate in the thinking process of designing algorithm, such as imaging a goal, formulating a goal, inventing a product, finding alternatives, choosing the solution, generating more alternatives, making choice and evaluating choice,

which are essential elements in algorithm design [5]. In contrast with the teacher-dominated and subject-centred method, the learner-centred approach is based on the idea that "people learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand" [10]. In learning with the TLSS, students are involved in active exploration, problems solving and construction rather than passive teacher-directed lecturing. Such learner-centred simulation tool also generates in learners a long-term pursuit of examining the subject which leads to lifelong learning. Further exploration enhances creativity and critical thinking. However, some students, in particular the case of Shirley, revealed that teacher's guidance is also crucial to make such active learning successful.

The design of the TLSS is based on the learner-centred principles as well as grounded from the experiences of teachers and students. The primary goal of the TLSS is to provide a daily life problem in a simulation environment. In solving the problem, students are encouraged to think and construct their own possible solutions. Simulation, by definition, is not real. Most simulations are artificial systems that can in no way come close to the real situation in complexity and variety. In TLSS, the operation of the traffic lights is certainly different from real life. Thus, students must always be alert for the limitation of simulation. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

References

[1] Brown, D.W., Giving Students a Logical Step Up, *Computer Science Education*, 5(2), 12-17, (1990).

[2] Glaser, B. and Strauss, A., *The Discovery of Grounded Theory*, Chicago: Aldine, (1967).

[3] Guimaraes, M.A.M. & de Lucena, C.J.P., A System Environment for Teaching Introductory Algorithms, *SIGCUE OUTLOOK*, 23(3), ACM Press, 2-11, (1995).

[4] Harel, D., Algorithms: The Spirit of Computing, 2nd Ed., Addison-Wesley, (1992).

[5] Jonassen, D.H., *Computers in the Classroom*, NJ: Prentice-Hall, (1996).

[6] Kann, C. et al., Integrating Algorithm Animation into a Learning Environment, *Computers Education*, 28(4), 223-228, (1997).

[7] Keegan, M. (1995), *Scenario educational software : design and development of discovery learning*, NJ: Educational Tech. Pub., p. 67-75

[8] Marques i Graells, P., Designing Educational Software for Pupils in the 12-16 Age Group: What to Product and How?, *Educational Media International*, 30(3), 138-42, (1993).

[9] McBeath, R., Facilitating Transitions in Learning and Teaching, *Improving University Teaching: Twentieth International Conference*, 10-13 July 1995, Hong Kong, 420-428, (1995).

[10] Norman, D.A. and Spohrer, J.C., Learner-Centered Education, *Communication of ACM*, 39(4), 24-27, (1996).

[11] Pidgeon, N.F. et al., The Use of Grounded Theory for Conceptual Analysis in Knowledge Bicitation, *International Journal of Man-Machine Studies*, 35, 151-173, (1991).

[12] Pressman, R.S., *Software Engineering*, McGraw-Hill, (1992).

[13] Schank, R.C. & Kass, A., Goal-Based Scenario for Higher School Students, *Communication of ACM*, 39(4), 28-29, (1996).

[14] Seidman, R.H., New Directions in Educational Computing Research, in R.E. Mayer (Ed.) *Teaching and Learning Computing Programming*, NJ: LEA Publishers, (1988).

[15] Strauss, A., Qualitative Analysis for Social Scientists, Cambridge: Cambridge University Press, (1987).

[16] Thomas, R. A. & Upah, S.C. Jr., Give Programming Instruction a Chance, *Journal of Research on Computing in Education*, 29(1), 96-107, (1996).

[17] Van Merrienboer, J., Instructional Strategies for Teaching Computer Programming: Interaction with the Cognitive Style Reflection-Impulsivity, *Journal of Research on Computing in Education*, 23(1), 45-53, (1990).

[18] Whiteside, M. & Whiteside, J., The successful multimedia development team - expertise and interaction, in J. Keyes (Ed.) *The McGraw-Hill Multimedia Handbook*, NY: McGraw-Hill, (1990).

[19] Woolf, B., Intelligent Multimedia Tutoring Systems, *Communications of the ACM*, 39(4), 30-31, (1996).

[20] Yuen, H. K. and Richards, T. J., Knowledge Representation for Grounded Theory Construction in Qualitative Data Analysis, *Journal of Mathematical Sociology*, 19(4), pp. 279-298, (1994).

Appendix: Sample Activities

How can you survive for 20 second?

- **Objective:** By the end of the activity, students should be able to use "IF ..Then" statement by using trail and error approach. Use basic problem solving skills. The activity allows the students to explore the implementation of the "If..Then" statement.
- **Activity:** In this simulation, students only use "IF-THEN" statement to control the traffic flow. (Hint: Ignoring Lights 3 to 5 and congests for route 3 to 5, control Light 1 and 2 only. Observe the pedestrians' flow).
- **Questions for Discussion:** Why there are some pedestrians standing on the traffic island? Is there any difference between the reality and the simulation?

How can we make the car running more than once?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "for" button.
- **Activity:** Students should first use "for i= 1 to n", where n is any chosen number. We should predict what would happen before we run the game. No instruction will be given to students so students can make the simulation by their own. For instance, how many times of car flow occur if we set for i = 1 to 5 and put in one condition such as controlling light 1 & 2 as we tried before, inside the loop?
- **Questions for Discussion:** What is the function of the "if" statement in programming? What is the benefit of using this button?

How can we make the car running continuously?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "while" button.
- **Activity:** Students are asked to control the car flow so that the car flow can run continuously. We can use the "while" statement to implement this task. "While" it is true, then do the following statement. Students are suggested to predict the effect of putting the "for-loop" inside the "while-loop" and the vice versa. They are asked to explain these effects.
- **Questions for Discussion:** What is the function of the "while" statement in programming? What are the differences between "if" and "while"?

Acknowledgements:

The research reported in this paper was funded by the CRCG research grants of the University of Hong Kong.

Learning with Computer Mediated Communication in Remote Off-campus Cross-Cultural Contexts: Bridging the Information Gap

Lyn Henderson*, Frank York*, Gail Jose, and Anne McGowan***
**School of Education, James Cook University, Townsville, Queensland. Australia 4811*
Lynette.Henderson@jcu.edu.au, Frank.York@jcu.edu.au , Anne.McGowan@jcu.edu.au
***Education Queensland, P.O.Box 2268, Cairns, Queensland. Australia. 4870*
gail.jose@qed.qld.gov.au

The research examined the anxieties and perspectives of first and final year Australian Indigenous Bachelor of Education students as they learnt with Computer Mediated Communication. The paper reports a qualitative study that utilised Likert Scale Questionnaires and focus and individual interviews in order to ascertain the factors involved in reducing the information rich/information poor gap through the use of Computer Mediated Communication. The factors identified involved technical, time, skills, costs, tutors, and "learning style" issues as well as isolation as tertiary students studying in offcampus remote communities. The students reported more positive attitudes and competency skills and less isolation with email than the WWW. There was general optimism concerning the role the Internet would play in their future lives as students, teachers, and, as they took their knowledge beyond the classroom, in their communities, particularly in terms of reducing the information gap.

Keywords: **Computer Mediated Communication, information gap, cross-cultural, Internet**

1 Introduction

Tertiary education institutions are rapidly investing considerable resources and faith in the Internet as a means of conveying both the administrative and the pedagogical materials for student learning [1, 2]. As vehicles for flexible learning, email and the World Wide Web (WWW) are seen to be free from geographical, time, and participation restraints [3, 4]. This is juxtaposed against international concerns that the Internet is widening the gap between the information rich and information poor [5, 6]. Tertiary institutions are amongst those that continue to widen the gap between information rich and information poor in Australia as technical, cost, and inappropriately designed distributed learning environments (email and the WWW) impose implementation restraints. This paper reports a case study of how Australian Indigenous students, who are studying in remote communities, and one Australian tertiary institution, James Cook University, are bridging that information gap.

The study was interested in the tertiary students' perspectives of the influences that impacted their interpretation of that gap and how it was being bridged. We therefore investigated the students' perceptions of (a) their attitudes and anxieties concerning email and the WWW and (b) the role email and the WWW played in teaching and learning in their degree program and their lives as Indigenous peoples in remote areas.

2 Methodology

Since mid-1990, James Cook University (JCU) has offered a Bachelor of Education to Aboriginal and Torres Strait Islander students through the Remote Area Teacher Education Program (RATEP). As in the rest of Australia, Queensland's Aborigines and Torres Strait Islanders have lived, and many continue to live, under various separatist legislation. The state government long held an isolationist and racist view of what constituted an appropriate education for them. As the official view was that they could achieve little academically, secondary education was withheld from Aborigines until 1964 and, for Torres Strait Islanders, education was left in the hands of the Department of Native Affairs, rather than the Department of Education, until 1984. RATEP was conceived as a program that would seek to redress issues of geographical remoteness, racial discrimination, economic exploitation, educational marginalisation, linguistic plurality, land alienation, and enforced dependency of the Indigenous communities. It was driven by the concepts of social justice, culturally contextualised education, empowerment, and use of information technologies. It is an inter-systemic teacher education program providing preservice teacher education studies to Indigenous students on-site in remote locations throughout the State of Queensland. The RATEP delivery partnership consists of James Cook University, the Far North Queensland Institute of Technical and Further Education, the Queensland State Education Department, and, importantly, the Indigenous communities. Multi-systemic collaboration is effected through the RATEP Management Committee which oversees finance and site selection, contributes to various corporate decisions, and provides for direct Indigenous input.

The program caters for eight to 35 Indigenous students in any year's intake with four to 12 students at any one site. The location of the 10 James Cook University RATEP centres is usually in a primary or secondary school classroom in locations where the population ranges from 250 in Aboriginal and Torres Strait Islander communities, in which non-Indigenous people are a very small minority, to 700 in the small townships. Typically, the centre consists of one classroom which houses the computers, modem, printer, facsimile machine, teleconference phone, conference table, and study desks as well as a sink and fridge. There are no community libraries available to the students.

RATEP is a mirror of the Bachelor of Education on-campus program, differing mainly in modes of delivery. RATEP students study the same courses, are taught by the same lecturers, complete assessment tasks at the same standard as their on-campus counterparts, and receive exactly the same award as students who undertake preservice teacher education at the Cairns and Townsville JCU campuses. RATEP uses various distance education technologies, materials, and delivery strategies: textbooks, workbooks, teleconferences, audio and video tapes, facsimile, JCU developed interactive multimedia (IMM) courseware, on-site tutors (self-labelled teacher-coordinators), and, now, the Internet.

The delay in accessing the Internet as part of their program was mainly due to the costs of hardware, long distance telecommunication fees, and the unreliability of sustained telecommunication connections. With support through a Telstra learn-IT research grant, the Bachelor of Education students through RATEP were able to enrol in two undergraduate information technology courses that utilised the Internet as a teaching-learning tool. The courses were a first year core on-campus course and a fourth year elective: *Information Technologies in Education* and *Design of Educational Media*, respectively. The first year course had the equivalent of two interactive lectures on the World Wide Web (WWW). Assessment included reactions to tutorial readings sent as email attachments, and the option to create a WWW home page. Interaction with the lecturer was via email and teleconference. The fourth year course required the students to access the WWW for key readings as well as to critique educational sites. In addition, they were responsible for conducting weekly email tutorials in which two students posed email questions about the set tutorial readings. All students replied individually. The tutorial leaders were also required to synthesise these responses in a culminating email. All students were encouraged to critique any of the contributions. Except for two teleconferences, interaction with the lecturer was via email. In both subjects, the students had previously met formally and informally with their lecturers during a short orientation oncampus program.

Twenty-three out of 33 Indigenous students volunteered to participate. Their ages ranged from 21 to 49 years. Reflecting teacher education enrolments generally, all but seven were female. The students generally speak either a traditional language, Aboriginal English, or Torres Strait Creole as their first language. Standard Australian English is their second or third language. When researching in cross-cultural contexts it is important that researchers acknowledge the cultural, linguistic, and individual differences existing within and across the student group. However, the historical-socio-cultural similarities are strong enough to speak in generalities in referring to Aboriginal and Torres Strait Islander patterns of experiences, values, and ways of

learning.

Audiotaped focus interviews were conducted either face-to-face (Yarrabah) or via teleconference (Normanton and Woorabinda) with students as a group at these three RATEP sites. The interviews involved open-ended questions to gather information about the issues identified by the students and teacher coordinators as relevant to learning with the Internet. A five-point Likert Scale Issues and Course Questionnaire for the first and final year courses were compiled from the focus interview data and the literature. It was administered towards the end of the courses, either along with audiotaped individual interviews conducted on site with students at six RATEP sites (Thursday Island, Bamaga, Napranum, Cairns, Palm Island, and Cunnamulla) or via fax or email attachment to the other four sites (Yarrabah, Normanton, Worrabinda, and Doomadgee). Another five-point Likert Scale questionnaire assessing Computer Mediated Communication Anxiety [7] was also administered at the beginning and end of the two university courses involving the Internet via fax or email.

3 Data Results and Discussion

The five point Likert scale questionnaires were reduced to a three point scale (see Table 1) for data analysis. Overall there was a positive swing on the Computer Mediated Communication Questionnaire (Items 1-13, Table 1) and the Issues and Course Questionnaire (Items 14-23, Table 1) that sought first and final year student anxieties and perceptions about current and future usage of email and the World Wide Web (WWW). (Ten items out of the 42 item Issues and Course Questionnaire are reported here; the other items included those that are common in end-of-course evaluations and, therefore, not relevant to this paper). The individual interviews supported this trend. The interviews revealed a decidedly positive emphasis on keeping but improving the use of CMC in RATEP subjects.

Table 1: Comparison of Pre to Post Test Changes on Selected Items from Computer Mediated Communications and Comparison between End-of-Semester First Year and Final Year Issues and Course Evaluation Questionnaires

Computer Mediated Communications Questionnaire: Responses of Students' Studying First and Final Year Course							
Item		Pre-Test			Post-Test		
		SA-A	U	D-SD	SA-A	U	D-SD
1	E-mail could open up new communication channels for me.	92%	8%		94%	4%	
2	My usage of e-mail will increase in the future.	67%	33%		91%	9%	
3	The thought of using e-mail makes me nervous.	50%		50%	30%	9%	61%
4	The Internet could open up new areas of communication for me	100%			100%		
5	I expect I will use the Internet in the future	83%	8%	8%	96%	4%	
6	I get nervous at the thought of using the Internet	50%		50%	39%	13%	48%
7	I believe that there are many useful ways to use the Internet.	67%	17%	17%	68%	17%	14%
8	The thought of learning from the Internet intimidates me.	36%	27%	36%	30%	17%	52%
9	Information overload frightens me.	50%	8%	42%	43%	30%	26%
10	I feel very negative about the Internet in general.	33%	17%	50%	26%	30%	43%
11	I would prefer not to use the Internet because of the uncensored material	25%	8%	67%	30%	22%	48%
12	Using the Internet could be more trouble than its worth	25%	33%	42%	17%	17%	65%
13	I think there is too much emphasis placed on	67%	17%	17%	35%	26%	39%

	the Internet						

First and Final Year Issues and Course Evaluation Questionnaire Responses

	Item	First Year Course			Final Year Course		
		SA-A	U	D-SD	SA-A	U	D-SD
14	I am more confident using email than the WWW	73%	9%	18%	67%	11%	22%
15	If I had the choice, I would use the WWW for serious information searches	100%			100%		
16	If I had the choice, I would use the WWW to catch up on what' s happening in soap operas.	27%	9%	63%	33%	22%	44%
17	The WWW is a diversion from having to do RATEP work.	20%	20%	60%	22%	33%	44%
18	I don' t feel as isolated as a university student now that I can use WWW	54%	36%	9%	56%		44%
19	I don' t feel as isolated as a university student now that I can use e-mail	82%		18%	100%		
20	I appreciated the flexibility in scheduling my learning times	73%	18%	9%	89%	11%	
21	The subject has made me feel a more independent learner	50%	30%	20%	78%	22%	
22	I no longer see the computer as just a word processing tool	100%			80%	20%	
23	I intend using the computer in the classroom with my students.	100%			100%		

* SA-A = Strongly Agree/Agree; U - Undecided; D-SD = Disagree/Strongly Disagree.

Students were originally divided on their willingness and nervousness to use email. By the end of the semester there was a substantial increase in their perception that their future usage of email would increase (67% to 91%) and a 20% decrease in their nervousness (Items 2 & 3, Table 1). This is encapsulated in one student' s interview statement: "I was a bit apprehensive at first because I think the newness with everybody was a bit scary. But, after I got the knack of things, I really loved it" (Interview). Most students acknowledged the efficiency and speed of communicating via email with their lecturers and fellow students; as one student explained: "..you don't have to fiddle around faxing or posting your assignments. You just type it right onto the computer and send it on the email and it's there!" (Interview). Some reasons for the maintenance of apprehension involved concerns about costs ("the time I' m using is costing money"), typing skills ("my typing speed is not up to my thoughts; that' s a bit slower so that' s what holds me back"), and privacy ("..the teacher-coordinator seemed as if to be spying" (Interviews). This last factor involved the way email accounts were established. Because of costs, only one modem was provided at each site. Thus, at the time of the research, the teacher coordinator accessed and therefore could read all exchanges as the single email account for each RATEP site was registered in their name. (This year, all students have a private email account.) Despite their concerns and apprehensions, 94% agreed that email would open up new communication channels for them while 91% indicated they would increase their use of email in the future (Items 1 & 2 respectively, Table 1).

Compared with email items, there was more initial negativity and some smaller positive swings concerning the WWW items. Indeed, at the end of the semester, both first and final year students admitted they were "more confident using email than the WWW" (73% and 67%, respectively; Item 14, Table 1). In the pre and post Computer Mediated Communication Questionnaire, for instance, although in the post test 68% agreed with the item, "I believe that there are many useful ways to use the Internet", there was little variation from the pre test (67%) (Item 7, Table 1). Other small positive results occurred in the following items as fewer students indicated agreement with the following statements: "I get nervous with the thought of using the Internet (50% pre test to 48% post test); "The thought of learning with the Internet intimidates me" (36% to 30%); and "Information overload frightens me" (50% to 43%) (Table 1, Items 6, 8, & 9, respectively).

However, it is noteworthy that on three of these items such positive swings were offset by a noticeable

increase in the "undecided" category. For instance, in the above item about nervousness and using the Internet, 50% agreed and 50% disagreed on the pre-test while 39% agreed and 48% disagreed on the post-test (Item 6, Table 1). The change in attitude was counteracted by an increase in the "undecided" (0% to 13%; Item 6, Table 1). Although more students felt less negativity about information overload (Item 9) and the WWW in general (Item 10), 30% reported being "undecided" in the post test compared with 8% and 17% in the pre test, respectively (Items 9 & 10, Table 1). As explained later, many of the first year students were prevented from hands-on use of the WWW course materials online. In the fourth year subject, the greater emphasis was on email tutorial interaction; in comparison, finding relevant resources and obtaining set readings from the WWW were the only compulsory WWW tasks. This paucity of "compulsory" usage, influenced the students perceptions concerning the Internet. During the interviews, most students equated the Internet with the WWW. The experiences that the students did have seemed to have resulted in understandable ambiguity concerning their anxiety and general attitudes about the WWW; the reality of their experiences was a contributing factor.

More substantial changes occurred when, in the post test, fewer students agreed with the statement, "I think there is too much emphasis placed on the Internet" (67% to 35%) (Item 13, Table 1) and more students confirmed that they would use the Internet in the future (83% to 96%) (Item 5, Table 1). As one student commented: "You have to keep up with the technology and pass it on; it's never-ending learning" (Interview). Additionally, regardless of their concerns and experiences, an optimism remained: all confirmed an unchanged hope that the Internet would open up new areas of communication for them (100% on both pre and post tests, Item 4, Table 1).

There were several factors affecting these data results, such as technical issues, time, skills, costs, and tutors (self-labelled "teacher-coordinators").

Technical problems were a significant factor. Getting hooked-up took two sites one month after the commencement of the courses. The reliability of the telecommunication links and difficulty in logging into the James Cook University site when 500 on-campus students were trying to log into the same first year course site influenced the RATEP students' perceptions (Interviews). The one computer that had the RATEP modem connection was also used for studying with the IMM courseware and wordprocessing assignments. An extra major inconvenience for two sites was having just one line for Internet access, facsimile, telephone, and teleconferencing. There was a ratio of approximately four students to this one line.

These factors obviously limited the time each student could spend using the WWW and email. Their other study commitments - described as "a mountain of work" by one student - imposed further time constraints reducing their usage of the Internet (Interviews). This was exacerbated by having English-as-a-second/third-language with respect to deconstructing academic genres. "If we'd had more time to explore it and build up that confidence, well, then, I probably wouldn't be feeling as bad as I do about getting onto it," was one student's summary of the effects that lack of time had on her self-confidence (Interview). Others echoed the impact that minimum usage had on their confidence to use the WWW (Interviews). The printout of procedures on the wall did not seem to inspire usage or confidence; it was the personal input from the teacher-coordinator or a peer that some students' maintained was crucial. This emphasis on the personal coach would seem to reflect Aboriginal and Torres Strait Islander preferred ways of learning and doing [8]. In this period of apprehension with using the Internet, students required the comfort zone of traditional ways of teaching and learning [9].

Underdeveloped procedural knowledge constrained student progress using the WWW. One student's clarification echoed other students' comments: "..it's just a matter of not being able to get where I want to be straight away ...and then I'll get real frustrated" (Interview). Students justifiably argued that this was compounded by the fact that the first year course did not encourage understanding or reinforcement of WWW searching strategies by requiring assessable activities in this area.

There was evidence of self-imposed moderation in usage by students (Interviews). In spite of their understanding that costs involved in browsing the WWW were met through the Telstra learn-IT grant, students were reluctant to abuse what they saw as a privilege.

The students who reported most positively in their interviews were those who perceived their teacher-coordinators as having competence in using the WWW and being able and willing to impart that confidence

to the students. Unfortunately a few students cited perceptions of teacher-coordinator reluctance or inability to share their knowledge. Also most of the teacher-coordinators printed out the first year course's WWW lecture notes. The teacher-coordinators contended they chose this strategy because of time constraints, technical hiccups, and, perhaps, admitted one, procedural insecurities. For them, this allowed a more efficient usage of time as they could conduct tutorials based on the printed text without having to wait for all the students to study from the WWW. In effect, it prevented students acquiring more proficiency with the Internet and, hence, much needed self-confidence. As well it prevented students (and these teacher coordinators) from obtaining a better understanding of how the WWW could be utilized as a learning tool as they had no chance to participate with the in-built question-answer-feedback interactions, the video clips of school children voicing their perceptions of various aspects of the Internet and its relevance to their lives, and the hypertext/hypermedia functions of the WWW.

These conditions would have influenced the differing perceptions about the courses allowing "me to feel a more independent learner" (Item 21, Table 1): only 50% of the first year students felt such independence with a further 30% being undecided; in comparison, 78% of the final year students reported that the Internet activities had helped them to take more self-responsibility for their learning. Of course, one would expect that final year students would be more independent learners than first year students. Nevertheless, the item required them to express an opinion if the Internet subject had made them "more" independent.

Even if many had not had much opportunity to browse the Web, all students reiterated the commonly quoted advantages of the WWW: up-to-date information, variety of topics, exploration, multiple sources relating to the same information, and flexibility (Interviews). With respect to flexibility, more final year students (89%) compared with first year students (73%) valued this attribute (Item 20, Table 1). The enforced tutorials without personal access to the WWW would have influenced the first year students' perceptions. One student situated her comment in the context of the realities of Indigenous community life: "We've had multiple tragedies in our class [deaths, suicides, and serious illnesses]; at least with the WWW lecture notes, we can come back and get them; we're not missing out [as we would have with teleconferences]" (Interview). For students who had taken opportunities to surf, the WWW was "Exciting!"; "It gets me; it draws me. I could see myself seriously getting hooked"; "It's like a big book; you don't want to put it down!" (Interviews).

Students unanimously agreed that they would use the WWW for serious information searches (Item 15, Table 1). It was reassuring to see that their usage went beyond the two courses requiring utilisation of the Internet. The following Web searches were mentioned by different individual students: green ants (for their science curriculum course); background information on a son's medical disease; solutions for our farm's fruit tree problems; Indigenous sites such as the internationally famous Aboriginal band, Yothu Yindi. Serious play [10, 11] was involved, too: finding out what was on at movie theatres; joining a jokes' listserv; 30% admitted to catching up on soap operas (averaged first and final year, Item 16 Table 1); and 21% reported using the WWW as an occasional diversion from their studies (averaged first and final year, Item 17 Table 1). Such responses demonstrate these students' awareness of the types of information available on the WWW and an ability to conduct searches and find out how to subscribe to a listserv. Because of the Internet and other computer requirements in the two courses, 90% (averaged first and final year students, Item 22, Table 1) agreed that they no longer perceived the computer as just a word processing tool.

The role of email and the WWW in their lives as students in remote Indigenous communities involved reducing isolation and person, societal and professional issues.

Feeling part of the wider JCU student cohort was an issue raised in the research. Both cohorts of students felt that isolation as a university student was decreased through use of email - 82% for first year students and 100% for final year students (Item 19, Table 1). One student put it succinctly: "Yeah. It took away the isolation a lot" (Interview). In comparison, approximately half (54%) of the students studying the first year course reported that they "did not feel as isolated as a university student now that I can use the WWW" (Item 18, Table 1). A further 36% were undecided. Likewise, only 56% of the final year students felt that isolation as a university student was reduced through access to the WWW (Item 18, Table 1). The course requirements and amount of access would have been significant issues in the differing percentages with respect to email and WWW as factors in lessening isolation. With respect to the first year students, these percentages are not surprising considering the large number of reports of inadequate access to the WWW, working from a print version rather than on-screen interaction of the first year information technology course, and technical constraints. The fourth year course demanded that the students conduct weekly email tutorials

and interact via email for a fortnight with students at the Royal Melbourne Institute of Technology as well as the fact that their compulsory WWW activities were limited. The results may also have been affected by the fact that the WWW activities were not people orientated whereas the email tasks were obviously so.

However, isolation was not just a matter of the difficulties imposed by distance learning with respect to cultural induction as university students. It was also a personal and community issue. A few students reported keeping in touch via email with relatives and friends living in other parts of Australia; for instance, one student was able to regularly contact her son who was in jail. This is a poignant reminder of the systemic injustices involved in Aboriginal and Torres Strait Islander peoples' reality and the role that email can play in helping families maintain contact at a geographical distance. The WWW was threatening for one student: " ... a whole new world, and I'm afraid in a way to experience all these different things" (Interview). For others, their world was expanded. This was insightfully expressed by one student: "When you're living in a remote community all you know is what's happening around here or what you get from your teleconference and stuff like that. You're living in your own world ...Well, then, when you get onto the Web, it's just like: 'Wow! There's a big world out there. All that information you can access'." (Interview).

The content in the first year course *(Information Technologies in Education)* appeared to have been influential in changing perceptions about the negative affects of the Internet. One involved society's concern that the Internet would significantly reduce or even prevent socialisation. For example, "I've changed", said one student. "I've done a complete [voice faded out] ...with the whole idea of technology taking away the emotional side of life and that we've been becoming too dependent on it, and I think, after going through the semester with it, that maybe as long as people are educated in the right way about it, it's not going to prove to be a big problem. It's probably going to prove to be a big asset, you know." Some students' comments highlighted their fear of children and themselves encountering pornographic sites: "It scares me - to come across something like that on the Internet"; "Children shouldn't have access to them" (Interviews). However, the 19% pre to post drop in their disagreement with the statement, "I would prefer not to use the Internet because of the uncensored material" (Item 11, Table 1), probably reflects a more realistic understanding of avoidance strategies and the general unlikelihood of a user encountering such sites; these were issues that were discussed with relevant hotlinks in the WWW course.

All the pre-service teachers reported their intention to use computers in the classroom with their students in order to enhance teaching and learning (Item 23, Table 1). One student commented that hers was a commitment to creating a new kind of learning environment for all, but particularly remote Indigenous, students. Another student saw that this would occur during her next practicum: " ..I think that I can go to the Web and find out interesting lessons, which is one of my main concerns. Kids sit down and get stuff poured into them that is not interesting." The students' commitment demonstrates a broader consideration of the role that the WWW and email needs to play in school and, as the students' take their understandings home, their communities.

4 Conclusion

Overall, at the end of phase one of the project, there was a favourable response to the introduction of the Internet into the students' Bachelor of Education course. Importantly, the research highlighted a number of issues that the RATEP Academic Coordinator, lecturers, and RATEP Management Committee can consider to help improve the incorporation of the Web and email for improved teaching and learning: technical issues such as the provision of more than one modem per RATEP site; incorporation of assessable items to do with effective searches on the WWW; meaningful use of email and Web discussion forums in various subjects across the degree program; seeing serious play that helps develop WWW procedural skills as part of the course structure; examination of the nature and role of WWW lectures in developing conceptual as well as procedural understanding of the WWW; and creating purposeful "authentic" links between the Internet subjects and their community.

It is argued that the Internet will prove to be an effective tool to combat colonisation. For instance, geographically dispersed Aboriginal communities and Torres Strait Islander communities are able through the Internet to set their own agendas to communicate and consult (network) on issues of mutual concern, such as the current attention concerning land and sea rights claims. In the second phase of the learn-IT research

grant, we conducted an Internet WebBoard International Conference linking Indigenous and non-Indigenous peoples interested in teaching and learning with the Internet. Once analysed, the rich data from this conference should provide further ideas for bridging the information gap, not only to empower, but to provide ownership of the Internet in school, tertiary, and community life.

5 References

[1] Paulsen, M. F., "Computer mediated communications and distance education around the world", Vol. 7, pp. 31-37, 1992

[2] Rudra, A. (1994). AARNet and ERNET: An era for fostering international academic research. In N. F. Ellerton (Ed.), Proceedings of International networking: Education, training and change (pp. 104-109). Perth, Western Australia: Edith Cowan University.

[3] Nguyen, A. T. A., Tan, W., & Kezunovic, L. (1996). Interactive multimedia on the World Wide Web: Implementation and implications for the tertiary education sector. In M. Nott (Ed.), Proceedings of AusWeb96: The Second Australian World Wide Web Conference. Gold Coast, Australia: Southern Cross University.

[4] Rossman, P. (1992). *The emerging worldwide electronic university: Information age global higher education*. Westport: Greenwood Press.

[5] Provenzo, E. (1986). Beyond the Gutenberg Galaxy. New York: Teachers College, Columbia University.

[6] Rowe, H. (1993). Learning with personal computers. Hawthorn, Vic.: Australian Council for Educational Research.

[7] King, J., Henderson, L., & Putt, I. (1997). Measuring affective aspects of www and e-mail use in course delivery. In Muldner, T., & Reeves, T. (Eds.), Educational multimedia/hypermedia and telecommunications, 1997, (Vol. 1), (pp. 595-600). Charlottesville: Association for the Advancement of Computing in Education.

[8] Osborne, A.B., (1982). Field Dependence/Independence of Torres Strait Islander and Aboriginal Pupils. Journal of Intercultural Studies, (3)3, 5-18.

[9] Henderson, L. "Instructional design of interactive multimedia: A cultural critique". Educational Technology Research & Development, Vol. 44, No. 4, pp. 85-104, 1996.

[10] Provost, J. (1990). Work, play and type: Achieving balance in your life. Palo Alto, CA: Consulting Psychologist Press.

[11] Rieber, L. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. Educational Technology Research & Development, 44(2), 43-58.

MathCAL's Diagnostic Sub-System

Janet Mei-Chuen Lin*, Chin-Yeh Hsu*
*Kevin Kaitse Huang**, and Jie-Yong Juang***
*Department of Information and Computer Education
National Taiwan Normal University, *Taipei, Taiwan*
E-mail: mjlin@ice.ntnu.edu.tw
**Department of Computer Science and Information Engineering
National Taiwan University, *Taipei, Taiwan*
E-mail: kevin@solar.csie.ntu.edu.tw

The Internet-Based MathCAL system provides a learning environment for students to practice mathematical problem-solving skills. The system uses Petri nets to represent domain knowledge and keep track of learners' problem-solving behavior. Learners' problem-solving steps are recorded dynamically and stored as Petri net graphs in the system's database. One of the major components of MathCAL is its diagnostic sub-system. The diagnostic sub-system matches a learner's partial solution path against all possible solution paths for the problem and tries to determine which problem-solving procedure the learner is most likely being using. The idea of *critical transitions* as well as other matching mechanism is used to achieve a best guess about the learner's thinking process. This provides the basis for offering guidance to the learner when s/he requests system help. The misconception or missing conception thus identified will enable the system to prescribe necessary tutorials to expose the learner to the concept(s) and guides him/her to practice on selected problems related to the concepts.

Keywords: **Mathematical Problem Solving, Petri Nets**

1 Introduction

MathCAL has been designed as an Internet-based learning system which allows learners to practice mathematical problem-solving skills. It is currently equipped with the knowledge base for solving problems requiring the use of trigonometry. Interested readers may refer to two of our previous papers for detailed description of MathCAL [1,2]. The functions provided by MathCAL, its system architecture and the implementation concerns were fully illustrated in those two papers.

As a problem-solving practicing system, it is essential that MathCAL offers timely and useful help to learners when they encounter difficulties during the interactive sessions. MathCAL tries to provide such assistance in two respects: built-in guidance by the computer and human guidance over Internet with MathCAL-provided communication functions. In this paper we concentrate on the former, that is, MathCAL's newly enhanced built-in diagnostic sub-system. The remainder of this paper is organized as follows: First we use an example to offer a glimpse of the role played by Petri nets in MathCAL. We then describe MathCAL's diagnostic mechanisms, including how it collects experts' problem-solving knowledge and how such knowledge is used to lead the learners out of the impasses they may face. In the end are our concluding remarks.

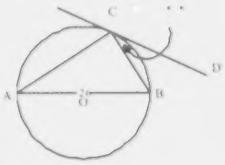
2 A Sample Petri Net Graph Generated by MathCAL

MathCAL uses Petri nets for representing mathematical problem-solving processes, both for recording the correct solution paths for each problem and for dynamically keeping track of users' problem-solving steps. There are three essential symbols in a Petri-net graph, which are *transitions, tokens* and *places* [3]. The process of solving a math problem can be modeled as a Petri-Net graph, where mathematical rules

correspond to *transitions*; the conditions for applying a rule are modeled as *places*; and the holding of a condition is represented by placing a *token* in the place corresponding to the condition. In the following we use an example to illustrate how Petri-Nets are used to store problem-solving knowledge.

The Problem Statement:

$\overline{AB}$ is the diameter of the circle with center O. The tangent CD touches the circle at C. • ÐCB = è and cosè = $\frac{12}{13}$. If $\overline{AB}$ =26, calculate the area of △ABC.



When a learner proceeds to solve the above problem, a Petri net graph is generated step by step. A possible graph thus constructed may look like the one shown in Figure 1. The transitions and places used in the graph are explained in Tables 1 and 2.

Table 1. The Transitions Used in Figure 1

Transition	Description
T3	Given the measures of the three sides of a triangle, calculate the trigonometric values.
T8	Given the trigonometric values and the measure of the hypotenuse, calculate the measure of the adjacent side.
T11_1	Calculate the area of a triangle
T17	Theorem: The angle in a semicircle is a right angle.
T18	The angle between a chord and a tangent of a circle equals the angle at the circumference standing on the arc subtended by the chord.

Table 2. The Places Used in Figure 1

Place	Description
P1	A tangent touched the circle at point C
P2	Diameter AB=26
P3	Cos• =12/13
P4	• ÐCB=• •
P5	A tangent CD
P6	• ACB is an angle in the semicircle
P7	• Ð of • ÐAB is a right angle
P8	• A of • ÐAB =• •
P9	Sin• =5/13
P10	The measure of the adjacent side AC = 24
P11	The area of • ABC = 120

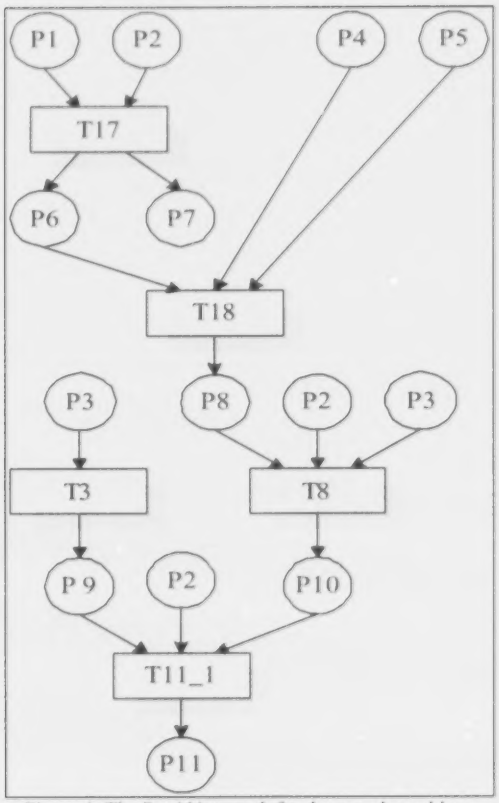


Figure 1. The Petri Net graph for the sample problem

3 How MathCAL's Diagnostic Sub-System Works

As is usually the case, there may be more than one solution for a given problem. For example, there are at least five different solutions for the problem given above. Accordingly, we may have five Petri net graphs associated with the problem, one for each solution. These graphs may be generated by either domain experts or learners. When an expert inserts a problem to MathCAL's problem bank, the system will request that the expert demonstrate how the problem may be solved. It is essential for MathCAL to store at least one correct solution path for each problem so that its diagnostic procedure will function properly. This is necessary because MathCAL needs to compare a learner's partial solution to the correct solution(s) stored when s/he requests system's help in the middle of problem solving. It is thus desirable that MathCAL stores as many solution paths for a problem such that it is capable of finding a solution path that matches most closely with a learner's partial solution. A closest possible match will allow the system to best approximate a learner's thinking process and offer the most suitable guidance. There may also be the case that a learner may successfully solve a problem while his/her solution path is different from any of the stored correct solutions. These new solutions will be detected by MathCAL and added to its database.

The task of identifying a closest match between a learner's partial solution and one of the stored solutions is non-trivial, especially when there are multiple solution paths for the problem. To facilitate this matching process, MathCAL relies on the concept of *critical transitions*. A transition is considered *critical* if the use of it is essential to the derivation of the final result. For any given solution path there may be more than one critical transition involved in the problem-solving process. Besides, different problem-solving methods may result in different critical transitions being identified. Since domain experts know best about what the critical transitions are for solving a particular problem, MathCAL requires that such critical transitions be specified when a new problem is entered into the system's database. For instance, transitions T17 and T18

Towards a Meta-Knowledge Agent: Creating the context for thoughtful instructional systems

Elspeth McKay
RMIT University, RMIT BUSINESS, School of Business Information Technology, GPO Box 2476V, Melbourne, Victoria 3001, Australia, elspeth@rmit.edu.au

This paper describes a creative approach to electronic courseware authoring. Many online learning systems adopt a generic framework in which cognitive modelling is difficult to achieve. A new CBT package called Cogniware is proposed to bridge this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive learning context. Learners are given the opportunity by this intelligent courseware to identify their cognitive style before embarking on the instructional material. Cogniware will use research findings on the interactive effect of cognitive style and instructional format on the acquisition of complex abstract programming concepts, involving spatial relations and logical reasoning [10], to direct the novice-learner to the instructional format that will best suit their cognitive style. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions.

Keywords: **Creative learning, educational agent, instructional design, interactive learning environments**

1 Introduction

Reliable mechanisms for courseware design, which provide beneficial flow-ons from research for the training and development sectors [10] are now available. Picking out the important instructional variables (learner's spatial ability, and method of delivery) for some types of instructional outcomes, progresses our ability to provide instructional environments for a broader range of novice-learners. These advancements give the learner a choice of information-transfer-agent, instructional format and instructional event conditions. Too often novice-learners are left to stumble their way through instructional material. We now have the means to deliver customised learning environments. Generic instructional formats often provide too much information, or too little. The meta-knowledge relating to an individual's likely perception of instructional strategies brings our courseware construction into the realm of being truly thoughtful instructional systems' development. In the past, there has been a traditional view that learners adopt a generic approach to make the learning of new abstract concepts meaningful. For instance, the intellectual skill associated with absorbing concepts should be included with the verbal information conveyed during instruction [20]. Cognitive processes involved in learning concepts, are generalization and discrimination [11]. For that reason, individuals generalise from a particular response to learning, to their overall learning experience. Learners look for common attributes that new concepts share with previously encountered ones [11]. However, while still assuming a generic learner cognitive profile, there is now some evidence relating to how an individual's initial mental construct might take the form of a graphical image [5]. That image could serve as a device for mental recognition if the actual object has been seen earlier. Furthermore, mental constructs include the perceptible and non-perceptible attributes of the concept and the cultural meaning given to the name of that concept.

However, there are few examples of research that make a connection between learning abstract computer-programming concepts and graphical-representation as an instructional strategy (see [8]; [9] & [10]. A colour

coding process to trace programming logic flow has been devised by Neufeld, Kusalik & Dobrohoczki [13]; and an interactive system, which traces the hidden activities of a computer-programming interpreter has been developed by Smith [18]. Courseware authoring involves the instructional designer in a complex pedagogical process. First, there must be some understanding of how learners deal with the learning content. Next, is the recognition of the interactive effect of an individual's knowledge processing and cognitive style. Finally, the designer needs to be aware of how the dynamics of the meta-knowledge processing (see Figure:1) impact on intelligent tutoring tools.

2 Dynamics of authoring an intelligent tutoring tool

The McKay [10] research has clearly identified the complexity of the meta-knowledge environment, and has outlined prospects for a customised learning shell. Progress is thus possible in linking research outcomes to actual learning contexts. The advent of computerized courseware dictates a need for innovative instructional strategies to articulate the visual (pictorial) approach to instruction. However, as this work has shown: not all individuals will cope effectively with a *graphical environment*

However, the observed interactive effect of the cognitive style construct [16] and instructional strategy, may be unique to the acquisition of programming concepts. Therefore, researchers/trainers will need to run an extensive pilot study programme to identify the interactive effects within their specific learning domain. In addition, the instructional material does not need to be limited to a textual/graphical comparison, but could be applied to any two or more instructional treatments of any kind. For instance, a structured versus exploratory strategy. Consequently, a special effort is required to reduce the measurable tension between the instructional mechanism (or dynamics of the tutor's view of the topic) and the actual instructional outcomes (or dynamics of the novice-learner's requirement for specific types of knowledge context). Figure:1 shows the interplay between learning and instruction.

Figure 1: Learning Process Dynamics

The Sternberg [19] approach was to concentrate on the basic information processes in analogical reasoning; while Dreyfus & Dreyfus [2] described stages of skill acquisition as five steps from novice to an expert: novice, advanced beginner, competence, proficiency, and expertise. Be that as it may, it was the sequencing of instruction that reflected the beneficial nature of meaningfulness to the act of learning [7]. Therefore, careful consideration needs to be given to the logical sequencing of instructional events to ensure participants are able to progress through the Dreyfus & Dreyfus skill acquisition steps. Intelligent tutoring systems seek to emulate the learning process, providing a novice-learner with a free fall approach to the pedagogy, or a feeling of being lost in hyperspace [4]. Many of the novice's failed attempts to construct the required domain knowledge are alleviated, when the courseware provides advance notification of the instructional content to promote the intended pedagogic framework. Thus the connection can be made between an individual's prior domain knowledge and their internal representation (Figure:1). This instructional device is called an advance organizer. It occasionally makes learning meaningful by relating new knowledge in a parallel fashion, to what is already known outside the content area [15].

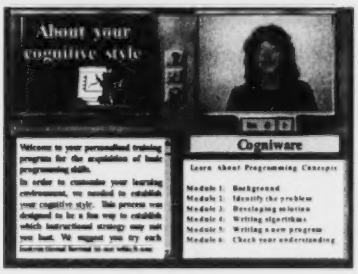
3 Taking a multi-sensory approach

Multi-sensory instruction can improve a student's capacity to learn effectively [1]. This instructional approach maximises the skills brought to the learning task, while minimising the experiences where their ineptitudes are emphasised. Nevertheless, this learning process is often overlooked in the literature, in terms of making new knowledge meaningful by relating to sensory events [17], or to actions already stored in a learner's experiential database (memory). This experiential (human) database is called a sensori-motor database [6]. Accessing this human database is probably the most important method we have for making new knowledge meaningful, during the early years of cognitive development [15]. An instructional strategy can tap into the power of an individual's sensori-motor database, with an innovative textual metaphor, for explaining conditional logic flow to a novice programmer. This textual metaphor describes a common event to support a reflective approach to acquiring the programming concept of conditional logic patterns, thereby encouraging a novice-learner to access their sensori-motor database, to implement a new concept. Experiential leverage for developing the procedural knowledge is gained through providing hands-on experience with example problems. There is a relationship between cognitive level and mental energy consumption in different learning activities [14]. Reading and listening are mentally and physically exhausting with dull and poorly designed material, thereby losing the reader's interest. Furthermore, there is another relationship between cognitive level and suggestive impact, for different kinds of instructional representations [9]. Therefore, designers should be conscious of this and strive to design their learning materials (text and pictures) in the most attractive, and relevant manner possible, so that novice learners are encouraged to process the content (message) on the highest possible cognitive level.

4 Cogniware

Following the premise that a multi-sensori approach is beneficial to learning. Cogniware has been developed using the Electronic Trainer authoring tool from Mindware Creative Inc. At present it consists of a front end module to determine the learner's cognitive style (the CSA [16]), and a choice of instruction method for the acquisition of programming concepts. Cogniware is multi-sensori in the sense that the instructional strategies on offer provide the learning material in a range of alternative instructional conditions. Figure:2 depicts a typical Cogniware screen interface with three instructional formats or separate viewing areas: graphical, textual, and voice. In addition there are cueing mechanisms for guided exploration, such as: directional icons, a learning module name tag, and an advance organizer screen.

Figure 2: Towards a Meta-Knowledge Agent



Cogniware provides the background material on different modes of learning in a textual description interface, while at the same time a voice description can be heard.

4.1 Choice of instructional format

Currently, Cogniware has three types of instructional format available: graphical, textual, and voice (see Figure:2), thereby providing the learner with the format which best suits their cognitive style. However, Cogniware is also flexible enough such that a learner can over-ride the default for the chosen format. Programming metaphors are used as expository instructional strategies. In so doing, they articulate the critical attributes of the concept-to-be-learned [12].

4.1.1 Textual

There are a number of ways in which we can aid the comprehension of the written word. To overcome one of the central difficulties associated with text processing, Cogniware provides the reader with the best possible means to select important information from the text [3]. Hotwords are included as pedagogical cues to navigate a novice-learner through a new concept. Text should not be considered as a flat structure, where all ideas are expressed with equal importance. The Cogniware text is therefore a highly structured communication tool, in which ideas are expressed hierarchically, where certain parts of the message can receive more attention than others. As a consequence, particular display techniques enable the reader to focus on the full context of the message by selecting the important issues without being overwhelmed by poorly structured text.

4.1.2 Graphical

Graphical metaphors used by Cogniware were chosen for their recognisable and distinguishing (or salient) features, to depict each programming concept to be learned. These visual metaphors serve to elicit prior experiential knowledge, enabling the learner to recognise the distinguishing features of the new concept, and to interpret the instructional context without specific prior learning.

4.1.3 Voice

The learner can view the video interface to hear a verbal description of the programming metaphors. Advice and reassurance is also provided to ensure maximum coverage of the multi-sensori platform. Voice directions for dealing with the CBT navigation are designed to reduce the cognitive effort required in dealing with the complexities of multi-media instruction. Reminders can be seen as a useful technique to keep the novice-learner on track. It is intended that demonstration video clips will be included in future releases of Cogniware to extend the multi-sensori capability.

5 Conclusions

Cogniware represents a creative approach to electronic courseware authoring. The sound instructional design foundation upon which this courseware is built, draws on the research conducted by Merrill's ID_2 team at Utah State University, USA, and recent research by McKay & Garner [9]. The latter research provided the experimental findings to link the important work on the Cognitive Styles Construct carried out at Birmingham University, UK , by Riding [16] with the effectiveness of various instructional formats. Cogniware was authored using The Electronic Trainer providing the ideal knowledge based framework for authoring electronic courseware. Online learning systems adopting a generic framework reveal that cognitive modelling is difficult to achieve. It is proposed that Cogniware bridges this gap by providing a novice-learner with a dynamic instructional device designed to deliver an inclusive rather than exclusive learning context. At the nexus of this CBT is the ability afforded to learners to identify their cognitive style before engaging with the multi-sensori instructional devices, allowing selection of an optimal instructional format. Cogniware will be of interest to educators, cognitive psychologists, communications engineers and computer scientists specialising in computer-human interactions. Researchers can now provide a better understanding of the interactive effects of the cognitive style construct and instructional format on the acquisition of abstract concepts, involving spatial relations and logical reasoning [10].

Educational researchers are reminded to work towards ensuring their instruction works for people rather than ensuring their instruction works for the technology.

References

[1] Diana, E.M., & Webb, J.M. Using geographic maps in classrooms: The conjoint influence of individual differences and dual coding on learning facts. *Learning and Individual Differences*, **9**(3), pp.195-214, (1997).

[2] Dreyfus, H.L., & Dreyfus, S.E. *Mind Over Machine: The power of human intuition and expertise in the era of the computer,* Free Press: New York, (1986).

[3] Jonassen, D.H., Hennon, R.J., Ondrusek, A., Samouilova, M., Spaulding, K.L., Yueh, P.-H., Nouri, V., DiRocco, M., & Birdwell, D. Certainty, determinism, and predictability in theories of instructional design: Lessons from science. *Educational Technology*, **37**(January-February), pp.27-34, (1997).

[4] Kashihara, A., Uji'i, H., & Toyoda, J. Reflection support for learning in hyperspace. *Educational Technology*, **39**(5), pp.19-25, (1999).

[5] Klausmeier, H.J. Concept learning and concept teaching. *Educational Psychologist*, **27(3)**(Fal), pp.267-286, (1992).

[6] Lindsay, P.H., & Norman, D.A. *Human Information Processing: An Introduction to Psychology,* (2nd ed.) Academic Press: New York, (1977).

[7] Mayer, R.E. The sequencing of instruction and the concept of assimilation-to-schema. *Instructional Science*, **6**, pp.369-388, (1977).

[8] McKay, E. Exploring the effect of graphical metaphors on the performance of learning computer programming concepts in adult learners: A pilot study. *Educational Psychology*, **19**(4), pp.471-487, (1999).

[9] McKay, E., & Garner, B.J. *The complexities of visual learning: Measuring cognitive skills performance.* Paper presented at the 7th International Conference on Computers in Education: New human abilities for the networked society, held 4-7 Nov, Japan. G.Cumming, P.Okamoto & L.Gomez (Eds.), IOS Press: Amstredam,Vol:1, pp. 208-215, (1999).

[10] McKay, E. *Instructional Strategies Integrating the Cognitive Style Construct: A Meta-Knowledge Processing Model (Contextual components that facilitate spatial/logical task performance):* Doctoral Dissertation in Computer Science and Information Systems: An investigation of instructional strategies that facilitate the learning of complex abstract programming concepts through visual representation, Faculty of Computing and Mathematics, Deakin University, Geelong Campus, Victoria. Australia, (2000).

[11] Merrill, M.D., Tennyson, R.D., & Posey, L.O. *Teaching Concepts: An instructional design guide,* (2nd ed.) Educational Technology Publications: New Jersey, (1992).

[12] Merrill, M.D. (1994). *Instructional Design Theory,* Educational Technology Publications: New Jersey.

[13] Neufeld, E., Kusalik, J., & Dobrohoczki, M. Visual metaphors for understanding logic program execution. *Graphics Interface* '97, pp.114-120, (1997).

[14] Pettersson, R. *Using digitial image elements to produce schematic pictures.* Paper presented at the 25th Annual Conference of the International Visual Literacy Association (held October 13-17): Visual literacy in the digital age: Selected readings, New York, (1993).

[15] Reigeluth, C.M. Meaningfulness and instruction: Relating what is being learned to what a student knows. *Instructional Science*, **12**, pp.197-218, (1983).

[16] Riding, R.J. *Cognitive Styles Analysis* : Birmingham Learning and Training Technology, (1991).

[17] Rosch, E. Principles of Cognition and Categorization. In E.Rosch & B.Lloyd (Eds.), *Cognition and Categorization.* Erlbaum: New Jersey, (1978).

[18] Smith, P. *The Development and Evaluation of a Glass-Box Interpreter for Teaching Novice Programmers.* Unpublished Doctor of Philosophy, Deakin, Victoria, Australia, (1998).

[19] Sternberg, R.J. Component processes in analogical reasoning. *Psychological Review*, **84**, pp.253-378, (1977).

[20] Tessmer, M., Wilson, B., & Driscoll, M. *A new model of concept teaching and learning.* Paper presented at the Annual meeting of the American Educational Research Association (March), California, (1989).

Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

Gin-Fon Nancy Ju, Soochow University
70 Lin-Shi Rd. , Taipei , Taiwan, R.O.C.
E-mail : gju@mail.scu.edu.tw

This research was to investigate the current situation of computer network usage, frequency and purposes between university students and occupational groups in Taiwan. The research also analyzed the influences of its related factors on computer network usage, such as computer experience background, the attitudes toward computers, personality, aptitudes, critical thinking ability, academic achievement and so on. The subjects of university students were sampled from the Soochow University. The subjects of occupational groups were sampled from various occupations. The Computer Experience Background Scale and the Computer Attitude Scale were conducted by author for this research. Lai' s Personality Scale, Differential Aptitude Tests and Critical Thinking Appraisal are three published tests selected appropriately by the author and used for the research purposes. Academic achievement in the research was based on the students GPA.

According to the computer network usage of university students, 150 students were sampled in 1997. The network usage was classified into three types of purposes: (1) information searching, (2) BBS, (3) e-mail. The findings were that the students used computer network for searching information the most frequently, then for BBS, for e-mail the least frequently. Besides, the male students significantly used computer network more frequently than the female students, especially for the usage of information searching and e-mail purposes. About computer experience background and the attitudes toward computers, the students who have more computer experience background and who have more positive attitudes toward computers significantly used computer network more frequently where the influences from computer experience background was larger than the influences from computer attitudes.

Since the subjects from the university students can be arranged and administered by the Lai' s Personality Scale, Differential Aptitude Tests and the Critical Thinking Appraisal, and their GPA can be retrieved from the university, therefore, the relationship between computer network usage and personality, aptitudes or critical thinking ability were analyzed. The findings of the Lai' s Personality Scale were that the students who were more objective, less depressed, and less nervous significantly used computer network for information searching purposes more frequently. The students who were

more social types of personality significantly used computer network for BBS purposes more frequently. The students who were more worry and distress significantly used computer network for e-mail purposes more frequently. The Differential Aptitude Tests was found that the aptitudes of arithmetic and abstract reasoning were significantly positively correlated with the frequency of computer network usage for BBS purposes. None of critical thinking abilities was significantly related to the computer network usage. The students' GPA was not found to be significantly related to the computer network usage either.

Since we sampled 110 university students for the same survey again in 2000, the changes of the computer network usage by time sequence were investigated in this research. It was found that no matter the usage of information searching, BBS, or e-mail purposes, the university students in 2000 have significantly more frequency in using computer network than the students in 1997. The university students in 2000 yielded significantly more computer experience background than did the students in 1997 too. However, for the attitudes towards computers, the university students in 2000 did not make significantly difference from the students in 1997. These results indicated that university students always respected the importance of computers in their lives. They significantly used computer network more and more by years. As a matter of fact, computer network will be the main tool to get survived in the future hi-tech world.

For surveying computer network usage of occupational groups, 115 adults were sampled in 1999. It was found that they significantly used computer network for information searching and e-mail more frequently than for BBS. No gender effect was found to be related to the usage of computer network. In addition, the more computer experience background the occupational groups have, the more significantly frequently they used computer network. However, their attitudes toward computers were not significantly related to the computer network usage. The results of age stages showed that the elder people significantly used computer network less frequently than the younger people.

General speaking, the occupational groups used computer network for e-mail purposes significantly more frequently but for BBS significantly less frequently than did the university students. The occupational groups significantly yielded more computer experiences than did the university students. It has to be mentioned here that since we sampled university students and occupational groups in different years, these results might confounded with the time effects. Further research and experimental design were suggested to verify these problems.

Reference

[1] Sternberg, R. J. "Diversifying Instruction and Assessment." Educational-Forum 59, p47-52. 1994

[2] Watson, G. & Glaser, E. M. "Critical Thinking Appraisal." The Psychological Corporation, Harcourt Brace Jovanovich, Inc. 1980

A Real-time Handwriting Communication System for Distance Education[+]

Hsin-Chu Chen* Jho-Ju Tu and Jianping Zhang*****

Department of Computer and Information Sciences, Clark Atlanta University , 223 J.P.Brawley Dr., SW, Atlanta, GA 30314. hchen@star.cau.edu.

*** Instructional Technology Center and School of Education, Georgia Southwestern State University, 800 Wheatley St., Americus, GA 31709. tu@canes.gsw.edu*

**** Department of Computer Science, Utah State University, Logan, Utah 84322. jianping@zhang.cs.usu.edu*

1 Introduction

In this paper we present the design and implementation of a handwriting communication system for real-time graphical information exchange. This system provides an environment for a user to write and erase messages on a computer screen using a light pen or a mouse and to transmit the handwriting message to another user on the Internet in real time. The communication techniques employed for the system include the basic client-server model and peer-to-peer model. The client-server model is mainly for sending handwriting information using the world wide web. The peer-to-peer model, however, is aimed at real-time communications between two end users on the network to conduct instant dialogues. The system is implemented using Java . It can be integrated into many different applications such as collaborative learning, on-line discussions, and distance education.

2 Communication Models

A handwriting communication system may be implemented using a client-server or a peer-to-peer model. Each model has its cons and pros. The client-server model, in which the client sends requests to the server and the server responds to the request [3], works well in situations when immediate responses are not necessary. For a real-time instant dialogue or information exchange, however, the client-server model alone is somewhat restrictive due to its limited degree of interactivity. To achieve a full degree of interactivity for this type of applications, a peer-to-peer model that allows for full duplex real-time communications is more appropriate, since the two end users of the system may send and receive information at the same time, roughly speaking.

In addition to communication models, we must also take into account the nature of the communication protocols and decide which to use. Information exchange carried over the Internet normally requires support from either TCP or UDP, which are the two protocols operated at the transport layer in the TCP/IP protocol suite [1]. When TCP is employed, the information is sent as a data stream, similar to a telephone conversation. Since TCP requires a connection setup prior to transferring data, it incurs an initial time delay. UDP, on the other hand, does not require such a connection setup. However, the delivery of datagram packets, which are independent data units sent individually from the source to the destination, is not guaranteed. Datagram packets may arrive out of order too. For textual information, UDP may not be a bad choice because the user normally can tolerate, to certain degree, occasional loss of packets or misplaced textual data. In our handwriting system, the handwritten information is represented as numerical data which are sensitive to the loss of any single bit of information, therefore, TCP is our natural choice.

[+] This work was supported in part by the Army Research Laboratory under grant DAAL01-98-2-D065.

3 System Design

Our design philosophy for the development of the handwriting portion centers around the following principles: interactivity, functionality, reliability, user-friendliness, and portability. A handwriting communication system must possess two important capabilities. The first is the ability to support the writing by a light pen, or a mouse if such a pen is unavailable, and the display of the handwritten data. The second capability should allow users to transmit and receive handwritten data from the network. To achieve these goals, a friendly graphical user interface, which requires the use of abstract windowing toolkit and event handling, is a necessity. In order to make the system a useful communication tool on the Internet, it must support both textual and graphical information exchanges. The system must also provide functions for users to overwrite or modify handwritten message received over the network. In addition, the programming language used for implementation must be platform independent so that the system can be easily ported to other machines with different operating systems.

4 Description of the System and its Applications to Distance Education

As mentioned earlier, we use Java [2, 4] as the programming language and TCP as the transport protocol for transferring handwritten data in our current client-server communication system. A graphical user interface consisting of buttons, radio check boxes, and a handwriting area, as well as the operations associated with the interface have been developed using the abstract windowing toolkit. All main tasks of the system are invoked from within the event handling functions. Our system currently allows users on the Internet to exercise handwriting from within a web page that contains the client code and send the information to the server that accepts the handwritten data. It can also be used to enhance online presentations over the Internet. This is due to the fact that the system allows users to perform handwriting directly on the specified writing area in a web page. By putting the presentation material inside the handwriting area, it is possible to add notes, make corrections, highlight important subjects on the spot during the course of the presentation.

The handwriting communication system has many applications in distance education and on-line collaborative learning. It can be used by an instructor to deliver on-line lectures via the web; the instructor may use one part of the screen to present prepared presentations and another part to highlight the important points of his/her presentation using a light pen. It can be used by fellow students in different locations to solve problems collaboratively and work on team projects. In addition, the instructor and students can use it to conduct on-line class discussions and answer student's questions by employing the communication capability.

5 Conclusions

In this article, we have presented the basic approaches, design considerations, and implementation of a real-time handwriting communication system on the Internet as well as its applications to on-line education. Our design philosophy centers around functionality, interactivity, portability, and user friendliness.

References

1. Andrew S. Tanenbaum, "Computer Networks", NJ: Prentice Hall, 3rd Edition , (1996).
2. David Flaganan, "Java in a Nutshell, Sebastopol", CA: O' Reilly & Associates, (1996).
3. David Gunter, et al., "Client/Server Programming with RPC and DCE", IN: Que, (1995).
4. Patrick Naughton and Herbert Schildt, "JAVA: The Complete Reference", CA: McGraw-Hill, (1997).

Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Robert M. Corderoy* **and Paul Cooper****
*Centre for Educational Development and Interactive Resources
E-mail: bob_corderoy@uow.edu.au
**Department of Mechanical Engine :ing, Faculty of Engineering
E-mail: paul_cooper@uow.edu.au
University of Wollongong. Australia

A well designed PBL environment can assist and support students in building heuristics that will enhance their ability to solve problems in the real world. Problem based learning is situated in the context of a meaningful 'real world' based environment which draws on 'real variables' without the 'risk factor' normally associated with everyday practice. It poses an ill-structured, 'real world' based problem which drives the learning. Posing the problem before learning takes place provides relevance, challenge and interest, and is a powerful motivational strategy. This paper reports on the development of an on-line, problem based learning (PBL) environment (the VECC) in which students develop and practice engineering consultancy skills. Evaluation of the pilot implementation with 3rd year Engineering students at the University of Wollongong is briefly outlined. The VECC models the skills and processes of an 'expert consultant' "a professional engineer" in the field of Heat Transfer within a supported learning environment so that 'novice' student's develop appropriate problem solving skills vital for their later engineering practice. The power of a web-based environment to provide platform which supports both synchronous and asynchronous computer mediated communication enables students to interact with a virtual client in an environment which is "safe" and highly flexible.

Key Words: **Problem based learning, virtual environments, problem solving, consultancy, virtual client.**

1 Introduction

Traditionally, students graduating from engineering courses have had limited if any exposure to the wide range of practical skills centred on 'real world' contextualized problem solving and client contact which engineers must have 'in the filed' to be successful. There are many reasons for this, often based in the pedagogical approach characteristic of the institution in which they are trained. Providing a 'risk free' and cost effective environment in which students may develop and practice such skills is perhaps the other major influencing factor. A possible solution to this impasse is to provide a means of developing and practicing these skills using simulated environments.

Universities and other tertiary institutions throughout the world are rushing to embrace alternative delivery methods, particularly those that utilise the versatility and power of the World Wide Web. This is in response to the globalisation of education, the recognition of the need to provide mechanisms which will maximise opportunities for and support life long learning and the need to expand the boundaries to encompass educational experiences which are set in 'real world' contexts. The scope and boundaries for what is possible in such environments is limited only by the imagination of developers and the limitations of the web in its

present form. The web is a dynamic medium whose boundaries are being extended almost daily.

Further, suggests Burnett (1997) [3], the use of the Web will continue to expand as it becomes more stable, easier to use and more accessible to everyone. What we are learning from using the Web today will provide the confidence and expertise to take advantage of the advances in its technology. Now is the time according to Alexander (1995) [1] to stop focussing on the technology itself and to start focussing on what students are to learn, and the best way for them to achieve these learning objectives. This indeed was one of the key issues of "Secrets of On-line Teaching".

In recent times many of these institutions have experimented with the use of on-line delivery with the purpose in mind of extending access to educational experiences to a wider audience on a any time, any place basis. In many cases, the results have been less than satisfactory and have fallen short of student expectations for a number of reasons. The problem is exacerbated by a number of factors. These include: time and funding restraints; the often unjustified self perception of expertise in the field and the mistaken belief by many that, putting a subject or teaching resource on-line involves little more than providing content as a web based document. Given that this situation will probably not change in the foreseeable future, how can we as teachers/designers/developers ensure that our web-based resources are effective, efficient and supportive life long learning?

"An understanding of the techniques and protocols of on-line teaching and learning and the processes of both the design of new and the conversion of pre-existing resources has become essential for academics, as universities throughout the world embrace alternative delivery methods in response to the globalisation of education." Corderoy & Lefoe (1997) [5]

2 Design Issues for On-line learning Environments

An integrated online environment such as the VEEC provides a set of tools, systems, procedures and documentation that facilitates the occurrence of any or all parts of the learning experience using some form of computer mediated communication. Moving to web based delivery of a subject or any aspect of that subject will carry with it the need for both the designers and the teachers to recognize and act on the many issues associated with such environments.

The logistics of setting up and running this type learning experience mirrors the issues that are addressed in setting up any on-line course. In general the issues can be identified as belonging to three basic categories identified in any on-line learning environment, namely technical support, pedagogical and equity issues.

Some of the more important issues include:

- Interface easy to use and navigate
- Bandwidth limitations
- Security and submission of work
- Equity of access to the technology
- Unfamiliar format for some - provide time to adjust
- Lecturer's participation - make regular contact - ensure all have accessed by a certain time
- Lecturer's willingness to moderate/facilitate collaboration
- Consider cultural differences
- Work load changes for lecturer
- Perceived inequality of experience

Of these, the authors single out technology problems including access, interaction and communication and workload as being crucial to successful learning outcomes for students working in on-line environments

2.1 Technology

The students need to be 'trained' in the basic use and operation of the technology before they start and this is often best achieved by 'face to face' instruction at the start of session. As a good rule of thumb, problems are minimised by designing to the 'lowest common denominator' in terms of available technology. Related to this aspect is the equity issue of student access.

2.2 Interaction/Student Participation and Enthusiasm

One of the most significant challenges for those using on-line teaching environments is the 'silent student'. Ensuring that the students engage in the learning is closely related to the degree of interactivity fostered between students and their peers as well as between the students and the instructor. Success in the latter is dependent upon an instructors commitment to providing 'rapid feedback' to submitted tasks and posed questions as well as regular personal 'checking in' on-line. Such commitment provides an incentive for all students to be active and enthusiastic.

2.3 Resources/Time and Workload

There is a need to consider carefully the design and structuring of on-line environments, particularly those which already exist in a traditional format. Content cannot be simply 'placed on the web'. Time and effort must be spent in considering the resources and structure needed to best present the materials in the 'new environment'. Developing materials for on-line delivery is not an easy or short process. Both the teacher and the students must be committed to accepting a greater workload as a trade-off for the value of working in an environments which mirrors 'real life' situations and skills application.

3 Developing the VECC

The VEEC has been developed on a sound pedagogical basis using a team approach, utilising the specific skills of each team member. The Faculty of Engineering and the design/development team at the Centre for Educational Development and Resources at the University of Wollongong, Australia, have been involved in the development of a prototype over the past 18 months. The VECC is a highly interactive and innovative web based simulated consulting environment, based in the 'real world' problems and processes usually associated with the task of a professional consulting engineer in the area of Heat Transfer. It provides an environment which models the 'experts' heuristic's for solving the problem, facilitating the development of an appreciation and understanding of the application of the skills and processes needed in a real world consultancy in the 'novice' student. The result will be a graduate engineer who is better prepared for the 'real world' engineering practice.

This flexible, web delivered, student-centred resource provides not only training in specific technical area, but also orientation and experience in professional practice. This type of advanced training has been demonstrated to have significant benefits to students entering the workforce. Ryan *et al.*, (1996) [8]

The framework of the VECC package is modelled on the resources that one finds in a real engineering consultancy office. The consultant in such an office will have developed an expertise in their chosen field - in this case Heat Transfer - and will also undertake continual professional development. This CAL learning environment will therefore foster a positive attitude in students towards lifelong learning. Candy *et al.*, (1994) [4]

The Industrial Problem Solving Assignments are the main educational vehicle for building students' confidence in tackling real world situations and complex tasks. This feature differentiates the VECC from other engineering CAL packages. To quote Laurillard (1993) [6], "we cannot separate knowledge to be learned from the situations in which it is used". In the VECC, students will immediately see the relevance of the engineering theory to be used, since they must actively search for the appropriate theoretical model. That search is the same process the student will eventually use as a practicing professional engineer.

When using this resource the student role-plays a consultant who carries out all the managerial and technical tasks required to expedite a number of high-level Industrial Problem Solving Assignments. This problem-based learning approach "confronts the students" Boud *et al.*, (1991) [2] with 'real world' based ill-structured problems and scenarios which provide a stimulus for learning and in so doing "encourages the students to take a deeper approach to learning". Ramsden (1992) [7]. The PBL approach enriches the learning outcomes by simultaneously developing higher order thinking skills and disciplinary specific knowledge bases and skills. It promotes the student to the active 'practitioners' role in the process.

The consultant's activities include:

- negotiating with the client on cost and timetabling of the consultant's services
- obtaining the client's technical brief and tendering for the project
- sourcing technical information such as plant dimensions
- making on-site measurements of temperatures or other parameters
- student-centred learning through the Computer Aided Learning (CAL) module integral to the Virtual Engineering Consultancy Company
- simulation of real-life problems using a toolbox of simulation resources.

4 Expected Outcomes

The most significant expected outcomes for students using this web-based package include:

- A PBL based CAL resource that provides Engineering students with training in professional practice as consultants in Heat Transfer Engineering through 'virtual access' to 'virtual clients'.
- The simulated 'real world' environment that the web provides will provide them with a better understanding not only of the processes involved in professional Engineering practice but also the relationship between the Engineers and client.
- Improved effectiveness of delivery to a diverse student population of full-time, part-time and off-campus students.
- Improved skills in collaborative working and negotiation.
- Improved attractiveness of University of Wollongong Engineering graduates to potential employers.
- Flexibility in terms of meeting the course requirements with regard to time and place and individual learning styles.
- Improved opportunity for students to be active members of the cohort in all facets of the course.

5 The Pilot Virtual Engineering Consultancy Company (VECC)

To date the fundamental structure of the VECC and a substantial number of software resources (including interactive Heat Transfer simulations) have been developed. The complete package will eventually contain in excess of 30 simulations which will support and develop the students understanding and proficiency in aspects of Heat Transfer including: furnace insulation; steel quenching; conduction and boiling heat transfer.

Extensive work has also been carried out on the structuring of the 'theory section' of the package. Consideration has been given the 'chunking' of this considerable resource so as to provide a meaningful resource for the students while at the same time being 'easily accessible' within a web based environment.

The centre of the VECC resource is the consultant's office (Fig 1) that models a typical engineering office in the real world and has facilities including:

Fig 1: The VECC Consultancy Office

In summary, the VECC resource will eventually comprise three main Modules;

BEST COPY AVAILABLE

- **Training (CAL) Module** - the student uses resources such as simulations, text-based material, videos, animations, etc to learn the fundamentals of Heat Transfer theory.

- **Trouble-shooting Module** - here the student has to solve challenging real-life problems that are far more in-depth than conventional engineering assignments. In an example already developed, the student's client is a corporation that has just built and commissioned a large hydrogen production furnace. The furnace is overheating and the student must find out why, suggest remedial measures and act as an expert witness in a court case.

- **Design Module** - Students design a number of pieces of thermal equipment to satisfy a specification from their client. Examples will include a transistor heat sink and car radiator. The detailed design of thermal equipment is not a topic normally covered in an undergraduate course on Heat Transfer perhaps because it requires a problem-based learning approach and yet it can be one of the most rewarding aspects of an engineering student's study.

- A **project management whiteboard** that will be automatically updated as a student progresses through the study programme.

- A **laptop computer** which is the virtual gateway to the web and provides contact with the clients (the lecturer) for each project, resources external to the VECC and the brief containing full technical details. (Appendix 1)

- A **video monitor** for access to video clips of site visits, illustrative fluid visualisation experiments, lecture presentations, etc.

- A **desktop computer** which represents a powerful computing resource where the heat transfer simulations are located. These already include four unique simulations of important conduction heat transfer situations. Each simulation deals with a real world problem and will be used as part of the consultant's exploration of the case studies.

- A **telephone** for initial contact with the consultant's clients achieved using an audio track.Hello, Chris Garbutt here. I'm the Engineering Manager of Heat Treat TM. Our company deals with a large variety of construction projects involving thermal and chemical processing. We struck some heat transfer problems with one of our projects involving a furnace that is not operating as was planned and we're asking your consultancy firm, along with others, to tender for a trouble shooting role in fixing the problem.

  If you are interested in taking on this challenging consultancy, a brief containing full technical details of the project at our company's web site can be accessed through your laptop computer. I hope you can help us out. Please E-mail me if you have any queries. Bye for now.

- A **virtual library** of books which is the link into the CAL module where the student explores the topic of Heat Transfer through the problem-based learning approach of the VECC.

6 Pilot Evaluation

Students who took part in the pilot implementation had access to a limited prototype version of the 'complete' site. At this stage of its development, some of the segments of the VECC exist as discrete units that are independent of the overall structure. It was expected that this may cause some navigational/continuity problems for some students, however early anecdotal evidence collected from the students seems to suggest that this was not the case. Approximately 80 3rd year engineering students (20 groups comprising 3 or 4 students each) used the VECC to complete a major assignment during semester 1. Each group consulted in various degrees with the client using the E-mail link, used the various resources available within the consultancy office to support their investigations and develop their 'solutions' to the 'posed problem'.

Data collected during this pilot includes: student interviews and comments including a special forum where technical issues and the learning processes were discussed; lecturer's observations; archived E-mail communication between the lecturer and students and; individual marks awarded to students together with the lecturer's 'quality of answer' evaluation.

6.1 The Students' perceptions

Comments made by students to the lecturer include:

- convenient and easy to use;
- provides for flexibility in their study schedules;
- provides access to a greater richness of resources;
- helped them develop an understanding of the issues critical to client management;
- motivating;
- provides time to consider actions and issues
- allowed them to develop collaborative networks
- use of a real world problem put the theoretical concepts learned and the analytical skills developed into the context of their future activities as professional engineers and;
- comfortable working in this delivery mode.

6.2 The Lecturers' perceptions

Although at this early stage in development there is no longitudinal data for comparison, the lecturer is confident that data to be collected during the continued development and use of the VECC will support and re-enforce observations made so far including:

- overall performance of the majority of groups is better than past years, not just in terms of the overall mark but in the quality of the answers;
- role play appears to have contributed to a deeper understanding of the problem and possible solutions and enriched the learning experience;
- there has been no change in the completion rate, the number of students 'opting out' is about the same as usual;
- students who took full advantage of this support by contacting the 'client' (lecturer) performed better than those who did not;
- seems to be a time efficient way of presenting both the technical information and the processes involved in consultancy in a richer environment;
- flexibility for both students and lecturer is a 'real plus' and;
- the students seemed to be more motivated and this is reflected in their willingness to explore the resource base fully, developing better quality answers.

7 Future directions

There are several issues unique to technology based delivery which need to be investigated with respect to the VECC. The student groups had minimal exposure to the 'structure' and process of the VECC in lectures. Did this add to the cognitive load placed on them so that unnecessary effort was expended on learning about the system, rather than from it? Experience shows that with poor design, there can be an enormous increase in the cognitive load for students and the result is a poorer outcome than expected. To address this, it is envisaged that an extensive help system will be provided within the package. Specific lab sessions prior to using the system will also be run to allow students time to become familiar with the package. Such 'user support' mechanisms are an essential part of complex learning systems and it is essential that all students avail themselves of it. Ensuring that they do is one of the keys to facilitating useful student interaction with the learning environment. The issue of preferred learning styles and the 'students' fit' to the delivery mode needs to be explored.

8 Conclusion

Flexible modes of delivery such as Web based instruction can provide an effective means of addressing the problems of increasing student demands, decreasing funds, the need to establish a presence in the

international market place and rapid technological change. The rapid rise in the development of sophisticated and improved technologies has been the driving force behind the widespread embracing of the concept of flexible delivery and the application of the many and varied tools upon which it is based in the field of education and life long learning. The VECC is a web based flexible learning tool which provides students with 'real world' based experiences in professional practice. Early indications suggest that students are benefiting from this virtual consultancy learning environment which uses a problem based learning approach to develop the skills which are vital to engineering practice in the real world.

References

[1] Alexander, S. (1995) Teaching and learning on the World Wide Web. *Proceedings of AUSWEB95 The First Australian World Wide Web Conference*, Southern Cross University, Lismore. Australia.

[2] Boud, D. & Faletti, G. (1991) (eds) The Challenge of Problem-Based Learning. Kogan Page, London.

[3] Burnett, D. (1997) TiLT Seminar Series – Confessions of an Online Teacher. http://www.scu.edu.au/services/tilt/tsf/on/dale/bsemsummary.html

[4] Candy, P. Crebert, G. & O'Leary, J. (1994) Developing Lifelong Learners through Undergraduate Education. *NBEET Report No 28*, Canberra.

[5] Corderoy, R. M. & Lefoe, G. (1997) Tips and Secrets for Online Teaching and Learning: An inside View. *Proceedings of ASCILITE 97*. Perth.

[6] Laurillard. D (1993) Rethinking University Teaching: A framework for the effective use of educational technology. Routledge. New York

[7] Ramsden. P. (1992) Learning to Teach in Higher Education. Routledge, London.

[8] Ryan G, Toohey, S. & Hughes, C. (1996) The purpose, value and structure of the practicum in higher education: A literature review. *Higher Education 31*, 355-377.

Appendix 1

YOUR BRIEF

Heat Loss Calculations

If you choose to accept this assignment HeatTreat requires you to:

- to calculate the total heat loss from the furnace walls and roof (as a first approximation assume a outside surface heat transfer coefficient to be $20W/m^2$ including both convection and radiation heat transfer)
- to calculate the interface temperature between the Zirconia Blanket and the Mineral Wool to ensure that the latter does not overheat.

Surface Temperatures

The client has measured outside temperatures on the outside of the furnace to be in the range of 105 to 170°C. These are potentially very hazardous. You must perform the following tasks. A map of some of the surface temperature measurements is shown below.

Outside Wall Temperatures

Furnace level	1	2	3	4	5	Floor
Mean outside surface temp (°C)	75	64	68	70	68	52

a) Carry out a sensitivity analysis of one of the wall the surface temperatures to the outside heat transfer coefficient (calculate the expected radiation heat transfer coefficient assuming emissivity, $\varepsilon = 1$, and then vary the convection heat transfer coefficient in a range that would be expected under normal weather conditions ie between 5 and $20W/m^2K$, say).

b) Determine whether the firebrick insulation shown in the design drawings is likely to have been put in place correctly (if the insulation has not been properly installed legal action may be taken against the insulation installation sub-contractors). Assume the flue duct wall temperature is equal to the gas temperature of Section 6 of the furnace.

c) Recommend a solution to these high surface temperatures problems. Some possibilities include:
Add extra insulation to outside of furnace (you must calculate how much must be added and whether the resulting temperature of the structural steel is within acceptable limits).
Shut down furnace and replace internal insulation in problem areas (very much a last resort represents a very high cost option).?

Summarise your recommendations.

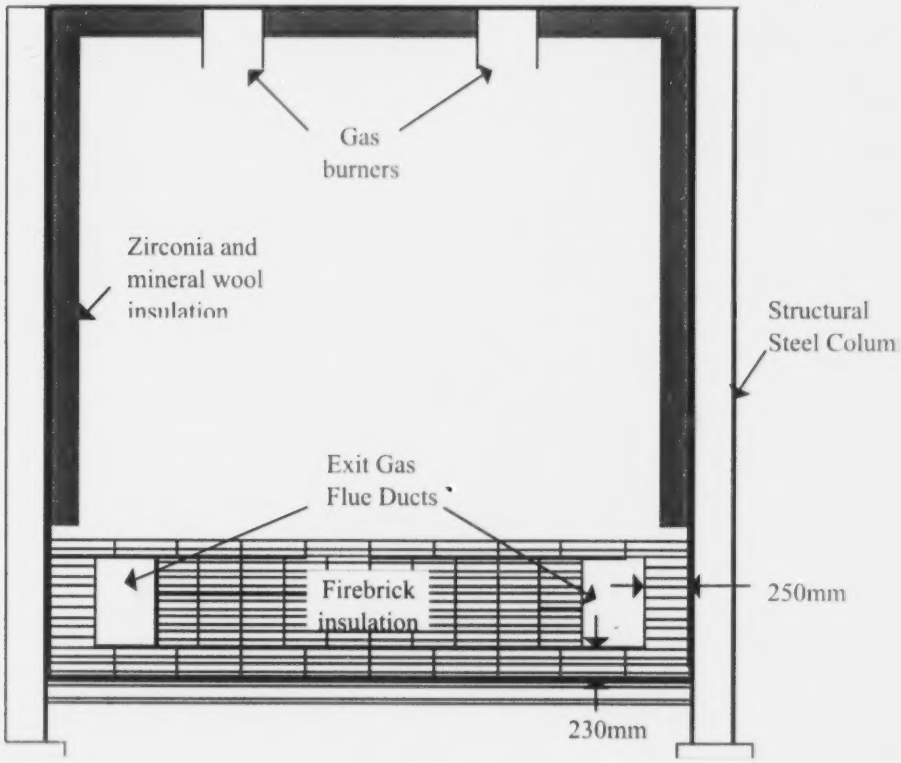
Further information

It is up to you to source any further information that is required. Local sources of information include:

- the training module "Conduction Heat Transfer" on your desk
- thermophysical data of various materials in the appendix of "Conduction Heat Transfer"
- simulations and video footage available on the desktop computer and video screen.

Remember that obtaining relevant information is often a critical task in high level engineering work and decision making.

If you require specific information on this Brief please contact your client at the following E-mail address. Paul_Cooper@uow.edu.au.



Layout of furnace insulation and structural steel.

Students' thinking processes when learning with computer-assisted mass lectures.

Nopphol Pausawasdi* and Dr Lyn Henderson**
School of Education, James Cook University,
Townsville, Queensland 4811, Australia
Phone: 617 4781 6984
Facsimile: 617 4725 1690
*Email: *Nopphol.Pausawasdi@jcu.edu.au,*
***Lynette.Henderson@jcu.edu.au*

This paper presents findings from a research project that examined students' thinking during mass lectures that utilized interactive multimedia (IMM). The data were obtained from six second year Thai medical students via stimulated-recall interviews. The reported thinking (or mediating) processes engaged in by the students during the mass lectures that related to the academic content of the physiology subject are detailed and discussed. We identified 18 different types of thinking skills including generating, anticipating/predicting, linking, metacognition, analyzing, and categorizing. These ranged from a high usage frequency (generating) to a low usage frequency (categorizing). Being able to understand such student thinking may result in more effective use of IMM in mass lectures. The data are also compared with studies that provided students' reported thinking processes when studying with the WWW, IMM, and text-based material. The significant differences in the mediating processes between using IMM in computer-assisted mass lectures, where the students did not directly interact with the IMM, and hands-on use of IMM, the WWW, and text-based material are discussed.

Keywords: **Thinking skills, Computer-assisted mass lecture, IMM, medical education, Thai medical students**

1 Introduction

There is increasing use of IMM in mass lectures in universities for teaching and learning. Yet IMM supported lectures do not guarantee better content learning or higher-order thinking than do traditional instruction methods. There is much research and literature concerning instructional design, the characteristics of IMM, and learning: for instance, the use of educational technology [1] and the effects of colors [2], animations [3], and interactivity [4]. Research has neglected how students engaged with the new technology in lectures. The research by Nowaczyk, Santos, and Patton [5] examined student perceptions of various characteristics of multimedia such as color transparencies, video, and PowerPoint in tutorials and mass lectures. However, they did not investigate students' thinking processes about the academic content. The research by Faraday and Sutcliffe [6] examined visual attention and comprehension of multimedia presentations. Research by Putt, Henderson, and Patching [7] and Henderson, Putt, Ainge, and Coombs [8] examined learners' mediating process about the academic content of IMM and WWW courseware, respectively. However, these did not focus on an IMM mass lecture context.

Studies report that IMM can be effective in encouraging higher order thinking skills when learners work with IMM individually or, better still, in pairs or small groups [9, 10, 11]. However, in a mass lecture, the IMM is controlled by the lecturer. Learners play a passive-receiver role. Are they focused on the content? What sort of thinking about the content do they engage in?

Heeding current literature in the field [1, 12, 13], the study does not aim to ascertain whether learningwith

IMM supported lectures produces better learning or test outcomes than traditional lectures. Rather, it utilizes qualitative methodologies to ascertain the students' thinking skills as they learned in the authentic context of a lecture theatre. Thus the study sought to:

(a) identify and categorize the thoughts concerning the content of the IMM supported lectures that were reported by the students;

(b) compare the mediating processes reported in the computer-assisted mass lecture study with those reported in research which identified the reported mediating processes that occurred in three studies where students had hands-on use of IMM software, WWW courseware, and text-based materials respectively; and

(c) with respect to (b), evaluate our hypothesis that the type of interaction with the learning materials would be a significant factor, that is, the lack of direct manipulation of the learning materials would result in lower percentage frequencies of reported mediating processes (our study) compared with those reported in the other studies that had direct hands-on interaction.

2 Methodology

Much existing research data regarding the efficacy of computer mediated environments is anchored in the process-product paradigm. The paradigm is based on the assumption that instructional stimuli give rise to learning outcomes. Recognition of the simplistic nature of this general cause-effect paradigm when applied in education, led to the adoption of the mediating process paradigm that focuses on student thought processes that mediate, or come between, instructional stimuli (the IMM supported lecture) and learning outcomes [14]. Mediating processes can be viewed as the fine-grained elements of cognition through which, and by which, learning outcomes are realized. Thus, learning outcomes are the function of the mediating processes activated by instructional tasks and other learning activities. Salomon [11] describes the contrast between analytic research that is focused on isolating effective instructional treatments and systemic research focused on understanding how instructional treatments work in practice. This study embraced systemic research focussing on the sorts of thinking that tertiary students engaged in during IMM supported lectures.

It is a qualitative study utilising stimulated recall interviews to ascertain students' thinking in authentic contexts. Learning is related to the quality and quantity of thinking undertaken by learners [15]. To categorize and tabulate students thinking skills, a process-tracing methodology is utilized. It involves appropriate self-reporting techniques through using a video to stimulate recall of cognitive processes engaged in during a learning/study session. The stimulated recall interview technique follows strict guidelines [14]. Triggered by such things as the students' non-verbal actions or what is appearing on the computer screen, non-leading questions are asked, such as: "You seemed to frown; can you tell me what you were thinking?" and, in order to confirm that the reported thought occurred during the learning session and not while being interviewed, "Did you think that then or just now?" Both the interviewer and students can stop the video when they believe something is significant and, for the student, when the video triggers a thought that he/she had had during the initial study session. This method has been used in different settings with different mediums and with individuals, pairs, and small groups [7, 8, 16, 17, 18].

2.1 Context, Participants and Data collection

The research context and methodology capitalize on authenticity [11]. The students' thinking processes were obtained in realistic, ecologically-valid situations as the data were collected from students working in their regular environment. Thus for the current study, the research was conducted with a physiology class in a mass lecture theatre, Faculty of Medicine Siriraj hospital, Mahidol University, Bangkok, Thailand. The lecturer used A.D.A.M., The interactive physiology-muscular system [19] in the one hour lectures. Two lecture sessions were video recorded. Six students volunteered to participate in the stimulated-recall interviews. There were four males and two females with ages ranging from 17 to 19 years. They were in the third semester of a six year Medical degree. The six participants self selected into 3 pairs, 2 male pairs and 1 female pair. Working in pairs was the favored study practice of these Thai medical students. The first male pair was interviewed after the first lecture session; the others after the second lecture session. The content of both lectures was the same topic and used the same IMM. All six participants attended both lectures.

The interviews were conducted with one pair at a time. The interviewer and each pair of participants together viewed a videotape of the lecture and a synchronized computer screen showing the A.D.A.M. IMM software that was used in the lecture. The video picture included the lecturer's verbal and non-verbal behaviors and the content of the computer-assisted lecture. The computer screen showed the A.D.A.M. IMM

software content which appeared on the videotape. Both videotape and computer screen facilitated the participant's recall and verbalization of their thinking during the lecture. The three stimulated recall interviews, one hour duration for each interview, were conducted immediately after the lecture sessions and were audio taped for later transcription and analysis.

3 Results

From the interview transcripts of the students' stimulated recall interviews, their thinking skills were identified, categorized, and then analyzed. Both authors together identified the thoughts from the first transcript. The others, they did individually. Then the data from each researcher were compared and discussed. Consensus was achieved when disagreement occurred. The data that were considered invalid, such as student's thinking that did not occur during the study session, the reports of students' activities that were not related to their thinking, and answers where the interviewer had led the student, were identified and discarded. Only students' thinking that occurred during the study session were identified as useable data.

The students' thinking data reported by participants were classified according to the mediating processes identified by Henderson, et al. [8]. The 18 mediating processes identified in our study are listed in Table 1 which provides a definition for each thinking skill and a clarifying example of each from the data.

Type	Description	Example
	Mental activity in which a student -	
Affect	reports feelings aroused by content during study	"He [the lecturer] clicked A. I was glad. My answer was correct."
Analyzing	Reduce, breaks down whole (e.g., problem, task) into parts	"I've learned that content. There were some new parts adding to it. The rest was old."
Anticipation	predicts or states expectations that problem, question, or textual feature will be encountered; wonders about: the possibility of an event, relevance of material, content	" He [the lecturer] was talking about timing. So, I thought ahead that it must higher. And when stimulated, a bit slower - it would be lower."
Applying	Considers the use of an idea, tactic in a different context.	"When I saw the clearer image, I thought they should use this technique in the textbook because it can't use animation."
Categorization	Sorts items, ideas, skills into different groups	"I thought I already noted this as asynchronous."
Comparison	identifies similarities, differences between two statements, concepts, models, situations, ideas, theories, points-of-view, etc.	"From the graph shown on screen, I thought it would appear in another way."
Confirmation	judges that ideas in text support one's own beliefs, practices, tactics	"When he [the lecturer] clicked, I just thought that one is correct."
Deduction	reasoning process by which a specific conclusion necessarily follows from a set of general premises	"I felt the image doesn't look real because the vesicle [4small bags within a larger bag] has just 4 bags and the water filled this space."
Deliberation	engages in "thinking" about a topic, prose segment, etc. (type of thinking not disclosed)	"I was thinking about the question."
Diagnosis	identifies strengths and weaknesses in idea, strategies, points-of-view	"I thought it made me understand better by cropping and enlarging the picture. So I can see it clearly"
Evaluation	makes judgments about the value, worthwhileness of textual materials, activities, in-text questions, own position or point-of-view	"I thought the topic shown at the top was good. It told me what I was going to learn."
Generating	formulates one's own questions, examples, ideas, or problems; interpolating; going beyond the data	"What does the handle look like? Stimulate by hands! Do we use hands to do that?"
Imaging	creates a mental image of an idea in text in order to gain a fuller understanding	"I thought about the real muscle and how it should look if I cut it"
Linking	associates or brings together two or more ideas, topics, experiences, tasks	"I thought about the frog's leg in the laboratory."
Metacognition	thinks about, reflects on, evaluates or directs own thinking	"I couldn't see the shrink in the first animation. I thought I need to focus more on the next one"
Recall	brings back into working memory an idea, opinion, fact stored in long-term memory	"This picture, I thought I learned it before."
Reflection	general indication of careful consideration or thought over past action and response; tries to establish the reason or causal link between the action and its response	"When this graph was shown, I thought the latent period is narrow. At first, I thought it would be wide and red like the previous one."

Strategy Planning	plans ways of processing or handling content material during study or learning sessions	"When I saw these, I would open the textbook. I did not wait. I would note the additional information in the textbook."

Table 1: Mediating Processes Identified in the Present Study

Note: Descriptions are adapted from Marland, et al. [14] and Henderson, et al. [8]; examples are from the current study.

The frequencies for each type of mediating process were tallied (Table 2). The data in Table 2 indicate the frequency of the 18 identified mediating processes. The data shows the different frequency of mediating processes between three pairs and the variation in the frequency of occurrence of mediating processes. These ranged from

Categories of classification	*Mediating Process (i.e., thinking skills)*	*Frequency (1st male pair)*	*Frequency (female pair)*	*Frequency (2nd male pair)*	*Total*	*Percentage (%)*
Content	Generating	3	19	11	33	14.5
	Anticipating/Predicting	1	10	20	31	13.7
	Linking	2	14	11	27	11.9
	Metacognition	11	7	6	24	10.6
	Evaluating	6	7	7	20	8.8
	Strategy Planning	0	6	10	16	7.0
	Recalling	8	3	4	15	6.6
	Affective	3	2	9	14	6.2
	Confirming	0	4	5	9	3.9
	Deliberating	1	2	6	9	3.9
	Diagnosing	6	1	2	9	3.9
	Imaging	0	0	7	7	3.0
	Reflecting	1	6	0	7	3.0
	Comparing	0	3	1	4	1.4
	Applying	1	1	0	2	0.9
	Deducing	1	0	1	2	0.9
	Analyzing	1	0	0	1	0.4
	Categorizing	0	0	1	1	0.4
	Total thoughts	45	85	97	227	100
	Mean number of mediating processes per pair from 3 pairs		76		based on responses	

Table 2: Frequency of Mediating Processes Related to Academic Content.

14.5% for "generation" to 0.4% for "analyzing" and "categorizing". A total of 227 mediating processes were identified from the transcripts. The mean number of reported mediating processes per pair was 76. The first male pair who were interviewed after the first lecture reported 45 mediating processes. The other male and the female pair who were interviewed after the second lecture reported 97 and 85 mediating processes, respectively. Familiarity with content and presentation probably influenced the higher number of thinking processes during the second lecture.

Mediating processes	*This study:* IMM in mass lectures (%)	*Study by Henderson, et al., (1997):* IMM study (%)	WWW study (%)	Text-base study (%)
Generating	very high (14.5)	high (8.4)	very high (10.1)	Low (3.6)
Anticipating/Predict.	very high (13.7)	high (7.8)	very low (1.4)	high (5.9)
Linking	very high (11.9)	very high (11.4)	very high (11.5)	very high (10.4)
Metacognition	very high (10.6)	very high (19.8)	high (9.4)	very high (12.4)
Evaluating	high (8.8)	very high (18.0)	very high (26.5)	very high (18.6)
Strategy Planning	high (7.0)	very low (1.8)	high (7.7)	very high (16.8)
Recalling	high (6.6)	high (6.6)	very low (1.0)	low (4.1)
Affectjve	high (6.2)	very high (14.4)	high (9.4)	high (7.8)
Confirming	low (3.9)	Very low (1.8)	low (4.5)	very low (2.8)
Deliberating	low (3.9)	very low (1.8)	very low (2.8)	none (0.0)

Diagnosing	low	(3.9)	none	(0.0)	low	(3.1)	low	(0.26)
Imaging	low	(3.0)	very low	(0.6)	very low	(2.4)	none	(0.0)
Reflecting	low	(3.0)	none	(0.0)	very low	(0.003)	none	(0.0)
Comparing	very low	(1.4)	low	(4.8)	very low	(2.1)	very low	(1.5)
Applying	very low	(0.9)	none	(0.0)	none	(0.0)	none	(0.0)
Deducing	very low	(0.9)	none	(0.0)	very low	(1.4)	none	(0.0)
Analyzing	very low	(0.4)	very low	(2.9)	none	(0.0)	very low	(1.1)
Categorizing	very low	(0.4)	none	(0.0)	very low	(1.0)	very low	(0.005)

Table 3:Comparative students' mediating processes frequency between this study and the study by Henderson, et al. [8]

The data in Table 3 show the variation in the frequency of occurrence of mediating processes in our study and that by Henderson, et al. [8] which reports data from three different studies. In these three studies, the tertiary education students had hands-on control of the IMM software, the WWW courseware, and the text-based materials. (Our research was not aimed at arguing that one type of learning material [the IMM in mass lectures, the hands-on IMM study, the WWW study, or the text-based study] was better educationally. Our intention with the comparison frequency of thinking processes was that, if the quality and quantity of reported thinking skills was comparable with those reported in the other three studies, and if hands-on interactivity did not appear to be a crucial factor, then lecturers would feel a level of confidence in using IMM in mass lecture.)

Based on four level divisions used in the Marland, et al. [14], Putt, et al. [7], and Henderson, et al. [8] studies, the frequency of occurrence is divided into very high, high, low, and very low in order. In all studies, the 3% and 10% cut-off figures were arbitrarily chosen, whereas 5.5% (100/18), the cut-off for the "high" category, was the average percentage frequency across all 18 categories.

In Table 3, the categories of generating, anticipating/predicting, linking, and metacognition have the highest frequency ($f>10$) in this study. According to the study by Henderson, et al. [8], linking was rated very high in learning with the WWW, IMM, and text-based materials as well. However, while anticipating/predicting rated as very high in this study, it rated as low in the WWW study and high in the IMM and text-based studies. Evaluating was reported often in all four studies. It was rated as high in this study and very high in the other three studies. Interestingly, strategy planning was very low ($f<3$) in the IMM study, but it rated as high in this study and the WWW study and very high in the text-based study. Recalling rated as high in only the two studies that used IMM. Comparison of the results show that ten mediating processes (confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing) occurred in the low to very low frequencies in all four studies.

4 Discussion

The following discussion focuses on the comparison of mediating processes that were reported by students during their learning sessions. In the computer-assisted mass lectures, the A.D.A.M. IMM software was used as a teaching-learning tool. It played a major role in the lectures. However, the students were not in a position that allowed interaction with the IMM. They were a group of passive-receivers who possibly consumed the content provided by the lecturer via the IMM features. Therefore, the data obtained in our study concerns the reported mediating processes of students who learned with IMM without direct hands-on interaction. The comparison data between our study and that reported by Henderson, et al. [8] reveals factors that influenced students' mediating processes while learning with different mediums. Moreover, it also revealed the differences in the quantity and quality of the reported thinking skills when students had direct hands-on interaction versus receiver interaction.

The top frequency percentages for the four studies are 26.5% (WWW), 19.8% (IMM), 18.6% (text-based), and 14.5% (our study). The data reveal a higher percentage frequency of the most reported thinking skills in the studies where students had hands-on interaction control. If we add the percentages of all mediating processes in the "very high" category for all four studies then the differences are 63.6% (IMM), 58.2% (text-based), 50.7% (our study), and 48.1% (WWW). Nevertheless, even though the students in the hands-on WWW study had the fewest reported mediating processes in the very high frequency range, there was only a small percentage difference (2.6%) between it and our study. In terms of these criteria, the data generally tends to support our hypothesis. The students in the hands-on IMM study obviously reported more mediating processes than those in the IMM computer-assisted mass lectures. However, when the number of mediating

processes per person in all four studies is averaged, the results are 38 per person for our study, 16 per person for the IMM study, 36 per person for the WWW study, and 28 per person for the text-based study. The low hands-on IMM number was affected by having learner groups of more than two students; beside two groups of two students there was one of three and one of four students in the stimulated recall interviews [20]. Nevertheless the highest number was in our study where students did not have hands-on control. Moreover students in our study reported more types (18) of mediating processes during learning. Students in the WWW, IMM, and text-based studies reported 16, 14, and 13 different types of mediating processes respectively. The students in the WWW study did not report applying and analyzing. The students in the IMM study did not report reflecting, applying, deducing, and categorizing. Those in the text-based study did not report deliberating, imaging, reflecting, applying, and deducing (Table 3). Breadth, that is, the number and type of different mediating processes are relevant to engaging meaningfully with the content as is the number per individual. Thus hands-on control does not seem to be the crucial factor here. The following discussion examines these issues concerning our hypothesis by singling out various mediating processes for analysis and reveals that our hypothesis is tenuous.

The top four mediating processes in our study were generating, anticipating/predicting, linking, and metacognition in descending order. "Generating" encompasses one or more of the following: (a) formulation of one's own questions, examples, ideas, opinions, problems, and answers; (b) interpolation by adding new knowledge through the elaboration of existing knowledge within a given framework; and/or (c) extrapolation which adds new knowledge by extending an existing framework and going beyond the data. The reason for the very high percentage for generating is because of the cause-effect relationship between their thoughts and the animation features of A.D.A.M., which led the students to focus on the content [21]. Generating has a very high frequency (14.5 %) in our study, a high frequency (8.4%) in the IMM study, a very high frequency (10.1%) in the WWW study, and a low frequency (3.6%) in the text-based study. Therefore, direct hands-on interaction might have caused the lower frequencies of generating in the hands-on study. Students in the three studies reported by Henderson, et al. [8] might have engaged in the jobs they needed to do to control the IMM and the WWW materials and underline or take verbatim notes from the text materials. Thus resulting in less focus on the content. Students in the computer-assisted mass lectures just followed the lecturer's presentation, which may have allowed them to allocate more time to focus on the content.

"Anticipating/predicting" includes predicting, looking forward to, speculating about, and expecting the likelihood of encountering problems, types of content, and features of the medium. Anticipating/Predicting is the second highest ranked mediating process having a very high frequency in our study. It had a high frequency in the other IMM study. A possible explanation for this finding is that the lecturer was the only person who controlled the A.D.A.M. IMM software, thus the students anticipated and predicted what the lecturer decided to present and what would emerge in the A.D.A.M. presentation. Students in the IMM study had direct interactive hands-on control of the IMM. Therefore, it is possible that they automatically clicked the mouse to move to the next page, clicked for the answer to embedded questions, and clicked to control the animation without allowing time for anticipation or prediction. The very low score (1.4%) for the WWW study appears to be an anomaly. Perhaps the content, particularly the instructional design of the content, did not promote these thinking skills. Or perhaps the students used the hypermedia functions of the WWW and engaged in thoughts such as "I will click on this link" rather than wondered what content ideas would be presented embedded in that link. In our study, students in the computer-assisted lectures had to wait for lecturer interaction. Thus, during waiting, they had more time to anticipate or predict the coming content.

"Linking" had a very high frequency in all four studies. It is defined as the process of associating, or bringing together in the mind, two or more ideas, topics, contexts, personal experiences, words, and so forth. From this finding, linking occurred easily when text, picture, graphic, or animation that illustrated the concept prompted recall of an associated item in the student's memory. Therefore, it is not surprising that linking occurred very often in all studies because they contain those elements that influenced students to consider how the information related to their experiences. This also shows that, in comparison with our study, direct hands-on interaction did not influence the linking processes.

Mediating processes classified as "metacognition" are those in which students reported awareness of, reflecting on, evaluating, or directing their own thinking. This definition reflects a widely accepted view of metacognition as referring to students' knowledge about, and control over, their cognitive processes. The findings show that metacognition had the fourth highest frequency of mediating processes in this study. The students were able to engage with the content and thinking about their own thinking as it related to the content, and were less inclined to be sidetracked by the features of IMM, the lecturer, and

student-idiosyncratic factors [21]. Metacognition had very high and high frequencies in the four studies (see Table 3). In three studies the percentage frequencies were similar: our study (10.6%), the WWW study (9.4%), and the text-based study (12.4%). However, there was a significant gap between these and that for the hands-on IMM study (19.8%). A factor that possibly made the gap is that the hands-on IMM study contained embedded questions that forced students to interact in order to receive feedback and to be able to move to the next section. In our study, the A.D.A.M. software also offers the same feature, but the students did not have hands-on control. The text-based study also provided embedded questions, but did not provide feedback and also did not "force " the students to answer those questions. The WWW study did not provide embedded questions. This comparison shows that the different pedagogical instructional design in conjunction with the hands-on control is a crucial factor that influenced metacognition. Nevertheless, it is still significant that students engaged in metacognition, which is a type of thinking that is considered to be one of the highest types of cognitive processes [22].

"Evaluating" is defined as the mental process in which a judgement is made about the value or worth of some aspect of the content of the instructional material. Evaluating had a high frequency (8.8%) in this study. The percentage of reported evaluative thoughts about content is very high in the other three studies (18.0%, 26.5%, and 18.6%). The gap between our study and the other three studies is significant. The students in the other three studies used the learning tools by themselves. Thus, it would seem that hands-on experiences and, hence, control over their own pacing and navigated sequencing with the learning tools produced more evaluative thoughts. In computer-assisted lectures, the students may not have had enough time to evaluate the content as well as generate new ideas, link to their past experiences, or metacognise. Perhaps, the students in our study rationalized that if the lecturer had purposely selected out this particular IMM A.D.A.M. material then it was important. In the hands-on studies, the students had to make the evaluative decision as to what content was worthwhile or relevant to their individual goals.

"Strategy planning" refers to thought processes in which students plan ways of processing or handling instructional material or activities during study or learning sessions. There is a dramatic gap between the frequency percentage for IMM study (1.8%) and the other three: our study (7.0%), the WWW study (7.7%), the text-based study (16.8%). The students in our computer-assisted mass lecture study had to follow the lecturer's presentation. One could therefore assume that the frequency rate would be "very low"; but why then the very low score for the IMM study? There appear to be three explanatory factors. The first factor suggests, as is the case with lectures in general, in our study students planned how to deal with the information and process the content through note-taking, drawing graphs, and deciding whether to annotate the textbook or attempt to draw or describe the animations that they cannot control. The second factor is that the students in the IMM study when interacting with IMM, did not appear to spend time thinking about how they would process the material but instead just followed the linear sequence programmed as the "default" choice [8]. The third factor is that, in comparison with the IMM study, in which assessment was not a factor, the students in the computer-assisted mass lectures, the text-based, and the WWW studies knew that the content was assessable. This might have influenced the students' strategy planning.

"Recalling" is defined as bringing back into working memory ideas, opinions, and facts previously stored in long-term memory. It has a high frequency (6.6%) in both studies that used IMM while it was rated very low (1.0%) in the WWW and low (4.1%) in the text-based studies. The gap between the studies that used IMM and those that did not use IMM is substantial. It is possible that the features of the IMM products, such as animation and enforced embedded questions, encouraged students to recall their previous knowledge and experiences during learning.

It is interesting that confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing were rated as low or very low (see Table 3) in all four studies. The type of interaction (hands-on or receiver), the mediums and their features did not seem to influence these types of mediating processes. This implies that factors that should be considered are the content and whether its instructional design prompted these types of thinking skills.

5 Conclusion

It has been argued that IMM is more useful as a learning tool when used individually or with others rather than in mass lectures where students could be seen as merely passive receivers. Our study shows that hands-on interaction does not appear to be such a crucial variable. Indeed in our study, the quantity, quality and range in type of mediating processes were greater than, or comparable to, the other studies. Therefore, the authors argue that IMM can be used as a cognitive tool in mass lectures to enhance various thinking

shills. This study draws the attention of instructional designers and lecturers to the existence, types, and relative frequencies of mediating processes in which students engage with while learning with computer-assisted mass lectures. They were not passive receivers but active receivers. Our study highlights the need for instructional designers to plan educational materials that will activate desired mediating processes as part of student learning in computer-assisted mass lectures.

References

[1] Glenna, T. K. & Melmed, A. (1996). Fostering the use of educational technology: Elements of a national strategy. A Rand Report. Santa Monica, CA: Rand. [Also Online] http://www.rand.org/publications/MR/MR682/contents.html Accessed 31 March 2000.

[2] Chapman, W. (1993). "Color Coding and the Interactivity of Multimedia," Journal of Educational Multimedia and Hypermedia, pp.3-23.

[3] Rieber, L. (1991). Theoretical foundations of instructional applying of computer-generated animated visuals," Journal of Computer-Based Instruction, 18(3), 83-88

[4] Sims, R. (1998) Interactivity for effective educational communication and engagement during technology based and online learning, [On line] http://wwwtlc1.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/rs/sims1.html. Accessed 3 March 2000.

[5] Nowaczyk, R., Santos, L., & Patton, C. (1998). Student perception of multimedia in the undergrad classroom. International Journal of Instructional Media, 25(4), 367-382

[6] Faraday, P., & Sutcliffe, A. (1996). An Empirical study of Attending and Comprehending Multimedia Presentations. London: City University, pp 265-275.

[7] Putt, I., Henderson, L., & Patching, W. (1996). Teachers' thinking elicited from interactive multimedia professional development courseware. Educational Technology Research & Development, 44(4), 7-22.

[8] Henderson, L., Putt, I., Ainge, D., & Coombs, G. (1997). Comparison of student thinking process when studying with WWW, IMM, and Text-based material.

[9] Park, I., & Hannafin, M. (1993). Empirically-based guidelines for the design of interactive multimedia. Educational Technology Research & Development, 41(3), 63-85.

[10] Simpson, M. (1994). Neurophysiological consideration related to interactive multimedia. Educational Technology Research and Development, 42(1), 75-80.

[11] Salomon, G. (1998, February). Novel constructivist learning environments: Some issues to be concerned with. Paper presented at Thinking in Teaching and Learning Conference, Jerusalem.

[12] Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42(2), 21-29.

[13] Reeves, T. (1997). Pseudoscience in qualitative research. [Online] ITFORUM listserv. ITFORUM@UGA.CC.UGA.EDU Access date: 3 March 2000.

[14] Marland, P.W., Patching, W.G., & Putt, I. (1992). Learning from text: Glimpses inside the minds of distance learners, Townsville: James Cook University.

[15] Litchfield, B. C. (1992). Evaluating 0f inquiry-based science software and interactive multimedia programs. Computing Teacher, 19(6), 41-43.

[16] Galluzzo, G.R. (1984, April). A study of student-teacher thinking. Paper presented at Annual Meeting of American Educational Research Association, New Orleans

[17] Mostert, M.P. (1996). Contextualized thinking about teaching: Special educators' metaphorical representations of practical knowledge. In L. Bouton (Ed.), Pragmatics and language learning (pp. 189-213). Urbana-Champaign, Ill: University of Illinois.

[18] Norton, R.A. (1987 April). Divining and defining a problem space: An investigation of preservice teachers' interactive thinking. Paper presented at Annual Meeting of American Educational Research Association, Washington, DC.

[19] Branstrom, M. (1996). A.D.A.M. The interactive physiology-muscular system [CD-ROM], A.D.A.M. Software, Inc. and Benjamin & Cummings Publishing, Atlanta, GA

[20] Patching, B., Henderson, L., & Putt, I. (1994, February). Interactive and Thinking: A report on research in progress. Paper presented at Second International Symposium on Interactive Multimedia, Perth.

[21] Pausawasdi, N., & Henderson, L. (2000, June-July). Students' Engagement Behaviors in Computer-Assisted Mass Lectures. Paper presented at World Conference on Educational Multimedia, Hypermedia, and Telecommunication, Montreal.

[22] Osman, E. M., & Hannafin J. M. (1992). Metacognition Research and Theory: Analysis and Implications for Instructional Design. Educational Technology Research and Development, 40(2), 83-99.

The Application of Scaffolding Theory on the Elemental School Acid –Basic Chemistry Web

***Zangyuan Own, Kai-Pein Wong**
Department of Applied Chemistry, Providence University
#200, Chun-Chi Road, Shalu, Taichung, Taiwan 433
Tel: +886-4-6329216
Fax: +886-4-6327554
E-mail:zyown@pu.edu.tw

The knowledge of chemistry is base on the realization of fact and experiments, students must try to infer, experiment and realize deeply to achieve the goal of highly efficient learning. Base on the scaffolding theory, we have designed a three- tier client-server web title which is a distributional database formats about the chemistry subject-"Acid and Base chemistry" for elemental school students. We use a lot of multimedia animation and Internet techniques to create a scaffolding environment make students learn it instantly and mutually. It turn out that all the students have excellent improvement learning outcomes. All the experts, the interaction designing experts, the network experts, software designers and primary school teachers gave a positive affirmation about the web title; the teaching content and the interaction design are all get the very positive confirmation. The result of learning effect is very convention; the statistical analysis shows that all learners who entered this web site made a great progress in their knowledge test. Besides, ANOVA statistical analysis shows that this scaffolding chemistry web site made a great help for L type learners. Learners' previous science knowledge has nothing to do with the study effect.

Keywords: **Scaffolding Theory• •Acid-Base Chemistry• •Web Title and Learning Effect**

1 Introduction

Because of the shortage of real experience and the misconception of teaching content, traditional teaching cannot inform the students about the concepts which teachers want to deliver. With the development of the Internet, the form of education is shifted from teacher center to the learner center. The future of science teaching is base on the new nine-year consistent project, it is important to integrate the Internet as a major tool to enforce this project. All of these will help improve the quality in elemental chemistry education for our children.

2 Motive and purpose

In these coming years, internet was the major domain of research academics and government officials. In the 1990s Internet software took giant leaps forward in usability. The biggest change came with the development of the World Wide Web (WWW), a vast tract of the Internet accessible to just about anyone who could point to buttons on a computer screen. It led the Internet's transformation from a text -only environment into a multimedia landscape incorporating pictures, animation, sounds, and even video.

The teaching by the Internet exceeds the traditional passive one-way learning, but stresses on interaction. Taking the advantage of instant pass by the Internet, you can browse through all kinds of fascinating information sources and discover worlds of knowledge. We create a web page about the chemical

experiments- the acid and base in nature environment. By the global of networks, we can easily transform the information by character, animation and video. The different learning effect which associated with different learning style students, different ages, different sex and different previous knowledge of science may cause the different learning out come.

3 Theory background

The scaffolding theory brought up by a Russian psychologist (L. S. Vygotsky). He sustains students with the scaffolding techniques through out his teaching process. In the beginning of the scaffolding, it would be a process from other-regulation develops to social negotiation. In teaching, the teacher will design a temporary supporting constructions thought out the whole lecture, which help the learner to develop his learning ability. It is called scaffolding. There are two important subjects within the scaffolding theory. There are communication and cognition, the function of social cognition is to make the learners improve his abilities in solution and self-examination, and students certainly be promoted by the active learning styles.

Scaffolding instruction means that the teacher can help the learner make the most of their potential. Under scaffolding instruction, student will join the learning activity positively instead of remaining passive. Thus, an individual would have his own cognition framework.

There would be six important principles about the instruction.

1.In the real teaching activity, the teacher is the scaffolding maker for the learner.
2.The supporting degree is dependent on the standard of the learners; there would be a modification.
3.The more the ability of the learner increases, the less the support decreases.
4.The support is in proportion to the standard of the activity.
5.The suppor will be modified gradually and at any time. Then it would keep on.
6.Make the learner independent.

In the learning effect, many scholars announce their research results. They would analyzed what kind of the learner is and then decide to create the appropriate on-line instruction web page. Different learning-styled students in CAI(Computer-assisted instruction) would have different learning effects in various feedback.

The feedback is composed of the following four parts:
No feedback. (2) Knowledge of results feedback. (3) Informative feedback. (4) Informative feedback in personal language.

According to the research results by the scholars Dori and Yohim(1990), students in proper sequence may have highly-efficient learning effects. On the contrary, learning by leaping ways was low efficient learning effect. The former is called L type, and the latter is called W type. It means that different learning style may cause various learning effects to students.

The learning ways of students are classified into Super-L, L, W and Super-W type. There are large parts of high school students with L type in particular. The second position is W type. The L type (straight-line) means students follow the learning materials and never change the route. The W type means students don't follow the learning materials and change the route all the time. The Super-W type means that students may play out the entire learning process. It has a strong relation between the learning style and the logical thinking talent.

4 The Research Method

System Installation

The research is base on a web title course, it is a Three-Tier Client-Server sets. Most browsers accepted this kind of device. Server can share responsibility for the management to the request of client. It can transform the information from the database by the request of the client, then the client will process the information it got from the server.

To achieve harmony with education, the government has computerized all elemental schools, but the

schools have not been equipped with highly-performance computer. Microsoft bring up an idea of thin client. A computer with modem and browser can use this system. To have a better web title designed, we got the type called 3-Tier (Figure 1). It bases on the platform of Windows NT 4.0 Server SP6. We created the Web Server with Microsoft Internet Information Server 4.0. As a result of dealing with the users' get-in information, we use the MS-SQL 7.0 Server system as a platform for database.

In the process of making the web site, we use a computer with Pentium III 450 processor, which is associated with Front page 2000 to design all the required homepages. And we use the common draft tools (Adobe Photoshop and Macromedia Flash) to deal with pictures and make them more interactive. Finally, we use the SPSS statistics system to analyze the results of learning effect.

The part of system interface, we use ASP(Active Sever Page) to design the interface, and take the advantage of Visual C++ to create a stable and efficient web page in the core part.

5 The Research Object

Our research is aimed at the students in Grade Six of elemental school. The design for course content

We take a lot of real household materials, which is concern about acid and base as teaching examples. Such as the lemon• Clorox and vinegar. The nature of soap water is slippery. If you wet your clothes carelessly with sulfuric acid• hydrochloric acid or sodium hydroxide, the clothes would be damaged. And they will scorch the skin. There would be the calculation of the PH. The definition of acid and base is on the produced amount of H^+ and OH^-.

The vinegar is composed of five percent of acetic acid. The molecular formula of acetic acid is written as CH_3COOH. The one hundred percent of acetic acid is called icy acetic acid. The reason why a lemon has acidity is that it is composed of lemon acid.

In the laboratory, the ammonia NH_3 is a base. It is because it produces a lot of OH^- in water. The ammonium ion is acid. It is composed of H^+. At the normal temperature, the HCl is gaseous state. It is a acid. The carbonic acid H_2CO_3, Sulfuric acid H_2SO_4, boric acid is all acids. There are common base such as sodium hydroxide NaOH and calcium hydroxide $Ca(OH)_2$. Sodium bicarbonate $NaHCO_3$ is a base; it has a common name called baking soda. People with much hydrochloric acid in gastric juice may take some medicine composed of magnesium hydroxide to neutralize.

The experts and scholars suggest that we should create a interactive web page of scaffolding theory should base on the acid-base knowledge map which is created at beginning of the course. The another major frame is an on-line discussion section. Initially we would have some general questions about acid & base, which the students have to find out their own solutions. If their answer is correct, then they can enter another subject, otherwise they have to keep on finding the answers. In the process of learning, students may have an efficient learning freedom by the active video program we provide with in the web page.

The content of the web
1.Question-learning function induce students to learn.2.Question of situation in our daily life.3.A simple operation interface.4.To stress on vision and hearing.5.Guided learning then learning control.

There are twelve units in the teaching material, which is a scaffolding design.
1.Litmus paper. 2.The nature of liquid.3.The definition of alkaline-liquid operation.4.The definition of acidic-liquid operation.5.The definition of neutral-liquid operation.6.The reaction between alkaline and acidic liquid.7.The neutralization of acid and alkali.8.The application of neutralization of acid and alkali.9.The nature of acid and alkali.10.The nature of sodium hydroxide.11.The advanced concept of acid.12.The advanced concept of alkali.

Most of elemental school students cannot understand the nature of acid and base. So we classify the course into two parts, which may happen in real life and in the textbook. We ask the student to register as they entering the studying web page. And let them brow though the entire house, which have five areas (kitchen, bathroom, living room, backyard and bedroom), all fill of the brand name items. The computer will record the pass way of learner, which then will be analysis to learning style (W-type or L-type). If the learner follow every step of the computer, they will have 10 points, which is classify as L-type, if the learner did not

follow the step which computer direct, they will deduct 2 point for each time, the points lower than 3, it is classify as W-type. The acid-base lecture is designed base on scaffolding theory. The system would determine when to removes the scaffolding setup or not by the amount of the correct analysis of computer generated data and suggestion by the experts and the scholars. After a serious study, this system is set up to remove the scaffolding structure when students scored seventy percent of designed questions. Before the system removes the scaffolding structure, the on-line instructor is standing by the side to help them solve some difficult problems. It's so-called on line ICQ.

For example, if students ask what the hydrochloric acid is by the on line ICQ. The instructor will pub out and tell the student that it's a kind of corrosive solution, which is used to clean your bathroom.

The hydrochloric acid also exists in our stomach; it helps us in the digest. You can clean the lavatories in the schools or in our home with it, too. And all of these questions and answers will be put into Acess database as a Q&A databank for future use.

If the scaffolding has been removed, a discussion section will appear on the screen. Students can ask any question or play the teacher part to answer questions. We can save lots of the teaching resource in the way.

All the pretest and posttest questions are substrate from ACS (American Chemical Society) test bank, which is careful designed and tested for, determine chemistry knowledge of students.

6 Result and Discussion.

From January 10 to March 10 we have selected 221 students to analyze. And the result of analysis is as follow (table 1):

Table 1. The analytic table about the learning style

Category	Amount	Average	Standard varies
Boy	118	5.65	1.13
Girl	103	5.81	2.08
Whole	221	5.72	1.57

Research Sample

There are 221 students enter our web site for learning acid and base concepts, base on their data collected, we picked up forty learners (twenty are L-type, twenty are W-type) as our study samples. L-type (Boys >7.78, Girls>7.89) and W-type (Boys < 3.52, Girls<2.73)

Evaluate the Web Site

We invited five elemental school science teachers, five teaching scholars, five software designers, and ten elemental school students to evaluate the web site. The average results are in table 2.

Table 2. Statistic of evaluation result

Item	Software designers	Teaching scholars	Elemental teachers	Elemental students
Homepage design	4.50(90%)	4.50(90%)	3.75(75%)	4.50(90%)
Teaching material	3.75(75%)	4.25(85%)	4.75(90%)	4.10(83%)
Interface	4.30(86%)	3.90(78%)	3.60(85%)	4.70(94%)
Whole style	4.25(85%)	4.25(85%)	4.50(90%)	4.50(95%)

In the aspect of homepage design, elemental schoolteachers gave us lower points (3.75). They thought that instructional contents should be more intensive, and the relation knowledge should increase to enrich our web site. The software designers thought that the homepage should be more vivid than previous to stress the topics.

In the aspect of teaching material, some students complain that contents are not obvious, and we should introduce topics clearly.

In the aspect of interface, the teaching scholars and software designers thought that the operation should be familiar with users. In the meanwhile, they generally praised us in animation, and encouraged us used more.

At whole aspect, they all thought that web base learning indeed archiving the instruction targets.
Learning Effect

After tested, all eighty students had been improved in their acid & base knowledge. The overall improved score average is 18.15. L-type learners average improved 23.35, and W-type learners average improved 12.95 (table 3). It is obvious that our web site have much help in learning acid-base chemistry.

Table 3. The statistics of achievement test

L-type	Pretest	Posttest	Improved	W-type	Pretest	Posttest	Improved
Average	55.80	79.15	23.35	Average	51.75	64.70	12.95

We used the SPSS statistics software running data to analysis the deviation. The P value of learning style relation to score of pretest is 0.063, which is greater than 0.05, indicated that the learning style has no relationship to the pretest score. (table 4)

Table 4. Deviation analysis of different learning style relate to pretest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	529.256	3.499	0.063
Inaccuracy	158	151.258		
Total	159			

The P value of learning style relation to the score of posttest was 0.015, which was smaller than 0.05. It indicate that posttest score was relation to learning style, which means that L-type learning style improved remarkable. (table 5)

Table 5. Deviation analysis of different learning style relate to posttest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	1829.256	5.993	0.015
Inaccuracy	158	305.240		
Total	159			

7 Conclusion

Instruction by Internet is the better way in teaching chemistry at present day. According to our research, we have three conclusions:

1. After using the web site, the learners all had improved their test score remarkably. It shows that it is a better learning process for students to study acid-base chemistry in the elemental school.
2. The P value of learning style relation to posttest score was 0.015, which was smaller than 0.05. It shows that L-type learner had positive progressed in using scaffolding web site.
3. After the experts evaluated the web title, this acid-base chemistry web indeed bringing on-line instruction into full play. This web site's design style could be a very good example for the future science web sites.

Reference

[1] Daonian Liu, L.J.W, David W;"*Delivering a Chemistry Course over the Internet*", Journal of Chemical Education ;Vol.75 No.1 January 1998.

[2] Chris M, Mohammed J N, Penny J G; "*Web-based technology in a constructivist community of learners*", British Journal of Educational Technology, Vol 30 No 1 1999 pp.65-68.

[3] K. A Burke, Thomas J. G, Mark A. W; "*Developing and Using Conceptual Computer Animations for Chemistry Instruction*" ,Journal of Chemical Education., Vol. 75 No. 12 December 1998.

[4] Ned H. M; "*Integration of Computational Chemistry into the Chemistry Curriculum*",*Journal of Chemical Education*", Vol. 75 No.2 February 1998.

[5] Richard D. M; "*Chemistry on the Web*", Journal of Chemical Education; Vol 73 No.1 January 1996.

[6] Willian J. T, Jr; "*The Multimedia Chemistry Laboratory: Perception and Performance*", Journal of Chemical Education; Vol 73 No.9 September 1996.

BEST COPY AVAILABLE

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

Chao-Fu Hong, Chiu-e Chen*, Ming-Hua Hsieh, Cheng-Kai Huang and Shih-Hsiung Chang
*Aletheia University and Dah-Yuan Elementary School**
cfhong@email.au.edu.tw
No. 32 Chen-Li Str. Tamsui City Taiwan ROC
Tel: 02-26212121-5536

After we discussed with teachers to understand their instructional politics, we integrate the teachers' instructional politics, the process of knowledge generation, memori ing to construct the concept graph. Furthermore, we used the dynamic web pages to track the learner's learning and used the tracking data to reconstruct the learner how to construct his knowledge to understand the learner's thinking logic. In this paper we proposed the dynamic knowledge generation model and learning ability potential model. These were according to link the concepts to generate the knowledge. As following above idea we integrated the constructing materials and the dynamic knowledge generation to consist the expert system. The system would analyze his learning data to rebuild he how to build his knowledge, to understand his learning ability and he already built the whole knowledge or not. Rely on these results the system could supply the suitable materials to him for study. And the learning cycle would continue until the learner completely constructs the new knowledge into his ground knowledge. Finally, we could from proto type system to collect the experimental data and rebuilt the learner's learning steps, then followed the expert system to understand his learning ability potential. The system could supply a suitable material to him and help him to cross over the learning obstacle. These results also proofed that our model could really understand the learner's thinking logic and learning potential.

Keywords: **dynamic knowledge generation, learning potential ability, concept graph, expert system**

1 dynamic knowledge construct process of learners

A meaningful learning must accord with three main conditions: Accepting the learning material, having the knowledge of dealing with learning material, and firing this knowledge at the learning time, (Mayer, 1975,1984). Accordingly, learning behavior has originality, creation and activity. It's easy to make learners to find the meaning of learning. If we want learners to have meaningful learning, we must do: "if you want to teach active knowledge for learners, you have to understand how to get the knowledge first. It's the same as you want to teach learners to think, you have to understand how learners think first." Therefore, if want to know the learner how to learn the knowledge, it can use the information process theory to discuss the human how to process his information like Fig.1. we design a structural material like a story, attaching pictures, and animations that attract learners. At the last section we give an additional problem among the units, which give learners integrating the prior knowledge. Then, the blind spot in every learner is obtained by using the model of a learning barrier analysis. The reason of inspiring learning barrier is obtained by using learners' browse web pages order and frequency. (Note: 3D learning barrier analysis) Meanwhile, learners will dynamically update their constructional knowledge network by learning number, browsing process, and test frequency. (Note: all of attributions of cognition nodes are dynamical.) Because learners are not static learning, we developed a dynamical model as Fig.1..

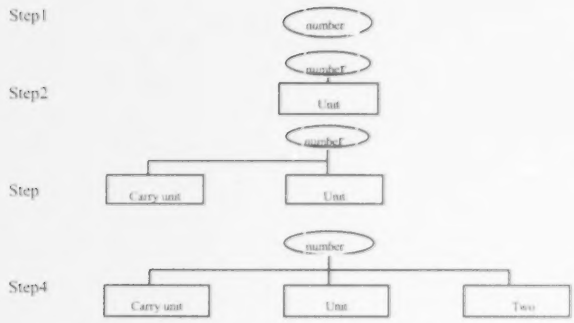


Fig.1 dynamic knowledge construct process of learners

2 the dynamical knowledge generation and learning ability analysis

In our model (**the model of dynamical knowledge generation and learning ability analysis**), using the teachers teaching experience, the system partition a judge learners' ability to achieve learning and the label of understanding course. And the Table1 is appropriate inference rule, what are the schools' teachers to classify the learners' learning ability.

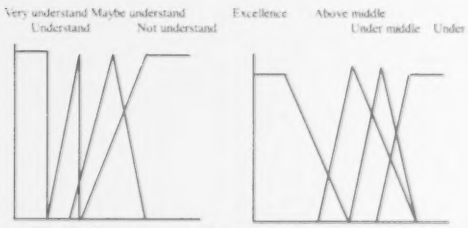


Fig.2 The relation of achieve a learning and the label of understanding course

Table 1. Inferring rule

TIMES / RESULT	UNDER	UNDER MIDDLE	ABOVE MIDDLE	EXCELLENCE
Cannot Understand	-2	-1	-1	0
Maybe Understand	-1	-1	0	+1
Understand	-1	0	+1	+2
Very Understand	0	+1	+1	+2

After the student had to go to the chapter's test. The testing results would according the learning obstacle analysis model to find his incompletely building knowledge and compared with the expert system to understand his learning ability. Finally, the system searched the suitable materials for him to study. The graph of learning cycle is shown in Fig. 3.

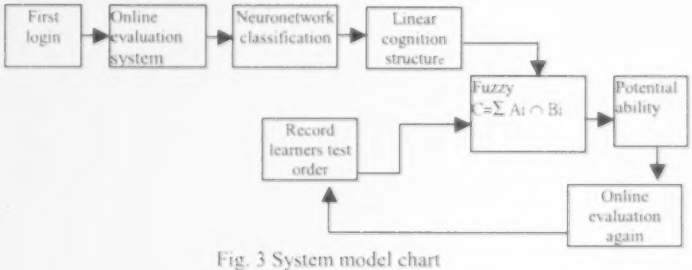


Fig. 3 System model chart

3 Conclusion

Although teacher can control his class ambiance and teaching trends, but he has many different individual

learners in the classroom. If teacher cannot understand the learners how to learn and how to integrate their knowledge on his teaching, the teaching does not only let learner have a stuff learning, but also increase his teaching load. Therefore, in our paper we proposed "dynamical knowledge-generation model and learning ability analysis", to integrate the conceptual knowledge generation into structuring material and connect with the dynamical estimating expert's system. This system can collect what material learner had learned and the result of online testing was transmitted to the system. These real data used our analyzing model to decide his learning ability and supplied a suitable material to him for study. Thus, we believe our system do not only can help the teacher to understand learner how to build his new knowledge, but also can reduce the learner's learning barrier.

Reference

[1] Chao-Fu Hong、Yueh-Mei Chen*、Yi-Chung Liu、Tsai-Hsia Wu :Discuss 3D cognitive graph and meaningful learning,ICCE99

[2] Chao-Fu Hong、Yi-Chung Liu、Yueh-Mei Chen*、En-Yi Jen :Apply OO and T cell Cognitive Structurein Discovery Teaching,ICCE99

The Externalization Support System of Self-explanation for Learning Problem-Solving Process

Kazuhide Kanenishi*, Takahiko Mendori, Masafumi Sawamatsu*** and Yoneo Yano*****

**Center for University Extension, Tokushima University,*
1-1, Minamijyousanjima, Tokushima, 770-8502 Japan,
mailto: marukin@is.tokushima-u.ac.jp

***Department of Information Systems Engineering, Kochi University of Technology,*
185, Miyanoguchi, Tosayamada-cho, Kochi, 782-8502 Japan,
mailto: mendori@info.kochi-tech.ac.jp

****Department of Information Science and Intelligent Systems, Tokushima University,*
2-1, Minamijyousanjima, Tokushima, 770-8502 Japan,
mailto: {yano, sawa}@is.tokushima-u.ac.jp

When a learner dose various tasks in the computer, the interaction of the learning support system is so a transition which happens inside the learner. At that time, educational effects such as knowledge structuring occurs due to externalization of representation. We developed the prototype system in so that externalization of self-explanation of the problem-solving process was supported. A learner externalizes the self-explanation "How do I solve the exercise?". At this time, she/he explains using not only words but also diagrams, in order to exploit the effect of diagrams. Self-monitoring happens with self-explanation, and the acquisition of a problem solving strategy on is learned. In this paper, we construct a model of "externalization on the computer," and we consider the occurrence of cognitive load. Learning is a kind of load, therefore any reduction of the load (as opposed to its extinction) is of assistance. We propose the presentation of an operation list as a method of load reduction. The memory dependent evaluation becomes more coherent by such a list. In other words, the cognition perspective improves. In this paper, it is shown in the prototype system how externalization is accomplished.

Keywords: **Self-explanation, Reflection, Externalization, HCI**

1 Introduction

Recently, the contents of interaction have been reconsidered in the context of the learning support system[1]. So far, a computer playing a teacher's role is aimed at the transfer of domain knowledge expressed by the system. The computer asks a learner several diagnostic questions. The computer is central to such interaction. The perspective "For whom is this interaction?" is absent. In this paper, we propose an learnig environment (externalization support system) that promotes the understanding of problem solving resulting from the externalization in the computer. The learner works independently on the computer with the interaction we propose, then the learner rewrites his internal state. Learning occurs at that time.

Recently, attention has focused on "externalization " and "meta-cognition." For example, a vague idea is sometimes clarified by writing text. Externalization promotes the arrangement of knowledge and learning. On the other hand, meta-cognition is a psychic activity of higher order, involving self-monitoring (reflection), and is concerned with deep level learning such as the acquisition of strategies, the transfer of knowledge.

We paid attention to the self-explanation of the problem-solving process, and we have researched that support[2]-[9]. At present, a learning support system that externalizes self-description of the problem-solving process has been utilized as an experiment. Exercises in statistical scales of geography were used. A learner expresses how she/he solved a problem. Geography though is considered mere memorization, the learner can acquire an understanding

of the problem-solving process by self-description. An example of this type of exercise is shown in figure 1.

We propose the usage of figure 1 as a method of externalization. We are constructing the environment where a learner can do self-explanation by writing memoranda. In this system a learner draws on the character and diagram of the explanation of the problem-solving process. Furthermore, the examination process of externalization is supported from the cognition perspective. The activities scrutinized are internal (understanding the behavioral reason of the learner) and are supported by the presentation of the operation history. This supports the self-monitoring that is crucial to meta-cognition

Idea support system, idea sketch, etc. are proposed in the HCI researches. However, we think learning involves a kind of load, and our purpose is to recommend support by control of the load, rather than by elimination of the load. The consideration of support by reduction of the load is a different point.

In chapter two, we describe the educational effect of externalization. We propose a support method of externalization targeting self-explanation of the problem-solving process in chapter three. The summary of our system is shown in chapter four. We present a summary in the final chapter.

2 The outline of externalization

2.1 The educational effect of externalization

Many researchers point to the educational effect of externalization[5]-[6]. The effect of diagram use in externalization has been acknowledged as well. The learner can acquire the educational effect if self-description is externalized by use of diagrams[7]-[8].

Externalization is the expression of internal psychic activities (images). We mention clarification of knowledge, structuring, etc. as a general effect. Moreover, internalization occurs by repeated externalization, and internal processing proceeds smoothly.

Self-description involves special explanation of a point[9]. Externalization is unique as well. Self-monitoring is enhanced by a learner's repeated externalization of the self-explanation.

2.2 Externalization model on the computer

We construct a model of externalization in this section; our objective is not to clarify the mechanism of externalization. In a sense, the model is to employ educational effect. Various models of externalization are available; we have elected to choose a model of externalization in the computer.

Externalization is considered to consist of several functional modules. The module described here is the functional unit that is comparatively independent.

The model of externalization and the state of repetition of each module are shown in figure 2. We classify modules of externalization into four ways.

(1) Image generation
(2) Expression form generation
(3) Operation sequence generation
(4) Examination (evaluation)

Module (1) is the creative impulse that forms an internal image. Externalization consists not only of the creative impulse of expression but also of the underlying representation. Though module (1) is a heterogeneous activity, it is a part of externalization. Creativity is a very complex psychic activity, and is beyond the scope of this paper.

Module (2) is the expression of vague internal images. Expression is based on the rule

Question: What are items(1),(2),(3)?

Item	Ranking	1	2	3	4
(1)	Exporting country Amount of export	U.S.A. 9,637	Australia 5,300	Poland 2,800	U.S.S.R. 2,000
	Importing country Amount of import	Japan 7,909	France 2,295	Italy 1,905	Canada 1,567
(2)	Exporting country Amount of export	Cuba 675	France 300	Australia 255	Brazil 253
	Importing country Amount of import	U.S.S.R. 672	U.S.A. 270	China 222	Japan 180
(3)	Exporting country Amount of export	Japan 1,612	West Germany 1,458	France 675	Belgium* 460
	Importing country Amount of import	U.S.A. 1,802	England 490	West Germany 483	Italy 460

(1)and(2)unit is 10,000 tons (3)unit is 10,000,000 dollars. * Includes Luxembourg
(1): 1982, (2): 1983, (3):1980

Fig. 1 Example of geographical exercise.

of generation. As a case in point, form of presentation (rule) that has been configured freely and formalization that has already been completed, may be employed. For example, in the case of pictures, expression is free, and a person who draws a picture decides the form of presentation. On the other hand, when we illustrate a phenomenon with a formula, formalization is predetermined, and we must obey mathematical rules. As for externalization of writing memoranda, existing formalization and independent formalization are being used together. We can think of module (2) as consisting of the following three usage forms.

(a) Existing formalization
(b) Independent formalization
(c) Existing formalization + Independent formalization

The burden of usage of the existing formalization is that a learner must understands formalization. However, when a learner acquires existing forms, internalization progresses, and the representation in module (1) becomes simplified. For example, when a learner is skilled in the use of the Japanese abacus, she/he becomes capable of mental arithmetic using a mental image of the abacus. The effect of the Venn diagram in the understanding of the set theory is similar.

When externalization is done on the computer, the process of module (3) is remarkable. The rate of this part increases when the expression is done indirectly using the computer. Expression can't be generated if the computer lacks the appropriate software. Thus, a learner plans an operation sequence to configure expression, and she/he will move the mouse based on that plan.

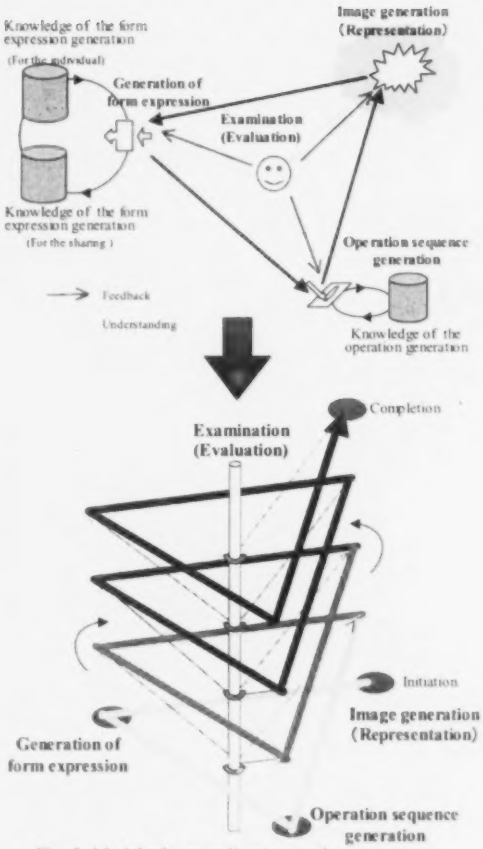


Fig. 2 Model of externalization on the computer.

Module (4) is different from the other modules. Examination is the evaluation of each process from module (1) to (3) with feedback. In other words, examination is a meta-level activity when compared with the other processes.

Modules (1) to (3) become a cycle. The processes from (1) to (3) are evaluated by process (4), which provides feedback. This cycle is repeated until a learner judges by examination. That the activity has been completed

3 Externalization support of self-explanation

3.1 The support of externalization by load reduction

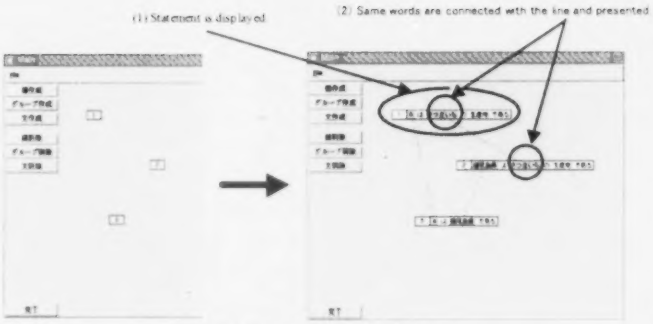
The general support method of externalization is considered in this section. First, we remove the cognitive load intuitively for externalization support. However, the purpose of learning is to put load on the learner. Even if a computer estimates the intention of the learner (even if an explanation is formed automatically,) learning does not progress. Hence, removal of the load does not support learning.

The real nature of the load lies in the multiple combinations of the loads. The load is classified by cause and category, it is necessary to separate the load that aids learning from the load that does not. We aim to reduce the load. In other words, consideration of the relevant control of the load is necessary. Arrangement and classification of each load is necessary for its support.

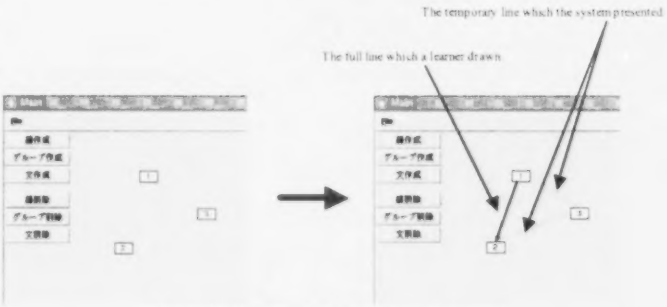
3.3 Drawing method of the problem-solving process

Support of the expression form generation process serves to prepare for the effective expression method. We show

(by way of drawing) the problem-solving process following. Problem-solving is a process, and it has a certain structure. Diagram usage is effective to express structured information. Graph expression is a relevant method like Tweedier's indication as an informational expression that has a flowing structure[10]. For example, though various methods are proposed, a flow chart is still used for the expression of a program structure.



(1) The display of the relation between the words



(2) The display of the temporary line which can be connected

Fig. 3 Model of operation support.

We use a style that combines the use of words and figures. We propose the arrow diagram that expressed structure between statements was symbolically used with the text of the items together. The externalization task with our learning environment consists of two tasks: text creation and graph drawing. Expression is constructed in the following procedures:

(1) The Entering of a simple sentence
+
(2) Placement (migration)
(3) Connection
(4) Grouping
(5) Attribute addition to the object

First, a learner constructs the explanation of the character form. The explanation of the solution reflects the problem-solving process of the exercise. We exclude compound sentences and complex sentences, and use only simple sentences. Each simple sentence during expresses each state of the problem-solving process. A learner is conscious of the order, and notices that problem-solving proceeds by the items. The order of the explanation copes with the process of the problem-solving.

Next, each simple sentence is connected with an arrow line to form a "node". A learner is specifically conscious of the structure by drawing these lines. As for the structural expression of the explanation, each statement is associated with the arrow line toward the explanation of the expressed goal from the explanation of the initial state. A learner encloses some statement, and gives color attribute as a supplementary activity. The diagram drawn with the arrow line is completed by repeating the above activity.

The part that decides expression is first and the part in which a learner himself can determine expression are both present in the above expression method. Such a method guarantees freedom of expression for the learner, while at the same time accepting ambiguity. Thus a learner can write a memorandum of the meaning of the attribute appended by the learner. For example, the system asks a learner for a reason when a learner changes the color of the line. This function is actualized as a fraction of the support of the look-over.

3.4 The support of the operation sequence generation

We describe the support of the operation sequence generation in this section. The following function is provided because the learning environment should be made convenient.

(1) The simplification of the operation
(2) The intersection of the operation and the phenomenon

BEST COPY AVAILABLE

The operations of the learning environment are statement creation, statement delete, line drawing, line erasing, movement, grouping, and the color alteration of the object. It prepares only for easy operations. A phenomenon can be easily imagined from these identifiers. We achieve a single function in our system. An operation and a phenomenon correspond one-to-one, and the understanding of the operation becomes easy.

The learning environment is tailored to notify the learner of deficient explanations and feasibility of the expression by the following operation support. The state of the support is shown in figure 3.

(a) The display of the related word information
(b) The display of drawing line feasibility

A simple sentence is displayed on the learning environment as a symbolic icon. One component is made according to statement, a learner can focus on structure between the statements. On the other hand, a certain word sometimes has significant meaning for structural grasping of the explanation. The learning environment manages word information, and employs it for support.

The indication of related word information This is the method in which the structural understanding of the statement is accelerated. When the same word in is used several statements, the learning environment shows them. When the same word is shown repeatedly, the system is made conspicuous. The system displays a statement next to the statement icon, and gives color to that word. The same word in different statements is connected by a line.

The indication of connection feasibility This is the method in which drawing between the statements is supported. The system presents the link that can be connected in the statement nodes as a temporary line. The system estimates the statement that relate to other statements in the placement step (which the statement icon on the workspace finished). The feasibility a line drawn is high in the statement which satisfies the following conditions:

(A) The statement operated just before
(B) The statement that encompasses the same word

The system presents a temporary line to the learner according to the stage at which placement was finished. All candidates are displayed when some lines are presumed. When a learner chooses a temporary line, the system re-establishes that temporary line as a permanent line. Because drawing lines is a possible option, the work of drawing is reduced for the learner.

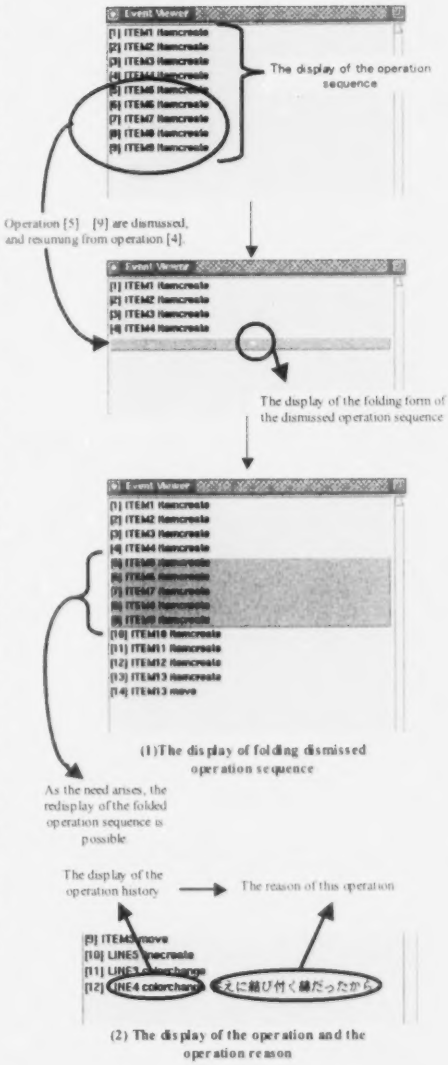


Fig. 4 Representation of the operation history list.

3.5 The support of the examination by cognitive perspective

We aim at the realization of the farsightedness of the cognitive perspective with the support of examination. Externalization is done so that a learner may learn about himself. We aren't aiming at deputy by the system. The approach of automating conception and drawing isn't embraced. Support toward examination of evaluating one's act is necessary. Therefore, we propose a method that assists the self-monitoring by the learner. The system uses the following two methods, as shown in figure 4.

(1) The display of the operation history
(2) The collection and display of the operation reason

Reflection on the personal task must depend on the current aspect of the activity subject and on memory. However, subject activity does not express variations in the middle of the task. Moreover, memory is often a temporal

BEST COPY AVAILABLE

effect, and often can't be extracted when necessary. Therefore the system preserves task history, and history and task process are reproduced to the learner. The system makes linear operation sequences and a learner can do an operation again from the arbitrary juncture of the operation sequence that is presented. In that case, a recent operation sequence occurs from the point that an operation was done again, and a previous operation sequence is dismissed.

However, when a learner reflects on an error, dismissed operational sequences encompass significant information. Because reflection support is critical, the system preserves all operation sequences. When a recent operation sequence occurs, the previous operation sequence is hidden temporarily from the learner. Then, if a learner requires, the previous operation sequence can be displayed. Cognitive perspective in the examination process improves due to the presentation of the operation history.

The display of the operation history provides an opportunity to look back at the operation. Furthermore, we not only present operation history but also present the reason of the operation. The system requires comment input at every operation. The set list of the operation and the reason are stored in the system. It is understood that comment is useful in order to reconsider program source. Ambiguity is present in expression, and the degree of freedom of expression is guaranteed. A learner himself sometimes forgets the intention of the figure on one side. A memorandum of the operation is useful in such a case as well. The presentation (collection) of the memorandum of the operation is not the active intervention of the system.

4 Self-explanation externalization support system

4.1 The configuration of the self-explanation externalization supporting system

Our system before this paper externalized a self-explanation only in character[3]-[4]. However, figures and text are mixed in the natural externalization. Drawing activity is separated from text creation activity in self-explanation, and it is unnatural to draw after text is written. Therefore our system was designed to enter text and to draw simultaneously.
We implemented three functions in the system.

(1) Explanation management
(2) Explanation structural management (visualization management)
(3) Operational history management

Module (1) manages information on the explanation sentence. This module is shared the entry of the explanation sentence and the display of the explanation sentence. A learner enters a simple sentence. The morphological analysis of each simple sentence is done by "Cyasen" developed with NAIST. Information on the word is extracted. By this processing, information on the noun and verb in a simple sentence is extracted. The system preserves the information with a simple sentence.

The order of the statement input can't be employed as an order of the explanation sentence. When a learner completes a drawing, the system decides the order of the explanation sentence based on the following information:

(a) Related to the arrow
(b) Grouping
(c) Related to the place
(d) Input order

First, the system gives priority to arrow line information. The beginning point and end point of the arrow shows a context. Next, simple sentences are grouped to the same level. The system fundamentally introduces the order of the input as the order of the explanation. When there is no grouping or arrows in the explanation figure, the system decides the order of the explanation sentence based on the co-ordinate information of the icon on the "canvas "screen. If there is a top-to-bottom relationship among icons, this relationship becomes the context. The order of input is used except in the case above. After the system shows the order, the alteration of the order by the learner is possible.

Module (2) manages the drawing task and the information acquired from this task. A learner enters a simple sentence, and next drawing becomes possible. Module (2) manages the whole drawing task on the "canvas", and it displays support information.

Module (3) presents the task history (operational history) of the learner. A learner sees this operation history, and adds various modifications to the externalized figure.

Various methods of presentation of the operation history are proposed. We think the list form is easy to understand. Various methods of Undo (Redo) are proposed as well[11]. We consider an operation to be a series of persistent sequences. We introduce the interface in which an operation can be done from an arbitrary part of the operation history list and the previous sequence folded under the recent sequence. The current sequence is important for the learner, so a dismissed sequence is rendered temporarily invisible. Hidden operation history can unfold the folded part if necessary (the icon indicates it has been folded.), but a learner only confirms a folded operation sequence, and a dismissed sequence can't be redone midway in the process.

4.2 Outlook of the system

We show how self-explanation is externalized on the system in this section.Six windows are displayed in the system that was manufactured. The screen configuration of the system is shown in figure 5.

(1) Canvas window (Operation button is encompassed.)
(2) Simple sentence input window
(3) Explanation sentence display window
(4) History panel
(5) Operation memorandum input window
(6) History display window

A learner does a drawing task on the canvas window (1), and then the drawing consequence is displayed. The learner starts an explanation through this window, and the explanation is written and modified. Various operation buttons are configured. This window performs the role of the console panel of the whole system.

The simple sentence input window (2) is a one-line editor for a learner to input a simple sentence. This window is invoked by the sentence-creation button on the canvas window, and closes when the input is finished.

The explanation sentence display window (3) displays an entered simple sentence with the items. Each sentence is displayed on this window by an entered order. When a learner estimates that externalization has been terminated (the stage in which the "completion" button is pushed), the order is evaluated, and the line of the explanation sentence is replaced. However, a learner can alter the line of the explanation sentence by using the mouse to "drag & drop".

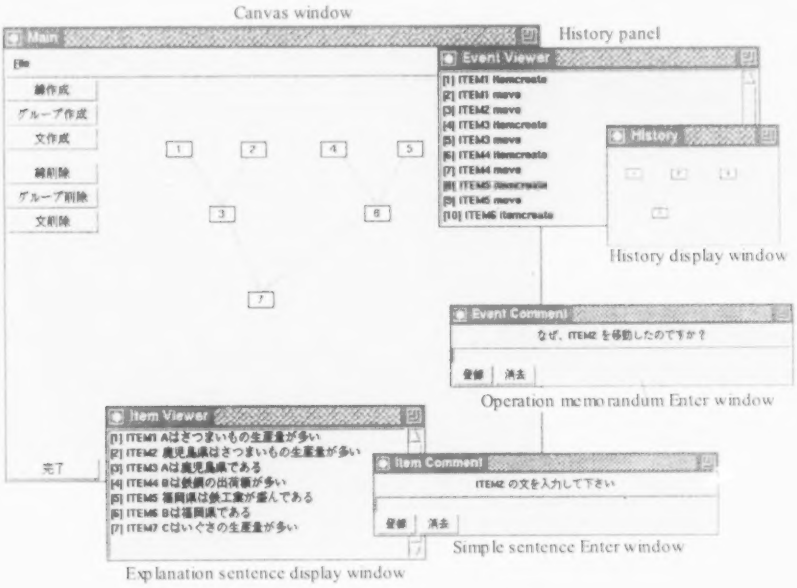


Fig. 5 Screen shot of the prototype system.

BEST COPY AVAILABLE

The history panel (4), the operation memorandum input window (5) and the history display window (6) are related mutually. The operation history of the learner and memoranda are displayed in the history panel. Though the memorandum input window is displayed at every operation, a learner doesn't necessarily need to enter memoranda. Entered comments are displayed in the history panel with the associated operation. When a learner chooses an operation from the operation history, the history display window displays the screen image when that operation is done. It is important to simultaneously present the screen image to support cognitive perspective. Moreover, if a learner chooses an operation from the operation history, she/he can redo the operation from there.

5 Conclusions

In this paper, we described a learning system in which externalization of self-explanation of the problem-solution process was supported. Recent attention is founded in the educational effect of externalization; however, the mechanism of externalization isn't clear, and the recommendation of the usage method isn't sufficient, either.

Therefore, we surveyed externalization first, and described the educational effect. Next, we considered the support method of externalization, and proposed the support method of externalization of self-explanation. The first is the method of externalization of self-explanation that employs expression by words and diagrams, such as memoranda. The other method is that of collecting the operation history and presenting it to the learner from the viewpoint in which the cognitive perspective is important for the examination process of externalization. Furthermore, we attempted a system that could leave operation reason when the operation history was collected. Self-monitoring becomes smooth by presenting operation and reason. Finally, an overview of our trial production system was shown. The state in which a learner externalized in that system was shown.

In the future, we will improve the system, targeting each operation to reduce user load, and we will evaluate the system.

Acknowledgment

This research was supported in party by the Grand-in-Aid for Science Research (A) No. 11780131 from the Ministry of Education, Science, Sports and Culture in Japan.

References

[1]Norman, D. A. :Turn Signals Are the Facial Expressions of Automobiles, Addison-Wesley, (1992).

[2]Metcalfe, J. and Shimamura, A. P. :Metacognition, MIT Press, Massachusetts, (1996).

[3]Kanenishi, K. and Yano, Y.: Guided Understanding for Problem Solving Process Using the Refining Self Explanation, Proceeding of HCI95(Vol.2), pp. 97-102 (1995).

[4]Kanenishi, K. and Yano, Y.: Development Self-Explanation Learning Environment Using the Explanation Refinement, Proceeding of IEEE SMC96(Vol.1), pp. 568-573, (1996).

[5]Stenning, K. and Oberlander, J. :A Cognitive Theory of Graphical and Linguistic Reasoning: Logine and Implementaion, Cognitive Science, Vol. 19, pp. 97-140, (1995).

[6]Zhang, J. :The Nature of External Representations in Problem Solving, Cognitive Science, Vol.21, No.2, pp.179-217, (1997).

[7]Larkin, J. H. and Simon, H. A. :Why a Diagram is (Sometimes) Worth Ten Thousand Words, Cognitive Science, Vol.11, pp.65-100, (1987).

[8]Marcus, N., Cooper, M. and Sweller J. :Understanding Instruction, Journal of Educational Psychology, Vol.88, pp.49-63, (1996).

[9]Chi, M.T.H., Bassok, M., Lewis, M. W., Reimann, P. and Glaser, R. : Self-Explanations: How students study and use examples in learning to solve problem, Cognitive Science, Vol.13, pp.145-182, (1989).

[10]Tweedie, L.: Characterizing Interactive Externalizations, Proceeding of CHI'97 (ACM Conference on Human Factors in Computing Systems), pp. 375-382, (1997).

[11]Myers, B. A. et al.: The Amulet Environment: New Models for Effective User Interface Software Development, IEEE Transaction on Software Engineering, Vol. 23, No. 6, pp.347-365,(1997).

THE GOOD, THE BAD, THE UGLY
OR
INTERACTIVE LEARNING ENVIRONMENTS

*Bobbie T. Biggs, Ph.D. and **James Swartz, Ph.D.
*bbiggs @comp.uark.edu and **jswartz@comp.uark.edu
*Professor and **Associate Professor
*Vocational & Adult Education and **Educational Leadership, Counseling & Foundations
*115 Graduate Education Building and **250 Graduate Education Building
University of Arkansas, Fayetteville, Arkansas, U. S. A.

Qualitative research methods of interview, observation, and document collection were used to analyze a three-hour (48 contact hours) distance education course. The research team consisted of a professor who was the instructor, an Associate Professor who taught qualitative research and five doctoral students enrolled in an advanced qualitative research class.

There were a total of eight learners in four sites. The learners consisted of a specialized population of male adults who were instructors at two-year technical colleges taking the class in response to a state mandate which stipulated that no one would be allowed to teach at the newly-created two-year technical colleges without a baccalaureate degree. The instructor was a female professor with about thirty-five years teaching experience and eight years experience with interactive compressed video distance education. Nine visiting guest speakers of varying teaching experience and no experience with interactive compressed video also participated.

Initial analysis indicated that strong teaching skills and classroom management skills were necessary to conduct the course. Far-site independence of movement, talk, and turn taking required special give and take between learners and the professor. Modifications of ordinary class behavior on the part of learners and the professor were noted.

Keywords: **Distance Learning, Classroom Environment, Classroom Management, Connectivity**

1 Introduction

The presenter's interest is not in distance education as a whole, but in the interaction between the qualities of distance education and teaching strategies for the professor and a particular set of learners. One of the research projects the presenter has completed in this arena was qualitative and the presenter was the subject of the research. The learners in the study were two-year technical college teachers, who were working on a bachelor's degree in vocational education. Since qualitative research is time and context bound, it is difficult to make inferences that would apply across time and context to all teachers who deliver instruction through distance education . That is, these distance education classes occurred in a specific context, with specific groups of people, in specific places, in specific situations, and at a specific time within the current guidelines of distance education technology. The significance of the research lies in the notion of transfer [9]. Transfer is the type of inference qualitative research uses instead of the quantitative notion of generalizability. Consequently, it is up to the reader to draw inferences about how the research time and context fits his/her own time and context. This is in direct contrast to quantitative research which makes decisions about the inferences generated by rejecting null hypotheses. Qualitative research is an appropriate research methodology because all distance education is conducted at a specific time, with specific people, in a specific place, and under specific circumstances [19]. Distance education is a practice rather than a laboratory setting; therefore, professors need to know more about the practice in a practical context-bound environment.

After eight years of teaching in a distance education classroom, the subject had many questions about what strategies were truly facilitating learning. There was also the question of whether a professor with more than thirty years of teaching experience in a traditional classroom could be successful in a distance education classroom. What were the similarities and differences between the classrooms? What issues would an experienced professor need to become cognizant of if he/she wanted to be a successful distance education teacher?

In qualitative research designs, the role of the researcher should be clear. Researcher roles range from participant observer to detached observer [15]. In this particular investigation, the researchers (excluding the subject) did maintain a role usually associated with detached observers. Their position was off camera in the back of the originating site. Although the researchers did travel to each site to observe and interview learners, the majority of observations were conducted in the originating classroom.

The primary observer, interviewer, and document collector was an Associate Professor who taught an advanced qualitative research seminar; the other five researchers were doctoral students in an advanced qualitative research seminar. The observations were overt in nature. The Associate Professor who was teaching the qualitative research seminar appeared on camera at the subject's invitation to introduce the research and inform the participants that their identities would be protected. Informed consent forms were sent to and signed by each person who participated in this research project, which included not only the professor and learners, but also guest lecturers and technicians.

Methods of assuring trustworthiness of the data were prolonged engagement, persistent engagement, triangulation, member checks, and peer debriefing [13]. Prolonged engagement means establishing a long enough contact with the object of research for the purpose of locating patterns in the data. Prolonged engagement was achieved to reveal patterns in the data as opposed to a collection of anecdotes. The entire distance education class was observed by one or more observers. Standardized open-ended interviews were conducted throughout the entire class; for example, three interviews were conducted with professor/subject and one interview was conducted with each class member. Documents were collected throughout the course at the same time the professor/subject distributed them to learners. Persistent engagement was achieved by constant analysis of the data as it were collected to establish patterns in the data and to exclude discrepant information which was anecdotal in nature. For example, sometimes learners who were present in the classroom with the professor might move closer to the professor to gain her attention. This was anomalous because the behavior was controlled for and was eliminated. Therefore, it was not a behavior that was a pattern throughout the course. Although possibly significant, it was an anecdote rather than a pattern. Data triangulation and researcher triangulation were also utilized to enhance the trustworthiness of the data. Data triangulation included observation of each class session, interviews with the professor, each learner, guest lecturers, and technicians. The instruction was documented through 48 hours of observation and approximately 30 hours of interviews with the professor/subject, learners, guest speakers, and technicians. Researcher triangulation was achieved through step-wise replication, which was a technique used during data collection. Step-wise replication is the use of multiple observers for the same observations. This technique was used in order to reduce the biases that might be present in any one single observer. Member checks were conducted with the professor because she was the focus of the research. A member check is a review by the research informant of interviews, observations, or documents. In the case of this particular research, the professor thoroughly reviewed interviews conducted with her in her role as a co-researcher. Peer debriefing was conducted by the six observers and interviewers at seven different meetings during the course.

2 Setting

The primary setting of the class was a state of the art distance education classroom at the University of Arkansas, College of Education and Health Professions. The classroom was designed for distance education and featured appropriate technical characteristics. The professor usually was seated at the front of the classroom behind a large desk approximately eight feet by four feet (8' x 4'). She also could stand behind or in front of the desk or sit at any table with on-site learners. The professor had three different cameras: one was mounted on a monitor (resting on an approximately 4' cabinet toward the center back of the classroom) which follows the movement of the professor; the second camera was attached to a monitor (resting on the same kind of cabinet as the monitors in the rear) to the

professor's right as she looked at the classroom and pointed toward the class; and the third camera had the appearance of an overhead projector and conveyed printed materials much in the way an overhead projector would except through the compressed video system (ELMO). There was also a computer and a SmartBoard available. The professor used a wireless lavalier microphone. There were microphones shared between every two learners, which when turned on activated the learner camera. There were four monitors resting on the aforementioned cabinets; one 52 inch monitor which showed the professor the far-site learners and one 36 inch monitor which allowed the professor to view the near-site and two 52 inch monitors on one side of the professor for the learners to see near and far-site camera outputs. There was sound absorbing material on the wall, carpet on the floor, and neutral colored wall coverings around the room. Behind the instructor the wall was covered with a camera-blue paint for possible use of special effects. Seating for learners consisted of six-foot tables placed in rows to one side of the room with comfortable office chairs, as opposed to standard learner desks and chairs. Far-site classrooms had varying arrangements and color schemes.

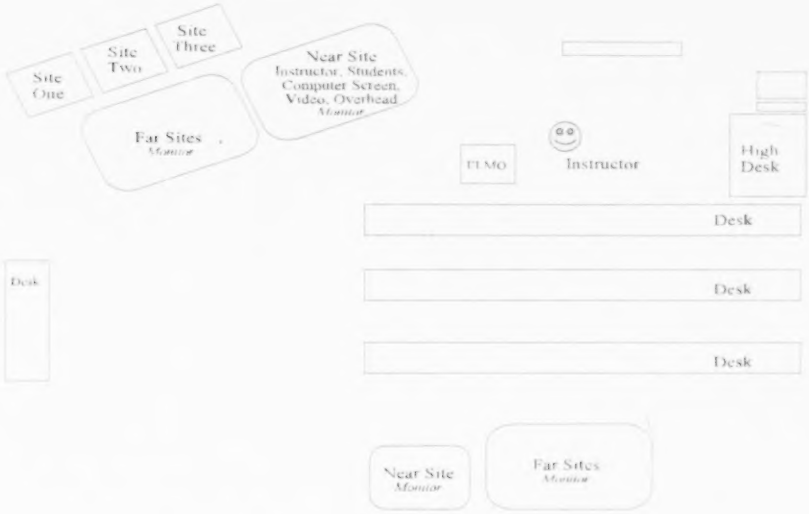


Figure 1. Distance Education Classroom

3 How the Technology Functions

There are four or five sites that combine to form the single distance education classroom. The professor was confined most of the time to the front desk in order to manipulate the controls for cameras and visuals. In her direct view were4 two large monitors, one side contained the camera feed for the near site while the other monitor showed the far sites. Only one far site could be viewed at a time. Selection of far-site location was voice activated; that is, if someone at a far site was speaking, the system automatically selected that site for viewing. Consequently, the professor could not select far-site locations for viewing at her discretion. Communication with learners was conducted through on-line compressed video imagery, world wide web, facsimile machine, electronic mail, standard U.S. mail service, and telephone. Of these options actual class time was centered around compressed video imagery. Guest speakers had been

invited to convey information to learners during the courses. Each of the guests was provided the opportunity to view the professor as she modeled utilization of the system before the guest presented. It has been interesting to note that most guests expressed discomfort with the system, but subsequently seemed to work well with the system. Guests were never required to manipulate the system; the professor performed that function for them. Technical difficulties have been noted as part of the functioning of the system. Technical difficulties included feedback, problems with playback of videos, and interruption of compressed video signal due to weather conditions. All sites had some local technical assistance, though it was minimal.

4 Activities

The professor used a variety of interactive activities, such as lecture and questioning, self assessment, in-class individual and group work, guest lectures, learner demonstrations, individual and group reports, and cross-site dialogue — teacher to learner and learner to learner. A typical class period featured an introduction by the professor, which included personal exchanges with learners. Other attributes of a typical class session were professor lectures with visuals, which consisted of projection of the content on the ELMO or on the monitor from the computer such as a slide show presentation, continual questioning and clarifying, and short video tapes. The professor might introduce a guest speaker. The class session would then proceed to engaging the learner in activities, such as group work, learner teaching demonstrations, and presentation of learner reports. The professor also traveled to each far-site two or three times during the semester, depending on the need.

5 INTERACTION OF DISTANCE EDUCATION CHARACTERISTICS WITH TEACHING STRATEGIES

This section is really the heart of the story. The following table lists the differences and similarities between traditional classroom instruction and distance education instruction for this particular professor and a particular group of learners [10]. Although the table describes both similarities and differences, the emphasis today will be on what teaching behaviors the professor had to modify because of distance education. Modifications include those associated with environment, presentation of knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

Table 1

Similarities and Differences Between Traditional and Distance Education Instruction

Similarities	Differences
• **Environment conducive to the teaching-learning process** ○ Become just as frustrated when cannot talk immediately ○ Learners want to be part of class ○ Diffuse anger or frustration ASAP ○ Face to face ○ Can establish rapport, but takes more effort ○ Make each learner feel welcome, at home, and glad they came ○ Nurturing positive attitude	• **Environment conducive to the teaching-learning process** ○ Difficult to read nonverbal cues ○ Situations may require explanations because all learners cannot see all that is happening in each classroom ○ Teacher and learners have narrow perception of the classroom itself, because all there is is the screen ○ Exhaustion of teacher and learners due to length of class period and number of previous hours in class ○ Rapport is more difficult because learners must be brought along at each meeting as if it is a new class, as you cannot see faces and cannot tell where they are, so you have to assume no one is with you ○ Informality is more difficult to maintain when teacher is confined to one spot ○ May be more stressful to professor than traditional classroom
• **Presentation of knowledge base** ○ Extensive preplanning ○ Transparencies for focus ○ Relevance of material ○ Setting up a learning activity ○ Teaching blocks of 15-20 minutes ○ Refer learners frequently to text	**Presentation of knowledge base** ○ Size of visual materials ○ Color of visual materials ○ Lectures need to be visible ○ Speak more slowly ○ Operating equipment without distracting from content
• **Classroom management** ○ Recreational stress management — joking, getting them ready to engage with me; an organization process ○ Have to manage learners the same — if they are not on target or if they are going things you do not want done — always a constant ○ Make assignment, which is introduction for next class	• **Classroom management** ○ Easier for the teacher to become isolated and self centered and be the fountain of knowledge because it is easier to handle class that way ○ Length of time it takes for class materials to reach learners and learner work to reach me (if the web and e-mail is not used) ○ May have to hold something that needs immediate discussion, because it is not in the hands of all learners — makes spontaneity difficulty ○ Timely feedback difficult ○ Encourage learners talk more and/or to work in groups if we are experiencing audio problems ○ Model for guests so they see what happens when camera jumps from site to site ○ Difficult to do group work across sites because of sound interruption to other learners ○ Have to make special arrangements for private conversations ○ Takes more direction for guests, especially to have appropriate visuals ready and class materials to learners ahead of time ○ Physical proximity cannot be used to control a disruption — all there is is verbal proximity
• **Nonverbal communication**	• **Nonverbal communication** ○ Observation difficult due to camera focus and lack of camera control in multiple sites ○ Limited movement unnatural

Similarities	Differences
• **Feeling of connectivity among class members and professor** ○ Connecting with learners personally through acquaintances or experiences ○ Be who you are and operate the same ○ Call each individual by name ○ Let learners know who you are ○ Introducing learners; establishing expectations; setting the stage for involvement	• **Feeling of connectivity among class members and professor** ○ Look regularly at the camera ○ Treat each site as if it were an individual in a larger class; call each person by name when they speak or when called upon ○ Learners may feel isolation, especially near-site learners, because camera is usually on teacher; the fewer the learners, the more the isolation ○ Professor had to make notes on learner needs, because in jumping from screen to screen (classroom to classroom), easy to lose site of needs ○ Learners usually have trouble speaking — breaking in and speaking up and out
• **Attention to physical appearance** ○ Clothing, makeup ○ Enthusiasm, humor ○ Voice tone/pitch ○ Pauses ○ Gestures	• **Attention to physical appearance**
	• **Methods of communication and or interaction** ○ Facsimile machine ○ Electronic mail ○ U. S. Mail ○ Telephone ○ World wide web
	• **Technical problems** ○ Manipulation of equipment distracts ○ Feedback in sound system ○ No on-site technician for problems ○ Exhausting for professor to have one screen moving them from site to site; split or multiple screen desirable ○ Limited professor movement due to microphone, camera and controls; otherwise, technician must be in room ○ Disconcerting to jump from classroom to classroom ○ Camera focus too distant for reading nonverbal communication ○ Having to look at another camera to see where professor is in relation to monitor may make teacher look distracted when checking it ○ Determining if system will be back up when it goes down and what to tell learners about staying or going home

Environmentally, the primary difference is a two-dimensional far-site communication that is limited to the focal length of the lens. This limitation excludes detail, relevant off-camera occurrences, and access to a great deal of nonverbal communication. For example, on numerous occasions learners requested that the professor move her camera closer to her face so they could see her facial expressions. This greatly restricted the professor's movement and eliminated hand gestures and body motion that she normally used to provide emphasis. Such a restrictive environment often causes stress to professors and learners and makes rapport problematic.

Presentation of the knowledge base required more time to deliver because lectures needed to become more visible and the professor needed to speak more slowly. On one occasion the professor was discussing an overhead transparency point by point and a learner remarked, "Please slow down; I can't hear you that well through the system." The combination of lack of screen resolution that is characteristic of a television image and the poor sound quality required more time to deliver instruction. One of the reasons that sound and picture quality can be poor is the need to reduce the band width in order to match the distributor's system which does not always match the originating signal. In addition, a distance education professor's attention must be devoted to operating equipment as well as to delivering content. Frequently it takes longer to deliver instruction via two-way compressed video; therefore, it may decrease the scope of the course.

The majority of the differences noted between traditional and distance education instruction appeared in the classroom management category. Normally physical proximity can be used to control classroom disruptions. That is not available to the distance educator. It is extremely difficult to take a learner aside for private conversations. The professor did this primarily through e-mail and telephone communications. Although it is beneficial to plan materials and instructional sequences ahead of time, the lack of physical proximity to learners and the inability to introduce new materials rapidly reduces spontaneity of instruction. For example, a far-site learner might request information about a regulation concerning affirmative action, which involved completion of certain forms. The professor would have to get the forms to the learner before he/she could discuss the specifics of the question. This is one example among many about how physical distance from learners reduces opportunities for the teachable moment. Physical isolation from learners means that organization and direction of the class can easily become centered on the professor which could cause the professor to utilize more controlling teaching strategies. It should be mentioned that guest speakers needed to be encouraged to prepare further in advance for their presentations and also had to be introduced to the technology. This sometimes produces a much more formal presentation than was appropriate for the particular teaching situation. The principle investigator's notes in the verification study included references to the stiffness of the guests as they presented. A member check with the professor revealed that the same guests were much more relaxed during traditional classroom presentations.

Nonverbal communication suffered significantly because the camera sees so little and with poor clarity. For example, with three or four remote sites and only one site visible on the monitor at a time and possibly only one learner on camera, the professor could not gain nonverbal feedback from the class as a whole. Even when as many as three learners were on camera at a single time, the camera was so distant that few nonverbal cues, except those involving the whole body, could be observed; for example, facial expression or hand gestures were not readily conveyed.

The feeling of connectivity among class members and the professor is different in the distance education setting. The system used in the College of Education and Health Professions is voice activated which causes learners problems with taking turns, because when they speak the picture jumps to their location; therefore, it is difficult for cross-site discussions to take place. The professor had to use special strategies to establish a classroom community from the four or five sites. The professor approached the task of creating one classroom by recognizing the personality of each site and then the personality of each learner at that site. These personalities were a product of the individuals and the technologies they had at their disposal. For example, there was one group that expressed a reluctance to use the ELMO at their location, while other learner sites would not speak in order to prevent the camera showing their location.

Methods of communication controlled methods of interaction. In a traditional classroom the professor can take a learner aside for a personal conversation while others are working on individual or group projects. However, in the distance education classroom what one learner hears, all learners hear. Of the means of communication utilized in the class, only e-mail or the telephone offered the possibility of a personal conversation.

Technical problems sometimes eliminated class or disrupted class. For example, line feedback made verbal communication very difficult on numerous occasions. On one occasion a storm at a distributing site caused the elimination of one class period. Other technical problems included picture quality, problems with showing videos in real time, and limits on my movements. In spite of these differences between the traditional classroom and the distance education classroom, it is still possible for a class to be conducted on a regular basis and with favorable results.

6 Conclusions

This discussion of similarities and differences between traditional and distance education instruction has centered on the differences rather than the similarities. The researchers have heard many speakers state that there is no difference in teaching in a traditional or distance classroom. The professor knows from eight years of experience there is a difference and is trying to understand the nuances about distance education. The differences cited were classroom environment, presentation of the knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

The cumulative effect of these differences resulted in a reduction of what is being called social abrasion. Social abrasion means being present which implies physical proximity and the social abrasion that such physical presence produces [14]. For this discussion social abrasion has been separated into the following categories: physical distance, emotional distance, simultaneous two-way verbal and visual access, private communication, and local knowledge.

Physical distance is an important part of social abrasion. In western civilization each person maintains approximately a three-foot distance between their body and the body of other people. This distance is either reduced or expanded based on interactions with others [6]. The expansion and contraction of this physical distance is an example of the abrasion between one person and another. Abrasion means contact and social exchange. This abrasion is done socially through verbal and nonverbal communications. If people are separated physically as they are in distance education, this sort of social abrasion is extremely reduced or nonexistent because there is no three-foot parameter to expand or contract. Physical distance also decreases interpretation of nonverbal communication. In a long camera shot facial gestures are lost, hand gestures become smaller, and a coherent sequence of body movements become unavailable to the viewer.

Emotional distance is increased through the possibility of physical presence. For example, the threat of being physically harmed or the pleasure of being physically touched are eliminated through distance education. Emotional identification with someone who is simply an image on screen may be more difficult [1]. This is one of the reasons why the professor visited the far sites. Trust in part may also be a function of physical distance. According to some researchers [5], credibility is a product of appearance and personal identification and is problematic when mediated. Authenticity can be achieved by the handling of real objects and the sharing of those objects in a common space [8]. Personal narratives delivered by professors or guest speakers may be less realistic when conveyed through a medium normally associated with fantasy [1]. Simultaneous two-way verbal and visual access are standard in a traditional classroom environment but are not guaranteed in distance education especially when visual access is limited to one site at a time in a multi-site communication. Social abrasion also means the possibility of one on one private oral and written conversations. This is extremely problematic with distance education because what one person says is heard by all. Also important to social abrasion is the honoring of local knowledge [7]. It is possible that knowledge like bread is best make locally [17]. For example, the classroom experience and interpretation of the meaning of course content can vary from site to site [2]. Meanings can vary from site to site because different sites may represent clusters of people with similar experiences that are unique to their areas. For example, professors sometimes have a site which will consist of persons who work at the same industry and may be at different levels of authority within the organization. It is probable that their experiences and knowledge and their meanings differed from other sites [4]. The inability to bring everyone together in one location to produce a common discussion seems impaired by distance education. The combination of these elements — physical distance, emotional distance, simultaneous two-way verbal and visual access, and private communication — and the maintenance of distinct knowledge bases (local knowledge) throughout the course may mean that distance instruction produces different outcomes than traditional classroom instruction. It is these outcomes upon which the research focused. It is the findings of that research the professor draws upon as she develops courses and teaches via two-way compressed video.

REFERENCES

[1] Altheide, D. L. (1976). Creating reality. Beverly Hills, CA: Sage Publications.
[2] Anyon, J. (1981). Social class and school knowledge. Curriculum Inquiry, 11(1), 3-41.

[3] Biggs, B. T., & Swartz, J. D. (1997) Evaluation of an interactive compressed video distance learning class: What we learned from the study. *The New Learning Environment: A Global Perspective* [18th International Council for Distance Education World Conference Papers, CD-ROM]. University Park, PA: The Pennsylvania State University.

[4] Breton, R. (1984). The production and allocation of symbolic resources: An analysis of the linguistic and ethnocultural fields in Canada. Review of Canadian Sociology and Anthropology, 21(1), 123-144.

[5] Fleming, M., & Levy, H. (1992). Instructional method design (2nd ed.). Englewood Cliffs, NJ: Educational Technology Publications.

[6] Goffman, I. (1974). Frame analysis. New York, NY: Harper Colophon Books.

[7] Greene, M. (1986). Reflection and passion in teaching. Journal of Curriculum and Supervision, 2(1), 68-81.

[8] Leiter, K. (1980). A primer on ethnomethodology. New York, NY: Oxford University Press.

[9] Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills, CA: Sage Publications.

[10] Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2nd ed.). Newbury Park, CA: Sage Publications.

[11] Orr, B., & Biggs, B. T. (1998). Distance education and two-year institutions — a match? ATEA Journal, 16 (1), 16-19.

[12] Orr, B., & Biggs, B. (1998). Issues and barriers in teaching through two-way compressed video. Refereed poster presentation at the 6th International Conference on Computers in Education. Beijing, China, October 14-17, 1998. [published in proceedings]

[13] Patton, M. Q. (1990). Qualitative evaluation and research methods (2nd ed.). Newbury Park, CA: Sage Publications.

[14] Polanyi, M. (1966). The tacit dimension. Gloucester, MA: Doubleday and Company.

[15] Strauss, A., & Corbin, J. (1990). Basics of qualitative research. Newbury Park, CA: Sage Publications.

[16] Swartz, J. D., & Biggs, B. T. (1999). Technology, time, and space or what does it mean to be present? Journal of Educational Computing Research, 20 (1), 71-85.

[17] Taylor, W. D., & Swartz, J. D. (1988). The emerging knowledge crisis in instructional technology. In M. E. Shorey & A. D. Evans (Eds.), Preparing educators with essential media competencies (pp. 141-152). Columbus, OH: The Ohio State Educational Library/Media Association.

[18] Wolcott, H. F. (1995). The art of fieldwork. Walnut Creek, CA: Altamira Press.

[19] Yin, R. K. (1994). Case study research: Design and methods. Newbury Park, CA: Sage Publications.

The Impact of Learning Style on Group Cooperative Learning

Fang-yi Hu* and Nian-shing Chen*
** Dep. of Information Management, National Sun Yat-sen University*
70, Lian-hi Road, Kaohsiung, Taiwan 804
Tel: +886-7-5252510
E-mail: fyhu@power2.nsysu.edu.tw; nschen@cc.nsysu.edu.tw

Cooperative learning has been around a long time and there are many researches and practical uses of cooperative learning. This study is to examine students' attitude toward group cooperative learning processing with individual's underlying learning style. We use Gregorc's Learning Style Delineator to group students heterogeneously and use some factors of Social Cognitive Theory to measure group processing. The findings indicate students with concrete/sequential learning style are tentative to be lack of self-efficacy on setting their goals and therefore teachers should take more care of them while doing group cooperative learning activities.

Keywords: **Cooperative Learning, Learning Style, Social Cognitive Theory**

1 Introduction

Cooperative learning means students working together to accomplish shared learning goals and to maximize their own and their group members' achievements (Johnson & Johnson, 1994). Cooperative learning is widely adopted by the educators since 1980s. Students perceive that they can reach their learning goals if and only if the other students in the learning group also reach their goals (Deutsch, 1962; Johnson & Johnson, 1989). A vast amount of evidence from research in related areas suggest that in cooperative learning situations there is a positive interdependence among students' goal attainments.

Although cooperative learning makes students to learn much better than competitive learning and individual learning in groups, there are still many potential barriers to make group effective, such as lack of sufficient heterogeneity, lack of groupthink, free riding, and lack of teamwork skills (Johnson & Johnson, 1994; Johnson & Johnson, 1996). The basic elements of making cooperative group with high performances are positive interdependence, face-to-face promotive interaction, individual and group accountability, appropriate use of social skills, and group processing (Johnson & Johnson, 1996). Thus how students interacting with other group members and groups processing are the critical successful factors in cooperative learning. By considering individuals' underlying learning style, the purpose of the study is to examine students' attitude toward group cooperative learning processing.

In the Bostrom, et al. (1988) framework individual difference variables define the cognitive aspects of human activities. Thinking process is at the heart of all such activities including learning. Learning style is one of the cognitive traits, which are static aspects of information processing affecting a broad range of variables (Bostrom, et al., 1990). To aim for sufficient heterogeneous grouping, this study chooses learning style as the main variable concerning the impacts of group cooperative learning.

To examine individual's interaction during group processing, this study use Social Cognitive Theory (SCT) (Bandura, 1986), a widely accepted and empirically validated model of individual behavior (Compeau & Higgins, 1995), to reflect the cognitive aspects of students' learning activities, such as self-efficacy. SCT emphasizes the triadic reciprocal causation of behavior, cognitive and some personal factors and environmental events (see Figure 1). Three aspects of Social Cognitive Theory are especially relevant to the organizational field (Bandura, 1988; Wood & Bandura, 1989): the development of people's cognitive, social, and behavioral competencies through mastery modeling, the cultivation of people's beliefs in their capabilities so that they will use their talents effectively, and the enhancement of people's motivation

through goal systems.

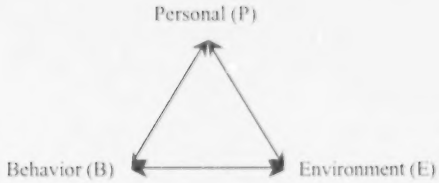


Figure 1. Schematization of the relations among behavior (B), cognitive and other personal factors (P), and the external environment (E) (Bandura, 1986; Wood & Bandura, 1989)

According to Social Cognitive Theory, many researches showed that past performance, self-efficacy and goal setting are the main personal factors effecting performance. Although there are many other factors in the range of the theory, we just discuss the impact of learning style on self-efficacy and goal setting in this study.

There are some other factors exerting considerable influence over group performance. For example, group cohesiveness and group norms. Cohesiveness means all forces (both positive and negative) that cause individuals to maintain their membership in specific groups. Group cohesion means the mutual attraction among group members and the resulting desire to remain in the group. Norms means the rules or expectations that specify appropriate behavior in the group and the standards by which group members regulate their actions (Johnson & Johnson, 1996). Group performance is affected by the combination of cohesiveness and group norms rather than cohesiveness alone (Langfred, 1998). In this study, we also investigate the impact of learning style in group cohesiveness and norms.

2 Method

2.1 Subjects

The subjects were 43 girl's senior high school students who participated in the AJET (Advanced Joint English Teaching, *http://ajet.nsysu.edu.tw*) project, which was supported by MOECC (Ministry of Education Computer Center, APNG-Education (Asia Pacific Networking Group) and I*EARN in Taiwan (*http://www.iearn.edu.tw*). Therefore there are no differences in sex and age among them. The subjects were run in groups and Table 1 is their proportion of learning style. We'll explain the types of learning styles later.

Table 1. Learning Style Frequencies

Learning Style	AR	CR	AS	CS	Total
Students Numbers	15	17	7	4	43

Every group was assigned a project to make English web pages about one topic: Signs or Foods in 6 weeks. Every week they had tow hours on learning how to make homepages by Microsoft FrontPage 98 and doing their group's project as exercises in the computer classroom. Before the experiment, they had learned some basic skills for building their own personal webs.

2.2 Procedure

During the 6 weeks, there were three 2-week sections in the experiment. In the first week, the subjects were asked to fill out the self-efficacy, goal setting and group cohesiveness questionnaires. The same questionnaires were conducted in every section. And in the second week, they were asked to fill out the group norm and satisfaction questionnaires after their performance measurement made by the teachers.

2.3 Measure

According to the procedure, this study assessed learning style and 5 constructs: group norms, group cohesiveness, self-efficacy, goal setting and satisfaction.

2.3.1 Learning Style

In this study, the Gregorc Learning Style Delineator was used to measure the learning style (Gregorc, 1982). Gregorc' s model is one of several models developed to improve understanding of the way students learn and the way teachers teach and is a cognitive model designed to reveal two types of abilities, perception and ordering. Perceptual abilities mean through which information is grasped, translate into two qualities; abstractness and concreteness. Ordering abilities are the ways the learner organize information, either sequentially (linearly) or randomly (non-linearly) (Leuthold, 1999). Thus there are four learning categories: abstract/ random (AR), concrete/random (CR), abstract/sequential (AS) and concrete/ sequential (CS).

2.3.2 Group Norms

Group norms was measured by 5 items on 7-point scales, which indicate the amount of effort put into work, the attitudes toward work load, the willingness to give up free time to work, the feeling of responsibility for work goal attainment, and the feelings of self-worth when work is accomplished well. This measure is developed based on the literature of group work norms (Langfred, 1998). The Cronbach alpha for the group norms measure was .839.

2.3.3 Group Cohesiveness

Group cohesiveness was measured by 6 items on 7-point scales, which defines the feeling of individual group members toward other members and the group. This measure is based on the literature of Langfred (1998). The Cronbach alpha for the group cohesiveness measure is .79.

2.3.4 Self-efficacy

Self-efficacy was measured by 8 items, which asked the respondents to rate their expected ability to accomplish the project with different levels of goal. For example, the respondents were asked whether they could accomplish fifty percent of the project and how much confidence they have. This measure is developed based on an extensive review of the literature of self-efficacy (Compeau & Higgins, 1995). The Cronbach alpha for the self-efficacy measure is .963.

2.3.5 Goal setting

Goal setting was measured by 4 items, which asked the subjects' commitment to their goal of the projects. This measure is developed based on the literature of goals (Locke, 1984). The Cronbach alpha for the goal setting measure was .68.

2.3.6 Satisfaction

Satisfaction was measured by 5 items on 7-point scales, which asked the subjects' satisfaction of the performance of their group project. This measure is developed based on the literature of satisfaction (Dennis, Kinney & Hung, 1999). The Cronbach alpha for the satisfaction measure was .913.

3 Results

Since the Cronbach alpha values of all experiment measures are .891, .8767 and .8646 respectively, this experiment was reliable. An overview of the data is displayed in Table 2, and the results are displayed in Figure 2, 3, 4, 5 and 6.

Table 2. The mean of every measure

Mean	Group Norms	Group Cohesiveness	Self-efficacy	Goal setting	Satisfaction
Section 1	5.16	4.90	529.77	5.66	4.94
Section 2	4.90	4.60	561.16		4.56
Section 3	4.86	3.76	574.42	5.60	5.05

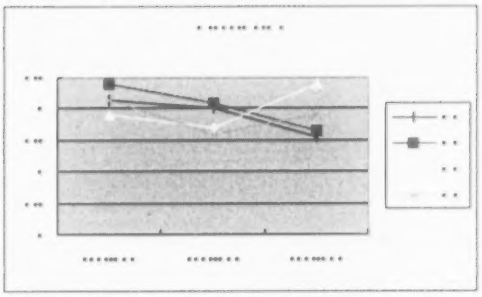


Figure 2. Effects of Learning style on group norms

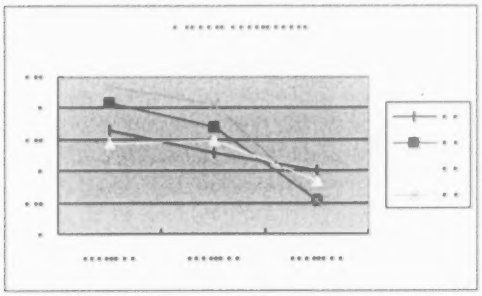


Figure 3. Effects of Learning style on group cohesiveness

The effects of learning style on group norms and group cohesiveness in the three 2-week experiments are not statistically significant, and the results are showed in Figure 2. Because the subjects were grouped since three months ago in the beginning of the semester, the group norms were already statically existed and were identified with group members.

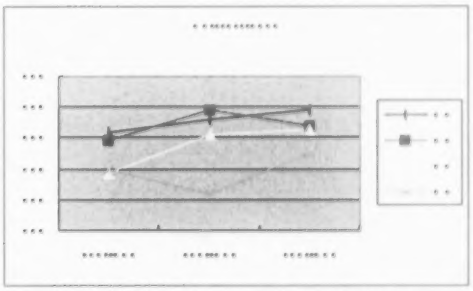


Figure 4. Effects of Learning style on self-efficacy

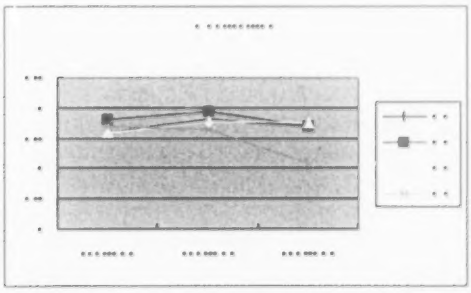


Figure 5. Effects of Learning style on goal setting

The effects of learning style on self-efficacy and goal setting are more significant than group norms and group cohesiveness. The results are showed in Figure 3. Students with concrete/sequential learning style had less self-efficacy during the experiment and were afraid to set their goal higher. Maybe the CS style students feel difficult to make web pages since it is somehow an abstract skill and needs to think randomly.

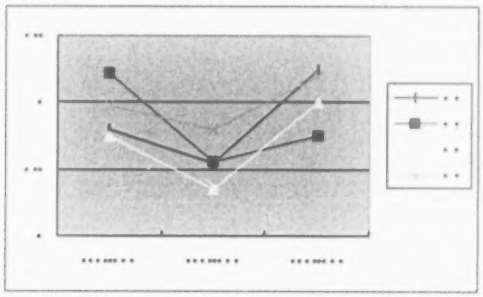


Figure 6. Effects of Learning style on satisfaction

The effects of learning style on satisfaction don't have significant differences, and the result is showed in Figure 4. It showed that all students enjoyed group cooperative learning and were satisfied in this way of learning.

4 Conclusions

In general, all students performed well in the group cooperative learning and felt satisfied with group processing. Although the students with concrete/sequential learning style were few and far between the subjects in this experiment, a quarter of general students would be this kind of learning style. Teachers should give them more encouragement to make them getting more self-efficacy and setting the right goal. Moreover, this study only uses Gregorc Learning Style Delineator to examine students' learning style. There are many other kinds of learning style evaluations, such Kolb's (1976) Learning Style Inventory (KLSI), Canfield's (1988) Learning Styles Inventory, etc. Future researches may use these questionnaires to examine which one is more suitable for cooperative learning.

And about the Social Cognitive Theory, there were many studies showed that the triadic aspects could form some models, which would affect each other in some relationships. Since the sample size is too small, this study doesn't prove the model by statistic methods. This is a limitation of this study. Understanding the effects between group norms, cohesiveness, self-efficacy and their performance will be an interesting research topic.

References

[1] Bandura, A., "Social Foundations of Thought and Actions: A Social Cognitive Theory", Englewood, Cliffs NJ: Prentice-Hall, (1986).

[2] Bostrom, R. P., Olfman, L. & Sein, M. K., "End User Computing: A Framework to Investigate the Training/Learning Process", Human Factors in Management Information Systems, H. M. Carey (ed.), Ablex Publishing Corporation, Norwood, NJ, pp. 221-250, (1988).

[3] Bostrom, R. P., Olfman, L. & Sein, M. K., "The Importance of Learning Style on End-User Training", MIS Quarterly, pp. 101-119, (1990).

[4] Compeau, D. R. & Higgins, C. A., "Application of Social Cognitive Theory to Training for Computer Skills", Information Systems Research, Vol. 6, No. 2, pp. 118-143, (1995).

[5] Dennis, A. R., Kinney, S. T., Hung, C., "Gender Differences in the Effects of Media Richness", Small Group Research, Vol. 30, No. 4, pp. 405-437, (1999).

[6] Deutsch, M., "Cooperation and Trust: Some Theoretical Notes", In M. R. Jones (ed.), Nebraska Symposium on Motivation, Lincoln: University of Nebraska Press, pp. 275-319, (1962).

[7] Johnson, D. W. & Johnson, R. T., "Cooperation and Competition: Theory and Research", Edina, MN: Interaction Book Company, (1989).

[8] Johnson, D. W. & Johnson, R. T., "Learning Together and Alone: Cooperative, Competitive and Individualistic Learning", 4th ed. Allyn and Bacon, (1994).

[9] Johnson, D. W. & Johnson, R. T., "Joining Together: Group Theory and Group Skills", 6th ed. Allyn and Bacon, (1996).

[10] Kolb, D. A., "The Learning Style Inventory Technical Manual", McBer and Company, Boston, MA, (1976).

[11] Leuthold, J. H., "Is Computer-based Learning Right for Everyone", Proceedings of the 32nd HICSS, pp. 1-8, (1999).

[12] Loke, E. A., Frederick, E., Lee, C. & Bobko, P., "Effect of Self-efficacy, Goals and Task Strategies on Task Performance", Journal of Applied Psychology, Vol. 69, No. 2, pp. 241-251, (1984).

The Usability Aspects of an Universal Brokerage and Delivery System for the Pan-European Higher Education

Borka Jerman-Blažic
University of Ljubljana, Faculty of Economics and Jožef Stefan Institute
Jamova 39, Ljubljana, Slovenia
Borka@e5.ijs.si

This paper gives short overview of a recently launched EU project for universal exchange of university course units for the higher education based on a brokerage and delivery system model. The basic components and characteristics of the approache are described. More attention is given to the approach that will be used for assesment of the innovation and for evaluation of the learning and educational achievements.

Keywords: **distance learning, brokerage and delivery system**

1 Introduction

The new technologies are transforming the ways business operate and the ways people work. They are also reshaping the expectations, needs, and opportuniies in education and learning. The customers of the education market are forcing the education to become demand-led, rather than production driven. The current technologies are providing basis for a new just in time, on demand approach the electronic educational products to be offered by virtual or classical universities through special platforms acting as intermediaries between the consumers and the suppliers of educational material. It is clear that the new tecnology alone will not make this new model of more efficient education to happen by itself. Rather, new innovative models of production, brokerage, delivery and presentation are needed that will put together the participants of the education process to collaborate globally and to use the advantages of the powerful technology.

The European project »UNIVERSAL-brokerage and delivery system for exchange of university course units for the Pan European Higher education« [1] is one of the attempts this model to start to work. The project is part of the Vth Framework program of User friendly information society [2] funded by the Commission of European union. The project started in March this year and will last 3 years. The conzortium of the project is large as it encompassess 17 partners from EU [3], among them twelve higher education instituitions from all over Europe, two research organisations, one SME [4] and two telecom service providers. The consortium has also partners from outside Europe as the model developed is expected to have global applications. These are: the Moscow research institut, HEC from Montreal and Nanyang Technological University from Singapore.

The model and the implementation in UNIVERSAL is based on an education brokerage and delivery system being developed to incorporate training by provision of valued-added services to both the customers of the system and the suppliers of the educational material. The major characteristic of the system is offer of different types of learning and delivery of the educational material and its distributive nature. There is no central site for delivery of educational material. Additional characteristic of the model is the system that will be developed for pan-european acreditation of the purchased and performed university course units by the participants belonging to institutions of the European higher education system. At this early stage of the

[1] UNIVERSAL –IST-1999-11747
[2] URL:http://www.ispo.cec.int
[3] EU stands for European Union
[4] SME- Small or Medium Size Enterprise

project is not possible to predict all expected circumstances and consequences that such system may have in the furure development of the educationa nad training. Brokergae approach in provision of distance education must first address a number of technological and educational issues which are part of the UNIVERSAL work program. In depth discussion of the pedagogical paradigms that may take place as well as te number of technological issues of the work program are not possible to be discussed in this article because of space restriction. Here, we concentrate on the basic characteristic of the model; highlithing the implementation scenario and giving more information about the usability aspects of the technology that will be evaluated through monitoring of the educational.

2 The model and the architecture of the system

The model being developed is based on creation of an open, cross-border, educational market environment coupling brokerage and delivery of "live" and "packaged"[5] courses. The proposed framework accommodates and adds value to the various business models and course structures employed in European HEI[6] institutions. It will enable:

- a single faculty wishing to experiment with the simple import of external material to enrich a specific course,
- an existing alliance between institutions to make their exchange more efficient and to enrich it with types of course units not previously exchanged,
- an Open University to extend the range and depth of its courses.

The UNIVERSAL brokerage platform is an interactive hypermedia environment offered to the academics and administrators of European educational institutions to plan and select courses. It de-couple offers and course units provision on the supply side from enquiry, booking and delivery on the demand side. The most important element that enable this de-coupling is the catalogue of offered educational material and the supporting processes, that adequately describes all the properties, educational and technological of the course units. This approach is implemented as brokerage platform and a number of delivery platforms, see Fig.1.

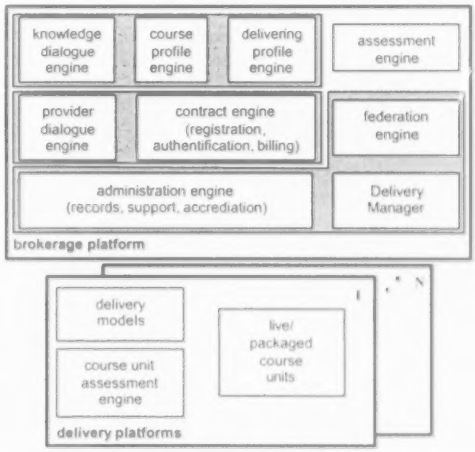


Fig.1 The general architecture

The brokerage platform is further divided in a customer part, a provider part and an administration part. In the customer part, a knowledge dialogue engine is responsible for the dialogue to the demanding institution or to the enquiring student. When interacting with customers, the dialogue engine establishes their background knowledge and guides them in the selection of a course unit. Prospective customers are

[5] Packaged courses are multi-media textbooks and WWW based courses, live courses are CWCS broadcasted courses

[6] HEI stands for Higher Education Institution

presented with choices according to a) pre-requisites and conditions attached to different types of courses (course profile engine), b) the suitability of different Institutions offering courses and c) the different delivery modes available for a particular course (delivery profile engine). Students will be able to make inquiries and express interest in course units that their home institutions have pre-selected and are willing to recognise and give credit. [7]In the provider part a provider dialogue engine is mainly used for feedback from the system back to the content provider. It is also used to handle the offer of content provision to the brokerage system to help academic and administrator users to plan new courses, submit course units, obtain customer records as well as learning progress profiles and assessment results. Demands for course units are sent to the administration engine, which looks for, offered course units fitting into the demand profile. The contract engine sets up the contract between offering and demanding side, thus it is dealing with registration, authentication and billing. In the administration part the system is driven by the administration engine, which is mainly a service database combined with a search engine. The tasks of observing and managing course scheduling and delivery issues, as well as timed interactions between the system and customers to enable the provision of joint courses are the responsibility of the delivery manager. The federation engine is dealing with distribution issues of the engineering implementation, like consistency, caching, forwarding of requests.

For each class of course unit there is an appropriate delivery platform. Variations in delivery platforms are due to the nature of the interactions and differences n media content and formats. The project will implement a limited range of delivery platforms, linked to the brokerage platform, sufficient to show the potential of the model. Each delivery platform contains an inherent delivery model and specific elements dealing with the media content itself.

3 The technology applied

The technology used is ubiquitous, Internet based, offering common, portable solutions and large-scale, shared, cross-border systems. These systems include, but are not restricted to:
Brokerage system is WEB based with Internet links. It is a central point of information, control and administration and logically will be centralized which means that only certain parts will be distributed or redundant for reasons of performance and high availability. The brokerage system will essentially be an E-business system that uses technologies like XML, Java / RMI, CORBA / ODP traders or agent based systems. standard security technology and intrinsic service negotiation for content delivery. Advanced transaction and billing functionality based on AAA[8] security technology, implement sophisticated administration and monitoring interfaces to the delivery systems and the integration of assessment capabilities

Delivery system similarly to the brokerage platform consists of an existing product/technology plus some enhancements ("glue" or "shell" around it), that acts as mediator between the delivery system and the brokerage platform. Defining a unique architecture for this interfacing allows adding additional systems / products by just implementing the appropriate interfaces that plug into the general architecture. A delivery system within the general architecture (see Fig.1) consists of content source, network and content sink. The content source can be a standalone system or part of a broader platform. The same applies to the content sink. The following delivery systems previously tested and used will cover the required functionality: Non-real-time delivery systems: retrieval of non-real-time mono-media and multimedia contents (e.g. browsing through text and hypertext information, download of content files). Real-time A/V systems: Real-time retrieval of multimedia contents (stored and live contents including A/V material like MPEG-2 streams) in synchronous and asynchronous manner (on-demand, live and scheduled broadcast scenarios) using IP technology (unicast, multicast), and broadband technology (ATM, ADSL,). CSCW systems: Videoconferencing and Computer supported co-operative work (CSCW) to enable interactive forms of tele-lectures combining parallel transmission of A/V streams and course material (e.g. slides) with the possibility to interact with the lecturer as well as with other parts of the audience. This family of delivery systems shall also support real-time experiments, simulations and case studies.

---

[7] Scheduling of actual course units remains the prerogative of the institutions and booking of places on courses is considered to be an internal function of the institutions

[8] AAA stands for Authentication, Authorization and Access Control

All delivery systems are inter-working with the brokerage platform and content provider systems to synchronise announcement and content delivery, to guarantee controlled user access, and to manage selection, compatibility and resource usage in delivery. All supported delivery modes will be available as profiles of the A/V delivery family. This means that each content provider can easily select the appropriate profile according to the nature of his contents and his network resources. It is important to note that used the A/V delivery technology is not based on the current average bandwidth and quality availability of the ubiquitous Internet. It will offer real high quality of A/V contents as broadband communication over the Internet (with technologies like ADSL) for a relevant number of users is available in Europe as well as the broadband services emerging in the convergence technology market (broadband over Satellite or cable-TV, interactive digital TV services) are expected to boost the widespread usage of broadband A/V information in the global IT environment. CSCW technology applied follows the principle of standards compliance and openness as for example the powerful CSCW tool ISABEL, developed in the RACE and ACTS projects ISABEL and NICE, then the standards-based (e.g. ITU H.323) COTS products (e.g. MS NetMeeting), MBONE multimedia conferencing tools (VIC, VAT, WB) developed within project MECCANO etc.

4 Content provision and description

The general architecture and model envisaged as a point of interaction of "sellers and buyers" on one hand, and of "place of commerce for actual content" requires an intelligent abstract description of the contents. Therefore, meta-data standards for multimedia contents and for educational environments are applied in the catalogue building of course units. The meta data system used is based on the specification of the IEEE LOM 3.8 meta-data scheme[9] with some extensions relevant to the platform developed as for example: attributes that specify the copyright and IPR[10] protection, attributes that describe information about digital signatures, watermarking, attributes that describe the network requirements for provision of appropriate quality of service, attributes relevant to live content and attributes defining the type of the course unit which may be: packaged, live, CSWC or mixed. The content provision and course description is based on a meta-dada system selected from available standard documents or previous projects results (1).

Several projects, that have investigated the management of information retrieval and the utilization of metadata for education and training have already proposed sets of meta-data requirements, like the Instructional Management System (IMS) project in the US (2) or the GESTALT (3) project in Europe. Some of the proposed sets have been evaluated and selected for the use in the UNIVERSAL project.

They are:

- **Learning resource content meta-data:**

Learning resource content meta data that enables cataloguing of contents of arbitrary aggregation level. UNIVERSAL supports the following granularity levels: *Fragment (Course Unit)*, *Lesson*, *Module* and *Course*. Each learning resource submitted by the "seller" is classified according to the aggregation levels and is added to the UNIVERSAL catalogue. UNIVERSAL supports "packaged" learning content, which is asynchronous in nature and synchronous learning content. Synchronous learning content is delivered as live transmissions of lectures, optionally supplemented by synchronous group ware communication technology. The special or unique features of the live content is described by specially developed attributes that are not part of the current existing meta-data standards.

- **Course structure meta-data:**

The UNIVERSAL brokerage platform not enables "buyers" to locate, use and re-use single course units. A functionality of the brokerage platform enables combination of single course units into higher levels of aggregation e.g. for full subject. This allows production of "custom" tailored complete courses. This is reflected in the course structure meta enabled by Course Structure Format (CSF) defined by the AICC and the ADL (1).

---

[9] IEEE Learning Objects Metadata document by WG 12 of IEEE Learning Technology Standardization Committee, URL:http://ltse.ieee.org/wg12/scheme.html

[10] IPR stands for Intellectual Property Rights

- **Contents packaging meta-data:**

Like many other LMS, the UNIVERSAL platform offers the possibility to access packaged course units, which are mainly pre-recorded. Packaged courses enable an interaction with the contents itself, the interaction with the lecturer is usually not offered. UNIVERSAL packaged courses are described according to well-defined rules, specified e.g. in available standards like the IMS CPS (Content Packaging Specification).

- **Descriptive information about assessment procedures:**

Assessment is an important concept in on-line education and learning. Although the UNIVERSAL platform is not designed to assess the student's advancement and the learning achievement, it will enable consumers or "buyers" to assess the functionality and usability of the platform and the delivery process. The assessment is performed with on line involvement of the students. Student's responses will be captured using some form of structured mechanism with designed template(s) for such purpose. This is especially required in the cases when questions in the templates involve multiple choice, matched items, text selection, etc. Several structures exits for this purpose already: QML, SATML, and the IMS "Question and Test Interoperability Information Model" (QTI), UNIVERSAL team will decide which of the proposed template will be used for particular part of the platform and the delivery system used.

- **Meta-data for synchronisation:**

The asset management is important if the system is built up from re-usable learning resources e.g. units of lower aggregation level as is the case with UNIVERSAL catalogue. . In such cases the lifecycle management of the unit must be supported e.g. a component is not deleted from the asset management system in cases when the course unit is added to a module or larger course. This property of the system is described within the meta-data for synchronisation.

The UNIVERSAL consortium brings together a selected group of engineering and business schools across Europe who are interested in pooling their academic resources for the purpose of broadening the choice of courses and pedagogical materials offered to students and teachers and to provide opportunities for international collaborative learning. Although a few of its members have already established bi-lateral academic exchange programmes, in the initial phase of the project, partners are collecting course units developed within particular partner or outside in order to build a catalogue for the greatest market potential for the brokerage platform. The catalogue contains in addition to the meta-data information also: brief description of the educational objectives of the academic content for the students to whom courses are offered. In addition to that, brief description of teaching methodology used at each institution, description of the academic calendar for each institution, and description of the academic accreditation process for each institution are also information provided in the catalogue. Currently course units are collected from the following fields: Introduction to Information Systems, Regional Economic Development and Telecommunication, Global Marketing Management, Business Case studies, Metallurgy simulations and experiments, Foreign Languages and Cross-cultural Behaviour, Statistics for Economist, Tele-management.

The UNIVERSAL brokerage platform enables to locate, use and re-use single course units and combine single course units into higher levels of aggregation. This approach makes possible a definition of custom tailored structure for a complete course, which will lead, to a definition of a standard system of granularity for learning resources with the other projects from the IST cluster "Flexible University".

Several institutions already made suggestions for a hierarchy of aggregation levels. The IEEE LTSC and the IMS so far define four levels of granularity: *Fragment*, *Lesson*, *Module* and *Course*. Some other US based systems of aggregation can be found in the bibliography enclosed (8).

A course structure representation defines all of the course elements, the course structure, and all external references necessary to represent a course and its intended behaviour. The ADL together with the AICC, IEEE and IMS have developed the so-called Course Structure Format (CSF) which was the recommended approach for the UNIVERSAL project. The CSF promotes reuse of entire courses and encourages the reuse of course components by exposing all the details of each course element. The CSF is intended to reduce or eliminate dependency of a course on a particular LMS implementation.

The CSF is also intended to represent a wide variety of course structures and content "aggregations".

Content structures can be represented by the CSF that range from very small "chunks" of content - as simple as a few lines of Hypertext Markup Language (HTML) or short media clip – to highly interactive learning content that is tracked by an LMS. The CSF is neutral about the complexity of content, the number of hierarchical levels of a particular course (i.e., "granularity"), and the instructional methodology employed to design a course.

The UNIVERSAL platform incorporates continuous assessment of content and the system itself based on the interactions between the customers using the delivery of course units and the system itself. This information will be used to improve the overall scheme and the content to teachers, administrators and other possible customers.

5 The usability and evaluation

"Evaluation is the activity that throughout the planning and delivery of innovative programs enables those involved to learn and make judgement about the outcomes of the innovation concerned "[11]. The UNIVERSAL project aims also to develop tools to monitor the innovation process of education and learning and to develop best practice guidance.

The assessment of the content and the overall system, components for functional assessment are incorporated in both the brokerage system and in each of the delivery systems. Results from previous projects including the deployment of trans-national multimedia learning schemes[12] have shown that it is vital that all participants involved in the creation of the exchange platform and its educational content have a mutual understanding of the platform's operations, functions and of the components' interaction. To fulfill this goal it is necessary to give the users the tools enabling an easy the use of the exchange platform such as: an administrator guide, oriented towards the management of the platform, from a technical ("how to use") point of view as well as from a content ("what to do") point of view; a user guide, describing the day-to-day use of the system e.g. to a teacher wishing to use content available through the platform (how to access the catalogue, how to book a live course, etc). In addition, in the case of "live" delivery systems (on-line live courses with CSWC), experience have shown that it is necessary to organise "hands-on" training sessions to free the teacher from the fear of new tools and to strengthen their "moderation" skills when working with a geographically distributed class through a TV-like systems. Classes in the live courses will be mainly cross-border meaning that most participants will not be working in their mother tongue and there will be a mix of cultures present in any one of the classes. As part of the preparation for participation in the main trials a short "Language & Behaviour" courses that will (I) help participants with their colloquial English (since the majority of the courses will be held in English) and (II) help them be aware of differences in cultural behaviour, e.g. questioning style will be provided.

The student/teacher ratio varies greatly among the UNIVERSAL consortium partners. A set of software monitoring tools are being studied to be implemented into the brokerage platform to make it possible for students to continuously assess their personal progress and to choose the academic path best adapted to his or her acquired knowledge and skills; for course unit providers tools will be used to improve the effectiveness of programmes offered to learners and modify content accordingly; tools will be used also to analyze the way learners use the courseware provided; to enable a global assessment of the usability of the platform etc. The monitoring tools as well as the usability evaluation techniques used for assessment of the innovation technology approach are being developed/selected in accordance with the ACTS Usability Evaluation Guidelines[13]. These guidelines define the testing and evaluation methods, experiments design, definitions of interviews, observations, heuristic evaluation and surveys.

The evaluation instruments for courseware evaluation and corresponding measures will include:

- Pre-task/post-task questionnaires
- Task experience questionnaires
- Computer experience questionnaires
- Exams or assessment of performance
- Post course questionnaires

---

[11] Stern(1988) in Evaluation of Learning Technology Implementation, by Barry Jackson, URL:http://ltdi.icbl.hw.ac.uk

[12] Project LEVERAGE AC 109 from the IV Framework Program-ACTS

[13] USINACTS – AC224, IV Framework Program -ACTS

- Knowledge quizzes
- Logs - logging times

The approach for educational assessment will follow the practical guidelines developed within the LTDI technology developed within the Learning Technology Dissemination Initiative funded by the Scottish Higher Education Funding Council[14]. As a result of this a set of guidelines identifying best practices for future users of an academic brokerage platform will be produced. Academic partners will have the possibility to review the existing experiences and pool their lessons learned from prior involvement in flexible, distance, and collaborative teaching and learning programmes. This information cover issues such as the choice and format for resources provided to students and teachers, access to tutors or teachers, methodology, independent study and collaborate work, learner motivation, learner monitoring, course accreditation etc.

6 Conclusion

The UNIVERSAL is a project that implements the EU policies regarding the development of the European higher education and the user-friendly information society in particular:

- By improving the quality and diversity of the pan-European HE system
- By promoting the globalisation of the exchange of HE course units
- By enabling partners from economically disadvantaged regions, particularly in Central and Eastern Europe to participate in these developments and helping them to strengthen and enrich their course offerings and the foster the education in general.

Most of the activity within the project will be tightly connected with the usability aspects of the applied methods and technology. Usability evaluation and proposed improvement will be based on the past experiences, guidelines and standards developed within projects that have addressed this issue of modern technology in depth. The consortium expects wide acceptance among the higher-level education institutions in Europe.

References

[1] Advanced Distributed Learning Network (ADLNet), *http://www.adlnet.org*

[2] Instructional Management Systems project, *http://www.imsproject.org*

[3] GESTALT:Getting Educational Systems Talking Across Leading-Edge Technologies, *http:www.fdgroup.co.uk/gestalt/*

[3] SCORM, Sharable Courseware Object Reference Model: *http://www.adlnet.org/Scorm/docs/scorm_2.pdf*

[4] IMS Question & Test Information Model, *http://www.imsproject.org/question/index.html*

[5] SATML Standardised Assessment & Testing Markup Language *http://www.engr.ucf.edu/aim/research/1998/tess/satml/default.htm*

[6] QML Question Markup Language, *http://www.questionmark.com/qml/index.htm*

[7] IEEE LTSC WG17: Content Packaging Working Group, *http://ltsc.ieee.org/wg17/index.html*

[8] IMS Content Packaging Specification, *http://www.imsproject.org/content/index.html*

[14] LTDI, Philip Crompton: Evaluation: A practical guide to methods and Stephen Draper: Observing, measuring or evaluating courseware URL:http://www.icbl.hw.ac.uk/ltdi

Virtual Inhabited 3D worlds and Internet Based Learning Environments

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper addresses some of the central questions currently related to 3-dimensional Inhabited Virtual worlds (3D-IVWs) and their virtual interactions and communication in Internet Based Learning Environments. First, 3D-IVWs-seen as a new and unique form of multimedia-are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVW s is denned and commented upon. Third, modes of interactivity and (virtual) interactions between users, avatar, bots, etc. in the new Virtual Worlds are briefly presented and typologized. Finally, two Internet based virtual inhabited 3D learning environments -one US-based and one based in Denmark- will be described and analysed.

*The paper was not available by the date of printing.

Web Speaking: A Language Learning System in the Web

David Lo, Wen-Tsai Liao and Ming-Syan Chen
Department of Electrical Engineering and Computer & Network Center
National Taiwan University
Tapei,Taiwan, ROC

Due to recent technology advances, an increasing number of applications are being ported to the Web at rapid pace. Such applications include Web Phone, Web Fax, Web BBCall, to name a few. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time. In this paper, we develop an interactive language learning system in the Web, called Web Speaking. By using Web Speaking, students are able to learn languages anywhere at any time as long as a Web interface is provided. Web Speaking is in essence a two-tier client-server architecture, and is divided into two components, namely (1) the language learning player at the client-side and (2) the course content provider at the server side. In this system, we put not only the course content but also the corresponding audio files in the server side in order to support a multimedia-teaching environment. The language-learning player runs at the client side and provides a user interface to access the course materials in the server. In addition, Web Speaking is able to improve the language speaking ability of the students with the display of the speech waveform which is generated by using the algorithms isolating the utterances of the speech. Students can capture the difference between the waveforms of their own speaking and the standard one provided by the instructor, and improve their speaking accordingly. By this language learning package, we can automate the procedures of preparing audio course materials, greatly facilitate the language learning by the students, and conduct data mining on student behavior. The teaching quality of language learning can thus be improved.

Keywords: **Distance learning, speech analysis, two-tier client-server architecture, World Wide Web**

1 Introduction

Recently, an increasing number of applications are being ported to the Web at rapid pace, including Web Phone, Web Fax, Web BBCall, and so forth. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time [1,2,3,5,6,7,8]. Traditionally, the students have to be present in the language-learning classrooms and use specific language learning mechanisms to improve their speaking ability. However, the major disadvantage of the traditional language learning is the limitation of time and space. For example, the students may have an English class in the Monday morning at the language-studio classroom and that class could be their sole opportunity to practice their language speaking, since the instructor is only present at that moment. Consequently, the effectiveness of the traditional language-learning systems is limited.

In this paper, we develop an interactive language learning system in the Web, called *Web Speaking*. The Web Speaking system we developed in the Computer and Network Center at National Taiwan University is in essence a two-tier client-server architecture. Through a Web interface, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space. In addition, using Web Speaking, students can communicate with the instructors interactively via the mechanism provided, and the teachers can timely edit the course materials

by writing the content of text and recording the audio files in response to the students' requests very easily. These are the very advantages of Web Speaking over some stand-alone commercial language-learning applications which are usually lack of interactive features.

In addition, the other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students to help the students to learn language speaking better. In Web Speaking, we implement the algorithms isolating the utterances of the speech [9,10] to improving the students' speaking ability. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. It is worth mentioning that Web Speaking system is meant to help the teachers to improve their teaching quality, and should be viewed as an auxiliary tool for teaching. By no means do we assert that Web Speaking is able to completely replace the role of an instructor or in any way to lessen the need for a teacher to personally interact with students. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

The paper is organized as follows. Section 2 depicts the whole system architecture. Section 3 presents the implementation and functionality of the Web Speaking. Section 4 concludes this paper.

2 The System Architecture of the Web Speaking

We use a two-tier client-server architecture for the Web Speaking system. The reason of using the two-tier client-server architecture is that it can provide our two key components, i.e., the language-learning interfaces at the client side and the course content provider at the server-side. This architecture can be easily extended to a three-tier one if an additional gateway is required in this application.

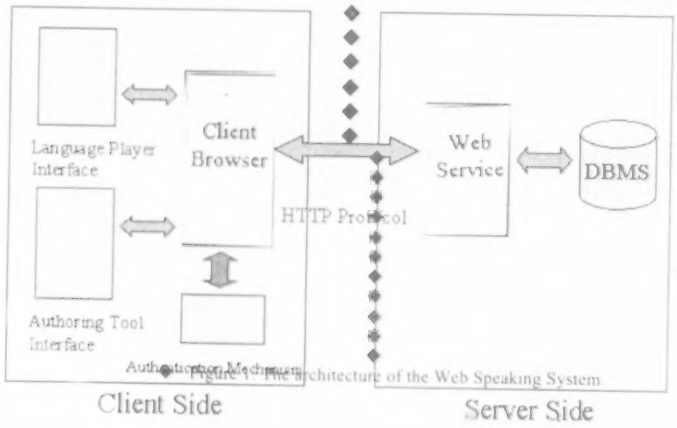


Figure 1 The Architecture of the Web Speaking System.

Based on the two-tier client-server architecture, the Web Speaking System is designed as the Figure 1. At the client side, both the language player interface and the authoring tool interface use the DBMS (Database Manager System) to access the course materials in the server via the HTTP protocol in the Internet/Intranet. The program at the serve side then accepts the requests from the clients and returns the results of the requests to the clients. The DBMS at the server side saves not only the course materials but also the information of the users, including the students and the teachers. Using an authentication mechanism, the player is able to verify the user identification via the Web and to provide different user interfaces for students and teachers, as one form of personalized service. For instance, the students are only allowed to use the language player interface whereas the teachers can use both the language player interface and the authoring tool interface. The following subsections will introduce the operations of the Web Speaking System briefly.

BEST COPY AVAILABLE

2.1 The language learning player at the client side

To assist the students in language leaning on listening and speaking, the user interface (UI) of Web Speaking provides the functions of playing the audio files and those of recording the user's voice. Furthermore, the UI displays the wave shapes of the audio files and the user's voice for users to capture the differences and to improve their speaking. For example, once the user selects one topic of the course in upper-left area of the Figure 2, i.e., "There are always two sides to everything." In Figure 2, not only will the content be shown in the upper-right area but also the shape of this audio appears in the middle area. When the users are playing back the audio in the middle area, an indicator will run along the shape of the audio to indicate the exact timing of audio playing.

In addition to listening the audio and watching the shape of it, the users are also able to record their voice into the system, play it out, and compare its shape with the standard one in the course material. In order to prepare the course materials easily and automatically, Web Speaking provides an interface to authorize the use of course materials and to upload and download materials automatically from the course content provider. This is a very convenient feature for the teachers who are not familiar with the operations of the transmitting files in the Web. Furthermore, the teachers could edit the content of the course material and record the audio easily via this interface, such as adding a new topic of the course material or creating a new course in the upper-right area in the Figure 3. They can also playback and record the audio file of the course materials in the bottom area. As such, the language-learning player, including the language learning interface and the course material authoring tools interface, runs at the client side and provides a user interface to access the course materials in the server. In addition, we use the algorithms isolating the utterances of the speech to display the speech waveform in order to facilitate the language learning of students.

Note that the user needs to use the local resources, such as the I/O of the audio interfaces and the I/O of the storage interfaces at the client side. However, this I/O access is not allowable for the browsers, such as the Internet Explorer and the Netscape Navigator. Therefore, we implement a stand-alone language-learning program at the client side by using the Microsoft Visual Basic 6.0 programming tools.

2.2 The course content provider at the server- side

The major tasks of the server are to save and update the teaching materials and to query the databases when so necessary. These tasks are implemented by using the PHP script language and MySQL database at the server side. Since the PHP script language has been integrated with MySQL database, we use it to query the databases (MySQL). The client can then use the HTTP protocol to communicate with the server.

The course content provider is mainly a server combining the Web service and the database manager. It employs the PHP script language to access the MySQL database and to response the client's requests. As mentioned earlier, the server side of Web Speaking saves not only the contents of the courses but also the corresponding audio files in order to support a multimedia-teaching environment. Once the server gets a request, the content provider fetches the requested materials by the user from the database, and then, if the corresponding authentication succeeds, returns the result to the client.

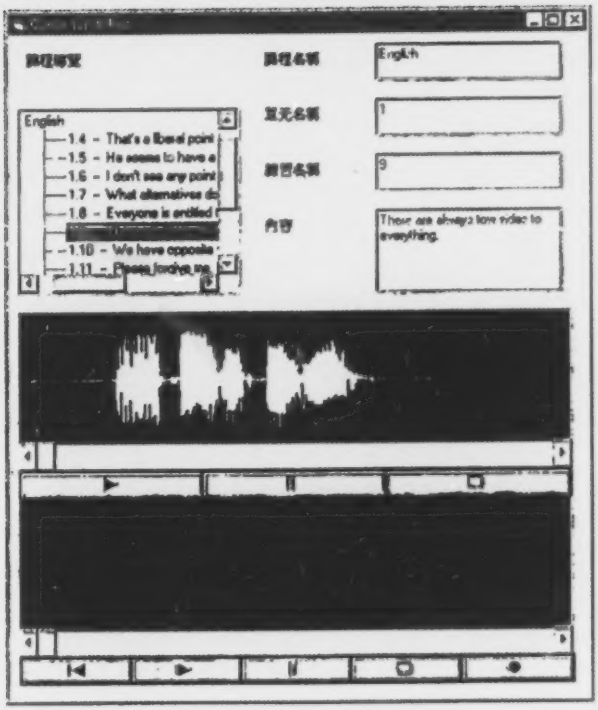


Figure 2: The language-learning player for the students

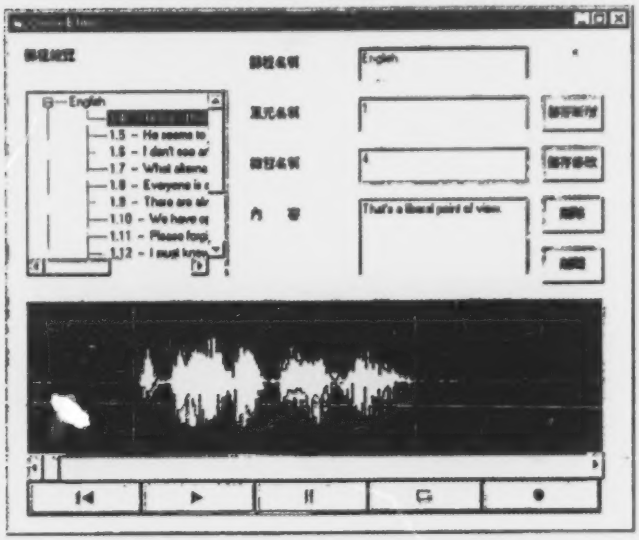


Figure 3: the authoring tools for the teachers

BEST COPY AVAILABLE

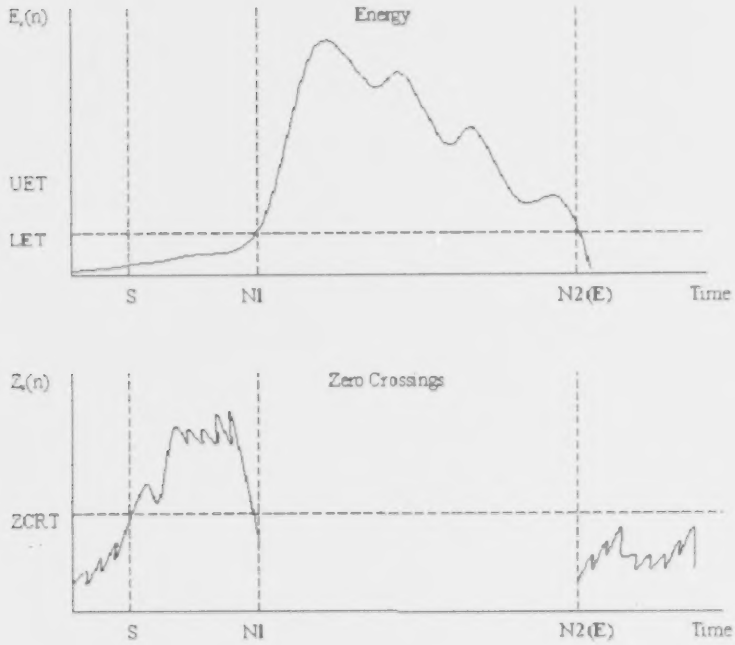
3 End Point Detection for Speech in Web Speaking

We introduce in this section the algorithm used to detect the endpoints of isolated utterances. To help the user learning the language speaking, we display both the waveforms of the speech produced by the user and the standard one prepared by the teacher. In addition, we isolate the utterances of the speech to help the user to understand how the speech looks like. This endpoint detection method [10] uses two parameters, i.e., the short-term energy ($E_s(m)$) and zero crossing rate ($Z_s(m)$), to detect the endpoints of an utterance. These two parameters are calculated as follows, where s(n) means the speech signal, w(n) means the window function, and N means the length of the window.

$$E_s(m) = \sum_{n=m-N+1}^{m} s^2(n)$$

$$Z_s(m) = \frac{1}{N} \sum_{n=m-N+1}^{m} \frac{|\mathrm{sgn}\{s(n)\} - \mathrm{sgn}\{s(n-1)\}|}{2} w(m-n)$$

$$where \quad \mathrm{sgn}\{s(n)\} = \begin{cases} +1, & s(n) \geq 0 \\ -1 & s(n) < 0 \end{cases}$$



◆ Figure 4: Illustration of the endpoint detection algorithm.

The endpoint detection algorithm is depicted in Figure 4 and described below.

Step 1. Assume that the window function *w(n)* is a rectangular function with the window size *N* being 10 ms, and the first 100 ms of the speech signal is background noise. Then, use this signal segment to calculate the mean and variance of $E_s(m)$ and $Z_s(m)$.

Step 2. Using the statistics derived from Step 1, determine three thresholds, i.e., the upper energy threshold (UET), the lower energy threshold (LET), and the zero crossing rate threshold (ZCRT).

Step 3. Search from the beginning until the energy $E_s(m)$ exceeds the threshold UET. Then, run backward until the energy $E_s(m)$ falls below the threshold LET. We call this point the tentative beginning point N1. The tentative ending point N2 is calculated in a similar way.

Step 4. From the tentative beginning point N1, we examine the zero crossing rate for the previous 250 ms

signal segment. If there are more than three occurrences of counts above the threshold ZCRT, we select the first point backward from N1 whose zero crossing rate is higher than ZCRT as the beginning point (S) of the word. If there are no more than three occurrences of counts above the thres hold ZCRT, the tentative beginning point N1 is directly selected as the beginning point of the word. The ending point (E) is decided in a similar way with exception that the forward searching direction replaces the backward one.

By using the above algorithm we can partition the waveforms of the speech. Furthermore, the language-learning player displays the shapes in the screen and also indicates the timing when the waveform of the speech plays. Thus, this functionality of the language-learning player offers not only the playout of the audio but also the display of the waveform shapes at the same time. This is a very helpful feature for students to learn language speaking.

Note that we can collect students' practicing records in the Web Speaking system. Through some data mining techniques, we can find useful information about the student behaviors, e.g., the common mistakes made by the students. Clearly, using such information discovered, the instructor is able to improve their language teaching by reminding the students of how to speak better when the students encounter common problems.

4 Conclusions

In this paper, we developed a Web Speaking system to improve the language learning and teaching for the students and the teachers. By using Web Speaking, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space in traditional teaching environments. The advantage of Web Speaking over some stand-alone commercial language-learning applications lies in the full interactivity Web Speaking provides. The other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students in order to help the students to learn language speaking better. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

Acknowledgement

The authors are supported in part by the Ministry of Education Project No. 89-E-FA06-2-4-7 and the National Science Council, Project No. NSC 89-2219-E-002-007 and NSC 89-2213-E-002-032, Taiwan, Republic of China.

References

[1] E. Bilotta, M. Fiorito, D. Iovane and P. Pantano, "An Educational Environment Using WWW", Computer Networks and ISDN Systems, 27, pp. 905-909, 1995.

[2] "CEIBA," High Performance Computing Lab of Department of Electrical Engineering of National Taiwan University, ftp://www.cc.ntu.edu.tw/pub/Webcourse/.

[3] J. Chang, M. S. Chen and I. P. Lin, "Design and Implementation of a Software Package for Network Education", Proc. of the 2000 International Conference on Engineering Education, August 14-16, 2000.

[4] M. S. Chen, J. Han and P. S. Yu, "Data Mining: An Overview from Database Perspective", IEEE Trans. on Knowledge and Data Engineering, Vol. 8, No. 6, pp. 866-883, December 1996.

[5] "Distance Learning in National Taiwan University", National Taiwan University, http://www.cc.ntu.edu.tw/~ccdl.

[6] D. Dwyer, K. Barbieri and H. M. Doerr, "Creating a Virtual Classroom for Interactive Educations on the Web", Computer Networks and ISDN Systems, 27, pp. 897-904, 1995.

[7] B. Ibrahim and S. D. Franklin, "Advanced educational uses on the World Wide Web", Computer

Networks and ISDN Systems, Vol. 27, No.6, Apr. 1995.
[8] J. C. Jehng, Y.F. Shih, S. Liang and T. W. Chan, "TurtleGraph: a computer supported cooperative learning environment", The Proceedings of the World Conference on Educational Multimedia and Hypermedia, Vancouver, Canada, AACE, pp.293-298, 1994.
[9] M. C. Lai, B. H. Chen and S. M. Yuan, "Toward a new educational environment", World Wide Web Journal, Issue One: Conference Proceedings, Fourth International World Wide Web Conference, O' Reilly & Associates, Inc., pp. 221-230, Nov. 1995.
[10] L.R. Rabiner and M.R. Sambur, "An Algorithm for Determining the Endpoints of Isolated Utterances", The Bell System Technical Journal, Vol. 54, No. 2, February 1975, pp. 297-315.

WWW-Supported Environments for Learning and Teaching Statistics

Katsuyuki Suenaga*, Hiroshi Yadohisa, Naoko Sakurai***, Kazunori Yamaguchi****, Michiko Watanabe*****and Chooichiro Asano********

** Graduate School of Science and Engineering, Kagoshima University, Kagoshima 890-0065, JAPAN; sue@sci.kagoshima-u.ac.jp*

*** Department of Mathematics and Computer Science, Kagoshima University, Kagoshima 890-0065, JAPAN; yado@sci.kagoshima-u.ac.jp*

**** Institute of Asia-Pacific Studies, Waseda University, Tokyo 169-0051, JAPAN; sakurai@wiaps.waseda.ac.jp*

***** College of Social Relations, Rikkyo University, Tokyo 171-8501, JAPAN; kyamagu@rikkyo.ac.jp*

****** Department of Economics, Toyo University, Tokyo 112-0001, JAPAN; michiko@hakusrv.toyo.ac.jp*

****** Department of Information Science, Soka University, Tokyo 192-8577, JAPAN; QYG04340@nifty.co.jp*

In this paper, we introduce an integrated environment for education of Statistics on WWW. The environment is composed of three Web sites; ITLS (Interactive Text for Learning Statistics on WWW), EBSA (Electronic Book for Statistical Analysis on WWW), and DLLSA (Dynamic Link Library for Statistical Analysis). ITLS is an electronic text of Statistics with graphics, sounds, and interactive software which made by JAVA. EBSA is an electronic library of statistical books which made of the PDF format files. These books are scanned and trans-formed from real books which copyright is expired. DLLSA is a statistical software library of DLL files.

Keywords: **Interactive learning environments, Multimedia and hypermedia in education, Self-driven experiments**

1 Background

Recent rapid coverage of computer networking over wide area of Japan has brought the big change of education environment at universities. In these 1 or 2 years there can be seen lots of universities, especially in non scientific division, have set up the computer networking education system over their several lectures where both teachers and students can access to internet Web sites during the lecture time. It also can be seen at overseas education institutes that there have been increasing of statistical education sites [11][12][13][14] or related reports [1][3][4][6][10].

On the other hand, the society needs the persons with the ability of economical data analysis or econometrical analysis among the general sections especially in finance division. It means graduates from social sciences department with an ability of data analysis will be much more needed who had not so many times got the lecture related to statistical data analysis during university days. Statistics is good discipline for computer networking education because it is important for students to learn not only the theory but also the moving of practical data with changing parameters which will lead them to another side of understanding of real world. It can be expected that interactive education with internet Web will bring the multi-dimensional effects to education world. Those are why we have started jointly developing new styled education system for statistics on Web site. It also could be seen that the government recommend to make more use of networking at education scene in line with the change of world education environment.

2 Purposes and Functions

The purposes of our statistical education system on Web are as follows. i) Joint development of education Web sites with which practical statistics education can be realized, ii) Non scientific students' master of data analysis for actual practice, iii) Teachers can keep their material for education jointly, aiming contents' standardization, iv) Students can learn everywhere they are. We are aiming students can participate to our Web sites and get effective learning chances of statistics and econometrics with interactive ways. It can be expected students would keep highly motivation of learning through active operation of some parameters or data on Web site by themselves. It is clear that this is quite different from traditional education way at the point of students are active in learning without their realizing.

Let me show the concrete functions. i) Retrieval by keyword and its supplementary explanation, ii) Download of lecture slides and practical data, iii) Linkage to reference sites, iv) Offering of database for practice, v) Setting of question and answer section, vi) Online questionnaires system. In addition, Web texts contain some easy comments, colored contents, hyper linked material, images and dynamic graphs to help students who are far from printing types can understand statistical concepts.

Figure 1: Top page of ITLS (http://www.sci.kagoshima-u.ac.jp/~itls/)

3 Contents and Characteristics

We have named our online education system as "ITLS (Interactive Text for Learning Statistics)" which is the abbreviation of interactive text for learning statistics (URL: http://www.sci.kagoshima-u.ac.jp/~itls/). Although students can learn statistics and econometrics along this system's chapter contents, chapters are independent each other, so it doesn't matter going to their objects directly. By trying to interactive learning with this system, students can get statistical, econometrical and other economical index or knowledge depending on their own ability. An interactive and visual learning will much make possible the diversified understanding comparative with the usual learning way only by paper texts.

BEST COPY AVAILABLE

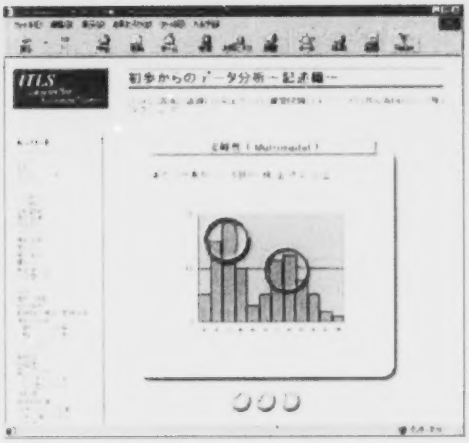


Figure 2: Descriptive statistics

Figure 3: Regression analysis

Figure 4: Dynamic graph of scattergram

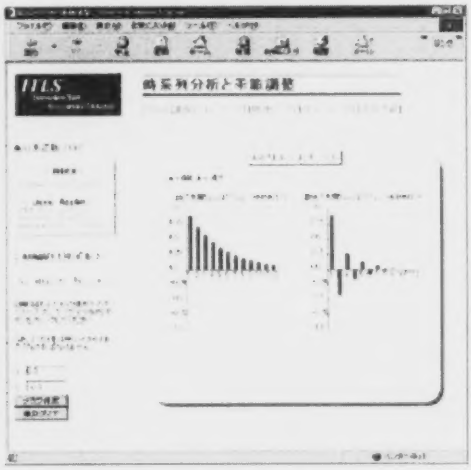


Figure 5: Dynamic graph of correlogram

Figure 2 shows multi-modal distribution in the chapter of descriptive statistics. In this chapter students can get the objective visual panel of contents by retrieving left side keywords list. There are any other explanatory panels of descriptive and inference statistics in this Web system. It is greatly more important for students to see the distribution form visually than to understand statistical concepts only without visualization. Figure 3 shows the regression analysis by familiar tool, for example, Microsoft excel. Each chapter has used the excel or other statistical analysis software as its practical tool, at the same time in the early chapter it has been showed how to use excel as statistical analysis tool mainly. At the demonstrative step of statistics learning, it will be indispensable for students to make use of at least one statistical and analytical software tool which is not common to install in each personal computer at universities except excel.

Figure 4 and 5 show interactive statistical graph. It is not so easy for students who are majo ring not scientific division to understand the relationship between graph and its fixing parameters. These styled system of viewing the dynamic change of various kinds of statistical graph have brought them both visual and intuitive understanding without mathematical formula. This interactive graph making system has been built by JAVA applet or other software tools. There are another contents such as download of lecture slides, making practices into database, setting question and answer section and online questionnaire survey of user along

BEST COPY AVAILABLE

whose analytical results we will update our Web contents better in the future. The bulletin of question and answer is very important for all users because it is the best database of several kinds of question and its response from anyone on all sorts of questionnaire of statistical stages. Developing resources and tools also are considered very important module with which the system will be organized better hyper-linked cooperative developing environment.

Figure 6: Top page of EBSA (http://www.sci.kagoshima-u.ac.jp/~ebsa/)

Figure 6 shows our new Web site of "EBSA (Electronic Book for Statistical Analysis)" with which everybody access to this site can do of online reading over old or new valuable books on Web. Now we have provided several important books on this site. These books open to the public under permission of the copyright holder and the publisher. Since these electronic books are scanned and transformed from real books into the PDF format files, we can download and print out all and/or selected contents of the books. Figure 7 shows one of the top page of an electronic book. Each top page contains four parts; the first and the second parts are the links to the contents and the index pages, respectively. The third part is used for keywords search. The fourth part is the print image of the real book. We rewrite these index and contents as text from the image so as to be used by keywords search.

BEST COPY AVAILABLE

5 Integration

When we use the statistical analysis software, knowledge of statistics is indispensable for us. It can be seen several reports about the effectiveness of the standing statistical analysis software with statistics education [5][7][8][9]. Working statistics with analytical software will much be an expected style of learning over interactive Web system. Under such background, our project team has already prepared a new library of Dynamic Link Library (DLL) for statistical analysis, which is available as a statistical engine or which can be called from existing general statistical software, for examples SAS, SPSS, S and so on.

The DLLs could be considered as a library for applications on the Windows system as well as that for programming. The DLL contains one or more functions that are compiled, linked and stored separately from the applications using them. One of the advantages of DLLs is that multiple applications can access the same DLL. The DLLs in our library can be accessed from any statistical software or spreadsheet-type software if such software has a facility to call functions or subroutines in DLLs. Source codes for DLLs can be written in several programming languages, for examples, C++, FORTRAN, BASIC, PASCAL and so on.

The contents of multivariate analysis section, for example, are as follows. i) Principal Component Analysis, ii) Metric Multidimensional Scaling, iii) Latent Class Analysis, iv) Hierarchical Cluster Analysis, v) Corresponding Analysis, vi) Discriminate Analysis. All contents of our library can be downloaded and used freely. Details for the library and published DLLs can be obtained from our web site (URL: http://www.sci.kagoshima-u.ac.jp/~dllsa/).

The necessary factors of integrated statistical education system of interactive way on Internet are now on ready among our project team members. To be concrete, it is important and urgent to merge statistical analysis software routines above with online learning system on Web as mentioned before, adding to attach the enrichment of interfaces.

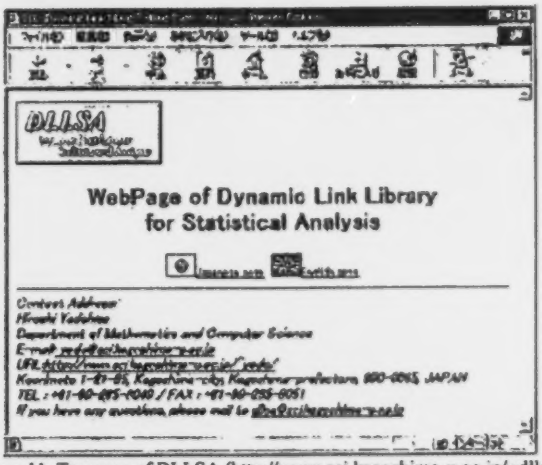


Figure 11: Top page of DLLSA (http://www.sci.kagoshima-u.ac.jp/~dllsa/)

6 Future

Though there are not so many reports about this kind of educational system whole over the world, we can meet some excellent reports about interactive education system on Web [11][12][13][14]. One of our mission is the enrichment of the contents. The join forces of lots of faculties belonging to statistics section will demonstrate the strong power for cooperative Web texts production system. Our next target is achievement of ``international cooperative project". We have the plan of translating the part of contents to international version. Now we appreciate the joint research with German colleague who had already established interactive Web site [3][14].

BEST COPY AVAILABLE

Finally, we would like to introduce the integrated site of our projects. All contents discussed in this paper can be obtained from this site (URL: http://www.sci.kagoshima-u.ac.jp/~stat/).

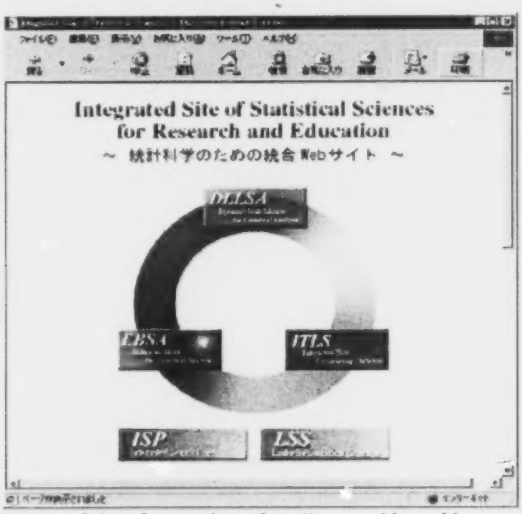


Figure 12: Integrated site of our projects (http://www.sci.kagoshima-u.ac.jp/~stat/)

References

[1] de Leeuw, J., "The UCLA Statistics Textbook and Module", Bulletin of the International Statistical Institute, 51st Session Proceedings, Vol. 2, Istanbul, Turkey, pp. 55-58, (1997).

[2] Liu, L.-M., Chan, K-K., Montgomery, A. L. & Muller, M. E., "A system-independent graphical user interface for statistical software", Computational Statistics and Data Analysis, Vol. 19, pp. 23-44, (1995).

[3] Mittag, H. J., "Emphasizing Visualization and Activities in Teaching Introductory Statistics by Interactive Multimedia", Bulletin of the International Statistical Institute, 52nd Session Proceedings, Vol. 2, Helsinki, Finland, pp. 275-278, (1999).

[4] Müler, M., "Computer-assisted statistics teaching in network environments", In: Payne, R. and Green, P. (Eds.), Proceedings in Computational Statistics 98, Physica-Verlag, Heidelberg, pp. 77-88, (1998).

[5] Nakano, J., "Graphical user interface for statistical software using internet", In: Payne, R. and Green, P. (Eds.), Proceedings in Computational Statistics 98, Physica-Verlag, Heidelberg, pp. 407-412, (1998).

[6] Sakurai, N., Watanabe, M., Hashimoto, H., Yamaguchi, K. & Inoue, T., "Developing a Textbook for Learning Statistics on the Internet", Bulletin of the International Statistical Institute, 52nd Session Contributed Papers, Vol. 3, Helsinki, Finland, pp. 481-482, (1999).

[7] Sato, S., "Introduction to "Web Decomp"-Seasonal Adjustment System on WWW-", Proceedings of the Institute of Statistical Mathematics, Vol. 45, pp. 233-243 (in Japanese), (1997).

[8] Thioulouse, J. & Chevent, F., "NetMul, a world-wide web user interface for multivariate analysis software", Computational Statistics and Data Analysis, Vol. 21, pp. 369-372, (1996).

[9] West, R.W., "Statistical Applications for the World Wide Web", Bulletin of the International Statistical Institute, 51st Session Proceedings, Vol. 2, Istanbul, Turkey, pp. 7-10, (1997).

[10] Yamaguchi, K., Inoue, T., Yadohisa, H. & Watanabe, M., "Educational statistical software on the world wide web", Proceedings in Computational Statistics 98: Short Communications, Bristol, Great Britain, pp. 127-128, (1998).

BEST COPY AVAILABLE

[11] Aoki, S., http://aoki2.si.gunma-u.ac.jp/lecture/index.html (accessed on July 31, 2000)
[12] Abe, K., http://www1.tcue.ac.jp/home1/abek/htdocs/stat/ (accessed on July 31, 2000)
[13] Ohnishi, H., http://econom01.cc.sophia.ac.jp/ (accessed on July 31, 2000)
[14] Mittag, H. J., http://www.fernuni-agen.de/STATISTIK/ (accessed on July 31, 2000)

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS

Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings

HOME

Proceedings

Content

▷ Full & Short Papers (Knowledge Construction and Navigation)

An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments
CedarLearning: The Development of Learner-Centred Environments
Controlling Problem Progression in Adaptive Testing
Design and Implementation of Cooperative Monitoring Agent using Mobile Agent
Development and Evaluation of a Mental Model Forming Support ITS-the Qualitative Diagnosis Simulator for the SCS Operation Activity-
Domain Specific Information Clearinghouses - A Resource Sharing Framework for Learners
Educational Newspaper Information Gathering Agent for NIE
LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES
Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education
Navigation Script for the World Wide Web
Proposal of an XML-based Knowledge Sharing and Management system supporting Research Activities
Scientific revolutions and conceptual change in students: Results of a microgenetic process study
The "Half-Life" of Knowledge in the University of the 21th Century
The Artistic Interface - A Transition from Perception to Screen
The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability
The Distance Ecological Model to Support Self/Collaborative-Learning in the Internet Environment
THE INTERNET-BASED EDUCATIONAL RESOURCES OF THE U.S. FEDERAL GOVERNMENT
The network learning supported by constructivism

▲ HOME

An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments

Juan-Diego Zapata-Rivera, Jim E. Greer, John Cooke
ARIES Laboratory, Department of Computer Science,
University of Saskatchewan, Saskatoon, Canada
Diego.Zapata@usask.ca

Conceptual maps have been used in many areas as a means of capturing and representing knowledge. Several authors have explored the use of visual tools to enhance the learning process. *Thinking maps* as well as *frame games* use visual patterns of relationships (learners thinking processes) to structure knowledge. Based on their graphical structure it is possible to recognize the thinking process(es) employed in the map. Several software applications have been created to support different kinds of maps, but they use proprietary files to represent their maps. It makes sharing of knowledge difficult and jeopardizes the widespread use of maps. This paper proposes XML (Extensible Markup Language) as the language to describe maps. A knowledge construction and navigation tool (KVT- Knowledge Visualization Tool) has been implemented using XML to represent the kinds of maps supported by *thinking maps* and/or *frame games*. This paper describes the uses of KVT in education and training environments.

Keywords: **Knowledge Construction and Navigation Systems, Conceptual Maps, Thinking maps, Frame Games, XML, and Learner Models.**

1 Introduction

Conceptual maps have been widely used in many disciplines for different purposes. Concept maps have been used in education and training as a means of capturing and representing knowledge. Concept maps are just one of a variety of visual tools employed in schools and corporations. Several authors [2,4,5,6,7,9,10, and 14] have explored the use of conceptual maps to enhance the learning process.

Several authors [1,3,7, and 14] have used map adaptation techniques in hypermedia systems to offer a pertinent group of links to a particular user in a particular situation. Existing map-based navigation systems use different adaptation techniques to change the structure of the map according to the users' goals or preferences.

In this paper, we present KTV (Knowledge Visualization Tool), a knowledge construction and navigation tool that allows students and teachers to create XML-based maps in which they can add different kinds of links to the nodes on the map and navigate throughout the content using their own map. In addition, learners can introduce their own links or use links suggested by the teacher and/or other learners. Students and teachers can remove any unwanted link and define the sequence in which the links will appear. XML-maps are viewed as an important step in the creation of an open representation of maps that facilitates sharing of knowledge and assessment of students' knowledge by comparing their maps.

2 Visual Concept-Mapping Tools

A Visual concept-mapping tools (maps) have been used for constructing knowledge and capturing information about people's thinking processes. Because of the many types of maps available, people may

get confused about what kind of map to choose for a specific problem. Hyerle [4] classifies maps in three categories:

- **Informal representations**, such as *brainstorming webs*, *web maps*, and *mind maps*, which are used mainly to support association and creative processes.
- **Task specific maps or organizers**, such as *life cycle*, *text structures*, and *decision trees*, which are used in specific content areas or tasks.
- **Thinking process maps**, such as *concept maps*, *system thinking maps*, and *thinking maps*, which are used to represent not only content relationships on a specific area, but also the thinking process or kind of reasoning behind the map.

Web maps, *mind maps*, and *brainstorming maps* have been used to support creative processes. Their informal structure is useful in areas, such as: brainstorming sessions, decision making, problem solving, taking notes, public speaking and planning. Figure 1 shows an example of a mind map created using Mind Manager® MindJET, LLC [8].

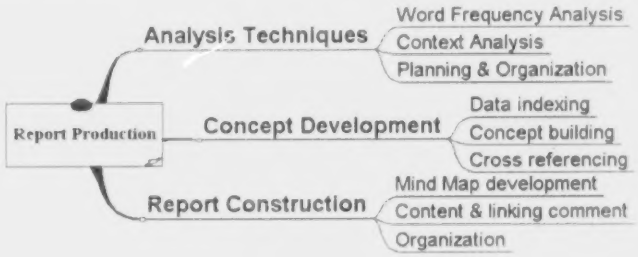


Figure 1. Example of a mind map [8].

Task-specific maps or *organizers* are designed to structure knowledge on a specific area. Figure 2 shows an example of a simple task-specific map (a classification tree) used in a biology class.

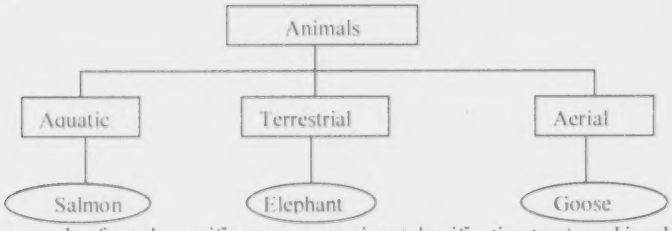


Figure 2. An example of a task-specific map or organizer (classification tree) used in a biology class.

Thinking process maps include concept maps, system maps and thinking maps. Thinking maps [4] are similar to frame games [6]. They use various kinds of visual patterns to represent information relationships and mental processes such as: sequencing, identifying attributes, cause-effect reasoning, analogical reasoning, part/whole reasoning, and classifying information.

Using *concept maps* [5,6,9, and 10] with different types of links, it is possible to represent more or less the same mental processes that thinking maps represent. The main disadvantage of *concept maps* over *thinking maps* is that their graphical structure does not necessarily reflect the thinking process. Figure 3 shows a simple example of a concept map.

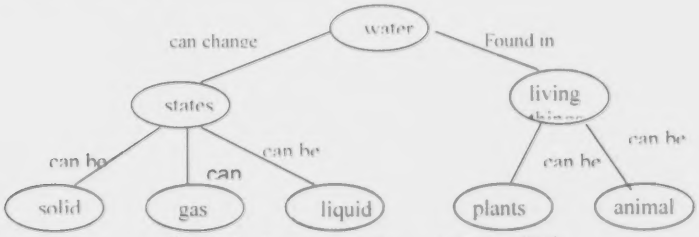


Figure 3. An excerpt of a concept map [10].

Thinking maps and *frame games* integrate knowledge views and make explicit fundamental human cognitive processes. According to Hyerle [1], by using *thinking maps*, it is possible to create any map that can be created using *brainstorming webs* and *task organizers* without being as informal as *brainstorming webs* and less content dependent than *task organizers*. Not only do *thinking maps* support structuring of content but also thinking processes, meta-cognitive abilities and reflection. Figure 4 shows some of the visual patterns supported by *thinking maps* and/or *frame games*.

Thinking map	*Frame game*	*Reasoning*
Bridge map	Analogy pattern	Metaphorical
Multi-Flow map	Cause-Effect pattern	Systems dynamics
Brace map	Part/Whole pattern	Inductive and deductive

Figure 4. Some of the maps (visual patterns) supported by thinking maps and/or frame games.

3 Proprietary Map File Formats vs. XML-Maps

Most of the available commercial products (i.e. [8,11, and 13]) support *mind maps* or variations of them for multiple purposes (i.e. brainstorming sessions, decision making, problem solving, taking notes, public speaking, etc.). These products provide links to external applications, to other maps, and to content on the web. Although, ThinkingMaps® [12] is a software tool for the creation of thinking maps in education and training environments, it does not provide links to external applications, to other maps, or to the web. All these products use proprietary map file formats to represent their maps. It makes difficult sharing of knowledge and jeopardizes the general use of maps.

Using XML as the language to represent maps it is possible to eliminate proprietary files. The creation of a DTD file (Document Type Definition) to validate XML-maps should consider the main characteristics of the maps, such as: linking nodes to external applications, to content on the web, and to other maps. The DTD file proposed in this paper ('XMLmaps.dtd') covers all of the eight kinds of maps supported by *thinking maps* [4] and the ten kinds of maps (visual patterns) supported by *frame games* [6]. We have chosen to work with *thinking maps* and/or *frame games* because of their property of providing different visual patterns to represent different thinking processes. Figure 5 shows a fragment of the DTD file created to validate XML-maps.

Some of the benefits of using XML as the language to represent *thinking maps* and/or *frame* games are:

- XML provides an open format to maintain and share maps as opposed to proprietary file formats.
- By using a common vocabulary in conjunction to XML -maps, it is possible to compare maps. That is, maps can be compared to find similarities and differences in the type of structure employed (thinking process(es) used by the learner to analyze the topic), relation among nodes and types of links and documents attached to each node.
- Any XML query language such as XML-QL or XQL can be used to create queries to compare maps. By comparing maps it is possible to assess learners' knowledge and determine possible misconceptions, or gaps on a specific concept or group of them. By analyzing the type of map used to represent the knowledge it is possible to identify possible problems of the learner with a specific kind of reasoning.
- XML permits collaborative viewing of maps. See section 4.3 (KVT- Navigation System).
- By maintaining the student's knowledge information (XML-maps) in the learner model, new interesting opportunities for assessment, collaboration, adaptation, and inspection can be explored.

- Opening visual knowledge representations is an important step towards the goal of capturing, sharing, and using knowledge across disciplines.

Figure 6 shows a fragment of an XML-map used to study Anatomy. This map has been validated using the grammar rules encoded in 'XMLmaps.dtd'. Figure 7 shows the graphical representation of the same XML-map. This map can be classified as a 'brace map' following the notation of *thinking maps* or as a 'parts-whole' pattern using the *frame games* representation. In both cases, they represent part-whole relationships among concepts and inductive/deductive kinds of reasoning.

```
# Author: Juan Diego Zapata Rivera
# Version: XMLmaps.dtd 1.0
<!--*****************************************************************
ELEMENT: XMLmap
COMMENT: thinking maps structures and frame games->
<!ELEMENT XMLmap  (CircleMap* | BubbleMap* | DBubbleMap* |
BridgeMap* |FlowMap* | BraceMap* | TreeMap* |MultiFlowMap* )
<!ATTLIST XMLmap
<!--*****************************************************************
ELEMENT: BraceMap
COMMENT: Brace map, whole/ part, Inductive and Deductive Thinking->
<!ELEMENT BraceMap (BraceNode+,Link*)
<!ATTLIST BraceMap
MapId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA   #REQUIRED
Description  CDATA   #REQUIRED
<!--*****************************************************************
ELEMENT: Link
COMMENT: Link description-->
<!ELEMENT Link (FromNode,ToNode,LinkMedia)
<!ATTLIST Link
LinkId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA   #REQUIRED >
```

Figure 5. Fragment of DTD for XML-maps

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="XMLmaps.xsl"?>
<!DOCTYPE XMLmap SYSTEM " XMLmaps.dtd">
<XMLmap>
   <BraceMap Type='"BraceMap"' Description='"Example of an XML-map"' Name='"The human body"'
   MapId='"Map001"'>
       <BraceNode NodeId="02" Type='"BraceMap"' Name='"head"' XMLthinkingMapLink='""'>
           <LinkMedia XMLConcept='"head"' Text='""' Application='""' URL='"I"' Sound='""'/>
           <Chlidren>05</Chlidren>
           <Chlidren>06</Chlidren>
           <Parents>01</Parents>
       </BraceNode>
       <BraceNode XMLthinkingMapLink='""' Name='"ears"' Type='"BraceMap"' NodeId="05">
           <LinkMedia XMLConcept='"ears"' Text='""' Application='""' URL='"www.body.xml"'
Sound='""'/>
           <Parents>02</Parents>
       </BraceNode>
       <BraceNode XMLthinkingMapLink='""' Name='"eyes"' Type='"BraceMap"' NodeId="06">
           <LinkMedia XMLConcept='"face"' Text='""' Application='""' URL='"www.body.xml"'
Sound='""'/>
           <Parents>02</Parents>
       </BraceNode>
       <BraceNode XMLthinkingMapLink='""' Name='"torso"' Type='"BraceMap"' NodeId="03">
           <LinkMedia XMLConcept='"trunk"' Text='""' Application='""' URL='"I"' Sound='""'/>
           <Parents>01</Parents>
```

Figure 6. Fragment of an XML-map about 'Anatomy'.

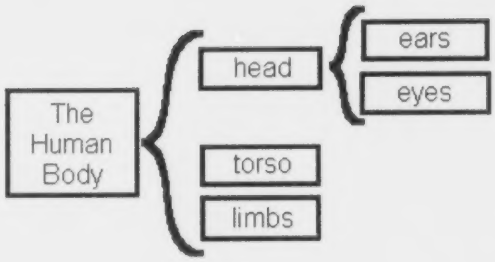


Figure 7. Graphical representation of an XML-map about 'Anatomy'.

4 KVT (Knowledge Visualization Tool)

KVT is a map construction and navigation system that allows the creation of XML-based *thinking maps* or *frame games*. KVT also provides the possibility to link different kinds of resources to specific nodes. In this way, KVT supports personalized navigation throughout the class content. Students can create their own knowledge structure using a set of predefined concepts (*common vocabulary* given by the teacher) and use their own map to access class resources. These resources are suggested by the teacher (*initial links*) or by his/her classmates during the creation of their maps (*collaborative browsing using XML-based maps*).

The class content is not limited to a specific group of pages, videos, sounds, etc. On the contrary, any student or teacher in the class can navigate through the map via the WWW, can add links, and can add new resources. Every participant has access to all of the resources that are associated with the nodes in his/her map. The list of resources attached to a node can be ordered arbitrarily by the learner.

4.1 KVT's Architecture

KVT (see figure 8) is composed of the following modules:

- ***Map Construction Tool***. KVT supports the ten kinds of maps identified in the context of *frame games* [6] and the eight types of *thinking maps* proposed by Hyerle [4,12]. Students select concepts from a predefined list and create their own structure. Having a predefined list of concepts (*common vocabulary*) makes it easier to share, compare, analyze and evaluate maps. Students can link different resources (course materials, web pages, documents stored on different applications, etc) to their map. They can even include other maps in a recursive manner. Students' maps are stored in the learner model for further modification, analysis and evaluation.
- ***The Browser***. This is the main interface to visualize one's map and its associated class content. Students can navigate throughout the content by clicking on any node of the map and selecting one of the links/documents that are available for this node. Furthermore, students can navigate freely and add links and documents to any of the nodes in the map. Students can navigate using links suggested by other students/teachers in a hyperspace created collaboratively for a particular topic and encoded on the map.
- ***The Learner Model***. The Learner module maintains basic learner information as well as their XML-maps (XML files including map structure, links, and order preferences). Students can add, order, modify, or remove links and nodes. Students and teachers contribute to populate each node with different sort of resources, but it is up to each person to remove unwanted resources and define the sequence in which he/she prefers to see the resources.
- ***Course Materials***. Class resources are classified into three main categories: web content, XML content, and general documents (text, sound, images, videos, etc.). They comprise an open range of materials that are organized first by the teacher. Using KVT, students and teachers can create different representations of the knowledge, and as a result of their contributions a highly refined subset of useful documents will be attached to each of the nodes. KVT supports the cooperative creation of information spaces to be used in educational contexts.
- ***Learners and Teachers Share Maps***. Learners and teachers can use KVT in a number of ways. For example, Teachers and learners can visualize maps using different levels of granularity. Learners can use an existing map as a guide to study the content, or use this system as a learning tool to facilitate remembering, create maps collaboratively, share their maps, and engage in interesting discussions

about a particular topic. Teachers can create maps to serve as 'guided tours', which can be used by students to navigate throughout the content. Teachers can use XML-maps to assess the student's knowledge. This can be done by comparing different maps (visually or through queries) to determine problems in the learning process for a particular student or groups of them. Finally, teachers can use this system as an adequate environment to promote reflection among students on a specific topic (map structure and content).

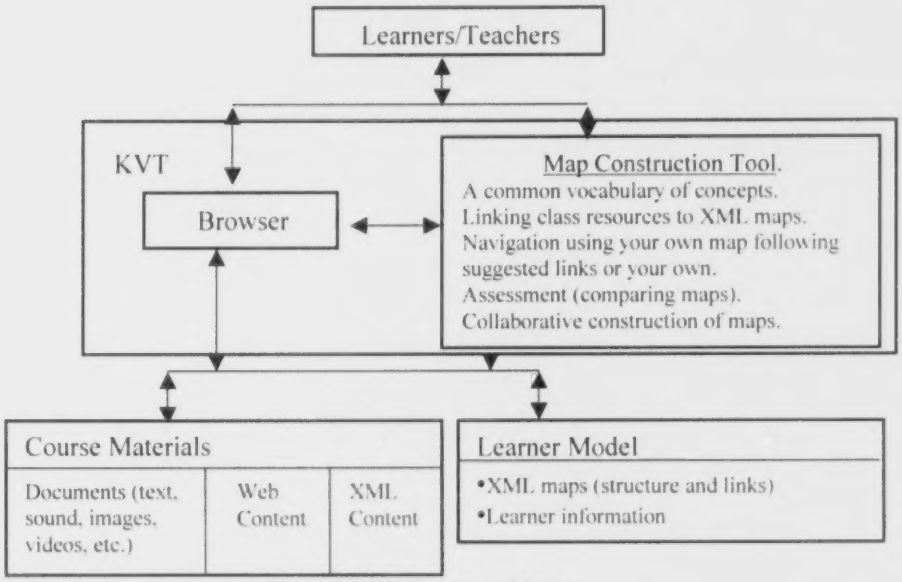


Figure 8. KVT- System Architecture.

4.2 KVT- Linking Documents to Nodes

Using KVT it is possible to add different kinds of documents to the nodes of the map. Figure 9 depicts the user interface provided by KVT to add, modify and remove documents. This interface allows students/teacher to attach a web page, XML document, video, sound, or image to any node on the map. KVT also provides the option to test any of the documents, edit the description and document fields and remove any unwanted link from the map. By clicking the headers on the grid it is possible to change the order in which the links will be presented to the student when navigating using the map. Order preferences are stored in the learner model for further use.

New links/documents for a particular node are automatically shared with all of the maps that contain such a node. This can affect maps of several students/teachers in the system. However, individual sequencing or removal of resources affects only the student's own map. Maps are stored as XML files in the learner model. The example on figure 9 shows a Brace-map that is used to organize information related to Anatomy. The grid of current documents shows the currently available links for the concept 'ears'. It is possible to visualize who included each link (user type/user), the document type location and description.

4.3 KVT- Navigation System

Figure 10 shows how students and teachers can navigate on the web using their own maps and their own links or the ones suggested by others. Just by clicking the concept, a list of current links/documents appears to be selected. If the student has not chosen any particular sequence of resource presentation, this list is initially ordered by type of user (teacher/student). In this environment, it is also possible to navigate freely on the web by entering a URL or just following the links on the current page. When an interesting page is found, it can be attached to any concept on the map by selecting the target concept and pressing the button 'Add Link' located at the bottom of the window.

The example in Figure 10 shows how the student uses the map to navigate by the links related to the concept 'ears'. The current web page corresponds to the first link suggested by the teacher 'Anatomical Tour of the Ear'.

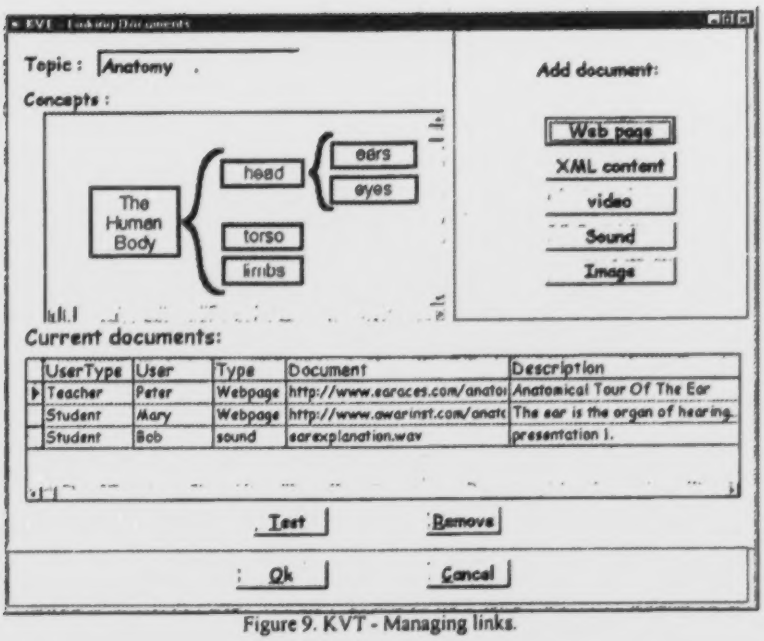


Figure 9. KVT - Managing links.

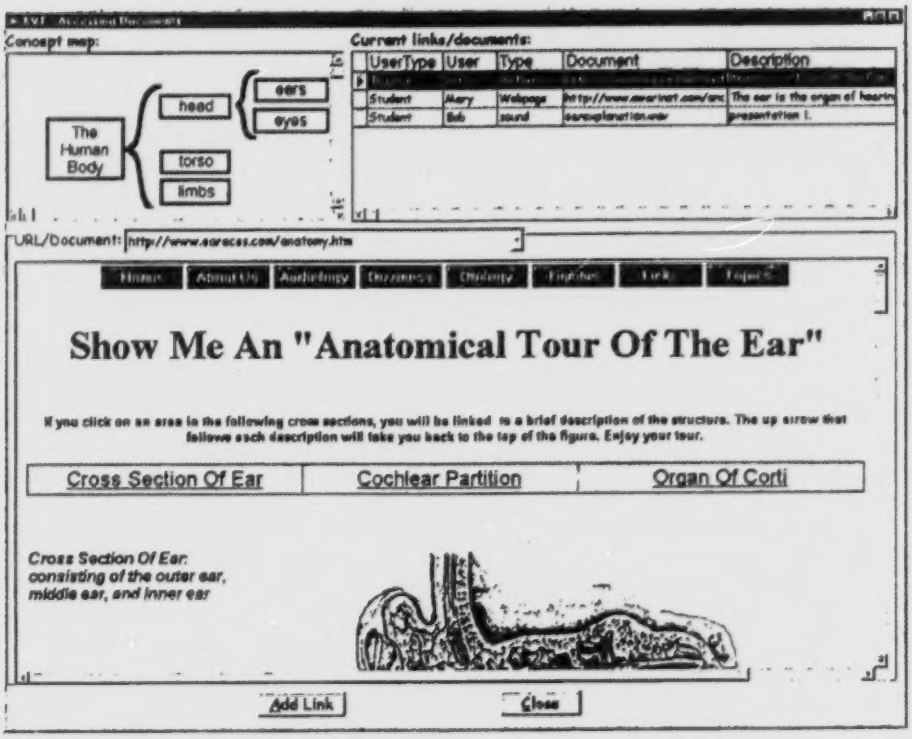


Figure 10. KVT- Navigating on the web using XML-maps and suggested links/documents.

5 Conclusions and Future Work

BEST COPY AVAILABLE

XML offers an excellent language to represent maps. Using XML maps, it is possible to support knowledge sharing without the problems of having proprietary files. By using a common vocabulary for the content and XML maps, it is possible to compare map structures.

XML-maps (*thinking maps, frame games*) are very useful in education and training environments because they support content structure and make explicit fundamental human cognitive processes.

KVT offers an attractive tool for the creation of maps and supports collaborative navigation throughout the content. By using XML-maps, KVT provides a better support to education or training setups that uses maps to create, share and assess knowledge. By including XML-maps into the learner model, new possibilities for visualization and inspection of XML-maps can be exploited in order to improve the learning process.

References

[1] Brusilovsky, P. "Methods and Techniques of Adaptive Hypermedia". In Adaptive Hypertext and Hypermedia. Brusilovsky, P., Kobsa, A., and Vassileva, J. (eds.) Kluwer Academic Publishers, pp. 1-41 (1998).

[2] Buzan, T. "Use both sides of Your Brain". Ed. Dutton. New York (1979).

[3] Gaines, B. R. and Shaw, M.L.G. "Web Map: Concept Mapping on the Web". (1995). Available on-line:http://ksi.cpsc.ucalgary.ca/articles/WWW/WWW4WM/WWW4WM.html

[4] Hyerle, D. "Visual Tools for constructing knowledge", ASCD press. Alexandria, Virginia, (1996).

[5] Jonassen, D., Wilson, B., and Cole. P. "Cognitive Approaches to Instructional Design". G.M. Piskurich (ed). The ASTD handbook of instructional technology. McGraw–Hill. New York, pp. 21.1-21.22. (1993). Also available on-line:http://www.cudenver.edu/~bwilson

[6] Jonassen, D., Beissner, K., and M., Yacci. "STRUCTURAL KNOWLEDGE. Technique for Representing, Conveying, and Acquiring Structural Knowledge". Lawrence Erlbaum Associates, Publishers. Hillsdale, NJ (1993).

[7] Micarelli, A., and Sciarrone, F. "A case-based toolbox for guided hypermedia navigation". In Proceedings of the Fifth International Conference on User Modeling, pp. 129-136 (1996).

[8] MindManager® by MindJET LLC. Test version V3.5.5.SP2. Apr 8, (1999).

[9] Novak., J. D.. Learning, Creating, and using Knowledge. Concept Maps as Facilitative Tools in Schools and Coorporations". Lawrence Erlbaum Associates, Publishers. Mahwah, NJ (1998).

[10] Novak., J. D., and B. D., Gowinn. "Learning how to Learn". Cambridge University Press. Cambridge, England (1984).

[11] THE BRAIN® by Natrificial Software Technologies. Free version 1.73. 9/1/99, (1999).

[12] ThinkingMaps® by Innovative Learning Group. Trial version 1.0.1, (1998).

[13] VisiMap® by CoCo Systems Ltd. Trial version 2.5 c. Nov 1999.

[14] Zyryanov, M. "Adaptive local maps in the hypermedia components of intelligent learning environments"'. In: P. Brusilovsky, P. Kommers and N. Streitz (eds.): Multimedia, Hypermedia and Virtual Reality: Models, Systems, and Applications. Lecture Notes in Computer Science, Berlin: Springer-Verlag, pp. 306-310 (1996).

CedarLearning: The Development of Learner-Centred Environments

Tanya Wilson, Jeanette Muzio, Roger Mundell, Denise Stockley, and Laureen Vickery
CEDAR, Royal Roads University, 2005 Sooke Road, Victoria, British Columbia, V9B 5Y2, Canada
tanyawilson@royalroads.ca; jeanette.muzio@royalroads.ca; roger.mundell@royalroads.ca; denise.stockley@royalroads.ca; laureen.vickery@royalroads.ca

Royal Roads University (RRU) is a four year old University situated on a 640 acre historic site featuring beautiful grounds and a nineteenth century castle. The mission of the University is to deliver world-class applied and professional programs to Canadian and international adult learners. RRU's degree programs are designed for the mid-career professional and its graduate programs combine periods of on-campus instruction and semesters of distance education. This delivery model (a) aligns with the needs of mid-career professionals, and (b) is dictated by the size of the physical buildings at RRU; currently only 250 learners can be accommodated on-campus at any one time. At RRU's Centre for Economic Development and Applied Research (CEDAR) we have developed tools that allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that creates the truly learner-centred environment. These tools are used in several of the MBA courses, such as finance and e-commerce.

Keywords: **Knowledge Construction and Navigation, Lifelong Learning, Web-Based Learning**

1 Introduction

Royal Roads University (RRU) in British Columbia, Canada is a five year old University situated on a 540 acre historic site featuring beautiful grounds and a nineteenth century castle. For 40 years the facility was used as a campus for Military officers, and became a public University when the Department of National Defense closed the facility and leased the space to the Province of British Columbia.

Although beautiful and steeped in history, The physical facilities limit the on-campus population to only 325 students at any one time. This forced the University to explore alternate delivery methodologies from the very beginning, and has resulted in an innovative and highly effective model that targets mid-career learners.

The University focuses primarily on Masters level programs which are offered at a distance to learners who are still in the workforce and continuing at their jobs. These students come together for a series of brief residencies and complete the remainder of their degree through Web-based distributed learning.

With busy mid-career learners, several issues had to be addressed. In addition to accommodating the usual issues of time and place, the University wanted to adopt a Learner-centred approach that would adjust for such variables as prior learning level; Learning Styles and use of granular knowledge objects. At the same time, designers were cognizant of the significant body of research evidence that points to learning communities and collaborative discourse as critically important components of any online courseware.

The resulting courseware seemed to effectively combine the best of the highly learner-centred techniques used in private sector training with the collaborative techniques that have proven effective in most successful post-secondary online courses.

Using commonly available web development tools the team at Royal Roads University created courses that are database-driven, and use dynamic templates to easily populate and modify course content. They devised a number of online assessment and feedback tools, as well as innovative "jig-saw puzzle" style group assignments to stimulate collaboration. They developed a navigation system to allow learners a choice of delivery styles to suit personal learning style preferences, and a self-assessment mechanism to help learners move through online material on a need-to-know basis.

Additionally, the system provides easy management tools for the instructors to control and modify content, as well as monitor the students' progress, without needing any knowledge of web page creation or HTML.

The development team at Royal Roads University is part of the Centre for Economic Development & Applied Research, (CEDAR). They are continuing to explore and evolve the understanding of what works and what doesn't in online learning. At RRU, the team is fortunate to have a "live" laboratory of more than 900 active online students, and a University-wide commitment to Web-based delivery.

In this presentation, we will demonstrate actual delivered courses, present our findings, and demonstrate our course design. We will show how the use of templates and database driven content allows course designers to adjust for variables of learning style, prior knowledge, and level of effort, in addition to time and place.

CEDAR's methodology is applicable to all forms of electronic distributed learning (EDL) regardless of the delivery mechanism – distance education or classroom delivery, over the Internet or via CD-ROM, instructor-led or instructor-free. Learner-centred EDL courses can be easily designed using commercially available software tools. These tools allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that is demanded by busy professionals seeking a learner-centered environment. These learners have a lifetime of experiences and want a course that is tailored to their needs and takes advantage of their prior knowledge.

Our methodology allows learners to navigate through the content according to learning style. Pre-testing on learning outcomes allows for prior learning assessment, adaptive self-assessment quizzes provide feedback, and technical assistance is built into the course. On-line communities are created through group jigsaw assignments and forum discussions. This allows learners from diverse backgrounds to participate in an on-line environment that is geared to their individual needs.

Some of our unique features include:

1. Learner-centred approach allows learners to navigate throuth the material based on their preferred learning style. This is in contrast to most EDL courses which follow a sequential text-book like approach,
2. Learners can pre-test for prior knowldege. This saves them time as they study only those parts of a course that they do not already know,
3. Self-assessment quizzes allow learners to monitor their progress throughout the course and review as needed,
4. The outcomes-based design of the database allows for the use of shareable courseware objects for different learning needs in different courses.

2 Design and Development of the E-Commerce Course

The development process began with the course designer showing the instructor previously completed courses. By seeing exemplars the instructor was presented with different teaching options that the technology facilitates and allowed the instructor imaginative application of the construction process. (integrating real world/live data, interactive diagrams, and animated examples).

The design and development of the e-commerce course was a three-way communication between the content expert, an instructional designer (who is a specialist in learning styles) and the technical designer. The instructor was actively involved in the course development and provided the learning outcomes for the course. The instructional designers established the appropriate navigation for the different Learning Styles and those navigation methodologies were then tagged into the database templates.

The Web based Discussion Forums were setup and the instructor was given early access. The course

underwent a period of testing before the students were given access and any noticeable glitches were corrected at that time.

3 Student Engagement

Instructional materials are delivered to distance-learners via the Internet or to classroom-based learners via CD-ROM. The primary thrust behind the methodology was to produce courseware that is truly learner-centred rather than content-driven or instructor-centred. The course material is navigated in a variety of database-driven, learner-selected methods, depending upon individual preferences. Students also have access to a 24-hour online support available for any technical problems that they may experience. PDF files or screen prints are available for offline browsing of the course content.

Each course module has a number of self-assessment questions, which allows the learner to measure themselves against the desired learning outcomes for that granule. A learner may choose to try this assessment before working through any of the material, or afterwards for self-formative evaluation of the module content. At the end of the assessment, the learner is informed which areas of the module require study. Learners returning later to the self-assessment questions are asked questions only on those areas incorrectly answered the first time.

The web application allows the learner to optionally take a learning style test that provides information about their preferred learning style. After completing the test, the individual is provided with information about their preferred style and each unit can be approached according to that style. Users can switch freely between styles at any point.

To enhance critical thinking and process skills, and the development of community, the courses have included:

(a) residency,
(b) group jigsaw assignment,
(c) case-based reasoning,
(d) electronic forums, newsgroups and live chat
(e) peer to peer and self evaluation
(f) real-world, just in time articles for on-line discussion,
(g) instructor acting as a guide on the side and not as a sage on the stage.
(h) Integration of real-world projects.

These opportunities provide for (a) immediate transferability to the workplace, and (b) building a knowledge network that extends long beyond the end of the degree program.

4 Lessons Learned

The results of the project were gathered from learners through formative feedback, summative evaluation, and focus group discussions.

In general, it was found that learners reacted positively to

(a) the different navigation styles for the four learning styles,
(b) the look and feel of the user interface
(c) the on-line technical helps,
(d) the internal consistency of links,
(e) the ability to pre-test prior knowledge,
(f) the on-line immediate feedback given in the self-assessment quizzes
(g) collaborating with their peers at a distance, and jigsaw style assignments.
(h) the flexibility of doing the course at a convenient time and place.

Some learners relied heavily on offline reading of the printed material, particularly those with poor connectivity or minimal familiarity with computers.

Some complained that the course required them to do too much on the computer, and they would have

preferred more offline work.

Very technically literate students suggested more use of multimedia in the content. In the finance course, several exercises required the student to use a separate spreadsheet, and it was felt that this functionality should have been incorporated into the online exercise. This can be easily done with the technology that was used.

Some saw the self-assessments as more threatening, (they carried no marks) while most saw them as a tool.

Some suggested allowing the student to mark up the content online, such as with the use of electronic "sticky notes". This suggestion will be implemented in the next course.

Three main lessons that we have learned from this project are:

1. It is possible to produce EDL courseware that is learner-centred and not content-driven or instructor-driven. This results in more satisfied learners who feel that their time, prior knowledge, and learning preferences have been considered,
2. Using off-the-shelf tools save on production time and costs and ensure that tried-and-tested software is utilized,
3. Courses that are database-driven provide opportunities for re-using data elements in different courses.

Controlling Problem Progression in Adaptive Testing

Roger E. Cooley & Sophiana Chua Abdullah
University of Kent at Canterbury
Computing Laboratory, University of Kent at Canterbury,
Canterbury, Kent CT2 7NF, The United Kingdom
Tel: +44-1227-823816
Fax: +44-1227-762811
Email: rec@ukc.ac.uk, sc34@ukc.ac.uk

Adaptive testing has, in recent years, been used as a student modelling technique in intelligent tutoring systems. One of the main issues has been to optimise the progression of problems posed as the student performs the adaptive test. Previous research has concentrated on finding a structure in a fixed collection of problems. This paper describes an algorithm for problem progression in adaptive testing. After describing current approaches to the progression problem, the paper discusses the role of expert emulation. It then describes a knowledge elicitation exercise, which resulted in a solution to the progression problem. Part of the knowledge elicitation process was supported by software based on constraint logic programming, clp(FD), and the paper concludes with an assessment of the prospects of developing an extended knowledge elicitation support system.

Keywords: **intelligent tutoring system, knowledge construction and navigation, adaptive testing, constraint logic programming**

1 Introduction

The major advantages of adaptive testing over fixed item testing are that a student's knowledge is explored thoroughly and efficiently, and with a minimum of redundancy. By asking an appropriate number of problems at appropriate levels of difficulty, adaptive testing neither bores by unnecessary repetition nor intimidates by posing a series of inappropriately difficult problems [1]. This makes adaptive testing attractive for student modelling in intelligent tutoring systems [2],[3].

This research was conducted in the context of providing remedial help in mathematics to a transient population of prisoners in a local prison. Here the students are studying courses such as City and Guilds (Key Skills), City and Guilds (Number Power) and for GCSE level examinations. Working with prisoners can face tutors with problems not normally encountered in more conventional settings. Unlike school students, the prisoners not only lack uniform prior knowledge in mathematics, but tend also to join or leave the prison at individual times. This makes the job of the human tutor difficult because of the need to assess the knowledge level of each prisoner before assigning them the appropriate level of one or more of the above courses and examination. Currently, fixed item testing is used as an assessment tool. This approach has a major disadvantage. Many prisoners are 'math anxious' and the use of fixed item testing may undermine their confidence and motivation in the subject. Adaptive testing avoids this danger by presenting problems at an appropriate level of difficulty.

One of the main issues in adaptive testing is the determination of an efficient progression from one problem to another. Previous proposals have included hard-wiring prerequisite relationships between knowledge items [3], and preparing an indexing framework for problems [4]. Section 2 of this paper reviews the major lines of research; and the paper then describes an approach to the progression problem based on the knowledge acquisition techniques used for expert systems. In doing so, it continues in the vein of Khuwaja & Patel's work [5]. The paper presents a rationale for this approach, describes briefly a semi-automated

method of eliciting syllabus content and characteristics, and then presents a progression technique elicited by standard techniques with an expert. It concludes with a discussion of the feasibility of automation in this area.

2 The Progression Problem

In a problem-solving environment, *problem progression* is concerned with the strategy in which the next problem is selected. In adaptive testing, this is usually based on the student's response to the current problem, as the process of selecting the next appropriate problem is crucial to the efficiency and precision of the whole student modelling process. Also, presenting *the right question at the right time* maintains the motivation of the student.

The structure of the domain, that is the way in which problems are related to one another, determines problem progression in adaptive testing; and the two significant and distinctive approaches to determining such structures are discussed in this section.

2.1 Item Response Theory

For adaptive testing systems which adopt the *Item Response Theory* or IRT [6], such as SIETTE [7] and CBAT-2 [8], the domain is made up of test items which are kept in an *item pool*. The construction of an item pool usually involves major empirical studies for content-balancing, to ensure no content area is over-tested or under-tested, and for item calibration. Each test item is associated with one or more of the following parameters – the *difficulty level, the discriminatory power and the guessing factor.* The *difficulty level* measures the difficulty level of a test item, the *discrimination power* describes how well the test item discriminates students of different proficiency, while the *guessing factor* is the probability that a student can answer the test item correctly by guessing.

Problem progression takes place like this. The adaptive test starts with an initial estimation of the student's proficiency, è. A *best* item or problem is selected. This is one which provides the most information about the student, and is calculated from the item's three parameters and current proficiency, è. An ideal item should have a difficulty level close to è, a high discriminatory power and a low guessing factor. A new proficiency, è', and its confidence level are calculated based on whether the student has answered the problem correctly or not, the old è, and the item parameters. The test continues until a stopping criterion is met, for example, when the confidence level of è' has reached a desired level.

2.2 Knowledge Space Theory

There are adaptive testing systems built on the theory of *knowledge spaces[9]*. Examples include a web-based, domain-independent system called RATH [10], a web-based system for the domain of mathematics called ALEKS [11], and a general purpose system for testing and training called ADASTRA [12].

Like the IRT-based systems, the domain is made up of test items of an academic discipline, each of which can be a problem or an equivalence class of problems that the student has to answer. The student's *knowledge state* is defined as the set of items in the domain that the student is capable of solving. For example, if a student has the knowledge state ***{a,b,d}***, this means that he can solve items ***a***, ***b*** and ***d***. Not all possible subsets of the domain are feasible knowledge states. Consider the example shown in [13]. In a domain of mathematics, if a student can solve a percentage problem, (item ***d*** say), then it can be inferred that the student can perform single-digit multiplication, (item ***a*** say), and thus any state that contains item ***d*** would also contain item ***a***. The collection of all feasible knowledge states is called the *knowledge structure*. The knowledge structure must also contain the *null state {}*, which corresponds to the student who cannot solve any item, and the *domain*, which corresponds to the student who can solve or master all items. When two subset of items are knowledge states in a knowledge structure, then their union is also a state. This means that the collection of states is *closed under union*. When a knowledge structure satisfy this condition, it is known as a *knowledge space*.

In practice, items for a domain are derived from instructional materials and systematic knowledge elicitation with teachers. This is also the case with establishing knowledge states where query procedures systematically elicit from human experts the prerequisite relationships between items [3], [14].

Once the domain is represented as a knowledge space, the adaptive testing strategy is then to locate as efficiently and as accurately as possible, a student's knowledge state. Problem progression becomes straightforward. For example, if a student has answered an item correctly (incorrectly), it can be inferred that he can (cannot) answer a prerequisite item and will thus not be asked to solve the latter.

2.3 Other Approaches

The domain can be represented as a *granularity hierarchy* [15] where items which represent a topic, subtopic or skill, are described at various grain sizes and connected together into a granularity hierarchy which allows focus shifts along either *aggregation* or *abstraction* dimensions. In this way, the ability to recognise student behaviour at varying grain sizes is important both for pedagogical and diagnostic reasons.

Other examples include an *indexing framework* for the adaptive arrangement of problems in the domain of mechanics [4], a problem-simplification approach [16], an optimisation expert system where both the knowledge structures of the student and the teacher are represented by structural graph, and problem progression is controlled by the relationship between the student's knowledge structure and that of the teacher's [17]. Evidence of a strong use of a student model in controlling problem progression can also be found in a system called TraumaCASE [18] which automatically generated clinical exercises of varying difficulty, and in the work of Beck, Stern & Woolf [19] who recorded information about a student using two factors – *acquisition* and *retention*. *Acquisition* records how well students learn new topics while *retention* measures how well a student remembers the material over time.

3 Knowledge Elicitation

The concern of the researchers discussed above is to exploit a structure of a syllabus to improve the efficiency of tests. The structure may either be revealed through elicitation, as was done by Dowling and her co-workers, or may be derived from a statistical analysis of student behaviour, (IRT), or it may be seen as being derived from the nature of the problem domain. Though there may be, from some given point of view, an optimal way of structuring a syllabus, the view adopted in this research is that it is a subjective matter to be determined by an expert teacher. Such a teacher might make use of informal statistical information, subject domain information as well as pedagogic information in determining a suitable structure. Studies of intelligent tutoring systems have shown that, as one would expect, it is difficult to transfer systems from one setting to another, because there is considerable cultural variation in both teaching and learning [20]. This provides the prime motive for investigating techniques based on expert emulation for the production of tests for local consumption.

Moreover, this is a natural extension of the *intelligent tutoring systems* endeavour, and it has an additional advantage. A lack of homogeneity amongst a student body can weaken the effectiveness of techniques based on population statistics; and the target body of students with which this paper has been concerned is, educationally, not very homogeneous.

4 Eliciting the Syllabus

There are several problems to be confronted when adopting an expert emulation approach to designing an adaptive test. They include the problems of finding suitable experts [21], selecting appropriate forms of knowledge representation and choosing appropriate methods of knowledge acquisition.

The approach to knowledge acquisition in the research described here is to separate the task of designing an adaptive test into the following sub-tasks:

- describing classes of problems,
- describing the skills used to solve problems,
- describing responses to problems,
- problem generation,
- problem progression based on student responses.

For the particular domain tackled, namely the arithmetic of elementary fraction addition, software has been developed to support the first four of these subtasks using Constraint Logic Programming, clp(FD), embedded in Prolog, [22]. This work has been described in a recent conference paper [23], and is briefly summarised here.

Clp(FD) is actively used by the knowledge engineer conducting knowledge acquisition interviews. The teacher, who is the target of the emulation, is not expected to write constraints, but is more than likely to take an interest in them. During discussions, which involve the production of example problems, the knowledge engineer enters the necessary constraints, or modifies existing constraints, to describe the particular class of problem under discussion. The set of constraints is then solved interactively to produce example problems. These form the basis of a discussion, and may lead to further rounds of discussion and modification.

The description of a class of problems is treated as a set of constraints. This consists of a set of variables, a statement of the domains of the variables, and a statement of the relational constraints that hold between the variables. For example, during an interview, the human tutor wanted to represent a class of problems, which involved the addition of two proper fractions with a common denominator of the form,

$$N1/D1 + N2/D2 = N/D$$

and he wanted to use single-digit integers.

This can be represented in clp(FD) as a code fragment:

```
domain([N1,D1,N2,D2],1,9),        % Single digit integers
N1 #<  D1,                        % First operand - proper fraction
N2 #<  D2,                        % Second operand - proper fraction
D1 #= D2.                         % A common denominator
```

The following is an example of the use of clp(FD) to describe skills. The *cancel fraction* skill can be represented in clp(FD) as:

```
% Simplify the fraction N/D into its lowest form to give X/Y
% Example:  63/81 gives 7/9
cancel(N,D,X,Y) :-
      domain([N,D,X,Y,F], 1,99),
      F*X #= N,
      F*Y #= D,
      maximize(labeling([], [F,X,Y]), F).
```

Here, variable F is the common factor to be cancelled. This is specified by the two relational constraints. The *maximize* predicate in the final line ensures that the largest value of F will be found.

5 Eliciting the Progression

The knowledge elicitation exercise involved approximately 20 hours of interviews spread over a period of three months. Conventional knowledge elicitation techniques, such as structured interviewing, task analysis and construct theory [24], were used.

Early interviews revealed the significance to the expert of the *skills* that students needed to exercise in order to solve particular problems. The following were identified:

a. Add equivalent fractions
b. Cancel fraction
c. Make proper
d. Find the lowest common multiple
e. Find equivalent fractions

The number of discrete skills required to solve a problem was considered as a measure of the difficulty of

the problem; and this measure was used to classify problems, and in so doing reveal a structure of the domain. This coincides with the findings of Beck, Stern & Woolf [19]. However, it is useful to note that this is only one of the many factors in measuring problem difficulty used by Lee [25], who identified, amongst others, the student's degree of familiarity with a particular type of problem.

In eliciting progression information, it is necessary to avoid the problem of combinatorial explosion. A *head on* approach requires the expert to provide a tree structure of sequences of problems indicating the appropriate *next* problem depending on the outcome of all previously asked problems. Such an approach is unattractive to both expert and knowledge engineer. Instead, an approach adopted was to attempt to uncover the underlying *algorithmic* strategy of the expert.

In general terms, the strategy of the expert is to test the students' abilities to exercise the identified skills at a particular level of difficulty. Failure to return a correct answer causes the questioning process to be resumed at a lower level of difficulty, that is, with problems requiring the demonstration of fewer skills. Whereas successful demonstration of all the identified skills causes the questioning process to be resumed with problems at a greater level of difficulty. The expert started with problems of middling difficulty and adopted a *binary chop* approach to selecting the next level. Within each level of difficulty, the selection of the *next* problem depended on the skills already demonstrated. Each available problem was scored using a set of weights, which favoured previously undemonstrated skills at that level. If the progression problem is viewed as a variant of state-space search, the expert's strategy has more in common with a *constrain-and-generate* paradigm [26], at a given level of difficulty, rather than a naïve *generate and test* approach. A schematic example of the use of this strategy is given below.

In a Prolog implementation of this strategy, a record of students' skills, demonstrated at each tested level of difficulty is recorded, and used to prepare a revision plan.

6 An Example

The human tutor first prepared the adaptive testing strategy for a domain of five skills described above. This is shown in Figure 1 for a domain of five skills.

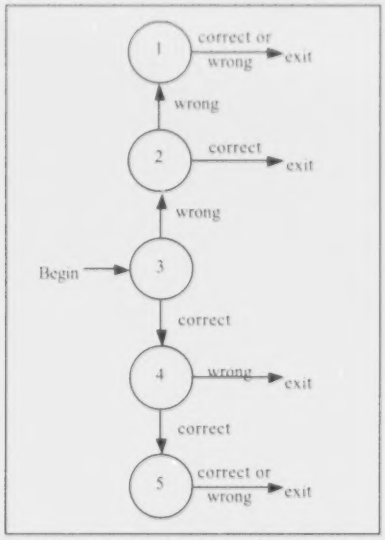


Figure 1: Human tutor's strategy in adaptive testing for a domain of 5 skills

In Figure 1, the adaptive test begins at node 3 which contains problems each of which can be solved by exactly three skills. If the student gets any problems wrong within that category, he moves onto node 2 which contains problems each of which can be solved by exactly two skills. If he gets all the problems correct within that category, he will exit the adaptive test. The rationalisation for this is described below.

If each of the skills were labelled as a,b,c,d,e, as in Section 5, then at node 3, there are ${}^{5}C_{3}$ that is 10 possible combinations of skills. For example, the combination [a,b,c] would involve a set of problems which each require all the skills **a**, **b** and **c** to be used. Skills **a**, **b** and **c** correspond to *add equivalent fractions*, *cancel fraction*, and, *make proper* respectively. However in practice, not all these combinations will be found in a valid problem type.

We introduced weights to each combination to enable the choice of the next best combination. We also imposed the following criteria for calculating the weight of each candidate set:

- If a skill has been not been asked yet, it carries a weight of 2
- If a skill has already been asked once, it carries a weight of 1
- If a skill has been asked more than once, it carries no weight
- Select the first set amongst the candidate set with the highest score

The following process shows how problems, each of which, require a combination of three skills are presented to the student.

a. Select [a,b,c] and scores are assigned to the other combinations, based on the above rules:

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	-	4	4	5	5

b. Based on these weights, combination [a,d,e] becomes the next best choice and is thus chosen. The scores for the remaining combinations are recalculated.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3

c. Combination [b,c,d] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1

d. Combination [a,b,e] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1
3	-	0	*	0	0	0	0	0	0	0

e. As there are no more candidate sets, no more problems are presented.

The above example shows that out of the ten combinations, only problems of combinations [a,b,c], [a,d,e], [b,c,d] and [a,b,e] were chosen. As described previously, the human tutor would consider the student's previous performance and if any answers to problems were found to be wrong, he would assign problems at node 2 (see Figure 1). Conversely, if all the answers were found to be correct, he would assign problems at node 4 which require problems to be solved with exactly four skills.

The human tutor took the view that if a student has already tackled problems of three skills, whether he got them right or not, information gathered in packets of three skills need not necessarily apply to problems involving two skills. He considered that students may become anxious about problems which require more skills, and although some of the skills may well have been demonstrated in *easier* problems, the student may find it difficult to apply them in *harder* problems.

BEST COPY AVAILABLE

7 Conclusion

The paper describes the development of an adaptive test in the domain of elementary arithmetic, which required two styles of knowledge acquisition. The first is concerned with describing problems and skills, and it is computer-assisted; whereas the second is entirely manual and is concerned with the ordering, or progression, of problems to be posed to the subject of a test. However, based on this experience, work is currently underway to develop software to aid with eliciting details of progression. A valuable insight gained is that some degree of formalisation of the problem, as well as being convenient for the knowledge engineer, is also acceptable to the expert who helped with this work.

A possible significant difference between the research reported here and the work reviewed in Section 2 is that the approach to progression is not restricted to a fixed collection of problems. In view of Lee' s findings [25], it would be inappropriate to enforce the equating of difficulty with the number of skills. Evidence encountered during the knowledge acquisition experience suggests that the sheer clerical complexity of mapping out sequences of problems, lead to some draconian simplification on the part of the expert. The task ahead, is to find an appropriate balance between convenience and efficiency.

References

[1] Vispoel, W. P., Rocklin, T. R., & Wang, T., "Individual differences and test administration procedures: a comparison of fixed-item, computerized-adaptive, and self-adapted testing", Applied Measurement in Education, 7, pp. 53-79, (1994).

[2] Collins, J. A., Greer, J. E., & Huang, S. X., "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 569-577, (1996).

[3] Dowling, C.E. & Kaluscha, R., "Prerequisite relationships for the adaptive assessment of knowledge", Proceedings of the Seventh World Conference on Artificial Intelligence in Education (AI-ED'95), Washington DC, USA, August 16-19, pp. 43-50, (1995).

[4] Hirashima, T., Niitsu, T., Hirose, K., Kashihara, A., & Toyoda, J., "An indexing framework for adaptive arrangement of mechanics problems for ITS", IEICE Transactions on Information and Systems, E77-D, pp. 19-26, (1994).

[5] Khuwaja, R. & Patel, V., "A model of tutoring: based on the behavior of effective human tutors", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 130-138, (1996).

[6] Wainer, H., "Computerized adaptive testing: a primer", NJ: Lawrence Erlbaum Associates, (1990).

[7] Rios, A., Millan, E., Trella, M., Perez-de-la-Cruz, J.L.,& Conejo, R., "Internet based evaluation system", Proceedings of the Ninth International Conference on Artificial Intelligence in Education (AI-ED'99), Le Mans, France, July 19-23, pp. 387-394, (1995).

[8] Huang, S. X., "A content-balanced adaptive testing algorithm for computer-based training systems", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 306-314, (1996).

[9] Doignon, J. P. & Falmagne, J. C., "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, 23, pp. 175-196, (1985).

[10] Hockemeyer, C. & Dietrich, A., "The adaptive tutoring RATH: a prototype", Proceedings of the International Workshop on Interactive Computer aided Learning (ICL'99), Villach, Austria, (1999).

[11] ALEKS 2000, http://www.aleks.com (accessed on August 15 2000).

[12] Dowling, C. E., Hockemeyer, C., & Ludwig, A. H., "Adaptive assessment and training using the neighbourhood of knowledge states", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 578-587, (1996).

[13] Villano, M., "Probabilistic student models - Bayesian belief networks and knowledge space theory", Proceedings of the Second International Conference on Intelligent Tutoring Systems (ITS'92), Montréal, Canada, June 10-12, pp. 491-498, (1992).

[14] Kambouri, M., Koppen, M., Villano, M., & Falmagne, J. C., "Knowledge assessment - tapping human expertise by the query routine", International Journal of Human-Computer Studies, 40, pp. 119-151, (1994).

[15] McCalla, G., Greer, J., Barrie, B., & Pospisil, P., "Granularity hierarchies", Computers & Mathematics with Applications, 23, pp. 363-375, (1992).

[16] Hirashima, T., Kashihara, A., & Toyoda, J., "Toward a learning environment allowing learner-directed problem practice - helping problem-solving by using problem simplification", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 466-314, (1996).

[17] Matsui, T., "Optimization method for selecting problems using the learner's model in intelligent adaptive instruction system", IEICE Transactions on Information and Systems, E80D, pp.196-205, (1997).

[18] Carberry, S. & Clarke, J. R., "Generating clinical exercises of varying difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 273-275, (1997).

[19] Beck, J., Stern, M., & Woolf, B. P., "Using the student model to control problem difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 277-289, (1997).

[20] Payne, S. J. & Squibb, H. R., "Algebra mal-rules and cognitive accounts of error", Cognitive Science, 14, pp. 445-481, (1990).

[21] Lightfoot, J. M., "Expert knowledge acquisition and the unwilling expert: a knowledge engineering perspective", Expert Systems, 16, pp. 141-147, (1999).

[22] Clp(FD) 2000, http://www.sics.se/isl/sicstus/docs/latest/html/sicstus.html#CLPFD (accessed on August 15 2000).

[23] Chua Abdullah, S. & Cooley, R. E., "Using constraints to develop and deliver adaptive tests", Proceedings of the Fourth International Conference on Computer Assisted Assessment (CAA), June 21-22, Loughborough University, UK, (2000).

[24] McGraw, K. L. & Harbison-Briggs, K., "Knowledge acquisition, principles and guidelines", NJ: Prentice-Hall, (1989).

[25] Lee, F. L., "Electronic Homework: an intelligent tutoring system in mathematics", PhD Thesis, The Chinese University of Hong Kong, (1996).

[26] Marriott, K. & Stuckey, P., "Programming with constraints: an introduction", Cambridge, MA: MIT Press, (1998).

Cooperative Monitoring System using Mobile Agent

Young-Gi Kim, Sun-Gwan Han, Jae-Bok Park
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1283
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
young7@compedu.inue.ac.kr {fish,jbpark}@eslab.inha.ac.kr

This paper is a study on the design and implementation of the cooperative monitoring system using a mobile agent for an educational portal site. Generally educational portal sites have many addresses of teacher's homepage related education. Therefore, portal site has a very difficult task with maintaining a consistent address of site as well as it is impossible that administration of portal examines all dead sites in searching education site and DB. In order to solve this problem, we designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. This monitoring system applies to the Korean educational portal site (KEPS) for elementary students and teachers. For efficiency this system, we made an experiment that compared a cooperative monitoring agent system with a stationary monitoring agent system.

Keyword: **Education Portal Site, Cooperative Monitoring System, And Mobile Agent**

1 Introduction

Today, the advent of the web that can easily be connected through the "Internet" is known to be an easy and popular method for teaching and learning. Web-based educational homepages are used in many computer assistance medias and also the numbers of educational sites are on the increase extremely.

An extremely increase in number of homepage raises a question whether a student can search appropriate homepage for learning. In case of finding educational contents using a general searching engines, the searched site can exist an irrelevant contents against a student's request. Moreover the result of searching content fell into learning confusion, because the contents are difficult to apply at learning intact.

In order to overcome this problem, an educational portal site was constructed to gather only educational homepages that had been made several times before. An advantage of educational portal site is that content is used correctly and rapidly in learning because searching site is well constructed. In addition student can easily get suitable contents. For gathering of an educational homepage, an educational portal system, called KEPS, was constructed by the EDUNET and Inchon National University of Education.

While walking past a type of the gathered homepage in KEPS, it can be seen as to make not by an expert institution or a special company but by a teacher and a private person. As a result, characteristic of the homepages have to be petty and is frequently updated. Because the educational homepage can disappear easily, portal site faces difficulty to maintain consistency of the site address. If a hyperlinked address of a portal site is not connected or the retrieval site is disappeared to user, then this portal site may bring discredit to student. In order to maintain consistency of portal, the administrator of portal site must validate all addresses of site. But this examination is impossible work that man completely manages and finds. Consequently, a monitoring of a site address for finding the dead site can be process by an intelligent agent instead of human.

A single agent needs comprehensive amount of time required for the monitoring of a portal site. If a single agent examines extremely a many site addresses, the monitoring work may be inefficient. Because a mobile agent is possible with decentralization and a parallel processing, the monitoring works using a mobile agent

can be process effectively [5].

Accordingly, this study designed and implemented a mutual cooperative monitoring system to filter off dead site using a mobile agent. In the following section, the mobile agent and monitoring scheme will be surveyed and the overview of the structure of monitoring agent will be designed. And the next section will be focused on implementation and experimentation of monitoring agent system. Finally the conclusion and future works will be described.

2 Mobile Agent and Cooperative Monitoring

The agent is a program with intelligent characteristics to help the users with the use of computers and take the user's place. The intelligent agent perceives any dynamic stimulation or condition and interprets the data collected for a solution to the problem and exercises reasoning for a final decision. It also acts to change the conditions within its environment in order to perform assigned duties. It has autonomy, social ability, reactivity, pro-activeness and a cooperative relationship, learning, mobility, and so on [9].

Generally an agent divides a kind of two by the mobility, a stationary agent to be executed roles in single system, while the mobile agent is executed at various systems after moving through the networks. An execution example of the mobile agent is shown in figure 1 and the mobile agent based environment is viewed figure 2. The mobile agent server must be installed to act a mobile agent as figure 2.

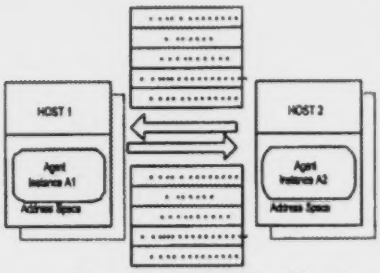


Figure 1. Execution of mobile agent

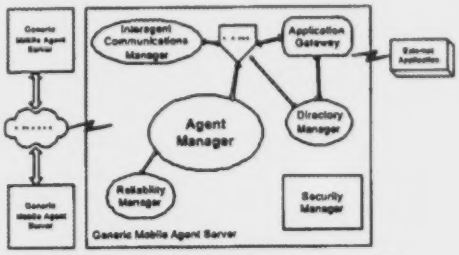


Figure 2. Mobile agent based environment

The mobile agent has a specific characters listed below compared with a stationary agent [5][6].

- The mobile agent reduces the network load.
- The mobile agent overcomes network latency.
- The mobile agent encapsulates protocols.
- The mobile agent executes asynchronously and autonomously.
- The mobile agent adapts dynamically.
- The mobile agent is naturally heterogeneous.
- The mobile agent is robust and fault-tolerant.

In the information retrieval, a monitoring work ascertains a state of gathering sites for the maintenance of data consistency. Generally, because the information of the web is changed frequently, a monitoring job by human is an impossible or inefficient work. This monitoring job can be processed by intelligent a computer program instead of a human. Such a program is called the web robot or an intelligent agent system [10][11].

In case of examining many sites in the monitoring work, if a single agent of the only server processes monitoring work, then the monitoring work may be needed long time and overloading of a monitoring server. The mobile agent has made possible cooperative and speedy monitoring job from distribution and parallel processing [8][11].

3 Cooperative Monitoring System

3.1 Overview of System

Overview of the KEPS system, including the temporary monitoring agent system is shown figure 3.

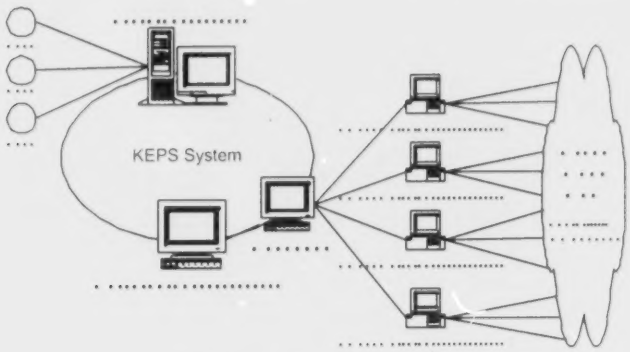


Figure 3. Overview of system

The portal system is consisted of four parts. There are the portal web server (PWS) and the monitoring agent server (MAS), the temporary monitoring server (TMS), a mediator. For using educational portal service, user must be connected with the Portal web server. Gathered address of an educational homepage is supported searching service of an education contents to user through the Portal web server. The Portal web server has searching engine, site DB and a query processor. The monitoring agent server has a stationary monitoring agent and a cooperative mobile agent, error DB, a mobile agent server. Also the monitoring agent server performs works as a creation and an allocation, a control, a gathering of the monitoring mobile agent. For the mobile agent perform it's task fully, each server is installed the mobile agent server necessarily.

The temporary monitoring servers are in existence out the KEPS system. In order to process a fast monitoring work, the TMS have function of distributed and parallel processing. The number of TMS is not fixed but dynamic by amount of monitoring job. Furthermore the TMS is used in temporary palace which mobile agent examines each a state of the registered site. At ordinary times, the TMS is not used usually for examining a state of the registered site. However the TMS can be only used when is requested by the mediator agent server.

The mediator is situated between the monitoring agent server and TMS, and acts as the role of mediation with the mobile agent and servers. All agents and agent servers must be registered in the mediator.

3.2 Design of KEPS System and Cooperative Work

The structure of the KEPS System is detail shown figure 4. The portal web server is consisted of searching engine and query processor, is shared the gathering DB of portal site. The searching engine provides searching service about education content and the query processor is shown the result searching at DB. The monitoring agent server is consisted of inference engine and agent manager, error DB. The monitoring system in monitoring agent server has a stationary agent and a mobile agent for distribution and parallel working. A stationary agent examines the state of gathering site and the confirmation of HTML documents through HTTP connection. After a failure sites are saved at temporary error DB, these will be deleted from site DB of portal web server. A permanent deletion of fail sites is executed by inference engine of the monitoring agent server.

When a monitoring agent server is overloaded or the stationary monitoring agent has difficulty processed by examination with many site, the monitoring agent server requests to the mediator about information of the registered TMS. If the number of the TMS is lacking, the monitoring agent server waits until the TMS becomes sufficient. Having sufficient number of the TMS, the mobile agent is created to divide as a suitable size of address by inference engine. And then the mobile agent has been created by a monitoring agent server, will be cloned with suitable number. Each mobile agent is allocated a monitoring work and will be dispatched to the TMS through ATP connection. The mediator agent can grasp each work states of an agent by using the agent finder.

Each agent is moved to temporary monitoring server and examines the allocated addresses of sites through HTTP. When a mobile agent is finished all checking of sites, it sends to the monitoring agent server with the result of observation. If the job of the mobile agent is occurred some problem, monitoring agent server creates a new mobile agent and re-dispatches to the TMS. All results gathers, result of examination saves at site DB and error DB. Finally, dispatching the agents retracted by the monitoring agent.

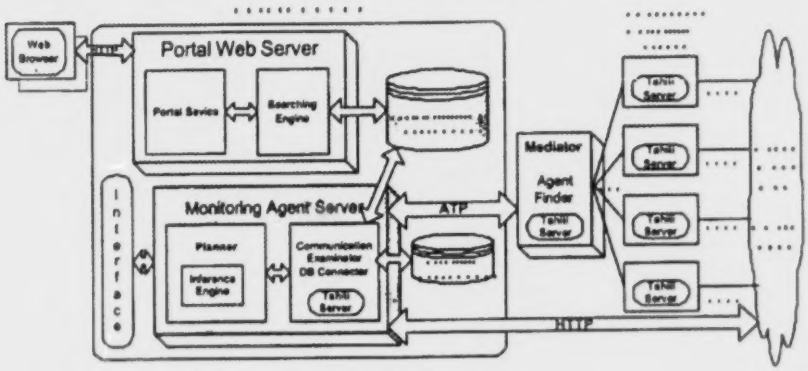


Figure 4. Structure of the KEPS system

The processing algorithm of execution about monitoring working is shown figure 5. The job of monitoring using the mobile agent has advantages that prevent an overloading of a single server and lessen monitoring time by distribution and parallel processing. Because agents are not used stationary server but are dynamically used in other servers, all servers performed share resources of monitoring system. Accordingly, each agent can do cooperative parallel processing using autonomous and society properties of agent.

4 Implementation and Experiment

4.1 Implementation and Application of System

The monitoring agent system proposed in this study was implemented two types. The stationary monitoring agent was implemented by using VC++ and CLIPS. Also the mobile monitoring agent system proposed in this study was implemented using JAVA based Aglet API and JESS. Aglet is the java class library for that can easily design and implement all the properties of the mobile agent. Moreover the Aglet provides with the Tahiti server and Agent finder for helping research of users.

The stationary monitoring agent interacts with the mobile agent of Tahiti server based environment. Inference engine of the stationary monitoring agent was used the CLIPS dynamic linked library and the mobile monitoring agent system was used the JESS class library. The CLIPS and JESS are rule based inference engine and was used to infer planning and allocation of the mobile agent. SQL was used for the gathering DB of portal site. ODBC and JDBC were used to connect the monitoring agent system and the gathering DB of site.

BEST COPY AVAILABLE

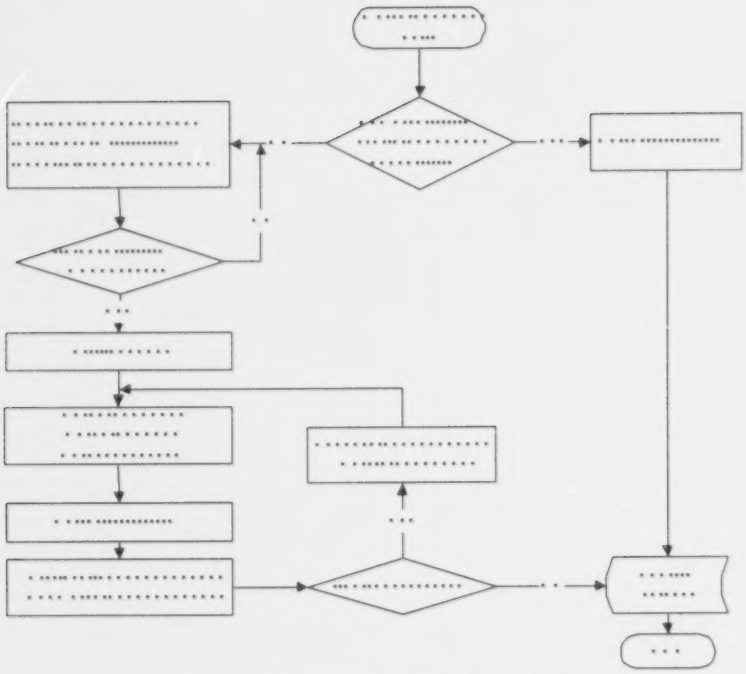


Figure 5. Algorithm of monitoring procedure

Figure 6 below is image of the interface of the stationary monitoring agent by making VC++. Figure is shown that the single monitoring agent is examining each site. The stationary monitoring agent was consisted of three parts mainly. The left screen of figure is represented list that the agent will examine site of DB. Also the center of screen is viewed results of a successful site and the right screen is represented results of a failure site.

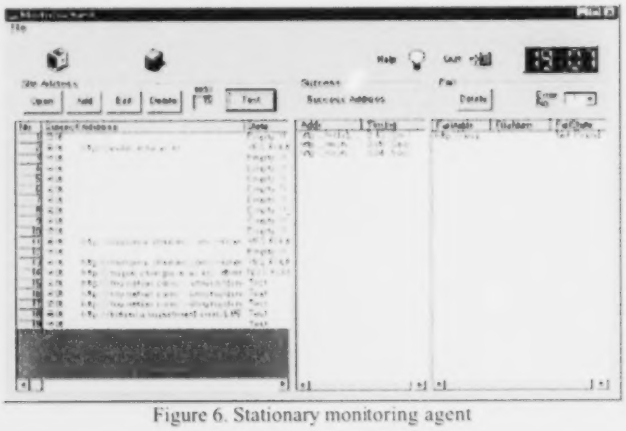


Figure 6. Stationary monitoring agent

Figure 7 is shown screen that the mobile monitoring agent is examining each site with distribution and parallel processing. If the numbers of sites are many in existence, the stationary monitoring agent executes the mobile agents to interact with the Tahiti server as followed image. Above window of figure is represented the stationary monitoring agent. Black screen below is viewed that mobile agent sever is executed by the stationary monitoring agent. Small screen below is shown the Aglet viewer. The Aglet viewer perform an important role as a creation, dialog, dispose, cloning, dispatching, retracting of a mobile agent.

BEST COPY AVAILABLE

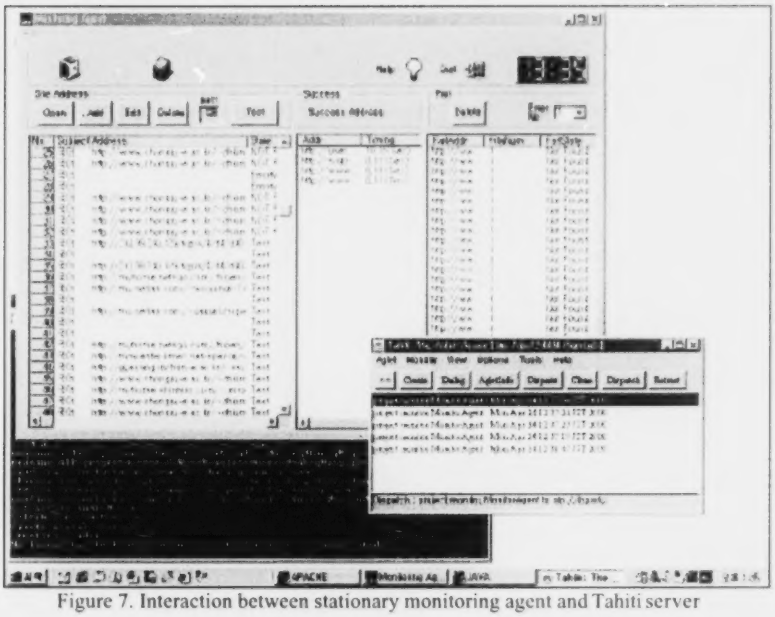


Figure 7. Interaction between stationary monitoring agent and Tahiti server

In order to use the implemented monitoring system in this study, we applied at the educational portal system and the KEPS system in the EDUNET server. Figure 8 is shown the searching screen of the web browser using KEPS system. This portal site in the EDUNET was constructed for the Korean elementary student and teacher. Also this site contains all contents about the curriculum of the Korean elementary school.

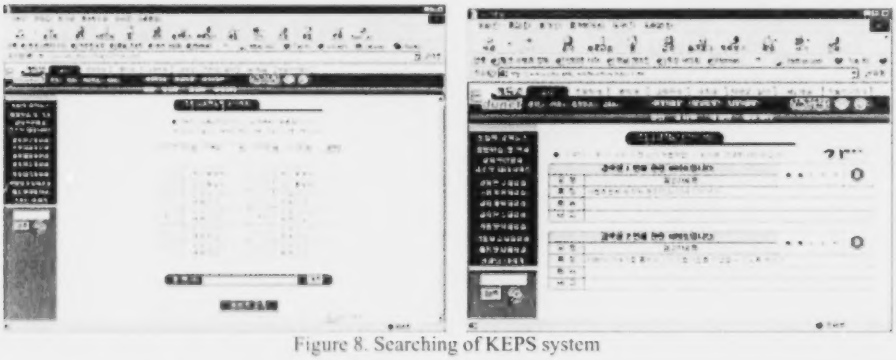


Figure 8. Searching of KEPS system

4.2 Experimental Results

For examining the efficiency of the cooperative monitoring system using the mobile agent, we compared and evaluated a monitoring time of each agent system. A comparative and estimative items listed below are as followed.

- Comparative item
  - *The single stationary monitoring agent vs. the cooperative monitoring agents.*
- Estimative items
  - *The monitoring time of the single monitoring agent*
  - *The monitoring time of the cooperative monitoring agents(3)*
  - *The monitoring time of the cooperative monitoring agents(7)*
  - *The number of sites: 10,30,50,70,90,110,130,150,170,190 ..etc.*

BEST COPY AVAILABLE

The experiment measures examination time of sites using a comparative and estimative items above. The estimative result is shown Table 1 and is represented figure 9 with form of graph. The horizontal axis of graph is represented the number of site and the vertical axis of graph is represented monitoring time of each agent.

In case of the number of an examine site is small, the result of experiment is viewed that the single stationary agent is faster speed of examination than the mobile monitoring agent. Also, when mobile agent is dispatched to three servers, speed of examination is faster than is dispatched to seven servers. The reason is caused by overtime occurred because the many mobile agents are created, allocated, gathered.

However, the more the number of site increases, the faster the mobile monitoring agent gets speed of checking than the single stationary agent. In particular, when the cooperative monitoring system using many agents, experimental result is shown that a speed of examination is very fast. If a single stationary agent processes very many sites, the result of execution can be useless though the result is very accurate.

Consequently, the cooperative monitoring agent can become higher execution speed by distributed and parallel processing and an overload of network by using a mobile agent can be decreased. If a server has an active environment of the mobile agent, the servers can be used with an active space of a searching agent and a monitoring agent.

Table 1. Result of monitoring time

Agent Type \ Number of Agent	10	30	50	70	90	110	130	150	170	190
Stationary Monitoring Agent	42	137	201	261	374	412	518	592	645	743
Mobile Monitoring Agent(3 Servers)	120	132	143	165	221	253	262	282	316	335
Mobile Monitoring Agent(7 Servers)	130	121	124	122	148	143	147	183	186	182

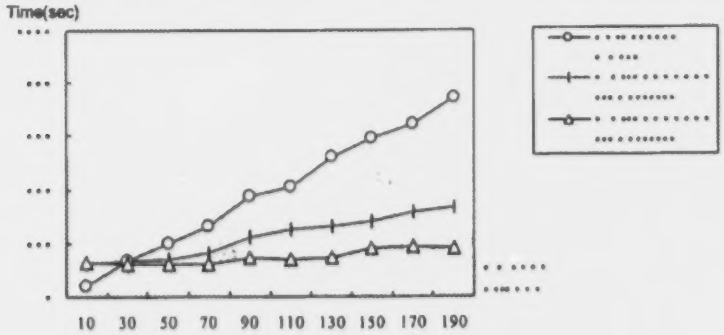


Figure 9. Graph of monitoring result

5 Conclusion and Future works

This study is on the efficiency of cooperative monitoring agent using mobile agent for educational portal site. The monitoring job has been getting difficulty processed by human. Thus, an intelligent agent can process the monitoring of the portal site instead of human. A monitoring work by using a single stationary agent needs long time for checking of many sites.

In order to overcome the problem in this study, the mobile agent is used in monitoring job. The monitoring job of educational portal site can be processed by collaborative method of decentralization and parallel using the mobile agent. The monitoring system was implemented by using the Aglet and Tahiti server. This system could execute cooperative monitoring job through an intelligent interaction between the stationary agent and a mobile agent. Also the KEPS system is possible with the mediation and the registration of agents by using the mediator agent between the monitoring server and the temporary agent sever.

The temporary agent sever is not fixed with the number but can be dynamically changed. Therefore all servers are by resources of monitoring job and each server can exe cute its role by inference.

More studies are required on research that constructs knowledge base for inference engine of the mobile agent. For effective portal site constructed, future work needs researches about not only intelligent monitoring but also intelligent searching and gathering of educational information. In order to interact between the mobile agents, we require research about KQML, language for sharing and exchange of knowledge between agent and agent.

References

[1] Akhil Sahai, Christine Morin INRIA-IRISA, • Mobile Agents for Enabling Mobile User Aware Applications• ; Just Research, 1998.

[2] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol 72, pp.329-365, 1995.

[3] Bryce L. Allen, Information Tasks: Toward a User-Centered Approach to Information Systems:, Academic Press, San Diego, CA, 1996.

[4] B.Venners,"Solve Real Problems with Aglets, a Type of Mobile Agent", Java World, www.javaworld.com/javaworld/jw-05-1997/jw-05-hood.html.

[5] Chang, D., Lange, D. "Mobile Agent: A new paradigm for distributed object compuing on the WWW. In Proceedings of the OOPSLA96 Workshop: Toward the Integration of WWW and Distributed Object Technology, ACM Press, N.Y., pp 25-32, 1996.

[6] Danny Lange and Mitsuru Oshima "Programming and Deploying Java Mobile Agents with Aglets", Addison-Wesley Longman, Mass., 1998.

[7] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[8] J.White, "Mobile Agents," in Software Agents, J. Bradshaw, ed., MIT Press, Cambridge, MA,1997.

[9] M. Wooldridge, M., Jennings, N. R., "Intelligent Agents: Theory and practice. The Knowledge Engineering Review, 10(2)", Springer-Verlag, pp 115-152, 1995.

[10] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[11] R. Tolksdorf, "Intelligent Information Agent: On Coordinating Information Agents and Mobility", Springer-Verlag, pp 396-411,1998.

Development and Evaluation of a Mental Model Forming Support ITS

- the Qualitative Diagnosis Simulator for the SCS Operation Activity-

Toru Miwata, Tatsunori Matsui, Toshio Okamoto and Alexandra Cristea
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621
Fax: +81-424-89-6070
E-mail:matsui-t@ai.is.uec.ac.jp

In this study, we built an educational qualitative diagnosis simulator, which models SCS (Space Collaboration System: system the remote conferences and education via satellite communications) conferences. A student engages in the conference, by operating a control panel and proceeds by making the necessary selections according to the agenda of the virtual conference, and its intention and purpose, which can change at any time. The purpose of this study is supporting the student to form a correct mental model in this environment. Therefore, we incorporate an abstract model of possible computations as a logical circuit attached to the SCS system. Using this model, the system has two functions: to diagnose the student' s conceptual understanding mistakes about the SCS system and to explain to him/her the cause of these mistakes. With these functions, we expect to be able to support the student in forming a correct mental model and in understanding the SCS essentials.

Keywords: **Mental Model, Space Collaboration System, Remote Conference**

1 Introduction

Recently, with the increased awareness of the necessity of individual, subjective learning, a change occurred in the building of computer based educational systems. The existing learning supporting systems are based on automatically generating the learning method, according to the relation between the state defining parameters and the subject' s (learner' s) behavior. However, in recent years, the trend to construct systems, that positively encourage the student to work, and allow him/her to change the current state parameters by him-/herself, offer system behavior simulation, moreover, verification and correction of the student inputs, emerged. In this type of subjective/ individual learning environment, it is necessary to add a causality explanation function of the target environment. This is important due to the fact that, by letting the student/ learner adjust and change the system parameters, and then showing him/her the system behavior simulation, as derived from the current configuration and structure, fundamental system comprehension can be supported and achieved [2..11]. We have, therefore, used the above mentioned specifications and background information, to implement an educational qualitative diagnosis simulator, for supporting fundamental system comprehension and understanding. For this purpose, we have based our mental model design on the object oriented approach. The mental model is a representation of the individual comprehension about the structure and functions of the objects involved in the simulated system model. Moreover, depending on the simulation of the object functions within the learner' s mental model, it becomes possible to predict the problem solving act results. Therefore, important learning can occur and, at the same time, causality explanation within the virtual learning environment can be offered. We based the mental model used in our system on the qualitative modeling. The qualitative model is a fundamental model representation based on the causality relations that generate the target system' s behavior. The causality relations are reflected in the relations between the system' s structure, behavior and functions. Here we consider the following definitions. The **structure** reflects how the elements of the target organization are combined. The **behavior** shows how the system characteristics, expressed by the object structure, change in time. The **function** expresses how the goal, related to the object behavior, is achieved. By modeling the

causality relations between the system' s structure, behavior and functions, and designing a qualitative model, the causality relation simulation becomes possible. In our system, we have constructed a qualitative diagnosis simulator for conferences via SCS. SCS, standing for Space Collaboration System, is a remote conferences and distance education system via satellite communications. The learner/ student follows the progress of the conference, by operating a control panel, and making the necessary selections, according to the agenda of the virtual conference, and its intentions and purpose, which can change in time. In this environment, we integrate a computable model abstraction of the remote conference via communication satellites, as a logic circuit. Moreover, based on this abstraction, we add a causality explanation function, and a diagnosis system of the student' s/ learner' s operation mistakes, which generate the appropriate guidance information for the student. In this way, we support the fundamental comprehension of the SCS system.

2 Qualitative reasoning

Qualitative reasoning is one of the most vigorous areas in artificial intelligence. Over the past years, a body of methods have been developed for building and simulating qualitative models of physical systems (bathtubs, tea kettles, automobiles, the physiology of the body, chemical processing plants, control systems, electrical circuits, and the like) where knowledge of that system is incomplete. Qualitative models are more able than traditional models to express states of incomplete knowledge about continuous mechanisms. Qualitative simulation guarantees to find all possible behaviors consistent with the knowledge in the model. This expressive power and coverage are important in problem-solving for diagnosis, design, monitoring, and explanation. Qualititative simulation draws on a wide range of mathematical methods to keep a complete set of predictions tractable, including the use of partial quantitative information. Compositional modeling and component-connection methods for building qualitative models are also discussed in detail [1].

3 SCS

Figure 1 displays the SCS based remote conference concept. SCS was established as a satellite communication network between universities, to enable real-time remote video conferences. Each participant' s station (called VSAT station) is enabled with a satellite communication control panel, an image and sound transceiver control panel, multiple video-cameras, monitors, and so on.

3.1 SCS constrains and limitations

The SCS conference can take place as an inter-station, bi-directional communication between two stations, or as a mult iple VSAT stations communication, where only one station has the role of the moderator, and has authority upon transmission control. In the latter case, all the other station, with the exception of the moderator station, are called client stations, and can participate as such in the conference. The moderator station is decided in advance, before the actual conference, by the conference organizer, according to the requested time-schedules and conference contents. The line control is usually under the sole authority of the moderator station. However, a client station can send a request for line usage for transmission to the moderator. This operation is enabled by the proposal request button existent on each VSAT station panel. By pushing this button, a proposal request notification is sent to the control panel on the moderator station. Moreover, during the conference, it is possible for two different stations to send image and sound, namely, the carrier, at the same time, so there can be up to two distinct proposing stations. The respective client stations are depicted in the lower part of figure 1.

The communication satellite has two reception parts, and a converting switch that allows the selection of the received carrier. Depending on the existing constrains and conditions, a decision mechanism is involved, before actually sending the carrier selection from the satellite. After verifying the current constrains and conditions, the carrier is sent from the satellite. This carrier is sent without exception to all client stations. In figure 1, the sending of the carrier to all the client stations is depicted. The station carriers depicted in figure 1 as a black solid arrows show the connection between the individual stations and the transmission part of the satellite. The figure shows also that the satellite receives only two carriers at a time. However as all stations are connected with the satellite, as depicted by the solid black arrows, all stations are prepared to send a carrier.

The satellite reception part is built of a receptor, and a converting switch. In this way, by means of the

restrictions set by the converting switch receptor, the satellite can receive, all in all, only two carriers. Moreover, these have to be from two distinct stations only. Also, in the case of multiple carrier reception, the moderator station operator can decide, according to his/ her free will, to commute to the receiving of one carrier only, disregarding the choices and modes of the client stations. These constrains, limitations and specifications, and the fact that the client stations can all in all send only two carriers, are depicted in the figure as dotted thick arrows. The two carriers that can be sent are named [send 1] and [send 2]. Their contents is re-sent from the satellite. The restriction that the two carriers, [send 1] and [send 2], should not come from the same station is enforced before this re-transmission. Only when al the above restrictions are fulfilled, can the received carriers be broadcasted from the satellite to all stations. At the reception of the broadcast signals, each client station can separate the two carriers, [send 1] and [send 2]. The station sending the carrier is also receiving the broadcast, without exception. Therefore, the sound and image received by the transmitting stations are:

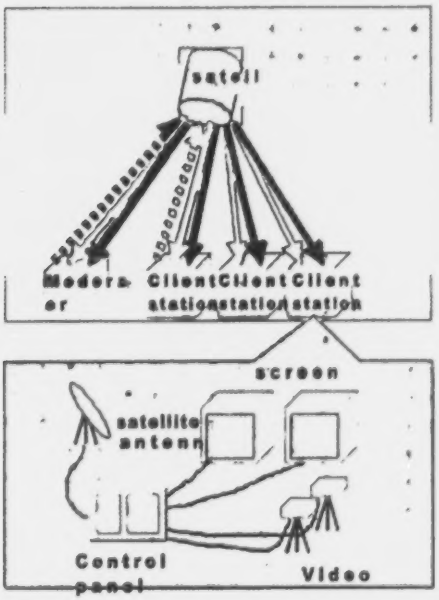


Fig. 1 Conference with SCS

(1) image+sound from the other transmitting station (if existent);
(2)the image and sound sent to the satellite by the station itself.

Moreover, as it is impossible to send the image and sound carrier to a specific station directly, by sending them to the satellite, they are broadcasted automatically to all stations. Bi-directional communication is also possible, but is actually a quasi-bi-directional communication, as the broadcast carrier of the two communicating stations is sent, at the same time, as a broadcast signal to all client stations.

3.2 SCS system frequent user errors

In table 1, the error types for different user skill levels of SCS conference practice, as gathered by surveying 4 domain specialists with over 2 years of SCS system operation experience, is shown. They were asked to give us first a list of frequently appearing user errors during the SCS usage and managing. This list is displayed in table 1 in the column headed by the label "Error/ misconception". Next, they were asked to evaluate the frequency of apparition of these errors for beginner, medium and alvanced user. In table 1 their replies were represented as follows: [• •] means high, [• •] means medium, and [• •] means low frequency of errors. The table presents therefore the specialists' primary classification of errors according to the operation skills. To this classification, we have added a new error classification, based on the previously explained SCS system constrains and limitations. We have managed to group all errors enumerated by the specialists into four big classes of errors and misconceptions: A, B, C and D. The definitions of these classes are given below.

Table 1 Error types

Error/ misconception	beginner	medium	advanced	Error classification
Disregarding the function of the satellite• • believing direct/ dedicated transfer between fellow stations is possible.	• •	• •	• •	A,B,C, D
Believing that the sending of two carriers from the same station is possible.	• •	• •	• •	A
Believing that receiving two carriers from the same station is possible.	• •	• •	• •	A
Not understanding that, by switching the carrier to a different station, the current proposing	• •	• •	• •	B

BEST COPY AVAILABLE

station carrier will disappear.				
Believing that all stations can send a carrier at the same time.	. .	. .	. .	C
Not understanding the concept and necessity of the carrier request proposal.	. .	. .	. .	C
Assigning carriers to three or more stations.	. .	. .	. .	C
Not understanding why the image and sound signal sent by ones own station is received again.	. .	. .	. .	D
Believing that bi-directional communication is possible only with a specific station.	. .	. .	. .	D
Assigning the carrier to each	. .	. .	. .	D

station consecutively.				
Believing that only one broadcast is possible.	. .	. .	. .	D
Not making the distinction between the moderator station and the other client stations.	. .	. .	. .	static state
Believing that the client station is in charge of the transmission control.	. .	. .	. .	static state
Not making the distinction between the two wave forms (signals), [send 1] and (send2).	. .	. .	. .	static state
Believing that the [send 1] wave form is the signal coming from the moderator station.	. .	. .	. .	static state

Class A: Misconception/ incomplete information about the sending of two different waves/ signals with the help of the judgement/ decision mechanism.

Class B: Misconception about the sending of one carrier to one station with the help of the converting switch.

Class C: Misconception/ incomplete information about the receiving of two carriers.

Class D: Misconception/ incomplete information about broadcasting to all stations.

4 The SCS qualitative model

Figure 2 shows the qualitative model of the SCS conference abstraction, in the form of a logic circuit. This qualitative model can express the structure, behavior and functions of the SCS system. In this figure, we displayed four client stations and one communication satellite. As can be seen, the satellite has two receptors, and one judgment/ decision mechanism, as a converting XOR switch between the two receptors. The two client stations sending carriers at one time can therefore have a pseudo- bi-directional communication. The structure, behavior and functions, so, the objects of the original SCS system are expressed, in this way, as a qualitative model.

The characteristics of this model make it possible to simulate the dynamic changes occurring during a distance conference, allowing to decide and evaluate the proper parameter settings for each station, moreover, to simulate the system behavior in the case of mistaken parameter settings. By using the XOR function, it is ensured that each reception part of the communication satellite can receive only one carrier from only one station. This station has sent a prior transmission proposal to the moderator station, which was accepted.

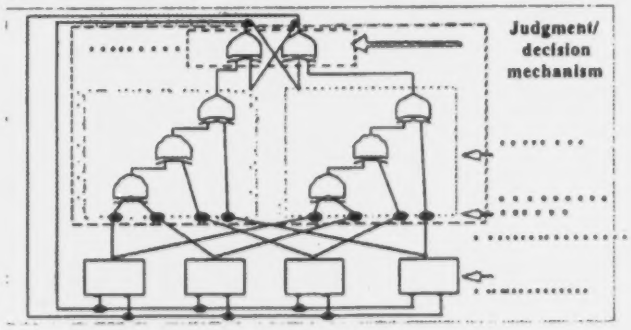


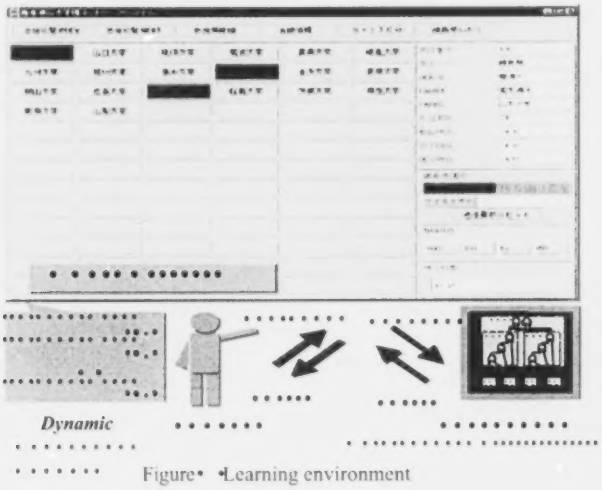
Fig 2 The qualitative model of the • • • system

BEST COPY AVAILABLE

Next, it is necessary to make sure that the two accepted carriers come from two distinct stations. This restriction is enforced by the judgment/ decision mechanism. The judgment/ decision mechanism eliminates via an extra XOR function the possibility that the two carriers were sent by the same station. If the two carriers, 1 and 2, are validated by the judgment/ decision mechanism, the communication satellite broadcasts one or both to all VSAT stations. Therefore, all VSAT stations will receive the two carriers 1 and 2 and will not be able to receive any other carriers from other stations, or any wrong transmissions. Moreover, by using this model it is possible to infer the error source, as shown previously, based on the SCS system structure. The previous A, B, C, D classification can be thought of as: (A) sending of two distinct waves by using the judgment/ decision mechanism, (B) sending of maximum one carrier per station by means of the converting switch, (C) using of two carriers by means of the satellite reception mechanism, (D) existence of broadcast type of transmission only. In this way, the virtual model enables the learner to derive the cause and source of the operation error, as related to the SCS system structure. Furthermore, we have presented here a model based on only 4 client stations, that is implemented via the XOR module, but as in the case of more than 4 client stations, we can increase the number of the reception part XOR modules, adapting them to the number of stations, we can express, cope with and model therefore the converting switch for any arbitrary, greater than 2 number of client stations.

5 Learning Environment

5.1 System outline and overview



Figure• •Learning environment

Figure 3 shows the overview of the system. The learner/ student is performing the conference steps by taking over the role of the moderator station operator. The goal is to cope with the dynamically changing agenda of the conference, proposed by the system. The agenda presents a description of a dynamic conference state, where bi-directional communication is required. The student can take decisions about the SCS system state and change parameter by operating the control panel. The previously described qualitative model evaluates these settings and parameters.

Next, disregarding if the parameter setup and assignment is appropriate or not, the result of the new user choices is reflected on the control panel of the interface, changing the current representation. The control panel displays also the transmission requests coming from other stations. The student has to choose the appropriate response to these requests. The student has to be able to judge the appropriateness of his/her own operations and actions, by interpreting the information presented on the control panel. By repeating the above steps, the student can learn the constrains and usage of the SCS system. Moreover, to prevent deadlock situations, where the student is unable to judge his/her own errors, due to misunderstandings regarding the SCS system constrains, an explanatory function was added. This is implemented via an explanation button, which can be pressed by the student in need. The student guidance follows as has been previously shown, conform with the SCS qualitative model. In this way, the student can achieve not just a quick, superficial understanding, but also a deep, structure related knowledge about the SCS system. For example, explanation are given such as: "There are only two

BEST COPY AVAILABLE

satellite receptors.", "There is an exclusive OR switch on each receptor, so each receptor can receive from one only station at a time.", "The judgment/ decision mechanism does not allow 2 carriers from the same station.", and so on. By leading the student to understand the connection between the parameter setup and the way the SCS system is actually built, as well as the real system components and the relations between them, via messages and state representations on the control panel, the student can be expected to perform the parameter setting by him/herself successfully in the future.

5.2 System flow

Figure 4 shows the system flow. The rapidly changing conference goal and intention of the agenda is described in chronological order. The contents of this description are on one hand, the conference state change requirements that have to be performed by the student, put into words that can be easily understood by him/her, and on the other hand, the description of the current SCS system state. In figure 4, this is expressed as [word] utterances, at the different moments in time (t0, ..,tn):

$$word : state(t0) \sim word : state(tn)$$

For example, [word] can be a prompting message about the conference state change, with the value of "Please reply to the question from university A!", and so on. As shown in figure 4, the operation panel managing module receives from the agenda, or from the other client stations the current parameter for each given conference state, and then reflects the resulting state on the panel. For example, the button of the station, which is currently in charge of a carrier, turns red. Also, in the case of requests from other stations, the button of the station sending the carrier request signal turns also red.

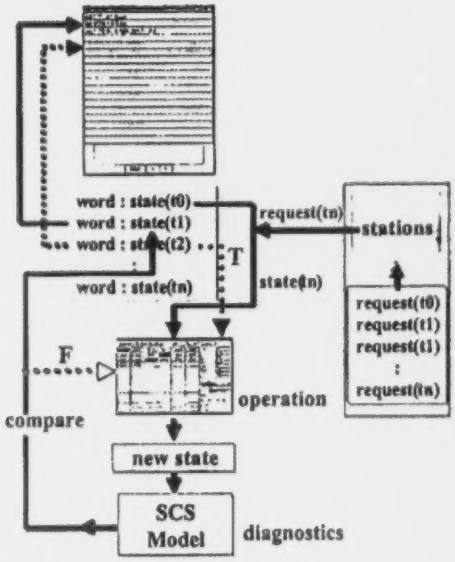


Figure 4 System flow

The student infers the present conference state from the state of the panel. Moreover, from here the student can notice if it is necessary to change the state of the conference, according to the agenda requirements. Next, to change the conference state, the student has to operate the control panel. By doing this, the parameters determining the conference are changed, and a new conference state emerges. This new state is evaluated with the SCS qualitative model. When evaluating with the SCS model, the result is compared with the next agenda. It is, in principle, possible to perform such comparisons on the SCS system without the computable module, and to judge if the operation is appropriate or not, but, in that case, the student cannot achieve a deep understanding of the SCS conference, that is, s/he cannot identify the SCS behavior as derived from structural constrains. In order for the learner to achieve a deep understanding, it is necessary to perform the parameter evaluation with the help of the SCS computable model. After the parameter evaluation, if the settings are judged as appropriate, the system moves to the next agenda. In figure 4, this is the case of "T" (True). In this case, the setup parameters decided by the student are handed over to the administrating module, which, in turn, reflects these changes on the operation panel. On the other hand, if, after the parameter evaluation, the settings are judged as not being appropriate, the system does not move to the next agenda. This case is shown in figure 4 as the "F" (False) case. In such a case, the wrongly set parameters are displayed on the operation panel. In this way, the deficient, real SCS state can be represented.

For example, in the case when three or more stations ask for the carrier at the same time, and the carrier is passed over to them, the moderator station's carrier disappears. The student notices that the respective state is not appropriate, and corrects the setup parameters. Moreover, in the case that s/he doesn't notice the errors, s/he cannot continue with the next agenda. When entering a deadlock situation, the SCS qualitative model can, at the student's request, explain to the student what kind of error s/he has done. In this way, by explaining not the protocol and process steps, but the SCS system behavior, as a result of the structural constrains, our system supports the formation of the SCS learner mental model. For instance, let us consider a case where the present transmission rights belong to universities B and C, and a proposal request is received from university A. This

request is represented on the panel by the button representing university A turning red, together with a simultaneous indication message appearing in the agenda window, stating "Please answer the question from university A". If the student decides to assign a carrier to university A, without previously modifying the state of one or both stations B and C, which have the current transmission rights, the result is that the system will have 3 or more simultaneous carriers at the same time. In this case, the system represents the buttons of universities A, B, C on the panel with red color, and lets the student therefore know that the parameter setup is not appropriate.

At the same time, the agenda window will also display a message for the student. The content of this message is something like: "There are only two receptors on the satellite.", so is an explanation of the behavior, as resulting from the structural constrains.

6 Agenda

Table 2 Agenda example

agenda(t0)	The conference starts.
agenda(t1)	The moderator station is the University of Electro-Communications.
agenda(t2)	Please allocate carrier • •to Yamagata University• •
agenda(t3)	Please start sending from the lecturer camera• •
request(t4)	Carrier request • •Tsukuba University• •
agenda(t4)	Please reply to the question from Tsukuba University• •
agenda(t5)	The conference has ended• •

The SCS conference is based on a general agenda. Our system offers SCS based remote conference simulation environment and, moreover, stores typical SCS agenda models, in order to dynamically produce conferences that require conference state changes.

In this way, the student becomes the operator of the moderator station, and has to take decisions compatible to the agenda, engaging therefore in the simulated steps of the SCS conference. In table 2 we show an example of a model agenda for our system. In this table, agenda(tn) represents the agenda at moment (tn) in time, and request(tn) represents the carrier request at moment (tn) in time. In the real SCS conference, the time moment concept exists, but, in our system, we have the supplementary restriction that, only after accomplishing the current agenda, it is possible to go on with the new one. As shown above, the agenda is organized as a time series, and the student receives indications and instructions from the agenda window. The changes occurring in the conference state in the respective agenda example above correspond to a respective intention and goal. Disregarding if these intentions and goals come from the original operator's decisions, or if they were prepared by the system from the beginning, the beginner student doesn't have to loose his/her way during the SCS conference proceedings, and can give the panel operation his/her undivided attention. In other words, the indications and instructions coming from the agenda window can be thought of as an experienced operator teaching the beginner student during the SCS conference proceedings. After receiving the indications and instructions from the agenda window, the student can decide on the next conference state that seems appropriate, given the present conference state and the indications received, and operates the control panel to perform the respective change. The new state that results as a consequence of the student's operations is checked by the system, to decode if it is appropriate or not, conform with the indications and instructions of the agenda. One agenda is recorded in the system as one word and 6 state descriptors. The words are the ones that appear in the agenda window. The six possible state descriptors are shown below.

• • *station name (list of all client stations)*
• • *carrier request (list of all client stations)*
• • *carrier 1 (list of all client stations)*
• • *carrier 2 (list of all client stations)*
• • *reception 1 (list of all client stations)*
• • *reception 2 (list of all client stations)*

The state descriptor called "station name" contains a list of all client station names. Next, the carrier request, carrier 1, carrier 2, reception 1 and reception 2 state descriptors contain respective lists of [on] and [off] states corresponding to each station. In figure 3, we show the correspondence between [1] and [0] and [on] and [off]. The reason of describing all client stations carrier and reception states with [off/on] descriptors is to be able to represent also the incomplete understanding of the learner/ student, as well as his/her mistaken parameter setups and assignments.

7 Testing, experiments and evaluation

Table 3 comparison of situation before and after learning takes

Error	Pre Test	Post Test	Error classification
Disregarding the function of the satellite and believing direct/ dedicated transfer between fellow stations is possible.	N/A	N/A	A,B,C,D
Believing that sending of 2 carriers from one station is possible.	3 persons	1 person	A
Believing that receiving two carriers from the same station is possible.	3 persons	1 person	A
Not understanding that, by switching the carrier to a different station, the current proposing station carrier will disappear.	5 persons	1 person	B
Believing that all stations can send a carrier at the same time.	3 persons	3 persons	C
Not understanding the concept and necessity of the carrier request proposal.	5 persons	1 person	C
Assigning carriers to more than three stations.	5 persons	1 person	C
Not understanding why the image and sound signal sent by ones own station is received again.	5 persons	3 persons	D
Believing that bi-directional communication is possible only with a specific station.	5 persons	1 person	D
Assigning the carrier to each station consecutively.	5 persons	1 person	D
Believing that only one broadcast is possible.	5 persons	5 persons	D

We have performed an evaluation experiment of our system over a small sample. 5 beginner students with no SCS system experience were selected as the object of our SCS conference experiment. We have first explained them the control panel representations, meanings and operation mode, as well as the agenda window functionality, and the SCS system setup as a bi-directional communication system. They were able to consult the SCS user manual. Next, we have done a pre-test with the system without the diagnosis mechanism, and followed and checked the operations and mistakes of the beginner operator. Then, we have performed the same experiment, this time, with the help of the diagnosis mechanism. In the last step, we have compared the understanding level before and after learning. The result is displayed in table 3. A system screen display during the experiment is shown in figure 3. This figure displays a student deadlock situation, where the student has asked for an explanation about the deadlock, and the system has next checked the SCS system structure related error cause, and finally displayed it on the screen for the student to see. In the case presented in figure 3, the student hasn't realized the fact that there are only two receptors on the satellite, and has mistakenly allocated carriers to 3 stations. The explanation of his/her error is displayed on the control panel. The state of 3 stations having the carrier is represented on the panel as the respective stations' buttons turning all red (left corner of fig. 3, darkened buttons). However, if the student doesn't grasp the meaning of the representation and the cause and source of his/her errors, and asks therefore the system for help, the system will display the following message: "There are only two receptors on the satellite". With this explanation, the student understands that, as there are only 2 receptors on the satellite, s/he cannot allocate carriers to 3 stations, and will operate the panel correctly in his/her next steps.

According to our system's result shown in table 3, the students can understand the SCS system constrains and limitations, the fact that the signal has to be sent from different stations, the fact that there are only two carriers, and the concept of the XOR receptors of the satellite. However, the broadcasting mechanism was not completely understood. This is probably due to the fact that, in the current simulation system, there is no visual display of the broadcasting mechanism, of the time and direction of the transmission.

7 Conclusion

In this paper, we proposed an educational qualitative diagnosis simulator based on an object-oriented approach to mental model formation. In our model, the structure, behavior and functions of the SCS system are the objects, and from the description of the causality relations between these objects, the student can determine the cause of his/her error, based on system structure judgment.

From educational strategy point of view, QUAD implements and supports a combination of learning methods, like "Reinforcement learning", "Learning by exploring", "Learning by asking", "Learning by applying", "Self-monitoring", and so on. From educational depth point of view, the QUAD system doesn't stop at the procedural surface level, but traces the structural implications, to gain a deep knowledge level.

For further research, we believe that, by expanding the current system, and identifying more precisely the mental model of the student, a more appropriate guidance system can be developed.

References

[1] B. Kuipers; Qualitative Reasoning: Modeling and Simulation with Incomplete Knowledge, Cambridge, MA: MIT Press (1994).

[2] T. Okamoto• O. Matsuda; About the mental model of the ITS based geometrical/ topological proof process, Japanese Journal of Education and Technology,Vol.4, No.15, pp.167-182 (1992)

[3] O. Matsuda, T. Okamoto; based on hypothesis inference/ deduction : about the ITS - student model and its recognition method, IEICE conference, A, Vol. J75-A, No.2, pp.266-274 (1992)

[4] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Japanese Journal of Educational Technology 20(4), pp. 207-226, (1997)

[5] T. Nishida; The basis of qualitative inference/ deduction, Journal of the AI society, Vol.4,No.5,pp.522-527,(1989)

[6] T. Okamoto; Education, Media and Artificial Intelligence, Journal of the AI society, Vol.10,No.3,pp.361 – 367 (1995)

[7] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Journal of the AI society, Vol.20, No.4, pp.207 – 226 (1997)

[8] T. Nishida; The common sense thinking way model of qualitative inference/ deduction• •Journal of the AI society, Vol.2, No.1, pp.30 - 43,(1989)

[9] T. Nishida; Towards applications of the thinking ways and intelligent problem solving techniques of qualitative inference/ deduction• •Journal of the AI society, Vol.32, No.2, pp.105 • •117 (1991)

[10] T. Nishida; Aspects of qualitative inference/ deduction, Asakura publishers (1993)

[11] K. Asai, H. Ohnishi, K. Kondo, K. Tanaka, O. Matsuda; Case base and Collaboration Application based on appropriate• • ¶(control) and the Internet system, technical Report of IEICE, ET97-24 (1997-05)

Domain Specific Information Clearinghouses – A Resource Sharing Framework for Learners

Wong Pei Yuen*, Yeo Gee Kin*, David Crookalland Lua Tse Min***
**Department of Information Systems*
School of Computing
National University of Singapore
Building S-15, Level 5, Room 12
3, Science Drive 2, Singapore 117543
Tel: +65 874 2908 Fax: +65 779 4580
E-mail: {wongpei1, yeogk, luatsemi}@comp.nus.edu.sg
***UNSA, Langues, 98 bd Herriot, BP 209, 06204 Nice cedex 3, France*
E-mail: crookall@jaydemail.com

The World Wide Web has presented researchers and learners all over the world with unprecedented opportunities to find and distribute information. An increasing number of valuable resources are made available online. This provides an excellent knowledge base for learners. However it is often very difficult to find these useful resources. This paper describes the framework of a domain specific information clearinghouse and how these clearinghouses can collaborate with one another to enable cross-domain learning. The resources in a domain-specific clearinghouse are submitted by trusted domain experts to ensure its quality. Learners with multiple domain interests can also effectively retrieve the information they need using the cross-domain collaboration framework presented. This is achieved with a union agent that manages the collaboration and sharing of resources between different domains. We also present a toolkit that facilitates the rapid deployment of such clearinghouses by domain experts.

Keywords: **Collaborative Learning, Educational Agent, Knowledge Construction and Navigation, Web-Based Learning, Domain Specific Information Clearinghouse**

1 Introduction

The tremendous success of the Internet and the World Wide Web has resulted in a global information revolution. With more and more information easily available online, people are now increasingly reliant on the Web for their information needs. They are constantly faced with the problem of finding relevant information that will suit their learning needs. Most commonly used tools for finding information, in particular search engines and Web directories, often return huge amounts of information which are neither useful nor relevant to the learners' needs. A more effective way of assisting these learners in finding information is lacking.

A possible solution would be the use of a domain-specific information clearinghouse managed by human domain experts. In a nutshell, a *Domain Specfic Information Clearinghouse*, or *DSIC*, is a Web-based clearinghouse and resource repository for information resources available on the Web. Learners would be able to find relevant and higher quality information from these resources. However, most information and research nowadays do not dwell on a single domain. Cross-domain learning requirements need to be met. This can be achieved through collaboration between multiple DSICs. With this cross-domain collaboration, we are able to discover and learn more about how each domain is related to one another.

In the following sections we will discuss the various approaches that are currently adopted by learners and

the concept of the Domain Specific Information Clearinghouse. Section 4 describes the framework of a Domain Specific Information Clearinghouse network to facilitate cross-domain learning. In Section 5, we describe a toolkit currently under development for the quick deployment of a domain-specific information clearinghouse. Finally, we would conclude with Section 6.

2 Current Approaches for Finding Information Online

The primary means by which learners find information on the Web are tools like search engines, Web directories and metasearch engines [1] [5].

Search engines operate by plowing through the Internet and indexing web pages. Typically, only keywords are indexed. Some examples of search engines are AltaVista[1] and Hotbot[2]. Using this method, a lot of information can be retrieved. However, there is a trade off between quantity and quality. In this huge list of results, though it may contain many relevant items, most of the search results are usually irrelevant. Learners will lose a lot of time following useless links.

Web directories like Yahoo![3] and Excite[4] are maintained manually by a dedicated group of catalogers. These directories contain user-submitted resources that are indexed categorically. These indices are usually human-created or computer-generated. They would usually include some description that helps the user in determining the usefulness of the resource. As the resources contained by Web directories are user-submitted, there is the problem of scalability: it is impossible to scale personnel to match the rate at which the Web is growing. Web directories are outdated rapidly due to the ever changing and ever growing Internet. Important resources for the different categories and topics are often missing.

Metasearch engines are web tools that poll multiple sources like search engines and Web directories. The compiled resources are then processed and returned as results to the user. Metacrawler[5] and SavvySearch[6] are examples of metasearch engines. However, as pointed out in [4], although metasearch engines can significantly increase coverage, they are still limited by the engines they use with respect to the number and quality of results.

After looking at the above approaches, the problem of finding relevant and useful resources is not solved. Although these approaches may be adequate for a casual Web user, they do not serve learners who require specific information from certain domains well. We shall discuss our proposed solution in the next section.

3 Domain Specific Information Clearinghouse

Figure 1 below depicts the DSIC model.

---

[1] http://www.altavista.com
[2] http://www.hotbot.com
[3] http://www.yahoo.com
[4] http://www.excite.com
[5] http://www.metacrawler.com
[6] http://www.savvysearch.com

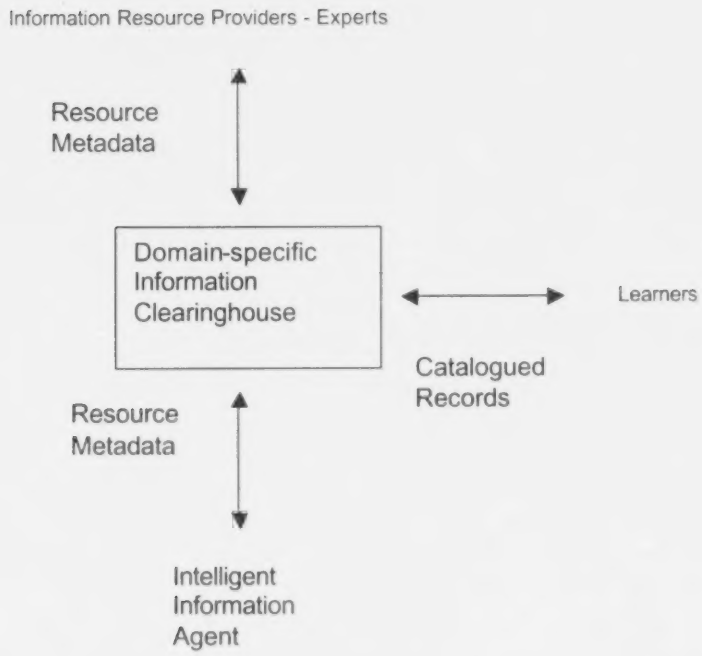


Figure 1: Domain-Specific Information Clearinghouse Model

As mentioned earlier, a Domain Specific Information Clearinghouse is a web-based clearinghouse and resource repository for domain-specific resources available on the web. One or more domain experts maintain the resources found in the clearinghouse. From now on, we will refer to *experts* as people who supply information to the clearinghouse and *learners* as people who access the clearinghouse for information.

The clearinghouse contains a classification of topics found in the domain and an intelligent information agent. With a good classification, the clearinghouse would be better organized and would increase learners' ease in finding the information they want. An intelligent information agent should be made available to facilitate the knowledge sharing and exchange both within and outside the clearinghouse.

An expert registers with the clearinghouse as a trusted information provider. He will then be able to submit resources that are in turn classified and cataloged. Using information found in these submitted resources, the intelligent information agent could scour the Web for more resources that can be added into the clearinghouse. The quality of these resources is much higher as they are being submitted by domain experts. What is useful and relevant to these experts are also usually useful to the learners as well. With all these information clearly classified, learners can then search or browse through the resource collection effectively in the domain specific clearinghouse.

4 Cross-Domain Learning

The DSIC caters to the needs of experts and learners in a single domain. However, learners often have not just one but multiple domains of interest. It would be useful for a learner with multiple domains of interest to be able to find the information he needs across all the different domains. Moreover, there are often no clear boundaries between domains, as the figure below shows. Resources from different but related domains may overlap.

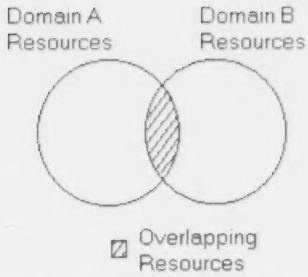


Figure 2: Overlapping Domain Resources

This potentially allows for different DSICs to collaborate and share resources with each other. To provide such a resource sharing framework, two issues needs to be addressed: distributed service and metadata exchange.

4.1 Distributed Service

The proposed framework for collaboration between multiple DSICs is essentially a distributed service. Domain experts maintaining each individual clearinghouse would register it with the *information union agent*, which is a central service that keeps track of all the existing clearinghouses that has been set up. This is illustrated in Figure 3 as follows:

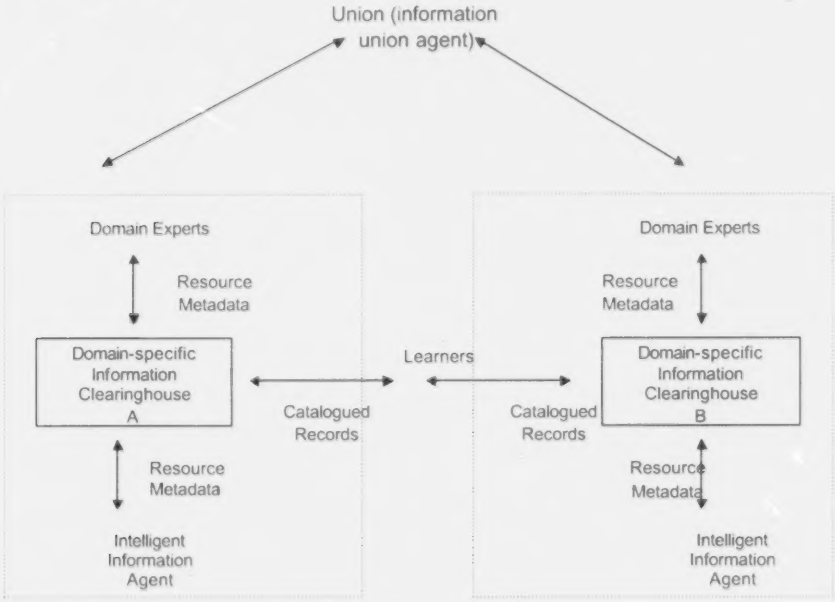


Figure 3: Multiple Domain Resource Sharing

Upon registration with the information union agent, each clearinghouse would declare the metadata attributes that are used to describe resources in that particular clearinghouse. Relationships with other domain clearinghouses are also declared. This information is then broadcasted to all the clearinghouses in the union to facilitate metadata exchange, which will be discussed in section 4.2

Besides maintaining the relationship links between the different domains, the information union agent would

also apply data mining techniques to learn and discover relationships between resources in the different domains. For example, when the number of similar resources that are found in two different categories of different domains exceed a threshold value, the union agent would automatically update the union with this relationship if it has not already done so. Through this process, the union agent can learn and discover new information and relationships between different clearinghouses in the union and update the respective clearinghouses with the new information. This allows the clearinghouses to provide learners with higher quality information.

4.2 Metadata Exchange

A DSIC union needs to provide a mechanism to facilitate the exchange of machine-understandable information among different DSICs. Being domain specific, each DSIC has its own set of metadata attributes and values. A mechanism needs to be provided for a DSIC to automatically interpret metadata that comes from another DSIC of a different domain and transform it to a human-readable form. This problem is non-trivial because classification schemes and metadata formats can vary widely between different DSICs.

The *Resource Description Framework* [7], or *RDF*, is an evolving specification developed by the World Wide Web Consortium. RDF's nucleus is an archetype for depicting named properties and their values. The properties are representations of resource attributes as well as the relationships between resources. This data model provides a syntax-independent means of representing RDF expressions.

We have developed a mechanism adapted from the RDF standard that would suit the needs of the DSIC union. We called this mechanism the *Metadata Schema*.

A metadata schema is simply a set of attribute names that is used to describe all the resources cataloged in a particular DSIC uniformly. Each DSIC is associated with exactly one metadata schema at any one time.

A metadata schema is unambiguously represented by an ordered n-tuple of the form

$$< N_1, N_2, N_3, \ldots, N_n >$$

In the above notation, each N_i, $i \in \{ 1, 2, 3, \ldots n \}$ can be any sequence of alphanumeric characters, including spaces, that starts with a letter. Usually, these would correspond to attribute names such as "Author", "Company", "Description" and "E-mail Address".

The Metadata Schema, together with the information union agent, are the main mechanisms for interoperability between different DSICs. The following scenario illustrates how the Metadata Schema is being used.

A learner using a particular DSIC X to search for information can indicate that he wants to cross-search another DSIC Y. Through the union agent described in Section 4.1, DSIC X would already know the Metadata Schema of DSIC Y and would request DSIC Y for metadata records that correspond to the user's search request. DSIC Y would then respond with a set of results of the form

$$R = \{ R_1, R_2, R_3, \ldots, R_m \}$$

where each R_i, $i \in \{ 1, 2, 3, \ldots m \}$ is an ordered n-tuple of the form

$$<V_1, V_2, V_3, \ldots, V_n>$$

Each element in the set R is then mapped to the known Metadata Schema of DSIC Y, after which the results are formatted and displayed by DSIC X.

The above scenario can be extended to more than 2 DSICs by simply requesting metadata tuples from each DSIC in turn. In this way, the DSIC union can be regarded as a single, distributed service with multiple access points, providing high quality cross-domain information to learners seeking such information.

5 An Example

An example of a domain specific information clearinghouse is the Simulation/Gaming eXchange [6]. This is a clearinghouse for resources in the simulation and gaming domain. Most of the resources in the clearinghouse are submitted by domain experts and are of high quality. Some entries are submitted by the *SGX Information Agent*, a software agent which uses techniques found in [2] and [3] to scour the Web and retrieve resource related to those submitted by the domain experts. A typical entry in [6] is show in Figure 4.

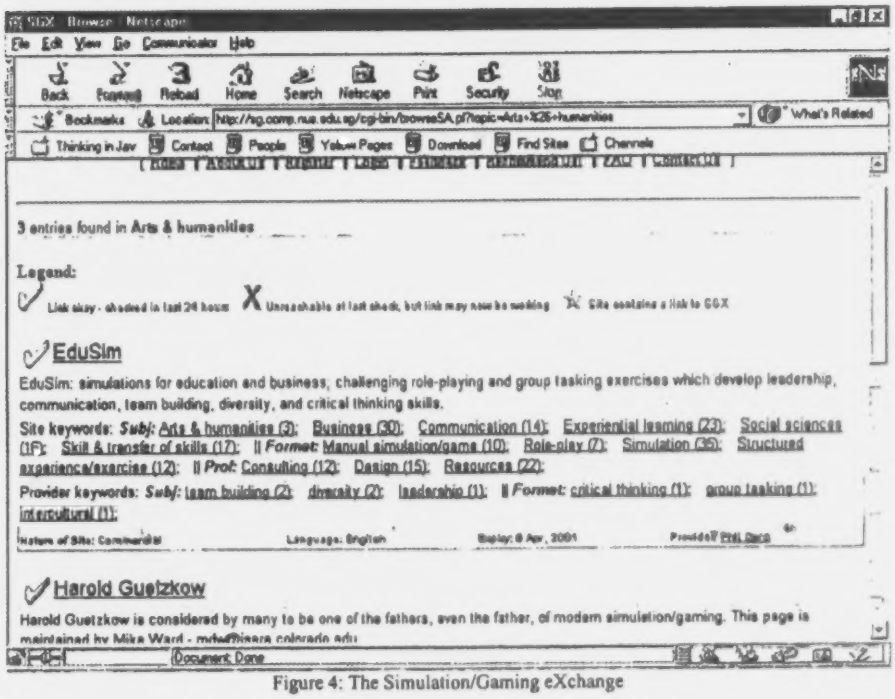


Figure 4: The Simulation/Gaming eXchange

Assuming that there is another information clearinghouse in the domain of CAI. This information clearinghouse also has its list of classifications and resources that have been submitted by experts. Upon registration into the union, the CAI clearinghouse will identify its relationship and links with the other clearinghouses that are already in the union. In this case, the CAI clearinghouse has to determine its relationship with the simulation/gaming domain. Some of the overlapping regions between CAI and simulation/gaming include edutainment, the use of simulations and virtual reality in learning. These resources can be applied to both the simulation/gaming domain and CAI domain when simulation/gaming is used as a tool in teaching using computers

Both CAI and simulation/gaming experts have submitted resources to their respective domain-specific information clearinghouses. Some of these resources are similar and will overlap each other. Using the overlapping regions as a starting point, the information agent in each clearinghouse will collaborate by sharing the resources they have. When a learner searches for virtual reality related resources in the CAI domain clearinghouse, he will be prompted that more resources are available in the simulation/gaming domain. He will also be linked and directed to these resources found in the simulation/gaming information domain. In this way, more resources can be retrieved without compromising on the quality of the results. This is very useful for learners with multiple domain interests. Furthermore, learners are also able to see how other domains relate to his domain interest. This sharing is done with the help of the union agent.

6 DSIC Toolkit

BEST COPY AVAILABLE

Although different domain specific information clearinghouses catalog resources in different domains, they have the same main functionality as follows:

- **Registration** – Users can register as information resource providers via online forms
- **Catalog** – Registered domain experts can login to the system and catalog resources. In addition, an automated information agent is used to gather resources from the Web automatically. Authors are identified by the agent and invited to refine the catalog of their own resources.
- **Browse** – Web users can browse through the resources cataloged in the clearinghouse using the classification scheme employed
- **Feedback** – A feedback mechanism must be provided for users to give feedback to the DSIC administrator
- **Administration** – An authorized administrator is allowed to make administrative changes to the system as an administrator

These similarities in different clearinghouses provide the foundation for the development of a generic, flexible toolkit for the rapid deployment of a domain-specific information clearinghouse. Domain experts with little or no Web development expertise but wish to deploy and maintain an information clearinghouse can make use of this toolkit to rapidly set up one.

The DSIC toolkit is designed as an integrated package with the following components:

- Web server
- Classification Scheme Editor
- HTML Template Editor
- Administration Module
- User Module
- Information Agent Module

A set of default templates are provided together with the toolkit so that a domain expert who wishes to set up a clearinghouse can selectively use the components of the toolkit and set it up in a short time span instead of having to start from scratch.

7 Conclusions

In this paper we have proposed a framework that allows learners to collaborate and share resources. With the use of domain specific information clearinghouses, learners are able to find useful, valuable and related resources. The clearinghouse union is a mechanism that allows different domains to come together and share their resources. This is especially useful for researchers and learners who have multiple domain interests. They are able to find resources across the different domains without compromising on the quality of the results.

Knowledge discovery and sharing is also made possible with the help of the union agent that overlooks all the domain clearinghouses in the union. The union agent not only helps learners retrieve related resources in other domains but also searches through the huge databank of resources to find hidden relationships about the different domains, giving us information on how different domains are linked and related to one another.

Finally, we also presented a clearinghouse toolkit currently under development for the rapid deployment of an information clearinghouse. Through the use of the toolkit, domain experts can quickly specify a classification scheme and set up a clearinghouse. The newly deployed clearinghouse is automatically registered with the union and start sharing resources with other clearinghouses already in the union.

References

[1] Loren T., Will H., and Brian A., "Constructing, Organizing, and Visualizing Collections of Topically Related Web Resources", in ACM Transactions on Computer-Human Interaction, Vol. 6(1), March 1999.

[2] Neri, F. and Saitta, L., "Machine Learning for Information Extraction", in Proceedings of the International Summer School on Information Extraction, SCIE '97 (Frascati, Italy, July 14-18, 1997.) Springer-Verlag Berlin Heidelberg, 1997, pp. 171 – 191.

[3] Theilmann, W. and Rothermel, K. "Domain Experts for Information Retrieval in the World Wide Web", in Proceedings of Second International Workshop on Cooperative Information Agents (Paris, France, July 4-7, 1998.) Springer-Verlag Berlin Heidelberg, 1998, pp. 216 – 227.

[4] Eric J.G., Steve L., William P. B. and C. Lee G., "Architecture of a Metasearch Engine that Supports User Information Needs", in Proceedings of CKIM 1999.

[5] http://www.usatoday.com/life/cyber/tech/review/crg842.htm

[6] http://sg.comp.nus.edu.sg

[7] http://www.w3.org/RDF

The Gathering and Filtering Agent of Education Newspaper for NIE

Chul-Hwan Lee, Sun-Gwan Han, Hee-Seop Han
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1284
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
chlee56@compedu.inue.ac.kr {fish,hansg}@compedu.inue.ac.kr

This paper presents the ENIG Agent to gather distributed information of educational newspaper in the web as well as student to provide the sound information for the NIE learning. The ENIG Agent gleans an appropriate newspaper headline of educational news portal site for real-time provision of the information. For gathering the optimized information, The ENIG agent performs the pre-process of educational news site, information noise filtering, pattern matching. The gathered educational newspaper information is removed a harmful data by using the pattern matching in the inference engine. The student can show the result of sound data through the web-browser as well as can use to learning with another application. For efficiency of this system, we evaluate the performance of the ENIG system by the experience of the NIE learning.

Keywords: **NIE, Newspaper Information gathering, Intelligent Agent, Supervised learning**

1 Introduction

These days, the web brings about a great change of education by a rapid growth of the Internet. It is not an easy work that a student finds the education information in the web. For searching the suitable information, a various search engines were developed and it provided a service for all. However, the general search engine is not fit that a student use at learning directly, because the information of search engine can contain a many data unconcerned learning. The learning requires the filtered information that can apply learning directly. Therefore, for efficient education, new type of search engine needs for the information retrieval and gathering [9].

Besides, the NIE means "Newspaper In Education", it is a method that student and teacher increases an efficiency of learning by using newspaper. The late web is used a good place for the NIE learning and a collaborative learning. However, when student and teacher study on the NIE learning through the web sites, they spend much time and repetitive efforts to find the newspaper contents. The student can lose a basic purpose of the NIE learning by the wasteful spending. The NIE learning needs an intelligent searching agent that searches automatically an important content about newspaper on the web. Moreover, because the gathered educational newspaper can contain harmful data, the data can remove by using the pattern matching in the inference engine [8].

Consequently, this paper describes about the ENIG Agent for the NIE learning. For providing the student just wants newspaper contents, we designed and implemented the intelligent agent system. In the following section, the NIE and the agent for information retrieval will be surveyed and the basic structure of the ENIG Agent will be designed. Furthermore, the next section will be discussed about implementation and experiment of ENIG Agent system. Finally the conclusion and future works will be described.

2 NIE and intelligent gathering agent

The NIE is the initials of 'Newspaper In Education'. It is the education method for individual who make friend with newspaper and improves the achievement of learning using the contents of newspaper. The newspaper, "a living text book", is applied with open education through the NIE learning.

Roles of newspaper for education are listed below [5].

- The newspaper is a bridge that can connect the disparity gap between school and society.
- The newspaper is the reflective of actual world.
- The newspaper reappears the scene of the history and is researching material of present society.
- The newspaper is the most suitable of clear text model and is used with subject matter of language learning.
- The newspaper is the unique textbook that everybody can read in ones lifetime continuously.

For the reasons stated above, we can expect a advantages that the NIE learning is originality, thinking power, ability to read and understanding and writing text, the establishment of sociality through ones sense of values, ability to practical use of information and so on[8].

When teacher will teach using NIE content on the web, we must consider below list.

- The newspaper is not be made data for the NIE. Because it is made for adult, it has a very difficult vocabulary. Therefore, teacher must supply to student a vocabulary database.
- The newspaper has an article about negative contents of society. Such contents must be edited or deleted by using an intelligent agent.
- Because the web is opened to everyone, the newspaper may have contents that student never see. In special, an article of obscene, crime, violence must be deleted.
- The contents of a newspaper are best the events of the day. But the NIE is used the contents of old newspaper. Such contents are good saving at scraping DB.

The method of information retrieval is variety. For information retrieval of educational homepage, intelligent agent used a very suitable tool [9]. The intelligent agents having the characteristics of autonomy, social ability, reactivity, pro-activeness and cooperative relationship can provide the searching results of a user demanded through machine learning [11].

An agent gathers information instead of the user. Because the agent system does not deal with basic data, instead it deals with knowledge information, can easily process the knowledge of education homepage. Moreover, an agent system is capable of using effectively gathering of information on the dynamic web environment. Therefore, the web based instruction using the NIE learning needs intelligent agent system [3].

3 ENIG System

Generally, the web document has many added tag information in contents. This added tag can represent efficiently information and data of HTML document. However, the user does not use the tag information but can use only the text or the multimedia information. The tag information treats only an unnecessary noise to users. If an unnecessary noise tag in a content is removed, the filtered document is translated a regular expression in the ENIG system. The pattern of information is extracted at transforming regular expression by the string matching method.

The extracting information of content is interpreted the accuracy of information by inference engine. Inference engine has the knowledge base augmented with a rule-based system, and it has function of learning and inference by a supervised learning.

3.1 Structure of the ENIG agent system

The structure of the ENIC Agent system is shown figure 1. This system consists of four parts. The document of homepage on web filters tags by the noise-filtering module in analyzer. The information of filtered document is translated from HTML document into regular expression. The regular document is matched with the string pattern provided by string matcher in an agent and it extracts the information of articles in educational newspaper. The information of an articles is removed harmful data by the knowledge base in an inference engine. The interface module consists of two screens. The rule and knowledge is edited and added, deleted through the knowledge manager and gathering information is supplied to student by using the result viewer. The learning environment is a learning space that studies the NIE learning through web browser and a learning application programs.

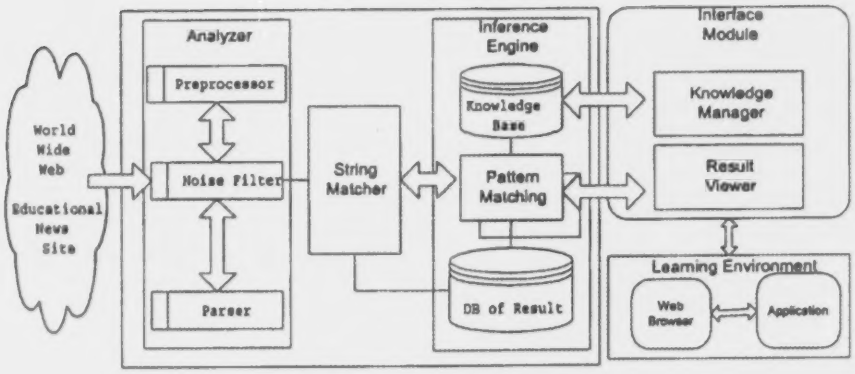


Figure 1. Structure of ENIG Agent

3.2 Noise filtering

Figure 2. Homepage of educational newspaper

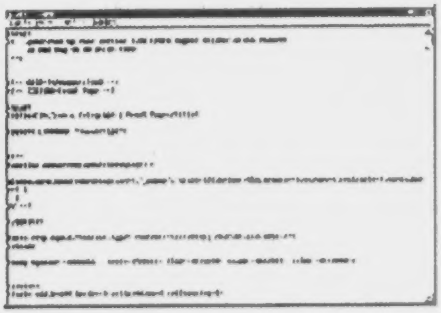


Figure 3. Source of homepage

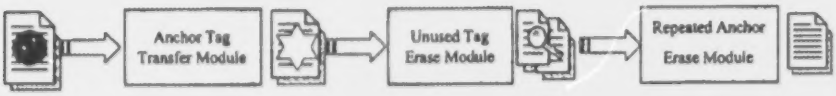


Figure 4. Steps of noise filtering

The example of educational newspaper site is shown figure 2. The tag information is not shown to user on the web-browser. While, the source of newspaper homepage is shown figure 3. The source is represented with a text and a complex tag information. Such tag information represents the arrangement of a document data and a multimedia information, a hyperlinked information.

The noise filtering is used to remove duplication data or an unnecessary data. For processing data called by HTTP, the noise filter processes work that removes a useless portion of the input data. The tags of HTML document have an irrelevant information to user, because tags only represent the formation of homepage and information of hypertext.

The noise filtering of the ENIG agent system removes an unnecessary tags in the document of an educational newspaper homepage except <A>...</A>tag, anchor tag of hyperlink and text data. The HTML sources are a difficult document to process noise filtering unconditionally, because the tag of document includes important information for the contents of document. Therefore, the noise filtering work must require a preprocessing module. Three steps of the noise filtering work is shown figure 4.

BEST COPY AVAILABLE

The preprocessing work for the noise filtering converts from basic <A>…</A> tag into suitable information and the works is listed below.

- Convert relative path for absolute path
- Change the URL of ASP form for the URL of HTML form
- Convert the path of CGI for general HTML form
- Change the path of script for absolute path
- Convert the hyperlink of image for absolute path

At the next step, the preprocessed documents are removed unnecessary tags by the noise filtering method except following items. <TABLE>,<TR>,<TD>,<LI>,<P>,
 tags are necessary the tags to keep the information of documents. The HTML document is composed one line of text or a record of table by such tags. Because most results of searching are represented with form of list or table, such tags is very an important information and may be not removed.

The final step of noise filtering is a work that gets rid of the duplicate from the URL of a document. The filtered document of educational newspaper homepage is show figure 5. We can know that the filtered document is ease for content analysis upon deletion of an unnecessary HTML tags. The advantage of noise filtering is that, it can process the same analysis about another newspaper homepages through removing tag.

```
Newspaper=Electronic Telegraph
URL=http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=3mmquqwM&atmo=3mmquqwM&pg=/
title=updatednews
date=2000.8.14
<table>
<tr>
<td>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
nhon14.html"
Honda to double British factory output
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
njake14.html"
Boy, 5, vanishes on trip to beach
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wiraq14.html"
West's raids spark Iraq fury
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
npaed14.html"
Labour welcomes Hague's paedophile plans
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wthai14.html"
Murder hostel was notorious for drugs
</a>
```

Figure 5 Result of a noise filtering

3.3 Pattern matching

The filtered document is translated from each information and data into regular expression. The pattern of regular documents is extracted with sequence of regular expression by the method of string matching. The hyperlink information of image may infer by using the pattern matching through regular expression, because the hyperlinked image do not contain the text information on hyperlink. The pattern matching is executed to extract text data and information of hyperlink in HTML documents. Specially, if image has been including hyperlink, the pattern matching is a very important work. The article information of the educational newspaper site has information of hyperlink as followed.

*< a href= ……> …… text …… *

Generally, the hyperlinked text information exists between <a> tag and tag. If an image exists between the anchor tags as " <img src=…> ", then text information can exist at front or back of the anchor tags. In this case, each tag and the text information is changed the defined tokens previously. In addition, each data is created a string of a regular expression by the pattern matching.

The portion of tokens for creation of regular expression is shown table 1.

Table 1 Token for regular expression

<table>	</table>			<tr>	</tr>	<td>	</td>	<a>		href	text
T	T	P	p	R	r	D	d	A	a	H	M

If the filtered document is represented with regular expression by tokens of table 1, the content of figure 5 is converted a tag page into the sequence of the alphabet as "TRDAHMaAHMaAHMaAHMa...". And the string pattern of regular expression has the process of pattern matching. This study used the three types of pattern for pattern matching as followed.

- *"AHMa" : "< a href= .....> ..... text ..... "*
- *"MAHa" : "... text ... <img src=...> "*
- *"AHaM" :" <img src=...> ... text ..."*

The extracted string by pattern matching restores to the original tag and text information in HTML document. The extraction strings are reverted with source records. Figure 6 shows result that article is extracted through pattern matching of regular expression.

The translation of regular expression and the pattern matching have a many advantages. The advantage of pattern matching method is that the complex matching of string can extract only one time by matching of substring, and that agent can easily learn the rule of pattern.

Therefore ENIG system eases the addition of new educational newspaper site and pattern by the addition of URL and the type of pattern.

```
Electronic Telegraph|updatednews|2000 8 14|Honda to double British factory output|http ://www telegraph co uk 80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/nhon14 html
Electronic Telegraph|updatednews|2000 8 14|Boy, 5, vanishes on trip to beach|http ://http ://www telegraph co uk 80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/njake14 html
Electronic Telegraph|updatednews|2000 8 14|West's raids spark Iraq fury|http://www telegraph co uk 80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wiraq14 html
Electronic Telegraph|updatednews|2000 8 14|Labour welcomes Hague's paedophile plans|http ://www telegraph co uk 80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/npaed14 html
Electronic Telegraph|updatednews|2000 8 14|Murder hostel was notorious for drugs|http ://www telegraph co uk 80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wthai14 html
```

Figure 6 Example of string exchanging for regular expression

3.4 Inference and learning method

The extracted newspaper information is not provided all good information to student. In case of an inserted advertisement site, such site can become an obstacle of learning by the useless content. Moreover, a negative content or a harmful page too must be not suitable site to student. Such sites can be provided about a lustful content and a crime, an slang, a violence and so on. The harmful data can be removed in advance learning by inference engine and knowledge base. Reasoning rule uses the rule-based production system. The representation of knowledge is shown below

IF A THEN B

The production system has a merit that it is simple and easy the representation of rule as well as the addition of knowledge. The learning method of the ENIG Agent system uses the supervised learning learned by human teacher. If new rule is occurred, teacher input new rule and knowledge in knowledge base. For example, if the extracted information contains harmful text as a sex and a narcotic, a knife, then teacher input new rule and knowledge as *"IF sex AND narcotic AND knife THEN delete"*.

The harmful site at gathering site reason a rule by the analysis of content and the rule are stored in knowledge base by teacher. The bad information of extracted document is removed by the vocabulary DB and the rule of knowledge base. For forbidding the access of the student, the addition and deletion of rule and fact in the knowledge base can be control only by a teacher.

4 Implementation and Experiment

The implemented ENIG Agent can extract only the important information of newspaper site. In addition, it can be had with only a text and URL information at various homepage. For implementation of the ENIG Agent, we used Visual C++ and the CLIPS DLL. The CLIPS is rule-based a production system shell and it is used as an inference engine.

The execution screen of the ENIG agent system is shown figure 7. The ENIG system is composed of three parts. The left side of the screen is a part that the directory manager manages and edits educational newspaper sites, and the mid-screen is a part to view the result of the gathering information, and the button of right above is part to add a rule for inference and machine learning. If 'gathering' button is clicked, the ENIG agent gathers and extracts an article from an educational newspaper site. If 'learning' button is clicked, a rule and knowledge is added and edited by teacher in the ENIG agent.

This ENIG agent system can be applied directly at the homepage of different domain without change of system. If site is constructed standard HTML document, an agent can search and gather even the document of a foreign site.

The applying example of NIE learning using the ENIG system is shown figure 9. This example is used the ENIG system and the Web Browser and word processor. The screen is the NIE learning about music using the ENIG agent system and the Window application. The information of newspaper on the web can be applied directly at a web-based instruction (WBI).

One of the advantages of this system is that the extracted information uses a mobile environment directly. Because the extracted information is very small data and hyperlinked information, such data can be inserted the mobile communication as a cellular phone, a PDA, a notebook computer, a portal computer, and so on. Furthermore, the information of this system can transmit the WML by WAP.

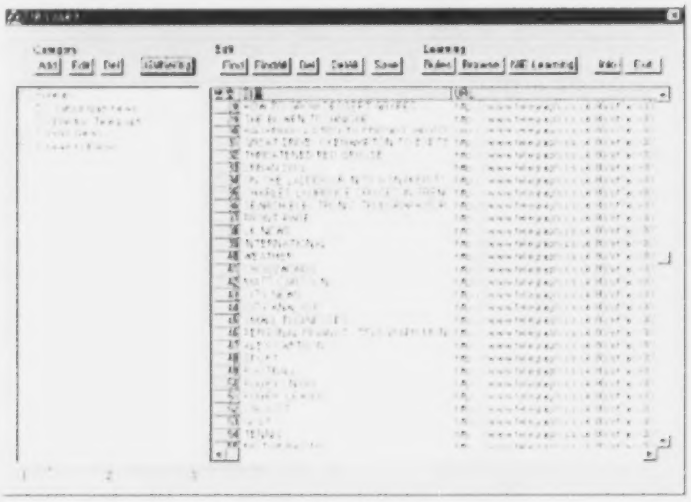


Figure 7 ENIG Agent system

BEST COPY AVAILABLE

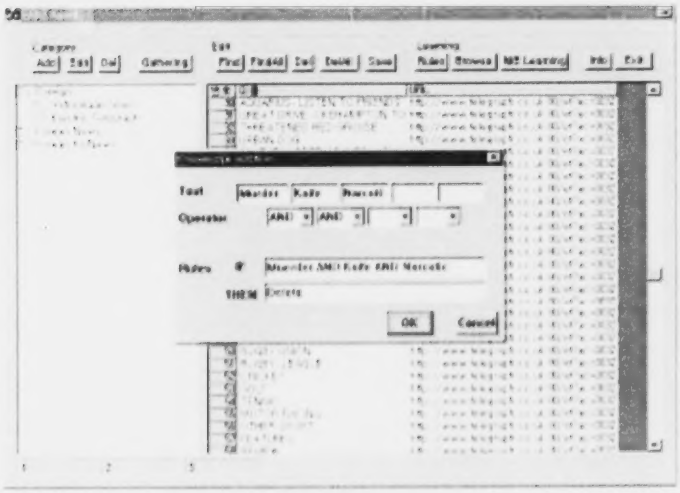


Figure 8 Addition of knowledge

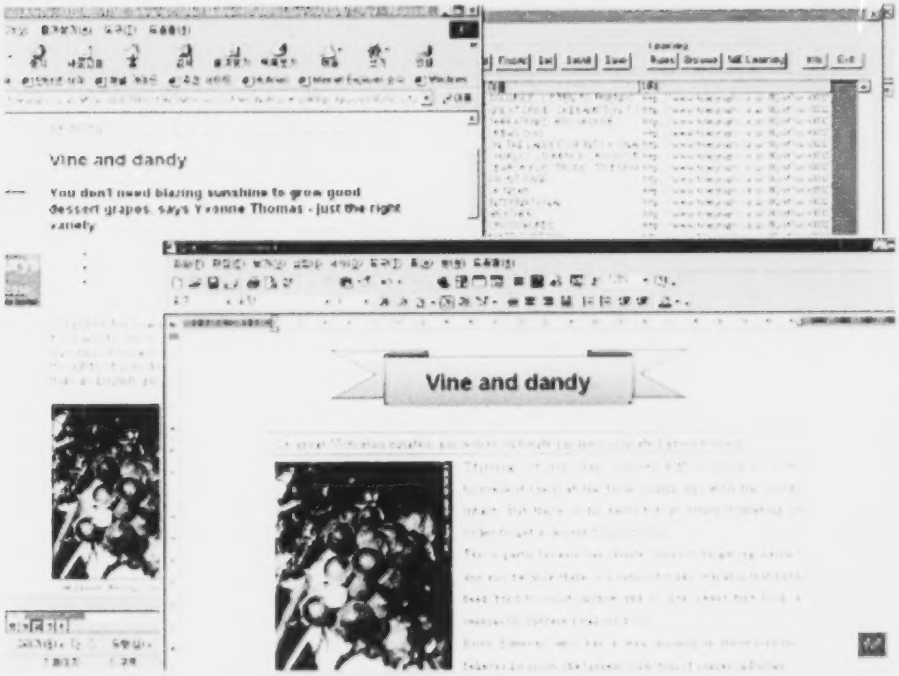


Figure 9 Example of NIE learning using ENIG agent

5 Conclusion and Future works

As mentioned above, we described about the ENIG agent system for the gathering information of educational newspaper homepage. In addition, we designed the method of noise filtering and pattern matching for suitable information. The method of noise filtering was used to remove unnecessary tags at source of HTML document and the method of pattern matching was used to extract necessary URL and text

BEST COPY AVAILABLE

information. The learning of agent was used to provide with good information to student by supervised learning. Most a web-based instruction was mainly learning about information retrieval. As student spent a lot of time to find learning information and data, so these lead deficiency of time for the essential learning.

Consequently, the ENIG agent system can provide not only to student for the learning of information retrieval but also can help them capturing the genuine NIE learning. And this system can execute the role of information treasury for the whole education through scraps of information.

The future works are that we improve the faculty of agent for information gathering of all sites; moreover, we need research about unsupervised learning of agent and not supervised learning. In addition, we need research to remove gathering information of header and footer through addition of heuristics and pattern type that requires the study about the method of keyword searching it. Finally, for providing a location of information to the agent, we will research the extension method of URL.

References

[1] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol. 72, pp.329-365, 1995.

[2] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[3] Erik Selberg, Oren Etzioni, "Multi-Service Search and Comparison using the Metacrawler", Proceedings of the 4th World Wide Web Cinference, Boston, MA, USA, pp 195-208, 1995

[4] Filippo Menczer, Alvaro E. Monge, "Scalable Web Search by Adaptive Online Agents: An InfoSpiders Case Study", Intelligent Information agents, Springer, USA, pp 323-347, 1998.

[5] Frances Anderson, "Classroom Newspaper Activities: A Resource for Teachers, Grades 1-8", Charles C Thomas Pub, 1985

[6] Henry Lieberman, "Personal Assistants for the Web: An MIT Perspective", Springer, USA, pp 279-292, 1998.

[7] Josheph Giarratano, Gary Riley, "Expert System, Principles and Programming", PWS Publishing Company, 1994.

[8] Paul Sanderson, "Using Newspapers in the Classroom: Cambridge Handbooks for Language Teachers", Cambridge Univ. Press, 1999.

[9] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[10] Sandip Sen and Gerhard Weiss, "Learning in Multiagent systems", The MIT Press, USA pp 259-298, 1999.

[11] Wooldridge, M., Jennings, N. R., "Intelligent Agents", Springer-Verlag, 1995.

LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES

Jim Jiunde Lee
Department of Mass Communication, Chinese Culture University, Taiwan
jiulee@giga.net.com

The flexible nature of hypermedia allows it to be tailored to an individual's needs. Despite the many degrees of navigational freedom, however, users of hypermedia often find difficulty locating information, feel disoriented, or even become "lost in hyperspace" within such large seas of data. Research findings suggest that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. How a learner can acquire correct structural knowledge of the information becomes an important issue to affect their learning performance in a hypermedia environment. Variables such as the different ways of structuring or conveying information and cognitive styles may affect learners' cognitive abilities in knowledge structuring and should be taken into account together. The results of this study will show whether the interactions between information conveying approaches and learners' cognitive styles have significant effects on learners' performances in terms of structural knowledge and feeling of disorientation.

Keywords: **Structural knowledge, Cognitive style, Concept map, Disorientation, Hypermedia**

1 Introduction

One of the recent developments in computer technology now applied in many educational institutions is the technology of hypermedia (Liu & Reed, 1994; Paolucci, 1998), in which users can access specific information by various paths. The flexible nature of hypermedia allows it to be tailored to an individual's needs. Reading in hypermedia allows more random access and offers overt ways of accessing (Tierney, 1994). However, users of hypermedia often experience difficulty locating information, feel disoriented, or even become "lost in hyperspace" (Elm & Woods, 1985) within such large seas of data. Scholars (Beasley & Waugh, 1995) have suggested that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. In other words, if users can substantially construct a structural knowledge (Jonassen, Beissner, & Yacci, 1993) of the information provided in the hypermedia system, their learning performance could be improved.

Ways to structure or convey information in the physical sense should not be the only concern when the instructortry to facilitate the formation of the learner's structural knowledge. Factors such as learners' characteristics that could affect their cognitive abilities in knowledge structuring should also be taken into account. Few studies have been conducted in this domain. The purpose of this study is to investigate

learners' cognitive characteristics in the dimension of cognitive styles and their effects on the acquisition of structural knowledge through the application of different information conveying approaches: the Less Explicit approach and the More Explicit approach.

2 Background of The Study

Learning is a process of reorganization of knowledge structure. Based on the concept of meaningful learning (Ausubel, 1963), in one way, learners structure knowledge to serve as a framework that helps them to associate new information with previous knowledge. As this framework becomes more complex, learners may in turn rely on this conceptual structure to filter the important from the irrelevant points (Anderson, Reynold, Schallert, & Goetz, 1977). The acquisition of correct structural knowledge has become a critical issue in learning. Among other computer technologies, hypermedia is a potential tool to mediate the structural knowledge of the target domain to learners. One of the current theories about mind structure, the "mind as rhizome" (MAR) metaphor (Eco, U., 1984), hypothesizes that the human mind is organized like an underground rhizome. Hypermedia tangibly simulates the learning assumptions of this mind metaphor in that learners can filter, link and search for new or existing information. These features have made hypermedia an ideal environment where experts' knowledge structures are made visible and navigable for learners in a graphical or a textual form (Wilson & Jonassen, 1989). Compared with novice users of a subject domain, expert users in this domain are believed to possess a better knowledge structure that enables them to effectively solve problems. The learning strategy of externalizing experts' knowledge structures to provide "idiosyncratic" intellectual thinking (Schwen, Goodrum, & Dorsey, 1993) has been deemed a pragmatic way to empower learners.

In comparing hypermedia with linear text in book-bound printed material, Conklin (1987) noted that any piece of text that the user wishes to locate in a book can only be further forward or further back from where the user is currently located. Hypermedia, on the other hand, is often designed to store or to locate information in a non-linear manner. Instead of a long run of narrative text on sequentially numbered pages, hypermedia is typically organized into small segments of text and learners control the reading flow of the materials (Berk & Devlin, 1991). Regardless of claims about the benefits of using hypermedia, however, Charney (1987) and Dias & Sousa (1997) pointed out that the ordering of topics and points as well as various traditional orientating devices, such as overviews and summaries which are usually taken for granted in books and papers, are non-existent in hypermedia. Without such orientating devices or narrative cues, and lacking the knowledge of hypermedia structure, users can barely determine where they are, what they want, and how to get there (Beasley, 1994; Tripp & Roby, 1990). These issues raise a number of questions. Is knowledge of the material's structure as important as scholars suggest? Can one attempt to represent the structure of a document cognitively, and if so, what form might it take?

3 Theoretical Framework

Learning in Hypermedia

Hypermedia is a developing concept that perhaps first originated with Bush (1945), who envisioned a text that was organized like the human mind. Unlike a traditional learning environment, hypermedia mainly relies on self-directed learning. With this system, the responsibility for identifying what is useful information and the selection of search strategies for locating that information are largely left to the user (Small & Grabowski, 1992). Instead of having an instructional-base, like conventional Computer-Based Instruction (CAI), the format of hypermedia is information-based. CAI materials normally include objectives, presentation of information, and drill-and-test activities (Gange, 1976). These materials lead users to engage in intentional learning, in which all learning activities are arranged to accomplish the pre-determined learning goal.

Conversely, the learning that occurs in hypermedia is a type of incidental learning: the instructional content is provided without a specific learning goal (Spiro & Jehng, 1990). Learners in a hypermedia environment are encouraged to interact with and explore the information by developing their own paths or knowledge structures.

Although hypermedia has had remarkable impacts (Jonassen & Grabinger, 1990; Mcaleese, 1991) on human

learning modes, accessing immense amounts of information within a hypermedia system is often not an easy task, especially for novices. As Hammond and Allinson (1989) indicated, people may encounter a number of common problems when they use hypermedia. They may have difficulty using interface tools in order to gain an overview and to locate specific information; they are also likely to wander without a strategy or goal and finally get lost. It is necessary that we investigate what types of cognitive characteristics might affect learners' performances involved in hypermedia learning and how hypermedia can thus be customized to fulfill learners' cognitive needs.

Hypermedia and Cognitive Styles

Hypermedia appears to be an ill-structured and non-linear type of conceptual networking environment. It seems to avoid prescribing a particular path for navigating information. Such a structure could be questionable for a learner who is in need of guiding pathways. A learner's performance in hypermedia may be affected by his / her individual cognitive style. Many variables, such as age, motivation, cognitive style, and prior knowledge / experience with the system (Heller, 1990; Lai, 1994; McAleese, 1989; Paolucci, 1998; Rhee, 1993) have been proven to be influential factors in the user's performance. Some of these studies were conducted in a conventional computer-based instruction environment. In those that were conducted in a hypermedia environment, cognitive style was found to be an essential factor in learning (Chang, 1995). Research findings support this notion that individual cognitive differences affect learning results among adults (Davidson, Savenye, & Orr, 1992; James & Blank, 1991). Understanding these differences can help instructors cope with the variations in performance exhibited by their students (Moore, 1994).

Cognitive style refers to a learner's information processing habits, this being manifestly reflected in his / her perceptual ability and in personality as well (Greco & McClung, 1979; Witkin, et al., 1977). It is "a superordinate construct involved in many cognitive operations that accounts for individual differences in a variety of cognitive, perceptual, and personality variables" (Vernon, 1973, p.141). There are no good or bad cognitive styles. They could only to be described as effective or ineffective in terms of their influence on a specific task (Strother, 1982). Studies on cognitive styles initially stemmed from the field of individual differences. These issues were extensively studied during the 1960s and remained popular in the early 1970s, but have since tended to fade out. As Riding and Cheema (1991) stated, this decline left the whole field of exploration fragmented and incomplete. In spite of their attracting little interest in the last two decades, cognitive styles are now once again being considered more seriously by scholars due to the coming of hypermedia technology.

In this research proposal, cognitive style will be examined in the two dimension of Wholist / Analytic and Verbal / Imagery. After reviewing work on the cognitive style study, Riding and Banner (1986) found that there was an interaction effect between Field-dependence / independence style and verbal / imagery style on the learner's performance. Riding and David (1991) concluded that the Group Embedded Figures Test (GEFT)(Witkin, 1962) that has frequently been used to identify Field-dependence / independence style has limitations. In order to overcome some weaknesses of the traditional method for assessing Field dependence / independence like GEFT (e.g. Witkin, 1962), the Cognitive Styles Analysis (Riding, 1991) was developed. This approach classifies learners' cognitive behaviors into four different categories: Wholist-Verbaliser, Wholist-Imager, Analytic-Verbaliser, and Analytic-Imager. In this classification, Riding felt that for educational and training purposes it is more meaningful to term Field-dependent as Wholist and Field-independent as Analytic. The Wholist trainee tends to view the information in whole and the Analytic trainee tends to separate out the individual parts of information. Riding method differs from GEFT in four significant ways. First, it positively measures the wholist tendency and does not simply assume that if a person does poorly on a disembedding task that they are Field-dependents. This overcomes a major objection to the notion of Field-independence being a learning style raised by those who have argued that since generally Field-independents are superior to Field-dependents, it is simply a correlate of intelligence or general ability. Secondly, it compares a person's relative performance on the to halves of the continuum. Thirdly, by using computer presentation, it allows more sensitive timing of the task. And finally, Riding's Cognitive Styles Analysis refines the GEFT method and incorporates the assessment of the second fundamental dimension: Verbal-Imagery cognitive style. The Wholist-Analytic (Field-dependence-independence) / Verbal-Imagery classification is considered to be particularly valuable when it is used to examine different learners' behaviors in a non-linear environment such as hypermedia (Roberston, 1982; Riding, 1997). These two dimensions of cognitive styles that reflect on learning involve the various cognitive restructuring skills and analyzing ability for incoming information that are especially demanded in an ill-structured environment such as hypermedia. It is likely that the best performance on learning task comes from combinations of these two style dimension that offer the greatest strengths, namely Wholist-

Verbalist learners and Analytic-Imager learners, whereas Wholist-Imager learners and Analytic-Verbalist learners are less complementary and might result inferior performances.

Hypermedia and Structure Knowledge

According to Conklin (1987), disorientation is one of major problems for hypermedia systems. Elm and Woods view this "disorientation" in terms of degradation rather than as a subjective feeling of being "lost". One of the assumptions in their 1985 study about users' performance is that users might attempt to create a comprehensive cognitive map of the knowledge domain. The problematic issue of getting lost in a display network is caused by the user lacking a clear conception of the relationships within the system, or as Jonassen, Beissner, & Yacci (1993) call it, *Structural knowledge*. Structural knowledge is a memory / cognitive structure, a collection of bits of information and relationships among concepts. It could also be termed the internal structure (Korthauer, R. D & Koubek, R. J., 1994), which refers to the knowledge structure of users who are experienced in the domain, and to a type of mental model that users must create and bring to bear as they work in an electronic information space (diSessa, 1986; Gentner & Stevens, 1983; Russell, 1986). The acquisition of structural knowledge, according to Ausubel (1963), involves the linking of new information to existing information, which results in a dynamic framework of knowledge. That is, through the information processing procedure, learners experience new information and refine or reconstruct their knowledge frameworks as needed.

In hypermedia, there are two approaches to help learners construct their structural knowledge (Korthauer, R. D. & Koubek, R. J., 1994). The first is the use of *hyperlink approach*. Hyperlink approach is designed according to the intrinsic attributes of the information; the designer finds the best way to organize it so that the information structure is salient to the user (Gordon & Gill, 1993). This approach could commonly be seen as the underlying organization embedded in the hypermedia database, such as the hierarchical, associative, and networking structures. The second is the use of *navigational aid approach*, which is usually based on the hyperlink approach but graphically represents hyperlinks (such as the concept map) to make the information hierarchy more explicit for learners (Nelson, 1990). It is thought that instead of relying on hyperlink approach, as experienced users do, novice users may rely more upon the navigational aid approach, as they have no knowledge structure of their own (Korthauer, R. D. & Koubek, R. J., 1994). In addition to the external factor, like the hyperlink and navigational aid approaches, learners' cognitive styles are the internal factor suspected to particularly affect novice users, by affecting the degree to which they can draw out the embedded structure of the hypermedia document.

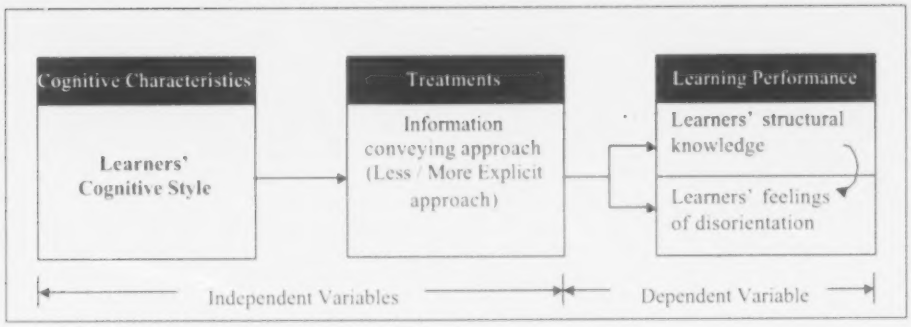
As Mandler (1983) indicated, "Meaning does not exist until some structure, or organization, is achieved" (p4). For designers and instructors, it would seem wise, then, to balance structural knowledge acquisition and the knowledge that users expect to learn in their consideration of learning results. Mental constructs could not be formed without structure. Learners might be able to remember each single object without structural knowledge, but they could not relate these isolated ideas to each other to form abstract knowledge, or even translate them into procedure knowledge (Jonassen, Beissner, & Yacci, 1993). It is important that the learner first develop an accurate structural knowledge of the knowledge domain being studied. Once the learner has a grasp of the bigger picture, he / she will be released from the burden of trying to organize the structure of the information while he / she is also required to study the content at the same time.

4 Methodology

Independent Variables

There are two independent variables in this study. First are the two types of information conveying approaches which mediate the hypermedia-based instruction. The second independent variable is the learner's cognitive style which is identified by a standard test. Figure 1 outlines a conceptual model for the variables of this study.

Figure 1. The conceptual model of variables for this study



Information Conveying Approach

In this study, there are two types of information conveying approaches:

1. The Less Explicit (LE) approach: the instructional material with the hierarchical-associative hyperlink

The More Explicit (ME) approach: the instructional material with an interactive concept map

Cognitive Style

The second independent variable is the learner' s cognitive style in the combination of the dimension of Wholist-Analytic and the dimension of Verbal-imagery.

1. Wholist-Verbaliser
2. Wholist-Imager
3. Analytic-Verbaliser
4. Analytic-Imager

A subject's particular style is determined by the subject's score on the Riding' s Cogntive Style Analysis (Riding, 1991).

Dependent variables

There are two types of dependent variables in this study: learners' structural knowledge and learners' feelings of disorientation.

Structural knowledge

Structural knowledge is defined here as the compilation stage of a knowledge development theory (Anderson, 1982, 1987, & 1990). It is a transition knowledge that helps learners to associate their declarative knowledge with their procedural knowledge (Jonassen, Beissner, Yacci, 1993). It represents the interrelationships between concepts that the learner forms in his or her memory.

Feeling of Disorientation

The second dependent variable in this study is a learner's feeling of disorientation which results from his / her use of different types of information conveying approaches.

Subjects

The researcher plans to collect a total of one hundred twenty subjects participating in this study. All of the subjects will be current students enrolled in Indiana University at Bloomington (IUB). Subjects' ages range from 19 to 45, and they have various majors in the School of Education in IUB. Before this experiment, a Human Subject Form shell be completed by each subject and has been approved by the University Committee for the Protection of Human Subjects.

A two-stage filtering procedure will be administered to identify the most appropriate subjects for this study.

In the first stage of the filtering procedure, subjects will be recruited by means of an Email flyer. Experienced subjects will be excluded according to their replies on the computer background questions sent together with the E-mail flyer. The remaining respondents will receive a confirmation message from the researcher to thank them for their participation and to set up a possible time with them to come for this study. The subject filtering procedure moves to the second stage.

In the second stage of the subject filtering procedure, Riding's Cognitive Styles Analysis (Riding, 1991) will be administered to all remaining students to determine their cognitive styles: Wholist- Imager, Analytic-Imager, Wholist-Verbaliser, or Analytic-Verbaliser. This computer-based test will give measure of a subject's position on both the Wholist / Analytic and Verbal / Imagery cognitive style dimensions.

Instructional Materials

Content

The topic of this web-based instruction – "Building a Homepage" was about building a personal homepage in the IUB domain. The categories of "Building a Homepage" were adopted from the "IU Webmaster" web site (http://www.indiana.edu/~wmhome/), which is maintained by the University Information Technology Service (UITS). This web site provides information for those who wish to build or maintain a web page by themselves.

Interface layout

Two different versions of hypermedia-based instructions were developed in this study: the instruction lesson using the Less Explicit approach (hierarchical-associative hyperlink) and the lesson using the More Explicit approach (concept map). Both versions contain the same instructional content but convey it through different interface layouts. The interfaces were functionally equivalent in terms of the amount of content available in each node, and both allowed access to top-level pages at all times. Therefore, one design was not viewed by the researcher as less functional than another. These two types of hypermedia-based instructions could be accessed through using Web browsers like Netscape Navigator or Internet Explorer. Additionally, in order to control the learning environment and also to remove unpredictable factors that might affect learning, the browser's (Internet Explorer) toolbar and address bar were removed and did not appear in either approach. This was viewed as necessary in order to attempt to isolate any learning effects that may have resulted from use of the "Back" function (Boling et al., 1996).

Experiment Procedure

Upon the completion of the two-stage filtering procedure, the selected subjects will be informed of the time and the place for this experiment by E-mail. Before the study, subjects are randomly assigned into two groups – the group using the Less Explicit approach and the group using More Explicit approach. Only one group is measured at each time. In this experiment, subjects will be required to study a hypermedia-based instruction lesson. The content of this lesson is designed to help subjects acquire the knowledge to build homepages in the IUB domain. In the beginning of this experiment, subjects will be given five minutes to practice and master the tutorial web page that had been loaded on their screens. After this five minute tutorial session, subjects are required to spend at least fifty minutes (or even longer time, depending on their wishes) to read through the "Building a Homepage" web site.

When subjects complete the self-directed study, they will be required to complete a three-part post-test and a disorientation questionnaire in order to measure their structural knowledge and perceived disorientation. Subjects have a total of twenty-five minutes to finish the post-test and the questionnaire and return them together with the signed consent form to the researcher.

5 Conclusions

This study attempts to make a contribution to our understanding of how learners' cognitive attributes affect their learning performances while using hypermedia. The study results should provide some useful design concepts for hypermedia development, especially when a hypermedia material is designed for novice learners.

Learning functions play a central role in theories regarding the regulation of learning processes (Vermunt, 1989). However, the question of how students carry out these functions in a hypermedia context, or the way in which this execution is regulated by internal and external factors has largely gone unproved (Burton, Moore, & Holmes, 1995). It is worthwhile to explore whether the hyperlink or the concept map is better for different cognitive-styled learners in the acquisition of structural knowledge. As structural knowledge has been proven to be a crucial predictor of problem solving skills (Chi & Glaser, 1985; Gordon & Gill, 1989; Robertson, 1990), the information regarding whether supplied models are useful and for what kinds of users is also important for hypermedia developers.

In addition, it is hypothesized that users could overcome the disorientation problem if they could acquire a more correct structural knowledge of the knowledge domain. The findings of this study may result in insight and shed light on the importance of acquiring structural knowledge as a learning goal. Hypermedia developers may accordingly develop guidelines for designing interfaces that help users to access information and which will accommodate their needs while preserving the quality of independent learning. This should improve the effectiveness of their designs.

References

Anderson, R. C., Reynolds, R. E., Schallert, D. L. and Goetz, E. T. Frameworks for comprehending discourse. American Educational research Journal, 14(4), pp. 367-381, (1977).

Anderson, J. R. Acquisition of cognitive skill. Psychological Review, 89, pp. 369-406, (1982).

Anderson, J. R., Skill acquisition: Compilation of weak-method problem solutions. Psychological Review, 94, pp. 192-210, (1987).

Anderson, J. R., The adaptive character of thought. Hillsdale, NJ: Erlbaum, (1990).

Altun, A., Patterns in cognitive processes and strategies in hypertext reading: a case study of two experienced computer users. Journal of Educational Multimedia and Hypermedia, 8(4), pp. 423-443, (1999).

Ausubel, D. P., The psychology of meaningful verbal learning: An introduction to school learning. New York: Grune & Stratton, Inc., (1963).

Berk, E. and Devlin, J., A hypertext timeline. In E. Berk and J. Devlin (Eds.), Hypertext / Hypermedia Handbook, NY: McGraw-Hill, Inc. pp. 13-16, (1991).

Beasley, R. E., The effects of three browsing devices on learner structural knowledge, achievement, and perceived disorientation in a hierarchically organized hypermedia environment. Doctoral dissertation, University of Illinois at Urbana-Champaign, (1994).

Boling E., Kira K., Avers D., Hsu Y. C., Lee J., and Frick T., Naviagting backward: concrete vs. abstract representation in hypertext buttons. Canadian Journal of Educational Communication, 25(2), pp. 161-176, (1996).

Bruner, J. S., Toward a theory of instruction. Cambridge, MA: Belknap, (1966).

Bush, V., As we may think. The Atlantic Monthly, 176(1), pp. 101-108, (1945).

Burton, J. K., Moore, D. M., and Holmes, G. A., Hypermedia concepts and research: an overview. Computers in Human Behavior, 11(3-4), pp. 345-369, (1995).

Chang, C. T., A study of hypertext document structure and individual differences: effects on learning performance. Doctoral dissertation, University of Illinois at Urbana-Champaing, (1995).

Charney, D., Comprehending non-linear text: the role of discourse cues and reading strategies. Proceedings of Hypermedia' 87, Chapel Hill, North Carolina, November 13-15. pp. 109-120, (1987).

Chi, M. T. and Glaser, R., Problem solving ability, In R. S. Sternberg (Ed.), Human abilities: an information processing approach. NY; W. H. Freeman, (1985).

Conklin, J., Hypertext: An introduction and survey. IEEE Computer, 20(9), pp. 17-41, (1987).

Duffy, T. M., and Cunningham, D. J., Constructivism: Implications for the design and delivery of instruction. In Jonasson D. (Ed.) Handbook of Research in Educational Communication and Technology, pp. 170-198, (1997).

Elm, W. and Woods, D., Getting lost: a case study in interface design. In Proceedings of the Human Factors Society 29th Annual Meeting, pp. 927-931, (1985).

Eco, U., Semiotics and the philosophy of language. Bloomington, IN: Indiana University Press, (1984).

Gagne, R. M., Instruction & conditions of learning. In L. Siegel (Ed.), Instruction: Some contemporary viewpoints , pp. 291-313. San Francisco: Chandler Publishing Company, (1967).

Greco, A. A. and McClung, C., Interaction between attention directing and cognitive style. Educational Communication & Technology, 27(2), pp. 97-102, (1979).

Hammond, N. V. and Allinson, L., Extending hypertext for learning: an investigation of access and guidance toos. In A. Sutcliffe and L. Macaulay (Ed.), People and Computer V, Cambridge University Press, Cambridge, (1989).

Jonassen, D. H. and Grabinger, R. S., Problems and issues in designing hypertext/hypermedia for learning. In D. H. Jonassen and H. Mandl (Ed.), Designing Hypermedia for Learning. Springer Verlag. Berlin, NY. pp. 3-25, (1990).

H., Beissner, K., and Yacci, M., Structure Knowledge: Techniques for Representing, Conveying, and Acquiring Structural Knowledge. Lawrence Erlbaum Associateds, Publishers. Hillsdale, New Jersey, (1993).

Keefe, J. W., Learning Style: Theory and Practice. Reston, VA: national Association of Secondary School Principals, (1987).

Korthauer, R. D and Koubek, R. D., An empirical evaluation of knowledge, cognitive style, and structure upon the performance of a hypertext task. International Journal of Human-Computer Interaction, 6(4), pp. 373-390, (1994).

Landow, G., Hypertext: the convergence of contemporary critial theory and technology. Baltimore, MD: Johns Hopkins University Press, (1992).

Liu, M. and Reed, M. W., The relationship between the learning strategies and learning styles in a hypermedia environment. Computers in Human Behavior, 10, pp. 419-434, (1994).

McAleese, R., Navigation and browsing in hypertext. In R. McAleese (Ed.), Hypertext: theory into practice. Oxford, England, pp. 5-38, (1993).

Nielsen, J., The art of navigating through hypertext. Communications of the ACM, 33, pp. 297-310, (1990).

Paolucci, R., The effects of cognitive style and knowledge structure on performance using a hypermedia learning system. Journal of Educational Multimedia and Hypermedia, 7(2/3), pp. 123-150, (1998).

Riding, R. J. and Banner, G.E., Sex and personality differences in second language performance in secondary school pupils, British Journal of Educational Psychology, 56, pp. pp. 366-370, (1986).

Riding, R. J. and Cheema, I., Cognitive styles – an overview and integration. Educational Psychology, 72, pp. 59-64, (1991).

Riding, R. J., On the nature of cognitive style. Educational Psychology, 17(1/2), pp. 29-49, (1997).

Robertson, W. C., Detection of cognitive structure with protocol data: Predicting performance on physics transfer problems. Cognitive Science, 14, pp. 253-280, (1990).

Schwen, T. M., Goodrum, D. A., and Dorsey, L. T., On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), pp. 5-9, (1993).

Spiro, R. J. and Jehng, J. C., Cognitive flexibility and hypermedia: Theory and technology for the nonlinear and multidimensional traversal of complex content domains. In D. Nix and R. J. Spiro (Ed.), Cognition, Education, and Multimedia: Exploring Ideas in High Education. Hillsdale, NJ: Lawrence Erlbaum Associates, (1990).

Tripp, S. D. and Roby, W., Orientation and disorientation in a hypertext lexicon. Journal of Computer-based Instruction, 17(4), pp. 120-124, (1990).

Wilson, B. G. and Jonassen, D. H., Hypertext and instructional design: some preliminary guidelines. Performance Improvement Quarterly, 2(3), pp. 34-49, (1989).

Witkin, H. A., Psychological Differentiation, Studies of Development. New York, Wiley, (1962).

Witkin, H. A., Moore, C. A., Goodenough, D. R., and Cox, P. W., Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, 47(1), pp. 1-64, (1977).

Learning Protocols for Knowledge Discovery: A Collaborative Data Mining Approach to Creative Science Education

Feng-Hsu Wang
Department of Information Management
5, The-Ming Road, Gwei Shan District, Taoyuan County 333, Taiwan
Tel: +886-3-3507001 ext. 3446
Fax: +886-3-3294449
E-mail:fhwang@mcu.edu.tw

One of the creative capabilities of scientists is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data mining approach to designing learning tools in educational environments for creative science education. Specifically, students can experience knowledge discovery by engaging in collaborative data mining activities that enable students to cooperate both with the computer and the other students. Data mining process is typically made up of a set of activities such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. The learning process is modeled as a set of learning protocols that properly distribute the data-mining work among students and computers. Based on these protocols, we design and implement a set of learning tools in a web-based learning environment for global climate exploration.

Keywords: **Learning protocol, knowledge discovery, data mining, learning environment, collaborative learning, science education.**

1 Introduction

Among the creative capabilities of scientists, the most important one is the ability to turn data (observations) into knowledge, that is, the capability for knowledge discovery. In this paper, we propose a collaborative data-mining approach to creative science education in learning environments. In this data-mining supported environment, students could observe real world data in different perspectives, derive their own classification rules and test the rules collaboratively, such that they can experience knowledge discovery by engaging in collaborative data-mining activities.

In this paper, we adopt learning protocols [9] to describe the learning processes. Learning protocols are a set of constraints, rules, or processes for structuring learning processes, and are externalized as executable methods, with roles, events, and actions made explicit. Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. In this paper, we will devise a set of learning protocols that properly distribute the data-mining work among students and computers.

Based on the collaborative data-mining protocols, we design and implement a set of learning tools in the CILSE-GCE learning environment [7, 8]. CILSE-GCE is a web-based collaborative learning environment for global climate exploration. The task domain, global climate exploration, is inherently a scientific classification problem. Students are expected to induce classification rules by making observations under a couple of climatic features. These tools are designed with the intention not only to teach students the target knowledge, but also the scientific ways of study skills. We believe the students will achieve higher learning goals through the collaborative process of creating knowledge by themselves.

2 The CILSE-GCE Learning Environment

The target domain draws sources from the instructional material in the geographic climate course of senior high schools in Taiwan. One of the domain knowledge is the classification of each climate pattern, which is recognized as a specific set of the climatic attributes. In this paper, we focus on the construction of the climatic classification knowledge. Three components of the CILSE-GCE learning environment were built. They are the Virtual Classroom, Visualized Data Viewer, and Intelligent Tutor, respectively, which are outlined below.

The Virtual Classroom serves as the origin where teachers and students coordinate and collaborate. Through the Virtual Classroom, students could access the multimedia coursebase, the climatic GIS database (via the Visualized Data Viewer) and the historical literature database. These rich data sources allow students to observe, search and collect related information in different aspects regarding to the problems at hand. The CILSE-GCE environment also provides an intelligent tutor to help students induce the classification rules. During the rule induction process, a student has to identify what the settings of the relevant attributes are by exploring resources of all kinds. When he/she determines a specific set of attribute values, the intelligent tutor would evaluate the student's answer, and give suggestions to guide the student's further exploration.

A set of rich data sources are needed to allow students to observe, search and collect related information in different aspects regarding to the problems at hand. In the Visualized Data Viewer, rich climate information could be displayed in different layers of maps covering the globe. Students could select, resize and combine different information layers for display to investigate the climate attributes in different perspectives. Hotlinks to climatic data and statistical graphs associated with the typical cities are also provided to allow students to do some measurements and inferences. Up to now, we have collected more than 1700 city records of various kind of climatic information, such as latitude, temperature, precipitation, height above sea level, etc. This database is the main data source that students can collect related data and perform data-mining process to discover the classification knowledge. Figure 1 shows a snapshot of the Visualized Data Viewer.

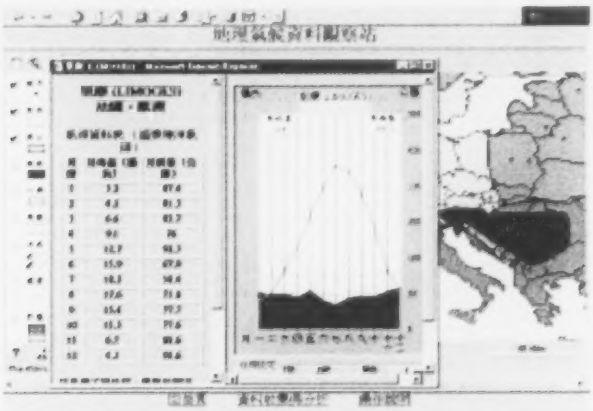


Figure1 A snapshot of the Visualized Data Viewer system.

3 Collaborative Data Mining as Knowledge Discovery

For creative science education, students are asked to acquire the learning skills of knowledge discovery, such as making observations and data collections, performing data analysis, generating hypotheses, testing hypotheses, and making conclusions. Standing from the viewpoint of knowledge discovery [2], we model the learning process as a data-mining process. Figure2 shows the set of data-mining activities, such as selection and sampling, preprocessing and cleaning, transformation and reduction, forming knowledge rules, evaluation and revising knowledge rules. Some steps of the data-mining process can be handled well with computer supports, especially those involving tedious computations and comparisons. Other steps are more suitable to be learning tasks for human students. In this section, we propose the framework of collaborative

BEST COPY AVAILABLE

data mining within which each student member first applies the data-mining process to generate his/her private knowledge base, and then all students collaboratively integrate their private knowledge bases to a more general knowledge base, a result of social consensus process.

The first step in the data-mining process is to select a target data of interest from database, and to possibly sample the target data. The learning skills required of the students are the capability of observation and data collection. Based on the aspects they observe data, students can select all relevant attributes they think might be important to the classification problems at hand. Besides, there are so many samples in the database that students have to learn the sampling skill by selecting as typical samples as they can.

Secondly, the preprocessing and data cleaning step handles noises and unknown values, as well as accounting missing data fields. This step can be dealt with quite well with computer software. Thirdly, the data reduction and transformation step involves checking relevant features depending on the goal of the learning task and certain transformations on the data such as converting one type of data to another (e.g., discretizing continuous values), and/or defining new attributes. It is this step that testifies the hypothesis of attributes that students generated at the previous data observation step.

In the knowledge formulation step, students may apply one or more knowledge discovery techniques and tools on the transformed data set to extract valuable patterns. In this step, students can learn domain-dependent skills as well as the ability to work with computers, as is practiced by most scientists nowadays. Finally, the knowledge evaluation step involves interpreting the result with respect to the goal/task at hand. And as is often the case, students may get back to previous steps based on the evaluation results. Well-designed OLAP (OnLine Analysis Processing) tools are required for students to practice such kind of data analysis tasks. Note that the data-mining process is not a linear one. It might involve a variety of feedback loops, because any one step can result in changes in preceding or succeeding steps.

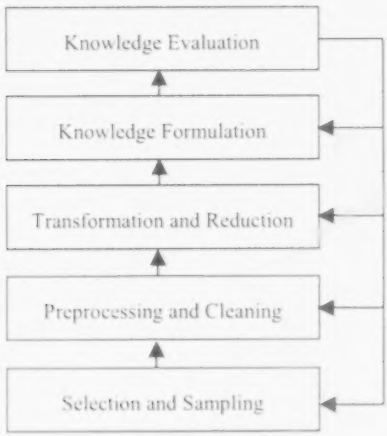


Figure2 The data-mining process.

4 Learning Protocols for Collaborative Data Mining

Learning protocols can be used to coordinate goal-directed, effective interaction in a group of learners. A learning protocol consists of a set of components. First, a protocol has a name signifying the situation type to which the protocol can be applied. Secondly, a protocol consists a set of states and transitions. In each state the users can perform actions such as communicate or manipulate artifacts. A transition to another state is triggered by an action or a specific condition. Actually, a learning protocol can be represented as an event-driven state-transition graph. Thirdly, a protocol includes different roles pertaining to the persons involved in the enactment of the protocol. Finally, a protocol may contain various types of artifacts, such as text documents, graphical objects, test forms, etc. In the following, we design a set of learning protocols for the collaborative data mining process.

4.1 The protocol to construct member knowledge

The protocol shown in Figure 3 outlines the actions of personal data-mining process and coordinates the interactions between a student and the computer. There are totally ten states in the protocol. Each state and transition is described as follows. In the Observing Data state, the student observes the data in all aspects he/she consider important to classify the climatic patterns. The main data source is the Visualized Data Viewer. The student then defines a set of attributes (in the Defining Attribute state) that will be used to classify the climatic patterns. In the Sampling state, the student starts to collect data (cities) and fill in all the details of the climatic attributes that he/she had defined. Since some of the attributes are numeric values, the student has to transform them into symbolic ones (like temperature is high or low) in the Discretizing Attributes state for more data understandability.

In the Mining Rule state, students have to extract and write down the classification rules hidden in the collected data. For this purpose, we design a set of data analysis tool that depicts the distribution graph or dependency graph of the climatic data based on the attributes specified by the students, such as the ones shown in Figure 4.

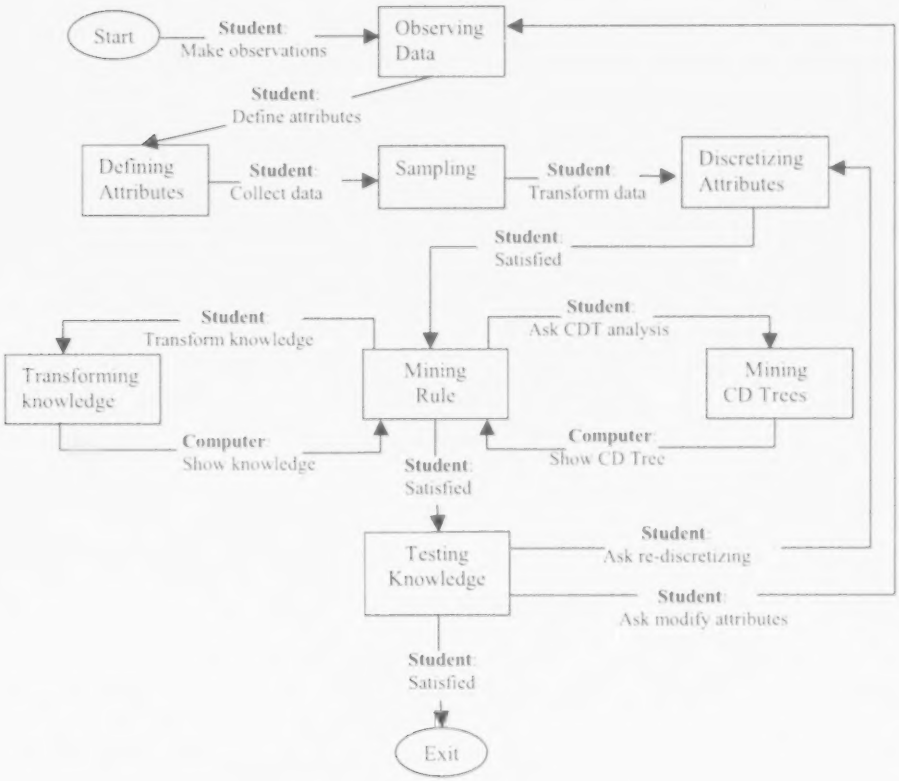
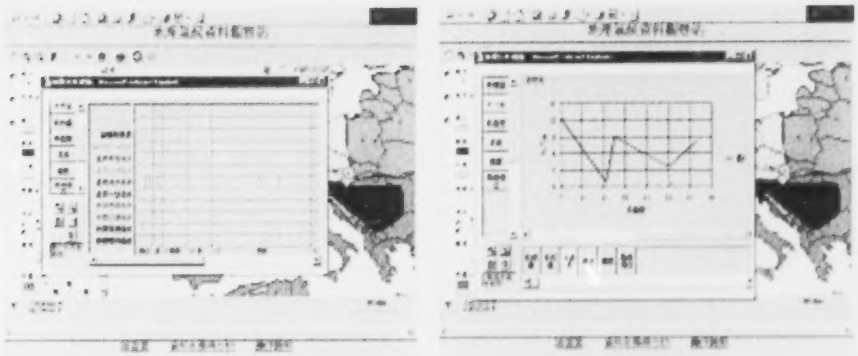


Figure3 The personal data-mining learning protocol.



(a) (b)

Figure4 (a) A data-mining support tool for comparing frequency distributions. (b) A data-mining support tool for depicting data dependency graphs.

Nevertheless, it would be still difficult for some students to discover the hidden knowledge (rules) without further computer supports. Hence, we design and implement another tool to facilitate the data-mining process in the Mining Decision Tree state. This tool uses a variation version of ID3 algorithm [4] to devise a Composite Decision Tree (CD Tree) out of the collected data. A As shown in Figure 5, students can use the CD tree to select and compose classification rules that are of more accuracy, stability and understandability. While rules provide a good local view of each knowledge unit, CD Trees provide another view that facilitates the comparison of different rule structures. . In the Transforming Knowledge state, the student can exchange the knowledge format from CD Trees to Rules, and vice versa. At last, the student can test his/her classification knowledge against the city cases in the Testing Knowledge state, and decide whether to further revise the knowledge.

Figure5 A data-mining support tool to help students extract hidden knowledge (classification rules) from data.

4.2 The protocol to integrate group knowledge

After each student member establishes his/her own knowledge, the student group starts to perform the knowledge integration task collaboratively. The students achieve the knowledge integration goal by solving the classification problem collaboratively, trying to reach a consensus, which is the group knowledge. The corresponding learning protocol is shown in Figure 6. In the Presenting Cases state, a Coordinator (a software agent) selects a city case from the database for the student group to identify its climatic pattern. In the Classifying Case state, each student member applies his/her knowledge to solve the problem, and shows the applied rule and related information (such as the symbolic terms for each numeric attribute) in a shared

 BEST COPY AVAILABLE

working space. With the information shown in the shared working space, each student member starts revising his/her own knowledge by references to the correct answers and the colleagues' knowledge. Detail of the Revising Knowledge state is described in next protocol. Each time the member knowledge is revised, a new applied rule is sent once again to the shared working space. This process will loop until a temporary consensus is reached. At last, the Coordinator store the final rule set into the integrated knowledge base (i.e., the group knowledge). We adopt the Blackboard Architecture [3] to implement this learning protocol.

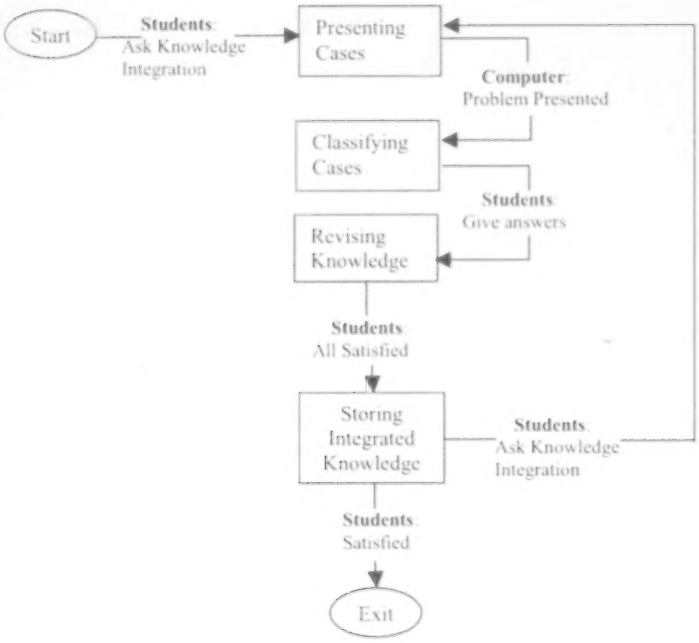


Figure6 The collaborative knowledge integration learning protocol.

4.3 The protocol to revise member knowledge

When students ask to revise his/her private knowledge, the knowledge revising learning protocol, as shown in Figure 7, is entered. In this protocol, two kinds of knowledge operations, the knowledge generalization and knowledge specialization operations, are supported. Each student member can revise his/her private knowledge by applying the two knowledge operations and/or exchange knowledge through the Group Chatting state that involves chatting-support tools. Each kind of knowledge operation can be applied to the various artifacts such as rule structures, numeric attribute intervals, and attributes. Specifically, in Knowledge Generalization state, students can delete conditions from rules, reduce numeric attribute intervals or delete some attributes from the attribute set, while in Knowledge Specialization state, the students can add conditions into rules, extend some numeric attribute intervals or add new attributes into the attribute set. To facilitate both kinds of knowledge revision, an automated rule testing and warning subsystem is implemented to list the rules that are potential for further generalization or specialization based on the test result against any data set.

5 Conclusions

In this paper, we have proposed and implemented a collaborative data-mining support tools for knowledge discovery in creative science education. These functional extensions are being integrated to our previous Web-based learning environment, CILSE-GCE. This collaborative process fosters all the constructive design

principles mentioned in [1, 5], such as observation, interpretation construction, contextualization, cognitive apprenticeship, collaboration, multiple interpretations, ownership of knowledge, self-awareness of construction process. In this collaborative learning model, students would experience the process of looking for patterns collaboratively. Besides, we find that learning protocols are very effective ways to the description and implementation of learning processes. Finally, it is indicated that during free exploration of a problem space, greater learning occurred if students adopted more systematic strategies for rule induction [6]. Further evaluation tests will be conducted to provide beneficial evidences of such kinds of discovery learning.

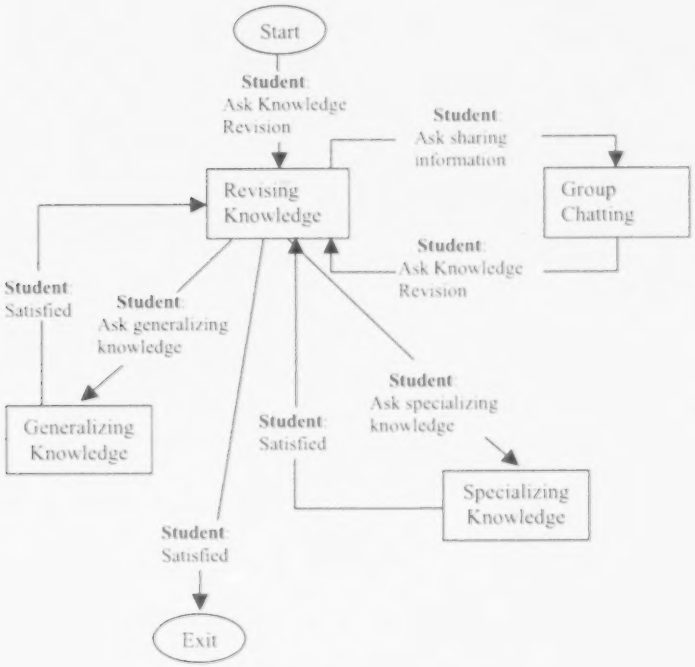


Figure7 The knowledge revising protocol.

References

[1] Black, J. B. & McClintock, R. O., "An interpretation construction approach to constructivist design". In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design" (pp. 25-32), Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[2] Fayyad, U. M., "Data mining and knowledge discovery: Making sense out of data", IEEE Expert, Vol.10, pp. 20-25, (1996).

[3] Nii, H. P., "Balckboard systems: Blackboard application systems from a knowledge based perspective", AI Magazine, Vol. 7, No. 3, (1986).

[4] Quinlan, J. R., "Induction of decision trees", Machine Learning, Vol. 1, No. 1, pp. 81-106, (1986).

[5] Honebein, P.C., "Seven goals for the design of constructivist learning environments", In B. G. Wilson & D. N. Perkins (Eds.), "Constructivist Learning Environments: case studies in instructional design", (pp. 11-24). Englewood Cliffs, NJ: Educational Technology Publications, (1996).

[6] Vollmeyer, R., Burns, B. D. & Holyoak, K. J., "The impact of goal specificity on strategy use and the acquisition of problem structure", Cognitive Science, Vol. 20, pp.75-100, (1996).

[7] Wang, F. H. & Chen, C. H., "CILSE-GCE: A collaborative intelligent learning support environment on world wide web", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 264-269, (1999).

[8] Wang, F.H., "On the design of an intelligent exploratory environment for geographic climates on WWW", Computer Networks and ISDN Systems, Vol. 30, pp. 699-700, (1998).
[9] Wessner, M., Pfister, H. R. & Miao, Y., "Using Learning Protocols to Structure Computer-Supported Cooperative Learning", Annual Meeting of ED-MEDIA, Seattle, WA, USA., June, pp. 471-476, (1999).

Navigation Script for the World Wide Web

Sachio Hirokawa*, Kengo Nishino and Daisuke Nagano*****
** Computing and Communications Center, Kyushu University,*
**E-mail: hirokawa@cc.kyushu-u.ac.jp*
*** *** Graduate School of Information Science and Electrical Engineering, Kyushu University*
***E-mail: Kengo.Nishino@ma3.seikyou.ne.jp*
****E-mail: nagano@matu.cc.kyushu-u.ac.jp*

In the World Wide Web, there is rich material for education. We propose a language to navigate students through the educational material on WWW. Navigation script makers can describe a tour with sequential, parallel and selective controls. It supports multiple Threads where video and audio accompany a browsing window. The language is described with XML and implemented in Java. So, the system can be used as an applet and as an application.

Keywords: **Hypermedia navigation ; Web graph ; XML ; JAVA**

1 Introduction

In the World Wide Web, there is rich material for education. For example, many university teachers give the contents of their lectures as their homepages. This paper describes a system which utilizes internet resources as educational material and makes them into an organized tour. The tour is described in a script language and an interpreter program navigates students through the material on WWW. Students are navigated automatically and interactively while they browse html-files and listen to and watch continuous multimedia.

We need to collect necessary pages from web resources containing a lot of garbage in order to make lists of URLs for our educational purpose. It is important to have students understand the relation between the collected pages and grasp the whole view of the field. When they do not understand the relation, or when they forget how they arrived the page, they feel that they got ''lost in webspace". There is a proposal of using web graphs as imaginary map of WWW[3]. A web graph is a directed graph whose nodes are URLs and whose edges are links between URLs. The web graph is more intuitive than just a list of URLs. But a web graph is nothing but a static representation of WWW. There is no mechanism how to lead students with material on the graph. There is no dynamic process to navigate them. We propose a script language that describes the navigation of WWW.

Maps are useful for navigation of real world and for navigation of WWW. For example, the page of Mapion http://mapion.co.jp/ shows geographic maps of towns. Besides, ''car navigation systems" based on GPS are becoming popular. RWML[5] and NVML[6] are proposal to combine the geographic map and the information on WWW. NVML describes the driving course, distance, time and supplies messages and images for specified points. When the car passes the point, a message and a image will appear according to a signal from GPS. The main concern of these researches is in geographic maps and navigation in real world. The maps we consider are imaginary maps of internet resources. Our goal is to design a language to describe a tour of WWW and to implement an interpreter of the language.

Ariadne[4] is a system of WWW navigation. It has a browser window and a separate window of tour. A user views the map of the tour and can proceed forward, backward and can choose if there are branches on the tour. But user needs to control every step of navigation. Our system supports both interactive and automated navigation. Another feature of our system which lacks in Ariadne is the parallel navigation. In our system, while a user is watching a browser window, another navigation thread can play audio data.

WebOFDAV[1] is a visualization system of web graph. When a user is traversing a series of URLs, the system draws the local graph of visited pages. The graph changes dynamically following the user. WebOFDAV is useful to tell where we are on WWW and powerful to get rid of the problem of lost in webspace. But the graph is used only for an aid for browsing and no navigation route is provided.

The rest of paper is organized as follows. The section 2 analyses the basic feature of navigation of WWW. The section 3 describes the navigation script using XML and explains the visualization of the scripts. The section 4 introduces a virtual machine with two stacks, which enables forward and backward navigation. The section 5 summarizes the paper.

2 Navigation Script

The most important feature of the navigation system is to guide the user around web pages in specified order. Therefore, we adapt sequentiality into navigation language. And to make the contents of html-files easier to understand, we need to combine audio, video, and images together with the usual browsing window. We introduce parallelism. To increase the variation of the navigation depending on each visitor, we add selection mechanism in the language. We design the language as a structured programming language with sequential, parallel and selective controls. The basic navigation units are multimedia data specified as URLs.

We chose XML as the description language of the navigation for simplicity and extendability. As implementation language we chose Java. We use "XML Parser for Java"[2] for XML parser,and "JMF"[7] for multimedia data. We describe the language as the following DTD (Document Type Definition).

```
<!ELEMENT statement (simple|sequential|parallel|select)>
<!ELEMENT simple (message)>
<!ATTLIST simple kind CDATA #REQUIRED
   target_name CDATA #REQUIRED
   play_time CDATA #REQUIRED
   delay_time CDATA #REQUIRED>
<!ELEMENT message (#PCDATA)>
<!ELEMENT sequential (simple|sequential|parallel|select)*>
<!ELEMENT parallel (simple|sequential|parallel|select)*>
<!ELEMENT select (selector)+>
<!ELEMENT selector (simple|sequential|parallel|select)>
<!ATTLIST selector selectname CDATA #REQUIRED>
```

Each tag and parameters have the following meaning.

- <statement>: This tag represents the root of navigation tour. It may contain subtours as children. There are four kinds of tours,<simple>,<sequential>,<parallel> and <select>.
- <simple>: This is the basic unit of the navigation. It contains a few lines of messages to describe the contents of the web page. It has the attributes of kind, target name, play time and delay time. Target name specifies the URL of the data. The kind describes the kind of multimedia data. Play time is the duration time and delay time is the time to wait before play.
- <sequential>: It may contain subtours of the kind <simple>, <sequential >, <parallel> and <select>. Subtours are followed consecutively.
- <parallel>: It may contain subtours of the kind <simple>, <sequential>, <parallel> and <select>. Subtours are activated in parallel.
- <select>: This tag causes a pause of the system. User can choose the navigation selectively from the given subtours. Those subtours are provided as children with the tag <selector>.
- <selector>: It may contain a subtour of the kind <simple>, <sequential>, <parallel> and <select>. It has the selectname as an attribute, which is used in the select menu.

3 Navigation Window, Control Panel and Browsing Window

Fig 1 is a screenshot of the system, which has a browser window, a quicktime movie screen, the controller screen and the window of navigation script.

We chose the representation with nested boxes for the visualization of navigation script instead conventional DOM-tree of XML nodes for several reasons. The most important feature of the navigation is the flow of time. To visualize this, we draw the subtours of a sequential tour from left to right. In Fig 1, time goes horizontally from left to right. Parallel tours and visualization of selection are placed vertically. The difference is that each subtour of the selection has its name, specified with its selectname, and the order in the choice. For example, if a selection has three choices, the second subtour is displayed as ``2/3 selectname".

Visualization of navigation script is not only for static view. It has a control panel and user can go forward and backward along the navigation. When a node is displayed on the browser window, the node in the navigation window is highlighted. So, the user has always global view of the navigation.

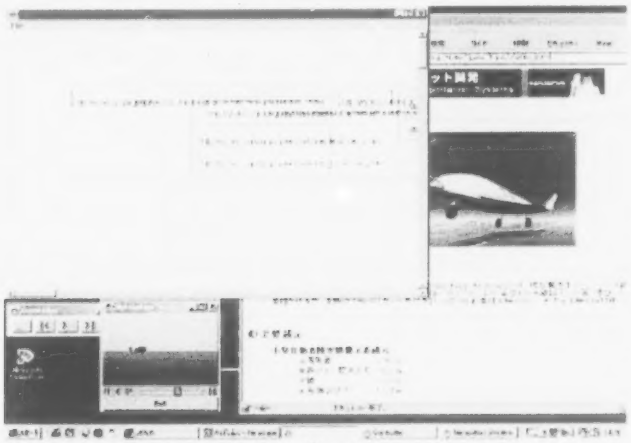


Figure 1: Screenshot

4 Interpreter of Navigation Script

Navigation is performed according to the kind of statement. Parallel statement opens a new browser window and a different thread performs the navigation in parallel.

The interpreter has two modes, the fully automatic mode and the interactive mode. Basically, the interpreter displays the specified html-files on the browser window. It displays the html-file on the screen for "play time" and changes to the next screen. When the user wants to see in detail, he can make a pause. He can go backward as well. The controller interacts with the user. The functions of the controller are "pause", "play", "forward", "backward", "rewind" and "stop". The "play" and "pause" toggles the mode. The "forward" and "backward" are for interactive mode. The browser screen moves one step in the sequential statement. This control is different to the controllers of multimedia players for the continuous media.

To realize forward/backward control in the navigation, we use two stacks of statements in the interpreter. The first stack "do"contains the list of statements to follow. The second stack "done" contains the list of statements already performed. The interpreter is realized by a transition of states depending on the top of the two stacks.

4.1 Forward Transition

Due to the limit of space, we only explain the forward transition concerning to parallel statement. If a parallel statement contains substatements, the interpreter creates n-1 threads which begin execution with "done" stack empty and whose "do" stack contains the substatements. For example, a parallel statement "<parallel>a b c</parallel>" creates two new threads(Fig 2).

BEST COPY AVAILABLE

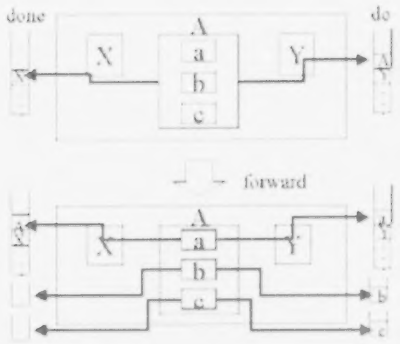


Figure 2: Forward Transition for Parallel Statement

4.2 Backward Transition

In the backward transition, the interpreter pops the statement at the top of ``done" stack and pushes it on "do" stack. If it is a sequential statement, then all the substatements are poped out of the "do" stack. A situation, where the "done" stack is empty, occurs only after a forward transition of a parallel statement. To go backward from such a situation, we need to delete such threads activated by the parallel statement.

5 Conclusions

We proposed a language for the navigation of WWW and described its implementation. The material of a navigation tour is web pages and multimedia data on WWW. The navigation script is defined as DTD of XML. Anyone can create a dynamic navigation from a static list of URLs. The language supports multimedia data and provides sequential, parallel and selective constructs of the tour.

References

[1] M. L. Huang, P. Eades, R. F. Cohen, ``WebOFDAV -navigating and visualizing the Web on-line with animated context swapping", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 638-642, (1998).

[2] IBM, ``XML Parser for Java", http://www.alphaWorks.ibm.com/tech/xml4j/(accessed on August 9,2000).

[3] D. Ikeda, T. Taguchi, S. Hirokawa, ``Developing a Knowledge Network of URLs", Proceedings of Discovery Science '99', Springer Lecture Notes in Artificial Intelligence Vol. 1721, 328-329, (1999).

[4] J. John, A.T. Jensen, K. Geronbak, ``Ariadne:a Java-based guided tour sys-tem for the World Wide Web", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 131-139, (1998).

[5] RWML Working Group, ``Road Web Markup Language (RWML) Draft Ver.0.71a (in Japanese)", http://www2.ceri.go.jp/its-win/RWML/RWML-071.html (accessed on August 9,2000), (1999).

[6] M. Sekiguchi, K. Takayama, H. Naito, Y. Maeda, H. Horai, M. Toriumi, "NaVigation Markup Language (NVML)", submission to the World WideWeb Consortium, http://www.w3.org/TR/NVML(accessed on August 9,2000), (1999).

[7] Sun Microsystems, ``Java Media Framework", http://java.sun.com/products/java-media/jmf/2.0/index.html (accessed on August 9,2000).

Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

Kyoko Umeda*, Takami Yasuda and Shigeki Yokoi***
**Graduate School of Human Informatics Nagoya University,*
***School of Informatics and Sciences Nagoya University*
Furo-cho Chikusa-ku Nagoya-City 4648601 Japan
umeda@info.human.nagoya-u.ac.jp

The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even f they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can colle vely work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

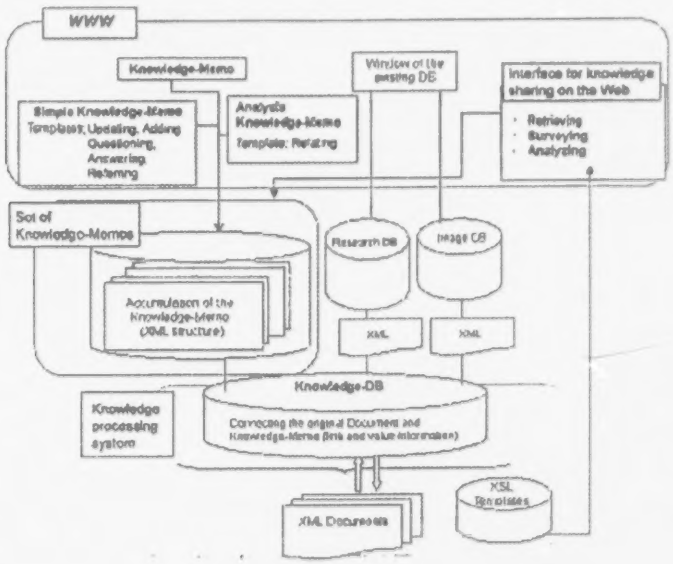


Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re-analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2 Collection and accumulation of Knowledge-Memo

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used: <key> for keywords, <hi> for highlights, <br /> for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

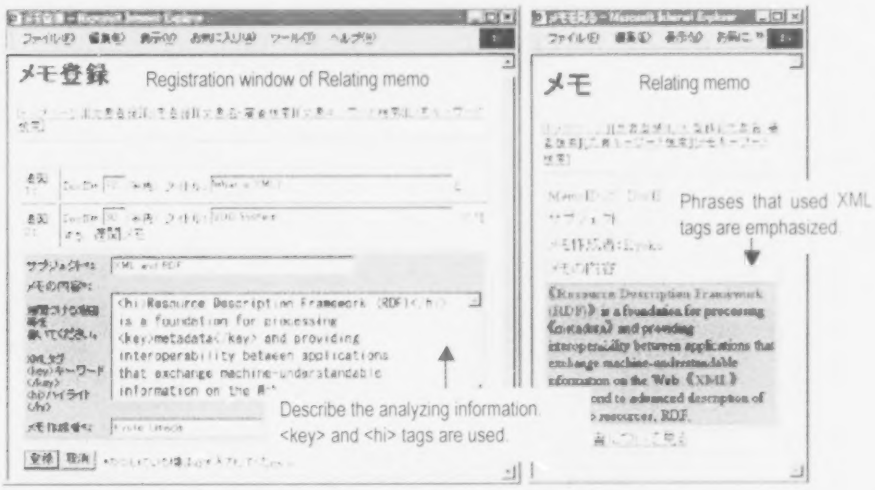


Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage

BEST COPY AVAILABLE

information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

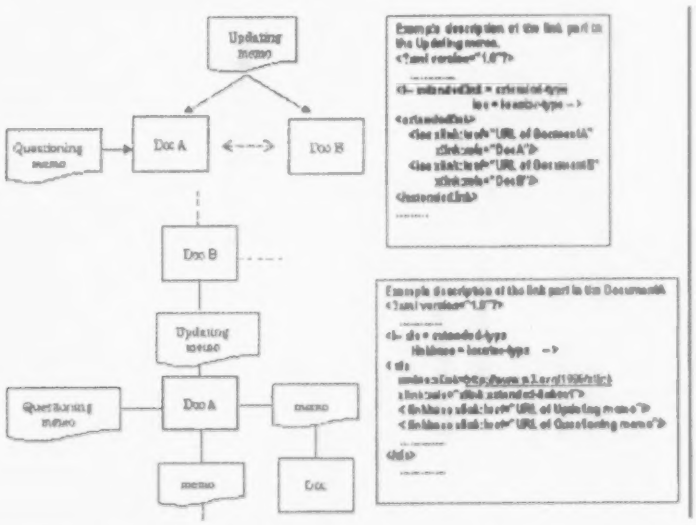


Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. I can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

BEST COPY AVAILABLE

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memo randums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities.

Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memo randums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A's report. He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

BEST COPY AVAILABLE

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.

(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.

(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.

(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;

- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.

(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.

(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.

(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

References

[1] D.K. O'Neill, L.M. Gomez, "The Collaboratory Notebook: a Networked Knowledge-Building Environment for Project Learning", Proc. of Ed-Media 94, pp.416-423 (1994)

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano, "Knowledge Awareness Map fro Open-ended and Collaborative Learning on World Wide Web", Proc. of ICCE99, pp319-326 (1999)

[3] I. Nonaka, "The Knowledge-Creating Company", Harvard Business Review, November-December1991, pp96-104 (1991)

[4] J. Oshima, "Students' Construction of Scientific Explanations in a Collaborative Hyper-Media Learning Environment", Proc. of CSCL97, pp187-197 (1997)

[5] N. Pitts-Moults, C. Kirk, "XML Black Book", The Coriolis Group. Inc. (1999)

[6] P. Bell, E.A. Davis, M.C. Linn, "The Knowledge Integration Environment: Theory and Design", Proc. of CSCL95 (1995)

[7] S. Puntambekar, "An integrated approach to individual and collaborative learning in a web-based learning environment", Proc. of CSCL 99, pp458-465 (1999)

[8] T.H. Davenport, "Integrating Knowledge Management into the Organization", Diamond Harvard Business, August-September 1999 pp26-36 (1999)

[9] Knowledge Forum 2.0, http://www.motion.com/lim/kf/KF1.html (accessed on August 1, 2000)

[10] XML Linking Language (XLink) Version 1.0, http://www.w3.org/TR/2000/CR-xlink-20000703/ (accessed on August 1, 2000)

Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

Kyoko Umeda*, Takami Yasuda and Shigeki Yokoi***
**Graduate School of Human Informatics Nagoya University,*
***School of Informatics and Sciences Nagoya University*
Furo-cho Chikusa-ku Nagoya-City 4648601 Japan
umeda@info.human.nagoya-u.ac.jp

The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even if they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML.**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can collectively work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

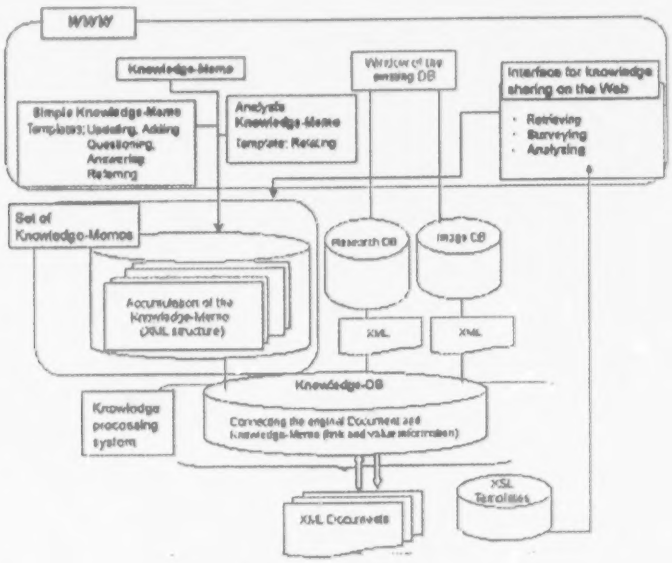


Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re-analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2 Collection and accumulation of Knowledge-Memo

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used:• •<key> for keywords, • <hi> for highlights, •
 for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

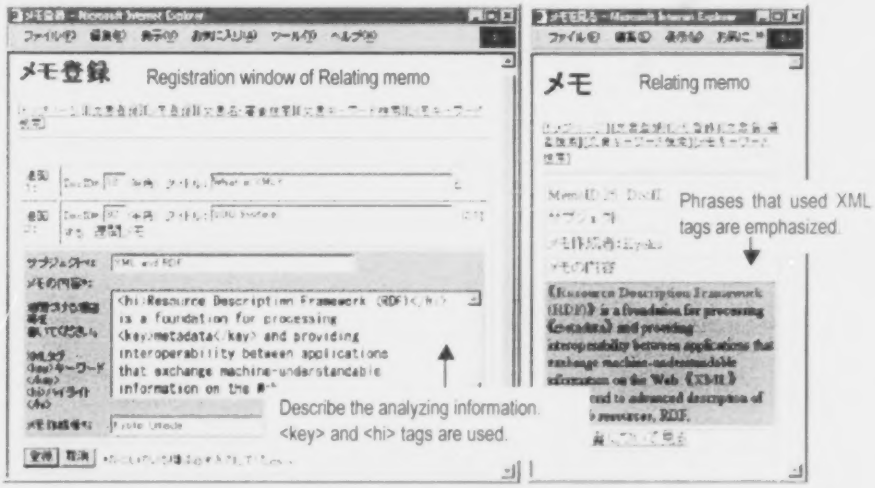


Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage

information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

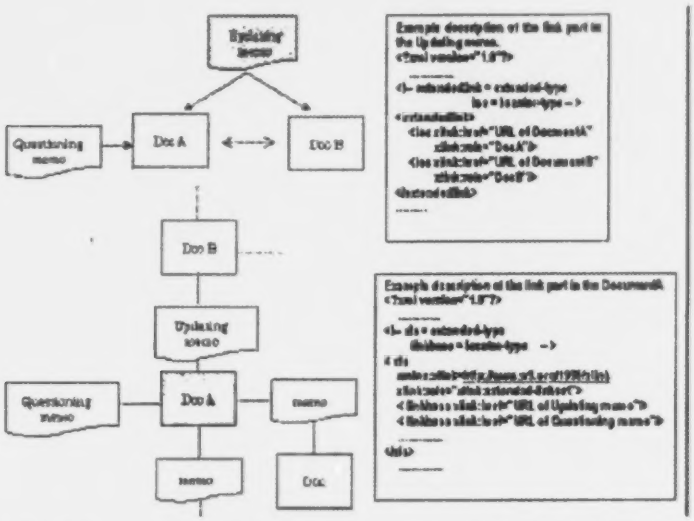


Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. It can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memorandums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities.

Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memorandums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A's report. . He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.

(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.

(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.

(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;

- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.

(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.

(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.

(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

References

[1] D.K. O'Neill, L.M. Gomez, "The Collaboratory Notebook: a Networked Knowledge-Building Environment for Project Learning", Proc. of Ed-Media 94, pp.416-423 (1994)

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano, "Knowledge Awareness Map fro Open-ended and Collaborative Learning on World Wide Web", Proc. of ICCE99, pp319-326 (1999)

[3] I. Nonaka, "The Knowledge-Creating Company", Harvard Business Review, November-December1991, pp96-104 (1991)

[4] J. Oshima, "Students' Construction of Scientific Explanations in a Collaborative Hyper-Media Learning Environment", Proc. of CSCL97, pp187-197 (1997)

[5] N. Pitts-Moults, C. Kirk, "XML Black Book", The Coriolis Group. Inc. (1999)

[6] P. Bell, E.A. Davis, M.C. Linn, "The Knowledge Integration Environment: Theory and Design", Proc. of CSCL95 (1995)

[7] S. Puntambekar, "An integrated approach to individual and collaborative learning in a web-based learning environment", Proc. of CSCL 99, pp458-465 (1999)

[8] T.H. Davenport, "Integrating Knowledge Management into the Organization", Diamond Harvard Business, August-September 1999 pp26-36 (1999)

[9] Knowledge Forum 2.0, http://www.motion.com/lim/kf/KF1.html (accessed on August 1, 2000)

[10] XML Linking Language (XLink) Version 1.0, http://www.w3.org/TR/2000/CR-xlink-20000703/ (accessed on August 1, 2000)

Scientific revolutions and conceptual change in students: Results of a microgenetic process study

Benson M.H. Soong* **and Yam San Chee****
School of Computing, National University of Singapore
3, Science Drive 2, Singapore 117543
Tel: + 65-874-8090
Fax: 65-779-4580
**Email: soongmun@comp.nus.edu.sg*
***Email: cheeys@comp.nus.edu.sg*

A microgenetic process study of dyad learning was conducted with the objective of further understanding conceptual change as students learn. This paper describes the knowledge negotiation, co-construction, and problem-solving efforts between two student volunteers, both aged 15, in a computer-mediated-communication (CMC) environment. We illustrate protocols of the students' problem-solving processes, showing how the students manifested, expressed, defended, abandoned, conjectured, and eventually transformed their (mis)conceptions on various aspects of velocities and distances. In doing so, we address important questions raised about students, their concepts and (lack of) theories, and the types of conceptual change that take place as students learn. This paper provides empirical evidence to show that as long as students do not think in theoretical terms, conceptual change in students will be very different from scientific revolutions. It not only agrees with the theoretical shift to viewing *learning* as *conceptual change*; it also lends empirical evidence in support of this view.

Keywords: **Cognition and Conceptual Change, Collaborative Learning, and Knowledge Construction and Navigation**

1 Introduction

The study and understanding of conceptual change is a field that is significant to the research community [10]. An example of macro-level conceptual change is the paradigm shift [8] from the phlogiston theory to the oxygen theory (commonly dubbed the chemical revolution). There have been numerous attempts to compare and contrast between such scientific revolutions and conceptual change in children and students. For example, Carey [2] contends that the development of the concept *living thing* in a child is analogous to scientific revolution because her study shows that between the ages of 4 to 10, children undergo a cognitive restructuring of their *living thing* concept; this restructuring is tantamount to theory change (from an animist theory to a set of biological theories). On the other hand, Harris [5] argues that "children do not think in theoretical terms, but on the basis of working models or concrete paradigms that serve as a basis for predictions and explanation" (p.303). Given these two opposing viewpoints, it is natural for Thagard [21] to state:

> The questions remain: do children have theories, does conceptual change occur by replacement, and is theory replacement the result of considerations of explanatory coherence? An affirmative answer to each question is a precondition of an affirmative answer to the succeeding one. (p.256)

Before discussing whether conceptual change in students is as revolutionary as scientific revolution, we should be reminded that scientific revolution involves a paradigm shift from one theory (or theories) to another competing theory (or theories). At the risk of oversimplification, we define a theory to be a set of *explicit* and *well-coordinated* principles that yield *predictions* based on their *explanatory mechanisms*. Since

all "conceptual structures provide some fodder for explanation", "the distinction between theory-like structures and other types of cognitive structures is one of degree" [2, p.201]; theories embody deep explanatory notions.

Given the above, if students do not possess theories, not only is conceptual change in students fundamentally different from scientific revolution, but we must also offer negative answers to Thagard's questions.

2 Context of Study

This study describes how two student volunteers, Tim and Ming (both aged 15), engaged in meaningful knowledge negotiation and co-construction in a manner that allowed their conceptions and thought processes to be made overt for our analysis. Tim and Ming are schoolmates (but not classmates) in an academically average neighborhood secondary school. Both students have learnt physics in school for one year prior to this study and hence, are familiar with the terms velocity, acceleration, time, and distance. Prior to this, both students have not worked academically with each other.

Tim and Ming were placed in a large room that was partitioned in the middle. Each student occupied onepartition, and conversed with the other exclusively via a computer-mediated-communication (CMC) environment. The CMC environment consisted of a chatbox and whiteboard facility. The chatbox facility allowed the two students to converse via typed text, while the shared whiteboard allowed pictorial drawings and ideas to be depicted and discussed. Figure 1 shows a snapshot of this CMC environment, implemented via Microsoft NetMeeting™. Besides the standard furniture such as tables, chairs, and a computer, each partition housed two unmanned video cameras. The main data collection method comprised the video recordings of the students' interactions through the CMC environment. In each partition, a video camera was directed at the screen, capturing every interaction sequence performed on the computer, while the other video camera was directed at the student, capturing the student's physical gestures and reactions. To further aid the transcription process, both the shared chatbox and whiteboard were regularly "saved."

The questions that we posed to the students to solve were adaptations of the "Context Rich Problems" formulated by the Department of Physics, University of Minnesota (for more information, see http://www.physics.umn.edu/groups/physed/Research/CRP/crintro.html).

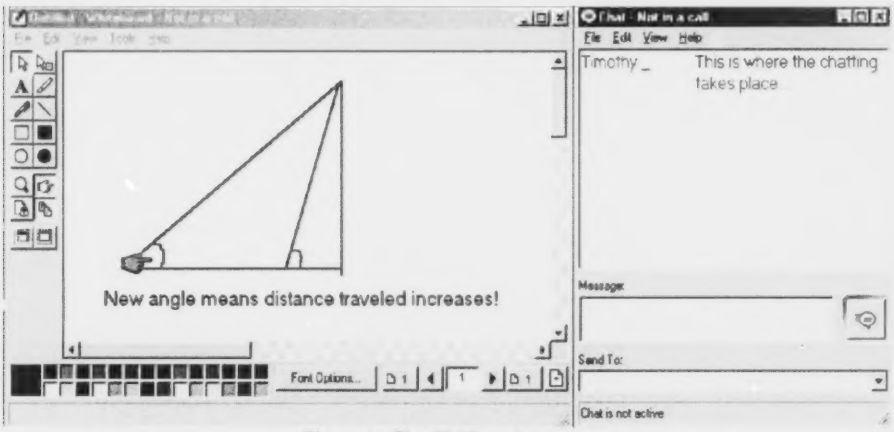


Figure 1: The CMC environment

3 Research Methodology

If we simply engage in endpoints analysis, we would not be able to understand conceptual change [10]. As such, we need to take into account the actual developmental process of conceptual change. A research methodology that focuses on microgenetic (developmental) processes is that of Ethnomethodology [4]. In short, ethnomethodology is interested in interaction sequences and requires that we focus on "participant categories" rather than "third person observer" perspectives [7]. It forces us to ask, "what questions can the data answer" rather than "what data do I need to answer these questions."

BEST COPY AVAILABLE

Since conversation analysis is the most productive and prolific form of analysis that has been developed with ethnomethodological concerns in mind [1], the protocol data obtained were transcribed into a log format, and then analyzed and annotated in accordance with the practices of conversation analysis (see also [6, 9, 12, 13, 17]). This was a time-consuming process as each tape had to be viewed and reviewed until the gaps in the data were resolved to the fullest extent possible.

4 Study Findings

In the following section, we illustrate portions of Tim and Ming's problem-solving processes through protocols collected in our study. Because this paper only presents portions of the protocols collected, see Soong [19] for full details. The question below details one of the problems attempted by Tim and Ming.

The cycling problem:

> You and your physics teacher are cheering your cyclist friends Alex and Bon who are taking part in a straight but uphill bicycle-racing contest. You and your teacher are watching the race from the side-lane just beside the racetrack, 132 meters away from the finish line. It so happened that both cyclists passed by in front of you at exactly the same point in time. Your teacher estimated Alex's velocity to be 12m/s and Bon's velocity to be 11m/s. Given your training sessions with Alex and Bon, you know that from this position, Alex will accelerate at the rate of $0.25m/s^2$, while Bon will accelerate at the rate of $0.4m/s^2$, for the next 10 seconds.
>
> - What is the final velocity of both cyclists at the end of that 10 seconds?
> - Who will reach the finish line first?

Comments in square brackets "[ ]" are remarks made by the author regarding the protocol statements. These comments aid understanding of the protocols by relaying contextual information not available to the reader. No attempts were made to correct the students' grammatical and spelling errors. Tim, Ming, and the author are represented by "T", "M", and "A" respectively.

```
4.    M: part a looks tha same as what we did in the last session
      [The first part of this question looks the same as what they previously attempted]
5.    T: yes....
6.    M: can we use that method?
  T: lets try
```

Both students drew structural similarity between Part A of this question and a question that they previously attempted. In that previous problem-solving session, T and M had agreed that "(acc. x acc. time) + initial velocity = final velocity". However, the reason they agreed on this formula was because "it's the only method where we could get the ans. so far". It is clear that the students lacked a conceptual understanding of the solution, but nonetheless that did not hinder them from solving the problem.

It is noteworthy that M referred to the problem-solving process as "that method", rather than "that theory" or even "that logic". It is clear that in this instance, the students did not think in theoretical terms. In fact, it was a mechanical application of the "method" that the students "did in the last session".

With this, the students worked collaboratively, using the formula *final velocity = (acceleration x acceleration time) + initial velocity*. They then obtained the (correct) solution that Alex's final velocity was 14.5 m/s while Bon's final velocity was 15 m/s.

```
11.   M: 12+2.5=14.5
12.   T: yes
13.   T: and bon = 11 + 4 = 15
17.   M: agree?
18.   T: yup
```

It was clear to both students that Bon was faster than Alex after the acceleration. However, both the students had the conception that an object with a higher final velocity travels further than one with a lower final velocity. This conception is true in some, but not all cases. This is a well-known misconception, and it has been documented extensively by Piaget [11], among others. In the context of our study, we will refer to this

as the "higher final velocity = winner" concept.

38. T: bon is faster after the acc.
39. M: yes
40. T: therefore if the speed be constant after the acc., bon would complete the race first
41. T: agreed?
44. M: agree.

Confident that their answer was correct, T checked their answer with the author, only to be informed that their answer was incorrect, since Alex will actually complete the race first. When T related this to M, he was surprised.

47. T: nope.....
48. T: wrong ans....
49. M: huh?
[M is surprised that their answer was incorrect]

When the author informed the students that their answer was wrong, the students tried again. T stuck to the concept that an object with a higher final velocity will travel further than one with a lower final velocity. Since T was basing his problem-solving attempts on this concept, he thought the only possible reason why Bon did not win the race was that his final velocity was lower than that of Alex's. To allow for this, he hypothesized that both bicycles returned to their initial velocities after the acceleration.

53. T: they will only acc. for that 10 s
54. T: after that their speeds will return to the same as b4

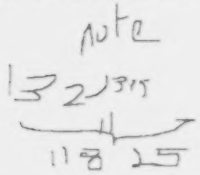
At this point in time, the author informed the students that the bicycles did not decelerate after that 10 seconds. Upon hearing this, both students felt that Bon should win. Their expression was totally consistent with their conception.

62. A to T: They did not decelerate after the 10 seconds.
65. T: the 2 didn't decelerate
66. M: then b should win
67. T: yah.....

In the episode above, T was trying to reconcile their findings via qualitative analysis of the situation. However, because their source of reasons came from their "higher final velocity = winner" (mis)conception, this yielded no alternative results.

The episode below shows M's attempt to obtain an alternative answer via mathematical formulations. In so doing, M unwittingly put aside the "higher final velocity = winner" concept.

84. [M writes on the whiteboard]



86. M: a travelled 118.25 to the checkpt
[M was referring to his workings on the whiteboard. See L88, L89 and L92 for an explanation of M's workings]
87. T: y is that so?
[T looks at M's drawing on the whiteboard]
88. M: 0.25+(2x0.25).....+(2.5)=13.75
89. M: the distance travelled during acceleration
[13.75m is the (additional) distance covered due to the acceleration]

The protocol above manifests another of M's misconception. M's workings imply that the bicycles gain speed instantaneously rather than incrementally. In short, M's workings imply that Alex's bicycle covered an additional 13.75 meters due to its acceleration of $0.25m/s^2$ for 10 seconds. We observe that this exact same working was also exhibited by M in one of his earlier problem-solving sessions.

```
90.   T: ok.....
91.   T: but i still dun get it....
      [T does not understand M's workings]
92.   M: 132(distance from check pt)-13.75=118.25
      [132m - 13.75m = 118.25m]
      [M is saying that the initial portion of Alex's velocity covered 118.25m]
93.   M: there/s no decceleration,then bon should reach first!
```

It is likely that, to M, the distance traveled by Bon due to Bon's higher acceleration was greater than Alex. Based on this method, Bon would have traveled 22 meters due to his higher acceleration. Hence, M drew the conclusion that Bon should reach the finish line first, since Bon was "faster". Clearly M's reasoning was flawed.

```
94.   T: how u get 13.75?
95.   M: 0.25+(0.25x2)+(0.25x3)+(0.25x4)...... +(0.25x10)=13.75
```

Upon further probing by T, M provided a fuller explanation of his conceptualization. M's formulation is as follows:

The velocity of Alex due to acceleration during the 1st second is = $0.25m/s^2$ x 1s
= 0.25m/s

Hence Alex, moving at 0.25m/s, travels 0.25m/s x 1s = 0.25 meters during the 1st second.

Likewise, Alex's velocity due to acceleration during the 2nd second is = $0.25m/s^2$ x 2s
= 0.5m/s.

Hence Alex, moving at 0.5m/s, travels 0.5m/s x 1s = 0.5 meters during the 2nd second. The same process was extended until the 10th second. As such, M conceptualizes that the summation of the distances from the 1st to the 10th second indicates the total distance traveled during the 10 seconds. Figure 2 and 3 pictorially illustrate M's conception and the actual acceleration process respectively.

Figure 2: M's Conception

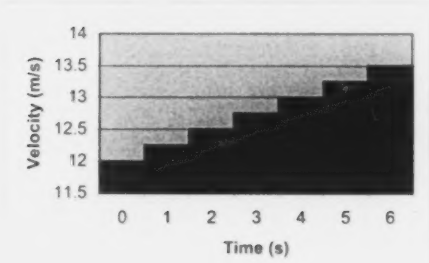
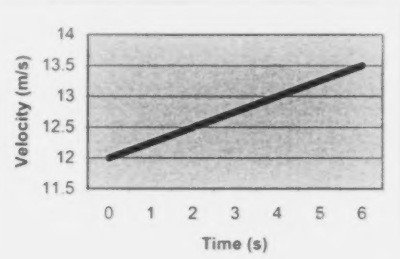


Figure 3: Actual acceleration process



T thought long and hard about M's formulation. After doing the math, he understood and agreed with M's conceptualization. This provides us with evidence that T had this misconception as well.

```
96.   T: [long pause (thinking)]
97.   T does the maths
98.   T: oic
      [This is a short form for "Oh, I see"]
```

Discussing the problem-solving process by qualitative analysis failed to provide new insights. As such, M started using mathematics as an alternative source of potential explanation. M's workings reveal that he had a misconception that the bicycles gain speed instantaneously rather than incrementally. We also see evidence that T suffered from the same misconception. Despite the use of both approaches, both students were unable to find any reason why Alex should win. Hence, they concluded that Bon would win. With this conclusion, they checked again with the author, only to be told that they were incorrect.

```
110.  M: no.............................
111.  T: huh?
      [T is surprised that the answer was incorrect]
113.  M: that's no the ans..
114.  T: i don't get it....
115.  M: smae here.....
```

Faced with this bleak situation, both students, perhaps unwittingly, put aside their "higher final velocity = winner" conception. Evidence of this is shown when, without first thinking it through, M suggested that perhaps both bicycles arrived at the same time.

```
117.  M: maybe they arrive at the same time?
118.  M: assume
119.  T: it may be possible but wat is the reasoning...?
120.  M: thinking.......
```

Perhaps unknown even to M, he was putting aside the "higher final velocity = winner" concept by suggesting that "maybe they arrive at the same time". This suggestion was made without even an initial reason, and hence this suggests that the students did not think in theoretical terms.

Because the students had put aside the "higher final velocity = winner" conception, they were able to make progress in solving the question.

```
124.  T: acc. = total dist travelled / total time taken
      [T makes overt his thought process to M]
125.  M: that's speed
      [M corrects T]
126.  T: aye.... yah hor.....
      [Local expression for "Oh yes, you are right"]
127.  M: acc=what formULA?
128.  T: the gradient of the distance time graph....
      [This is actually incorrect; acceleration is the gradient of the velocity-time graph]
129.  M: huh?
      [M was not expecting this]
130.  T: the acc. is the gradient of the distance-time graph
134.  M: could u find the time ?
135.  A to M: Do you agree that "acc. is the gradient of the distance-
   time graph"?
136.  M: acc.=changes in velocity/time taken
      [After pondering over the author's question, M gives an accurate definition for acceleration]
```

As T searched broadly for answers, he drew upon the formula of acceleration. However, his definition was incorrect. This set M thinking about the actual formula of acceleration and "the time" (L134). M then started to use the formula *time = distance traveled / (velocity+acceletion)* in order to find the time taken for each bicycle to complete the final 132 meters. While M's actual workings were incorrect (there is no such formula), it nonetheless provided the students with an alternative answer suggesting the conclusion that Alex won the race. More importantly, it allowed the students to derive the relation between the time of race completion and the winner of the race.

```
151.  M: a move faster than b.....reach first.......z???????
      [M draws the relation between time of completion of race and winner of race]
156.  M: 132/(12+0.25)=132/12.25=10.76
      [132 is the distance traveled, 12 is the initial velocity, 0.25 is the acceleration]
157.  M: A
158.  M: 132/11.4=11.58
      [132 is the distance traveled, 11 is the initial velocity, 0.4 is the acceleration]
159.  M: B
160.  M: i getting a little bit confused
      [Perhaps M noticed that the formula he used made no sense]
161.  T: oic/......these ans are the time taken for the cylist,....
```

```
162.  T: therefore, A takes less time and b takes longer..
164.  T: so A will reach first
```

M's workings were incorrect. He had used a formula that had no basis, but nonetheless, T was able to make sense of it and concluded from M's answer that since Alex took less time than Bon, Alex will reach the finish line first. This provided the students with an alternative answer, and they were excited. M immediately asked the author if they were correct.

```
165.  M to A: Correct?
166.  A to M: The answer is correct, but the working is wrong
167.  M: working XXXXXXXXX
```

Upon hearing that the answer was correct, M deduced correctly that because Alex traveled faster initially, Alex was at a point ahead of Bon such that Bon could not overtake him despite Bon's higher acceleration. This provided the students with a reason why, despite his higher acceleration and final velocity, Bon lost to Alex.

```
172.  M: a travelled faster aT FIRST SO HE'S AT A POINT FURTHER THAN
   WHERE B COULD OVER TAKE EVEN THOUGH B ACCELERATE FASTR.
```

The above problem-solving endeavor took about 50 minutes. From here onwards, the students continued their problem-solving efforts. After considerable struggle, they eventually "corrected" their second manifested misconception (the "stepwise velocity increment" conception). They were also able to obtain a correct mathematical process to show Alex completing the race before Bon. The total time taken to solve this question was 130 minutes.

5 Results

The results of our study show that our student volunteers did not think in theoretical terms when attempting to solve the physics (kinematics) problems. Instead, they used a variety of methods such as simulations, conceptions, and even baseless conjectures. While these students certainly have concepts and based their reasons on these concepts, they were loose, unsystematic and highly fragmented. We may be tempted to call these students "naive learners", but further research by the authors reveal that the vast majority of elementary physics students who were studied worked in this fashion.

The students' "higher final velocity = winner" conception stemmed from their prior knowledge, and because their source of reasons came from this conception, they were unable to understand how it could be that Bon, who had the higher final velocity, did not reach the finish line first. Only upon putting aside this concept were they able to appreciate how it could be possible for an object with a higher final velocity to reach the finish line later than an object with a lower final velocity; it was because the slower object was at a point further than where the faster object could overtake. The protocols strongly support constructivist learning theory, which posits, among other things, that new knowledge is built (or constructed) from prior knowledge [15, 16]. Our study not only agrees with the theoretical shift to viewing *learning* as *conceptual change* [21]; it also lends empirical evidence in support of this. It also shows the conceptual change process (and hence learning process) to be continuous, but non-cumulative. This particular *feature* is strikingly similar in structure to scientific revolutions.

With respect to Thagard's request to "pin down the kinds of conceptual change that occur as children learn" [21, p.260], the kind of conceptual change that occurred here is that of "adding a new strong rule that plays a frequent role in problem solving and explanation" [21, p.35]. Initially, the students had the conception that an object with a higher final velocity (B) implied that it would travel further than one with a lower final velocity (A). Their problem-solving efforts added a new rule to this concept: B would travel further than A *only if* A is not at a point ahead of B such that B could not overtake A despite B's higher acceleration and higher final velocity.

6 Conclusions

Here in Asia (and in many parts of the world), the current method of teaching and assessing primary, secondary, and pre-tertiary students (aged 7-18), is still very much based on the over a century-old Western

pedagogy of teaching boys and girls nothing but *facts* [3]. Such a methodology is efficient for dissemination of information, but this decontextualised-content focus causes students to suffer from a lack of deep conceptual understanding of the domain being taught, and immensely decreases their exposure to expert problem-solving processes and strategies. As such, they do not look at problem solving through a "theoretical lens." Since "advancement in science is a continual dance between the partners of theory and experiment, first one leading, then the other" [14, p. 796], as long as students do not think in theoretical terms, negative answers should be offered to Thagard's opening quote.

Learning environments, computer-based or otherwise, should be designed to play a more *strategic* role with the *objectives* of the educational system as their core focus. Since the objectives of educational systems are rarely to produce unadaptable and inflexible graduates concerned only with egotistical benefits, then the learning environment, as well as the evaluation methodology, should be designed to reflect their intended objectives (also see [18]).

References

[1] Benson, D. & Hughes, J., "The Perspective of Ethnomethodology", Hong Kong: Longman, (1983).

[2] Carey, S., "Conceptual Change in Childhood", Cambridge, MA: Bradford/MIT Press, (1985).

[3] Dickens, C., "Hard Times", London: Collins, (1954), (original work published in 1854).

[4] Garfinkel, H., "Studies in Ethnomethodology", Englewood Cliffs, NJ: Prentice-Hall, (1967).

[5] Harris, P., "Thinking by Children and Scientist", In Hirschfeld, L. & Gelman, S. (Eds), Mapping the Mind (pp. 294-315), NY: Cambridge University Press, (1994).

[6] Have, P., "Doing Conversation Analysis: A Practical Guide", London: Sage Publications, (1999).

[7] Hung, D., "Epistemological change through peer apprenticeship learning: From rule-based to idea-based social constructivism", International Journal of Computers for Mathematics Learning, Vol 3, No. 1, pp. 45-80, (1998).

[8] Kuhn, T., "The Structure of Scientific Revolutions", Chicago: University of Chicago Press, (1970).

[9] Mehan, H. & Wood, H., "The Reality of Ethnomethodology", NY: John Wiley & Sons, (1975).

[10] Nersessian, N., "Conceptual Change", In Bechtel, W., & Graham, G. (Eds), A Companion to Cognitive Science (pp 157-166). Oxford, UK: Blackwell Publishers, (1998).

[11] Piaget, J., "The Child's Conception of Movement and Speed", London: Routledge & Kegan Paul, (1970), (original work published in 1946).

[12] Potter, J., "Representing Reality: Discourse, Rhetoric and Social Construction", London: Sage Publications, (1996).

[13] Psathas, G., "Conversation Analysis: The Study of Talk-in-Interaction", Thousand Oaks, CA: Sage Publications, (1995).

[14] Redish, E., "The Implications of Cognitive Science for Teaching Physics", American Journal of Physics, Vol 62, No. 6, pp. 796-803, (1994).

[15] Resnick, L. "Introduction", In Resnick, L. (Ed.), Knowing, learning and instruction. Essays in honor of Robert Glaser (pp 1-24), Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).

[16] Roschelle, J., http://netra.exploratorium.edu/IFI/resources/museumeducation/priorknowledge.html (accessed on Nov 1, 1999).

[17] Sacks, H., "Lectures on Conversation", Vols. I & II, (Ed.) Jefferson, G., Oxford: Basil Blackwell, (1992).

[18] Salomon, G., http://construct.haifa.ac.il/%7Egsalomon/edMedia2000.html (accessed on Jul 18, 2000).

[19] Soong, B., "A Novel CMC-assisted Constructivist Environment for Learning Physics", MSc. dissertation, National University of Singapore, (in preparation).

[20] Strike, K. & Posner, G., "A conceptual change view of learning and understanding", In L.H.T. West and A.L. Pines (Eds.), Cognitive Structure and Conceptual Change (pp. 211-229), NY: Academic Press, (1985).

[21] Thagard, P., "Conceptual Revolutions" Princeton, NJ: Princeton University Press, (1992).

The "Half-Life" of Knowledge in the University of the 21st Century

Roger Mundell, Denise Stockley, Jeanette Muzio, Tanya Wilson, and Laureen Vickery
CEDAR, Royal Roads University, 2005 Sooke Road, Victoria, British Columbia, V9B 5Y2, Canada
roger.mundell@royalroads.ca; denise.stockley@royalroads.ca; jeanette.muzio@royalroads.ca; tanyawilson@royalroads.ca; laureen.vickery@royalroads.ca

In this paper, the role of the post-secondary institution in promoting half-life, and short half-life knowledge skills is examined. We provide an overview of the role that the university traditionally played in transmitting knowledge and lead into a discussion regarding the need for change in order to adapt to the knowledge society of the present and future. Four different models of online technologies in North American virtual universities is presented, followed by a comparison of the approaches that academia and private sector have taken towards educational technology. In conclusion, we argue that there are not competing ideologies for online learning. Rather, we are all addressing different parts of the same problem.

Keywords: **Knowledge Construction and Navigation, Methodologies, and Teaching and Learning Processes**

1 Introduction

As we move away from the industrial society to a knowledge-based society, how we view teaching and learning in the 21st century is changing as well. Duderstadt [3] argued that information technology contributed to this shift by "dramatically changing the way we collect, manipulate, and transmit knowledge". He suggested that four themes were converging in the last decade: (a) the role knowledge would play in determining security, prosperity, and quality of life for the individual, (b) movement towards globalization, (c) the ease and speed that information technology allows us to obtain information, (d) formal social structures were being replaced through informal networks and collaborations among individuals and institutions.

Currently our university system is geared toward an undergraduate student who attends the university after their high school completion. Many institutions also offer graduate courses and courses for the distance learner. Beyond that, most institutions do not have course offerings geared towards the mid-career learner. Denning [1] suggested that these professional programs would play a role in the business design of a successful university in the next century. This corresponds to a rising number of requests from industry requesting professional development for their employees to be provided by post secondary institutions [1]. This has resulted in a significant trend that the traditional divisions between post-secondary institutions, the workplace and government are becoming less visible [5].

2 Theory of the "half-life" of Knowledge

Knight [4] discussed the concept of the "half-life" of knowledge. He discussed two broad categories: (a) core knowledge or skills, and (b) economically relevant knowledge. These core skills have a longer half-life, and include things like critical thinking and reasoning skills, communication skills, and social skills. These types of skills are the on-going skills that are part of lifelong learning. The economically relevant knowledge has an even shorter half-life. These skills or knowledge relates to what makes you marketable (e.g., job skills,

knowledge of an industry or profession or trade). The concept of the half-life suggests that over a period of time this knowledge is worth less economically, therefore, in orderto retain your economic value and marketability you have to learn more.

This half-life knowledge is making us feel more pressure as we attempt to keep up with the pace of learning new skills. Twenty-five years ago, you would be able to use the knowledge you learned for approximately twenty-five years. A person could learn a skill at age twenty and build their entire career around it. Ten years ago, the average half-life for economically relevant skills was only seven years. Three years ago, it was four years. Today it is eighteen months in the knowledge society. This half-life is even less in technology related fields. Individuals in the workforce will need to constantly upgrade their skills, as their current knowledge base needs to continually evolve to keep up with how rapidly technology is changing [6].

The "early adopters", the ones in high tech and engineering, re-invent themselves by jumping from job to job to stay on the newest wave of invention. This has created the "skills shortage crisis" found in larger organizations. These people constantly migrate to newer companies and even other countries in order to stay on the cutting edge and to market themselves while their skills are still relevant. That accounts for in Canada what is coined the "brain drain" that the government assures us does not exist.

3 Need for A Change

In a 1995 study, Dolence and Norris [2] suggested that this upgrade of skills might need to take place on average every five to seven years. They predict that by the year 2010, the full-time equivalent of one-seventh of the American workforce will be enrolled in higher education or retraining. This would mean that everybody in the workforce in Canada alone needs to do some new learning every three years that would put approximately five million new learners into the system every year. This would be over and above the entry level people that are currently in the workforce. You can imagine the size of the market in The United States, or India, or Asia. (see Dolence & Norris chart).

Country	Labour Force 2000	FTE Learners	Campuses	Cost to Build Campuses
United States	141.1M	20.2M	672.00	$352.8B
Japan	64.3M	9.2M	306.00	$160.8B
Germany	37.2M	5.3M	177.00	$93.0B
United Kingdom	29.1M	4.2M	139.00	$72.7B
France	25.8M	3.7M	123.00	$64.5B
Italy	24.2M	3.5M	115.00	$60.4B
Spain	15.7M	2.2M	75.00	$39.3B
Canada	14.6M	2.1M	70.00	$36.5B
Australia	8.9M	1.3M	42.00	$22.2B
Sweden	4.6M	7M	22.00	$11.5B
			TOTAL $	$913.7Billion
The World	2,752.5M	100.0M+	3,300.00	??????

To accommodate this demand would require a re-invention of our education and training systems to cope with these new demands. For now, competition is not the issue. We have not yet refined a product or an approach that promises to satisfy the enormous demand that is already emerging, and that will reach a crescendo over the next decade. To add to this increasing demand, the first wave of the so-called "echo-boomers" is set to hit our post-secondary system this year. This increase will pressure an already overburdened system, if we keep it the way it is today.

4 Application of Online Technology in Academia

The following are four different models of online technology usage in four North American virtual Universities.

BEST COPY AVAILABLE

Athabasca:

Pioneers in electronic distance education, they focused on the time and place needs of their students. They offer self- paced learning with mentors and instructors available online, instead of by snail mail. Their program is built on Lotus notes. They are now moving into some more collaborative models, particularly with their MBA program, this is cohort based. They are reporting phenomenal demand, but still report a high rate of in-completion.

Western Governors University:

This university can be viewed as more of an accreditation collective. They offer a widely diverse collection of program offerings using diverse delivery technologies from diverse university departments. It has been slow to get off the ground, but the cross-accreditation concept is good, but still needs to evolve.

Royal Roads University:

A hybrid model. Students attend the campus at the beginning, middle, and end of their degree program for a very intensive "boot-camp" like experience designed to bond them as a community. In between, they work online in-group oriented and collaborative exercises. They go through the program in "Cohorts" all at the same time, with the same start and finish dates, but with flexibility built into each course to allow for "learner-centred" approaches. In this way, the University can put 1800 students through a former military college with only 300 classroom seats. Most students are fully employed while taking the programs, and are able to apply immediately what they learn.

Tech-BC:

Here's an interesting model. Perhaps the one with the most implications for Universities as we know them. Imagine if you were to divide the learning objectives into the ones that must be learned on campus and the ones that can be accomplished online. Have the students attend University a couple of days per week and do the rest of the work online. Leverage the facility, and potentially offer partnered learning with industry while the student remains employed. We think this model offers a blueprint for how we can leverage overtaxed facilities. This model is dependent of course on having a market within commuting distance.

If we revisit the concept of long half-life learning, and short half-life learning, we envision a future where we use Universities to teach that "long half-life" stuff that is best learned on campus, or face to face with other students. In this model, academics drive the "long-half life" stuff, but we use the technology to cover the "short half-life" material that is constantly changing, and is driven by economics and industry. There will be some crossover of course, but it is interesting to note that there are already some noticeable leanings in the two camps of academia and industry.

Academia and the Private Sector

The following is a comparison in general trends between the Academic and Private sectors:

Academic online programs tend to favour:

- Asynchronous
- Community based
- One to many
- Semester based
- Everyone covers everything

These things lend themselves to those "long half-life" skills.

Private sector training has tended to favour:

- Synchronous
- Learner-Centred
- Many to one
- Just in time
- Just enough
- Performance support

These, you could argue, are better suited to the "short half-life" skills.

So should we be marrying all these techniques together? Or on the other hand, should each sector start to focus on the niche to which they are best suited? Of course for the last 40 years, the lines between academic training and job-skill training have become increasingly blurred. Employers tell us they value critical thinking, reasoning skills, pattern recognition, organizational skills, and communication abilities. Many tell us they find these skills are well developed in individuals who have studied for example, anthropology, music, and history. They like these people to have a University education; however, they don't want to spend a year or six months grooming them after University, because today's graduates don't stay that long. They need to have the necessary job skills from day one.

These are those "short half-life" skills. Obviously, we cannot take two, three, or even four years to teach skills with a half-life of eighteen months. Would the answer be a model like the one at Tech-BC or at Royal Roads? On the other hand, will the new educational institution be a combination of new kinds of university offerings, perhaps with a robust new private industry creating big budget online units that can be used as adjuncts to University courses?

5 Concluding Thoughts

The point we are trying to lead to is that there are not really competing ideologies for online learning. We all are actually all addressing different parts of the same problem. We are like the six blind men in the parable of the elephant.

The Blind Men and the Elephant
by John Godfrey Saxe

It was six men of Indostan
To learning much inclined,
Who went to see the Elephant
Though all of them were blind,
That each by observation
Might satisfy his mind.

In the next six verses, each of the blind scholars grasps a different part of the elephant. One thinks that the elephant is like a snake, and another thinks they are like a tree, another like a fan, and in the last verse, it says,

And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong.
Though each was partly in the right,
They all were in the wrong!

We think this describes quite well our present confusion about technology and where it will fit into our need to learn. We are all working on different bits of the elephant. The question we need to address as a community at this and other academic conferences, are where do we go from here?

References

[1] Denning, P.J. (1996). Business designs for the new university. Educom Review, 31(6), 20-30.

[2] Dolence, M.G., & Norris, D.M. (1995). Transforming higher education: A vision for learning in the 21st Century. Ann Arbor, MI: Society for College and University Planning.

[3] Duderstadt, J.J. (1997). The future of the university in an age of knowledge. Journal for Asynchronous Learning Networks, 1(2). Available: http:www/aln.org/alnweb/journal/issue2/duderstadt.htm

[4] Knight, P.T. (1997). The half-life of knowledge reform of the education sector for the global knowledge-based economy. Paper prepared for the Forum on Education in the Information Age, Cartagena, Colombia, 9-11 July 1997.

[5] Lewis, B., Smith, R., & Massey, C. (1999). Mirroring the networked society: Government policy, higher education, and telelearning technology in Canada. Canadian Journal of Communication, 24, 319-336.

[6] Muzio, J. (1999). The development of a prototype learner-centred electronic distributed learning course for Royal Roads University. Doctoral Dissertation Nova Southeastern University.

The Artistic Interface - A Transition from Perception to Screen

Peter D Duffy
Queensland University of Technology
66 Harts Rd, Indooroopilly, Brisbane, Qld 4068
p.duffy@kormilda.qld.edu.au

1 Introduction

At present a dichotomy of computer art instruction exists, where the computer as an art medium, presents the learner with almost limitless possibilities of image manipulation; yet instructional methodology and current art curriculum provide no coherent framework through which the learner can effectively access this information.

2 Research

Throughout the last five years the researcher has taught numerous art concepts and involved students in art tasks using the computer. The reality of the researcher's teaching situation is that the use of the computer within an art context is not debated, but accepted as a part of the everyday teaching process. After several years and testing different ways of approaching the teaching of computer programs several issues emerged which warranted further consideration:
1. Frustration exists due to the limited time that students had available to use the computer and the amount of information students were expected to utilize.
2. Many computer graphic programs are structured in similar ways (display a similar interface) and use similar symbols (icons) to represent functions within the program
3. Students seem unaware of these similarities and unable to transfer an understanding of one programs GUI (Graphic User Interface) to another computer graphic program.
4. Students appeared to have no mental map or problem solving strategies with regard to searching for answers to problems within a computer art environment.
These thoughts led to the intention within this research study which is to document the qualitatively different ways that students interact with the graphic user interface of computer graphic software in an art education context in order to create art.

It is hypothesized that students need to build some form of mental model regarding the software program they are interacting with in order to understand its application domain. That by examining the influence of different types of interface cues regarding navigation within a computer art context a greater understanding of students' conceptions regarding utilizing the computer as an artistic medium could be facilitated. Interface cues in this regard pertaining to the icons, layout and menus presented to the user. This is defined by the researcher as the Artistic Interface. This Artistic Interface is the interaction that occurs between the student's artistic intent and the graphic user interface of the computer.

The underlying art educational assumption here is that the clearer the mental model the student has, the more capable the student will be at understanding the program, at locating a specific function and achieving the desired artistic result. Within the context of this study it is postulated that students with a clearer mental model of the graphic user interface (GUI) will have a more effective art educational experience (a more effective Artistic Interface) when utilizing the computer as an artistic medium.

In order to develop this 'mental model' a phenomenographical mode of inquiry will be used. Roth and Anderson (1988) stated that they consider learning to be a change in one's view of some phenomenon. Also Marton (1992) suggested that: "In order to develop teaching methods that help students arrive at new understandings of a given phenomenon, we must first discover the finite ways individuals may understand that phenomenon. Then, through experimentation, we may discover the most effective ways to bring

students from a given conception to another, more advanced one, that is, from 'misunderstanding' to understanding." (p.253) Thus if students' conceptions of how they interact with the computer in an art educational context can be documented, then a learning framework could be developed which could enhance their understanding of the GUI of a particular program, and maybe other computer graphic programs.

3 Educational Considerations

Within a consideration of the influences of the GUI this study situates itself into the line of those devoted to the analysis of a possible correlation between the user's cognitive skills and his / her navigation abilities in an interactive, iconic, multimedia environment. This has been supported and further documented by Castelli, Colazzo, and Molinari, 1994; Elm and Woods, 1985; Osborne, 1990; Thuring, Hannemann, and Haake, 1995.

An effective analysis of students utilizing the computer in art education must begin with 'what is the student trying to do? Previous studies (Elm and Woods, 1985; Osborne, 1990) have demonstrated that getting lost is a consequence of the lack of a clear conception of the relationships within the system. In relation to this study this statement seems to imply that an effective use of the computer as an artistic medium depends upon the ability of the user to abstract from the system display discrete understandings relevant to the desired artistic result and that this may involve building a conceptual representation of a particular software programs GUI. It is further postulated within this study that if a learner can construct an effective mental map, or conceptual representation of a particular software programs GUI then this mental map maybe facilitate an easier and more effective understanding of another program due to the similarities in their GUI.

4 Conclusions

There is ongoing educational debate about the nature of the information society and the range of 'literacy's' needed to handle, understand, and communicate information in a variety of forms (Baker, Clay and Fox, 1996). The researcher has suggested that literacy in the information age requires not only the skills to operate the technology, but also the ability to identify and structure a line of inquiry in order to solve a particular problem. In this instance what is being analyzed is the range of 'literacy's' needed to form a line of inquiry into a computer art domain.

This research into the Artistic Interface is an attempt to document students' understanding of differing computer graphic arbitrary symbols (a software programs vocabulary) placed according to a systematic formula (a software programs grammar) to produce an understanding of various icons (pictograms used to represent a function of the computer). The researcher will seek to examine the qualitatively different ways that students understand the GUI in a particular computer graphic program and within a particular art educational context. This will involve a phenomenographical study that will lead to further understandings regarding students' perceptions of the Artistic Interface.

References

[1]. Baker, D.A., Clay, J., and Fox, C. (1996). "Challenging ways of knowing in English, maths and science". London: Falmer Press

[2]. Castelli, C., Colazzo, L., and Molinari, A. (1994). "Ht-Dedalus: Analysis of some models of hypertext performance". EC Newsletter, 6(1), 15 - 27.

[3]. Elm, W.C., and Woods, D.D. (1985). "Getting lost: A case study in interface design". Human Factor Society, 927 - 931.

[4]. Marton, F. (1992). "Phenomenography and "the art of teaching all things to all men"" Qualitative Studies in Education, 5(3), 253-267.

[5]. Osborne, D.J. (1990). "Browsing and navigation through hypertext documents: A review of the human-computer interface issues". Interactive Multimedia, 1, 3-32.

[6]. Roth, J.J., and Anderson C.W. (1988). "Promoting conceptual change and learning from science textbooks". In P.Ramsden (ed.) Improving learning: new perspectives. London: Kogan Page.

[7]. Thüring, M., Hannemann, J., and Haake, J. (1995). "Hypermedia and cognition: Designing for comprehension". Communications of the ACM, 38(8), 57-66.

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

Chao-Fu Hong, Chiu-e Chen*, Ming-Hua Hsieh, Cheng-Kai Huang and Shih-Hsiung Chang
*Aletheia University and Dah-Yuan Elementary School**
cfhong@email.au.edu.tw
No. 32 Chen-Li Str. Tamsui City Taiwan ROC
Tel: 02-26212121-5536

After we discussed with teachers to understand their instructional politics, we integrate the teachers' instructional politics, the process of knowledge generation, memorizing to construct the concept graph. Furthermore, we used the dynamic web pages to track the learner's learning and used the tracking data to reconstruct the learner how to construct his knowledge to understand the learner's thinking logic. In this paper we proposed the dynamic knowledge generation model and learning ability potential model. These were according to link the concepts to generate the knowledge. As following above idea we integrated the constructing materials and the dynamic knowledge generation to consist the expert system. The system would analyze his learning data to rebuild he how to build his knowledge, to understand his learning ability and he already built the whole knowledge or not. Rely on these results the system could supply the suitable materials to him for study. And the learning cycle would continue until the learner completely constructs the new knowledge into his ground knowledge. Finally, we could from proto type system to collect the experimental data and rebuilt the learner's learning steps, then followed the expert system to understand his learning ability potential. The system could supply a suitable material to him and help him to cross over the learning obstacle. These results also proofed that our model could really understand the learner's thinking logic and learning potential.

Keywords: **dynamic knowledge generation, learning potential ability, concept graph, expert system**

1 dynamic knowledge construct process of learners

A meaningful learning must accord with three main conditions: Accepting the learning material, having the knowledge of dealing with learning material, and firing this knowledge at the learning time, (Mayer, 1975,1984). Accordingly, learning behavior has originality, creation and activity. It's easy to make learners to find the meaning of learning. If we want learners to have meaningful learning, we must do: "if you want to teach active knowledge for learners, you have to understand how to get the knowledge first. It's the same as you want to teach learners to think, you have to understand how learners think first." Therefore, if want to know the learner how to learn the knowledge, it can use the information process theory to discuss the human how to process his information like Fig.1. we design a structural material like a story, attaching pictures, and animations that attract learners. At the last section we give an additional problem among the units, which give learners integrating the prior knowledge. Then, the blind spot in every learner is obtained by using the model of a learning barrier analysis. The reason of inspiring learning barrier is obtained by using learners' browse web pages order and frequency. (Note: 3D learning barrier analysis) Meanwhile, learners will dynamically update their constructional knowledge network by learning number, browsing process, and test frequency. (Note: all of attributions of cognition nodes are dynamical.) Because learners are not static learning, we developed a dynamical model as Fig.1..

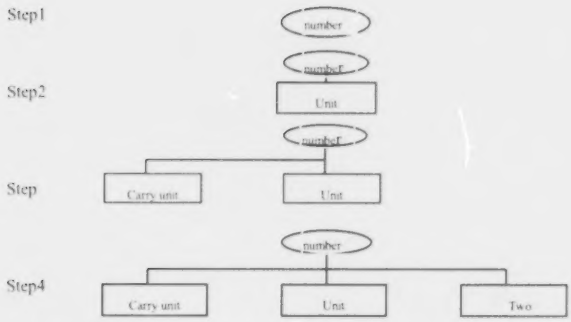


Fig.1 dynamic knowledge construct process of learners

2 the dynamical knowledge generation and learning ability analysis

In our model (**the model of dynamical knowledge generation and learning ability analysis**), using the teachers teaching experience, the system partition a judge learners' ability to achieve learning and the label of understanding course. And the Table1 is appropriate inference rule, what are the schools' teachers to classify the learners' learning ability.

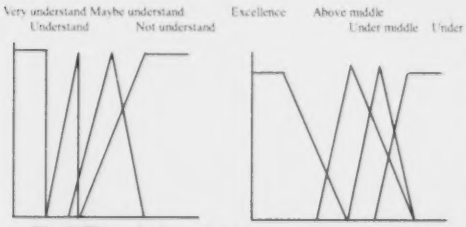


Fig.2 The relation of achieve a learning and the label of understanding course

Table 1. Inferring rule

TIMES / RESULT	UNDER	UNDER MIDDLE	ABOVE MIDDLE	EXCELLENCE
Cannot Understand	-2	-1	-1	0
Maybe Understand	-1	-1	0	+1
Understand	-1	0	+1	+2
Very Understand	0	+1	+1	+2

After the student had to go to the chapter's test. The testing results would according the learning obstacle analysis model to find his incompletely building knowledge and compared with the expert system to understand his learning ability. Finally, the system searched the suitable materials for him to study. The graph of learning cycle is shown in Fig. 3.

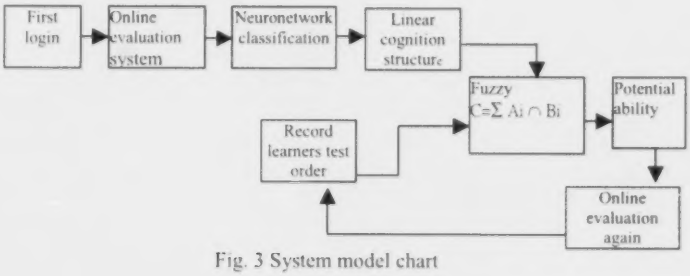


Fig. 3 System model chart

3 Conclusion

Although teacher can control his class ambiance and teaching trends, but he has many different individual

learners in the classroom. If teacher cannot understand the learners how to learn and how to integrate their knowledge on his teaching, the teaching does not only let learner have a stuff learning, but also increase his teaching load. Therefore, in our paper we proposed "dynamical knowledge-generation model and learning ability analysis", to integrate the conceptual knowledge generation into structuring material and connect with the dynamical estimating expert's system. This system can collect what material learner had learned and the result of online testing was transmitted to the system. These real data used our analyzing model to decide his learning ability and supplied a suitable material to him for study. Thus, we believe our system do not only can help the teacher to understand learner how to build his new knowledge, but also can reduce the learner's learning barrier.

Reference

[1] Chao-Fu Hong、Yueh-Mei Chen*、Yi-Chung Liu、Tsai-Hsia Wu :Discuss 3D cognitive graph and meaningful learning,ICCE99

[2] Chao-Fu Hong、Yi-Chung Liu、Yueh-Mei Chen*、En-Yi Jen :Apply OO and T cell Cognitive Structurein Discovery Teaching,ICCE99

A Distance Ecological Model to Support Self/Collaborative-Learning via Internet

Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5620; Fax: +81-424-89-6070
E-mail:okamoto@ai.is.uec.ac.jp

With the rapid development of information technology, computer and information communication literacy has become the main new ability required from teachers everywhere. For enhancing teaching skills and Internet and multimedia information literacy, a new teachers' education framework is required. Here we propose a Distance Educational Model, as a School-Based Curriculum Development and Training-System (SCOUTS), where a teacher can learn subject contents, teaching knowledge, and evaluation methods of the students' learning activities (subject: "Information") via an Internet based self-training system. We describe the structure, function and mechanism of the model, and then show the educational meaning of this model in consideration of the new learning ecology, which is based on multi-modality and new learning situations and forms.

Keywords: **Distance Education, Teacher Training System, Learning Ecology, School Based Curriculum Development**

1 Introduction

Recently, with the development of information and communication technologies, various teaching methods using Internet, multimedia appeared. Most of them emphasize, in particular, the aspect of collaborative communication between students and teacher during interactive teaching/learning activities. Therefore, now-a-days it is extremely important for a teacher to acquire computer communication literacy [1]. So far, there were many studies concerning system development, which aim at fostering and expanding teachers' practical abilities and comprehensive teaching skills, by using new technologies, such as computers, Internet, multimedia. In Japan, systems using communication satellites such as SCS (Space Collaboration System) are developed and used as distance education systems between Japanese national universities. In the near future, a teacher's role will change from text based teaching, to facilitating, advising, consulting, and his/her role will be more that of a designer of the learning environment. Therefore, a teacher has to constantly acquire/learn new knowledge and methodologies. We have to build a free and flexible self-teaching environment for them under the concept of "continuous education". At the same time, we build a collaborative communication environment to support mutual deep and effective understanding among teachers. In this paper, we propose a Distance Educational Model, which is based on the concept of School Based Curriculum Development and Training System, advocated by UNESCO and OECD/CERI (Center for Educational Research and Innovation), and describe the structure, function, mechanism and finally the educational meaning of this model. Based on such a background, it is necessary to construct an individual, as well as a collaborative learning environment, that supports teachers' self-learning/training, by using Internet distributed environments and multimedia technologies. A teacher can choose the most convenient learning media (learning form) to learn the contents (subject units) that s/he desires.

2 Distance Educational Model based on SCOUTS

Until now, when a teacher wanted to take a class on "IT-education", s/he had to leave the office or school. Now it is possible to learn various kinds of subject contents by building a virtual school on the Internet environment.

2.1 Distance Educational Model

Our Distance Educational Model is built on 3 dimensions. The first one is the subject-contents, which represents what the teachers want to learn. The second one represents the teaching knowledge and skills as well as the evaluation methods of the students' learning activities. From the third axis, the favorite learning media (form) can be chosen, e.g., VOD, CBR, etc. By selecting a position on each of the 3 axes, a certain cell is determined. A cell stands for a "script", which describes the instruction guidelines of the learning contents, the self-learning procedure, and so on (Fig. 1). In the following, I will explain the meaning of each axis in more details.

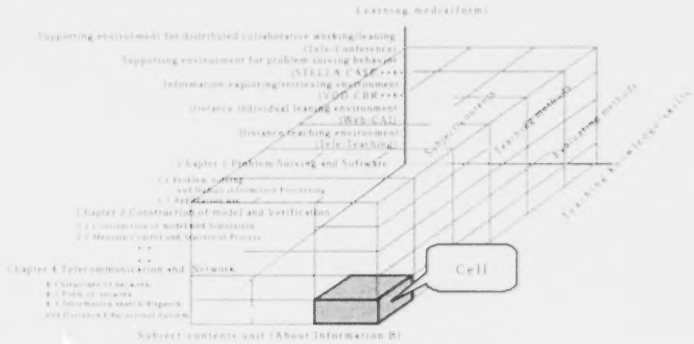


Fig.1 Structure of the Distance Educational Model

2.1.1 Subject –contents unit

In this study, we focus on the subject called "Information", which is due to be established as a new obligatory subject in the regular courses of the academic high school system in Japan. The subject "Information" is composed of three sub-subjects, "Information A", "Information B" and "Information C". The contents of each sub-subject are as follows.

Information A: *raising the fundamental skills and abilities to collect, process and transmit "information" using computers, the Internet and multimedia.*

Information B: *understanding the fundamental scientific aspects and the practical usage methods of "information".*

Information C: *fostering desirable and sound behavior of participation, involvement and contribution in an information society; understanding peoples roles, and the influence and impact of technology, in the new information society.*

2.1.2 Teaching knowledge/skills

On this dimension, we have represented sub-subject contents, teaching methods and evaluating methods for "information" classroom teaching. 'teaching methods' stands for how to use and apply IT, to enhance a student's problem solving ability, involving comprehensive learning activities, like problem recognition, investigation and analysis, planning and design, implementation and executing, evaluation, report and presentation. We aim at teachers acquiring the proper students' achievements evaluating skills, according to each of the above activities.

2.1.3 Learning media (form)

This dimension represents five different learning environments, as follows: 1) "Distance teaching environment (Tele-Teaching)" based on the one-to-multi-sites telecommunications 2) "Distance individual learning environment (Web-CAI)" based on CAI (Computer Assisted Instruction) using WWW facilities 3) "Information-exploring and retrieving environment" using VOD, CBR (Case Based Reasoning) 4) "Supporting environment for problem solving", by providing various effective learning tools 5) " Supporting environment for distributed collaborative working/learning" based on the multi-multi-sites telecommunications. Brief explanations for each environment are given in the following.

(1) ***Distance teaching environment (Tele-Teaching)****: This environment delivers the instructor's lecture image and voice information through the Internet, by using the real-time information dispatching function via VOD (Video On Demand).*

(2) ***Distance individual learning environment (Web-CAI)****: This environment provides CAI (Computer Assisted Instruction) courseware with WWW facilities on the Internet.*

(3) ***Information-exploring and retrieving environment****: This environment delivers, according to the teacher's demand, the instructor's lecture image and voice information, which was previously stored on the VOD server. For delivery, the function of dispatching information accumulated on the VOD server is used. In addition to it, this environment provides a CBR system with short movies about classroom teaching practices.*

BEST COPY AVAILABLE

(4) ***Supporting environment for problem solving****: This environment provides a tool library for performance support, based on CAD, Modeling tools, Spreadsheets, Authoring tools, and so on.*
(5) ***Supporting environment for distributed collaborative working and learning:*** *This environment provides a groupware with a shared memory window, using text, voice and image information for the trainees.*

2.2 • Cell" definition

The concept of a "cell" in the Distance Educational Model is quite important because it generates the training scenario, including the information to satisfy the teacher's needs, the subject materials learning-flow and the guidelines for self-learning navigation. The frame representation of the "cell" is shown in Table 1. These slots are used when the system guides the process of the teacher's self-learning.

Table 1 The frame representation of the "cell"

	Frame name	Slot-value
Slot-name	Learning objectives for a student	Subjects which should be understood Subjects which should be mastered
	Subject-contents	The unit topic
	Teaching method	The students' supervision method and instructional strategies
	Evaluating method	The students' evaluation method
	Useful tools	The software used for the training activity
	Operational manual of tools	The software operation method used for the training activity
	Prepared media	The learning media which can be selected
	Guide script	The file which specifies the dialog between the trainee and the system

3 Outline of the teacher training system

The system configuration of the teacher's training environment is composed of two subsystems based on the Distance Educational Model. One of the subsystems is the training system, where a trainee can select and learn the subject adequate for him/her guided by the script in the "cell". The other subsystem is an authoring system with creating and editing functions for "cell" description. The users of the second environment are, e.g., IT-coordinators or IT-consultants, who can design lecture-plans in this environment.

3.1 Training system

The training system aims to support teachers' self-training. The configuration of this system is shown in Fig.2. The role of this system is first to identify a "cell" in the model, according to the teachers' needs. Then, the system tries to set up an effective learning environment, by retrieving the proper materials for the teacher, along with the "guide script" defined in the corresponding "cell". Therefore, the system offers programs for both Retrieving and Interpreting. The training system works as shown in the following.

STEP 1: Record the teacher's needs.
STEP 2: Select a "cell" in the Distance Education Model according to the teacher's needs.
STEP 3: Interpret the "cell" in the guide WM (Working Memory).
STEP 4: Develop the interactive training with the teacher according to the "guide script" in the guide WM.
STEP 5: Store the log-data of the dialog (collect information on the learning histories and teachers' needs and behaviors).
STEP 6: Provide the needed applications for the user's learning activities and set up an effective training environment.
STEP 7: Give guidance-information, according to "cell" script guidelines, decide on the proper next learning step "cell".

The interpreter controls and develops the dialog process between user and machine according to the information defined in our "guide script" description language. This "guide script" description language (GSDL) consists of some tags and a simple grammar for interpreting a document, similar to the HTML (Hypertext Markup Language) on the WWW. The interpreter understands the meanings of the tags, and interprets the contents. An example of GSDL is shown below.

*(1)**<free>***	*Definition: description of the text (instruction)*
*(2)**<slot (num.)>***	*Definition: a link to a slot value in the "cell"*
*(3)**<question>***	*Definition: questions to a trainee*
*(4)**<choice>***	*Definition: branching control according to a trainee's response*
*(5)**<exe>***	*Call: to relevant "cells"*
*(6)**<app>***	*Definition: applications used for training activities (e.g., Tele-Teaching, etc.)*

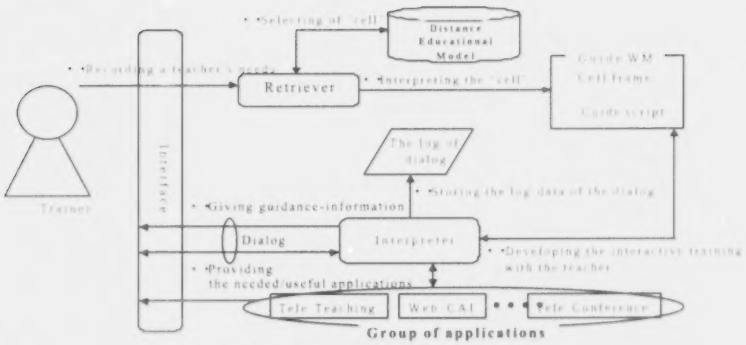


Fig.2 Configuration of Training system

3.2 Authoring system for creating and editing a "cell" description

The system provides an authoring module to create and edit the information in the "cell". This module also offers the function of adding new "cells", in order to allow supervisors (experienced teachers) to design the teachers' training program. The configuration of this system is shown in Fig.3. The tasks that can be performed by this system are: adding new "cells", editing the existing "cells", receiving calls for Tele-Teaching lectures, and managing the lectures schedule. This system is composed of the "cell" frame creating module, and the "guide script" creating module. A cell design can be performed as shown in the following.

STEP 1: Get the slot-values of "student's learning objectives", "subject-contents/teaching method/evaluating method", and "useful tools" from the "cell".
STEP 2: Substitute the return value of the slot of the prepared media with the training-contents corresponding to the user's needs.
STEP 3: Substitute the slot-value in the "cell" for the corresponding tag in the "guide script" template.
STEP 4: If "Tele-Teaching" as learning media is selected, then get some information about the lecture, by referring the lecture-DB and the VOD short movie-DB.
STEP 5: Add the new "cell" to the Distance Educational Model.

The lecture-database consists of "lesson managing files" containing user-profile data, lecture schedules, trainees learning records, lecture abstracts, and so on. The "guide script" template file contains tag-information, written in the "guide script" description language (GSDL), for all subject-contents items in the Distance Educational Model.

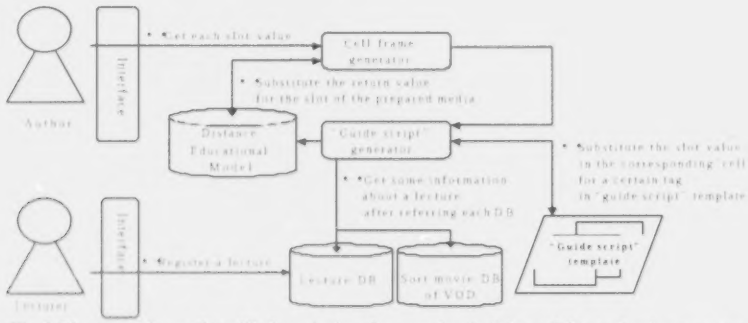


Fig.3 The procedure of "cell" description for creating/editing of the authoring system

4 Conclusions

This paper proposed the Distance Educational Model called the School Based Curriculum Development and Training System (SCOUTS). This model stands for the networked virtual leaning environment based on a three dimensional representation, which has on the axes 1) subject-contents, e.g., "information" for the training, 2) teaching knowledge, skills and evaluation methods and 3) learning and teaching media (forms). This represents a new framework for teachers' education in the coming networked age. We have mentioned the rationale of our system and explained the architecture of the training system via a 3D-representation model. Furthermore, we have described a "guide script" language. This system is superior to a simple rule-

BEST COPY AVAILABLE

based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. The aim of our system is to support teachers' self-learning, provided as in-service training. At the same time, we need to build rich databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" will be implemented. As a result, we trust that a new learning ecology scheme will emerge from our environment.With this system, we can construct various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalized knowledge-acquisition and knowledge-sharing, via the communication process, and support learning methods such as "Learning by asking", "Learning by showing","Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining"'. Among the learning effects expected from this system, we also aim at meta-cognition and distributed cognition, such as reflective thinking, self-monitoring, and so on. Therefore, we expect to build a new learning ecology, as mentioned above, through this system. Finally, we will apply this system to the real world and try to evaluate its effectiveness and usability from experimental and practical point of view.

References

[1]. Nishinosono, H.: A Teacher Education System for Information Education Teachers at High School Level in the Information Society. Proc. of the conference JET, pp.523-524 (1998)

[2] Collis, B.: Design, Development and Implementation of a WWW-Based Course-Support System. ICCE99, pp.11-18, IOS Press (1999)

[3] Seki, K., Takaoka, R., Matsui, T., Okamoto, T.: A Teaching Model in Distance Education based on Teacher's Needs. IEICE Technical Report, ET98-12, pp.49-56(1998)

[4] UNESCO Report: World Declaration on Higher Education for the 21 Century Vision and Action, Paris (1998)

[5] Salvador, L. G.: Continuing Education Through Distance Training. ICCE99, pp.512-515, IOS Press (1999)

The Internet-based Educational Resources of the U.S. Federal Government

Andy Wang* and Krishelle Leong-Grotz**
**University of California at Berkeley,*
2325 Blake Street, #201, Berkeley, CA 94704,
andy@café.berkeley.edu
***Case Western Reserve University*
School of Medicine, Class of 2003,
ktl3@po.cwru.edu

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right information on a particular topic for their students takes time. Current initiatives, such as FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning resources. This paper aims to introduce some of the United States' successful programs.

1 Introduction

One of the main priorities of the Clinton administration is to make sure that all Americans have the best education in the world. One of the goals of this "Call to Action for American Education" is to bring the power of the Information Age into all schools in the United States. This initiative requires connecting every classroom and library to the Internet, making sure that every child has access to multimedia computers, giving teachers the training they need to be as comfortable with the computer as they are with the chalkboard, and increasing the availability of high-quality educational content. When America meets the challenge of making every child technologically literate, children in rural towns, suburbs, and inner city schools will have equal access to the same knowledge base.

United States Federal agencies have made significant contributions to expanding this knowledge base. For example, "White House for Kids," is a home page with information on the history of the White House. NASA has a K-12 initiative, allowing students to interact with astronauts and to share in the excitement of scientific pursuits such as the exploration of Mars and Jupiter, and the experiments conducted on the Space Shuttle. Students participating in the GLOBE project (Global Learning and Observation for a Better Environment) collect actual atmospheric, aquatic, and biological data and use the Internet to share, analyze, and discuss the data with scientists and students all over the world. With support from the National Science Foundation, the Department of Energy, and the Department of Defense's CAETI program (Computer-Aided Education and Training Initiative), the Lawrence Berkeley Laboratory has developed a program that allows high school students to request and down-load their own observations of the universe from professional telescopes.

Of these government programs, four of these are as follows:

2 FREE (Federal Resources for Educational Excellence)

On April 18, 1997, President Clinton asked Federal agencies to determine what "resources you can make available that would enrich the Internet as a tool for teaching and learning." In response, more than 40

Federal agencies formed a working group to make hundreds of federally supported education resources available on the FREE website.

Some of the subjects of the FREE include arts, educational technology, foreign languages, health and safety, and mathematics. Agencies involved include Centers for Disease Control and Prevention, National Gallery of Art, National Science Foundation, Peace Corps, Consumer Product Safety Commission, and the Smithsonian Institution.

3 GEM (Gateway to Educational Materials)

GEM began in 1996 after the National Library of Education (NLE) Advisory Task Force sought to find ways to apply library and information science skills to help educators find lesson plans and teacher guides on the Internet. GEM provides links to free Internet materials, partially free materials, and to resources that require a fee or registration to be used. There are two ways to access the education resources on GEM —Browsing and Searching. Browsing GEM is sampling from lists of predetermined categories (e.g. mathematics, language, education by grade level). Searching GEM is looking for any information containing the keywords of the query (e.g. algebra lesson plan). This website provides access to educational materials found on various federal, state, university, non-profit, and commercial Internet sites.

4 ERIC (Educational Resources Information Center)

The Ask ERIC service (Education Resources Information Center), supported by the Department of Education, has a virtual library of more than 900 lesson plans for K-12 teachers, and provides answers to questions from educators within 48 hours -- using a nationwide network of experts and databases of the latest research. Abstracts of some 1,300 (Educational Research Information Center) ERIC Digests are available online and text-searchable. A menu of services offered on the Internet not only introduces the user to ERIC documents, but also leads to other databases in education. It began in 1992 as a project of the ERIC Clearinghouse on Information and Technology and is now, with the ERIC Clearinghouse, a component of the Information Institute of Syracuse at Syracuse University. Today, Ask ERIC encompasses the resources of the entire ERIC system and beyond. Got an education question? Ask ERIC! The main components of Ask ERIC are:

1. Ask ERIC Question & Answer (Q&A) Service
   Need to know the latest information on special education, curriculum development or other education topics? Just Ask ERIC! When you submit your education question to Ask ERIC Q&A, you' ll receive a personal e-mail response from one of our network information specialists within two business days! We will send you a list of ERIC database citations that deal with your topic and will also refer you to other Internet resources for additional information. It' s that easy!

2. Ask ERIC Virtual Library
   The Ask ERIC Virtual Library contains selected educational resources, including 1000+ Ask ERIC Lesson Plans, 250+ Ask ERIC Info Guides, searchable archives of education-related listservs, links to Television Series Companion Guides, and much more!

3. Search the ERIC Database
   The ERIC database, the world' s largest source of education information, contains more than one million abstracts of documents and journal articles on education research and practice. By searching Ask ERIC' s web-based version of the ERIC Database, you can access the ERIC abstracts, which are also found in the printed medium, Resources in Education and Current Index to Journals in Education. The database is updated monthly, ensuring that the information you receive is timely and accurate.

5 Parents Guide to the Internet (16 page informational booklet)

This new, 16-page booklet, produced by the U.S. Department of Education, gives parents an introduction to the Internet and is "intended to help parents --regardless of their level of technological know-how--make use of the on-line world as an important educational tool. The guide cuts through the overwhelming amount of

consumer information to give parents an introduction to the Internet and how to navigate it. Most importantly the guide suggests how parents can allow their children to tap into the wonders of the Internet while safeguarding them from its potential hazards.

This guide was produced with the sort of collaborative effort that American schools need in order to succeed. U.S. Department of Education staff worked with leaders from parent and education organizations, the private sector, nonprofit groups and others in order to give parents a clear and comprehensive overview of the Internet and its vast educational potential. In the same way, schools need support from every corner of the community in order to provide students with a high-quality education.

6 Conclusion

More than ever before, a high-quality education offers Americans the best path to a rewarding career and a fulfilling quality of life. As citizens of the Information Age, Americans must include access to technology among the elements of an education that is based on high standards of achievement and discipline. But incorporating technology into the Nation's schools is too big a job for the schools to tackle on their own. Teachers need support and involvement from parents, grandparents, businesses, cultural institutions and others in order to make effective in-class use of the wonders of technology.

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right resource on a particular topic for their students takes time. And time is in short supply for our teachers. Current initiatives, such as those outlined, FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning.

References

1. Becker, Henry J. Information Technology in Teacher Education: Survey of Current Status. Washington, D.C.: National Technical Information Service, U.S. Department of Commerce, March 1994.
2. Bernie Poole's EdIndex, Web Resources for Teachers and Students, http://www.pitt.edu/~poole/edmenum.html
3. Consortium for Policy Research in Education. CPRE Policy Briefs, June 16, 1995.
4. Cotton, E. G. (1998). "The Online classroom: Teaching with the Internet, third edition." Bloomington, IN: EDINFO Press. (ISBN-1-883790-29-8). (ED 413 606)
5. Educational Resources Information Center (ERIC) web site, http://www.askeric.org/
6. Federal Resources for Educational Excellence (FREE) web site, http://www.ed.gov/free/.
7. Gateway to Educational Materials (GEM) web site, http://www.thegateway.org
8. Junion-Metz, G. (1996). "K-12 resources on the Internet: An instructional guide." Internet workshop series, number 5. San Carlos, CA: Library Solutions Press. (ISBN-1-882208-14-5). (ED 389 316)
9. K-12 computer networking. (1995). "The ERIC Review," 4(1). (ED 392 413)
10. Lankes, R. D. (1996). "Bread and butter of the Internet." ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 402 925)
11. Maeroff, Gene I. Changing Teaching: The Next Frontier. The National Foundation for the Improvement of Education, 1994.
12. McKinnon, P. Alistair, and Clesson S. Bush. "Technology for Education: What is the Federal Role?" Educational Technology 4 (1993): 37-41. Michalski, Jerry. Release 1.0: Esther Dyson's Monthly Report. New York: EDVenture Holdings, Inc., May 1995.
13. Milken Family Foundation. Expanding Classroom, Shrinking World: Resource Guide. Los Angeles, May 4, 1995.
14. National Center for Education Statistics, U.S. Department of Education. Advanced Telecommunications in U.S. Public Schools, K-12. Washington, D.C.: U.S. Government Printing Office, 1995.
15. National Center for Education Statistics, U.S. Department of Education. Annual Revenues and Expenditures: Public K-12 Schools. Washington, D.C.: U.S. Government Printing Office, 1991 and 1994.

16. Parents Guide to the Internet web site, http://www.ed.gov/pubs/parents/internet/
17. Serim, F. & Koch, M. (1996). "NetLearning: Why teachers use the Internet." Sebastopol, CA: Songline Studios, Inc. and O'Reilly & Associates, Inc. (ED 396 700)
18. Tennant, R. (1996). Internet basics: Update 1996. ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 392 466)
19. U.S. Congress, Office of Technology Assessment. Teachers and Technology: Making the Connection. Washington, D.C.: U.S. Government Printing Office, April 1995.
20. U.S. General Accounting Office. School Facilities: America's Schools Not Designed or Equipped for 21st Century. Washington, D.C.: U.S. Government Printing Office, 1995.

The network learning supported by constructivism

Song-Min Ku
E-mail:sppman@icemail.nknu.edu.tw

1 Introduce

Network learning gives a chance to educators to rethink and investigate the learning modules and styles. Therefore the educators can rearrange learning strategies and develop new learning environment to validate the learning strategies and ideas. Although network learning cannot affect the learning completely and fully, at least network learning offer the environment to fulfill the ideas of constructivism.

2 Setting up the network learning environment

2.1.To provide multiple and abundant materials:

The network learning resources provide the objective and existed knowledge, the multi-angle and multi-level experiences to give learners various stimulations. In other words give the learners a chance to create multiple constructions, the same learner create different level construction at distinct time.

2.2.Give learners the authentic problems:

The important mission when teachers proceed with the instruction of constructivism is to arrange and provide the abundant and fitted learning environment, to offer and assist learners to construct knowledge actively and successfully.

2.3.Encourage learners raise various solving methods for the problems:

Promote learners to think of the problems by multi-angle ways. In order to encourage learners to discuss, think, argue and learn cooperatly, thus the learning have to be proceeded with dialog and communication.

2.4.Clear learning goals and concepts:

In internet world no place is too far away to be reached. If let learners grope or learn alone, it's usually happen that learners disorientate in the internet world. Thus if there is no clear goal, learning activity will be one pattern of browse and the emphasis will be neglect. Let learning activities concentrate at the learning goals or concepts, learners will get more complete knowledge, understand the key points, thus increase learning effects.

2.5.Learners can present viewpoints fully:

The internet world is a multi-person and pluralistic environment . In addition to self-learning, learners can see the learning portfolios of others. The learners review the cognition of others by self-viewpoint, furthermore to imitate and learn the others, and self-viewpoint can also be referred by others. Learners develop one kind of self-thinking in the environment of arguing with others again and again. Thus learners are no more silencers, but the learners are encouraged to present their viewpoints or opinions.

2.6.Adaptive courses:

There are individual differences between learners, learning processes or learning strategies of learners are different from others. Thus the design of courses should be considered about the individual

difference,adapted to learning situation of learners. Arrange different course to match the learning situation and abilities of learners, thus learners got the individual learning.

3 Conclusion

It's convenient to search information and data in World Wide Web. The convenience is important factor to encourage learners to construct the self-knowledge. In the process of learners participating and learning actively, learners will feel that they have got self-learning goal.

In constructivism it's important factor that learners participate actively in learning process. Thus learners must participate self-learning activity positively. Learners should search and find knowledge what they want actively.In network learning environment the learning activities are emphasized the" internal control" directed by learners, and requesting learners to learn by their strategies in the process of learning activities.

4 References

[1] Chih-Yu Chan(1996),"Cognition and Knowledge: Constructivism VS. Acceptance", Journal of Education Research, 49,25-38.

[2] Chi-Hsien Lin(1999),"The design and application of network leaning environment", Journal of Information and Education,67,34-48.

[3] Kuei-Fa Chiu,(1996). "Situation learning concept and computer aided learning: The study of learning community " Taipei: Shih Ta Press.

[4] Kuei-Fa Chiu,(1996). "The study of network learning: The another space of education research", The 12th Science Education Seminar, Roc. December.

[5] Kuei-Fa Chiu,(1997), " The development of network learning environment supported by education", Environment education and information network seminar, May.

[6] Shih-Ju Chang(1997),"The meaning of internet hypertext and hypermedia applied in instruction with constructivism", Journal of Information and Education, 58 ,39-48.

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

Full & Short Papers (Lifelong Learning)

A Study on the School Information Technology Pilot Scheme: Possibilities of Creative and Lifelong Learning
Attitudes of Older Taiwanese Adults Toward the Elderhostel Model of Residential Educational Programs
CedarLearning: The Development of Learner-Centred Environments
Design and Implement CAI Programs for Adult Literacy Learners
Development and evaluation of web-based in-service training system for improving the ICT leadership of schoolteachers
Empowering Secondary School Teachers to Effectively Exploit Internet Resource for the Enhancement of Teaching and Learning
Learning from the Learning of other Students
Strategies for Searching in the WWW
The Development of a Multimedia Program for Teachers to Integrate Computers into the English Curriculum
The Production of Web-based Interactive Video From Structured Script
The web of the Teacher Professional Development

▲ HOME

A Study on the School Information Technology Pilot Scheme: Possibilities of Creative and Lifelong Learning

Siu-Cheung KONG*, Wing-Kee AU and Sai-Wing PUN*****
Department of Information & Applied Technology,
Hong Kong Institute of Education,
10, Lo Ping Road, Tai Po, N.T.,Hong Kong
**Phone: +(852)29487646, Fax:+(852)29487726, Email: sckong@ied.edu.hk*
***Phone: +(852)29487693, Fax:+(852)29487726, Email : wkau@ied.edu.hk*
****Phone: +(852)29487651, Fax:+(852)29487726, Email : swpun@ied.edu.hk*

The Hong Kong Special Administration Region (HKSAR) Government is promoting the use of Information Technology (IT) in education for creative and lifelong learning. A two-year IT-pilot scheme has been launched among 10 primary schools. The first phase of the current study had reported on the planning and implementation of the schools in the first year of the scheme. This paper reports findings from the second year. All 10 primary schools are studied by a case-study approach. This phase aims to investigate the effect of using IT in learning and teaching. Data were collected via browsing web sites, visits and interviews. The research results show that some schools are optimizing students' opportunities for accessing the computing and networking capabilities. Acquiring a LCD projector in each general classroom is an important part of the IT infrastructure for promoting the use of IT in schools. All schools are motivating teachers to use IT to improve the traditional mode of learning and teaching by developing multimedia-teaching unit. Schools need to develop teachers' sense of harnessing technology for rethinking and redesigning educational practice through staff development. It is speculated that school policy plays a crucial role in promoting the paradigm of creative and lifelong learning.

Keywords: **IT in education, lifelong learning, school policy**

1 Introduction

Within the nine-year compulsory education system in Hong Kong, students have to learn in large groups with very few choices of school curriculum. Teachers have to teach more or less the same subject knowledge specified in the formal curriculum and approved textbooks. Chances for learners to keep in contact with the real life experiences were limited. Cheng [1] points out that this kind of learning from traditional school experience is an isolated mode of learning. Perelman [2] further argues that such kind of educational management operated by the government is similar to the socialism planning economy mode of operation. It can be surmised that curricular contents and instructional methods that are structured and rigid do not really cater for the needs of learners in the information era. These arguments indicate that the traditional school education system is seriously "disconnected" from the information society. Contents learnt from school education can rarely be used in real life. In this context, the Hong Kong Special Administration Region (HKSAR) government is promoting the use of Information Technology (IT) in education for creative and lifelong learning to cope with the rapid changes in contemporary society [3, 4, 5, 6]. A document on the reform proposals of the education system review of the HKSAR government stated its vision as follow:

Students are the focus of the whole education reform. **The basic premise is to enable every individual to pursue all-round development through lifelong learning.** ... However, in tandem with changes taking place in the community, our students' learning needs have also changed. It is essential or our education system, including its academic structure, content and modalities, to be duly adjusted in response to these changes [6,

p.4].

A two-year IT-pilot scheme was launched in September 1998 for 10 primary schools and 10 secondary schools. These pilot primary schools, with the support of US$480 000 from the government, were expected to experiment with integrating IT in learning and teaching with a resultant change in the paradigm of learning and teaching which may empower both the learners and the teachers. A study on the planning and implementation of the first year of the scheme in nine primary pilot schools was conducted by using a case-study approach and the results were reported [7, 8]. This paper reports the second phase of this study. During the second-phase study, the research team revisited the schools and aimed at investigating the changes in the mode of learning and teaching of the pilot schools experienced in the second year of the scheme after the implementation of the IT infrastructures in the first year of the scheme.

There are various kinds of models, which attempt to conceptualise the integration of technology into learning and teaching, for example, the Concern-Based Adoption Model (CBAM), the Planning Process Models (PPM) and the Technology Maturity Model (TMM) [9, 10, 11]. CBAM serve as a diagnostic tool for the technology integration planning and implementation by studying the stages of concerns of the planners. CBAM considers developing items in different stages of the integration plan. It better suits longitudinal research. PPM provides general guidelines on the planning process that emphasizes on establishing a comprehensive administrative framework for the technology integration plans and the planning must address the local situation. PPM is especially designed for setting up a well-organized administrative structure and ensuring the implementation of the plan. PPM focuses on the study of a particular school. TMM mainly evaluates the depth of integration of IT with education through observation, such as school planning and implementation of IT in learning and teaching. It also concerns the daily use of IT in school and studies the effectiveness. TMM is appropriate for the study of the implementation of IT in education of several schools for identifying favourable factors or obstacles.

The framework of this study is derived from the guidelines of TMM. Five main items of the model are selected for detailed study. They are student use, teacher use, curriculum integration, staff development, and school policy. This research will report on the daily use of IT in learning and teaching and will discuss the effectiveness of integration. IT in education is developing at its initial stage in Hong Kong. Schools have limited experiences on integrating IT in education. The experiences of pilot schools can be a useful reference for most of the schools intending to integrate IT into learning and teaching. The findings of the study will be important for promoting the use of IT for creative and lifelong learning in Hong Kong.

2 Research Question

The first phase of the study had reported on the planning and implementation issues in the first year of the scheme. Nine pilot primary schools were studied. This study is the second phase of the research and all 10 IT pilot primary schools participates. During this phase, the research team re-visited the nine schools and also visited the one missed in the first phase. The aim of the study is to further investigate the pilot schools' use of IT and to obtain an in-depth knowledge profile of the schools' integration of IT into the curriculum. The core research question of the study is to investigate the changes introduced by the use of IT in learning and teaching with particular reference to the five selected items in the framework of the study [12, 13]. In this regard, two subsidiary research questions are explored.

1. How does IT improve the traditional learning and teaching paradigm?
2. How learning can be enhanced for the emerging paradigm of creative and lifelong learning in the information era when learners are empowered by IT?

3 Research Methodology

A case-study approach was adopted in this research in order to obtain the in-depth profile of the pilot schools relating to the implementation of IT in education [14]. Data were collected via browsing school web sites; school visits and interviews. Table 1 shows the web sites of all pilot primary schools in Hong Kong.

Table 1: Web sites of all pilot primary schools in Hong Kong and number of visitors as at the 16, May 2000

URL	Visitors	URL	Visitors
http://www.buddhist-wingyan-sch.edu	No counter	http://kws.hkcampus.net/	No counter

.hk/			
http://bwcss.school.net.hk/	40200	http://www.lkw.edu.hk/	1951
http://am.npgps.edu.hk/	No counter	http://www.tpomps.edu.hk/	123453
http://plklht.school.net.hk/	72984	http://www.ychchtps.edu.hk/	No counter
http://www.pm.plkhsn.edu.hk/	28126	http://www.skhsjs.edu.hk/	No counter

Samples of lessons plans of teachers and students' work were also collected [15]. These data were organised and interpreted according to the framework of the study. During the school visits, interviews and site visits to all IT facilities of the schools were conducted. The interviewees included school principals and IT coordinators. In all, ten school principals or deputy principals and five IT coordinators were interviewed.

4 Results and Discussions

The initial research result of this phase of study shows that schools are struggling for offering opportunities to students for creative and lifelong learning by different approaches. This section will report on the development or changes of the pilot schools observed in the second phase of the study on the five selected items. They are students' use of IT for learning, teachers' use of IT for teaching, integration of IT in the curriculum, staff development and school policy.

4.1 Students' Use

All ten pilot schools offered Computer Awareness Programme (CAP). This programme provided software operation skills and basic IT knowledge to students. Nine schools scheduled these programmes in regular lessons. One school infused the awareness programme contents in various subjects according to the nature of the content. For example, spreadsheet was taught in mathematics lessons and word processing and email were integrated in English lessons. Results of the first-phase study indicated most students in the pilot schools might access to the computers only once or twice a week in the computer awareness lessons [7, 8]. Students could use computers before or after school hours, recesses or lunch breaks but students' use was infrequent in the first phase. There is a change observed during the site visits of the second-phase study. Students had access freely to the computing and networking facilitates around the environment of some schools. Table 2 shows the location of free access to computing and networking facilities for students in the pilot schools. Schools with more free access locations for students are put towards the right-hand-side of the table.

Table 2: Location of free access to computing and networking facilities for students in pilot schools

Location of Access	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
Classroom Computers			✓				✓	✓	✓	✓
Computer Classrooms		✓		✓	✓	✓			✓	✓
Library Computers	✓			✓	✓		✓	✓	✓	✓
Corridor Computers						✓				✓

There were computers free to use in the general classrooms, computer classrooms, libraries and the corridors. According to the figures estimated from the pilot schools, the home computing access rate ranged from 30 to 60 percent. Therefore free access of computing and networking facilities become an important tool to achieve equity and to promote a school culture of using IT to learn and teach. On average, there were 1.8 computer classrooms in the ten pilot schools. Sixty percent of the schools arrange their computer rooms for students' access besides scheduled classes. Seventy percent of the schools provide 3 to 10 computers in the library for drop-in access. Half of the schools admitted students to use computers in general classrooms. The number of classroom computers ranged from 1 to 4. It was interesting to note that some pilot schools even allowed students to share the only classroom computer with the teachers. All pilot schools allowed students to explore freely on the World Wide Web (WWW) except some of them used filters to bar access to pornographic sites. It could be speculated from the site visits that optimising students' free access opportunities might provide a solid foundation for creative use of the computing and networking capabilities and hence might nourish skills and processes that could support learning as a lifetime habit [16].

4.2 Teachers' Use

A teacher may need to deliver curricular contents in the traditional paradigm of learning and teaching. A teacher may serve as a learner's counsellor, a coach and a facilitator who extends the intelligence of the students by helping them in the emerging paradigm of creative and lifelong learning in the information era [16]. No matter with which paradigm teachers are working, there are chances that learners and teachers need to share and communicate. The existing class structure as learning group requires support to facilitate such sharing and communication in the general classroom. There is preparation work for teachers to carry out their roles using the computing and networking facilities of general classroom.

Three kinds of technical installation modes were reported in the first phase of the study [7, 8]. They are: TV connection, fixed LCD, and mobile LCD. TV connection needs a TV connector to connect the classroom computer and the classroom TV for display. TV sets are standard equipments in general classrooms. Fixed LCD set up requires the setting up of a ceiling-mounted classroom LCD projector for projection but there is no set up work during routine use. Mobile LCD set up requires the transportation of LCD projector for on-site setting. Some schools provide desktop computer in general classroom while the other provide school notebook computers. Teacher needs to obtain both a projector and a computer to conduct class presentation in general classroom. Table 3 summarizes the number of schools by mode of projection preparation and by type of classroom computer.

Table 3: Number of schools by mode of projection preparation and by type of classroom computer

Type of Classroom Computer	TV Connection	Mobile LCD	Fixed LCD
Provide Notebook Computer for Classroom Use	1	3	1
Provide Classroom Desktop Computer	1	1	3

All schools in the pilot scheme provided computing and projection facilities for class use in general classrooms. Teachers could use the facilities to deliver teaching contents through the projection screens or TV sets. Teachers could also conduct interactive teaching by retrieving multimedia teaching units from the Intranet or browsing teaching resources from the Internet. Students could use the facilities to present their project work to their classmates and teachers.

Results of the first phase study indicated that teachers of the pilot schools used the IT facilities more frequently in their workplace for those schools installed ceiling-mounted digital projectors in general classrooms [7, 8]. The second-phase of the study confirmed this case and there was a further development of the trend. Although the cost of setting up a ceiling-mounted LCD projector was expensive, which costed around US$4000 per projector and set up, it was commented as worth for promoting the use of IT in learning and teaching. Teachers showed willingness to use the IT facilities in general classrooms when it was so convenient and easy to carry out their work by using these facilities in classrooms. Table 4 tabulates the findings of the current study on the planning, acquiring and existing distribution of LCD projectors of pilot schools.

Table 4: Planning, acquiring and existing distribution of LCD projectors of pilot schools

Distribution of LCD Projectors	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
a. Existing Projector per School Hall	0	1	1	1	1	1	N.A.	1	1	1
b. Existing Projector per Computer Classroom	1	1	1	1	1	1	1	1	1	1
c. Existing Projector per General Classroom	0.25	0.23	0.25	0.25	0.25	0.25	1	1	1	1
d. Existing TV Connector per General Classroom	1	0	0	0	0	1	0	0	0	0
e. Acquiring Projector per General Classroom					1	1				
f. Planning Projector per General Classroom		1	1							

Results of the study showed that eighty percent of the pilot schools installed LCD projectors in their school halls for large group sharing and presentation. All computer classrooms of the pilot schools possessed ceiling-mounted LCD projectors for instruction and class presentation. Forty percent of the pilot schools set up ceiling-mounted LCD projector in all general classrooms. The ratio of existing projector per general classroom was 1. The other six schools had such ratio ranged from 0.23 to 0.25. Two schools resolved the problem on classroom projection by using TV. However, one of the schools told the research team that ceiling-mounted projector would soon replace TV display because projector could provide better quality

display and the school had acquired sufficient funding for the replacement. For the other four schools, one of them acquired funding for updating the projector per classroom ratio to 1; two of them were planning for the updating but there was no funding at that moment; and another one of them was designing a rotational plan of the school timetable so that all classes could use the ceiling-mounted LCD projection for a certain day of the week. In other words, nearly all schools recognize that ceiling-mounted LCD projection was a necessary tool for presentation in classroom. This finding indicated that integrating IT into learning and teaching needed the support of the IT facilities and those issues such as their readiness, convenient to use and reliability must be addressed.

4.3 Integration of IT in Curriculum

All pilot schools attempted to integrate IT in school curriculum. Data collected from the first phase of the study indicated that there were three ways of curriculum integration. They were (1) interactive delivery of multimedia-teaching unit, (2) presentation of digital knowledge object, and (3) active learning. Interactive delivery of multimedia-teaching unit refers to the use of interactivity and multimedia capability of the computer to deliver units of curriculum contents. Teachers themselves develop most of the teaching units. The main aim of this type of integration is to improve the efficiency of teaching. Presentation of digital knowledge object means teachers present knowledge objects such as pictures, animations, or videos related to the curriculum to students. The main objective of this type of integration is to offer authentic stimuli facilitating class discussion. The third type of integration is to organize learners to learn actively when they are empowered with IT.

All teachers and school principals in the pilot schools showed a strong sense of developing multimedia-teaching unit for improving the traditional classroom learning and teaching activities. The general phenomenon is that there was a great demand on the multimedia-teaching units but the supply was scarce. This was the results of the study of the first phase. Data collected from interviews, site visits of classroom, browsing school websites and Intranets, teaching plans and sample work of students from the second phase of the study indicated that the three ways of curriculum integration were still dominant but the proportion of the three types of integration had changed and the ways to advocate active learning were extended. Active learning included not only project-based work but also learning-on-demand. Table 5 summarizes the three types of integration of IT in curriculum. Pilot schools practising project-based work is denoted by a letter "a" and learning-on-demand by a letter "b" in table 5.

Table 5: Types of Integration of IT in Curriculum

Types of Integration	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
Multimedia-Teaching Unit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Digital Knowledge Object				✓	✓	✓	✓	✓	✓	✓
Active Learning				b	b	B	a, b	a, b	a, b	a, b

Results of the current study clearly indicated that developing multimedia-teaching units for improving traditional classroom teaching was still the dominant type of integration. However, there were some further developments. One of the pilot schools stated that they had developed all multimedia-teaching units for the traditional curriculum. This school planned to deliver one-third of the teaching units on its Intranet for students' self-directed learning. The other nine schools required teachers to participate the development by producing some teaching units. Most schools required teachers to develop two multimedia-teaching units in an academic year. One school started to assist teachers to develop web-based learning contents with feedback instead of developing multimedia-teaching units. Another school revised its plan of developing teaching unit by requesting teacher to design storyboard and provide digital knowledge objects. The implementation work would be handed over for commercial software vendors.

The percentage of pilot schools, using the computing and networking capabilities for presentation of digital knowledge objects, increased from twenty to seventy. There were at least two reasons. Firstly, digital knowledge objects could be collected relatively more easily than developing multimedia-teaching units. Presenting digital knowledge object may enhance the effectiveness of teaching. Interview results reflected that knowledge objects were particularly applicable to subjects like General Studies, Art, Music, Physical Education and Civil Education. Digital knowledge objects such as pictures, music and videos allow students to learn by simulation, and learn how to appreciate. They help students to act with sympathy, and may stimulate discussion and critical thinking.

The third type of integration increases even more. The ratio of pilot schools, adopting this type of integration, increased from less than ten percent to seventy percent. These schools encouraged and organized learners to learn actively with IT. There are two types of activities that advocate learners to learn actively. They were (a) project-based work, and (b) learning-on-demand. One of the prominent learner-centred activities was to organize learners to do project-based work. Learners empowered by IT could use tools such as the search engines and presentation software to collect data and present information. This type of integration may facilitate collaborative learning and can polish lifelong learning skills.

Schools found that a content-rich Intranet can encourage learning-on-demand learning. Teachers discovered that learners liked to revise those multimedia-teaching units used by teachers. Two schools provided digitised Educational TV programme on video server or VCD for students' free access. Students could access these learning resources on demand. During the school visits, it was observed that students began to access schools' Intranet to retrieve learning resources and teacher's multimedia teaching units. A variation of learning-on-demand type of activity is learning-on-demand with feedback. Learning-on-demand with feedback attracted learners to learn actively by providing immediate feedback. Two of the pilot schools installed virtual CD towers in their Intranets. Learners could access educational CD-ROMs by connecting to the school Intranets. These CD-ROM learning materials were attractive to students because feedbacks were usually provided and learning pace could be adjusted. Another pilot school developed web-based learning materials with feedback. It was speculated that feedbacks could motivate students to learn.

4.4 Staff Development

Results from the study of pilot schools in the first phase indicated that most schools were organising school-based training for developing teachers' competencies in using technology for learning and teaching. School-based staff development solved some problems like tailor-made training for teachers of the teaching environment. However, school-based staff development also limited the perspective of teachers on the potential of technology to improve only the traditional paradigm of learning and teaching. This argument is supported by the fact that all pilot schools regarded developing multimedia-teaching unit as a prominent part of integrating IT in school curriculum. It was observed that this was still the dominant approach in the second year of the IT pilot scheme. It could be inferred that most schools were adopting the gift-wrapped approach in promoting IT in education by adding technology to traditional educational practice [16]. However, the gift-wrapped approach will limit the development of skills and processes of learner that support learning as a lifetime habit. Therefore it is critical to conduct staff development by developing teachers' sense of harnessing technology for rethinking and redesigning educational practice.

Staff development is the key for cultivating culture of learning and teaching. Therefore, teacher's development on IT competency should not just focus on developing teachers' IT ability but should also provide space to encourage teachers to redesign educational practices for creative and lifelong learning [17]. It is speculated that organizing staff development by visiting schools with best practices on redesigning educational practice could facilitate cultural shift. This kind of activity may excel the emerging paradigm of learning and teaching in the information era.

4.5 School Policy

All schools attempted to articulate policies to address issues derived from implementing IT in education. The following are the observed common policies of the pilot schools on integrating IT in the school curriculum. Firstly, organizing CAP for students. Secondly, requiring all teachers to contribute in the development of multimedia-teaching units. Thirdly, advocating teachers to share the developed teaching-units within the school. Fourthly, providing computing and networking capabilities in classroom for learning and teaching.

The following are individual policies on integrating IT in the school curriculum advocated by some pilot schools:

- Optimizing students' opportunities for accessing the computing and networking capabilities of the school.
- Organizing the computer awareness curriculum to synchronize with application for learning subject curriculum.
- Reinterpreting and reorganizing the traditional school curriculum to cope with the changes introduced by IT.
- Optimizing students' opportunities to access curriculum learning resources.
- Encouraging teachers to visit schools demonstrating best practices on IT in education.
- Encouraging students empowered by IT to do project-based work.

It can be speculated from the last three common policies that all pilot schools are working for improving the traditional learning and teaching practices using the computing and networking capabilities. However, the individual school policies on integrating IT in curriculum reflect that some pilot schools are attempting to establish a favorable environment to welcome the emerging paradigm of learning and teaching. Principals should work with teachers to think and design school policies for such a pursuit.

5 Discussions and Implications

The core research question of the study is to investigate the changes introduced by the using of IT in learning and teaching. This section will discuss the two subsidiary research questions from the result of the study. Firstly, **what are the observed roles of IT in improving the traditional mode of curriculum instruction?** Secondly, **what are the critical factors identified from the study that will enhance learning for the emerging paradigm of creative and lifelong learning when learners are empowered by IT?**

5.1 Improving Traditional Curriculum Instruction

Exploring ways to improve classroom teaching is the main concern of principals and teachers in the pilot scheme. Joyce and Calhoun [18] studied the effectiveness of teaching mode on students' learning for more than forty years. Results of their studies indicated that learning should include both the memorization of factual knowledge and knowledge construction. There is the basic knowledge of the core school curriculum, such as the fundamental knowledge for learning language and mathematics, which need effective transmission. There are also parts of the curriculum that involve conceptual understanding, communication skill, problem solving ability and creativity. Teachers should assist students to learn them by knowledge construction and assist learners to learn how to learn such ability. Traditional curriculum instruction put efforts to knowledge transmission. The emerging paradigm draws focus to knowledge construction.

Results of the study indicated that the use of IT could improve traditional curriculum instruction in two ways. They are **interactive delivery of multimedia-teaching unit** and **presentation of digital knowledge object**. Teachers of the pilot schools reflect that interactive delivery of teaching contents and presentation of digital knowledge object can shorten teaching time and may enhance teaching quality. There are three main reasons. Firstly, context of teaching and scenes of discussion can be displayed in one shoot. Teachers can ask contextual questions or stimulate students to think immediately with the help of the authentic presentations. Time can be saved from wordy description of scenarios or spending time on sticking diagrams on boards. Secondly, adopting multimedia technology and interactivity of computing capability can assist the teaching of abstract concepts. Interactive teaching contents can be easily replayed for consolidation of concept to be learnt. Therefore the efficiency and effectiveness of learning and teaching may be attained with the help of multimedia-teaching units. Thirdly, there are many drill and practice exercises in the traditional paradigm of learning and teaching. Teachers spend quite a lot of time on validating answers with students. With the help of the TV sets or LCD projectors, teachers can display answers and check them with students efficiently. Time for writing answers on board or reading answers aloud can be saved. Time saved from efficient teaching maybe used for exploring possibilities of learner-centred learning.

5.2 Possibilities of Creative and Lifelong Learning

In responding to the need of every individual to become a lifelong learner, one of the main objectives of the school IT pilot scheme is to develop students with lifelong learning abilities. "Lifelong learning is a continuous engagement in acquiring and applying knowledge and skills in the context of self-directed problems" [16, p.12]. Therefore, learners in the information era are required to work independently, to possess skills and abilities to learn, to communicate and work collaboratively with workmates, and to work with self-initiatives.

Results of the study indicates that those pilot schools which advocate active learning such as group project work and learning-on-demand will favor learners to meet the need of the future society. IT facilities themselves cannot enhance learning and teaching for the emerging paradigmof creative and lifelong learning. It depends on how the learner makes use of the IT facilities to either learn independently or work collaboratively with their workmates. Establishing school policies, such as optimizing students' opportunities for accessing the computing and networking capabilities, organizing a coherence computer awareness curriculum to support subject curricular learning, and reducing curriculum content of the traditional formal

curriculum to cater self-directed work, will increase the possibilities to support learners to learn like a lifelong learner. For example, using those expensive classroom LCD projectors as content delivery tool or group project presentation and communication tool will be one of the reliable indicator to illustrate the possibilities of creative and lifelong learning of our learners.

Therefore, pilot schools desire to contribute in the information era should provide not only **a convenient and reliable IT infrastructure** for learners and teachers, but should also develop **a content-rich Intranet** and devise **appropriate school policy** to support and promote lifelong learning. Whether IT facilities can enhance the paradigm of learning and teaching depends on how learners make use of the facilities to learn independently or work collaboratively in projects with their workmates. Devising school policy to promote the emerging paradigm will be a crucial role of principals and teachers. School policy should be formulated from **strategies developed by principals and teachers**, who rethink and redesign educational practice for lifelong learning support.

6 Conclusion

Five main items of the TMM model were selected for detail study in this research. They were the student use, teacher use, curriculum integration, staff development, and school policy. They formulated the framework of the study. The initial research results of the study show that some pilot schools are **optimizing students' opportunities** for accessing the computing and networking capabilities of the school environment. It is also speculated that acquiring a **LCD projector in each general classroom** is an important part of the IT infrastructure for promoting the use of IT in schools. The convenient use principle for acquiring IT infrastructure was proposed in the first phase of the study and was re-confirmed by the current study. All schools are motivating teachers to use IT in order to improve the effectiveness of the traditional mode of learning and teaching. All schools are **developing multimedia-teaching units** as one way of integrating IT with the existing school curriculum. Seventy percent of the schools integrate IT with the curriculum by selecting digital knowledge objects for presentation. Some schools are struggling for offering opportunities to students for active learning. It is critical to conduct staff development by developing teachers' sense of **harnessing technology for rethinking and redesigning educational practice**. Four **common school policies** of using IT to improve the traditional paradigm of learning and teaching are identified. They are organizing CAP; developing multimedia-teaching unit; sharing the developed teaching-units; and providing computing and networking capabilities in classroom. A number of individual school policies are identified from some of the pilot schools for promoting active learning.

Results of the study show that **IT plays two roles to improve the traditional mode of learning and teaching**. They are the interactive delivery of multimedia-teaching unit and the presentation of digital knowledge object. Time saved from efficient teaching may be used for exploring possibilities of learner-centred learning. **Four factors were identified from the study as critical to enhance learning for the emerging paradigm of creative and lifelong learning**. They are a convenient IT infrastructure, a content-rich Intranet, appropriate school policy and strategies for lifelong learning support. School policy should be formulated from rethinking and redesigning current educational practice for lifelong learning support. This study is still in progress. Further result of the research will be reported after collecting more detail data from the pilot schools.

Acknowledgement

This research [RG999040] was supported by the Hong Kong Institute of Education. The authors would like to acknowledge the support of the Institute and to express gratitude to the 10 IT pilot schools participated in this study.

References

[1] Cheng, Y.C., "A CMI• • Triplisation paradigm for reforming education in the new millennium", International Journal of Educational Management, Vol 14, No. 4, (2000).

[2] Perelman, L.J., "School' s out• • the hyperlearning revolution will replace public education", Wired Vol 1, No. 2, (1993).

[3] Tung, C.H., http://www.info.gov.hk/pa97/english/patext.htm(accessed on July 20, 2000).

[4] Education and Manpower Bureau, "Information technology for learning in a new era: Five-year strategy 1998/99 to 2002/03", Hong Kong: Author, (1998).

[5] Education Commission, "Review of education system: Framework for education reform", HKSRA: Author, (1999).

[6] Education Commission, "Review of education system: Reform proposals", HKSRA: Author, (2000).

[7] Kong, S.C., & Pun, S.W., "Information technology and school education: A critical reflection", Hong Kong: Joint Publishing (Hong Kong) Company Limited, (2000).

[8] Kong, S.C., Au, W.K., & Pun S.W., "A Case Study on the Implementation of Information Technology Education Pilot Scheme in Hong Kong", Advanced Research in Computers and Communications in Education Volume 2, Amsterdam: IOS Press, pp. 27-34, (1999).

[9] Illinois Staff Development Council, http://isdc.org/CBAM.html (accessed on July 20, 2000).

[10] National School Boards Association (NSBA), "Plans & policies for technology in education: A compendium", VA: National School Boards Association, (1995).

[11] Edmin Open Systems, http://www.edmin.com/tp/tmm.cfm (accessed on July 20, 2000).

[12] Pelgrum, W.J., & Anderson, R.E. (Eds), "ICT and the emerging paradigm for life long learning: A worldwide educational assessment of infrastructure, goals, and practices", Amsterdam: IEA (1999).

[13] Okamoto, T., "The framework and its meanings of new curriculum for Information Technology-Education from primary to senior high school in Japan", Educational Technology Research, Vol 20, No. 1-2, pp. 25-32, (1997).

[14] Kember, D., Lam, B.H, Yan, L., Yum, J.C.K., & Liu, S.B. (Eds.), "Case studies of improving teaching and learning from the action learning project", Action Learning Project: Hong Kong Polytechnic University, (1997).

[15] Crompton, R. & Mann, P. (Eds.), "IT Across the Primary Curriculum", Singapore: Cassell, (1996).

[16] Fischer, G., http://www.cs.colorado.edu/~l3d/ (accessed on July 20, 2000).

[17] Au, W.K., Kong, S.C., Leung, K.P., Ng, M.W., Pun, S.W., "Levels of Information Technology (IT) competency core course elements and assessment tools for teacher training in IT in education", Hong Kong: Education Department, (1999).

[18] Joyce, B., & Calhoun, E., "The conduct of inquiry on teaching: The search for models more effective than the recitation", International Handbook of Educational Change, Great Britain: Kluwer Academic Publishers, pp. 1216-1241, (1998).

ATTITUDES OF OLDER TAIWANESE ADULTS TOWARD THE ELDERHOSTEL MODEL OF RESIDENTIAL EDUCATIONAL PROGRAMS

*Bobbie T. Biggs, Ph.D. and **Chang, Hsiu-Ying, Ed.D.
**bbiggs @comp.uark.edu and ** bibocop@hotmail.com*
**Professor and **Department Chair*
**Vocational & Adult Education and **English*
**115 Graduate Education Building and ** #2580 Lane Yung-Tung St.*
*University of Arkansas, Fayetteville, AR, U. S. A. & **Lung-Chin, Taichung 43443, Taiwan*

The demographic characteristics of Taipei Evergreen College participants were identified. Since females outnumbered males, housekeeping was most often indicated as an occupation. Most of respondents were 65 to 69 years of age, married, healthy, fully retired, possessed a college degree, and were living with spouse with a monthly income between NT$ 30,000 to NT$ 39,999. The students' attitude toward the Elderhostel program was significantly influenced by two demographic variables: gender and health status. No significant differences were found with age, household income, occupation, level of education, with whom they reside, marital status, and retirement status. Reasons related to learning were identified as the most important reasons that influenced participation for both female and male respondents. The majority of respondents felt that the factors presented in each of the statements did not limit their participation. Nevertheless, the respondents in this study indicated that the length of the program, the time program offered, and accommodations were the first, second, third factors in the list. Respondents in this study had a positive opinion toward the Elderhostel program and demonstrated an interest in cognitive growth. It was concluded that the Elderhostel program was applicable to Taipei Evergreen College students but needed to be modified as suggested in the implications.

Keywords: **Lifelong Learning, Elderhostel Program, Older Learners**

1 Introduction

Since the 1920s, the Republic of China (Taiwan) has gradually entered a landmark "period of demographic transition" [43, p. 428]. In recent years, a consequence of the improvement of nutrition and public hygiene, both the death rate and the birth rate have been substantially changed. Studies reported that the birth rate was at an all-time low, and the decline in mortality rates has increased life expectancies for men and women [39, 43]. This shift has resulted in the inevitable phenomenon of an aging population in Taiwan.

From data published by the Human Resource Department of The Council for Economic Planning and Development, The Executive Yuan, one of the governmental branches, indicates that Taiwan will witness a gradual but persistent increase in the average age of its citizens as a result of the extension of the average life span of its population. The elderly population age 65 and over will increase from 1 million (5.2%) in 1986 to an estimated 2.32 million (9.8%) by the year 2010 [8]. Statistics released in 1999 revealed that the elderly population has increased to 1.81 million (8.2%) in the present year [15].

The increase in the number of older people is a general indicator of a country's scientific, technological, social and economic improvement [19, 40]. In the past several decades, the rapid development in knowledge together with the

radical progress in science and technology has accelerated the changes in society [40]. To successfully adapt to social changes, educators agree that learning is demanded throughout the cycle of life [3, 12]. As Knowles indicated, "Learning in a world of accelerating change must be a lifelong process" [23, p. 171]. Therefore, the growing number of older adults has brought the issue of education of the older adults to the attention of educators.

The concept of learning as a lifelong process is gaining credibility in recent years in Taiwan. In 1980, the Taiwan government set up the Welfare Law of the Aged, which specifies that participation for older adults in society, education, religion, and scientific research should be encouraged by organizations and institutions to enrich the spiritual life of older adults. Accordingly, the extended aspects of the Welfare Law of the Aged have been expanded to the development of educational activities which could make later adulthood more prosperous. The Social Bureau of the Kaohsiung City Government conducted a survey in 1982 to determine senior citizens' needs and desires toward further learning. The analysis of questionnaire data revealed that 66 percent of older Taiwanese adults were considerably interested in involvement in educational activities. The learning aspirations of older people are distinct, and it is incumbent on the Taiwan government to cultivate the learning aspirations.

Responding to the coming aging society, the first Evergreen College was begun in Kaohsiung City in December 1982, and the Taipei Evergreen College was established in June 1983 [37]. Currently, 20 other cities and counties have joined the Evergreen College network in offering educational programs for persons age 55 and over[38]. A few programs offered focused on literacy education of which the Evergreen College is the chief provider. When the Evergreen College first established, the emphasis was on social welfare not on education. Programs were offered mostly in leisure and entertainment. Since December 1982, the Evergreen College has become the leading provider of educational activities for older people in Taiwan [42]. Due to the traditional youth and occupational orientation, the higher education institutions have never responded to the learning needs of the aging Taiwanese. Evidence confirms that Taiwanese older people are getting ready for higher education; whereas, they are healthier, better educated, and exposed to more educational opportunities than previous cohorts.

Elderhostel is an example of an extremely successful residential program hosted by universities and colleges in both the United States and Canada. Elderhostel was developed for adults 55 years or over who like to have new experiences and adventures in knowledge or social activities in their later years. Researchers have suggested using Elderhostel as a model in planning programs, but research was needed to understand whether the Elderhostel concept would attract the older people in Taiwan.

2 Statement of the Problem and Purpose

The increasing potential for a longer life and the need to cope with rapid social change have made it important to understand lifelong learning as a necessity for participation in today's world. The development of adequate educational programs in meeting older people's needs is the primary factor associated with this condition. Much of the information offered about the educational activities of older adults has been produced in the field of literacy education and older adult participation [19, 27, 28, 42]. However, there are limited studies that provide information on older adults as a community of learners in higher education settings.

Although education for older adults has received increased attention in the 1980s, no evidence indicates that older people have been considered as potential clientele by higher education. According to Liou [28], universities have not responded to the needs of older people because of their conventional youth and occupational orientation. Consequently, it is also not likely that older adults will actively participate in higher education. Therefore, the field of education for older adults has not evolved in higher education. Moreover, institutions that accept adult students into the traditional college environments are usually satisfying administrative convenience rather than meeting students' needs [28]. An institution must gain insight from the nontraditional students (age 25 plus), recognize their special interests and accommodate their unique needs to juggle the responsibilities of family life and work [9, 17, 29].

Given that aging Taiwanese are increasingly likely to participate in educational activities [28, 38, 40], program planners need to be able to speculate what kinds of programs will attract and serve this audience. One aid to prediction

is the inspection of existing successful programs. It is suggested by Kaplan that "...other groups will use Elderhostel as a model in planning programs to meet these student needs. The implications are many in terms of expanding colleges and universities to integrate elders into the university system" [22, p. 43]. The Elderhostel concept works well in the United States and Canada, but it is not yet known whether the Elderhostel concept will attract the older people of Taiwan.

The purpose of this study was to determine the attitudes of older adult students enrolled at the Taipei Evergreen College toward the Elderhostel program and to examine the possibility of using the Elderhostel model of residential educational programs for Taiwanese older adults. Two research questions were investigated: a) Are older Taiwanese adults' attitudes toward the Elderhostel program influenced by the demographic variables in terms of gender, age, health status, household income, occupation possessed, level of education, with whom they reside, marital status, and retirement status?; b) What is the possibility of using the Elderhostel model of residential educational programs for Taiwanese older adults?

3 Significance of the Study

The composition of population of modern society is aging daily, and the problems of the aged rise correspondingly [19]. According to a report of the Council for Economic Planning and Development in 1991, the percentage of citizens above age 60 will gradually increase from 5.2 percent in 1986 to 8.7 percent in the year 2000. A liberal estimate indicated that the percentage will increase to 9.8 percent which represents an 83 percent increase by the year 2010. These trends suggest that an aging society is inevitable in the future of Taiwan, the Republic of China [15, 40]. Each advanced country has attempted various strategies in working with the aging society. Acordingly,it is pressing for Taiwan to establish a more thorough social welfare agenda based on the needs of older people and to serve the aged by enriching their spiritual life with educational activities.

Education has traditionally been defined in terms of formal schooling [2]. However, an educational philosophy, lifelong learning, is reforming the way Taiwanese people think of education and the way educators think of their mission, which is that learning is a continual, lifelong process, not one that stops at adolescence [39]. Lifelong learning emphasizes the complete development of one's life span, education for the period between birth and death [3, 11, 19]. Although each individual's developmental stages are different, people have educational needs at every developmental stage [34]. Reed [35] stated, "Only recently has the realization surfaced that myriad changes are faced in the later years of life which learning can address" (p. 1). Education is one way of keeping abreast of the world and maintaining a healthy attitude on life.

Under the influence of lifelong education, programs for the aged are being considered by higher education in many developed countries [28]). In Taiwan, owing to its youth orientation, the population served by the university has not been expanded. According to [42], however, Taiwanese older people are getting ready for higher education. They are healthier, better educated, and exposed to more educational opportunities than previous cohorts. Most research with the elderly in Taiwan concerns psychological adjustment, health care, and mental and physical status. In 1985, an academic research meeting was held by the National Science Council, Executive Yuan, with Professor Huang, Kuo-yen as the convener [42]. According to Wu, the primary purpose of this academic research was to study the problems of the aged in the following four aspects: medical treatment, social economics, social welfare, and psychological education. Nevertheless, the emphasis of psychological education is still on psychological adjustment not on learning and education. Therefore, there is a gap in the Taiwanese literature concerning learning and education of older adults. The significance of this study was discussed in relation to an aging society, lifelong learning, educational needs of older adults, and research. Hence, it is hoped, the results of this study will provide a basis for making recommendations for future development of educational programs in higher education in Taiwan.

4 Subjects, Instrument, Pilot Study, Data Collection and Analysis

The study population was comprised of 1,124 adults age 55 and over who participated in the Taipei Evergreen College in 1997. However, due to the absence of 103 students the actual number of participants in this study was 1,021. The

demographic characteristics of participants were identified. Since females outnumbered males, housekeeping was most often indicated as an occupation. Most of respondents were 65 to 69 years of age, married, healthy, fully retired, possessed a college degree, and were living with spouse with a monthly income between NT$ 30,000 to NT$ 39,999.

Data were collected with a questionnaire which consisted of 29 questions, which were factors that influence and limit participation in the Elderhostel program, plus personal information. The survey instrument used in the present study was adapted from an instrument developed by Ostiguy [32]. According to Ostiguy, face validity of the original research instrument was determined by having the instrument screened by a panel of five experts. Three additional questions related to accommodations were selected by the researcher from the basic model of the Elderhostel program [1, 18, 24, 31]. Accommodations was often mentioned as one of the major considerations of choosing the Elderhostel as an educational setting for learning [3]. Therefore, adding three questions on accommodations was validated by the literature. The face validity of the modified research instrument used in this study was addressed during the pilot test and by having it screened by the four committee members. A pilot study was conducted with six older Taiwanese adults to assure that they could understand the concept of the Elderhostel program and to validate the survey instrument. The questions could be completed in ten minutes after incorporating suggestions from the pilot study group.

The tests of reliability of the survey instrument were conducted for all the respondents as a whole and were conducted separately by gender. All the tests yielded high alpha coefficients for the first set and the second set of questions on the instrument. The high Cronbach's alpha coefficients indicated a strong degree of internal consistency on both reasons that influence potential participation and factors that limit potential participation. The survey instrument was, then, verified to be sufficiently reliable. The researcher obtained permission to work with Taipei Evergreen College. She personally administered the survey to all classes over an eight-week period. Since the public was not informed about the Elderhostel program, the researcher gave a short presentation about the Elderhostel program and showed a ten-minute video before administering the survey.

A demographic profile of participants was generated by calculating frequencies and percentages. Eighteen ANOVA tests were conducted to examine the potential participation and non participation by the demographic variables to determine significant differences among group means. Reasons and factors that influence and limit participation were ranked by means and standard deviations to identify participants' preferences toward the Elderhostel program.

5 Research Question One

The Taipei Evergreen College students' attitude toward the Elderhostel program was significantly influenced by two demographic variables in terms of gender and health status. No significant differences were found with age, household income, occupation, level of education, with whom they reside, marital status, and retirement status.

Discussion

The present study revealed that females and males differed significantly in potential participation in the Elderhostel program. Females were more likely to participate in the Elderhostel program than males; therefore, gender was identified as an indicator of potential participation in the present study. This finding is inconsistent with Ostiguy's [32] study with Canadians which indicated no significant difference between female and male non-participants on both reasons and factors that influenced and limited potential participation. Edlow's [16] study with people participated in the Iowa Elderhotel program revealed similar results as the present study.

The attitudes of the respondents in this study were substantially different in non-participation based on health status. Respondents who were healthier demonstrated a stronger interest in the Elderhostel program than those who were not in good health. Health status was also identified as an indicator of potential participation. This finding supports studies by Brady [4], Brady and Fowler [7], and Ostiguy [32] which reported that potential participation was highly influenced by perceived health.

There were no significant differences found in potential participation and non-participation in the Elderhostel program based on age, household income, occupation possessed, level of education, with whom they reside, marital status, and retirement status. Ostiguy's [32] study also found significant difference on formal educational attainment and level of life satisfaction.

6 Research Question Two

The older adults enrolled in the Taipei Evergreen College tended to be interested in the Elderhostel program. Reasons related to learning were identified as the most important reasons that influenced participation for both female and male respondents. The majority of respondents felt that the factors presented in each of the statements did not limit their participation. Nevertheless, the respondents in this study indicated that the length of the program, the time program offered, and accommodations were the first, second, third factors in the list. It was concluded that the Elderhostel program was applicable to Taipei Evergreen College students but needed to be modified as suggested in the implications.

Discussion

The respondents of this study were intrinsically a group of lifelong learners. It is not surprising that they displayed an interest toward the Elderhostel program. The demographic profile of the respondents was similar to the characteristics of Elderhostel participants that were specified by many studies [1, 4, 5, 6, 16, 24, 25, 31, 32, 33, 36]. The typical participant was a female, married, in good health, well educated, financially stable, was employed and now retired.

Both female and male respondents indicated reasons related to learning as the most important reasons that influenced participation. The results of this study support the findings of Ostiguy's [32] study which suggested that reasons related to cognitive interests were at the top of the list of reasons influencing participation. This may be elucidated by the high education accomplishment level of the respondents. Many other studies [3, 10, 13, 16, 36] also indicated cognitive interest as a significant reason for older adults to enroll in the Elderhostel program. However, in this study, social reasons were additionally found to be important reasons that influenced male respondents' participation. Studies also indicated social needs as the important reasons for older adults, without specifying gender, to participate in the Elderhostel programs [3, 10, 13, 32, 36]. The least important reasons influencing potential participation in the Elderhostel program identified by the female and male respondents were reasons related to escaping from life's stresses and learning new skills for leisure purposes. This finding is supported by previous studies [3, 13, 32] which indicated that escape, the need to get away or take a break, was not a major reason of participating in educational programs.

According to the findings, both female and male respondents of this study reported problems with leaving home too long, living in a dormitory room, and sharing a room with others. Male respondents also indicated one different factor, do not have time. Leaving home too long was also indicated as one of the major problems in Ostiguy's [32] study. Accommodations were often mentioned as an important factor affecting older adults' decisions to participate in the Elderhostel program [3].

7 Implications for the Taipei Social Bureau

1. To live with the escalating pace of change, lifelong learning becomes a necessity for everyone including the elderly (Cross, 1981). Currently, only a few educational programs are provided especially for older people in Taiwan. As the number of older Taiwanese adults increases, so does the need to offer more educational activities to meet their learning needs. According to the findings, the respondents seemed to be very interested in taking part in the Elderhostel program. It is recommended that the Taipei Social Bureau affiliate with universities and colleges to offer an educational program which is designed based on the basic model of the Elderhostel program. It must be noticed that the name Elderhostel is a registered service mark in both the United States and Canada, and permission is needed for using the name [14, 16, 24, 35].

2. The programs offered by the Evergreen College are mainly for leisure and social purposes [42]. The findings indicated that the most important reasons that influenced the respondents to engage in Elderhostel were reasons related to acquiring new knowledge. The Taipei Social Bureau needs to remain true to the nature of Elderhostel which is to offer programs related to the cognitive skills (liberal arts) when designing the program.

3. In a typical Elderhostel program participants live in university dormitories and take three courses during one week [1]. There have been exceptions to the model when some Elderhostel programs lasted less than one week while some lasted more than one week. Some host institutions lodged hostelers at comfortable hotels instead of university dormitories [18]. In this study, leaving home too long, living in a dormitory room, and sharing room with others were indicated as problems by the respondents. Based on the findings, adjustments of the length of the program and accommodations should be made more appealing to older Taiwanese adults.

4. In the present study, females were found to be more likely to participate in Elderhostel than males. However, both females and males were likely to participate in the Elderhostel for the sake of learning. It is recommended that the Taipei Social Bureau should offer courses that are truly appealing to older female and male adults. A needs assessment, therefore, is essential to decide what courses in the domain of cognitive should be offered.

5. According to the findings, respondents who were healthier reported a stronger interest in Elderhostel than those who were not in good health. Given 240 (39.4%) respondents were not in good health, it is recommended that the Taipei Social Bureau ensure and strengthen the supplementary services at program sites, such as health, transportation, or counseling.

6. Elderhostel is designed for older adults of all educational levels. However, according to the demographic profile, 195 (32.7%) of the respondents reported college experience. Those with better education may desire to seek an advanced learning opportunity than someone with a lower level of educational attainment. Since the reason, to learn something new, was identified as the most important reason for participation, it is recommended that opportunities for optional advanced study become part of each course.

7. To understand the educational needs and interests of older Taiwanese adults, it is recommended that the Taipei Social Bureau continue to fully support research investigations. The Taipei Social Bureau should consider initiating a research fund to assist the endeavor of expanding understanding of older learners.

8 Implications for Future Research

1. The population of this study was limited to older adults enrolled in the Taipei Evergreen College. The results, therefore, are not appropriate to be generalized to the population of all older Taiwanese adults. A more heterogeneous population with ample variety in demographic background should be taken into consideration. It is recommended that future studies replicate this study with a greater sample size in all the geographic areas in Taiwan.

2. This study is the first investigation concerning using Elderhostel as a model to develop new educational programs for older Taiwanese adults. To be deliberate, further research is needed to examine the results of this study and to provide additional comparative data.

3. A valuable research problem which was not included in this study is the investigation of the other indicators of potential participation and non-participation, such as geographic area, self or familial experience in adult education, and first participation in adult education at what age. Future studies are needed to examine what specific factors can be used to predict potential participation and non-participation.

4. In order to increase educational opportunities for older Taiwanese adults, the investigation of the intention of universities to cooperate with the Taipei Social Bureau in providing new educational programs is in demand. Programs designed based on the Elderhostel model would be appropriate due to the strong interest toward the

Elderhostel program indicated by the respondents. Owning to the unique tradition and culture of each university, a qualitative research approach would be appropriate to provide an in-depth explanation of the intentions of the 45 universities in Taiwan.

References

[1] Abraham, S. C. (1992). A study of the satisfaction of participants in university administered Elderhostel programs as related to selected personal variables (Doctoral dissertation, the University of Texas at Austin). Dissertation Abstracts International, 53, 0916.

[2] Academy for Educational Development (1974). Building a bridge between lifelong and learning. Taipei: Taiwan.

[3] Arsenault, N., Anderson, G., & Swedburg, R. (1998). Understanding older adults in education: Decision-making and Elderhostel. Educational Gerontology, 24, 101-114.

[4] Brady, E. M. (1982). Selected correlates of participants' perception of growth in Elderhostel programs (Doctoral dissertation, The University of Connecticut, 1982). Dissertation Abstracts International, 43, 3673.

[5] Brady, E. M. (1983). Personal growth and the Elderhostel experience. Lifelong Learning, 7, 11-13.

[6] Brady, E. M. (1984). Demographic and educational correlates of self-reported learning among older students. Educational Gerontology, 10, 25-38.

[7] Brady, E. M., & Fowler, M. L. (1988). Participation motives and learning outcomes among older learners. Educational Gerontology, 14, 45-56.

[8] Council for Economic Planning and Development. (1991). ROC 1986-2010 year Population Inferential Statistic.Taipei, Taiwan: The Executive Yuan.

[9] Covey, H. C. (1982). Preliminary findings on designing higher education programs for older people. Educational Gerontology, 8, 463-471.

[10] Covey, H. C. (1983). Perceptions of activity and participation in the college student role by older people. Educational Gerontology, 9, 463-469.

[11] Cross, K. P. (1981). Adults as learners: Increasing participation and facilitating learning. San Francisco, CA: Jossey-Bass Inc.

[12] Cross, K. P. (1982). Older adult and higher education (GPO Document Service NO. HE 23.3003.OL) Washington, D.C.: National Council of Aging.

[13] Danner, D. D., Danner, F. W., & Kuder, L. C. (1993). Late-life learners at the university: The Donovan Scholars program at age twenty-five. Educational Gerontology,19, 217-239.

[14] Davidson, R. (1986). The Elderhostel experience in Pennsylvania (Doctoral dissertation, Columbia University Teachers College, 1986). DissertationAbstracts International, 47, 1981.

[15] Directorate-General of Budget, Accounting and Statistics, Executive Yuan. (1999). The evidence of aging population [On-line]. Available: http://www.dgbasey.gov.tw/dgbas03/bs7/report/87/07.htm

[16] Edlow, M. D. (1983). Motivational orientations of participants in Elderhostels (Doctoral dissertation, Iowa State University, 1983). Dissertation AbstractsInternational, 44, 1712.

[17] Edwards, B. & Marullo, S. (1999). Editor's introduction: Universities in troubled times–institutional responses. The American Behavioral Scientist; Thousand Oaks, 42, 754-761.

[18] Elderhostel United States and Canada Catalog (1997). Boston, MA: Elderhotel Inc.

[19] Huang, Fu-Shuenn. (1990). Taiwan's adult education: The current situation and future trends. Societal Education, 20, 37-60.

[20] Jan, Mei-jiuan. (1994). Learning preference among non-traditional students in higher education: A comparison with traditional students. Unpublished master thesis, National Taiwan Normal University, Taipei, Taiwan.

[21] Kaohsiung Social Bureau. (1982). Adult education convention. Kaohsiung, Taiwan: Educational Expansion Department.

[22] Kaplan, M. (1982). Elderhostel: Any college can (Master thesis, San Francisco State University, 1982), Master Abstracts International, 46, 2571.

[23] Knowles, M. (1990). The adult learner: A neglected species (4th ed.). Houston, TX: Gulf Publishing Co.

[24] Knowlton, M. P. (1977). Liberal arts: The Elderhostel plan for survival. Educational Gerontology, 2, 87-93.

[25] Larsen, D. C. (1983). The Illinois Elderhostel program: Its evolvement operation, and 1982 Summer student characteristics (Doctoral dissertation, Southern Illinois University at Carbondale, 1983). Dissertation Abstracts International, 44, 2014.

[26] Lin, Mei-Jen. (1988). The Chinese grandparent in three generation household in Taiwan (Doctoral dissertation, Northwestern University, 1988). Dissertation AbstractsInternational, 49, 3325.

[27] Lin, Mei-Ho. (1989). New research subjects of older people'sproblems. Taipei: Gwo-Chang.

[28] Liou, Lin-Tzy. (1992). Adult education and higher education. Unpublished master thesis, National Taiwan Normal University, Taipei, Taiwan.

[29] Moore, M. L., & Piland, W. E. (1994). Impact of the campus physical environment on older adult learners. Educational Gerontology, 20, 129-138.

[30] National Taiwan Normal University,(1990). New Research Subjects of Older People's Problems. Taipei, Taiwan: Department of Societal Education.

[31] O'Donnell, K. M., & Berkeley, W. D. (1980) Elderhostel: A national program. New Directions for Higher Education,29, 97-102.

[32] Ostiguy, L. J. (1993). Identification of factors that influence participation and non participation in Elderhostel programs (Doctoral dissertation, the University of Iowa, 1993). Dissertation AbstractsInternational, 55, 0448.

[33] Patterson M. F. (1988). An analysis of the Elderhostel experience at one university. (Doctoral dissertation, North Texas State University, 1988). DissertationAbstracts International, 49, 2898.

[34] Peterson, D. A. (1983). Facilitating eduation for older learners. San Francisco, CA: Jossey-Bass Limited.

[35] Reed, N. J. (1992). Characteristics of successful long-term Elderhostel programs across diverse sites (Doctoral dissertation, University of Georgia, 1992). Dissertation Abstracts International, 53, 2208.

[36] Romaniuk, J., & Romaniuk, M. (1982). Participation motives of older adults in higher education: The Elderhostel experience. The Gerontologist, 22, 364-368.

[37] Taichung Social Bureau. (1990). Education of SeniorCitizens. Taichung, Taiwan: The Ministry of Education.

[38] Trends of adult education in 1997. (1996, December 1). Central Daily News, p. A8.

[39] Tsai, Pei-tsuen. (1998a). Adult Education and Career Development. Kaohsiung, Taiwan: Li-Wen Publishing Co.

[40] Tsai, Pei-tsuen. (1998b). Learning and Career Development for Older Learners. Kaohsiung, Taiwan: Li-Wen Publishing Co.

[41] Unparalleled opportunities abound with the Elderhostel program. (1999, April 18). Fifty Plus, p. 2.

[42] Wu, Wan-Chen. (1992). Older adults' educational needs: A relationship with demographic variables. Unpublished master's thesis, National Taiwan Normal University, Taipei, Taiwan.

[43] Yang, Chu-Yin. (1992). The aging: A great potential human resource of Taiwan. International Review of Education,38, 427-446.

[44] Zoller, D. M. & Long, H. B. (1995). Outcomes of Elderhostel participation. Educational Gerontology, 21, 113-127.

Design and Implement CAI Programs for Adult Literacy Learners

Pi-Chi Chen
Department of Information Management, I-Shou University
1, Section 1, Hsueh-Cheng Rd., Ta-Hsiang, Kaohsiung County, Taiwan 84008
E-mail: pchen@isu.edu.tw

This paper discusses adult learners' learning characteristics and how to integrate their characteristics with proper learning theories to make the CAI design more appropriate for adult learners. Three important issues concerning CAI design features are discussed: (1) learner control, (2) feedback and reinforcement, and (3) cooperative learning. Suggestions for CAI software designers about CAI design features and for adult literacy educators in implementing CAI programs are provided at the end of the paper.

Keywords: **Computer-Assisted Instruction (CAI), Adult Literacy Education**

1 Introduction

The computer has been attracting adult literacy educators' attention because it provides solutions to problems which have been plaguing adult education. For instance, it allows self-directed learning. Privacy is also possible. In addition, it provides flexible scheduling for adult learners. However, several limitations exist. One of the biggest problems with computer-assisted instruction to adult literacy education is the lack of CAI designed to meet the specific needs of adult learners. This paper discusses learning characteristics of adult learners, issues concerning CAI design features for adult literacy learners and provides suggestions for computerized adult literacy education.

2 Adult Learners' Learning Characteristics

Summarizing many adult educators' findings about adult learners' development and learning, the author generated a list of learning characteristics of adult learners. (1) Self-motivated: adults have a self-concept of being responsible for their own decisions and for their own lives. They want to be involved in making mutual decision about the learning process. (2) Experienced: adult learners want the learning experience to relate to their real-world experiences. (3) Practice-oriented: adults learn better by really doing something rather than hearing theory only. (4) Pragmatical: adults need to know exactly what the learning objectives are and how they will apply them in their daily lives. (5) Self-evaluated: adults like to know how they are progressing, but they tend to shy away from tests because of the fear of being humiliated if they do not do well. (6) Varied learning style: adults have adopted a particular learning style and it is not easy to change it. Thus adults want a variety of learning techniques utilized.

3 Issues Concerning CAI Design Features for Adult Literacy Learners

Learner control is particularly important for adult learners for three reasons: (1) adults need to control their learning, (2) they may need more time to make decisions about the learning topics and procedures, and (3) their learning may be ineffective in a learning situation with speed constraints [7].

Researchers have suggested effective instructional materials for adult learners should include feedback and reinforcement [2, 7, 9]. Chen [4] also asserted that positive and explanatory feedback had significant positive effects for adult learners' achievement and attitude toward instruction.

The rich resources of each adult's unique experiences and differing contexts should be focused on and integrated into the learning environment [11]. Steeples [11] concluded that, "Learner collaboration not only emphasize a positive, constructive approach to learning but it also allows the knowledge and skills of the participants to be shared with their peers and with others who have similar interests and concerns" (p. 452).

4 Suggestions

1. Design CAI for knowledge application. CAI for adult literacy education is still limited to specific learning subjects, such as language and mathematics. However the final goal is for the individual to be able to apply these skills to meet the needs for dealing with daily life. CAI designers should expand adult literacy learning subjects from the basic knowledge level to the advanced application level.

2. Develop daily-life-related simulation programs. To expand learning subjects from the basic knowledge level to advanced application level, a more complex learning environment is needed. A daily-life-related program could simulate real world environment, such as food markets, banks or hospitals, and allow learners to experience and solve problems happening in daily life. A tutorial section might also be integrated with the simulation program to provide instruction whenever needed.

3. Apply advanced computer technology. A simulated real environment can be displayed in a video segment or a Quick Time movie. The learner uses the computer to control the video to playback and retrieve information needed to solve the problems presented in the computer. A daily-life-related simulation program delivered by a multimedia system would motivate adult learners and improve their achievement.

4. Consider adult learners' vocabulary ability. Instructional developers must understand adult learners' vocabulary ability and develop easy-to-read text for adult learners improve their literacy ability in a progressive way. An option for audio to explain program usage methods and important information in plain daily-life language should be provided.

5. Develop CAI for both cooperative and individualized learning environment. When designing CAI software, neither individualistic nor cooperative learning should be viewed as the ultimate delivery system for adult literacy education. CAI programs that can be implemented in both individualized and cooperative learning environments would be more practical and effective for adult literacy learning.

6. Integrate varied software interactivity. The interactivity level of CAI should be carefully determined and designed after considering learners' characteristics, subject matter, and learning outcomes. When drill-and -practice learning mode is needed to help learners master some specific skills, semi-interactive CAI software might be a good design approach. If the learning outcomes are advanced knowledge application, CAI which provides high level of interactivity would be needed.

7. Apply multiple media with adult literacy teaching activities. When a learning environment provides varied learning media to facilitate students' learning, it is called a multimedia learning environment. If a computer-controlled multimedia is not available, adult literacy educators are encouraged to create a human-controlled multimedia learning environment for learners.

8. Let learners decide to learn individually or cooperatively. CAI designers are suggested to develop CAI which can be implemented in both individualized and cooperative environments. Adult literacy educators are also encouraged to let learners decide their CAI learning strategies. Learners can choose to learn individually, in pairs, or in groups of more than two.

9. Help learners obtain positive attitudes toward using computers. Teachers or trainers should avoid jargon when explaining how to operate a computer and access CAI program. Adult education organizations should offer a short pre-training program to help learners orient themselves to a computerized learning environment. Finally, adult learner grouping should pair learners who have never used computers before with learners who have had some computer experience.

10. Provide flexible learning schedule and learning location. CAI adult literacy educators should provide adult learners, who usually have many different obligations, with flexible learning schedule and choices of learning locations when implementing CAI programs for adult learners. This special feature of CAI—always providing organized and uniform instruction—should be fully used and enjoyed by adult learners.

References

[1] Askov E. N., & Brown, E. J., "R.O.A.D to success: Evaluation of workplace literacy efforts", Adult Basic Education, Vol 2, No. 3, pp. 167-175, (1992).

[2] Askov, E. N., & Clark, C. J., "Using computers in adult literacy instruction", Journal of Reading, Vol 34, pp. 435-448, (1991).

[3] Boucouvalas, M., & Krupp, J., "Adult development and learning", in S. B. Merriam & P. M. Cunningham (Eds.), Handbook of Adult and Continuing Education (pp. 183-200). San Francisco: Jossey-Bass. (1989).

[4] Chen, P. C., "The effectiveness of computerized adult literacy education: a meta-analysis of literature from 1979 to 1994", Unpublished Ph.D. dissertation. Purdue University, West Lafayette, Indiana, (1996).

[5] Ewing, J. B., London, J., & Ramirez, S., "Adult education and computer literacy: A new challenge", Lifelong Learning, Vol 10, No. 3, pp. 21-23, (1986).

[6] Fletcher-Flinn, C. M. & Gravatt, B., "The efficacy of computer-assisted instruction (CAI): A meta-analysis", Journal of Educational Computing Research, Vol 12, pp. 219-242, (1995).

[7] Manheimer, R. J., "Older adult education: A guide to research, program, and policies", Westport: Greenwood. (1995)

[8] Merriam, S. B., "An update on adult learning theory", San Francisco: Jossey-Bass, (1993).

[9] Mills, H., & Dejoy, J., "Applications of educational technology in a self-directed learning program for adults", Lifelong Learning, Vol 12, No. 3, pp. 22-24, (1988).

[10] Shaw, D. S., "Computer-aided instruction for adult professionals: a research report"., Journal of Computer-Based Instruction, Vol 19, No. 2, pp. 54-57, (1992).

[11] Steeples, C. A., "Computer-mediated learning environment for adult learners: Supporting collaboration and self-direction", Journal of Educational Multimedia and Hypermedia, Vol 2, pp. 443-454, 1993.

[12] Woldkowski, R. J., "How to plan motivational strategies for adult instruction", Performance and Instruction, Vol 24, No. 9, pp. 1-6, (1985).

Empowering Secondary School Teachers to Effectively Exploit Internet Resources for the Enhancement of Teaching and Learning

Y. T. Yu* and B. C. Chiu**

**Department of Computer Science, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong. Email: csytyu@cityu.edu.hk*

***Curriculum Development Institute, Education Department, HKSAR, 24 Tin Kwong Road, Kowloon, Hong Kong. Email: scdodp1@ed.gov.hk*

There are great potentials for the use of computers in the enhancement of teaching and learning in secondary schools, but in some subject areas, the realisation of these potentials is critically limited by the lack of appropriate educational software. Custom development of this kind of software is often not a viable alternative, since such a task is well known to be non-trivial and time-consuming that is frequently beyond the capacity of individual secondary school teachers. As computer science researchers and educators, we are aware that vast amount of teaching resources are freely available on the Internet. Such resources are often used by tertiary educators for enriching their teaching, but largely under-utilised by secondary school teachers. This paper reports our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources for use in their schools. Our approach is enabling in that it fosters participants' lifelong learning beyond the contents of the present course, and is applicable to a broader context than ours.

Keywords: **Teacher education, lifelong learning, program visualisation, algorithm animation**

1 Introduction

For a long time, educators and computer scientists have been exploring the use of computers in education [9]. The rapid drop in hardware price and the tremendous improvement in computing power in recent years have rendered computers more affordable to schools, teachers and students. Hardware is no longer the bottleneck that hinders the integration of information technology (IT) into the school curriculum. There are increasingly great potentials for using computers to enhance teaching and learning at all levels of education. In some subject areas, however, the realisation of these potentials is severely limited by the lack of appropriate educational software.

The development of good quality CAI software is well known to be a non-trivial and time-consuming task that calls for the combined expertise of programmers, experienced educators, graphics/multimedia designers, and others [10]. Such a task is often beyond the capacity of individual teachers in primary and secondary schools, due to their limited time, technical expertise and perhaps monetary resources. More fundamentally, it would not be realistic to require every teacher to develop their own CAI software from scratch for use. This is even true for most university educators. As Resmer [13] argues, "if every professor in a university had to write their own textbook, typeset it, print it, publish it, bind it, and distribute it before their students could use it, [textbooks] would not be a viable learning resource". Likewise, for widespread and effective use of computers in education, there is a need for teachers to be well informed of the source of available

educational software.

The Internet promises to be a source of many valuable teaching resources that are frequently available freely or at affordable costs. There are many advantages of exploiting Internet resources for use in teaching. Apart from cost savings, software tools on the Internet are more likely to be kept up-to-date as technology advances, and their evaluation versions could be put to trial use before making actual purchases.

By nature of their work, many university educators are accustomed to the exploitation of Internet resources for both research and teaching purposes [14]. In contrast, these resources have largely been under-utilised by secondary school teachers due to various reasons. Firstly, many teachers are not aware of the existence of such resources on the Internet. One example is the use of visualisation and animation tools that are great aids to program understanding. Although the existence and effectiveness of these tools have been well known to computer science researchers in the field, our experience is that few secondary school teachers are aware of this.[1] Secondly, teachers might not know where these resources are, even if they are aware of their existence. Blind searches on the Internet are likely to be inefficient and sometimes not productive, in terms of the time taken to retrieve useful materials. Thirdly, the use of some resources requires a level of technical competence that a typical secondary school teacher might lack. Finally, some software tools have to be adapted to suit the needs of individual teachers, and without any support or assistance, such tasks could be daunting.

In this paper, we report our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources. Our approach is enabling in that it fosters participants' self and lifelong learning beyond the contents of the present course. We believe that our approach is actually applicable to a broader context than ours and therefore would be of interest not only to secondary school computer teachers, but also to teacher educators and teachers of other disciplines at all levels.

The rest of this paper is structured as follows. Section 2 introduces the context and goals of our short course. Section 3 provides the background of the subject area: computer programming and visualisation tools. Section 4 describes how we exploit Internet resources for use in the course. Section 5 describes the implementation of the course and the feedback from participants. Section 6 discusses our approach. Section 7 concludes this paper.

2 The Teachers Update Course

2.1 Background and objectives

Our university has been organising the Teachers Update Course (TUC) annually as a service to local secondary schools. It aims at refreshing practising school teachers with updated knowledge on the subject areas they teach, and offering advice and assistance on the teaching and learning of the subjects. It serves to show our university's concerns to secondary education, to share our professional expertise, and to promote communication and cooperation between our university and secondary schools.

TUC consists of a series of half-day short courses that encompass many subject areas such as Use of English, Mathematics, Computer Studies, Physics, and others. This paper reports our experience in the design and delivery of the course on Computer Studies. Participants of the course were mainly secondary school teachers of computer subjects such as Computer Studies and Computer Literacy.

2.2 The local secondary school context

In Hong Kong, school teachers are often heavily loaded with both teaching and non-teaching commitments. Typically, a teacher has to conduct six to seven lessons per day, each lesson lasting for 35-40 minutes. In

[1] One author of this paper previously taught a class of student teachers in a Postgraduate Certificate in Education programme who were major in Computer Studies, and none of them were aware of the existence of program visualisation and algorithm animation tools. Similarly, none of the practising computer teachers who participated in the Teachers Update Course described in this paper were aware of such tools.

addition to such work as lesson preparation, setting and marking tests and examinations, most teachers have to share school administrative work as well as leading students to participate in extra-curricular activities.
In recent years, the Government of the Hong Kong Special Administrative Region (HKSAR) has undertaken numerous initiatives to promote the integration of IT into the school curriculum [3]. Since teachers of computer subjects are usually more acquainted with the use of computers than other colleagues, they are often busily involved in the setting up and management of the IT infrastructure of their schools, and they are generally expected to assist other teachers in solving various problems in using IT.

Increasingly, there are pressures for teachers of all subjects to apply IT in their teaching activities. Many teachers have to spend a great deal of time after school hours to attend in-service IT training courses [8,9]. However, one common problem they encounter is the limited availability of appropriate educational software, and few of them have the time and expertise to develop their own courseware. Moreover, budgets are limited in schools for the purchase or development of courseware.

2.3 Goals and strategy

During the planning and preparation of the short course on Computer Studies, the following goals were formulated in an effort to maximise the usefulness of the course to the participants:

- *The course had to provide materials that are directly relevant to teaching in schools.*

  The course in the previous year was intended to broaden the computer knowledge of school teachers by providing updated information on multimedia and their applications. As such, the course was organised in the form of a condensed lecture of part of an undergraduate subject, supplemented by demonstrations of the applied research work of our staff in the area. Although the subject materials were interesting, many teachers subsequently indicated a preference of topics that are more directly related to their own teaching in schools. Simply acquiring further knowledge in the computing field was not as welcome as knowing something directly useful for solving the problems they encountered in their teaching.

- *The course had to offer practical assistance to teachers.*

  Considering the heavy workload of secondary school teachers, any teaching resources must be easy to use and demonstrably useful, or they would not be used at all. In selecting the course materials, preferences were given to those that are easily and practically applicable in the secondary school context. This strategy is also in response to the feedback by teachers in the previous year of their desire to learn something that is "more relevant [to their teaching]".

- *The course should motivate teachers' interests and empower them to pursue further via self-learning.*

  The course was a short one and naturally limited in the amount of teaching materials we could possibly provide. Even with a much longer duration, it would still be impossible to inform the teachers everything they had to know about the topic. Moreover, even for the same topic, there are considerable variations in their needs (for example, due to different teaching styles or their students' background). The same technique useful to one teacher might not work for another. What is more important is to foster their ability to pursue the topics further beyond what we offer, whenever they have the need to do so. Therefore, from the outset the course was designed to "have an empowering or enabling effect on the participants" [9]. We hoped that the course could enable school teachers to acquire what they need via self and lifelong learning.

Setting the right goals was important, but the real challenge was how to achieve these goals within a few hours of contact with the participants. We now outline our strategy as follows. Firstly, we selected a topic that would likely interest most computer teachers: computer programming and algorithms. This topic is clearly directly related to their teaching. Secondly, we collected useful information and software tools for the enhancement of teaching and learning of this topic. Most of these resources were originated from overseas and would be hard to access were they not put on the Internet. Thirdly, among them, we selected only those information and software tools that were judged to be practically useful in the local secondary school context. Finally, we demonstrated to teachers how they could have found and utilised these resources on their own through the Internet.

In retrospect, we believe that although the first step (topic selection) is important in ensuring the relevance

of the course, it is our approach in the remaining steps (use of the Internet resources) that would have more profound influence to the participants. Our approach will be discussed in detail in Section 6. Meanwhile, we briefly introduce the subject area in Section 3 and then elaborate on what we did in the course in Sections 4 and 5.

3 Computer programming and visualisation tools

3.1 Computer programming as a common major part of many computing curricula

Computer programming and algorithms is usually considered a significant and fundamental component in undergraduate computer science education [6]. In most universities, introductory programming and the design of elementary algorithms are the first courses that a computing major undergraduate student has to take (unless these courses were exempted due to credit transfer or advanced standing). Elementary programming courses are also frequently offered as electives to non-computing students with a broad variety of backgrounds [10].

At the secondary school level, computer programming is historically the major component of a typical computer subject. Although the emphasis of learning programming has now been reduced as compared to the past, there is, arguably, still a place for it to be included in the secondary school curriculum. In Hong Kong, both the Computer Literacy subject (offered to almost all junior secondary students) and the Computer Studies subjects (offered as electives to senior secondary students) include programming as a major part of the curriculum [2].

3.2 Difficulties of teaching and learning computer programming and algorithms

The teaching of computer programming and algorithms presents a great challenge to educators at both the secondary level and the tertiary level [15]. To understand a computer program or an algorithm, the student needs to have a good understanding of the internal execution model of computers, as well as the dynamics of variables, data structures and control flows in the algorithm [7]. Such concepts are abstract in nature and could be difficult to even novice programmers [16], let alone non-computing major undergraduates and secondary school students. Indeed, according to our survey to secondary school teacher participants of our short course, about 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.

There is usually considerable overlap between the contents of a computer subject in a secondary school and those of a first year course on computer programming in a university. As such, the difficulties encountered by secondary school teachers are in many ways similar to those faced by the professors in universities, as far as the teaching of basic computer programming and elementary algorithms is concerned.

Nevertheless, usually only the academically more capable students will enter universities. As a whole, the secondary school student population is less mature in intellectual development and more diverse in their academic ability. Compared with university students, many of the secondary school students tend to be less motivated and less capable of independent learning; they normally require more guidance in their studies.

Secondary school teachers are generally less well informed and possess far less resource under their disposal than university educators. To our knowledge, a great deal of research has been done in many universities to address the difficulties in learning computer programming and algorithms [1,5,6,7,12,15]. Unlike universities, however, secondary schools seldom have the resources and expertise to perform similar work to solve their problems. In fact, they might not be aware of such research activities. Our approach in the course is to facilitate the use of university resources on the Internet by secondary school teachers to solve their own problems.

3.3 Program visualisation and algorithm animation

Program visualisation refers to the use of graphical artifacts to represent both the static and dynamic aspects of a program [11]. Algorithm animation portrays the dynamics of the execution of an algorithm by means of animation tools [7]. Educators and researchers have long believed that visualisation and animation are useful in helping students understand the abstract concepts and dynamics involved in computer programming and

algorithms [15]. It is believed that visualisation and animation tools help the learners by displaying in concrete form the mental model of the execution of computer programs. Indeed, many universities worldwide have been actively researching and experimenting with the use of visualisation and animation tools. As a result, a variety of such tools have been developed for different purposes [1,5,6,7,12,15]. Many experimental results have been reported that favour the use of such tools for enhancing program understanding [6,7,15].

4 Exploiting Internet resources for useful educational software tools

Despite years of active research, program visualisation and animation tools are still not widely used in secondary schools, and few such tools designed for teaching and learning are available commercially.[2] As discussed in Section 2.2, it is often impractical for secondary schools to develop their own tools.

As computer science researchers and educators, we are aware that many program visualisation and algorithm animation tools have been developed as results of research work in various universities. Even though some tools have been developed mainly for demonstrating the research ideas and therefore might not have as many features as commercial software, most have been designed for teaching and learning. More importantly, they are usually available for free and easy access through the Internet for educational purposes. To our judgment, there are great potentials of utilising such tools in enhancing teaching and learning in secondary schools.

The idea of utilising research tools on the Internet for enhancing secondary school education is obviously appealing and has many advantages over acquiring similar tools by other means. We shall discuss these further in Section 6. However, before being convinced of the practicality of this idea, we had two concerns. Firstly, although these tools had been successfully applied in the tertiary education context, would they be useful in secondary schools as well? Secondly, would secondary school teachers be competent enough to make use of these tools that have originally been designed for use by tertiary educators who are technically more proficient?

To develop this idea further, we set out to evaluate the practicality of using Internet resources as teaching and learning aids in secondary schools. As program visualisation and algorithm animation do not fall into our own research areas, we started our search from only the scarce information that we had. Beginning with the Web sites of two well known researchers in these areas that we incidentally came across and made note of a few years ago, we followed links over links, and so on. It turned out that there was little difficulty in the search of relevant Internet resources. The more tedious and time-consuming task was to evaluate the contents of these resources one by one. Even so, within a few weeks' time, we were amazed to have collected and evaluated almost a hundred sites of related interest! These resources range from the innovative use of common spreadsheet software by researchers in the University of Helsinki [12], to ambitious laboratory projects such as the DYNALAB project of Montana State University [1], and university students' research projects such as Jeliot [5].

We selected and evaluated the resources according to several criteria: (1) relevance in content and level to the syllabus of secondary school computer subjects, (2) accessibility, (3) flexibility (customisability), (4) software and hardware requirements, (5) difficulty in technical content, (6) ease of setup and customisation. After evaluation, we decided to recommend about 30 web sites. The contents of these web sites range from ready-made animations of common algorithms, to downloadable program visualisation tools that support both forward and backward execution [1], and even online animation of user-defined algorithms using customisable 'actors' in a 'theatre-like environment' [5].

Through the process of selection and evaluation, we are increasingly convinced of the practicality of our approach. Many of the tools we found could be effectively used by people with some elementary knowledge of computer programming and concepts of program visualisation. Our participants were computer teachers who clearly possess knowledge of the former but not necessarily the latter. Therefore, part of our short course was to explain the program visualisation concepts and how they could be useful to aid program

[2] Although most commercial program development environments do provide some limited facilities such as the display of the contents of variables during program execution, these are primarily designed to aid software development (particularly to aid debugging) by programmers. These facilities are not targeted to beginner learners and usually not well suited for the purpose of teaching and learning.

understanding.

5 Course implementation and feedback

Our course began with discussions on the common problems in developing CAI software. Then we introduced various sources from which useful CAI software could be obtained freely or at nominal costs for topics in computer subjects in general. These sources included higher educational institutions, students pursuing higher education, professional educational bodies, textbook publishers and others. The use of these Internet resources was more straightforward and requires no further elaboration other than the provision of pointers.

Next, we introduced the concept of utilising program visualisation techniques for the enhancement of teaching and learning, and the corresponding selected Internet resources. For ready made animation tools that were straightforward to use, we simply provided pointers and made two representative demonstrations, leaving the participants to try and pursue the tools at their own pace after the course.

A few selected tools, however, were introduced in much more detail. These tools have one or more of the following characteristics: (1) they were technically more advanced; (2) they could be used in several ways to suit different educational purposes; (3) they had features that were particularly useful or illuminating; (4) their designs were based on notions that were innovative and less obvious to understand but practically very useful. Fortunately, the participants were mainly computer teachers whom could be safely assumed to possess the necessary programming skills and concepts to perform the required customisations. Were we to simply show the links of these resources, it could be difficult for them to tap the potential benefits of these tools effectively.

The participants were so interested in the selected Internet resources that the course was substantially overrun. At the end of the course, participants were requested to complete a questionnaire about their background (for planning of future courses) and about how well they felt the course had been organised (for evaluation of the present course). Some of the statistics obtained are as follows:

1. About 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.
2. About 90% of the respondents agreed (with 26% strongly agreed) to the statement that "I will try to make use of the course materials at school when appropriate". None disagreed; the rest were undecided.
3. About 87% of the respondents agreed that the course was useful to them; none disagreed and the rest were neutral. The same number of respondents agreed that they were satisfied with the course. Some felt that the course could have been improved by extending the duration to allow more time for further discussions.
4. All respondents agreed that the demonstration of the Internet resources for teaching was the most useful part in the course.

6 Summary and discussions

6.1 Characteristics of our approach

We began with the ideas that program visualisation tools are useful for learning computer programming, but such tools are not widely known, of limited availability and hard to develop by secondary school teachers themselves. Yet Internet resources abound that could be effectively exploited for use in secondary schools. As researchers in the university, by nature of our work we are usually better informed with the availability of such resources and the advancement of the latest technologies. In planning and designing the short update course for teachers, we positioned ourselves as mentors in the search of relevant teaching resources. We aimed at offering practical assistance to secondary school teachers by providing the source of relevant information on the Internet, by demonstrating the potential benefits of utilising such information, and by guiding them through the solutions to the technical problems that might arise in utilising such information. We attempted to motivate the interests of participants, to help them overcome the initial barriers (that is, to make "jump start") so that they could eventually help themselves exploit the vast potentials of Internet resources via self and lifelong learning. Incidentally, in so doing, we have exemplified our course as an alternative model of "teaching in the information age" in which teachers serve more like a mentor than an

authoritative knowledge provider.

Our approach is characterised in several ways which distinguish it from that of a traditional teacher education course. Firstly, our goal was modest yet pragmatic in trying to address a specific but real problem that a typical secondary school computer teacher encounters daily: the difficulties of teaching computer programming. Secondly, we demonstrated to the participants how Internet resources could be effectively and practically utilised for addressing their problems. What is even more distinctive is the recommended use of tools developed by researchers with the latest software technologies of the field for use in tertiary education. We have argued that both tertiary educators and secondary school teachers share many common problems that call for similar solutions. Secondary school teachers could learn a great deal from the experience of educators in universities when dealing with their common problems. Finally, the course was designed to be enabling and empowering, with the explicit a priori goal that participants could pursue the subject further via self and lifelong learning.

6.2 Reflections and discussions

On completion of the course with encouraging feedback from the participants, we reflect on the factors contributing to our success. We note that a key factor is our decision to take advantages of the use of selected Internet resources, especially those from universities worldwide. Firstly, these resources are easily *accessible* to teachers and students alike, as long as they are connected to the Internet. The ease of access also minimises the problems that might occur in the distribution and installation of custom developed or commercial software. Moreover, the use of educational tools on the Internet is *cost-effective*. Many of these tools have been demonstrated to be effective through their use in universities. They are typically designed by computer scientists for demonstrating the advantages of applying their research ideas in education, and have subsequently been experimented and evaluated for continuous enhancements, with such evaluations adequately documented in their research papers. More importantly, they are available freely or at affordable costs. Cost is often a critical factor determining whether an educational software tool will be widely used in secondary schools, as resources at their disposal are usually fairly limited.

Some of the software tools we recommended were developed as prototypes with source codes publicly available [12]. They are usually based on sound theoretical principles and accompanied by technical or educational papers describing the theory and implementation in detail. Teachers may customise these tools to suit their specific needs that might vary due to differences in teaching styles, objectives, and students' backgrounds. They may choose to use the whole or part of the tool, or write small program components to be integrated with these tools. For computer teachers who are acquainted with and probably interested in writing programs, such "lightweight customisation" is usually easier and more feasible than building a complete CAI system from scratch. Customisation by users is not normally adequately supported by commercial software that comes with no source code and only limited documentation such as operational guides.

Technologies and knowledge have been advancing very rapidly. On the Internet, new resources keep emerging as results of continuous research by academics who explore the latest technologies for the enhancement of teaching and learning. An example is the experimentation of using 3D visualisation, multimedia and virtual reality technologies in education as they emerge [4]. Teachers who are well informed of such activities through self-learning on the Internet will be in a better position to make use of the latest research results and technologies for continuous improvements to their teaching and learning in ways that are not otherwise possible.

The use of research tools for teaching and learning is not without problems. However, most of these problems would not be deterrent; they could be solved or avoided. Other problems are present in the use of other sources of educational software anyway. For instance, research tools are often imperfect, with some functionality not fully implemented; but as long as the implemented features are considered useful, the tools can be used in part rather than in full. There might be a lack of instant technical support, but many researchers who develop the prototypes are keen to collect feedback, as these might be crucial for their continuous research work. Inevitably, frequent revisions might occur to these tools for research purposes, but if the teacher finds an earlier version useful, that version could be downloaded and kept for use instead of relying on its availability at the source.

7 Conclusions

University educators possess the necessary resources, expertise and freedom to fulfil their roles of performing experimentation and researches, and producing prototypes to demonstrate the usefulness of their innovative ideas. In comparison, secondary school teachers are too occupied with teaching activities and other professional commitments. Most teachers cannot afford the purchase of expensive commercial software for teaching, nor do they generally have the capacity of developing appropriate educational software on their own. Success of integrating IT in the school curriculum is critically determined by the availability of easy-to-use and adaptable tools that satisfy the diverse needs of teachers and students of a variety of backgrounds in different contexts.

The Internet has provided a medium on which tertiary educators can make their resources and experience publicly available to be shared by all, including secondary school teachers. Around the world, numerous tertiary educators have gladly done so as part of their service to the community. Unfortunately, such resources are largely under-utilised by secondary school teachers, due to reasons such as the lack of knowledge and technical competence. For computer teachers, these barriers are relatively easy to overcome, as long as appropriate support and assistance is provided. For teachers of other disciplines, more help might be required. Ultimately, secondary school teachers have to learn, adapt and use these resources by themselves, and to keep themselves updated via self and lifelong learning to respond to the rapid changes that the world has been undergoing.

In this paper, we have reported our experience in the design and delivery of a short course that has progressed towards this direction. Our course also exemplifies itself as one possible model of "teaching" as "facilitating the self and lifelong learning of the participants". Most tertiary educators have now become regular users of Internet resources for enhancing their teaching and learning. It should not be long before secondary school teachers have to follow suit. What we have contributed is but a small part of the continuing collaborative effort to empower teachers to use IT effectively in secondary schools, and ultimately to better education of our younger generations.

References

[1] Boroni, C. M., Eneboe, T. J., Goosey, F. W., Ross, J. A. and Ross R. J. (1996). "Dancing with DynaLab – Endearing the science of computing to students". In *Proceedings of the Twenty-Seventh SIGCSE Technical Symposium on Computers Science Education (SIGCSE'96)*, 135-139, Philadelphia, USA, February 1996.

[2] Curriculum Development Council (1993). *Syllabuses for Secondary Schools, Computer Studies (Secondary 4-5)*, Hong Kong Government Press.

[3] Education Manpower Bureau (1998). *Information Technology for Learning in a New Era: Five-year Strategy 1998/99 to 2002/03*. November 1998, HKSAR.

[4] Gloor, P. A. (1998). "Animated algorithms". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (eds), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[5] Haajanen, J., Pesonius, M., Sutinen, E., Tarhio, J., Terasvirta, T. and Vanninen, P. (1997). "Animation of user algorithms on the Web". In *Proceedings of IEEE Symposium on Visual Languages (VL'97)*, 361-367, Isle of Capri, Italy, September 1997.

[6] Kalayar, M., Ikematsu, H., Hirashima, T. and Takeuchi, A. (1999). "Intelligent learning support system for algorithm learning". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 840-843, Chiba, Japan, November 1999.

[7] Kann, C. and Lindeman, R. W. (1997). "Integrating algorithm animation into a learning environment". *Computers and Education*, **28**(4): 223-228.

[8] Kong, S.-C., Au, W.-K. and Pun, S.-W. (1999). "A case study on the implementation of information technology education pilot scheme in Hong Kong". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 27-34, Chiba, Japan, November 1999.

[9] Law, N., Wan, J., Lau, M. F., Lee, R. and Yuen, A. H. K. (1999). "Towards a model of IT training for inservice teachers". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 51-58, Chiba, Japan, November 1999.

[10] Mulholland, P. and Eisenstadt, M. (1998). "Using software to teach computer programming: Past, present and future". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[11] Price, B.A., Baecker, R.M., and Small, I.S. (1993). "A principal taxonomy of software visualisation". *Journal of Visual Languages and Computing*, **4**(3): 211-266.

[12] Rautama, E., Sutinen, E. and Tarhio, J. (1997). "Excel as an algorithm animation environment". In *Proceedings of Annual Joint Conference Integrating Technology into Computer Science Education (ITiCSE'97)*, 24-26, Uppsala, June 1997.

[13] Resmer, M. (1999). "IMS – Distributed learning standards". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 567-570, Chiba, Japan, November 1999.

[14] Sloane, A. (1997). "Learning with the Web: Experience of using the World Wide Web in a learning environment". *Computers and Education*, **28**(4): 207-212.

[15] Stasko, J. and Lawrence, A. (1998). "Empirically assessing algorithm animations as learning aids". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[16] Yu, Y. T. and Poon, P. L. (2000). "An approach for evaluating the quality of software developed by novice programmers". In *Proceedings of the 4th World Multiconference on Systemics, Cybernetics and Informatics (SCI'2000) and the 6th International Conference on Information Systems Analysis and Synthesis (ISAS'2000)*, **2**: 485-490, Florida, USA, July 2000.

Learning from the Learning of other Students

Stuart Garner
Edith Cowan University
Pearson St., Churchlands, 6018, Western Australia
email: s.garner@ecu.edu.au

This paper concerns the use of dialogues in student learning and how such dialogues can be captured for subsequent use by other learners. The process of learning by observing another person's learning is known as vicarious learning. The paper begins by discussing the movement towards more flexible types of learning and the belief by many that traditional dialogue has been omitted from a lot of today's courseware. Dialogue can be considered as one of the stages in the learning cycle and to support it there is a need to create tertiary courseware, this being the third stage in the cycle. Some of the research that has taken place into vicarious learning is described and this has shown that it has some benefit to learning and also produces positive feelings in students of being part of a learning community. Finally the vicarious learning resources that have been produced within a software development course at Edith Cowan university using a dynamic screen capturing tool are discussed together with a possible dissemination system.

Keywords: **Distance Education, Flexible learning, Vicarious Learning, Programming**

1 Introduction

Universities and colleges today have record numbers of students and yet the cost being spent per student is steadily decreasing as budgets are cut and universities become ever more competitive. One of the consequences of this is that many managers are turning to the Internet as a means for delivering courseware to students in a supposedly cost-effective manner. Students are also demanding more flexible learning with learners being able to earn when they want (frequency, timing, duration), how they want (modes of learning), and what they want (that is learners can define what constitutes learning to them) [14].

The situation has therefore arisen that students spend more time away from a traditional campus and technology is being used to provide the necessary flexibility with computer networking empowering connectivity and communication, allowing synchronous and asynchronous one-to-one and one-to-many communication [13]. However, such technology does not necessarily support some of the learning situations that are necessary in higher education. Laurillard [6] points out that learning in many educational contexts, particularly in higher education, requires learning about descriptions of the world, knowledge derived from someone else's experience, and from understanding someone else's arguments. She states that:

> *We cannot claim to have sorted out once and for all what students need to be told if they are to make sense of topic X. No matter how much detailed research is done on the way the topic is conceptualised, the solution will not be found in new ways of putting it across. The new way of telling may sort out one difficulty, but it may well create others. All we can definitely claim is that there are different ways of conceptualising the topics we want to teach. So all we can definitely conclude is that teachers and students need to be aware of those differences and must have the means to resolve them.*

The main way this has been done in the past has been by students participating in dialogue with fellow students and their tutors. We do have email and synchronous "chat" available to support dialogue to some extent but it may well be argued that this is insufficient to support the above.

2 The Learning Cycle

Dialogue can be considered as a crucial part of the learning cycle [9]. The cycle is shown in figure 1.

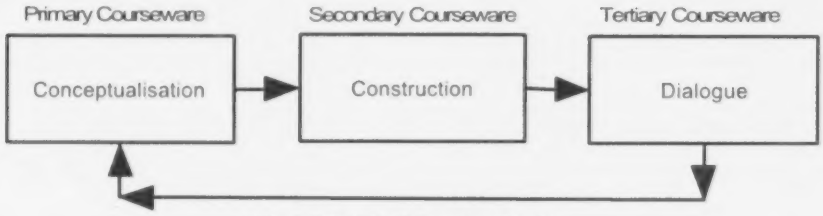


Figure 1: The learning Cycle

It can be considered to comprise:

- conceptualisation which comes from interacting with the primary content and relates to a learner's current state of understanding.
- construction and the use of knowledge occurs with the use of secondary courseware tools such as concept mappers. It involves picking out particularly relevant material, putting the information together in ways which have meaning for the learner, and relating old and new material into a coherent whole.
- dialogue which involves the testing of understanding and can possibly be facilitated with tertiary courseware.

Mayes et al [9] suggest that the third section of the learning cycle, dialogue, can itself be broken up into three stages, these being discussion, reflection and reification. Mayes et al agree with Laurillard that discussion is fundamental to effective education and that a deep understanding is promoted far more effectively and efficiently during discussions. Reflection has always been thought to be an important aspect of learning and can be considered as the testing of new knowledge against the schemata that hold our existing knowledge. And finally reification is a term put forward by Mayes et al and concerns the structuring of newly acquired knowledge into a new object of thought integrated with other knowledge.

The question then arises as to what sort of tertiary courseware can be produced and utilised to support the dialogue aspect of the learning cycle bearing in mind that the material will have to be used in flexible learning environments. One particularly interesting line of research has been into recording of discussions and making them available to other students in a flexible mode. This concept is known as vicarious learning where this is defined as [2]:

> *The potential benefit to learners of being able to observe or 'listen in' on experts or their peers as they discuss a new topic.*

The following can be considered to be vicarious resources:

- Frequently asked questions (FAQs). Here students can learn from the answers to typical questions posed by other students.
- Listservers. These promote vicarious learning as students receive the text dialogues that take place between various subscribers. The term "lurker" is often used for the person who does not participate in dialogues but prefers to simply observe.
- Bulletin boards. These provide the means for asynchronous dialogues and again can be used by "lurkers".
- Chat rooms. These provide the means for synchronous dialogues.

3 Research into Vicarious Learning

Research initiatives are in two main areas, the first attempting to determine if vicarious learning is of benefit to students and the second looking at how such dialogues might be made available as tertiary courseware for re-use by other students.

There are several interesting questions that might be worthy of investigation in the first area. Cox et al [2] suggest that we need to determine who are useful models for the vicarious learner, experts or novices. It might be better to observe experts as skilled behaviour would hopefully be modelled in a clear way, although this is not of course always true as many experts find it difficult to make their knowledge explicit. It could be argued that student – student dialogues would be better to observe as the observing student would be better able to identify with other students. Also the students participating in the dialogue might use more appropriate language and also ask questions of each other that they may not have wished to ask their tutor. Cox et al also point out that observing unskilled behaviour may also prove to be of benefit as the observing student would determine from the dialogue what sort of errors to avoid without having to make those errors themselves. Also of course, the dialogue type to observe may depend on the type of student who is the observer. It might be more appropriate for a strong student to observe experts and for a weak student to observe novices.

In one particular piece of research on vicarious learning [7] benefits were found that were both cognitive, with an increase in knowledge and understanding in the particular curriculum area, and social with exposure to peer discussion creating positive feelings of being part of a learning community.

Lee et al [7] carried out research within an on-line Masters level course in Computers in Teaching and Learning. They created task-directed discussions (TDDs) in order to capture good learning dialogues amongst students and to overcome the "barriers of silence" that might otherwise occur. Over 30 hours of discussions among students, and between students and a tutor (the expert), using the TDDs were videoed.

An architecture called the Dissemination System (DS) was created from primary instructional materials and integrated clips taken from the videos. The DS allows a multimedia database of video and audio clips, text transcriptions, and annotated graphics to be integrated with primary expository teaching material and delivered via the Web. The system was then used in an experiment to investigate the vicarious resources in a controlled laboratory setting.

The experiment used a section of the course on Models of Learning with Technology. Two sets of learning materials were created, the first comprising primary learning materials (approximately 45 web pages) and the second comprising both primary learning materials and an integrated set of vicarious learning resources. The vicarious resources had been obtained from the videoed dialogues and comprised 108 video clips, 13 audio clips, 43 text transcriptions, and 27 audio annotated graphics. The resources were accessible by either clicking on highlighted keywords or by a search mechanism.

Two groups of students took part in the experiment, one using only the first set of learning materials whilst the other used the second set of learning materials which included the vicarious resources. The conclusions that Lee et al drew from the experiment were that there were some benefits in learning and substantial positive changes in attitudes and discussion behaviour for the students who used the vicarious learning resources. The researchers also make the point that although some people claim that learning can only take place when students are personally engaged in discussion, the evidence suggests that observing peer dialogues can, on the contrary, provide a useful source for learning, both cognitively and socially. The researchers have in fact suggested that such vicarious learning may sometimes be more beneficial than being a participant, depending on the state of the learner [11].

The web based materials used in the experiment are available at http://www.herc.ed.ac.uk/Vicar/TT/. They are fairly slow to download from the Web but realistically they could be put onto a CD ROM for use with distance learners. The audio dialogues that are available are played whilst a static graphical image is displayed to the learner. Such a dialogue concerns the graphic being displayed and I felt that something was lost in this type of dialogue and that it would have proved to be more useful and meaningful if objects on the graphic could have been "pointed to" in order to draw the observer's attention to the important aspects of the graphic.

4 Creation of Vicarious learning Resources with Dynamic Screen Capturing Tools

During the summer school of 1998 at Edith Cowan University, I made use of Lotus ScreenCam for student-tutor dialogues within a Software Development unit. Between lectures and laboratory sessions, students had

no contact with me as I was off campus, however I did have access to email at home enabling students to send me ScreenCam movies of any programming problems that they were having. In addition to movies, students would also send the programming code enabling me to use this when making a "reply" movie. An example of a screenshot taken from a movie, which was sent to me by a student, is shown in figure 2.

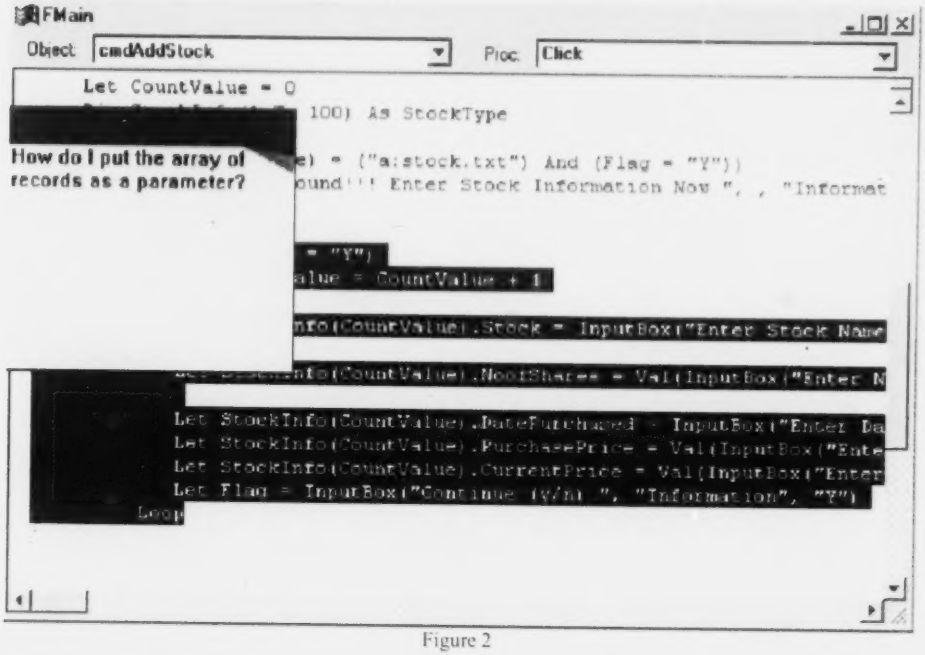


Figure 2

The movie had several text captions and concerned a problem that this student was having with passing arrays to subprograms in Visual BASIC. A screenshot taken from the movie, which I made and subsequently sent back to the student, is shown in figure 3.

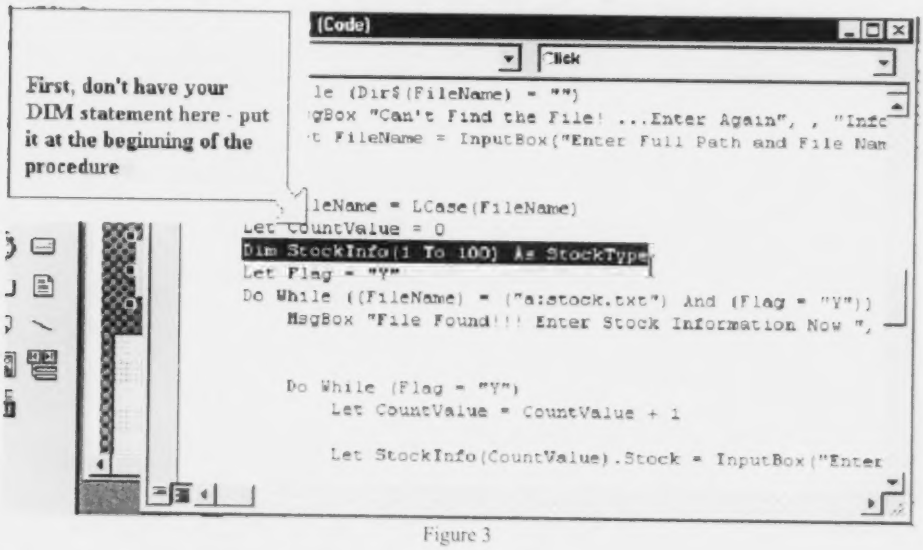


Figure 3

The screenshot in figure 3 includes a text caption that has nothing to do with the original student problem. It

BEST COPY AVAILABLE

is the sort of comment that I would make if I were looking at the code that a student had produced in a laboratory session. In the rest of the movie, I was able to make suggestions on how to overcome the original problem and I also included a captioned comment about the lack of comments within the student's programming code. By using ScreenCam, I had been able to engage in a richer asynchronous dialogue with the student than I would otherwise have done by conventional means. In addition, as a side effect, I was building up vicarious learning resources for use in future semesters.

In addition to capturing asynchronous dialogues as described above, Lotus ScreenCam can be used to provide rich feedback to students on their assignment work. Simple "low-tech" audio tapes have been used in student feedback [1] and it is suggested that such feedback adds a social dimension to the commentaries with the tutor being able to talk personally to each student, whereas written comments lacked context and sounded impersonal.

I produced a set of such movies for the small group of campus-based students that were involved in the 1998 summer school session mentioned earlier. Each week the students attempted a small programming problem and handed in the relevant programming code together with a small text -captioned movie explaining their program. I then made a feedback movie for each student. Each feedback movie had audio commentaries to keep the production time to a minimum and the movies were placed onto ZIP disks that had been provided by the students. I was able to go through the programming code on the screen, highlighting areas of interest with the cursor whilst making comments and in addition run the student programs with a variety of data whilst passing comments about both the good and the bad points of the programs.

The sets of movies that the students handed in and that I produced have now become another vicarious learning resource for use by students in subsequent semesters. Each week, students are given a small programming problem to attempt and they can then use the movies to view the student – tutor interactions for a similar programming problem. In practice, students have commented on how useful they have found these resources. Feedback was elicited on-line and some of the comments follow:

- I found it helpful and interesting in giving clear visual instructions or explanations.
- All the other students solutions were very helpful. And they were informative.
- Only used the movies once, but they do provide a good resource for students experiencing difficulty.
- Pick up other students mistakes.
- Always forgot how to get to them
- Probably slack, but using the sound was too much hassle.

5 Delivery Mechanisms for Vicarious Resources

The last two student comments above indicate that there is a need for some form of technological delivery mechanism for the vicarious resources that have been produced that is simple and easy to use. Students need to be able to quickly find movies that are appropriate for the programming problem that they are attempting and then view the movie. We have experimented using the Web to deliver the movies however this has been a problem as movies with audio are of the order of 1MB in length per minute and take too long to download. Realistically it is necessary to make the movies available on CD ROM and we will be using a Windows Help file as a way of delivering the movies. There are several Help file authoring tool available and one that I have used extensively is ForeHelp [4]. A Help file can be produced with the usual contents and index pages with little effort and programs can be launched seamlessley thereby permitting the running of ScreenCam movies.

6 Discussion

It would appear that the use of vicarious learning resources by students can benefit learning and also provide positive feelings of being part of a learning community. However the creation of such resources needs to be done very carefully so that they are relevant and of interest to learners. If a synchronous dialogue is to be recorded by the use of video or audio then it is important to use task directed discussions [7] to ensure that a relevant dialogue ensues. Asynchronous dialogues usually take place by email or bulletin boards, however

they can be made richer if a dynamic screen capturing tool is used. Finally the vicarious learning resources that have been collected need to be made available to other learners and to this end Lee et al created a web based dissemination system. Another approach is to use a Windows Help file for disseminating such resources assuming that delivery is to be by Wintel hardware only.

In the future I intend to look at capturing synchronous dialogues using a dynamic screen capturing tool. These would be both student – student and student – tutor where the two participants sit in front of a PC whilst having a dialogue concerning a program that is being displayed.

References

[1] Anson, C. M. (1997). In Our Own Voices: Using Recorded Commentary to Respond to Writing. New Directions for Teaching and Learning, Spring 1997(69), 105-113.

[2] Cox, R., J. McKendree, et al. (1998). Learning vicariously from educational dialogue and discourse. 20th Annual Conference of the (US) Cognitive Science Society, Madison, Wisconsin.

[3] Domingue, J., & Mulholland, P. (1997). Teaching Programming at a Distance: The Internet Software Visualization Laboratory. Journal of Interactive Media in Education (http://www-jime.open.ac.uk), 1, 1-28.

[4] ForeHelp User's Guide (1995). ForeFront Incorporated

[5] Garner, S. (1997). Cost Effective Multimedia Production for Frequently Updated Courseware. Paper presented at ASCILITE 97, Curtin University, Perth.

[6] Laurillard, D. (1993). Rethinking University Teaching: A Framework for the Effective use of Educational Technology, London Routledge.

[7] Lee, J., F. Dineen, et al. (1999). Vicarious Learning: cognitive and linguistic effects of observing peer dialogues. American Educational Research Association (AERA '99), Montreal, Quebec.

[8] Lotus Corporation. (1997). White Paper (Technical) http://www.lotus.com/home.nsf/welcome/screencam, (accessed on June 23, 1999)

[9] Mayes, J., J. McKendree, et al. (1996). The Vicarious Learner: Rethinking the use of dialogue in teaching and learning. http://www.hcrc.ed.ac.uk/gal/vicar/VicarPapers/vicar.html (accessed on Aug 4, 2000).

[10] Mayes, J. T., & Neilson, I. (1996). Learning from other People's Dialogues: Questions about computer-based answers. In B. Collis & G. Davies (Eds.), Innovating Learning with Innovative Technology . Amsterdam: North-Holland.

[11] McKendree, J., K. Stenning, et al. (1998). "Why observing a dialogue may benefit learning." Journal of Computer Assisted Learning **14**: 110-119.

[12] Neville, L. (1995). Sense-making and Sensitivities: New Pedagogies? New Practices? New Acceptance of Old Ways of Learning? Australian Educational Computing (May 1995), 15-19.

[13] Nikolova, I. and B. Collis (1998). "Flexible learning and design of instruction." British Journal of Educational Technology **29**(Jan. '98): 59-72.

[14] Van den Brande L (1993). Flexible and distance learning John Wiley, Chichester, UK

The web of the Teacher Professional Development

Hsu, chia-ling*,She Hsiao – Ching, and Lin,Min-Sheng*****
**Tamkang University clhsu@mail.tku.edu.tw*
***National Chiao-Tang University sheposei@ms14.hinet.net*
****National Taipei University of Technology mslin@ee.ntut.edu.tw*

1 Introduction

The education reform is one of the main issues in Taiwan. It provides an opportunity for the universities to open a teacher education program. In teacher education program, it emphasis on pre-servise, internship, and in-servise teacher training. Therefore, the lifelong learning and teacher professional development become very important for teachers. In, addition, the Department of education in Taiwan listed the lifelong learning as one of the main objectives since 1986. The government also declared the year of 1997 as the lifelong learning year (Yang, 1996). Hence, the result of this study, the TPD web site, is to enrich the lifelong learning environment for teachers to improve their professional knowledge.

Today is an age of information. The computer and Internet are changing our daily life. These new communication technologies will replace the traditional communication technologies (Hsu & Hsu, 1998). The traditional computer education emphasized the tutoring function. Although the CAI provides the learner control and independent study, it is lack of the opportunity to the students to explore their learning and to experience the discovering the results. On the other hand, the Internet connects all computers and all the information to be a big information sharing system. Moreover, people who are using Internet in education can learn the lesson in anytime at anyplace with any kind of computer system. The Internet changes the learning style from the physical, aerial, closed system into a virtual, long-distant, and opened learning environment. The resoult of this study is a teacher professional development website system. There is information for the pre-education students, for the interns, and for the in-servise teachers.

One of he main characters in the information society is changing quickly. Teachers are asked to improve their teaching knowledge and skills while they are studying in the teacher education program, or practicing their teaching skill in the internship training, or attending workshop in their daily teaching job. The process of the teacher professional development begins from the pre-servise education, and then into the internship education, and finally the education for the in-servise teachers(chang & Hsu, 1996). In the pre-servise education, students start to study a set of the education professional knowledge, and start to form their attitute, education vision, and education commitment in order to develop the special characters of the educator for these students (Jaoun, 1984). The teacher education program contains the teaching theory-based courses, the teaching method-based courses, and the teaching internship-based courses (Yang, 2000). During the teaching internship program, the students learn with the in-servise teacher and the professor. The students get into the school system to learn all kinds of the knowledge and skills in school based environment (chen, 1995). For the in-servise teachers, though, they are accumilating lots of teachiing experence, they need to reflash their teaching knowledge and skills (Lee, 1996). Therefore, for those in-servise teacher with different kinds of teaching needs, the education program should consider the teachers needs and encourage them to work togather to help each other in order to meet their teaching needs (Moursuond, Bielefeldt & Underwood, 1997). Hence, this study is based on the theory of the teacher professional development to development a virtural communication environment for teachers in order to achieve the goal of the teacher professional development.

The TPD web site will provide the information for all kinds of teachers. There are two purposes of this study. One of the puropose of this study is to enrich the literature of the teacher professional development. The other purpose of this paper is to build up a network-learning environment for those who are in pre-teacher program, internship, and on job training to improve their professional ability.

2 Conclusions

The result of this study is to build up a teacher professional development web site(http://www.tep.tku.edu.tw/3ic). It contains pre-servise education program courses, the information for the internship teachers, and the lifelong infromatioin for the in-servise teachers. There is a virtural classroom to provide the teaching manegement function to teachers. In addition, it contains the communiction function to various of teachers by using disscussion groups or BBS. The function of the questionnare is to provide a tool for action research. When teachers use this function to create the questionnare and send it by e-mail or web, the system will collect and analysis the data.

This study is based on the theory of the teacher professional development to develop a web site. The result of this study is not only to build up a teacher professional development web site but also to enrich the literature of the co-operative learning model. By developing this virtural lifelong learning web system, the future studies on the co-operation between different kinds of teachers are needed.

3 References

Hsu, F. C. & Hsu, C. L.(1998). The behavior for Media choice in Taiwan. Proceeding of the International Information Management Conferrence. pp.469-479.

Chang, Y. F. & Hsu, C. L.(1998). System Development for Teacher Professional Development, *Instructional technology & media*, No. 40, pp.3-11

Yan, K. S.(1998). Lifelong Education Policy and Strategy in Taiwan. Paper present at Educational Technology and Lifelong Learning.

Joan, C. W.(1996). Teacher Professional Development Theory and Practice. Taipei. Wu-nan.

Chen, M. Y.(1997). Teacher Profession-Teaching Concept and Practice. Kaochun. Li-wen

Moursund, D., Bielefeldt, T., & Underwood, S. (1997). Computer Technology and Professional Development: Suggestions for schools. Http://www.iste.org/Resources/Projects/RoadAhead/Pd.html

ICCE / ICCAI 2000

Learning Societies in the New Millennium : Creativity, Caring & Commitments

Proceedings

Content

▸ Full & Short Papers (Methodologies)

A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents
Courseware Engineering Methodolgy
Defining Educational R&D: A Content Analysis of Journal Articles and Implications for Instructional Technology
Design and Implementation of a Chinese web-mail system
Facilitating examples understanding through explicit questioning
Organization of the introductory and motivational stage of activity in a computer tutoring system
Relating telecommunication training objectives to SMEs' actual needs
The "Half-Life" of Knowledge in the University of the 21th Century
The Rhetoric of the Web. A semiotic approach to the design and analysis of Web-documents
Towards a model of using Information Technology in education for pre-service teacher education
Traversing the Case Graphs. A Computer Model for Developing Case-based Learning Systems

▲ HOME

A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents

Chih-Kai Chang and Kuen-Shan Wang
Department of Information Management
Da-Yeh University
Da-Tsuen, Chang-Hwa 51505 Taiwan, R.O.C.
E-mail: chihkai@mail.dyu.edu.tw

As Web-based course become popular, the Web system accumulates a large amount of log data. Because the log data was generated by learners' behavior on the Web-based course, many researchers agree that analyzing the Web log will bring benefits for learners, instructors, and the Web site manager. In general, one record of Web log can indicate "which Web page was accessed", "who access that Web page", and "when the Web page was accessed". Although many interesting results can be derived merely depending on the general Web log, some important meanings of the Web log were not considered in previous researches. In other words, the content, represented by the Web page, is not included in the general Web log. For instance, a Web page may present homework, a discussion article, a section of curriculum, or a grade reports. However, previous research did not consider the represented content of a Web page in the Web log, in which only the file name of the accessed Web page is generally identified. This paper use data mining technology to analyze learners' online behaviors for mining learner's patterns by transforming general Web log to a content perspective. Hence, the methods of previous research still can be used to find the more meaningful results. Most important of all, our methodology finds patterns based on learning behaviors instead of browsing behaviors.

Keywords: **Web-based course, Web log, Data mining technology.**

1 Introduction

As Web-based course becomes popular, various learning activities can be running on the Web [1]. The asynchronous discussion activity, homework assignment and submission, announcement, and grade reports all can be executed on the Web. Because all the learning activities are represented as Web pages, the Web server will accumulate a large amount of log data for every Web page. Basically one record of the Web log can indicate which page was access by someone in sometime. Hence, many researches analyzed the Web server log to figure out users' motivation, users' response, browsing pattern, and the network traffic [2, 3, 4]. Furthermore, analyzing students' on-line learning behaviors and on-line problem solving activities can also discovery meaningful results [5].

There are at least 116 products of Web log analysis for commercial web sites [6]. The technologies used for analyzing Web server log evolve from traffic-based or time-based assessment to user access pattern analysis. For example, Perkowitz uses access patterns to construct an adaptive Web site [7]. Hence, the interested Web pages will be linked and organized as a proper view for every user according his/her access patterns. The *path* concept, users' sequential Web page access records, is important for constructing user access pattern for Web logs. For instance, Stuart Schechter [8] create users' path profile to predicate users' browsing behavior. Consequently, the field of Web log analysis is growing for the purpose of custom services.

Recently, applications of Web log analysis integrate data mining techniques to focus on the customer behavior patterns. It is because the predictive modeling and link analysis operations in data mining

techniques can be used to answer questions such as "Which of my customs will prove to be good, long-term valuable customers and which will not?", "How can I sell more to my existing customers?", "Is there a recognizable pattern in which my customers acquire products or use services so I can market to them just-in-time?", and so on [9]. Consequently, we intuitively apply data mining techniques to Web log analysis of an instructional Web site.

For Web-based instructors, their requirements for Web log analysis differ from managers of commercial sites. One of the reasons is as Raphen Becker said, "Because many existing systems are targeted toward commercial webs, the answer is yes, course webs require different systems. One reason is simple: most instructors (and even institutions) cannot afford the commercial products, which are priced toward industry and not towards academia."[10]. Although researchers realize the differences between course webs and commercial sites, the proposed methodology for Web log analysis still inheritance from the Web logs analysis products for commercial sites. For instance, Clio project pays efforts to answer the questions such as "What are the more popular parts of the course web?", "How do readers reach particular pages?", and "Can they quickly reach the pages they want?" so on. Unfortunately, most questions of that kind can be answered by existing Web logs analysis products.

When analyzing Web logs of a course Web, we concern that one encounters what specific problems, which can not be answered by existing Web logs analysis products. In other words, only the learning characteristic of the Web-based learning environment can originate the specific problems. Our previous research focus on providing various summary report for Web instructor to solve that problems, which can not be answered by Web log analysis, from any perspectives [11]. Hence, the questions, which a instructor may ask, should be "What are the meanings of the more popular parts of the course web in learning hierarchy?", "What is the concept that leads learners to reach particular pages?", and "Can learners quickly reach the learning goals by reorganizing Web pages?" so on. In other words, the reports of existing Web logs analysis products should be interpreted to mining the pedagogical meanings by instructors, instructional designers, Web designers, and course web architects. Consequently, it is necessary to propose methodology for discovering learner (not user) access pattern in the Web-based course.

To mining the pedagogical meanings from Web logs, the first requirement is to understand the content of every Web page. In other words, the instructor of the Web course not only need to know ' who accessed the Web page', 'when the Web page is accessed', and 'from where the learner come', but also should know 'what the Web page contains'. However, it is difficult to represent the content of a Web page with symbols. The reason is that the content of a Web page may contain many concepts. Consequently, the first step for understanding the pedagogical meaning is reconstructing the Web pages in the site of a Web-based course by endowing only one topic or concept for each Web page. While breaking a Web page into single concept Web pages, one would find that some concepts are not atomic concepts. That is because a major concept will contain many sub concepts. Hence, the second step for understanding the pedagogical meaning of a Web page is to identify its location within a concept hierarchy instead of its location within the hypertext hierarchy.

The second requirement for discovering learners' learning pattern is to mining sequential access paths on previous aforementioned concept hierarchy. Although there are methodologies to reconstruct navigating paths of users' behaviors on a Web site, that information is not enough for a Web instructor to make some pedagogical decisions. The users' access (behavior) pattern can only help Web site manager improving Web site schema because a Web instructor still can not figure out learners' intention merely by analyzing Web logs without supports of the Web page content. The proposed concept hierarchy presents a feasible style for supports of interpreting the Web page content. After learners' navigating paths on a Web site are transforming to navigating paths on the concept hierarchy, a Web instructor can comprehensive how learners learn from the information of what learners read.

This paper proposes a methodology to mining learners' learning pattern by transforming learners' Web page access sequences to sequences of learning a concept in Web logs. The methodology is supported by traditional web logs mining algorithms, which is designed for discovering users' access pattern on a Web site. This methodology is not used to replace traditional web logs mining algorithms nor is arguing that concept hierarchy is a suitable web site schema. Rather, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor get more feedback from learners' navigation on the Web course site. Broadly speaking, this methodology contribute to apply traditional web logs mining algorithms to a specific domain in the technical aspect and progress assessment skills in the Web-based distance learning aspect.

2 Illustrative Example

In overview, there are two steps in this illustrative example of detecting learning status. The first step is data preparation. We design a sophisticate structure of a Web site so that we can recognize the content of the accessed Web page. The second steps will find pedagogical meanings from the contents of the preferred Web pages. In this illustrative example, the result of step two will show that learner is not familiar with the learning topic.

2.1 Data Preparation

The required data was collected from the students in an undergraduate course of Perl programming. Perl is a high-level programming language written by Larry Wall. Perl is a very popular programming language for system administrators and CGI script authors. After a brief introduction of Perl, students were asked to study the Web pages extracted from Perl manual. There are three topics in the prepared Web pages. First topic of Web pages demonstrates how to execute the Perl interpreter, called *Perlrun* in Perl manual. Second topic of Web pages explains the Perl model for declaring importing, and calling a subroutine, called *Perlsub* in Perl manual. Third topic of Web pages describes associativity and precedence of Perl operators, called *Perlop* in Perl manual. Consequently, learners' behaviors recorded by Web logs can be recognized by the topic of accessing Web page.

Synopsis and description compose each topic of Web pages. Synopsis is a summary of a topic and generally contains no more than one page. Figure 1 illustrates the synopsis of the Perlsub topic. Description explains the details of a topic in original Perl manual. For illustration, description for each topic was reorganized into two Web pages. In general, synopsis of a topic is prepared for learners who are familiar with that topic. Learners who are learning a topic will prefer the description of that topic. Hence, we can help a learner just in time if he/she is always looking around the description of a topic.

Aforementioned structure is content structure of learning materials. To present learning materials in a hypertext style, a hyperlink structure is required. We use the full connection style to link all Web pages so that learners can navigate to any destination in any Web page.

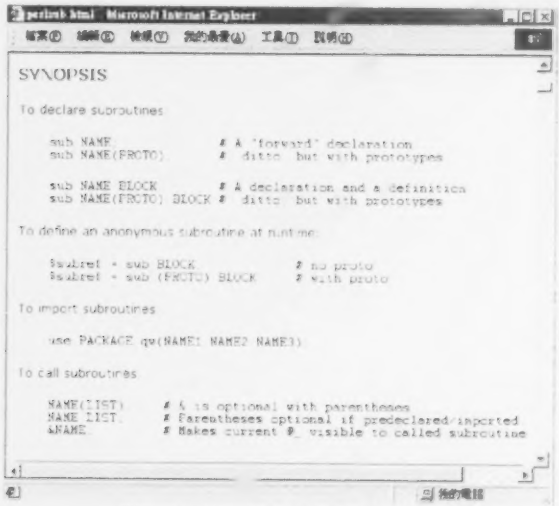


Figure 1. Synopsis of Perlsub.

Figure 2 shows the concept structure of the learning materials on the Web site. The notation P_i indicates the Web pages. Although the overview structure is composed of concept hierarchy and contents of learning materials without hyperlink information, the tree structure above the P_i can be used to interpret the content in the page. For instance, the P_1 belongs to concept synopsis, which is the partial content of the Perlrun topic.

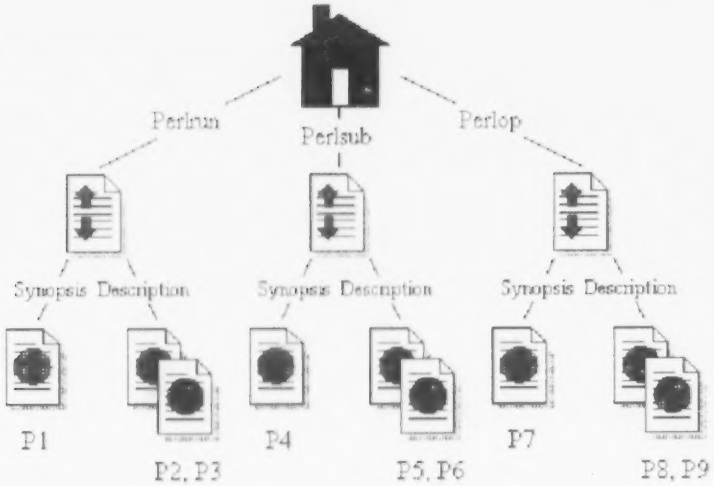


Figure 2. The concept hierarchy of a Web site.

2.2 Mining Processes

There are three learning topics in the Web site, denoted as Perlrun, Perlsub, and Perlop. Each learning topic has two sub concepts, denoted as synopsis and description. The word "synopsis" is used to indicate the Web page for summarizing a topic and the word "description" represents the Web pages that explain a topic in detail. There is an index Web page linking every Web pages to serve as communicating interface with learners. Hence, learners can study any topic in any order through the index Web page. Assume that there is a learner who prefers the "description" Web pages of any topic. In other word, that learner is not familiar with all topics. Hence, the logs of that learner' s browsing behavior on the Web site may be like the sequence:

p2, p3. p2, p8, p9. p5, p8. p5, p1. p2, p5, p6

Because learning can happen in any time, only time nearly browsing behaviors will be related in a learning pattern. Hence, the transaction idea, used in database theory, is involved to cluster learners' browsing behavior. The T*i* means a transaction of the learner' s browsing behavior.

T1: p2, p3
T2: p2, p8, p9
T3: p5, p8
T4: p5, p1
T5: p2, p5, p6

The content of every Web page can be interpreted as a pair of topic and representation style. For instance, p2 belongs to topic Perlrun and is a description of the topic. Hence, p2 is interpreted as (Perlrun, description). After interpreting the transaction data of learner' s behavior, the results are follows.

T1: (Perlrun, description), (Perlrun, description)
T2: (Perlrun, description), (Perlop, description), (Perlop, description)
T3: (Perlsub, description), (Perlop, description)
T4: (Perlsub, synopsis), (Perlrun, synopsis)
T5: (Perlrun, description), (Perlsub, description), (Perlsub, description)

Most of algorithms for mining pattern are derived from aprior [12]. We divide the problem of discovering multi-dimension learner access pattern into four sub procedures, that is litemset phase, transformation phase, sequence phase, maximal phase. Hence, we can use the aprior algorithm for mining pattern. We use the illustrative example to depict the four sub procedures. The litemset phase will generate the large-1 itemset as Table 1.

ID	Large-1 itemset	Support
1	(Perlrun, '*')	3
2	(Perlsub, '*')	3
3	(Perlop, '*')	3
4	('*', description)	4
5	(Perlrun, description)	3
6	(Perlsub, description)	3
7	(Perlop, description)	2

Table 1. Large-1 itemset.

The transformation phase use the feasible IDs of items in the large-1 itemset to substitute items in the transaction of learners' behavior. For instance, the (Perlrun, description) in T1 can be substituted by (Perlrun, '*'), ('*', description), or (Perlrun, description). Hence, the set of feasible IDs is {1, 4, 5}. The result after the transformation phase is following.

T1: {1, 4, 5}, {1, 4, 5}
T2: {1, 4, 5}, {3, 4, 7}, {3, 4, 7}
T3: {2, 4, 6}, {3, 4, 7}
T4: {2, 4, 6}, {1}
T5: {1, 4, 5}, {2, 4, 6}, {2, 4, 6}

The problem is simplified to mining sequential patterns after the transformation phase [13]. Consequently, the sequence phase can generate the large-2 itemset and larget-3 itemset as Table 2 and Table 3.

Large-2 itemset	Support
{1, 4}	3
{2, 4}	2
{4, 3}	2
{4, 4}	3
{4, 7}	2
{5, 4}	3
{6, 4}	2

Table 2. Large-2 itemset.

Large-3 itemset	Support
{1, 4, 4}	2
{4, 4, 4}	2
{5, 4, 4}	2

Table 3. Large-3 itemset.

Finally, the maximal phase will find the most meaningful pattern from large-2 itemsset and large-3 itemset. Initially, the union of large-2 itemset and large-3 itemset is used as the result. Then, some items will be eliminated because they are the subsets of some larger items. For instance, the meaning of {5, 4, 4} is more than its subset {5, 4} and {4, 4}. Hence, the large-2 items, {5, 4} and {4, 4}, will not be deleted from the initial result. Finally, some items will be eliminated because they are less meaningful then items in the result. For instance, the {4, 3} will be deleted because {4, 7} implies {4, 3}. Similarly, the {2, 4} will be deleted because {6, 4} implies {2, 4}. The following table illustrates the result.

Maximal itemset	Real patterns	Support
{6, 4}	{(Perlsub, description), ('*',description)}	2
{4, 7}	{('*', description), (Perlop, description)}	2
{5, 4, 4}	{(Perlrun, description), ('*',description), ('*', description)}	2

Table 4. Maximal itemset.

3 Conclusion

The Web-based learning environment offers opportunities to precisely observe learning processes. However, it is tedious for a Web instructor to discovery useful information from the huge amount of Web logs. Traditionally, a Web instructor uses the Web logs analysis products to realize the unusual parts of a Web site. From the pedagogical standpoint, the results of the Web logs mining algorithms are not very useful for figure out learners' learning process because the contents of Web pages are not considered. This paper proposes a methodology to mining learners' learning pattern, which is related with the Web page contents, from Web logs. The methodology uses Web logs mining algorithms, which is used in Web logs analysis products, and the concept structure embedded in Web pages to mining patterns with pedagogical meanings, so called learning patterns. In our opinions, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor figure out learners' navigation on the Web course site from the concept hierarchy perspective. Consequently, the approach presented here may be not only a feasible application of traditional web logs mining algorithms, but also a possible direction of Web-based learning assessment research.

Acknowledgements

This project is supported by the National Science Council in Taiwan under contract number NSC 89-2511-S-262 -001.

References

[1] C.K. Chang and G.D. Chen. Constructing Collaborative Learning Activities for Distance CAL Systems. Journal of Computer Assisted Learning, Vol. 13, No. 1, pp. 2-15, March 1997.

[2] R. Fuller and J. de Craaff. Measuring user motivation from server log files. In http://www.microsoft.com/usability/webconf/fuller/fuller.htm

[3] T. Sullivan. Reading reader reaction: A proposal for inferential analysis of web server log files. In Proc. Third Conf. Human Factors on the Web, Denver, Colorado, June 1997.

[4] Sun, C. T. & Ching, Y. T. (1995). Hypermedia Browsing Pattern Analysis. International Journal of Education Telecommunications, 1(2-3), 293-308.

[5] Jihn-Chang J. Jehng. Exploring Learning Potentials in Network-enhanced Learning Environment. In Proc. of ED-MEDIA 99, Seattle, Washington, USA, 1999.

[6] Internet Product Watch (1999). Internet Product Watch: Analysis Products. Online document at http://ipw.internet.com/analysis/index.html (accessed March 25, 1999; no creation or modification date available).

[7] M. Perkowitz and O. Etzioni. Adaptive sites: Automatically learning from user access patterns. In Proc. 6th Int. World Wide Web Conf., Santa Clara, California, April 1997.

[8] Stuart Schechter, Murali Krishnan, Michael D. Smith, Using path profiles to predict HTTP requests. Computer Networks, (30)1-7, pp. 457-467, 1998.

[9] Peter Cabena, et al. Discovering data mining: from concept to implementation. Prentice-Hall, Inc.

[10] Raphen Becker, Kevin McLaughlin, and Samuel A. Rebelsky. Project Clio: Tools for tracking student use of course webs. In Proc. of ED-MEDIA 99, pp. 981-986.

[11] C.K. Chang, G.D. Chen, and Kou-Liang Ou. Student Portfolio Analysis by Data Cube Technology for Decision Support of Web-Based Classroom Teacher. Journal of Educational Computing Research, Vol 19(3), 307-328, 1998.

[12] Rakesh Agrawal, Heikki Mannila, Ramakrishnan Srikant, Hannu Toivonen, A. Inkeri Verkamo: Fast Discovery of Association Rules. Advances in Knowledge Discovery and Data Mining, pp. 307-328, 1996.

[13] Rakesh Agrawal and Ramakrishnan Strkant, Mining Sequential Patterns. ICDE, pp. 3-14, 1995

Courseware Engineering Methodology

Lorna Uden and Neil Willis
School of Computing, Staffordshire University,
The Octagon, Beaconside, Stafford, ST18 0AD, UK.
Phone: +44 (0)1785 353276
Fax: +44 (0)1785 353497
E-mail: L.Uden@staffs.ac.uk

The design and development of effective courseware is complex process involving many forms of expertise. Several disciplines such as instructional design theories, software engineering principles, human-computer interaction and multimedia are involved. It is not always feasible for a novice to be familiar with such a range of expertise. A methodology integrating all of these various disciplines is urgently needed. The Courseware Engineering Methodology (CEM) has been developed by the author to guide novices to design effective courseware, based on the integration of the various disciplines. CEM has been used successfully by over seventy students at an UK university to develop their courseware in the last few years. This paper describes the CEM development process. The CEM process consists of four models. The pedagogical model concerned with the pedagogical aspects of the courseware; the conceptual model, dealing with the software engineering aspects of the design; the interface model relating to the interface of the courseware, and the hypermedia modelling that deals with the navigational issues of the courseware. Each of the models will be briefly reviewed. The paper concludes by stating the benefits of using a modular approach to courseware development and reuse.

Keywords: **Pedagogical Model, Conceptual Model, Navigational Model, Interface Model**

1 Introduction

Computer technology offers great potential as a valuable instrument in teaching and learning. However, the impact of its use in education is not very impressive. One of the main problems attributed to this disappointing fact is that developing effective courseware is not trivial. Although there are tools that minimise the computer-related knowledge required, they are merely implementation tools. Successful designers need to understand both the subject upon which lessons are based and the principles of instructional design and learning theories. On top of these are the issues of software engineering principles, human-computer interaction and hypermedia involved. It is rare that a novice would possess such a wide range of expertise. A methodology is urgently needed to enable novice designers to design and develop effective courseware. The different types of expertise need to be integrated and transformed from one form to another in order to maintain a seamless transition. This is necessary because courseware development consists of several phases. The task of courseware design extends from the analysis of the domain knowledge to be taught, to the development and delivery of instructional materials.

1.1 Problems with the traditional approach

There are many problems associated with the traditional approach to courseware development, among which are:

- a lack of prototyping facilities to allow early evaluation of the lesson;
- a lack of separation of the various components of the development process;

- a lack of support for reuse;
- a lack of a method for interfacing and hypermedia modelling.

In order to overcome these limitations, an engineering approach to courseware development is desirable. The methodology should be based on sound principles from the various necessary disciplines that have implications for effective courseware. To be effective, it should contain design principles and guidelines, which can help designers, in particular novices, in the various phases of the courseware development process. The Courseware Engineering Methodology (CEM) has been developed specifically to help novices to develop courseware.

In order to evaluate the methodology, CEM was used by over seventy student designers over a period of three years in the Instructional Software Design (ISD) module at a UK university to develop their own courseware.

2 The CEM Development Process

Because courseware development is such a complex task, it is not possible to cope with handling all requirements at once. In order to reduce the complexity, a model-based approach is taken in CEM for courseware development. By allowing the development of courseware with a number of different models, designers are allowed to focus on each aspect of the courseware one at a time. Each partial model is an abstraction of the system, which enables designers to make the necessary decisions at each level in order to move closer to the final model.

Model-based design facilitates the principles of decomposition, abstraction, and hierarchy. It also allows designers to describe the application in an implementation-independent way. Besides the model-based approach, the methodology adopts an evolutionary prototyping process for its development. In addition, there is a separation of the domain from the instructional strategies. For hypermedia courseware such as the World Wide Web, there is navigation modelling to structure the hypertext links and contents. There are four main models involved in CEM. These are the pedagogical, conceptual, navigation and interface models; each dealing with the various aspects of the development process.

2.1 Iterative Incremental Development

Counter to the traditional linear model of courseware development, iteration and incremental development is at the heart of CEM. Incremental development, in this context, is a process that involves continuous integration of components into the system' s architecture to produce releases, with each new release embodying incremental improvement over the other [2]. An overall system architecture is established early in the process to act as a framework. System components are incrementally developed and delivered within this framework. User feedback from delivered components can affect the design of components scheduled for later delivery. An iterative incremental development is based on successive enlargement and development of a system through multiple development cycles of analysis, design, development and evaluation. Each cycle tackles relatively small sets of requirements and the system grows by adding new functions within each development cycle. This approach offers the benefit of allowing requirements to be adjusted to match changing user needs as the product proceeds.

CEM is an iterative and incremental design approach, based on the construction of a sequence of models, which begins from analysis and continues through implementation. It thus produces a seamless transition from abstract pedagogical model to concrete courseware design, allowing for a clean traceability between models. This means that objects in one model can be traced to objects in another [7]. Development in CEM is also architecture-centric. The process focuses on the early development and baselining of courseware architecture. Having a robust architecture in place facilitates parallel development, minimises rework and increases the probability of component reuse and eventual system maintainability. This architectural blueprint serves as a solid basis against which to plan and manage component-based courseware.

The development process of CEM consists of four main phases, which are known as the macro phases. These are (a) inception; (b) elaboration; (c) construction; and (d) deployment. Associated with these phases are models and subprocesses.

2.2 Inception

During the inception phase, the organisational rationale and scope of the project are established. The inception phase includes the investigation of alternatives and planning. Central to the inception phase is the conceptualisation process. Conceptualisation is the process of coming up with an idea for a system along with a general idea of its requirements and form. It is the process that determines the system to be built and its high-level outline and structure, based on the organisational needs and the technology.

Because this process may unearth 'needs' that either should be, or cannot be met by instruction, part of the process includes filtering out the learning needs. Since more learning needs may be discovered than it is desirable to address, another part of the process is to analyse all such needs and establish priorities. When conceptualisation is performed, it contains its own conceptualisation, analysis, design and implementation phases of development. Throw-away prototyping is what is used to carry out the conceptualisation process. The prototype is created to aid understanding of the problem and requirements. Outputs from this process may include a statement of the problem, resources, budget, alternative organisational needs, scope of the project and core requirements for the system.

2.3 Elaboration

The designer so far has only a vague idea of requirements. In elaboration, more detailed requirements are collected, high-level analysis and design are performed to establish baseline architecture and a plan for construction is created. Several processes are involved in the elaboration phase. These include use case modelling, learner analysis, environmental analysis and domain analysis.

2.3.1 Use case modelling

A good technique to improve understanding of requirements is the creation of use cases - narrative descriptions of domain processes. One of the biggest development challenges in courseware development is building the right system: one that meets the users' needs at a reasonable cost. Use case modelling is one of the most widely used analysis techniques for object oriented development [2][7]. The use cases are goals that are made up of scenarios, which in turn consist of a sequence of steps to achieve the goal. Each step in a scenario is a sub, or mini, goal or use case. Each sub goal requires another use case (subordinate use cases) or an autonomous action that is at the lowest level desired by the use case description. Use cases and scenarios work on many levels in CEM. During the elaboration phase, it is useful to write the most important and influential use cases in the expanded format, but the less important ones can be deferred until the construction cycles in which they are being tackled.

Use cases model the functionality of the system as perceived by the actors. Actors are users of the system in a particular role. They may be people, computer systems or processes [7]. The use case model captures the behaviour of a system or a class as it appears to an outside user. The purpose of a use case is to define a piece of coherent behaviour without revealing the internal structure of the system. Each use case represents an orthogonal piece of functionality whose execution can be mixed with the execution of other use cases. Use case modelling in CEM helps with three of the most difficult aspects of courseware development: capturing requirements, planning iterations of development and validating systems. For a detailed description of *use cases* refer to Jacobson, Christerson, Jonsson and Overgaard [7]. Thus, *use cases* describe how people interact with a system in the context of working toward some goal.

In order to deal with the different formats in which use cases are used in the courseware development process, use cases can be either 'essential' or 'real' [8]. An essential use case describes the process in terms of its essential activities and motivation. High-level use cases are always essential in nature, due to their brevity and abstraction. Essential use cases are often created during early requirements elicitation in the elaboration phase in order to more fully understand the scope of the problem and the functions required. In contrast, a real use case concretely describes a process in terms of its real current design, committed to

specific input and output technologies. Use cases dealing with the interface aspects of design are generally real use cases.

The system functions identified during the elaboration phase should all be allocated to use cases. In addition, it should be possible, via the cross-reference section of the use cases, to verify that all functions have been allocated. Ultimately, all system functions and use cases should be traceable through implementation and testing.

2.3.2 Learner analysis

It is important during this process to define the 'target audience' accurately and in sufficient detail to make design decisions. Determining the characteristics of the students will help to determine where the instruction should begin. Learner analysis begins with a clear definition of the target population. It ends with an identification of those characteristics of the target population that are likely to influence the design, delivery and utilisation of instruction. The output for this process is a chart containing the profile of the users who will be using the system.

2.3.3 Environmental Analysis

The purpose of this analysis is to analyse the context, that is the target environment in which the courseware will be delivered. In order to get a survey of the context features and constraints, it is necessary to interview customers/sponsors to obtain necessary information.

2.3.4 Domain Analysis

Use cases are not the whole picture in the elaboration phase. Another important task is to come up with the skeleton of a conceptual model of the domain. A domain is a representation of concepts in a subject matter. Data modelling is adjunct to use case modelling. The goal of domain analysis is to obtain a basic understanding of the topic and tasks used in the requirements identification.

In traditional courseware development, the domain knowledge is intertwined with the teaching knowledge, both being contained in pre-stored frames and fixed sequences. In CEM, domain knowledge is separated from instructional strategies. This gives rise to a more flexible and adaptive system for the reuse of domain knowledge and instructional strategies. A subject domain is an area of content to be learned. The outcome of domain analysis results in a structure of a subject domain to be learned. Domain concepts (i.e. types) are represented as objects, whilst links are used to denote relationships which may exist between them. The notation that has been chosen to represent the objects and links of the domain is a subset of the Unified Modelling Language (UML) notation [2]. The output from this process is a domain model that consists of topics, sets of topics and structures.

2.4 Construction

The construction phase consists of many iterations in which each iteration builds production quality courseware, tested and integrated, that satisfies a subset of the requirements of the system to be built. Each iteration contains all the usual life cycle of analysis, design, development, testing and evaluation as shown in Figure 1. This is the micro-process level of the CEM development.

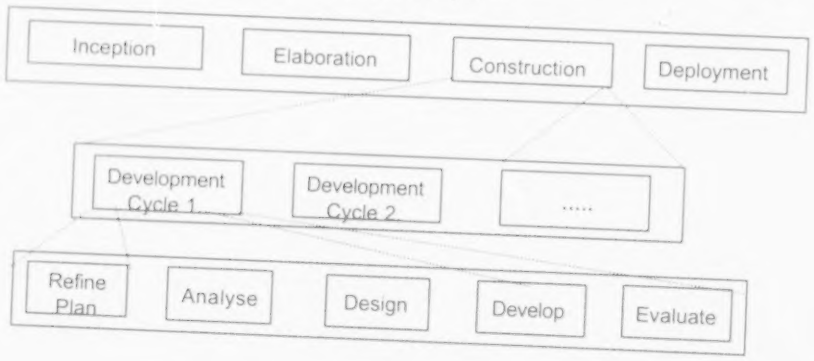


Figure 1 Iterative Development Cycles

2.4.1 Analysis and Design

The analysis and design processes in the construction phase are concerned with the design of the pedagogical model. So far, only the topics from the domain to be taught have been analysed. There is still some information missing, although the learner analysis has been addressed. It is now necessary to examine the prerequisite skills and knowledge that must be mastered for a student to achieve the goals or objectives of learning. Instead of rushing to write the courseware lessons, designers should first spend some time in determining exactly what learners must acquire in order to reach the goals or objectives. In order to analyse exactly what learners have to learn for the objective or goal, it is first necessary to identify the type of objective of the learning.

According to Gagné [4], there are different learning objectives, each requiring different analysis and instructional strategies. To help designers in identifying the right type of learning outcome, a Courseware Learning objectives (CLO) has been developed. CLO is used by designers in CEM to identify the learning objective, analysis method, and instructional strategies to be designed.

2.4.2 The pedagogical model

The aim of the design process during the construction phase is to produce the pedagogical or instructional model. This involves objective definition, assessment definition and instructional strategies definition. The objective definition describes the learning outcomes of the intended courseware. Once the objectives have been defined, the optimum sequence of the instruction is determined. Having defined the learning objectives, the next process is to decide how learners' attainment off the objectives will be measured or tested. Development of assessment follows the objectives definition. Assessment of learning is a crucial part of an instruction process. There is a need to assess student performance to determine whether the newly designed courseware has met its design objectives. There are various types of tests available in CEM to assess students' performance. The decision on what type of testing to use is determined by the purpose of the course, the students' needs and the skills required. Guidelines are provided in CEM for designers to choose the most appropriate tests for their learning objectives.

The writing of instructional strategies follows the assessment definition. Instructional strategies to be used are determined by the type of learning required. The CLO is used to assist designers in determining the most appropriate strategies to be used for the particular type of learning. Once the instructional strategies are defined, the design of instructional messages can begin. This completes the design process and the output is the pedagogical model, a blueprint of the courseware to be developed. The pedagogical model produced so far is independent of any medium or vehicle of instruction. It may be used to deliver on any chosen medium.

2.5 Development process

The next process in the construction phase is the development process. It consists of three subprocesses: conceptual modelling, navigation modelling and interface modelling.

2.5.1 The conceptual model

To be useful as input to a computer, the pedagogical model needs to be transformed into concepts and notions acceptable to a computer. One of the limitations of traditional courseware is that development is performed independently of other phases, there is no means of integration and reuse. In CEM there is separation of domain from instructional strategies and also there is complete integration of the conceptual model, the navigational model and the interface model, providing a seamless transition between the three.

The pedagogical model is transformed in CEM into a conceptual model that can be input to a computer by using the object-oriented Unified Modelling Language (UML) notation [2]. UML is a graphical language for visualising, specifying, constructing and documenting the artefacts of a software-intensive system. The

pedagogical model developed is transformed into the conceptual model using classes, relationships, and sub-systems. The object-oriented approach is chosen because it provides a natural framework for modelling the subject domain of the courseware application. In addition, it supports reuse and design patterns [5]. In order to show the lesson structure in the conceptual model, activity diagrams are used instead of flowcharts. Activity diagrams are a graphical depiction of the lesson, showing what happens under all possible circumstances.

2.5.2 The navigational modelling

Navigational modelling is the second step of the development process. This step is particularly relevant if hypermedia or the web is used as the authoring platform. One essential distinguishing feature of hypermedia courseware applications is the notion of navigation, in which users of an application in this domain navigate in a space made out of objects. In CEM, the navigational model is built over a conceptual model, thus allowing the construction of different models according to different users' profiles. The navigational design is expressed in two schemata, the navigational class schema and the navigational context schema. The navigation class schema gives a snapshot of the navigation structure. Once the navigational classes have been decided, it is necessary to structure the navigational space that will be available to users. In CEM, this structure is defined by grouping navigation objects into sets called contexts. The main structuring primitive of a navigation space is the notion of navigational context. A navigational context is a set of nodes, links and contextual information. It provides a consistent way to specify the navigational aspect of the design.

The navigational structure of the courseware application is defined in a context diagram known as the navigational context schema. The dynamic aspect of the hypermedia courseware is defined in CEM using navigational charts. Navigational charts are a type of statechart [6]. A navigational chart is basically composed of navigational objects, states and transitions. The last step of the development process is the interface modelling. Although interface design is a crucial part of courseware development, this step is rarely mentioned in the courseware development literature[1]. Storyboards are developed instead. A good software design avoids unnecessary dependencies by separating the interface from the rest of the system and dividing it into several loosely coupled parts. An abstract interface approach is used in CEM to describe the interface modelling. The idea of an abstract interface design is to separate the underlying semantic information of a courseware domain from the various ways of presenting the information to learners (user interface). This allows the building of different interfaces for the same navigational model, leading to a higher degree of independence from the user-interface technology.

2.5.3 Interface modelling

The Abstract Data View (ADV) design approach is adopted in CEM to describe the user interface of a courseware application [3]. A typical application using ADVs would have a set of Abstract Data Objects (ADOs) managing data structures and control within the application and a set of interface objects (instances of ADVs) managing interface aspects of the application such as user input and system output to the user. ADV charts are used to express the dynamic aspects of the interface. They are the interface expression of navigational charts; i.e. they express transformations at the user-interface level. The overall application behaviour of the hypermedia courseware is completely specified by defining the way in which external events affect both navigation and the interface appearance of the application. The navigational semantics specify the 'internal state' of the application and how it changes during the navigational process. The effect of each external event in terms of the transformations occurring in the interface must be shown. This is shown by using ADV charts that show the possible states and corresponding transitions of each ADV event in order to understand the way in which individual interface components behave when reacting to external events. An ADV chart is composed of ADVs, states, attributes and transitions. Nesting of ADVs allows designers to show the aggregation structure of the interface objects. The use case is then built and tested, making sure it is working.

2.6 Evaluation

Evaluation is the last step in the construction phase of CEM. Lessons are evaluated for their overall quality, their applicability to a curriculum, performance and usability. Another purpose of evaluation is to assist in lesson development and maintenance. Although evaluation is discussed as the last step of the development

process, it should not be assumed that evaluation is merely the last step in CEM. On the contrary, evaluation is part of an iterative cycle of designing, evaluating and revising. It is carried out in all of the processes involved. There are two types of evaluation measures in CEM, which measure the students' performance and lesson effectiveness. CEM provides a very detailed and comprehensive plan for formative evaluation of the courseware produced. The three steps involved are quality review, pilot testing and field-testing. During quality review, the materials developed are reviewed to assess the content, appearance and attention to good instructional practice. The main objective of pilot testing is to analyse the effectiveness of the learning process involved with students, and use of the courseware product. Field-testing is validation of the lesson - checking how well the lesson works in the real instructional setting. It is only after full and thorough evaluation that the courseware can be released for deployment.

2.6.1 Summative evaluation

The case studies showed that CEM does provide a development methodology that is easily implemented by novice designers. In order to evaluate the effectiveness of the courseware applications produced, they needed to be used by the school children of the schools that commissioned their development. Feedback from teachers and children of these schools revealed that the courseware produced were very useful.

Post-tests were given in order to evaluate the school children's understanding of the chosen subjects. The results of these tests showed marked improvements in the children's performance of their respective subjects.

2.7 CEM Evaluation

The primary goals of CEM are to assist in the courseware development process and to increase the quality of the courseware product. In order to determine the usability of CEM, it is necessary to evaluate these two goals. The most appropriate research method to evaluate the methodology is the Developmental Research Method [9]. Developmental Research is the systematic study of designing, developing, and evaluating instructional software programs, processes and products that must meet the criteria of internal consistency and effectiveness.

Two case studies were used in the evaluation of CEM that include descriptions of the actual design and development process by novice designers in the creation of a particular product. The main data collection methods used were surveys, in the form of written questionnaires, and interviews. An instructional software design (ISD) module was offered as part of the final year programme for students at the university in 1996 and 1997. There were twenty-five students in 1996 and thirty-one in 1997. In addition to these students, there were also twenty students who were not taking the module, but who used CEM as the methodology for their courseware design method for their final year projects. As part of the instructional software design (ISD) module, students were required to develop a substantial piece of courseware to be evaluated by target learners. These students were taught several courseware methodologies. All but one, who chose Gagné's methodology, chose CEM to develop their courseware products. None of these students had any previous experience in courseware production. Among the cohorts of students, approximately half were female. Their backgrounds, experience and cultures varied widely including Chinese, Indians, Greeks, French and English. Students were allowed to chose their own authoring tools from Authorware, Macromedia Director, Visual Basic, HyperCard, HTML, Java and C programming. Evaluation of the methodology by questionnaires and interviews revealed that all students found CEM very useful and they were able to follow the guidelines in helping them develop their respective subject matter, different types of learning and tools chosen. A full report of the evaluation is available from the author. The courseware produced included subjects such as biology, mathematics, history, geography, networking, programming languages, cookery, chemistry, physics, etc.

3 Conclusions

CEM differs from traditional courseware in many ways. It incorporates carefully selected state-of-the-art techniques from software engineering including object-orientation and use cases. It also provides guidelines and methods for hypermedia and interface development. The various techniques and methods are integrated

from various required disciplines within a framework of inter-related models. The modular approach enable designers to focus on particular aspects of the development process one at a time. Within the methodology there are many specific advances including the development of courseware learning objectives, the use of conceptualisation for needs analysis, separation of domain from instructional strategies, the modelling of hypermedia courseware applications, support of reuse through design patterns and interface modelling. Evaluation of CEM by novice designers has demonstrated its value.

References

[1] Alessi, S.M. & Trollip, S.R. "Computer-based instruction: methods and development", Prentice-Hall. 2nd Edition, (1991).

[2] Booch, G. Rumbaugh, J.& Jacobson, I. "The Unified Modelling Language User Guide", Addison-Wesley, Longman Inc. (1999).

[3] Cowan, D.D. & De Lucena, C.J.P. "Abstract Data Views: an interface specification concept to enhance design for reuse", IEEE Transactions on Software Engineering, 21(3), 229-243. (1995).

[4] Gagné, R. M., "The Conditions of Learning", Holt, Rinehart & Winston, 4th edition, (1985).

[5] Gamma E., Halini, R., Johnson, R. & Vlissides, J. "Design Patterns: Elements of reusable object-oriented software", Addison-Wesley, Longman, (1985).

[6] Harel, D. "Statecharts: A visual formalism for complex systems", Scientific Computing Programming, Vol. 8., 231-274 (1987)

[7] Jacobson, I., Christerson, M., Jonasson, P. & Overgaard, G. "Object-oriented Software Engineering: A use case driven approach" Addison-Wesley, (1992).

[8] Larman, C. "Applying UML and Patterns: an introduction to object-oriented analysis and design", Prentice-Hall, (1998).

[9] Richey, R.C. "Research on Instructional Development", Educational Technology Research & Design, 45(3), 92-100, (1997).

Design and Implementation of a Chinese Web-mail System

Chang-Sheng Chen*, Jian-Liang Liu and Shian-Shyong Tseng****
Department of Computer & Information Science, National Chiao-Tung University
1001, Ta Hsueh Rd., HsinChu, Taiwan 300, R.O.C.
Tel: +886-3-5731721 Ext.56605
Fax: +886-3-5721490
**E-mail: cschen@cc.nctu.edu.tw*
***E-mail: jlliu@cis.nctu.edu.tw, sstseng@cis.nctu.edu.tw*

E-mail is one of the most popular services on Internet. Fast message transportation, good GUI designs and enhanced localization capabilities in end-user environments are the key factors. However, there still exist some addressing problems for many users since it is based primarily on the ASCII character set. For those who do not know English well, ASCII set is hard to memorize and is prone to making errors. As more users joining the Internet, this kind of problems should not be ignored. Especially, these become major problems for students and teachers in primary/secondary schools. Currently, many approaches are proposed to support the Chinese and/or multilingual DNS name resolution. However, according to our study, most are designed to support URL addressing with Chinese characters in between. Few if any works on the e-mail addressing issue. This paper presents a description of our experimental system, which supports localized Chinese e-mail address mapping by using the LDAP directory service. In the future, if there is any standardized multilingual addressing scheme available, it could be incorporated into our system. The same user interface could still be used. With minor modifications, the same approach should be easily adapted for utilization in other language system.

Keywords: **Chinese, LDAP, URL, web-mail**

1 Introduction

E-mail is one of the most popular services on Internet. Fast message transportation, good GUI designs and enhanced localization capabilities in end-user environments are the primary keys. Most people would like to communicate with each other via their native language(s) if possible. By the efforts of computer scientists, most of us could write and read e-mail contents in local language today. However, as to the addressing part, that is another story. There still exist some addressing problems in internetworking for many users because they are based on the 7-bit ASCII character set. For those who do not know English well, ASCII character set is hard to memorize and is prone to making errors. With more users joining the Internet, this kind of addressing problems should not be ignored.

Up till now, there is no multilingual addressing standard, no multilingual registry in gTLD[11], ccTLD on the DNS[7] naming infrastructure. Currently, RFC 1035[7] is the main implementation obstacle. It limits the valid domain name character set to be a subset of the ASCII character set. Furthermore, while using in DNS, all the capital letters and their corresponding little characters are treated as the same by historical reason. These make the non-ASCII addressing still not possible in general.

There are many proposed approaches [10][13][17] to support the Chinese and/or multilingual DNS name resolution. To name a few, internetworking scientists in Asia Pacific region (including China, Hongkong, Japan, Korea, Singapore, Taiwan, etc.), RIPE, etc., are undertaking some IDN projects for developing multilingual addressing environments. However, according to our study, most of the proposed solutions are mainly designed to support the URL addressing with multilingual characters in between. Few if any

addresses the e-mail addressing issue.

We had designed and implemented a web-mail system with Chinese addressing capabilities by incorporating the LDAP directory services [3][4]. Conceptually, we could view an ASCII e-mail address as one of the attributes of some user's profile. By storing users' profiles on directory servers, software with directory-enabled capabilities could be easily used to extract the ASCII e-mail information for further utilization. In this way, our system provides a workaround solution for the Chinese e-mail addressing problem indirectly by translating a Chinese name to its corresponding ASCII e-mail address. The same approach could be easily adapted for utilization in other language system.

1.1 Chinese E-mail addressing

Every e-mail message could be divided into two parts: the header and the body. Now the problem to send messages with multilingual characters in the body can be dealt with by using MIME [1]. Before sending, the sender programs encode messages with the MIME standards. The messages are then transported over the Internet to the destinations. At last, they are decoded with MIME enabled clients. However, as for header sections, we still do not have a standard solution for non-ASCII addressing. Up to now, almost all mail client and server software on Internet communicate with the ASCII addressing expression only. Could there be any systematic approach (or workaround solutions) for supporting non-ASCII e-mail addresses?

To further describe the main ideas, let us check the three (pseudo) e-mail expressions shown below:

- jsc.cis84@nctu.edu.tw
- Jian-Shyong Chen< jsc.cis84@nctu.edu.tw >
- • • • •< jsc.cis84@nctu.edu.tw >

On the first look, they seem different; however, basically they mean the same thing. That is, jsc.cis84@nctu.eu.tw is the true component for e-mail address routing. However, using LDAP addressing book, the last form with Chinese name could be a good candidate for providing a workaround solution to support multilingual addressing.

1.2 Web-based Environment

WWW browsers have become standard applications for Internet access today. For those who do not have their own computers on working places (e.g. students in school environments), there are some obvious advantages through using browsers to send or receive mails:

- No additional software is necessary. All one need is a browser program.
- The browser programs (e.g. IE, Netscape, etc.), being the most popular software, can often reduce the learning time of users.
- Web-mail systems could be easily adapted for supporting roaming access.

1.3 Mail Routing with Directory Service Support

By putting e-mail addresses with forms like the last one shown above onto LDAP directory servers and through the translation of directory-enabled web-mail systems, we could achieve the goal of communicate with multilingual addressing indirectly. This is promising for many people.

Let us describe the working paradigm shown in Figure1. The mail routing is performed as below.

- The user types the Chinese name of the recipient (for example, "• • • •"), together with additional information (e.g. school name, city name, etc.), through the client mail interface.
- The client then consults the LDAP server to see if there is any one matching the search condition. If yes, all the matched people's information will be returned to the client, and the user can choose the one wanted. After that, the LDAP Server will return the related ASCII e-mail address of the recipient
- Using the returned ASCII e-mail address, the client sends the message to the destination SMTP server.

In principal, there is no need to alter the original mail server routing. It works as before on one condition. That is, if there are distributed LDAP servers on the related sites, with chaining and referral capabilities enabled.

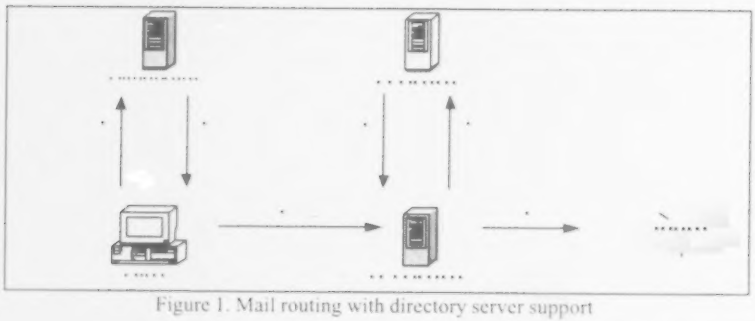


Figure 1. Mail routing with directory server support

2 Related Work

There are several proposed approaches to solve the Chinese URL addressing problem. Three of them will be described briefly in Sec.2.1, Sec.2.2, and Sec.2.3. Interested users are encouraged to visit the related web sites for more details. In Sec.2.4, we will describe the main practical problems of these systems.

2.1 mDNS [13]

The mDNS project is under joint development by researchers in TWNIC, Academia Sinica, and National Central University, Taiwan. The goal is to develop an internationalized DNS system to help the "non-English" DNS architecture to become standardized. mDNS would not effect the existing gTLD or ccTLD. Although the proposed experimental architecture can accept Chinese (BIG5) URL, it is not full Chinese URL. It is necessary to modify the source code of the ".tw" root server; however, it is not necessary to modify the existing client software.

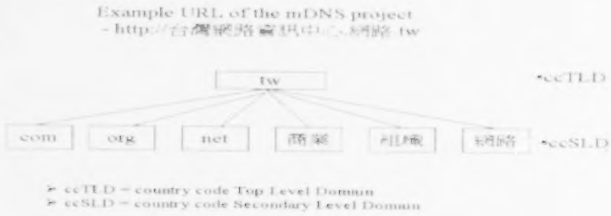


Figure 2. The experimental architecture of the ccTLD "tw"

2.2 iDNS [17]

The iDNS project is mainly under development by Singapore researchers. As shown in Figure 3, the key component of iDNS is the domain name proxy server, which translates the i18n (internationalization) domain name to the format of UTF-5 and transmits the translated format to the real DNS server. When the iDNS system receives the ASCII domain name, it will consult the old existing DNS system. However, if it receives the non-ASCII domain name, it will be routed to the i18n branch system.

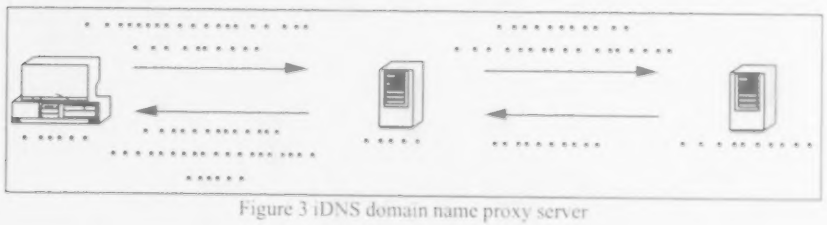


Figure 3 iDNS domain name proxy server

2.3 cDNS[10]

The cDNS project, run by researchers in CNNIC, is developing similar scheme. The main idea of cDNS is the proposed ***DNS forest*** architecture instead of the traditional rooted DNS tree structure. Interested users are supposed to refer to the web site of CNNIC for further details.

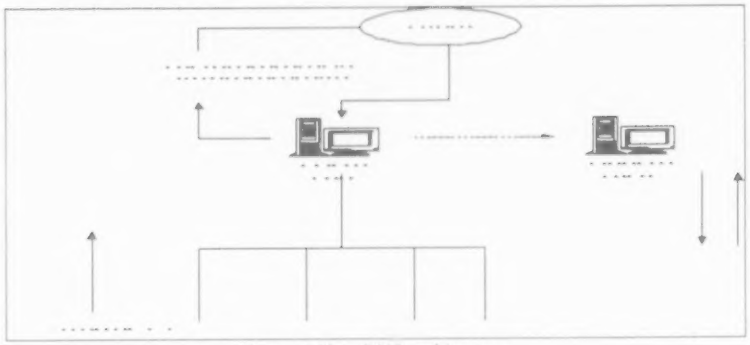


Figure 4 The cDNS architecture.

2.4 Practical Application Problems

Although it looks promising in the first place; however, up to now most of the proxy/caching and mail servers (ex. Squid and sendmail) cannot accept non-ASCII addressing. As mentioned in the introduction section, RFC 1035 is the current implementation obstacle, which breaks all the paradigms. It's nearly impossible to keep compatibility with the current system without modifying the source code of these servers, recompiling and reinstall the systems.

3 Overview of the LDAP Directory Service

It seems that we could not get an immediate multilingual addressing solution without modifying the existing servers all over the Internet. That is why we think that the LDAP enabled web-mail system might be a good workaround solution to try. Before further on, let us make some introduction on LDAP.

3.1 Why LDAP?

Historically, X.500 [3][4] is based on the ISO stack. It is just too complex and hard to implement in the real environments. LDAP [3][4][8][9] is the protocol initially designed as one front end of X.500. Since LDAP can be easily implemented and can be used to exchange information between LDAP servers, standalone LDAP directory server becomes popular gradually. As shown in Figure 5, Desktop PC can access the data of LDAP/X.500 directory server by LDAP protocol.

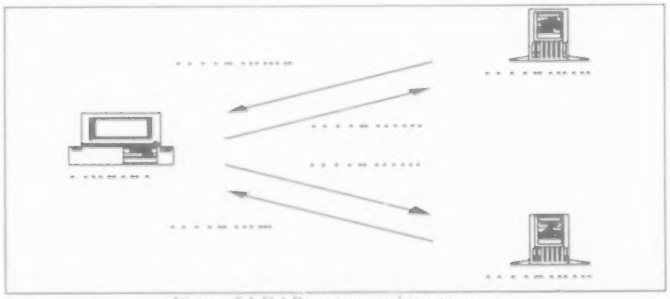


Figure 5 LDAP system architecture.

3.2 How Does LDAP Work?

LDAP stores the information hierarchically, where data is stored as key-value pair. [4][6] Each key will be mapped to one or many values. For example, *cn* (common name) will be used to store user name, mail will be used to store user's email address, etc [2][4]. Every node in the tree architecture of the LDAP directory will be viewed as an object, which has one or many *objectclass* attributes to identify the node. The *objectclass* definition of the system is that it should have what kind of attributes and it is allowed to have what kind of attributes. We also can extend the original *objectclass* by adding the attributes we want. Every node in the tree will be identified by *DN* (Distinguished Name) attribute [4][6]. The hierarchical relationship of the tree can be divided by locality or corresponding categorization. For example, the directory tree could be constructed according to the domain name. From the top level, c=tw (country code), o=edu (organization), ou=NCTU (organization unit) to ou =CIS (organization unit), the information in an example leaf node is a student named jacky, studying in the Dept. of Computer and Information Science. Through the tree architecture, LDAP clients can perform search, delete, modify operations and any site manager can add ACL (Access Control List) mechanism to control the access. [3][4] For more details, interested users are encouraged to read the related LDAP documents listed in the reference sections. [3][4][6][15]

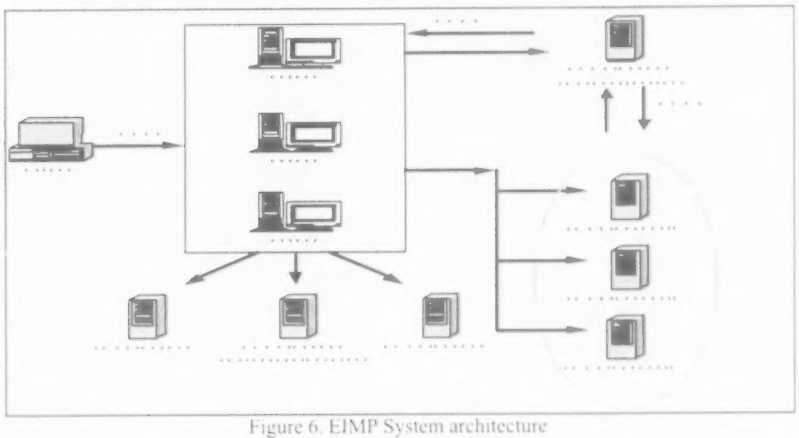


Figure 6. EIMP System architecture

4 Our System Design

We built up an EIMP (Enhance IMP; based on the IMP[12] project) system on a Linux platform [14][15]. The main system components are Apache+PHP(WWW), IMAP+Sendmail(Mail), OpenLDAP(LDAP), etc. We enhance the web-mail system by integrating the LDAP directory service and adding the Chinese naming capabilities. As shown in Figure 6, users can connect the logon server through www browsers and types his/her user name (Chinese or ASCII) and password. After passing the authentication, the LDAP server will return the user's IMAP[14] server location to the logon server. Then it will connect the related IMAP server to retrieve the user's mail(s). On the other hands, users can send mails through the SMTP server and store their address book information in the database server. Thus, for users wishing to send mail to his friends, even if they do not remember the exact email address, they can still find the email addresses by the help of LDAP servers, as shown in Figure 7.

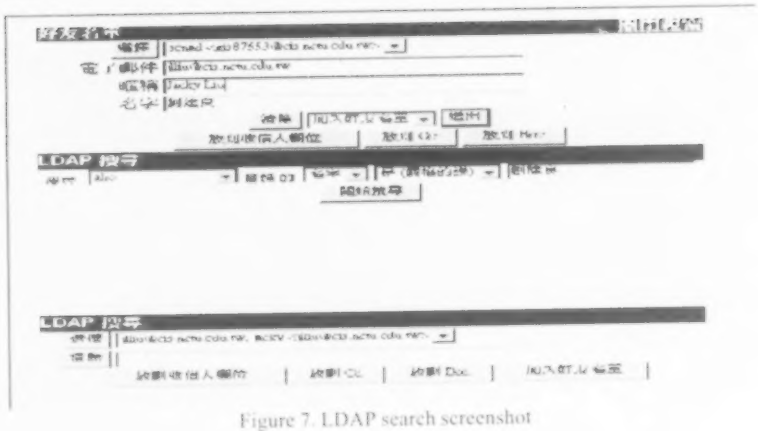


Figure 7. LDAP search screenshot

5 Problems and Discussions

As we know that, although it looks promising; however, up to now most of the proxy and mail servers (e.g. Squid and Sendmail, etc.) cannot accept non-ASCII addressing. Hence, it's nearly impossible to keep compatibility with the current system without modifying the source code of these servers, recompiling and reinstall the systems.

Non-ASCII communication issues are new hot topics in many research applications. While this is true in the DNS system, similar situation appears on the LDAP protocol suites. As more directory servers have been set up, there are more chances for directory servers to share and exchange their information through chaining or referral [3][4][5]. LDAPv3 addresses the issue by using the UTF-8 [16] encoding, while LDAPv2 use T.61, which lacks the capabilities to handle 8-bit data. Hence, in building distributed Directory server groups, software packages with LDAPv3 ready should be the proper choices.

We choose the IMAP (and not POP3) protocol for serving our mail access since IMAP servers support both the offline and the online modes. Currently, most sites use POP3 as the access protocol since it is simple and usually gives low impact to the system performance. However, as the POP3 protocol operates only in off-line mode, it could not meet the new trend for supporting the e-mail roaming access.

6 Conclusions

E-mail is one of the most used Internet applications today. However, non-ASCII addressing system is still a research issue. Most of the proxy and mail servers (e.g. Squid and Sendmail, etc.) still cannot accept non-ASCII addressing. Internetworking scientists from members at APNIC, RIPE, etc. are undertaking some piloting projects for producing multilingual internetworking standards. However, no one knows when the solutions will be ready. This is not good for primary/secondary school education on most parts of the world.

In this paper, we describe our approach for the Chinese e-mail addressing and authentication problems. We have designed and implemented a web-mail system with Chinese addressing capabilities by incorporating the LDAP directory services. Conceptually, we could view an e-mail address as one of the attributes of some user's profile. By storing users' profiles on directory servers, software with directory-enabled capabilities could be easily used to extract the ASCII E-mail information for further utilization. In this way, our system provides a workaround solution for the Chinese e-mail address problem by translating a Chinese name to its corresponding ASCII e-mail address. This should be promising for many people. For example, using such LDAP-enabled web-mail system, primary/secondary school education could benefit a lot since most of the communication activities could be done in their local native language.

In the future, if there is any standardized multilingual addressing scheme available, it could be incorporated into our system. The same user interface could still be used as well. Furthermore, with minor modifications,

the same approach should be easily adapted for utilization in other language system.

Acknowledgment

This work was supported by the National Science Council of the Republic of China under Grant No. NSC89-2511-S-009-014. We would like to thank the anonymous reviewers for suggesting improvements and offering encouragement.

References

[1] Freed, N., Borenstein, N. "Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies", RFC 2045, (1996)

[2] Howes, T., etc., "The String Representation of Standard Attribute Syntaxes", RFC 1778, (1995)

[3] Howes, T., etc., "A Scalable, Deployable, Directory Service Framework for the Internet", INET 95

[4] Howes, T., etc., "Understanding and Deploying LDAP Directory Services", Macmillan Technical Publishing, (1999)

[5] José, Rui J.P.; Costa, António; Macedo, Joaquim; Freitas, Vasco, "Providing multiple external views on directory user interfaces" in Computer Networks and ISDN Systems, Vol 28, No. 4, pp. 543-550, (1996)

[6] Kille, S., "A String Representation of Distinguished Names", RFC 1779, (1995)

[7] Mockapetris , P., "Domain Names--Implementation and Specification" ,RFC 1035, (1987)

[8] Wahl, M., etc., "Lightweight Directory Access Protocol (v3)", RFC 2251, (1997)

[9] Yeong,W., Howes, T., Kille, S., "Lightweight Directory Access Protocol", RFC 1777, (1995)

[10] Chinese Domain Name Consortium, http://www.cdns.org/e-index.shtml (accessed on August 1,2000)

[11] ICANN, http://www.icann.org (accessed on July 1,2000)

[12] IMP@horde.org, http://www.horde.org/imp (accessed on April 23,2000)

[13] mDNS TANet Testing Project, http://mdns.twnic.net.tw, (accessed on June 1,2000)

[14] Message Access Paradigms and Protocols, http://www.imap.org/papers/imap.vs.pop.html (accessed on May 9,2000)

[15] LDAP Linux HOWTO, http://www.linux.org/help/ldp/howto/LDAP-HOWTO.html (accessed on May 10,2000)

[16] Unicode - Basic Questions, http://www.unicode.org/unicode/faq/ (accessed on June 1,2000)

[17] Welcome to iDNS , http://www.idns.org (accessed on June 1,2000)

Relating telecommunication training objectives to SMEs' actual needs

Paola Forcheri, Maria Teresa Molfino, Alfonso Quarati
Istituto per la Matematica Applicata del Consiglio Nazionale delle Ricerche, Genova -Italy
Via De Marini, 6 –16149 Genova, Italy
Tel: +39-010-6475673
Fax: +39-010-6475660
E-mail: {forcheri,molfino,quarati}@ima.ge.cnr.it

The need of studying training measures to help European Small and Medium Enterprises (SMEs) to avail themselves of new information communication technology is generally acknowledged. To be effective, however, these measures must be based on sound knowledge of the context in which they are to be implemented. This type of approach is particularly important for SMEs located in areas experiencing serious industrial decline, where the development of exchanges and co-operation is vital for opening up new opportunities. Accordingly, we carried out a survey to gauge companies' attitudes towards teleconferencing tools so that methodologies could be devised to exploit the potential for growth within SMEs. The survey was based on a series of interviews conducted from late 1998 to early 1999 with organisations reflecting the socio-economic make up of the economy of Liguria, a region in north-west Italy. The results of the survey, that are discussed in this paper, formed the basis for the design of training schemes about teleconferencing tools and applications devoted to SMEs. The activity is framed into the project called Teleconferencing, part of the European Community's ADAPT II initiative.

Keywords: **Telecommunication education, Training in enterprises, Teaching/learning strategies**

1 Introduction

Current socio-economic trends and the shift towards a global market are highlighting the need for companies to keep abreast of the new opportunities offered by Information and Communication Technologies (ICT), whose development has itself been a major factor in market globalisation. Doing so also means gaining awareness of the economic, organisational and company policy issues involved.

In this context, the mastery of teleconferencing tools assumes particular importance. By giving impulse to distance interaction, these tools increase companies' opportunities to control a share of distant markets and to draw on resources spread over a wide area. This is borne out by numerous theoretical and applied studies that analyse the effects of tele-collaboration on the development of new communication patterns and their influence on company organisation [2].

Let's take a look at some of these. [1] examines the pros and cons of desktop videoconferencing from the technological, economic, operational, psychological, and managerial viewpoints, as seen by both the company and the end user. Wiesenfeld, Raghuram & Garud [15] analyse the characteristics of communication means and the impact these have on the way remotely located employees identify with the company's central offices. Kraut, Steinfield, Chan, Butler & Hoag [11] examine how the use of computer networks influences inter-company collaboration (such as that created in a European project) and how the use of those networks for co-ordination alters production output.

Jarvenpaa and Leidner [8] examine problems linked to creating and maintaining a climate of confidence whenever communication is largely conducted via ICT, while Anderson and Kanula [3] study a virtual

forum attended by people engaged in lifelong learning, focusing on participation levels and attendees' perception of the forum's effectiveness and value. Email as a tool for supporting company policy is the theme explored by Romm and Pliskin [12], who draw on a set of case studies.

Rosen [13] provides numerous case studies on the use of videoconferencing in large corporations in an effort to stimulate discussion on the integration of collaboration and communication. This is done by analysing the competitive edge that those companies gained and the changes brought about in their way of doing business.

For their part, Schreiber and Berge [14] analyse the advantages and opportunities that teleconferencing systems offer to distance in-service training, reporting a number of cases where the goals pursued arise from a clear company need. Teleconferencing as a tool for lifelong learning is the topic focused on by Kaye [10], who examines in particular the possibilities that this instrument offers for learning in an informal context. Economic issues involved in the use of videoconferencing systems within the education sector is the area investigated by Jacobs and Rogers [7], who provide a detailed analysis of the cost/benefit ratio in a case of trans-European ISDN-based distance learning.

The above-mentioned studies generally refer to large, technologically-advanced corporations with considerable financial resources. However, in today's global market, it is also vital for Small and Medium Enterprises (SMEs) to harness ICT in order to maintain market share. The problem they often face is that they cannot afford the investment needed to cope with increased competition and to get a foothold in new markets. Distance interaction technology offers SMEs useful support in tackling this problem. On the one hand, it fosters collaboration between companies which operate in complementary sectors but are located at a distance from each other. On the other, it permits SMEs to offer their services to large companies both as suppliers and as mediators in local markets they know well. It is widely recognised that if SMEs are to harness the potential this technology offers, they not only require suitable and affordable infrastructure but also need training and technology transfer schemes to help them acquire the necessary competence and know-how ([6], http://europa.eu.int/comm/dg12/publ/globalisation.html).

These kinds of considerations form the basis of the numerous initiatives launched by the European Union and aimed to devise efficient training and orientation measures suitable to help SMEs to cope with innovation in communication.

To be effective, however, these measures must be based on sound knowledge of the context in which they are to be implemented. In this way, they can take account of the company's effective needs, economic situation, skills base, technological potential and cultural heritage. This type of approach is particularly important for SMEs located in areas experiencing serious industrial decline, where the development of exchanges and co-operation is vital for opening up new opportunities. For mainly economic reasons, these companies have little chance to develop competencies and to benefit from distance collaboration.

This is the background our work is set against. In particular, we carried out a survey to gauge companies' attitudes towards teleconferencing tools so that methodologies could be devised to exploit the potential for growth within SMEs. The survey was based on a series of interviews conducted from late 1998 to early 1999 with organisations reflecting the socio-economic make up of the economy of Liguria, a region in north-west Italy.

The activity is framed into the project called Teleconferencing, part of the European Community's ADAPT II initiative. The purpose of the project is to study the potential of network technology, especially teleconferencing tools, in response to the need for intra-company and cross-company collaboration. The project is run by IMA-CNR, who drew up the project guidelines in partnership with eight companies representing a cross-section of the local economy in Liguria.

We shall report here the findings of the survey, focusing in particular on cultural problems hindering the spread of teleconferencing in companies. In addition, we shall propose orientation and training methodologies that help overcome these barriers.

Henceforth, we shall use the term teleconferencing to refer to interpersonal communication systems based on the written word (e-mail, chatting, etc) or on sound and images (videoconferencing).

2 The Survey

2.1 Background

Liguria has been seriously hit by the general decline in industry; the reduction in heavy industry in particular has wrought serious consequences, including high unemployment, demographic decline and ageing of the population. The socio-economic transformation underway calls for considerable flexibility, the capacity to exploit innovation and the fostering of exchanges and co-operation in order to open up new opportunities. Thus the region of Liguria represents a good test-bed for studying opportunities and problems regarding the use of teleconferencing technology within companies.

Our survey involved a series of interviews conducted from late 1998 to early 1999 with 41 companies in Liguria that varied in size, both in terms of turnover and staff numbers (see Table 1). Of the total, 20% are from the public sector and 80% from the private sector, and they are spread throughout the four provinces of the region (32% Genoa, 32% La Spezia, 20% Imperia and 17% Savona).

Revenue 1997 (Millions of EURO)	Percentage	Staff members	Percentage
To 2.5	**37%**	To 10	**17%**
2.5 to 50	**49%**	10 to 100	**63%**
Over 50	**15%**	Over 100	**20%**

Table 1. Breakdown of the organisations interviewed according to turnover and staff numbers

2.2 Methodology

The survey was carried out through interviews based on a questionnaire. Staff members from companies involved in the project were consulted during the drafting of this questionnaire to ensure that the language used and the approach to problems adopted matched their way of thinking as closely as possible. The companies themselves carried out preliminary evaluation of the questionnaire.

2.3 The Questionnaire

The questionnaire is divided into four sections.
The first section is designed to identify the type of company in terms of economic structure (public or private, size, field of activity) and its organisation, with special attention to teamwork. In this way it is possible to investigate the relationship between these parameters and the attitude manifested towards teleconferencing tools.

The second section looks at the organisation's level of technological advancement and its attitude towards communication tools. The purpose here is to understand whether and how networking can modify the kind of relationships established within the organisation.

The aim of the third section is to analyse the type and quality of computer tools devoted to information exchange. Investigation centres on the use made of the Internet and on the organisation's attitude towards the Web, with a[illegible]ve to determining whether the staff is familiar with this tool, the needs the Web may fulfil and possible training requirements (depending on the type of information usually exchanged).

The fourth section focuses on teleconferencing, assessing the degree of knowledge about tools of this kind and determining whether and when the organisation considers teleconferencing useful for its purposes. The point of this section is to study the types of support (methodological, technical, training, orientation, infrastructure, etc) that the organisation may need in order to use teleconferencing effectively.

3 Results

3.1 Type of organisation and group work

Type of organisation. The public-sector organisations interviewed were from the fields of public administration, public services, the health service and state-run industry.
The breakdown of private companies was as follows:

- industry (14%) – steel, photographic chemicals, electronic engineering, parts machining, plant building, construction, olive oil production, floriculture;
- companies involved in port-based activities (17%) – port authority, shipbuilding, container terminals, transport, brokerage;
- service and commercial companies (49%) – gas and water distribution, medical services, company support services, research and training, tourism, logistics, storage, consultancy, wholesaling and retailing. Sectors like port activities, olive oil production, floriculture and tourism are of vital importance to the Ligurian economy.

Teamwork. All of the companies interviewed engage in teamwork, and most (82%) do so on a regular basis; there are no notable differences here between the different types of companies. Teamwork mainly concerns organisation (90%), document and information sharing (63%) and brainstorming (63%). Other significant areas are internal documentation (61%), followed by external relations (59%) and internal messaging, while internal surveys play only a minor role (29%).

Interestingly, given that in nearly half the cases (46%) teamwork involves most of the staff, tools that make collaborative activities more efficient would be extremely valuable for the organisation. Hence it is worth studying the possibility of teleconferencing, at least for some specific situations such as electronic bulletin boards advising recipients about 'technical' events. These may include notification of a circular being received or a service being temporarily suspended. Another instance may be an in-house electronic bulletin briefing all the staff on the main events concerning the organisation. The application of teleconferencing to these situations does not curb interpersonal relationships and has the advantage (even in small companies with a staff of 10 to15) of reducing time wasting, the risk of misinformation and subsequent misunderstandings [1].

3.2 Office Automation

Level of office automation. Computers, in-house networks for management purposes and Internet connections are found in most of the organisations (see Table 1).

	Used	To be introduce	Not to be introduced
Mainframe	63%	5%	12%
Terminals	66%	0%	15%
Personal computers	100%	0%	0%
LAN	63%	5%	15%
Intranet	15%	22%	22%
Internet connection	85%	12%	2%

Table 1: Computer tools used in organisations

However, while PCs are used by the majority of staff members (either for individual work or management applications), the Internet is still only used by a minority (see Table 2).

We can therefore state that while computers have by now permeated corporate life, the same is not true of communication and information sharing tools, although awareness of their potential does exist.

	PC for individu work	Terminals o PC for database management	LAN or Intranet for shared applications	External connection/Internet
More than half	34%	37%	23%	9%
About half	13%	14%	15%	9%
Less than half	53%	49%	62%	82%

Table 2: Number of users by type of tool and kind of use

Use of networking. Networks are widely employed for exchanges between headquarters and branches (14

positive answers, two planning introduction in the short term). They are used mainly for handling administrative/accounting matters and sales orders, for organising production, as well as for structuring and maintaining the network itself.

Far less significant is the level of network use by travelling salesmen (two cases, for transmitting sales and exchanging messages), although the trend is growing (six planning to introduce it for this purpose).

Tele-working from home is equally uncommon, with only two of the organisations surveyed adopting it, and five cases where there has been talk of introducing it. In both of the affirmative cases, tele-working is used for remote network maintenance, and only one of the two companies conducts other activities in this way.

In our view, the answers indicate that network connection is seen as an advantage when it is capable of improving work efficiency without changing work organisation or modifying internal relationships. By contrast, when the introduction of new technology requires methodological innovation or the development of new types of interpersonal relationships, its appeal is not so strong. One fact supports this consideration: although many of the organisations hire external consultants (68% have at least one consultant, 46% more than one), only one currently uses tele-working for this purpose and three are considering it. Clearly, technological innovation demands a change in attitude and therefore requires gradual phasing in, together with training that makes people aware of the impact of new communication tools rather than just illustrating their technical features.

3.3 Networking and communication with the outside world

Typology of dedicated connections and connections to the Internet. Those interviewed appeared to be greatly perplexed by this set of questions, apart from a handful of cases where the interviewee was the head of EDP. To our way of thinking, this shows that the spread of the network has not been matched by a general grasp of network-related concepts. Consequently, training and orientation dedicated to network concepts and opportunities are called for, so that companies understand the kind of network services that might meet their needs.

Companies and the Web. The Web is used somewhat more for gathering information (86%) than for spreading it and for presenting the company on the market (80%). Nonetheless, the response to the question regarding the potential benefits of using the Web shows that companies recognise that the Web is a medium for addressing a wider market (49%) and improving their public image (37%).

In our view, the reason for this lies in cultural and economic factors. Coverage of the Web in the press and electronic media till recently mainly focused on the possibility to acquire information rather than provide it. What's more, while acquiring information is relatively straightforward, providing it entails more complex know-how. Company presentation in the Web's hypermedia format is culturally different from more conventional forms, thus requiring great investment in terms of conception, design and implementation. Finally, the investment and maintenance entailed in information acquisition is fairly low in cost, being limited to getting Web access and covering communication costs. By contrast, information providing is quite costly both in terms of site construction and maintenance.

In order to help companies use the Web as a tool for market presentation, it may well be worthwhile providing implementation methodologies that are in line with company goals. To make information hunting more efficient, it would be useful to give tips about the most interesting commercial sites and advice on search methods.

Advantages, disadvantages, information to include on the site. The main advantages that companies see in the Web are the possibilities for market expansion (49%), for improving public image (37%) and, obviously, for low-cost access to information (49%) (see Figure 1). This response shows that companies now view the Web as a standard means for widespread distribution of information, and the sort of information they envisage providing at their sites matches this vision.

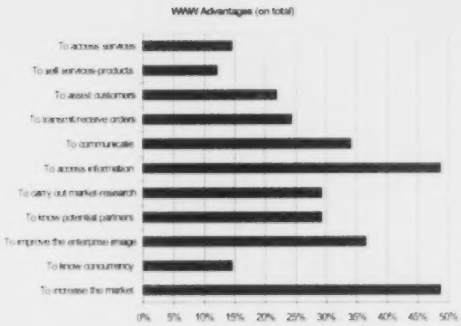


Figure 1 - Advantages of the We

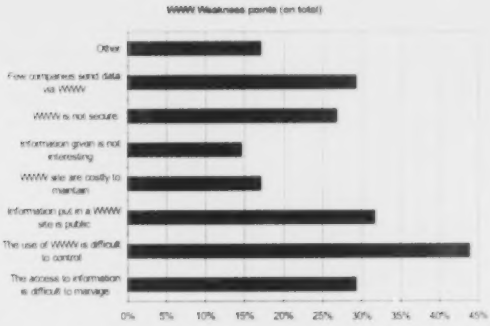


Figure 2 - Disadvantages of the Web

There is far less interest in using the Web for commercial purposes such as placing orders (24%), acquiring information about competitors (15%), product sales and services (12%), or customer support services (22%). This lack of confidence is confirmed by the answers regarding the Web's perceived weak points: lack of security (27%), competitors' access to information (32%), and unwillingness to transmit data over the Web (29%) (see Figure 2).

In our view, a further hurdle to commercial use of the Web is the lack of control over how the user accesses a site (29%). Technological mediation makes it particularly difficult to discern client needs and provide the right response. This, together with the fact that many of the companies interviewed see the Web as a means of serving clients and providing information on products, highlights the economic importance of building web sites that can also offer customer-care services.

An interesting perspective on this problem comes from research into adaptivity concepts, which seeks to construct Web sites that dynamically select the information to be displayed according to the user's behaviour during site navigation [4, 5]. We believe it would be useful to draw companies' attention to these studies, as application of such techniques might give their web sites a crucial edge in marketing and business.

To our way of thinking, there are many factors that contribute to the Web's image as an unreliable commercial tool, most notably: the lack of thoroughly tested sales methodologies; the need to invest both in technology and in the study of new models of sales organisation; the uncertainty of results; the market's suspicious attitude.

A further obstacle to widespread Web use within companies is the impossibility of controlling the use the staff makes of it (44%). This is a major hindrance to the spread of network-based distance communication. The problem is a realistic one, even if psychological restraints exist that allow general use of the Web under acceptable conditions.

3.4 Teleconferencing and interpersonal communication

Analysis of the answers reveals that while e-mail is widely employed, other teleconferencing systems are not so common; what's more, there is little interest in evaluating their adoption in the future and even a certain degree of reluctance to examine the possibility at all (see Table 3).

What lies behind this situation is poor knowledge of teleconferencing tools, as demonstrated by the small number of responses about related benefits and drawbacks. This is understandable, given that networks have only recently reached Liguria's small and medium-size enterprises [9].

	Used	To be introduced	Not to be introduc	No answer
Video-conference	7%	20%	44%	29%
E-mail	85%	12%	2%	0%
Computer conferencing	7%	15%	49%	29%
Desk-top video-conferencing	5%	10%	51%	34%
Chat	2%	2%	56%	39%

Table 3 – Attitude towards teleconference systems

Let's take a closer look at the answers about e-mail's benefits and drawbacks and compare them with those regarding other teleconferencing tools. It must be noted, however, that the comparison can only be qualitative because the number of responses varies depending on the tool in question.

E-mail is considered advantageous in terms of communication potential, lower communication costs, image and innovation. It is relatively straightforward for the staff to use, relies on fairly simple technology and is regarded as highly beneficial. It meets companies' basic need to communicate swiftly in writing, and calls for innovation only in the tool to be used for the task, not the underlying methodology. The technology required is simple and relatively cheap, and what's more in many cases it has already been tested by the company's decision-makers on a personal basis.

In addition, it must be noted that the introduction of e-mail within a company is in itself capable of enlarging the company's market both for reasons of prestige (as the answers reveal) and because e-mail is becoming a standard form of communication parallel to telephone and fax.

Conversely, other types of teleconferencing systems, and particularly those that involve computers, are look upon with suspicion; people are clearly concerned that the perceived drawbacks (complex technology, lack of know-how among the staff, and modest gains) may outweigh the advantages. In our opinion, the reason for this kind of response lies in technological and socio-economic factors.

In technological terms, it cannot be denied that these systems are fairly intricate, apart from chat-oriented ones. This is particularly true for those who are relative newcomers to computer-mediated communication. Employing these systems efficiently presupposes technical know-how within the company and well-trained staff.

From a socio-economic viewpoint, these tools contribute to modify work organisation and methodology, thus entailing a transformation in social relationships. For these systems to be fully exploited, considerable innovation effort is required: the organisation must have the need and the ability to carry through change, as well as the capacity to develop methodological skills. In addition, costs are incurred that cannot be offset either by greater prestige or by access to widely used forms of communication.

It must be added that advanced teleconferencing systems have not yet gained a high profile in popular culture; they have received far less media attention than e-mail and the Web, as their usership remains fairly small.

Despite all this, companies acknowledge that computer-based teleconferencing tools might offer valuable assistance in certain corporate areas (see Figure 3). Furthermore, the boom of outsourcing and the introduction of tele-working will probably have an impact on the development of computer-driven teleconferencing tools. These forms of collaboration have brought various problems to the fore: that of identifying oneself within the organisation, of conveying one's ideas to the interlocutor without misunderstandings, of conducting effective discussion about a written document, a graph, etc.

Considering these factors, we believe that orientation and training programmes are vital in order to help companies understand the potential of these tools, both in operational as well as theoretical terms.

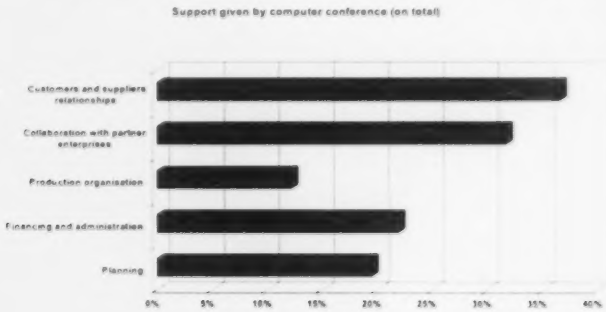


Figure 3 – Support given by computer conference

4 Conclusions

The survey shows that the spread of the network among Liguria's small and medium-sized enterprises has not been matched by a general grasp of network-related concepts. Consequently, training and orientation dedicated to network concepts and opportunities are called for, so that companies understand the kind of network services that might meet their needs.

Moreover, the survey reveals that these enterprises are aware of the potential of networking tools in expanding information sharing and communication possibilities. This awareness, however, is restricted to forms of use that do not modify work organisation and interpersonal relationships; one reason for this is that companies do not yet have the firm grasp of network concepts required to envisage applications in less immediate contexts. In fact, there is no perception at all of such applications because this would require awareness of the tools, an understanding of the actual possibility of achieving greater productivity, changes in organisational structure and internal relationships, and an investment in technology and know-how.

As these results reveal, there is a clear need to develop orientation and training projects addressed to SMEs. These should provide:

1. Network concepts and opportunities, so that companies understand the kind of network services that might meet their needs. In particular, enterprises should be helped to learn the following:
   - 1.1. Basic notions about network technology;
   - 1.2. Infrastructure and public services;
   - 1.3. Distance communication methods and techniques;
   - 1.4. Methods of sharing documents and applications.

2. General skills in teleconferencing tools as well as methodological and content-based knowledge of potential advantages in relation to specific needs. In particular, enterprises should receive training so that they are able to do the following:
   - 2.1. Explore typical working tasks and decide what type of teleconferencing tools, if any, can increase the quality of the job;
   - 2.2. Investigate if and how the use of teleconferencing tools can favour the introduction of organisation methods not adopted in the enterprises, but able to improve competitiveness;
   - 2.3. Critically analyse a communication technology to define how useful it can be in a specific work situation;
   - 2.4. Recognise specific tools as particular examples of communication models;
   - 2.5. Abstract the communication features of a software tool so as to be capable of comparing one tool with another of the same class without difficulties.

3. Awareness of the psychological and cognitive issues entailed in communication and collaboration through the computer. Specifically, enterprises should gain practical awareness that:
   - 3.1. Computer-mediated communication differs from direct communication, and calls for adjustment in the ways one interacts with others;
   - 3.2. All those involved in an activity requiring computer-mediated communication, especially those without a technological background, must be able to call on technical support. In this way they will be encouraged, psychologically as well as practically, to use the new tool;
   - 3.3. If an experiment in the use of distance interaction methods is to be successful, there first needs to be a well-established atmosphere of reciprocal trust between the participants;
   - 3.4. People must be aware of both the opportunities and technical limitations of the tools used;
   - 3.5. To encourage the use of these systems, the work needs to be organised in such a way that each person gets a turn at assuming responsibility for some task or other;
   - 3.6. The system must be made indispensable for getting access to information and joining in discussion.

It is no easy task to create training schemes, including experimental ones, that meet these conditions. There are a number of reasons for this. From the educational viewpoint, an approach to training is called for that combines conventional training with a situated approach to the learning of teleconferencing opportunities and problems. When it comes to choosing the topic on which the training initiative is to be based, it is necessary to ensure that it is one of common interest to all the companies involved. Then there is the matter of the required expertise, calling for the involvement of various actors: training experts, to select the best methodology for tailoring the programme to the context; company representatives, to spell out production and organisational requirements; experts in the subject area; and experts in the specific technology. In economic terms, a balance must be struck between the need to provide up-to-date technology and the

necessity for companies to contain costs.

European projects like *Teleconferencing* that are designed to help enterprises cope with innovation provide strong impulse in this direction. They create the conditions under which pilot projects of the kind described above can be introduced, provide tools for evaluating their effectiveness, and form the cultural background needed to built advanced technology training systems that meet the needs of enterprises.

Acknowledgements

The Teleconferencing Project is carried out by an international consortium comprising IMA-CNR (Italy), Thati Gmbh (Germany), AMT (U.K.) and OPCAREG (France). It is jointly funded by the European Commission's Social Fund and by Italy's Ministry for Employment and Social Security. The Italian partnership involved in the project comprises: IMA-CNR, Genoa (Italian promoter), CONSULTEAM (Savona), the Employment Agency of Liguria, Enaip Liguria, ERG Petroli S.p.A. (Genoa), Gruppo Imation (Ferrania, Province of Savona), ISOMAR (Savona), Nuova Magrini Galileo (Bragno, Province of Savona), Ricerca e Progetto S.a.s. (Genoa) and STEM - ISI Impianti S.p.A (Genoa).

References

[1] Angelides M.C., "A Framework for Examing Desktop Video Conferencing in the Organisatonal Context", CIT Journal Vol. 6, No. 3, pp.285-296, (1998).
[2] Ahuja M.K. & Carley K.M., "Network Structure in Virtual Organisations", JCMC Vol. 3, No.4, http://jcmc.huji.ac.il/vol3/issue4/ahuja.html, (1998).
[3] Anderson T., & Kanula K., "On-line Forums: New Plarforms for Professional Development and Group Collaboration", JCMC Vol. 3, No.3, http://jcmc.huji.ac.il/vol3/issue4/anderson.html, (1997).
[4] Eklund J., & Brusilosky P., "Individualising Interaction in Web-based Instructional Systems in Higher Education", http://www.uow.edu/auc/Conf98/papers/eklund.html, (1998).
[5] De Bra, P., & Calvi L., "AHA: a Generic Adaptive Hypermedia System", Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia, http://wwwis.win.tue.nl/ah98/DeBra.html, (1998).
[6] European Commission, "The green paper on innovation", December (1995).
[7] Jacobs G., & Rodgers C., "ISDN-based distance learning: tangible costs, intangible benefits", Computers & Education Vol.31, pp.41-53, (1998).
[8] Jarvenpaa S.L. & Leidner D.E, "Communication and trust in global teams", JCMC Vol. 3, No.4, http://jcmc.huji.ac.il/vol3/issue4/jarvenpaa.html, (1998).
[9] Forcheri, M.T. Molfino, & A. Quarati, "Design of learner-centered tools for continuous training in SMEs", Education & Information Technology, Vol. 3, pp.261-276, (1998).
[10] Kaye A.R. (Ed.), "Collaborative Learning through Computer Conferencing", Springer-Verlag, (1993).
[11] Kraut R., Steinfield C., Chan A., Butler B. & Hoag A., "Coordination and virtualization: the role of electronic networks and personal relationships", JCMC Vol.3 No.4, http://jcmc.huji.ac.il/vol3/issue4/kraut.html, (1998).
[12] Romm C.T., & Pliskin N., "Toward a Virtual Politicking Model", Communication of ACM, Vol.40, No. 11, pp. 95-100, (1997).
[13] Rosen E., "Personal videoconferencing", Manning, Greenwich, (1996).
[14] Schreiber D. A., & Berge Z. L. (Eds), "Distance Training", Jossey-Bass Publishers, San Francisco, (1999).
[15] Wiesenfeld B.M., Raghuram S., & Garud R, "Communication Patterns as Determinants of Organisational Identification in a Virtual Organisation", JCMC Vol.3, No.4, http://huji.ac.il/vol3/issue4/wiesenfeld.html, (1998).

The Rhetoric of the web—A semiotic approach to the design and analysis of web-documents

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper seeks to discuss possible approaches through which semiotics and rhetoric can be applied to the World Wide Web seen as a multimedia; or, in other words, possible approaches through which Web-sites and Web-pages can be studied and designed from a semiotic point of view-The aim of the paper is thus to outline a coherent theoretical, methodological and analytical framework for the study and design of Web-documents based on semiotics and rhetoric. This paper has analytical, theoretical, methodological, as well as practical implications. It is of interest in relation to the analytical and theoretical understanding of the new and rapidly growing web medium, and in relation to methods of examining this phenomenon. The study shows the concepts and categories from the field of semiotics and rhetoric are highly relevant to the area of the web and it indicates that the concepts presented here can form the building blocks for a more general 'Semiotics of Cyberspace'. The observations from this study may also have an effect on conventional theory formation and understanding within semiotics, rhetoric, and communication research and media studies. However, it also has implications for the construction and design aspects since the design of Web-documents and Web-sites must be based on actual knowledge of the conditions and possibilities for communication and the construction of signs, codes and meaning in the new medium.

*The paper was not available by the date of printing.

Towards a model of using Information Technology in education for pre-service teacher education

Kai-ming LI, Yiu-sing LAM, Pak-hung LI and Kwok-leung WU
Department of Curriculum and Instruction,
Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T. Hong Kong
kmli@ied.edu.hk, yslam@ied.edu.hk, phli@ied.edu.hk, klwu@ied.edu.hk

This paper reports the present scenario of using computer and traditional instructional media for primary class teaching in HKSAR. 323 primary teachers who have attended staff development seminars and refresher training workshops in the use of IT in education were invited to provide information for the study. The teaching time in a week and the teaching modes with 16 instructional media including computer technologies were examined. Results showed that textbook, blackboard and printed text materials remain the dominant instructional media in current practice of teaching in primary schools. The use of computer technology is rare despite the expectation that computer and computer-related technologies will make learning more effective and efficient and even to replace the traditional "educational technologies". The findings also indicated that technologies were used mostly as information delivery tools. Teaching strategies were limited to mass teaching and teacher-centered presentation. This phenomenon may have relationship with the ineffective training in the use of IT as indicated in many researches though courses in this area have been included in most teacher education programmes around the world. The last section of this paper will discuss on the contents of IT courses and to suggest a teaching model of using IT in education for pre-service teachers education programmes.

Keywords: **Methodologies, Teaching and Learning Process, Instructional Design**

1 Introduction

The Hong Kong Special Administration Region (HKSAR) government has already launched a five-year strategic plan of promoting the use of Information Technology (IT) in education aiming at enabling our students to be competitive and technological competent in the international arena since 1998 [1]. A total of about three billion dollars in capital cost and five hundred million dollars in annual recurrent cost will be used.

Computer and computer related technologies were expected to make teaching and learning more effective and efficient when it entered the classroom in 1980s [2]. Many teacher education programmes around the world have already started incorporating computer courses as basic requirement for teacher certification. In HKSAR, the previous colleges of education[1] have also started to include computers in education and computer applications courses in the Educational Technology subject which is compulsory to all the pre-service teachers in late 1980s. However, despite the provision of this training in many teacher education programmes, many researches report that the actual usage of new technologies in teaching was very limited. Teachers are not prepared to use new technology effectively in the classroom [3] [4]. Abdal-Haqq (1995) [5] even stated that "...few teachers routinely use computer-based technologies for instructional purposes" (p.1). In U.K., the HMI also commented that "new teachers make little use of Information Technology in the lessons"[6].

The purpose of this study is to find out the present scenario of the use of instructional technologies in primary

---

1 The previous colleges of education were amalgamated into the Hong Kong Institute of Education in 1994.

school teaching. The teaching time and the modes of using computer and traditional technologies are examined and compared. Such information will act as the base line for future investigation on the changes in teaching modes, strategies, and the use of new technologies in the 21st century classrooms. The last part of this paper will discuss on the contents and a teaching model that may be useful for preparing pre-service teachers to use computer more effectively in their future class teaching.

2 Method

2.1 Participants

The participants in this study were 323 primary teachers who attended staff development seminars and refresher training workshops in the use of IT in education offered by the Department of Curriculum and Instruction of the Hong Kong Institute of Education in 1999. 76% of them were female primary teacher. 95% of them possessed personal computers at home. 56% of them have received computer training in pre-service teacher education programme. This sample was further divided into three groups according to their teaching experiences: 27%, under 5 years; 25%, 6-10 years; 48% over 10 years.

2.2 Data Collection

The participants were asked to complete a survey at the beginning of the seminar and workshops. The first part of the survey was the demographic data of the participants while the second and third part required the participants to respond to the time spent in a week and the different modes of using 16 instructional media selected for this study respectively (see Table 1 and 2).

3 Results

3.1 The time of using instructional media in a week

Table 1 shows that board writing remains the most frequently used medium in the classroom. About 75% of the participants spend more than half of their teaching time with it. The second frequently used medium is board drawing (about 38%) while the third one is printed medium (about 30%). The table also reveals that 10 items have their using time less than half of the total teaching time in a week (item 6-11 and 13-16). It is also obvious to see that computer technologies were seldom used in class teaching at this stage. This phenomenon may be well explained by the un-readiness of computer facilities in most of the primary schools in the period of this study.

However, the figures revealed in the mean percentage of the use of traditional media in Table 1 show that about a quarter of the participants did not use any traditional instructional media and about 57% of them taught with these media less then half of the teaching time in a week. Only 17% of them used them for more than half of the teaching time in a week. This result shows that "text-book" teaching remains the dominant strategy in most primary school teaching despite those traditional instructional media have already placed in the schools as standard equipment.

Types of Media	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
Traditional Media					
1. Blackboard/Whiteboard Writing	1.5	2.9	20.4	33.8	41.4
2. Blackboard/Whiteboard Drawing	2.9	28	31.5	22.6	15
3. Realia/Model	1.9	51.3	33.2	10.6	3
4. Graphics	3.3	53.1	32	9.6	2
5. Printed Material	3.6	32.4	34	18.4	11.6
6. Photo	13.1	69.3	12.8	4.5	0.3
7. Slide	71.8	23.1	4.2	0.6	0.3
8. Overhead Transparency	40.8	38.7	17	1.9	1.6
9. Audio Tape	30.8	44.8	17.4	3.5	3.5
10. Video Tape	35.5	42.8	15.8	4.9	1

11.	Tape-Slide Programme	88.5	8.9	1.6	1	0
12.	Learning Package	13.1	49.4	25.6	9	2.9
Computer						
13.	Computer Generated Texts and Graphics	53.8	32	11.3	1.9	1
14.	Computer Presentation Programme	82.8	12.7	3.2	1.3	0
15.	Computer Assisted Learning Programme	86.4	9.1	3.9	0.6	0
16.	Internet	94.8	2.9	1.3	0.7	0.3
	Mean Percentage :	79.45	14.18	4.93	1.13	0.33

Table 1: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Primary Teachers of the Study (N=323)

3.2 The modes of using instructional media

Participants who have used the instructional media were asked to respond to the types of instructional modes of how these media were used. Table 2 shows that for the first three frequently used media as identified in last paragraph, they were used mostly for teacher's presentation (82%, item1; 79.2%, item2 and 66.7%, item4). The average percentages for group learning and individual learning activities for traditional media are 16.6% and 8.2% while those for computer are 8.6% and 4.5% respectively. These figures show that teacher's presentation is still the major mode of teaching among primary teachers at the present moment.

Types of Media		Teacher's Presentation (%)	Group Learning Activity (%)	Individual Learning Activity (%)
Traditional Media				
1.	Blackboard/Whiteboard Writing	82	-	-
2.	Blackboard/Whiteboard Drawing	79.2	-	-
3.	Realia/Model	66.4	30.6	9.5
4.	Graphics	66.7	23.5	7.6
5.	Printed Material	31.5	47.4	36.7
6.	Photo	48	24.5	9.8
7.	Slide	20.5	4.3	3.7
8.	Overhead Transparency	41.3	15	6.4
9.	Audio Tape	36.4	10.4	6.1
10.	Video Tape	35.5	8	4
11.	Tape-Slide Programme	11	3.1	1.5
12.	Learning Package	40.7	32.4	13.5
	Mean Percentage :	46.6	16.6	8.23
Computer				
13.	Computer Generated Texts and Graphics	26.3	17.1	9.5
14.	Computer Presentation Programme	9.2	7.3	3.7
15.	Computer Assisted Learning Programme	7.3	5.5	3.1
16.	Internet	4	4.6	1.5
	Mean Percentage :	11.7	8.63	4.45

Table 2: The Percentage of Responses to Teaching Modes Used with Instructional Technologies by Primary Teachers of the Study (Respondents can select more than one mode)

3.3 Effects of difference in gender and teaching experience on the use of instructional media

Since the sampling was not randomized, normal distribution of the sample could not be assured. A non-parametric analysis using the Mann Whitney U test was then used to compare the difference of the distribution of the responses between female and male primary teachers and the three groups of teachers with different teaching experiences.

Types of Media	Gender	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
3. Realia/Model*	Female	1.3	46.4	37	11.9	3.4
	Male	4.1	67.5	21.6	5.4	1.4
4. Graphics*	Female	3	48.1	35.1	11.7	2.2
	Male	4.2	70.4	21.1	2.8	1.4
5. Printed Material*	Female	3	31.8	30.5	20.3	14.4
	Male	5.6	34.7	44.4	12.5	2.8
6. Photo*	Female	11.8	66.8	15.1	5.9	0.4
	Male	17.8	76.7	5.5	0	0
7. Slide*	Female	74.8	19.7	4.3	0.9	0.4
	Male	61.6	34.2	4.1	0	0
11. Tape-Slide Programme*	Female	90.9	6.9	1.7	0.4	0
	Male	80.8	15.1	1.4	2.7	0
13. Computer Generated Texts and Graphics*	Female	58.7	30.6	8.1	1.3	1.3
	Male	37	37	21.9	4.1	0
14. Computer Presentation Programme*	Female	89.8	7.7	2.1	0.4	0
	Male	60.3	28.8	6.8	4.1	0
15. Computer Assisted Learning Programme*	Female	91.5	6.4	1.7	0.4	0
	Male	69.4	18.1	11.1	1.4	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Table 3: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Female and Male Primary Teachers of the Study

Significant differences were found in the distributions of 9 items between female and male teachers. In Table 3, referring to the "never use" column, it is interesting to see that female teachers used simple and traditional media (item 3,4,5 and 6) more than male teachers while male teachers used more complicated traditional media (item 7 and 11) and computer technologies (item 13,14 and 15) in this study. Similar analysis was conducted among the teachers with different teaching experiences. Only one item was found to be statistically different between the less experienced and more experienced teachers. Table 4 shows that experienced teachers used slide more than the less experienced teachers.

Types of Media	Teaching Experience	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
7. Slide*	Group A	82.4	14.1	3.5	0	0
	Group B	66	29.1	4.3	0.7	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Group A: Teaching experience less than 5 years; Group B: Teaching Experience greater than 10 years

Table 4: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week Between Two Groups of Primary Teachers with Different Teaching Experience of the Study

Analysis on the teaching modes of using these instructional media, however, showed that no significant differences were found between the female and male teachers and also among the three groups of teachers with different teaching experiences.

4 Discussion

From the above findings, it is obvious that the use of instructional media including computer technologies was limited. The teaching strategies employed by most primary teachers were still very teacher-centered although they have already completed instructional technology and related courses in the teacher education programme. Computer uses were rare even though more than 50 % of the participants have attended computer courses while receiving their pre-service teacher training and 95% of them possess home computers. It is evident that future teaching is influenced by the learning experiences that pre-service teachers gained in their tertiary education [7]. Researches also show that the provision of instructional models for classroom implementations

of technology is far more important than the training of the "know-how" skills [8]. The instructional strategy should act as the model and should be student-centred rather than terminology and hardware centred [9]. Task-based or problem based activities are more effective than skill drilling of certain hardware or computer software by direct demonstration. A course with well–designed contents and effective teaching model for the use of IT in education is believed to have positive influence on the actual implementation in school teaching.

4.1 The Contents

We suggest that for an IT in education course to be successful, the following areas should be included. We believe that such contents allow our pre-service teachers to have more comprehensive mastery of knowledge and skills of using IT in education and enable them to put theories and practical skills into real practice in primary school teaching.

1. Understanding the development, trends, advantages and limitations of using IT in education.
2. Understanding the roles and contributions of IT and teachers in the communication and learning process.
3. Designing and producing instructional materials with IT.
4. Operating computer hardware and application software while producing and using computerized instructional materials
5. Selecting and deriving learning activities with computerized instructional materials and resources
6. Evaluating the effectiveness of computerized instructional materials and programmes that involves the use of IT.

4.2 The Teaching model

Figure 1 is a proposed teaching model of using IT in education for teacher preparation programme. This model is informed by constructivist views of learning in which the learner is the center and the actor of learning. There are six major components in the model:

1. The teacher – is the one who build this model, creates a constructivist learning environment, acts as the resource, guide and the facilitator of the learning process and models the actual implementations and strategies of using IT in an authentic context.
2. The learner – is the master of this model, comes with different background and learning style, interacts with other components of this model and to construct the knowledge and skills actively.
3. Resources and support – assist the learner to complete his/her task throughout the learning process.
4. Integration – is the experience that the learner gains when applying IT in teaching and learning in an authentic situation.
5. Reflection – is the introspective thinking allowing the learner to have deeper understanding of the IT applications and be able to examine related issues critically.
6. Monitoring strategies – provide clear instructions and directions allowing the learner to have a complete picture of the objectives and significances of the learning, the tasks to be completed and the access to relevant resources and support.

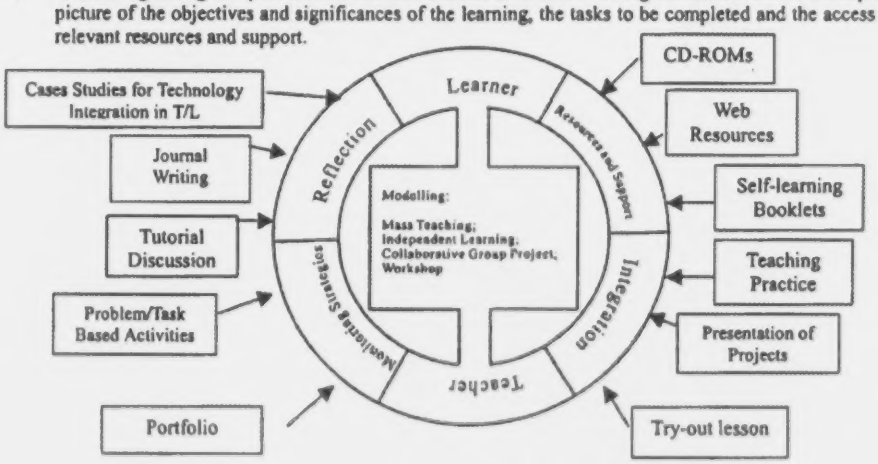


Figure 1: A teaching model of using IT in education for teacher education

5 Conclusion

The components of the teaching model guide the development of various strategies, learning activities and resources that can be found in Figure 1. Evaluation of the effectiveness of this model has been started and the results will be reported in due course. The findings of the survey in the first part of this study signal the ineffective use of instructional media both in terms of teaching time and strategies in primary school teaching. Change is expected if our students are to be really benefited by the five-year strategy of using IT in education. Teacher education, therefore, places an important role in this aspect.

References

[1] Education Manpower Bureau (1998). Information Technology for learning in a new era: 5-year strategy 1998/99 to 2002/03, November 1998, HKSAR.

[2] Goodlad, J.I. (1984). *A place called School*. New York: McGraw Hill.

[3] Bosch, K.A. and Cardinale, L. (1993). Preservice teachers' perceptions of computer use during a field experience. *Journal of computing in Teacher Education*, 10(1), 23-27.

[4] Office of Technology Assessment (OTA)(1995) Teachers and Technology: Making the Connection. US. OTA 1995 Report.

[5] Abdal-Haqq, I., "Infusing technology into pre-service teacher education", ERIC digest. (ERIC Document Reproduction Service #ED 389699). (1995)

[6] Her Majesty's Inspectors (1993). *The new teacher*. London: HMSO.

[7] Adams, P.E. and Krockover, G.H. (1997), Beginning science teacher cognition and its origins in the pre service secondary science teacher program. *Journal of Research in Science Teaching*, 34, 633-653.

[8] Novak, D. and Knowles, J. (1991). Beginning elementary teachers' use of computers in classroom instruction. *Action in Teacher Education*. 8(2), 43-51.

[9] Bigum, C. (1990). Situated computing in pre-service computer education. In A. McDougall and C. Dowling (Eds.). *Computers in Education*. North Holland: Elsevier Science.

Traversing the Case Graphs A Computer Model for Developing Case-based Learning Systems

Isaac P.W. Fung & R. H. Kemp
Institute of Information Sciences and Technology
Massey University
Palmerston North, New Zealand
Fax: +64-6-3502259
P.W.Fung@massey.ac.nz; R.Kemp@massey.ac.nz

This paper presents an extended theory for representing cases in a case-based physics learning environment. There are two issues with which developers of case-based tutoring systems often contend: one is assessing and retrieving similar cases from the case library; the second one is delivering the case contents to the students. Whilst an earlier paper has addressed the former issue, this paper focuses on the latter by defining a computational mechanism that is used for delivering the case content. The mechanism is developed by defining a procedural semantics on the case graph which incorporates the dynamic modelling capability of petri nets. A case is initially opaque to the student. During case interaction, however, it will be made transparent gradually by engaging the students with problem-solving activities. The activities are modelled using the notions of marking places and firing transitions, where places and transitions represent case variables and operations, respectively. The idea is illustrated with an example of providing guidance to students solving problems in the domain of Newtonian mechanics.

Keywords: **Artificial Intelligence, Conceptual Graphs, Intelligent Tutoring Systems, Case-based Reasoning**

1 Introduction

This paper presents an extended theory of representing problem-solving cases proposed in [5] for the purpose of modelling instructional activities between the cases and the learners within the context of case-based tutoring systems (CBTS) [11]. In response to the classic criticisms [12] leveled at the first-generation of computer-assisted learning software that frequently have to go back to inflexible, pre-compiled problem solutions, CBTS is very attractive for several reasons. Two of them are particularly appealing to us. From an instructional perspective, students are highly influenced by past examples (i.e. real cases) to guide their problem-solving activities [1] or completing cognitive tasks [8]. Our project sponsor demands that the final system should faithfully reflect what students actually do when completing their homework. It is, therefore, our aim to ground our system design at the outset on sound psychological findings about pupils' learning behaviours. Secondly, from a technical viewpoint, case-based adaptation techniques are powerful in adapting interface components to the user's need [14].

Individual learner's needs, style and progress do differ substantially. Case-based reasoning technology [7] endows the system with the capability of inferring what is considered 'best' for the students by referring to their past learning histories. [5] proposed the use of conceptual graphs (CG) [13] for representing tutorial cases. While this method elegantly tackles the issue of assessing case similarity, how the case graphs are built remains a 'black-box'. The case users have no way to inspect the internal processes for constructing the graph. To ensure

the cases are useful in tutorial contexts, the knowledge components of the cases need to be 'available' to the students. What we mean by 'available' is making the case solution transparent, i.e. the system is capable of justifying each problem-solving step being shown to the students in terms of the underlying physical principles.

The procedural semantics defined on case graphs which forms the core contents of this paper, provides a way of making the solution procedures explicit to the students. The idea is to synthesize a CG and the actor graph defined in [13] into one single global graph instead of treating them separately. The resulting structure is a tripartite graph that has three types of nodes: concept nodes, symbolic relation nodes and mathematical relation nodes. The mathematical relation nodes are for handling mathematical calculations in the domain of Newtonian mechanics, the targeted subject domain of our project These calculations are important in many science and engineering applications. In making the synthesis, two important ontological commitments were made. Firstly, human cognitive functions in studying a concrete case are viewed as a process of constructing graphs. Relevant concept nodes are created and linked to each other via some appropriate relation nodes (whether symbolic or mathematical). A case represented by the graph consists of sets of concept nodes and relation nodes, but to what extent the students understand the case contents remains unknown until some observable actions are seen. Secondly, the process of building the graph is based on the notion of concept node marking. Initially, the sets of nodes in a case are all opaque to the users because they are not yet marked. The set of nodes representing the initially given physical quantities are marked first. Each problem-solving step is viewed as generation of new graph nodes, but they are implemented as the nodes states change from unmarked to marked. To mark a set of nodes, the mathematical relation nodes (or operators) which link the marked and the unmarked nodes have to be fired. The procedures of solving the problem are defined as the firing sequence for marking the target concept nodes. The subgraph associated with a particular fired node represents the semantics of the knowledge behind its firing.

2 Formal Definition of the Case Constituents

We represent a typical case abstractly by a directed graph which is composed of

* Three disjoint sets of vertices C, R *and* R_m (i.e. $C \cap R = \varnothing$; $C \cap R_m = \varnothing$; $R \cap R_m = \varnothing$ and $C \cap R \cap R_m = \varnothing$) where C represents the set of concept nodes; R represents the set of symbolic relation nodes; and R_m represents the set of mathematical relation nodes.
* A set of directed arcs E such that $E \subseteq (C \times R) \cup (R \times C)$. Each arc $e \in E$ connects a concept $c \in C$ to a symbolic relation $r \in R$ or vice versa.
* A set of directed arcs E_m such that $E_m \subseteq (C \times R_m) \cup (R_m \times C)$. Each arc $e_m \in E_m$ connects a concept $c \in C$ to a mathematical relation $r_m \in R_m$ or vice versa.

Shown in Figure 1 is an example case graph where

$C = \{c_1, c_2, c_3, c_4, c_5, c_6\}$;
$R = \{r_1, r_2, r_3, r_4\}$;
$R_m = \{r_{m1}, r_{m2}, r_{m3}, r_{m4}\}$;
$E = \{(c_1, r_1), (r_1, c_2), (c_3, r_2), (c_4, r_2), (r_2, c_2), (c_5, r_4), (r_4, c_2), (c_6, r_3), (r_3, c_1)\}$; and
$E_m = \{(c_1, r_{m1}), (r_{m1}, c_2), (c_2, r_{m2}), (c_2, r_{m3}), (c_5, r_{m3}), (r_{m2}, c_3), (r_{m3}, c_4), (c_3, r_{m4}), (c_4, r_{m4}), (r_{m4}, c_6)\}$.

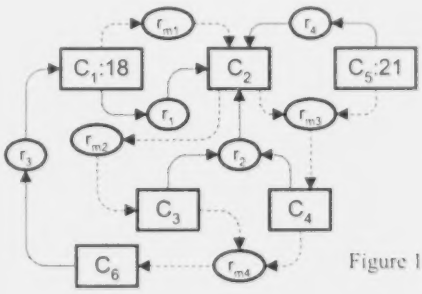


Figure 1

* For every $r_m \in R_m$, there exist an input set $I_r(r_m)$ and an output set $O_r(r_m)$ such that

$I_r(r_m) = \{ c \in C \mid (c, r_m) \in E_m \}$; (c, r_m) is called the input arc of r_m, and c is called the input concept of r_m; and
$O_r(r_m) = \{ c \in C \mid (r_m, c) \in E_m \}$; (r_m, c) is called the output arc of r_m, and c is called the output concept of r_m.

For example, the input/output set of the node r_{m3} in Figure 1 are $I_r(r_{m3}) = \{c_2, c_5\}$ and $O_r(r_{m3}) = \{c_4\}$ respectively.

* For every $c \in C$, it is defined as *marked* if it is being instantiated to a specific individual. In Figure 1, c_1 and c_5 are marked whereas the others are non-marked.
* The marking μ of a graph G can be represented by a *n-vector*: $\mu = (\mu_1, \mu_2, \ldots, \mu_n)$, where each $\mu_i \in (T, F)$. For example, the graph in Figure 1 has the marking $\mu = (T, F, F, F, T, F)$.
* A mathematical relation node $r_m \in R_m$ is *enabled* whenever each concept $c \in I_r(r_m)$ is marked. In Figure 1, only r_{m1} is enabled at that marking.

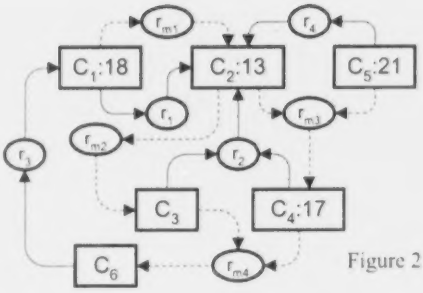


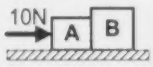
Figure 2

* When a mathematical relation node is enabled, it can be fired at any time and every time a mathematical relation is fired, every $c \in O_r(r_m)$ will be marked[1].
* For every $c \in O_r(r'_m)$, where r'_m is the fired mathematical relation, the content of c is evaluated according to the formulas inscripted in the respective $r'_m \in I_c(c)$.
* Supposing the formulas inscripted in r_{m1} is $c_1 = c_2 + 5$ and r_{m3} is $(c_2 + c_5) / 2$, the firing of r_{m1} will mark c_2 which enables r_{m3} because c_5 has already been marked. If r_{m3} is fired later, a new marking (shown in Figure 2) will be formed and become $\mu = (T, T, F, T, T, F)$.

3 Representing Mechanics Problem-solving Cases

In our application domain, Newtonian mechanics, two categories of physical entities are identified with respect to the cases we use for tutoring: *physical objects* and *physics concepts*. Both are represented, however, as rectangular-shaped concept nodes. In each case, a number of physical objects are involved, such as a block, a car, a plane, a spring, etc., but they are normally described abstractly just as a physical object. Various meaningful relations obtain between the objects, which essentially represent the physical configuration between them. For instance, it makes sense to represent the 'rest_on' relation that holds between a block and a plane whenever the block is on the plane. Other meaningful relationships are: 'above', 'contact_with', 'moves_on', and so forth. There are attributes, intrinsic and motion-related, of the physical objects which refer to one object only. For example, 'acceleration'(a motion-related attribute) and 'mass' (an intrinsic attribute) applies to a single physical object on its own. In representing a physical situation, there are some other domain-related ideas such as external force or friction, which characterize the case being described. All these concepts are categorized as physics concepts as they are used to describe the state of the world depicted by the case. Figure 3 shows a typical case adopted from a standard physics textbook.

Two blocks A & B are resting on a frictionless horizontal plane as shown. If an external force of 10N is acting on A, what is the acceleration of the blocks and the force of contact between them? (The masses of A and B are 3kg and 7kg respectively).



[1] The notion of marking and firing is borrowed from the petri nets formalism [9]

Solution: Apply Newton's 2nd Law on A&B

$$\begin{aligned}
\text{Net Force}_{A\&B} &= \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \\
\text{External Force}_{A\&B} &= \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \\
10 &= (3 + 7)\ \text{Acceleration}_{A\&B} \\
\text{Acceleration}_{A\&B} &= 1\ m/s^2
\end{aligned}$$

Apply Newton's 2nd Law on A

$$\begin{aligned}
\text{Net Force}_{A} &= \text{Mass}_{A} \times \text{Acceleration}_{A} \\
\text{External Force}_{A} + \text{Contact Force}_{A} &= \text{Mass}_{A} \times \text{Acceleration}_{A} \\
10 + \text{Contact Force}_{A} &= 3 \times 1 \\
\text{Contact Force}_{A} &= -7N
\end{aligned}$$

Apply Newton's 2nd Law on B

$$\begin{aligned}
\text{Net Force}_{B} &= \text{Mass}_{B} \times \text{Acceleration}_{B} \\
\text{Contact Force}_{B} &= \text{Mass}_{B} \times \text{Acceleration}_{B} \\
\text{Contact Force}_{B} &= 7 \times 1 \\
\text{Contact Force}_{B} &= 7\ N
\end{aligned}$$

Figure 3: A typical Newtonian mechanics case and its solution

As the complete graph representing the case occupies too much space, the whole graph is divided into several subgraphs. To illustrate the idea, three representative subgraphs are shown in Figure 4, 5 and 6. The subgraph in Figure 4 represents the physical objects involved in the case and their relationships. The (component) nodes encodes the part-whole relationship between the whole system A&B and its constituents A and B. The tuple [Blocks: A&B] → (component) → [Block: B] depicts the block labelled as 'B' as part of the whole system labelled as 'A&B'. The other relation nodes essentially represent the spatial relationships between the objects.

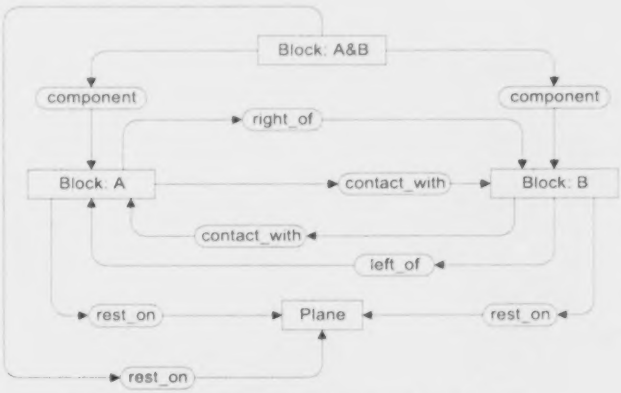


Figure 4: The subgraph showing the physical objects involved in the case and their relationship

The subgraph shown in Figure 5 concerns the attributes, both intrinsic and motion-relationed, of block A, and other relevant physical concepts centred around it. The absurd type [T] as the agent of the Net_Force_A and External_Force_A indicates it is something that is of no relevance to us. In Figure 6, those concept types that participate in some sort of mathematical relations are shown. Note that most of the arcs in Figure 6 are dotted indicating they are different from the usual symbolic relations.

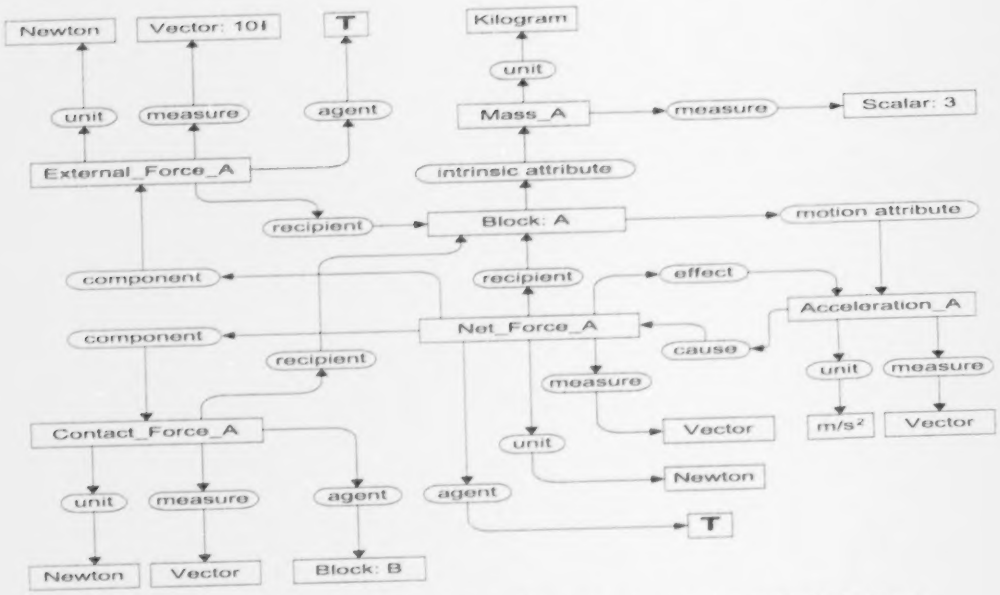


Figure 5: Subgraph showing the attributes of block A and other relevant physical concepts.

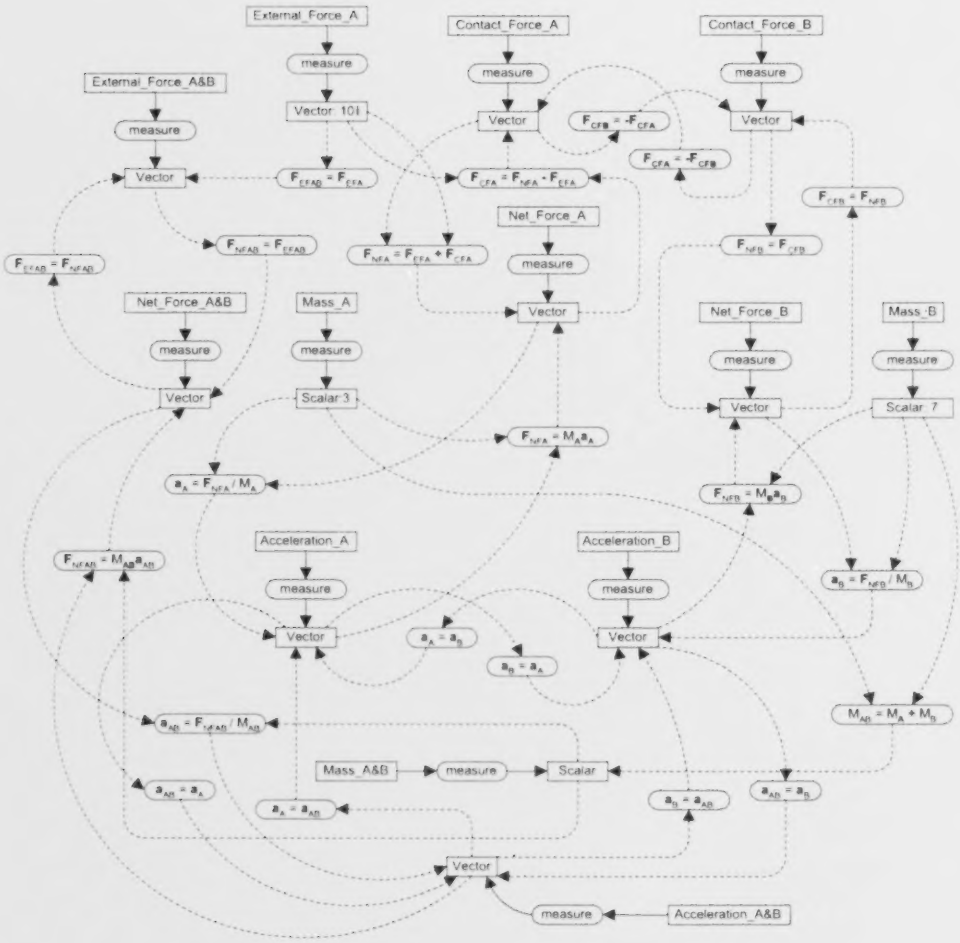


Figure 6: Subgraph showing the mathematical relationships between the relevant concept types

4 Modelling Variables Instantiation as Node Marking

Once a case has been encoded with the formalism, problem-solving activities can be modelled. When given a problem to tackle, the students will generally be asked for a new value from a set of given data. This is modelled as marking the concept nodes such as C_1 and C_5 in Figure 1. The goal is to get the concept node C_6 marked. At the initial marking, only r_{m1} is enabled and therefore any attempt to trigger other mathematical operations is not allowed and, thereby, invites tutorial intervention. The whole process of creating successive markings can be illustrated with a search tree (see Figure 7). The tree

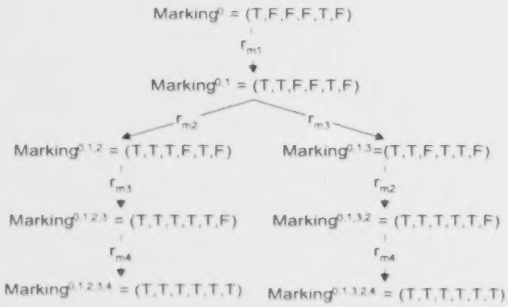


Figure 7

indicates the student can gain access to a large solution space for him/her to explore but in the mean time the tutor can keep track of what can/cannot be done.

5 CLASP: A Case-based Learning Assistant System in Physics

A system called CLASP, has been developed to implement the idea. At the current stage of development, two types of activities associated with examples have been identified: providing solutions for studying, and exercises with answers; hence the modes of interaction in the CLASP prototype are also designed around these two themes. When the users issue a request (in terms of the problem description of their own problems) the system will search through its whole case library and provide them cases which match their request. The style of presenting the case will follow the user's wishes, but only two modes of interaction (solution studying and guided-problem-solving) are available. This is to reflect the common way of using examples in physics textbooks. In the study mode, the system presents the whole case (i.e. both the problem and solution statements) for the user to study. This looks like an electronic reference book and the student may browse through the relevant cases. In the guided-problem-solving mode, the system only presents the problem situation to the users, but appropriate system guidance will be provided in solving the problems. The schematic architecture of CLASP is shown in Figure 8. The students interact with the system with the support of the back-end knowledge base.

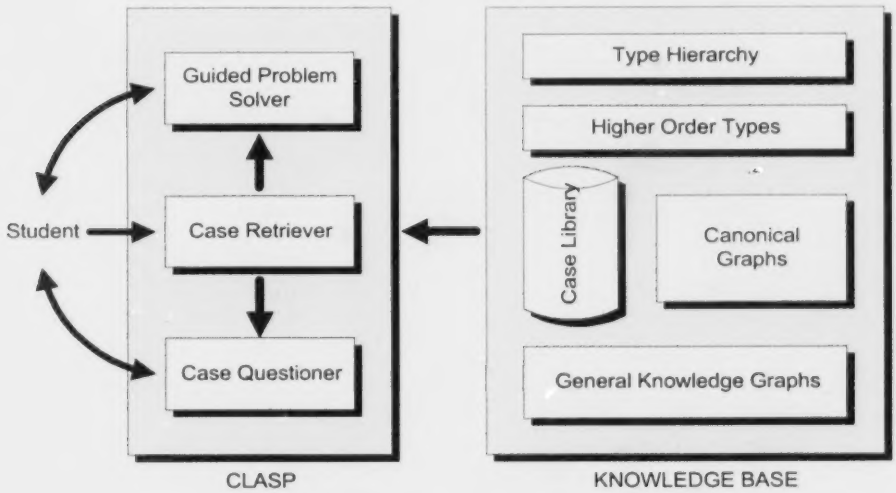


Figure 8: Schematic description of the CLASP architecture

Problem-solving in CLASP is modelled as a graph search. When a problem situation, such as the one shown in Figure 3, is encountered, the initial data are represented as concept nodes being instantiated to specific values and they are displayed to students on the working pad (Figure 9). Now the problem-solver can start tackling the problem by searching through the graph and seeing what additional information can be inferred from the initial given data. For the system to perform the tasks, the expertise has already been encoded in the case graphs, therefore the next step to be taken is searching the graph to find out which operators can be fired. The inferred steps may be unfolded or kept hidden for a while as a hint to advise the student. The intelligence of the system's problem-solving ability comes from its inference engine, being implemented by different graph search methods.

Problem Space	System's Comments:
External_Force_A: 10N Mass_A: 3 kg Mass_B: 7 kg	Initial Conditions: M_A = 3kg; M_B = 7kg; and External Force $_A$ = 10N.

Figure 9: The working pad and the corresponding system responds

The explanatory capability of the system comes from the matching of the input-operator-output nodes with the consequences of the general knowledge graphs. Whenever an operator is fired, the associated nodes will be matched against the consequences of the general knowledge graphs. If one is found, and it should be, then that particular graph will be tagged. If the student requests a justification of the step taken, the system can explain the graph in general terms. For example, the firing of an algebraic summation operator on the values of masses of two physical objects will match the consequence of the general knowledge graph in Figure 8 so the whole graph can be retrieved for explanation (Figure 10). The working pad, showing the problem space, and the explanation combinations supply the integration of what and why the step happened and the whole process becomes transparent to the student.

Problem Space	System's Comments:
External_Force_A: 10N Mass_A: 3 kg Mass_B: 7 kg 1 Mass_A&B: 10 kg	Step 1: For a system comprising two components, the mass of the whole system is evaluated by the algebraic sum of the masses of their individual components. $M_{A\&B} = M_A + M_B$

Figure 10: The working pad and the corresponding system responds

6 Conclusions

Case-based reasoning (CBR) is a versatile AI technology and can been found in many industrial applications [2] but its potential in training and education is still not fully explored. The work reported here may serves to strengthen the position of CBR in developing instructional systems.

The contribution of the paper to the endeavour of computer-assisted learning is twofold. Firstly, technically, a formal framework for representing cases for learning purposes has been developed. Its formal basis provides a solid foundation for developing robust computer-based instructional systems. With this methodology, the developers only have to concentrate their effort on collecting and encoding the cases. The rest (generating relevant instructional activities from the cases) will be taken care of by the system. This approach offers another advantage for rendering the cases amenable to further analysis. This may be used for providing tool to verify the case-base for internal consistency. Secondly, educationally, our approach paves the way for systematic educational software engineering because it is built on the needs of users, not the technical skills of the developers. Often, educational software developers have adopted a technically-driven design philosophy. Such systems run the risk of losing sight of what is actually happening in the real learning setting.

Our approach avoids the temptation of jumping onto the hi-tech bandwagon but, instead, concentrates firstly on what the students really need. The reason we developed a case-based learning system was not due to the existence of the technology and trying to find what role the technology can play in learning. Rather, we choose

to develop a case-based approach to learning because students do learn from referring to past cases. This principle we consider crucial in determining if the final system proves itself useful to our students. Other features of the system have not been described due to space limitation. They include generating different categories of questions from a case graph [6] to promote self-explanation from the students. The model proposed in this paper can also perform qualitative reasoning [4], and causal order between system variables can be represented succinctly.

References

[1] Anderson, J.R. et al., "Learning to Program in LISP", Cognitive Science, Vol. 8, pp.87-129, (1984).

[2] Bergmann, R. et al., "Developing Industrial Case-based Reasoning Applications", Springer-Verlag, (1999).

[3] Fung, P.W., "Designing an Intelligent Case-based Learning Environment with Conceptual Graphs", PhD Thesis, Dept. of Computation, UMIST, England, (1996).

[4] Fung, P.W., "Generating Qualitative Predictive Problems in a Case-based Physics Tutor" In B. du Boulary & R. Mizoguchi (Eds.) Artificial Intelligence in Education: Frontiers in Artificial Intelligence and Applications Vol. 39, Ohmsha: IOS Press, (1997).

[5] Fung, P.W. & Adam, A., "Conceptual Graphs for Similarity Measurement in a Case-based Physics Problem Solver" In Proceedings of AI-ED 95 – World Conference on Artificial Intelligence in Education. Washington D.C, (1995).

[6] Fung, P.W. & Adam, A., "Questioning Students on the Contents of Example Solutions" In Proceedings of European Conference on Artificial Intelligence in Education, Lisbon, (1996).

[7] Kolodner, J. "Case-Based Reasoning" San Mateo, CA: Morgan Kaufmann Publishers, (1993).

[8] LeFevre, J.A. & Dixon, P., "Do Written Instruction need Examples?" Cognition and Instruction, Vol.3, pp.1-30, (1986).

[9] Peterson, J.L., "Petri Net Theory and the Modeling of Systems." Englewood Cliffs. NJ: Prentice-Hall Inc. (1981).

[10] Sanders, K.E., Kettler, B.P. & Hendler, J.A. "The Case for Graph-Structured Representations" In D.B. Leake & E. Plaza (Eds.) Case-based Reasoning Research and Development. Lecture Notes in Artificial Intelligence, Vol. 1266, pp. 245-54, Springer-Verlag, (1997).

[11] Schank, R.C., "Case-based Teaching: Four experiences in Educational Software Design." Report No.7, The Institute of Learning Sciences, Northwestern University, (1991).

[12] Self, J., "Student Models in Computer-aided Instruction." International Journal of Man-Machine Studies, Vol. 6, pp. 261-76, (1974)

[13] Sowa, J., "Conceptual Structures: Information Processing in Mind and Machine" Reading, MA: Addison-Wesley, (1984).

[14] Specht, M. & Weber, G., "Episodic Adaptation in Learning Environments" In Proceedings of the European Conference on Artificial Intelligence in Education, Lisbon, pp.171-176, (1996).

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

Proceedings

Content

Full & Short Papers (Multimedia and Hypermedia in Education)

A Learner-Centered Navigation Path Planning in Web-based Learning
A Study on the Relation between Touch-typing Skill and Thinking-typing
A Virtual Classroom for Algorithms with Algorithmic Support
An Adaptive Navigation Support with Reorganized Learning Resources for Web-based Learning
An Empirical Study of Design and Use of a Multimedia Composition-Making System for Children
Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space
Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet
CAI system generator on web -- using automatic trace recording
CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL
Design and Implement CAI Programs for Adult Literacy Learners
Design for Interactivity
Design of Multiple Metaphors in User-Interface
Development of 3D simulation programs for classical mechanics - Using Java 3D -
Evaluating educational multimedia: a case study
Learner Control in Technology-mediated Learning within a Constructivist Model
LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES
Learning Algorithm Design Through Interactive Simulation
Making Exploration History Interactive for Web-based Learning
Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools
Multimedia Design for Chemical Visualisation
Multimedia Intelligent Tutoring System for Context-Free Grammar
Multimedia Whiteboard Design in WWW-Based Remote Cooperative Education System
Multimedia-Based Teaching Material For Learning Digital Signal Processing
MyEnglishTeacher A WWW System for Academic English Teaching
Natural language-like knowledge representation for multimedia educational systems

On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

SimPCS: A Web-based PCS Learning Tool

Students' thinking processes when learning with computer-assisted mass lectures

System Development for Learning through the Internet, Providing Function to Make Chinese Character Readable for Students

The Automated Teaching Assistant: Automatic construction of teaching materials from course outlines

The Criteria and Evaluation of Metadata/Keywords in Image Retrieval

The Development and Evaluation of a Learning Support System for Converting Web Pages

The Estimation of Music Genres Using Neural Network and its Educational Use

The Rhetoric of the Web. A semiotic approach to the design and analysis of Web-documents

Visual Presentation Format and Knowledge Discrepancy in Scientific Learning

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

▲ HOME

A Learner-Centered Navigation Path Planning in Web-based Learning

Akihiro Kashihara, Ryoichi Suzuki, Shinobu Hasegawa, and Jun'ichi Toyoda

The Institute of Scientific and Industrial Research, Osaka Univ., JAPAN
8-1, Mihogaoka, Ibaraki, Osaka 567-0047, JAPAN
kasihara@ai.sanken.osaka-u.ac.jp

The main issue addressed in this paper is how to help learners navigate in existing web-based learning resources. Towards this issue, we introduce a learner-centered navigation path planning. The key idea is to provide learners with a space, in which they can see through WWW pages to plan a navigation path. In this paper, we also demonstrate an assistant system, which is composed of hyperspace map, page previewer, and path previewer. The page previewer generates an overview of each WWW page in the map by extracting representative information from the HTML file. The path previewer helps learners make a sequence of the pages previewed as navigation path plan. These facilities help learners decide which page to visit and plan a navigation path without visiting hyperspace. This paper also describes a preliminary evaluation with the assistant system. The results indicate that the system facilitates learning and navigation in a more complicated hyperspace.

Keywords: Navigation Path Planning, Learner-Centered, Page Previewer, Path Previewer

1 Introduction

An increasing number of hypermedia/hypertext based resources on the Web has been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based learning resources has accordingly become important, particularly as the realization of lifelong and distance learning.

Web-based learning resources provide learners with hyperspace where they can explore domain concepts/knowledge in a self-directed way from a WWW page to others by following the links among pages to achieve a learning purpose. However, learners often fail in making the navigation path since they do not know which link to follow for achieving their learning purpose due to the complexity of hyperspace [3], [9]. They may alternatively reach an impasse due to a cognitive overload, which is caused by diverse cognitive efforts at setting up local learning purposes, comprehending the contents included in nodes, etc., in the exploratory learning [6], [11]. How to facilitate learners' navigation and learning is consequently a major issue in educational hypermedia/hypertext systems [1], [11].

The main topic addressed in this paper is how to help learners navigate in existing web-based learning resources. Current work on educational hypermedia/hypertext systems has provided a number of navigational aids such as spatial/concept maps and adaptive navigation [1], [4], [5]. However, these aids can not be always available to existing web-based learning resources since it is hard to grasp semantic relationships among the WWW pages, on which the navigational aids are founded, without analyzing the contents of the learning resources.

In this paper, we discuss a learner-centered navigation path planning. The key point of this idea is to provide learners with a space, in which they can see through web-based learning resources to make a navigation path plan, apart from hyperspace. Such planning space is also expected to facilitate their learning since they can focus mainly on comprehending the contents of the learning resources in hyperspace. We have accordingly developed an assistant system for the navigation path planning. This system provides learners not only with hyperspace map but also with page previewer and path previewer. The page previewer extracts information attached to some HTML tags in a WWW page, which can be considered representative of the page, from the HTML file, and displays it as an overview of the page. The path previewer also makes a sequence of the pages previewed, and displays it as navigation path plan. These facilities help learners decide which page to visit and make a navigation path plan without visiting hyperspace.

This paper also describes a preliminary evaluation of learner-centered navigation path planning with the assistant system. The results indicate that the system facilitates learners' navigation and learning in hyperspace, particularly in more complicated hyperspace.

Before discussing the learner-centered navigation path planning, let us first consider navigation in hyperspace.

2 Navigation in Hyperspace

2.1 Problems

In hyperspace, learners can explore nodes in a self-directed way by following links among the nodes to learn domain concepts/knowledge embedded in the explored nodes. The exploration involves making a path called navigation path [9]. However, learners can not foresee what they can explore next from the current node and can not decide which link to follow for achieving their learning purpose, often failing to make their navigation path [11]. This is mostly caused by the complexity of hyperspace. The learners may alternatively reach an impasse since they need to concurrently make diverse cognitive efforts at setting up local learning purposes, comprehending the contents explored, etc., in exploratory learning [6], [7], [11].

2.2 Navigation Aids

The important points towards the navigation problem are how to give learners an unobstructed view of hyperspace and how to call their attention to making a navigation path.

As current representative navigational aids, there are spatial maps and concept maps. Spatial maps represent nodes and links that compose the structure of hyperspace [4], [8]. Concept maps consists of nodes and links representing the structure of domain concepts to be learned, which nodes are mapped on the corresponding nodes in hyperspace [5]. In both of spatial and concept maps, nodes are tagged with their titles, which are intended to represent the contents of the nodes. In concept maps, links are also tagged with descriptions representing the semantic relationships between the nodes. Although such tag information may be insufficient for learners to make a navigation path plan, the spatial and concept maps provide learners with a space, apart from hyperspace, for considering navigation paths.

Another solution to the navigation problem is adaptive hypermedia, which supports navigation in hyperspace by annotating nodes and links to be visited, hiding nodes and links not to be visited, etc [1]. Such adaptive navigational aids are founded on semantic relationships among domain concepts/knowledge and learners' exploration status.

These above representative navigational aids would generally work well in educational hypermedia/hypertext whose semantic structure has been given or analyzed [2]. However, it is doubtful whether they apply to web-based learning resources [12]. Existing web-based learning resources mostly have no concept maps. It is also hard to identify semantic structure of domain concepts/knowledge embedded in the learning resources. Although there are web-based learning resources with site maps, the anchors included in the maps do not always allow learners to foresee the contents of the WWW pages. In addition, adaptive navigational aids are not always applicable since existing web-based learning resources generally have no clear description of semantic relationships among WWW pages, which is indispensable for executing the adaptation. In order to apply these navigational aids to existing web-based learning resources, it is necessary to analyze semantic structure of the domain concepts/knowledge beforehand. In this paper, however, we address the issue of how to support learners' navigation without the analysis.

2.3 Navigation Path Planning and Execution

Let us now introduce a learner-centered navigation path planning. The key idea is to provide learners with a space where they can plan a navigation path with an overview of each WWW page. In other words, learners have two spaces, which are space for navigation path planning and hyperspace for executing the plan. In the planning space, learners decide which page to visit and the sequence of pages visited. In the hyperspace, they are expected to explore hyperspace as planned. The navigation path planning and plan execution are repeated during learning in hyperspace.

The distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of learning resources in hyperspace. Since the navigation path plan also gives learners an overview of the contents to be learned before exploring hyperspace, their learning can be improved.

3 Learner-Centered Navigation Path Planning

We next discuss how to support learner-centered navigation path planning and demonstrate an assistant system that has been already implemented.

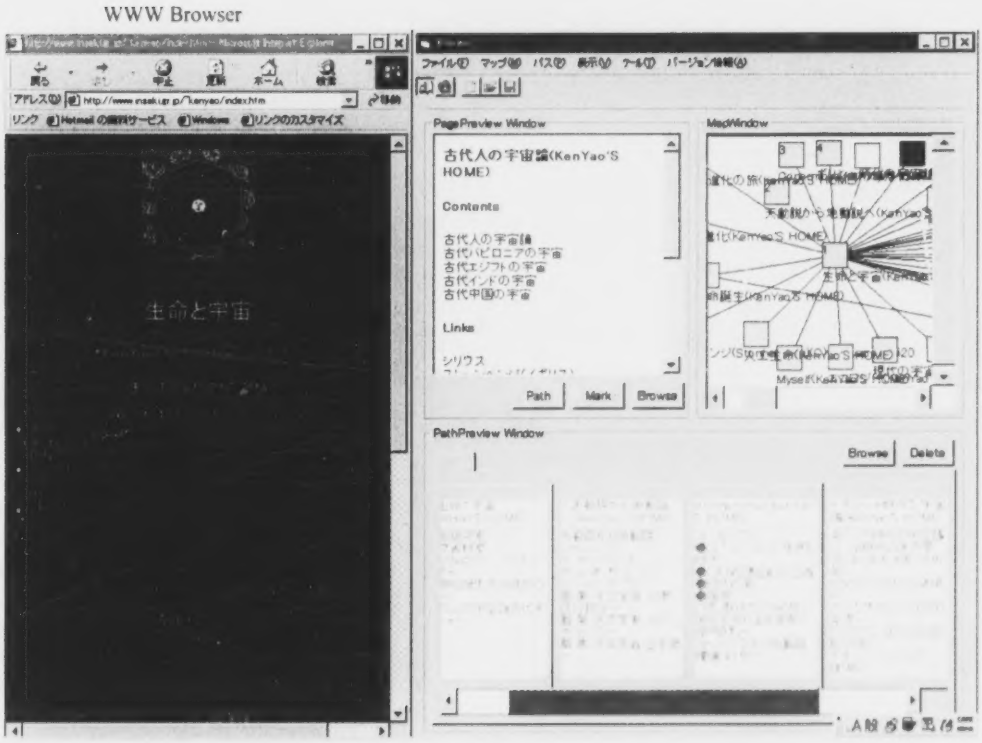


Figure 1. User Interface.

3.1 Framework

Let us first consider what kind of information should be presented for supporting navigation path planning. Although spatial maps of web-based learning resources are necessary for considering navigation paths, the maps alone may be insufficient for learners as mentioned above. It is indispensable to provide them with some additional information. However, planning with the full contents of the WWW pages causes the same navigation problem as hyperspace usually produces. This suggests the necessity to give learners an informative overview of the contents. In this paper, we introduce a page previewer that tries to extract keywords, sentences, or images to be considered representative from a WWW page to display them as the preview of the page.

In addition, the navigation path planning involves considering the relationships between WWW pages explored, changing the plan, and replanning over again. We accordingly introduce a path previewer that makes a sequence of the previewed pages the learners want to visit. The path previewer helps the learners plan, change, and remake navigation path with the sequence of the previewed WWW pages.

Figure 1 shows a user interface of the assistant system for learner-centered navigation path planning. The system is composed of spatial map, page previewer, and path previewer. The spatial map represents hyperspace of a web-based learning resource selected by learners as network of nodes corresponding to the WWW pages. It is automatically generated and displayed in the map window when they select the learning resource. The spatial map represents the WWW pages only within the same WWW site where the homepage selected by the learners is located. The links from the site to others are omitted. Nodes in the spatial map are tagged with page titles indicated by title tags in the HTML files.

In the spatial map, the node corresponding to the WWW page learners currently visit with browser is colored with red. The learners can start planning a navigation path from the current node by following the links. The path planned is restricted by the structure of the spatial map. In left mouse-clicking a node, they can have an overview of the WWW page corresponding to the clicked node in the page preview window. The color of the node previewed is also changed into red. Nodes next to the red node are also colored as yellow. If it is hard to see connections between the red node and the next nodes, a pop-up menu including the titles of the next nodes appears by means of right mouse-clicking the red node. Selecting one title from the menu, learners can see an overview of the corresponding node in the page preview window.

BEST COPY AVAILABLE

Table 1. HTML Tags Searched.

HTML Tags	Meanings
- About contents	
1.Title	Title of page
2.H1 to H3	Headings of page
3.Font Size/Color/Face	Font size, color, and figure
- About links	
A href	Link to another page
- About images	
Img	Image file

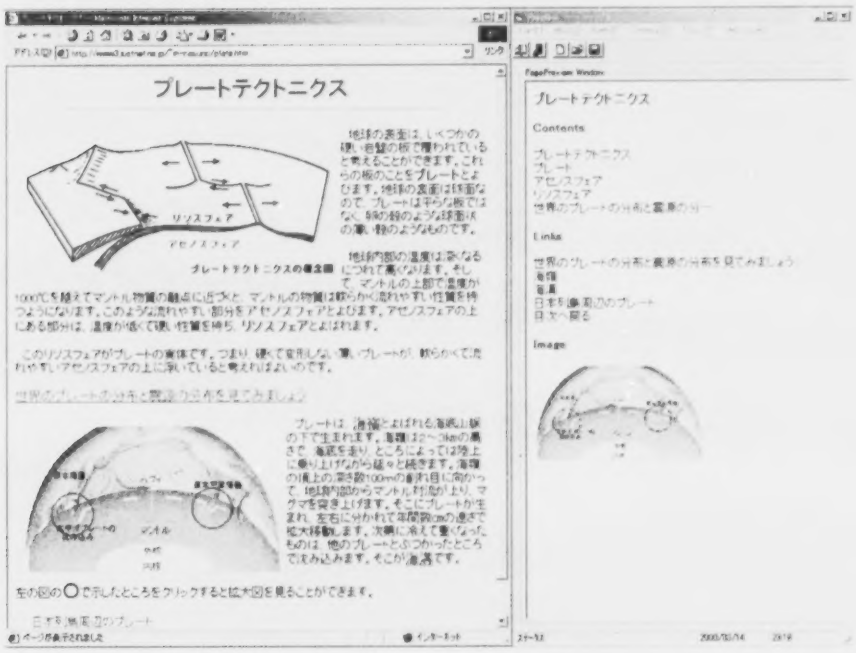


Figure 2. An Example of Page Preview.

The learners can also put the previewed node in the path preview window, making a navigation path plan. The learners are expected to explore hyperspace as planned with browser. When they want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a new path.

In the following, let us explain the page previewer and path previewer in more detail.

3.2 Page Previewer

The important point to generating an overview of a WWW page is how to extract information representing the contents of the page. Assuming that such information is located with the HTML tags shown in Table 1, the page previewer extracts words, sentences, or images indicated by these tags to display them as page preview. We heuristically consider such assumption valid. Figure 2 shows an example of the page preview. The right window shows the preview of a WWW page shown in the left window.

The information extracted from a WWW page is classified into the contents, the links out of it, and images included. As for the contents, the page previewer searches for the HTML tags in order from top to bottom in Table 1, and extracts words or sentences attached to the tags. When extracting a sentence, it displays not all words but

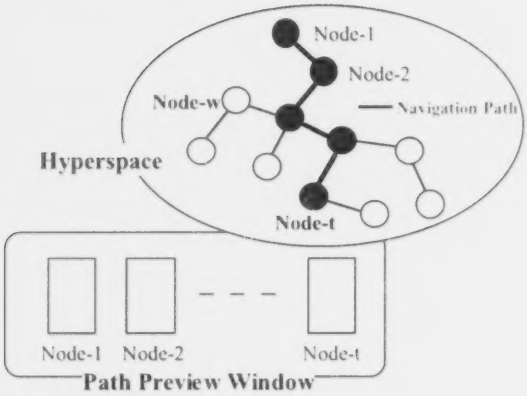


Figure 3. Restriction on Navigation Path Planning.

fifteen words from the head of the sentence. If the number of HTML tags included in the HTML file is large, the page previewer deals with ten HTML tags that are searched from the top in Table 1. For example, let us consider a WWW page including a large number of HTML tags such as one title tag, six *H1* tags, seven *H2* tags, nine *H3* tags, etc. In this case, the page previewer focuses on ten tags, which are the title, six *H1* and three *H2* tags, and displays the information attached to these tags.

As for the links out of the page, the page previewer searches for *A href* tags in the HTML file to display the descriptions of the links. If the descriptions indicate the URL, they are not displayed. If the number of *A href* tags is large, the page previewer displays only five link descriptions to be found from the head of the HTML file. As for the images included in the page, the page previewer searches for *Img* tags in the HTML file, and displays one image whose file size is the largest.

Learners can see the preview of a WWW page by mouse-clicking the corresponding node in the spatial map. Since the node previewed is colored with red, they know where they are previewing in the spatial map. If they can not foresee the contents of the page, they can push the *Browse* button under the page preview window or double-click the node to look at the full contents in browser. However, these operations are not recommended in planning. In making a navigation path plan, the learners can include the node previewed in their navigation path by pushing the *Path* button. Mouse-clicking the *Mark* button, in addition, they can mark the node previewed, which they do not want to immediately put in the path preview but to memorize.

3.3 Path Previewer

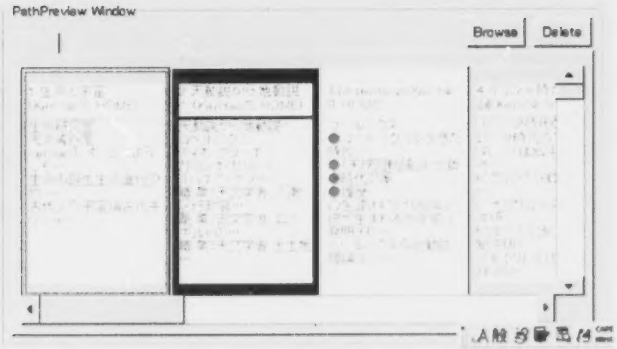
In the path preview window, the path previewer sequences the nodes previewed, which nodes are put in order by learners. The order of the previewed nodes represents a navigation path plan. The adjacent nodes are also adjacent each other in hyperspace. If the learners attempt to put a node in the sequence, which is not directly linked to the tail node of the sequence in hyperspace, the path previewer disables the *Path* button. For example, let us consider a learner who works out a navigation path plan as shown in Figure 3. If he/she tries to put *Node-w* in the plan, he/she is provided with a warning from the path previewer since the *Node-w* is not linked to the tail node (*Node-t*) of the sequence in hyperspace. In this way, the navigation path planned has to follow the link structure of hyperspace.

The learners can also delete any node in the navigation path plan by mouse-clicking it and selecting *Delete* button in the upper right corner of the path preview window. In order to help learners select one of some branches from a node, the page previewer additionally displays these branches with some path preview windows concurrently.

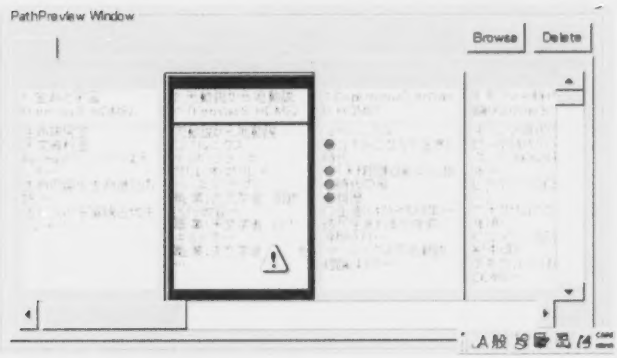
3.4 Plan Execution and Replanning

Using the page preview and path preview windows, learners are expected to decide a navigation path and then to start exploration in hyperspace. They are also expected to follow the navigation path plan during the exploration. The node in the plan corresponding to the WWW page, which the learners currently browse, is framed with blue. This allows them to know which node they are browsing. When they put the mouse-cursor on a link in the WWW page, which link indicates the node next to the framed node, the node is also framed with yellow such as Figure 4(a). This also allows them to know which link to follow in the WWW page.

The learners do not always need to follow the plan. They can explore nodes with browser, which are not included



(a) Attention to Next Page.



(b) Warning.

Figure 4. Attention and Warning in Path Preview Window.

in the plan. As shown in Figure 4(b), however, the path previewer put a warning icon on the node at which the learners run off in the plan. When they also want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a navigation path plan from the node corresponding to the current page on browser.

In this way, learners are expected to repeat the navigation path planning and plan execution to accomplish the exploratory learning in hyperspace.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the effectiveness of learner-centered navigation path planning with the assistant system, we have had a preliminary experiment. The main purpose of this experiment was to ascertain if navigation path planning with the system facilitates navigation and learning in hyperspace compared to navigation and learning without the system. We also prepared two learning resources, which had comparatively simple and complicated hyperspace, and ascertained for which resource the system can assist in navigation and learning more effectively.

Table 2 shows the two learning resources, which describes the number of pages, the number of links per page, which was calculated except for navigation links such as *Next*, *Back*, and *Top*, and the longest distance from the homepage to terminal page that has no link. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were 7 graduate and undergraduate students in science and technology.

We set four conditions, which were (1) planning and execution with the system in the learning resource 1 (*Simple-With*), (2) exploration in the learning resource 1 without the system (*Simple-Without*), (3) planning and execution with the system in the learning resource 2 (*Complicated-With*), and (4) exploration in the learning resource 2

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	32	161
Number of Links per Page	1.2	2.2
The Longest Distance from Homepage to Terminal Page	3	7

Domain of learning resource 1: Life and space.
Domain of learning resource 2: Life in sea.

Table 3. Average Scores of Problem-Solving.

Condition	Total	Single Problems	Compound Problems
Simple-With	75%	100%	60%
Simple-Without	71%	78%	67%
Complicated-With	79%	83%	75%
Complicated-Without	62%	78%	50%

Table 4. Average Scores of Revisit per Page.

	Revisit		Revisit
Simple-With	1.58	Complicated-With	1.83
Simple-Without	1.56	Complicated-Without	4.04

without the system (*Complicated-Without*). Subjects were provided with Microsoft Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource without the system and learned the other with the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given several problems as learning purposes for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, the effects on learning were measured by the scores on both problems. The effects on navigation in hyperspace were measured by the number of revisiting pages in hyperspace [10]. The time of learning in each condition was limited to thirty minutes.

The procedure of the experiment with each subject was as follows:

(1)The subject was given the explanation about how to use the assistant system before learning and then single and compound problems for the learning resource 1 or for learning resource 2.

(2)He/she was required to explore answers to the problems. In *Simple-With* or *Complicated-With*, he/she was next required to use the assistant system for making a navigation plan and to use the WWW browser for exploring hyperspace. In *Simple-Without* or *Complicated-Without*, he/she was next required to use only the WWW browser to explore hyperspace. In each condition, he/she was provided with a space where he/she can copy and paste the contents of the WWW page considered as the answers.

(3)When he/she finished finding out the answers or thirty minutes passed, the contents copied and pasted by him/her was checked and the scores was calculated as the percent of corrected answers. The number of revisit per explored page was also checked.

Comparing the scores and the numbers of revisit per page explored under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the effectiveness of the assistant system.

4.2 Results and Discussion

Table 3 shows the average score on each condition. The average score (75 %) on *Simple-With* was slightly higher than the average score (71 %) on *Simple-Without*. On the other hand, the average score (79%) on *Complicated-With* was considerably higher than the average score (62 %) on *Complicated-Without*. The difference between the average scores in the compound problems on *Complicated-With* and *Complicated-Without* was particularly large.

Table 4 shows the average number of revisit per page explored on each condition. Although the difference between the average numbers of revisit on *Simple-With* and *Simple-Without* was very small, there was a great difference between the average numbers of revisit on *Complicated-With* and *Complicated-Without*.

The above results indicate that the assistant system produced good effects on learning such as integrating the contents of some pages in a more complicated hyperspace. As for effects on navigation, the system facilitated navigation in a more complicated hyperspace. In a simpler hyperspace, on the other hand, the assistant system could not be so fruitful since it was able to easily see through the learning resource even without the system. Although we need a detailed experiment with more subjects, the assistant system can effectively help learners navigate and learn in a complicated hyperspace.

5 Conclusion

This paper has proposed a learner-centered navigation path planning for learning with existing web-based resources. The important point is to provide learners with a space where they can see through WWW pages to make a navigation path plan. As the advantages, learning in hyperspace can be improved since the distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of the learning resources in hyperspace. The navigation path plan can also give learners an overview of the contents to be learned before exploring hyperspace.

This paper has also demonstrated an assitant system including page previewer and path previewer. These previewers allow learners to decide which page to visit and make a navigation path plan without visiting hyperspace. In addition, this paper has described a preliminary evaluation of the learner-centered path planning with the system. The results indicate that the system produces good effects on learning and navigation in a complicated hyperspace.

In the future, we need a more detailed evaluation of the learner-centered navigation path planning. We would also like to provide more adaptive aids in the page and path previews.

References

[1] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia, Journal of User Modeling and User-Adapted Interaction, 6, (1996) 87-129.

[2] Brusilovsky, P., and Eklund, J. A Study of User Model Based Link Annotation in Educational Hypermedia, Journal for Universal Computer Science, Vol.4, No.4, pp.429-448 (1998).

[3] Conklin, J. Hypertext: An Introduction and Survey, Computer 20, 9 (1988), 17-41.

[4] Domel, P. WebMap - A Graphical Hypertext Navigation Tool, in Proc. of Second International WWW Conference (1994), http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Searching/doemel/www-fall94.html.

[5] Gaines, B.R. and Shaw M.L. G. WebMap: Concept Mapping on the Web, in Proc. of Second International WWW Conference (1995), http://www.w3.org/Conferences/ WWW4/Papers/134

[6] Kashihara, A., Uji'i, H., Toyoda, J. Visualizing Knowledge Structure for Supporting Exploratory Learning in Hyperspace , in Proc. of HCI International 99, pp.667-671 (1999).

[7] Kashihara, A., Uji'i, H., and Toyoda, J. Reflection Support for Learning in Hyperspace, Educational Technology, Vol.39, No.5, pp.19-22 (1999).

[8] Mukherjea, S., Foley, J., and Hudson, S. Visualizing Complex Hypermedia Networks through Multiple Hierarchical Views, in Proc. of ACM SIGCHI 95 (1995).

[9] Nielsen, J. The Art of Navigating Hypertext, Communication of the ACM, 33, 3 (1990), ACM Press, 297-310.

[10] Tauscher, L., and Greenberg, S. How people revist web pages: empirical findings and implications for the design of history systems. International Journal of Human-Computer Studies, 47, 1 (1997), 97-137.

[11] Thuering, M., Hannemann, J., and Haake, J.M. Hypermedia and Cognition: Designing for Comprehension. Communication of the ACM, 38, 8 (1995), ACM Press, 57-66.

[12] Zeiliger, R., Belisle, C., and Cerratto, T. Implementing a Constructivist Approach to Web Navigation Support, in Proc. of World Conference on Educational Multimedia and Hypermedia '99 (1999).

A Study on the Relation between Touch-typing Skill and Thinking-typing

Yuji YOHINAGA* and Hiroaki KAWABATA**
The Graduate School of System Engineering, Okayama Prefectural University
111 Kuboki, Soja, Okayama, 719-1197, Japan
*E-mail: *yoshinaga@mx3.tiki.ne.jp **kawabata@cse.oka-pu.ac.jp*

Word processor is more and more widely used as a tool of externalization and reflection of thinking in recent years in Japan. In that case, it will be necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). The experiments were made to study the relation between touch-typing skill and thinking-typing. The examinees were 46 non-computer majors of the university. The students were asked to type words or sentences appearing in their heads on 3 subjects. The touch-typing skill of the students was measured by touch-typing exercise software. The results suggested that a touch-typing speed of 2 strokes/second is necessary, at least, to type smoothly words or sentences appearing in the head. What's more, the results of the experiments suggested that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Key words **Thinking-typing, Touch-typing, Externalization, Self-evaluation, Analysis of variance**

1 Introduction

The methods for human beings to externalize their thinking are language expression, diagram expression, letter expression and so on [1]. Among these expressions, letters are widely expressed by word processors in recent years in Japan. The method of word processor's usage has been changed by the popularization of them. In other words, the method that uses a word processor to transcribe a manuscript written by handwriting, has been changed to the method that uses a word processor in the process of externalization and reflection of thinking. With the latter method, it is necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). Thinking-typing needs a certain level of typing skill. Although a number of studies have been made on typing [2][3], there are few studies on thinking-typing.

In the lesson of computer exercise at the university, the first author is raising the level of students' typing skill through touch-typing education and, at the same time, is raising the ability of the students' utilizing a word processor as a tool of externalization and reflection of thinking [4]. In the lesson, the experiments of thinking-typing by touch-typing were made to study the relation between touch-typing skill and thinking-typing. Touch-typing speed and self-evaluation of thinking-typing were adopted as the scale of thinking-typing level. The first experiment (Experiment 1) was made in July, 1999, and the second experiment (Experiment 2) was made in February, 2000. In this paper, results regarding Experiment 2, and comparison between Experiment 1 and Experiment 2 are reported, because results regarding Experiment 1 had been reported already [5][6].

2 Method

The experiments of thinking-typing by touch-typing were made in the lesson of the computer exercise for the first-year students at the university. In this study, the data of 46 students, whose data of Experiment 1 and Experiment 2 were complete, were analyzed. In the experiments, the students typed the following subjects by touch-typing.

【Subjects of Experiment 1】

Subject 1 Type words that you think with *shiritori* (a Japanese word chain game). Type them by *hiragana* (Japanese alphabet). The time limit is 3 minutes.

Subject 2 Type words that you image with "university". Type them by *hiragana-kanji* (Japanese alphabet – Chinese characters) translation. The time limit is 5 minutes.

Subject 3 Type sentences of your self-introduction. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

【Subjects of Experiment 2】

Subject 1 Same as Subject 1 of Experiment 1.

Subject 2 Type words that you image with "student life". Type them by *hiragana-kanji* translation. The time limit is 5 minutes.

Subject 3 Type sentences of your impression about the lesson of the computer exercise. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

After the experiment, the students evaluated themselves on the 3 subjects. In Experiment 2, the students evaluated themselves on whether they could think out words and sentences or not (thinking evaluation), whether they could type words and sentences by touch-typing or not (typing evaluation). The evaluation standard was divided into 6 levels "very good", "good", "a little good", "a little bad", "bad" and "very bad".

The touch-typing skill of the students was measured in the lessons before and after the lesson of the experiments. The measurement content is testing typing time of entering Japanese sentences of *hiragana* (about 240 strokes) that were displayed in a monitor at random, by *romaji* (Japanese Roman characters) input and touch-typing.

3 Results and Discussion

3.1 Relation between Touch-typing Skill and Thinking-typing Speed

Touch-typing skill in Experiment 2 was divided into 4 levels: under 1 minute (Level under 1 minute), between 1 minute and 2 minutes (Level of 1 minute), between 2 minutes and 3 minutes (Level of 2 minutes), between 3 minutes and 4 minutes (Level of 3 minutes). The mean and the standard deviation of thinking-typing speed in each touch-typing level are shown in **Table 1**. Thinking-typing speed in each subject was calculated by the next equation.

$$s = \frac{L}{T}$$

s Thinking-typing speed in each subject

L Typing linage in each subject*

T Time limit in each subject (minute)

*Number of letters per line, after *hiragana-kanji* translation, is 40.

Table 1. Touch-typing skill and thinking-typing speed

Touch-typing skill	Number of persons	Thinking-typing speed (linage/minute)					
		Shiritori		Imagination		Impression	
		M	*SD*	*M*	*SD*	*M*	*SD*
Level under 1 minute	6	1.13	0.25	0.65	0.16	1.07	0.14
Level of 1 minute	23	0.84	0.23	0.52	0.14	0.72	0.19
Level of 2 minutes	12	0.59	0.11	0.35	0.06	0.47	0.11
Level of 3 minutes	5	0.51	0.13	0.28	0.09	0.42	0.10
All the examinees	46	0.77	0.27	0.47	0.17	0.67	0.25

One-way analysis of variance was used to test for significant differences in thinking-typing speed among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the 3 subjects(*Shiritori* $F=12.46$, $df=3$, $p<.01$ Imagination $F=11.31$, $df=3$, $p<.01$ Impression $F=23.55$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in thinking-typing speed among the 4 touch-typing levels or not. The results are shown in **Table 2**. Homogeneity subgroup is a group of similar levels whose difference is not significant. In the 3 subjects, there were significant differences of thinking-typing speed between the level under 2 minutes and the level over 2 minutes. These results show that reaching touch-typing level under 2 minutes in Experiment 2 was one of the conditions to type smoothly words or sentences appearing in the head.

Tabel 2. Tukey's multiple comparison of thinking-typing speed

	Touch-typing skill	Number of persons	Homogeneity subgroup		
			Gr1	Gr2	Gr3
Shiritori	Level under 1 minute	6	1.13		
	Level of 1 minute	23		0.84	
	Level of 2 minutes	12		0.59	0.59
	Level of 3 minutes	5			0.51
Imagination	Level under 1 minute	6	0.65		
	Level of 1 minute	23	0.52	0.52	
	Level of 2 minutes	12		0.35	0.35
	Level of 3 minutes	5			0.28
Impression	Level under 1 minute	6	1.08		
	Level of 1 minute	23		0.72	
	Level of 2 minutes	12			0.47
	Level of 3 minutes	5			0.42

p .05 *f*

3.2 Relation between Touch-typing Skill and Self-evaluation of Thinking-typing

Self-evaluation of Experiment 2 was divided into positive self-evaluation and negative self-evaluation to study the relation between self-evaluation and touch-typing skill. Positive self-evaluation is "very good", "good" and "a little good". Negative self-evaluation is "a little bad", "bad" and "very bad". As for self-evaluation point, positive self-evaluation is 1 point, and negative self-evaluation is 0 point. The mean of self-evaluation point of each touch-typing level is shown in **Table 3**.

Table 3. Touch-typing skill and self-evaluation

Touch-typing skill	Number of persons	Self-evaluation point					
		Shiritori		Imagination		Impression	
		Thinking	Typing	Thinking	Typing	Thinking	Typing
Level under 1 minute	6	0.50	1.00	0.17	1.00	1.00	1.00
Level of 1 minute	23	0.61	0.96	0.52	0.96	0.74	0.96
Level of 2 minutes	12	0.67	0.75	0.42	0.83	0.83	0.75
Level of 3 minutes	5	0.40	0.60	0.40	0.40	0.80	0.40
All the examinees	46	0.59	0.87	0.43	0.87	0.80	0.85

One-way analysis of variance was used to test for significant differences in self-evaluation point among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the typing evaluation of imagination and in the typing evaluation of impression (typing evaluation of imagination $F=5.11$, $df=3$, $p<.01$ typing evaluation of impression $F=4.86$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences about the typing evaluation of imagination and the typing evaluation of impression among the 4 touch-typing levels or not. The results are shown in **Table 4**. Typing evaluation of Level of 3 minutes in imagination was significantly lower than other touch-typing levels, and typing evaluation of Level of 3 minutes in impression was significantly lower than Level under 1 minute and Level of 1 minute. These results show that the students of Level of 3 minutes could not type smoothly imagination or impression, comparing with the students of other touch-typing levels.

Table 4. Tukey's multiple comparison of self-evaluation

	Touch-typing skill	Number of persons	Homogeneity subgroup	
			Gr1	Gr2
Typing evaluation of imagination	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.83	
	Level of 3 minutes	5		0.40
Typing evaluation of impression	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.75	0.75
	Level of 3 minutes	5		0.40

p .05 f

3.3 Relation between Learning of Touch-typing Skill and Change of Thinking-typing Speed

The mean of learning ratio of touch-typing skill and the mean of change ratio of thinking-typing speed in each touch-typing level of Experiment 2 are shown in **Table 5**. Learning ratio and change ratio were calculated by the next equation.

$$\alpha = \frac{T1}{T2} \qquad \beta? \frac{s1}{s2}$$

α Learning ratio of touch-typing skill
$T1$ Touch-typing time of Experiment 1 (minute)
$T2$ Touch-typing time of Experiment 2 (minute)
β Change ratio of thinking-typing speed
$s1$ Thinking-typing speed of Experiment 1 (linage/minute)
$s2$ Thinking-typing speed of Experiment 2 (linage/minute)

Two-way analysis of variance was used to test for significant differences in the 4 touch-typing levels and the 3 subjects about change ratio of thinking-typing speed in Table 5. As a result, main effect of the 3 subjects was significant($F=4.14$, $df=2$, $p<.05$). Main effect of the 4 touch-typing levels and interaction were not significant. What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in change ratio of thinking-typing speed among the 3 subjects or not. As a result, there were significant differences of change ratio of thinking-typing speed between Subject 3 and other subjects. Next, correlation between learning ratio of touch-typing skill and charge ratio of thinking-typing speed is shown in Table 6. A moderate significant positive correlation was observed between learning ratio of touch-typing skill and change ratio of thinking-typ ng speed in Subject 3. So it can be said that learning of touch-typing skill is very effective on the increase of thinking-typing speed of Subject 3. What is the qualitative difference between Subject 3 and other subjects? It is the easiness of thinking. Thinking evaluation point in Table 3 expresses the easiness of thinking in each subject. Thinking evaluation point of impression (Subject 3) is higher than other subjects. So it is considered that words of impression (Subject 3) was easier to be thought out than other subjects. Therefore, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Table 5. Learning ratio of touch-typing skill and change ratio of thinking-typing speed

Touch-typing skill	Number of persons	Learning ratio of touch-typing	Change ratio of thinking-typing speed		
			Subject	Subject 2	Subject 3
Level under 1 minute	6	1.69	1.35	1.61	2.03
Level of 1 minute	23	1.58	1.24	1.47	1.93
Level of 2 minutes	12	1.57	1.18	1.57	1.61
Level of 3 minutes	5	1.50	1.89	1.47	1.80
All the examinees	46	1.58	1.31	1.51	1.84

Table 6. Correlation between learning ratio of touch-typing skill and change ratio of thinking-typing speed

	Change ratio of thinking-typing speed		
	Subject	Subject 2	Subject 3
Learning ratio of touch-typing	0.245	0.089	0.565**

**p .01 f

4 Conclusion

From what has been discussed about the relation between touch-typing skill and thinking-typing speed, and relation between touch-typing skill and self-evaluation of thinking-typing, it can be concluded that a touch-typing level under 2 minutes is necessary, at least, to type smoothly words or sentences appearing in the head. The speed of 240 strokes in 2 minutes equals 2 strokes/second. 2 strokes are needed to input a *hiragana*. So the speed of 120 *hiragana* in 2 minutes equals 1 *hiragana*/second. The aim of touch-typing education for thinking-typing should be set at 2 strokes/second (1 *hiragana*/second). What's more, from what has been discussed about the relation between learning of touch-typing skill and change of thinking-typing speed, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

References

[1] Y. Saeki, "New Computer and Education", Iwanami Sinsyo, pp.104-105 (1997).

[2] T. Ohno, "The Effect of the Typing Skill for the Typing Process", Research Report of Information Processing Society of Japan(Human Interface), 63-6, pp.31-36 (1995).

[3] C. Kogo, "Use of electronic mail in assignments, term paper and final examination in college courses, and relationships between grades of them and typing skill", Research Report of Japan Society for Educational Technology Conferences, 96-4, pp.1-4 (1996).

[4] Y. Yoshinaga and H. Kawabata, "Touch-typing education in considering of self-evaluation", Proceedings of the 2000 IEICE General Conference(Information and System 1), p219(2000).

[5]Y. Yoshinaga and H. Kawabata, "A Experiment Report about Thinking-Typing by Touch-Typing", Proceedings of the Federation of Cyugoku Branch Electronics and Information 1999, pp.366-367(1999).

[6]Y. Yoshinaga and H. Kawabata, "A Study on the Effect of Touch-Typing Skill for Thinking-Typing", Advanced Research in Computers and Communications in Education(2), pp.833-834(1999).

A Virtual Classroom for Algorithms with Algorithmic Animation Support[1]

Shyong Jian Shyu*, Yin Te Tsai and R. C. T. Lee*****

** Department of Information Management*
Ming Chuan University
Gwei Shan, Taiwan
Email: sjshyu@mcu.edu.tw

*** Department of Computer Science and Information Management*
Providence University
Shalu, Taiwan
Email: yttsai@pu.edu.tw

**** Department of Computer Science and Information Engineering*
National Chi Nan University
Puli, Taiwan
Email: rctlee@ncnu.edu.tw

A virtual classroom on algorithms with algorithmic animation and reference database supports is presented. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. The hypermedia courseware is designed to ease the navigation. A maintenance program is devised to automatically update the hyperlinks whenever the courseware is updated. Interactive algorithm animations are applied as knowledge construction assistance. It is expected that with visualization aids learners could demonstrate their comprehension of abstract algorithms. A reference database on algorithms is built up for both educational and research purposes. Studying communications such as self-testing, bulletin board, related web links, ..., etc., are also provided.

Keywords: **Multimedia and Hypermedia in Education (15), Virtual Classroom(19), Web-Based Learning(21), Algorithm Animations**

1 Introduction

The technologies of multimedia and networking on personal computers lead the research of computer-assisted learning into a new era in the last decade. Researches on the design issues of the hypermedia courseware recently please refer [17, 3, 4, 19]. Many evaluation studies also reveal positive results on learning via hypermedia courseware [7, 10, 12, 18]. With the popularity and maturity of hypermedia and web technologies, distant learning with a synchronous style via the web attracts many researchers' attention in both of the theoretical and practical points of view. The characteristics of such a web-based virtual classroom encourage the students to actively participate the construction of knowledge with their own pace and without the limitations of time and space. It is our aim in this paper to propose our design and implementation of a virtual classroom for studying algorithms with supports of interactive animations and a research paper database.

Material about algorithms is a core component for undergraduate degrees in computing. A major problem in teaching algorithms is the difficulty of capturing the dynamic movement of data and complicated data structures in static materials such as books and lecture notes [16]. Because different students learn at

[1] This work was supported in part by National Science Council of Republic of China under grant NSC 89-2511-S-126-003

different rates, whatever pace the lecturer chooses will be wrong for some students. A virtual algorithmic classroom would be very crucial to assist students constructing their understanding with their own pace. Further, since the abstraction of algorithms might be challenging to learn and understand, it is hoped with graphical depictions the students' comprehension could be more effective and concrete. Thus we develop animations interactively by Java in our virtual classroom.

An algorithm animation is a dynamic graphical depiction of the data and operations of an algorithm. The animation purpose is to illustrate how the algorithm functions to someone seeking to learn the algorithm [15]. Researches concerning with the studies of algorithm animation or software visualization can be found on [9, 5, 13, 15, 14, 11]. A number of practical algorithm animation systems have been built over the last ten years. Some well-known systems include
BALSA [1], Tango [13], Zeus [2], AACE [6], Zeus (http://www.research.digital.com/SRC/home.htm0),
PAVANE and Opsis (http://swarm.cs.wustl.edu/pavane.html),
ZADA (http://ls4-www.informatik.uni-dortmund.de/RVS/zada.html), ...etc.
These systems typically have been used to create animations to accompany a lecture in an electronic classroom, or to prepare animations for students to observe and interact with outside the classroom. The updated technologies of multimedia tools and web programming and a complete hypermedia courseware helping students' comprehension make our algorithmic animations differ from theirs.

Besides the animations, in order to ease the tracing of the newest research results or referencing the related papers on algorithms, we built up a paper reference database to store research papers of algorithms, which can be queried and appended for educational or research purposes at the remote sites. We also provide some studying communication aids in a asynchronous mode such as self-testing, bulletin board, related web links, ..., etc., to improve the social communication among students in this virtual classroom.

The rest of this paper is organized as follows. The content of our algorithmic virtual classroom and the implementation result of our hypertextbook are presented in Section 2. The implemention of algorithm animations is illustrated in Section 3. The facility of the paper reference database is discussed in Section 4. Section 5 gives concluding remarks and future studying.

2 The Content of Our Algorithmic Virtual Classroom

There are four main themes in our algorithmic virtual classroom: (1) The Fundamentals of Algorithms, (2) Algorithmic Strategies, (3) Algorithmic Reference Database and (4) Studying Communications. Our design focuses on undergraduate students in science or management departments, while the database might have benefits for various kinds of users. The material is mainly based upon [8].

We re-organized the course material on algorithms as the hypermedia courseware (or hypertextbook) which helps the learners' actively exploring the knowledge. Each keyword (term or concept) on the web-courseware is linked onto its explanation page where the meaning is explained and all the links to the other occurrences in our courseware are also listed. A query facility for these keywords also provided. Consider that the course materials might be updated and the linkage relationships among keywords and their positions of occurrences on the web pages might also be changed. We developed a courseware maintenance program in C to automatically re-construct the linkage relation of all hyperlinks into its newest version whenever the courseware is updated. Figure 1 shows our hypertextbook on web. As the left frame shown in Figure 1, a tree-view browser is applied for learners to locate where he is in the courseware space. Figure 2 is the query result page of the keyword "insertion sort" which can also be reached by clicking "insertion sort" on the web content in Figure 1.

Figure 1 The web page format of our hypertextbook

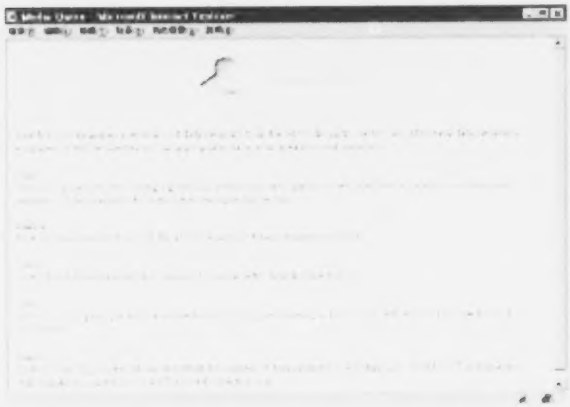


Figure 2 The query result of the keyword "insertion sort"

The content of the four main themes is described more in detail in the following sub-sections.

2.1 The Fundamentals of Algorithms

The content in this subject includes:

(a) Celebrity Hall: The contribution of some well-known computer scientists for algorithmic study such as D. E. Knuth, R. E. Tarjan, R. M. Karp, S. A. Cook, ... etc, are introduced here.

(b)The Introduction of Complexity: The concept of complexity such as order, upper bound, lower bound, ... etc, are explained.

(c)The analysis of computer algorithms: The analytic models of computer algorithms are explained. Proper examples are presented also.

All of the above materials are prepared as a web hypertextbook to ease the navigation.

2.2 Algorithmic Strategies

In current stage, three strategies are ready in our web classroom: greedy, divide-and-conquer and tree searching strategies. We not only construct the hypermedia courseware but also apply interactive animations as our learning assistants. Three interactively animated examples, i.e., solving the stamp problem, the minimum spanning tree via Kruskal's and Prim's algorithms respectively, are prepared for exploring the spirit of the Greedy method, while three, i.e., finding the maximum, quick-sort and merge-sort, interactive

BEST COPY AVAILABLE

animations are for Divide-and-Conquer and three, i.e., breadth-first-search, depth-first-search and hill-climbing, for tree searching. The implementation result is illustrated in Section 3.

2.3 Algorithmic Reference Database

It is most critical in almost every research areas, including of course the research of algorithms, to maintain a mostly updated reference database. We construct a web-based database via CGI technology to maintain those important references related to algorithms. Section 4 shows the implementation result in detail.

2.4 Study Communications

To increase the content of our courseware, we collect links of some important related web sites in our external-resource pages which enlarge the learners' view on the studying of algorithms. Meanwhile, to help students to self-evaluate the learning effect, self-tests are provided for learners to answer yes-no question sheets on the web. The system will score the result and give explanations automatically.

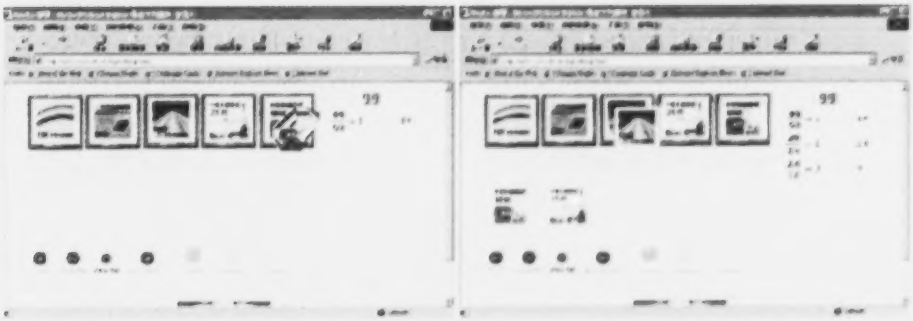
In order to improve the social communications for students in this asynchronous learning environment, we provide some interactive facilities:

(a)Bulletin board: This is an area for learners and teachers to post their idea, suggestions, questions, ...etc., on the web pages remotely. They could share the learning experience or learn from peers without the limitation of time or space.
(b)Paper up-loading: A web interface is provided for users to up-load their finding of new research papers on algorithms.

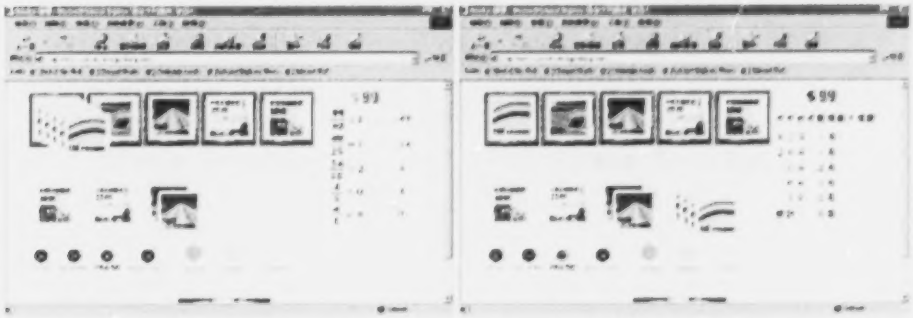
3 Interactive Algorithm Animations

Algorithm animations might be an effective tool for understanding the behavior and abstraction of algorithms. However, most approaches mentioned in Section 2 have focused on much sophisticated graphical depictions and not on the process of how learners construct their comprehensions via animations. As a way, two categories, static animation and dynamic animation, are considered in our virtual classroom. The former cannot be changed once built, while the latter might be changed according to some predefined parameters. We call the dynamic animation as interactive animation if the learners can assign values to those parameters in an on-line manner. The learners can choose either one to observe the actual data moving and to demonstrate their abstract concept. A control panel is provided for learners to control the running speed.

The static animations by Director offer multimedia presentations. Figure 3 illustrates an animated example of solving the stamp problem, which is to explain the greedy method. The interactive animations by Java allow the learners to change the animated results by assigning input variables with different values. Through observing the various running situations in terms to the given variables, learners can realize how those algorithmic steps are actually executed. It is expected that the conceptual cognition of these abstract strategies can be enhanced via the visualized running examples and the learners' comprehension could be more concrete. Figure 4 shows an example of merge-sort where the number of input instance can be assigned in an on-line manner.



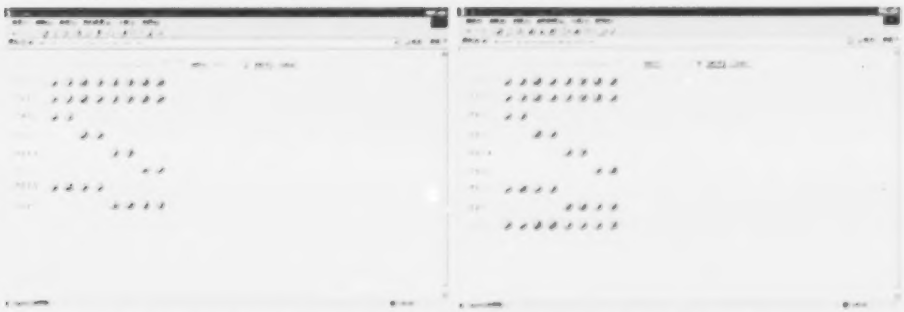
(a) the stamp with largest value is chosed (b) running with greedy



(c) running with greedy (cont.) (d) the final result

Figure 3 The static animation for the stamp problem

(a) input instance is assigned as 8 (b) the left half balls are sorted



(c) the right half balls are sorted (d) the final result

Figure 4 The interactive animation for the merge-sort problem

BEST COPY AVAILABLE

4 Reference Database Support

To meet general researchers' requirements, it is designed to supporting query by using various fields such as: problem name, data domain, computational model, complexity class, lower bound, algorithm characteristics, result, reference and comments. It also supports the up-load functionality for interested researchers to up-load their new findings all over the world. This database is valuable not only for the researchers but also for students who could access the newest or related results at their interests. Figure 5 illustrates the query form, where k-MST problem with NP-complete complexity and other constraints are given, and the queried result of our reference database. This service would like to attract interested users' participation to our virtual classroom where discussions via the bulletin board are welcomed.

(a) a query form (b) the quried result

Figure 5 The query and result reference database on algorithms

5 Concluding Remarks and Future Studies

We propose the design and implementation our virtual classroom for algorithms in this paper. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. It is expected that such a learning environment could help students to learn algorithms more effectively at their own pace. The hypermedia courseware will be increased and updated as a long-term project.

The activities in the traditional classroom are simulated to a great extent in our virtual classroom. However, we are not intending to give up the face-to-face interactions. The authors applied this hypermedia courseware on web as a learning assistant in a part of this semester. Students showed interests on constructing their knowledge via the hypermedia courseware and animations. Some students expressed that they supposed to understand the recursion in quick-sort before feeding data to the interactive animation, however they found their misleading after the visualization of data movement in the animation. This is one of the benefits what we intend to give in this virtual classroom. The construction of the knowledge tree is underway to help tracing the learning pattern of learners. Also an empirical evaluation of the learning effect will be studied in the near future.

The reference database gradually gathers interested researchers' attention. The authors would express their special thanks to those who up-loaded their findings of new papers and those who gave valuable suggestions.

References

[1] Brown, M. H., Exploring algorithms using Balsa-II, Computer, Vol.21, No.5, 1988, pp.14-36.
[2] Brown, M. H., ZEUS: A system for algorithm animation and multi-view editing, Proceedings of the 1991 IEEE Workshop on Visual Languages, Robe Japan, Oct. 1991, pp. 4-9.

BEST COPY AVAILABLE

[3] Carver, Jr., Curtis A., Howard, Richard A. and Lane, William D., Enhancing student learning through hypermedia courseware and incorporation of student learning styles, IEEE Transactions on Education, Vol. 42, No. 1, February 1999, pp.33-38.

[4] Chou, Chien, Developing hypertext-based learning courseware for computer networks: the macro and micro stages, IEEE Transactions on Education, Vol.42, No.1, February 1999, pp.39-44.

[5] Glassman, Steven, Turbo Environment for Producing Algorithm Animations, IEEE Symposium on Visual Languages, 1993, pp. 32-36.

[6] Gloor, P. A., AACE—Algorithm animation for computer science education, Proceedings of the 1992 IEEE Workshop on Visual Languages, Seattle, WA, Sept. 1992, pp. 25-31.

[7] Goodman, J. and Blake, J., Multimedia Courseware transforming the classroom, Computers in Nursing, Vol.14, No.5, 1996, pp.287-296.

[8] Lee, R. C. T., Tseng, S. S., Chang, R. C. and Tsai, Y. T., Introduction to the Design and Analysis of Algorithms, UNALIS, Taipei, 1999.

[9] Najork, M. and Brown, M. H., A Library for Visualizing Combinatorial Structures, IEEE Visualization, October, 1994.

[10] Marchionini, G. and Crane, G., (1994). Evaluating hypermedia and learning: methods and results from the Perseus project, ACM Transactions on Information Systems, Vol.12, No.1, pp.5-34.

[11] Mukherjea, Sougata and Stasko, John T., Toward Visual Debugging: Integrating Algorithm Animation Capabilities within a Source Level Debugger, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 3, 1994, pp. 215-244.

[12] Novick, D. G. and Fickas, S., Collaborative Networked hypermedia education: lessons from the Nero project, International Journal of Computers and Education, Vol.24, No.3, 1995, pp.157-162.

[13] Stasko, J. T. TANGO: A framework and system for algorithm animation. Computer , Vol.23, No.9, Sept. 1990, 27-39.

[14] Stasko, et al, Software Visualization: Programming as a Multimedia Experience, MIT Press, 1998.

[15] Stasko, J. T, Using Student-Built Algorithm Animations as Learning Aids, Proceedings of the ACM Technical Symposium on Computer Science Education (SIGCSE '97), San Jose, CA, 1997, pp.25-29.

[16] Stern, Linda, Sandergaard, Harald and Naish, Lee, A Strategy for Managing Content Complexity in Algorithm Animation, ITiCSE'99, Cracow, Poland, June 1999. pp.127-130.

[17] Sun, Chuen-Tsai Chou, Chien and Lin, Bing-Kuen, Structural and navigational analysis of hypermedia courseware, *IEEE Transactions on Education*, Vol. 41, No. 4, November 1998, pp.347-357.

[18] Thuring, M. Hannemann, J. and Haake, J. M. (1995). Hypermedia and cognition - designing for comprehension. *Communications of the ACM*, Vol.38, No.8, pp.57-66.

[19] Valdes, D., Moure, M. J. and Mandado, E., Hypermedia: A Tool for Teaching Complex Technologies, *IEEE Transactions on Education*, Vol. 42, No. 4, November 1999, pp.361-376.

An Adaptive Navigation Support with Reorganized Learning Resources for Web-based Learning

Shinobu Hasegawa, Akihiro Kashihara, and Jun' ich Toyoda
The Institute of Scientific and Industrial Research, Osaka University,
8-1, Mihogaoka Ibaraki Osaka, 567-0047 JAPAN
Tel: +81-6-6879-8426
Fax: +81-6-6879-8428
E-mail: hasegawa@ai.sanken.osaka-u.ac.jp

On the Web, there are diverse learning resources with the same learning topic, each of which is designed by different authors. Properly using these web-based resources, learners can study the topic from diverse points of view. This is one of the prominent merits of web-based learning. However, learners would have difficulty in finding a learning resource suitable to their learning contexts because there are currently an enormous number of learning resources on the Web and because most web-based learning resources do not have a clear description of their characteristics such as what kind of learners should use, what kind of learning goal can be achieved. Our approach to this issue is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to provide learners with an adaptive navigation support, which recommends them some learning resources to be learned next in accordance with their needs and knowledge states. We also report a preliminary experiment to evaluate the validity of the adaptive navigation support with a demonstration system. From the results of this experiment, we have made sure that it is valid.

Keywords: **Learning Resource, Web-based Learning, Resource Index, Resource Navigation**

1 Introduction

Over the past several years, an increasing number of hypermedia/hyperdocuments based resources on the Web have been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based resources has accordingly become more important, particularly as the realization of lifelong and distance learning [1].

On the Web, there are many learning resources with the same topic, each of which is designed by different authors. Some of them are suitable for augmenting domain concepts/knowledge in the topic. Some are also suitable for having a deeper understanding of the topic with examples/simulation/illustration, or applying knowledge with exercises. Properly using these kinds of learning resources, learners can study the topic from diverse points of view. This is a prominent merit of learning a topic on the Web.

This paper describes a web-based learning environment that makes use of diverse learning resources involving a certain topic to promote learning. The main issue addressed here is how to help learners select some instructive learning resources according to their learning contexts. There are currently an enormous number of learning resources on the Web. In addition, most web-based learning resources do not have a clear description of what kind of learners should use, what kind of learning goal can be achieved and so on [7]. Learners consequently have difficulty in finding an instructive learning resource [4].

The approach presented in this paper is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to build a learning resource database. At present, there exist a number of Web sites collecting URLs of web-based learning resources. These sites use resource indexes, which mainly represent learning topics/subjects, to classify the learning resources. The resource indexes allow learners to know what they can learn beforehand. In other words, they can select learning resources from a "what to learn" point of view. However, the indexes are not enough for them to find a learning resource suitable to their learning contexts since they would usually think of not only "what to learn" but also "how to learn". They would particularly think of in which learning phase they try to learn. There are generally several phases of learning a topic such as augmenting new knowledge/information about the topic, deepening understanding of knowledge, applying/stabilizing knowledge, etc [5]. Which learning resource to select depends on in which phase learners try to learn. Learning phases should be accordingly represented as resource indexes.

In this paper, we propose a way to reorganize web-based learning resources with "how to learn" indexes (HTL indexes for short) including learning phases in addition to conventional "what to learn" indexes (WTL indexes for short), building a learning resource database. We also demonstrate an adaptive navigation support with the database, which recommends learners some resources to be learned next in accordance with their learning contexts such as needs and knowledge states. This aims to promote their learning from knowledge accretion phase to knowledge stabilization phase.

In the following sections, we first describe the way to build a learning resource database with WTL and HTL indexes. Next, we demonstrate the adaptive navigation support with the database. Furthermore, we report a preliminary experiment to evaluate the validity of the adaptive navigation support. From the results of this experiment, we have made sure that it is useful.

2 Reorganizing Web-based Learning Resources

2.1 Learning with Existing Resources on the Web

Before discussing the way to reorganize learning resources on the Web, let us first consider learning with them. In this paper, a learning resource means a hyperdocument, which describes a learning topic within a Web site. It provides learners with a hyperspace that consists of a number of Web pages. Learners can explore the hyperspace to learn domain concepts/knowledge [2], [6]. On the Web, in addition, there are diverse learning resources with the same topic, which could facilitate diverse learning phases such as augmenting and applying domain concepts/knowledge. Properly using these learning resources, learners can study the topic from diverse points of view.

As shown in Figure 1, we view web-based learning as learning a topic in three phases and as the transition between learning phases. The learning phases are as follows: accretion, understanding, and stabilization [3]. Each phase is also explained as follows:

- Accretion phase is the one in which domain concepts/knowledge are augmented;
- Understanding phase is the one in which known concepts/knowledge are understood with examples, simulations, illustrations, etc.;
- Stabilization phase is the one in which known concepts/knowledge are stabilized by means of problem-solving with exercises.

The transition between learning phases is expected to occur according to completion or impasse of learning in a phase. It is also expected to take place from knowledge accretion phase to knowledge stabilization phase or in the opposite direction. Learners' knowledge is finally expected to stabilize. However, learners need not always start learning from the accretion phase. They can start learning from any learning phase according to their knowledge states.

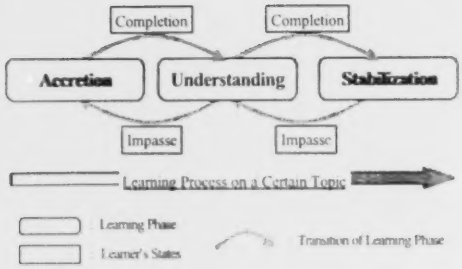


Table 1 Resource Index

WTL Index	Academic Year Subject Learning Topic	
HTL Index	Learning Phase	Accretion Understanding Stabilization
	Media	Texts only Graphics Animations Sounds Simulations E-Mail BBS, Chat Others
	Communication Channel	High Immediacy High Interactivit Questions and A

Figure 1 Web-based Learning

2.2 Resource Index

In learning a topic, learners would select a learning resource according to their knowledge states. However, most existing learning resources on the Web do not usually have a clear description about which learning phase could be facilitated. Therefore, the proper selection of learning resource is not so easy for them. One way to resolve this problem is to provide learners with a learning resource database.

There currently exist many Web sites, which collect URLs of web-based learning resources. In these sites, they are classified with resource indexes that mainly represent learning subjects/topics. These indexes allow learners to select learning resources from a "what to learn" point of view. However, such indexes are not enough for them to find a learning resource according to their learning contexts. When a learner wants to stabilize his/her knowledge of a topic, for example, he/she could select a learning resource suitable for augmenting knowledge about the topic. Learners would usually think of not only "what to learn" but also "how to learn" especially in which learning phase they should learn.

We have consequently provided resource indexes that consist of "How To Learn (HTL)" indexes in addition to conventional "What To Learn (WTL)" indexes, and have proposed a way to reorganize learning resources. In helping learners select learning resources proper for the transition between learning phases as shown in Figure 1, "learning phase" is first most important as HTL indexes. In helping learners continue learning in a phase, second, some HTL indexes are necessary for differentiating learning resources that could facilitate the phase. In fact, some learners may try to resolve an impasse, which occurs in one resource, with other resources that could facilitate the same learning phase. Considering web-based learning resources with the same topic, we can see various media for representing the contents such as text, diagram, chart, illustration, etc. We can also see various interactive/real time environments such as simulation, chat, BBS, etc. Such media and communication channels would have an influence on how to learn. In addition to learning phase, we accordingly regard them as HTL indexes as shown in Table 1.

2.3 Reorganization

Figure 2 shows how to reorganize learning resources with WTL and HTL indexes. First, the learning resources are classified with WTL indexes so that learners can see from a "what to learn" point of view. Next, the resources are classified with learning phases so that learners can select fom a number of learning resources with one topic. Some learning resources may have two or three indexes of learning phase. Finally, indexes of media and communication channels are attached to each learning resource as its attributes so that learners can select from a number of resources that could facilitate the same learning phase.

Following the above way, we have implemented a learning resource database where many existing resources have been indexed. We have also addressed the issue of how to support indexing (See [5] for more detail).

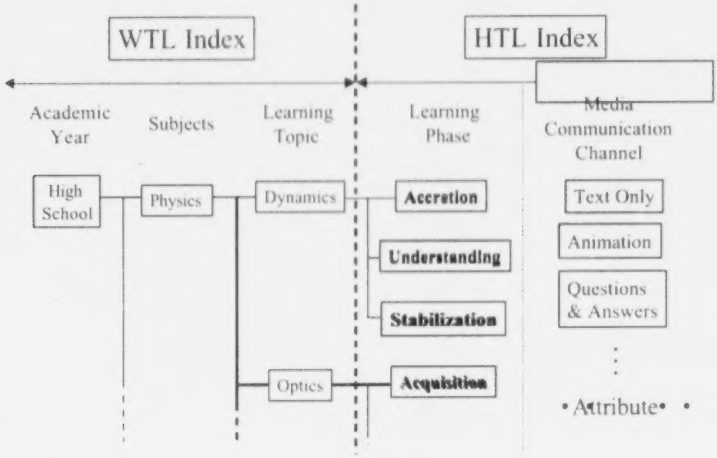


Figure 2 Hierarchy of Indexes

3 Adaptive Navigation Support

3.1 Learning Resource Navigation

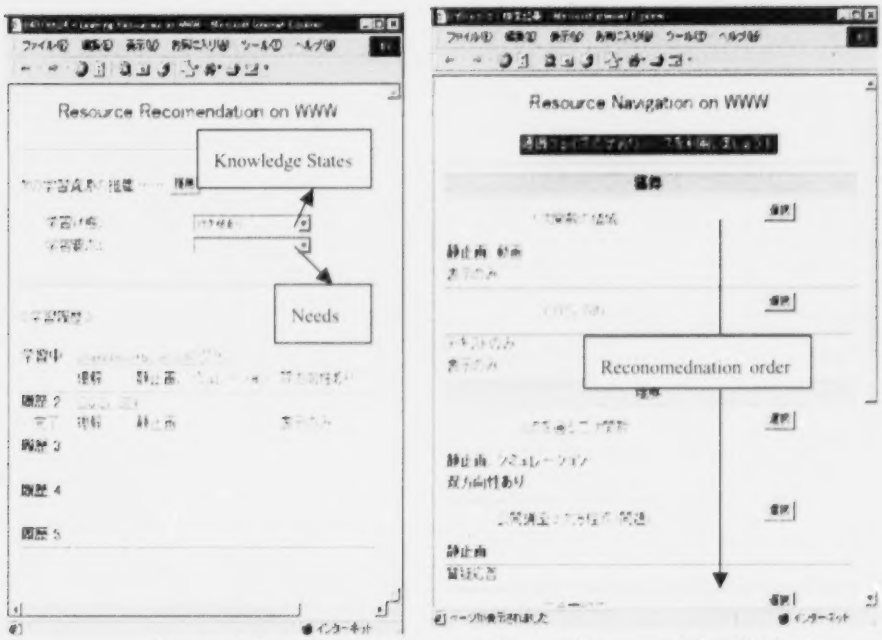
Let us now introduce an adaptive navigation support with the learning resource database. Although the resource indexes allow learners to search learning resources they want to learn, it is still difficult for them to select a learning resource in accordance with their learning contexts to promote learning from knowledge accretion to knowledge stabilization. We have accordingly proposed a navigation support, which recommends learning resources to be learned next according to learners' knowledge states and needs.

The main aim of this support is to promote learning of a specific topic with diverse learning resources so that learners' knowledge can be stabilized. For this aim, in particular, it attempts to facilitate the transition between learning phases and to change media/communication channels for promoting learning in one phase. If a learner reaches an impasse in the understanding phase, for example, he/she is encouraged to return to the accretion phase to resolve it. If he/she completes the understanding phase, on the other hand, he/she is encouraged to move to the next phase that is stabilization phase. He/she is alternatively encouraged to continue learning in the same phase with different resources that have different media/communication channels.

3.2 Recommendation

Let us next explain how to execute the learning resource recommendation in accordance with learners' knowledge states and needs. In the navigation support, we consider two knowledge states: impasses and completion of learning a resource. Learners are asked which state they reach after learning the resource. If necessary, they can also demand change of media/communication channels for a learning resource to be learned next as their needs.

The learning resource recommendation uses the information given by the learners to make a list of learning resources to be learned next. The learning resources are put in the order of priority. The aim of the recommendation is not to give the learners the most instructive resource from the database. The list provides them with a guide in selecting instructive learning resources.



< Learner' s Input Window> <Resource Recommendation Window>

Figure 3 Resource Navigation System Interface

Figure 3 shows the interface of the prototype system for adaptive navigation support. This system, implemented with Common Gateway Interface (CGI), consists of two windows. The left window enables learners to input their needs and knowledge states in learning the current resource. It also shows a history of learning resources used, and encourages the learners to reflect on their learning processes. The right window displays a list that puts learning resources in order of priority for recommendation.

3.3 Procedure

Let us next explain how to decide the order of priority for recommending learning resources to be learned next. It corresponds to deciding which resource indexes should be given priority.

3.3.1 Ordering with Knowledge States

(1) Case of Impasse

When learners reach an impasse in a learning phase, learning resources, which could facilitate the previous learning phase, are first recommended so that they can resolve the impasse. The previous phase as index is accordingly given priority. On the other hand, the next phases are not given priority. Learning resources that have the same media/communication channels are also recommended since the learners may get confused with a change of media/communication channels in addition to the change of learning phase. The same media/communication channels as indexes are accordingly given priority. In case learners' knowledge state is in an impasse, therefore, learning resources that have the previous phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

(2) Case of Completion

When learners complete learning in a learning phase, learning resources that have the next phase as index are first recommended so that they can further their knowledge. The next phase as index is accordingly given priority. The previous phases, on the other hand, are not given priority. The media/communication channels as indexes are given in the same way as the case of impasse. In case learners' knowledge state is in completion of learning, therefore, learning resources that have the next phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

BEST COPY AVAILABLE

3.3.2 Ordering with Learners' Needs

In learning a resource, some learners may demand change of media/communication channels for the learning resource to be learned next. Regardless of learners' knowledge states, in this case, the same learning phase and different media/communication channels as indexes are given priority. The same media/communication channels are not given priority. Second, the different learning phases as indexes are not given priority according to learners' knowledge states. In case of impasse, the next phases are not given priority. In case of completion, the previous phases are not given priority. Learning resources that have the same phase and different media/communication channels as resource indexes are consequently recommended as resources that are more instructive. However, the way of ordering discussed in 3.3.1 is executed if learners reiterate learning in the same phase.

3.3.3 Calculation for Recommendation

Let us explain the way of calculation for ordering learning resources with an example. Learning resources are ordered with recommendation score, which is calculated every resource. Each learning resource has a number of HTL indexes. The recommendation score is calculated as follows. It is first scored ten points per learning phase index that is given priority, and is scored minus ten points per learning phase index that is not given priority. Next, it is scored one point per media/communication channel index that is given priority, and is scored minus one point per media/communication channel index that is not given priority. The larger the recommendation score is, the higher the priority of recommendation is.

Figure 4 shows an example of ordering five learning resources. In this example, a learner inputs "impasse" as his/her knowledge states in learning a resource. The learning resource has the "understanding" phase, "text only" media as HTL indexes. In this case, the accretion phase as index is given priority. The stabilization phase is not given priority. In addition, the "text only" media as indexes is given priority, while the other media/communication channels are not given priority. Therefore, the recommendation scores for the five learning resources calculated as shown in the right side of Figure 4. The learning resource that has the accretion phase and "text only" media as HTL indexes is recommended in the highest priority.

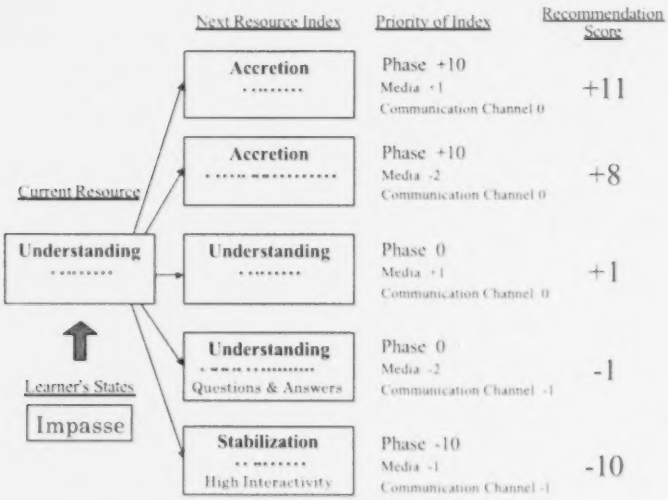


Fig. 4 Example for Recommendation

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the adaptive navigation support with the resource indexes and the learning contexts, we have had a preliminary experiment. The main purpose of this experiment was to ascertain the validity of the way of calculation for the recommendation order.

In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources by reading them carefully. Table 2 shows learning resources used in the experiment, which are described about a learning topic of "Global Warming Issue". Subjects were 12 graduate and undergraduate students in department of engineering. In spite of a well-known topic, the results of pretest indicated that they did not necessarily have sufficient domain knowledge.

The procedure of the experiment with each subject was as follows:
(1) He/she was asked to learn the resource A and then to input his/her knowledge state after learning. If he/she wanted to change media/communication channels, he/she could also input it as his/her need.
(2) He/she was asked to read the remaining resources carefully and place them in the order where he/she felt them more proper for his/her knowledge state and need.

Table 3 shows the order of priority for recommendation in each learning context considered. The order is calculated by the way discussed in section 3.3. For example, the recommendation is done in order of resource C, B, D and E, when a subject's knowledge state is in completion. Comparing the order of priority for recommendation to the order that subjects decided, we evaluated the validity of the learning resource recommendation.

4.2 Result

Table 4 shows the results of this experiment. The vertical axis is the order in which the system placed the learning resources (System-decided Order for short) and the horizontal axis is the order in which subjects placed them (Subjects-decided Order for short). The smaller the number of the order is the higher the priority for recommendation is. Each value in the table means the number of cases that fulfilled the System-decided order and the Subjects-decided order. For example, there were six cases where both System-decided and Subjects-decided orders were the first place.

In order to look into an approximate tendency in Table 4, we divided the order of priority into High and Low. As shown in Table 5, the High order including the first and second places of both System-decided and Subjects-decided orders, and the Low order also including the third and fourth places. We then performed Fisher's exact probability test in Table 5. As a result, there was a significant relevancy between System-decided order and Subjects-decided order($p=0.00867$), and these orders were positively related with a correlation ($\ddot{o}=0.42$). It indicates that System-decided order agreed with Subjects-decided order approximately.

Table 2 The Learning Resource for Experiment

	Resource	HTL Index
A	Think about global warming http://www.nature-n.com/g_wrm/index-j.htm	Phase : Accretion Media : Graphics
B	Eco-Life Guide • The Issue of Global Warming http://www.eic.or.jp/ecolife/t001.html	Phase : Understanding, Stabilization Media : Graphics, Others Communication Channel : Questions
C	Kyoto-Earth's Homepage • Environment• Global Warming http://www.pref.kyoto.jp/intro/21cent/kankyo/h3.html	Phase : Accretion, Understanding Media : Graphics, E-Mail
D	Global Warming http://www.wnn.or.jp/wnn-eco/cop3/index.html	Phase : Accretion, Understanding, S Media : Graphics, Others Communication Channel : Questions High Interactiv
E	Tackling to the global environmental problems • Global Warming http://www.epcc.pref.osaka.jp/apec/jpn/earth/index.htm	Phase : Accretion Media : Graphics

Table 3 Order of Priority that the System Ordered

Case of Completion

Resource	Priority			Or
	Phase	Media	CC	
B	+1	+1,-1	-1	
C	+1	+1,-1	0	
D	+1	+1,-1	-1,-1	
E	0	+1	0	

Case of Impasse

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	-1	
C	-1	+1,-1	0	
D	-1,-1	+1,-1	-1,-1	
E	0	+1	0	

Case of Change (State : Completion)

Resource	Priority			Or
	Phase	Media	CC	
B	0	+1,-1	+1	
C	+1	+1,-1	0	
D	+1	+1,-1	+1,+1	
E	+1	-1	0	

Case of Change (State : Impasse)

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	+1	
C	+1,-1	+1,-1	0	
D	+1,-1,-1	+1,-1	+1,+1	
E	+i	-1	0	

(CC : Communication Channel)

Table 4 Result of Experiment

System-decided Order	Subjects-decided Order			
	1	2	3	4
4	2	1	4	5
3	1	3	3	5
2	3	3	4	2
1	6	5	1	0

Table 5 Result of Experiment

	Subjects-decided HighOrder	Subjects-decided LowOrder
System-decided LowOrder	7	17
System-decided HighOrder	17	7

5 Discussion

From the results of the experiment, we have made sure that the adaptive navigation support is useful for learners to learn a certain topic with diverse learning resources. However, it does not work well for learners who cannot input their knowledge states and needs by themselves because these are important information for the adaptation. One way to resolve this is that teachers/instructors help such learners input. In addition,

some learners may input their wrong knowledge states. However, this is not a serious problem from a whole learning process point of view since inputting "completion" as knowledge state despite his/her incompleteness of learning would cause a serious impasse in the next learning phase, for example. Alternatively, inputting "impasse" despite his/her completeness of learning as knowledge state would cause a complete learning in the previous phase without difficulty.

Lets us next discuss the adaptive navigation support compared with related work on courseware generation on the Web [8]. Courseware is generally generated in order to facilitate learning of a series of topics and relationships between these topics. Each topic included in a courseware accordingly needs to be designed as learning resource from a specific point of view. In related work on courseware generation, the same designer prepares each learning resource for each topic on the Web. However, it is hard to make a courseware from existing web-base resources since they are usually designed from different points of view. On the other hand, we focus on properly using diverse resources with the same topic, not with related topics, to promote learning of it from diverse points of view.

6 Conclusions

This paper has proposed a learning resource database that reorganizes learning resources on the Web with resource indexes. This paper has also presented the adaptive navigation with the database, which recommends learners some resources to be learned next according to their needs and knowledge states. This allows learners to use existing learning resources with a certain topic to promote their learning. In addition, the paper preliminarily evaluated the adaptive navigation support. In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources. As a results, we have made sure that it is valid.

In the future, it is necessary to evaluate the adaptive navigation support in more detail. We would also like to develop a more practical system and open to the public.

Acknowledgments

This research is supported in part by International Commuication Foundation, and in part by The Telecommunications Advancement Foundation.

References

[1] Brusilovsky, P., "Methods and Techniques of Adaptive Hypermedia", Journal of User Modeling and User-Adapted Interaction, 6, 87-129, (1996).

[2] Conklin, J., "Hypertext: An Introduction and Survey", Computer 20, 9, 17-41, (1988).

[3] Eklund, J., "Cognitive models for structuring hypermedia and implications for learning from the world-wide web", Proc. of The First Australian WorldWideWeb Conference (AusWeb95), http://www.scu.edu.au/sponsored/ausweb/ausweb95/papers/hypertext/eklund/index.html, (1995).

[4] Hasegawa, S., Kashihara, A. and Toyoda, J., "A Framework for Estimating Usefulness of Educational Hypermedia", Proc. of World Conference on Artificial Intelligence in Education (AIED-99), pp.711-713, (1999).

[5] Hasegawa, S., Kashihara, A., and Toyoda, J., "Estimating Design Scenario of Educational Hypermedia on WWW", Proc. Of 7th International Conference on Computers in Education (ICCE 99), Vol. 2, 229-236, (1999).

[6] Kashihara, A., Kinshuk, Oppermann, R., Rashev, R., & Simm, H., "An Exploration Space Control as Intelligent Assistance in Enabling Systems", Proc. of International Conference on Computers in Education '97, 114-121, (1997).

[7] Kashihara, A., and Toyoda, J., "Report on Experiences of Telelearning in Japan", Informatik Forum, Wien, Vol.12, No.1, 39-44, (1998).

[8] Vassileva, J., "Dynamic Course Generation on the WWW", Artificial Intelligence in Education IOS Press, 498-505, (1997)

An Empirical Study of the Design and Use of a Multimedia Composition-Making System for Children

Kaori Iwashita*, Shinya Kawakami and Bipin Indurkhya**
Department of Computer Science, Tokyo University of Agriculture and Technology, Koganei City, Tokyo, Japan, tel: 81-42-364-3311
**e-mail: kaorii@ma.neweb.ne.jp, **e-mail: kawakami@fairy.ei.tuat.ac.jp*

In this paper, we describe our experiences in designing and using a multimedia composition-making system for children. The system allows children to make compositions using pictures, sounds and text. Moreover, it also allows pictures in the composition to be animated. We experimented with children using this system in three different settings. In the first setting, no topic was assigned to the children. In the second and third experiments, children were given a topic (different for each experiment) for composition related to their activity. We present here the results of our experiments and comment on how the constraints imposed by the topic affect children's expressive abilities.

Keywords: **animation, children's expressive abilities, constraints and creativity, multimedia composition.**

1 Introduction

In recent years, many researchers have studied multimedia techniques and have incorporated them into various educational systems. For example, Silva [5] described a multimedia soundscape system, "They Are Catching Sounds in the Park!", for environmental education. In this system, children search for sounds by clicking anywhere in the picture. When they click an appropriate object, its associated sound and information are presented to the children. Brna [1] proposed a system for composing and writing stories via cartoons. Harviainen [2] presented a co-authoring system in which many users work together to compose a story. Ishii [3] and Kawakami [4] have developed other systems for making stories with multimedia. All this research demonstrates that multimedia has much potential for stimulating the ability of children to express themselves. In particular, we find that children can express their creative and imagined ideas much better with pictures and words than with words alone. Moreover, if we add an ability to attach sounds to pictures, and allow pictures to be animated, then this expressive power increases considerably.

Motivated by these factors, we have developed a system to help children write multimedia compositions, and have tested it with children in three different settings. In this paper, we describe our system and report on our experiences with children using the system.

2 Prototype of the System

We developed a prototype of a multimedia composition-making system. Using our prototype,

- Children can express their thoughts and ideas via pictures, sounds, text, and animation sequences. In our system, children must first choose a background scene, in which they can then insert picture objects, sounds, and text.
- Except for the background, children can attach sounds and text to picture objects, and can animate them to make a multimedia composition.

This system has two modes: a 'Set up' mode for the teacher or supervisor to allow them to determine which background scenes, picture objects, sounds, etc. are made available to the children for writing a composition,

and a ' User' mode for children to write compositions.

The ' Set up' mode has the following two functions:

1) Select situation: Set the context or theme for the composition.
2) Edit situation: Set the categories of background scenes, picture objects and sounds corresponding to a theme.

The ' User' mode has the following seven functions:

1) Select background scenes.
2) Select picture objects.
3) Select sounds.
4) Write text.
5) Animate composition.
6) Save composition.
7) Load composition.

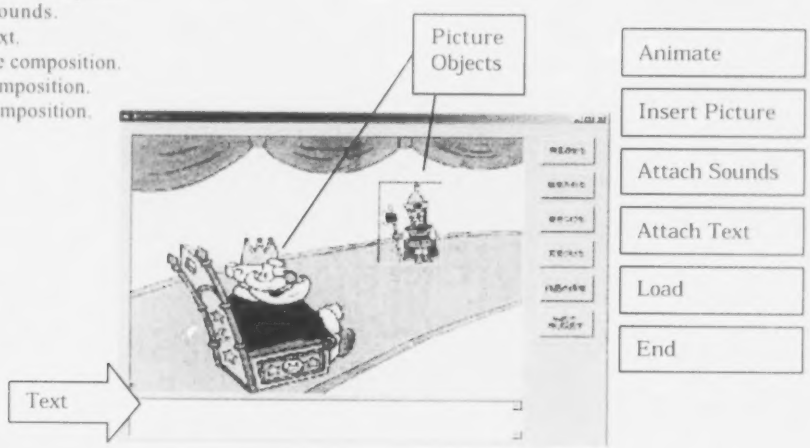


Figure 1. An example of the main window

By double clicking on a picture in the main window, the sound attached to that object (if any) can be heard. Also, when the picture of an object is selected in the main window, the text attached to it is displayed in the text box.

The animation module has five functions: show picture, hide picture, output sound, show text, and move picture.

To replay animation, children click the 'start' button in the animation window. When the button is clicked, the system starts the animation sequence as previously specified. It replays each action one by one, but it pauses when the action is ' show text ' . To continue from there, the user needs to click the ' start ' button again.

3 Experiments with the system

We did three different experiments in which children used our system. In each experiment, the setting and the tasks given to children were different, as described below.

3.1 Experiment I

In this experiment, we studied a constraint-free use of the composition system. The children were not given any specific topic of composition, and they could use the system any way they like to create any composition freely. We prepared 54 background scenes, 185 pictures and 68 sounds. Because no topic was given, children chose a variety of themes.

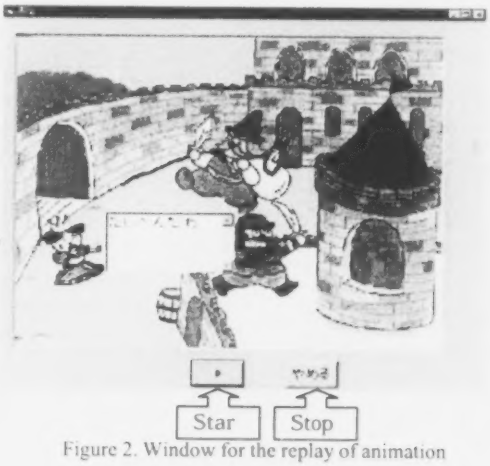


Figure 2. Window for the replay of animation

BEST COPY AVAILABLE

3.2 Experiment II

In this experiment, we introduced a constraint by giving a topic of composition to the children, and analyzed the generated compositions. The experiment was done at an activity center for children. At this center, children of each grade come periodically, and play or make some handicraft. One of the handicraft projects for third-grade children was making kites. So, the following week, we asked the children to make a composition about kite making. For the experiment, we prepared a version of the system with six backgrounds scenes of craft rooms. Three of these were scenes with kites in them, and the others were scenes with only a room and tables without kites. We also prepared 68 pictures and 35 sounds appropriate for kite-making activity.

3.3 Experiment III

In this experiment, we introduced a tighter constraint by giving a more specific topic of composition to children, and studied its effect. We asked the children to make a composition for the story "The coward king and robber" (original title in Japanese). The original story is written in Japanese. At the same activity center for children used in Experiment II, the children made an extended version of this story, made a picture book to illustrate various scenes in the story, and then told the story using these pictures at their Christmas party. The week following the party, we asked the children to make a composition for this story using our system.

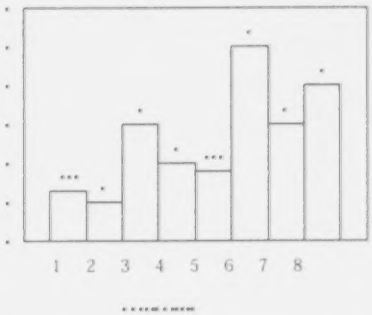


Figure 3. Differences between the composition picture and the original picture from the picture book (for each background scene)

For this experiment, we prepared a version of the system with eight background picture scenes related to the story. We also prepared 66 picture objects and 33 sounds appropriate to the story.

In this experiment, we were interested in analyzing the differences between compositions made using our system and the corresponding pictures in the picture book for this story that the children had made earlier. We used the following method for computing the difference. The picture objects were grouped into ten categories, and the difference between two pictures (with the same background scene) was calculated as follows:

> For each picture object category: if there is an object of that category in both the pictures, we say that the difference between the two pictures with respect to that category is zero. If one picture has an object from that category, and the other has none, we say that the difference with respect to that category is one. The difference between two pictures is the sum of the differences over all ten categories.

Figure 3 shows the result of applying this procedure.

We see that the differences for the climactic scenes (scenes 6• 7) are higher than the other scenes.

3.4 Discussion

An analysis of the compositions produced in the three experiments is shown in Tables 1, 2 and 3. Table 1 shows the average number of compositions produced by a participant in each experiment. We see from it that the children were most expressive when the topic was most constrained (Experiment III).

Table 1. Number of compositions per participant

	Experiment I	Experiment II	Experiment III
Number of participants	11	7	5
Number of compositions per participant	1.3	1.4	4.6

Table 2 shows a more detailed analysis of compositions with respect to how multimedia features of the system were used.

Table 2. Number of multimedia features per composition

Multimedia feature	Experiment I	Experiment II	Experiment III
Picture objects	3.6	11.2	6.9
Sound attachments	1.1	2.4	1.6
Text attachments	-	1.1	1.6
Animation	1.0	2.8	9.9

Here we see that picture and sound attachments are used most in Experiment II. This may be because in this setting children were describing a situation using generally one page (screen). For this, they used many objects and sound attachments to provide information about the depicted situation. We also see that text attachments and replay actions were used most in Experiment III. It might be because in this setting they were describing a story, for which text attachment is a useful way to express characters' utterances, and animation is useful to express characters' movement. We also would like to point out that in Experiment III there were fewer picture objects and sound attachments per composition. This is because to show the flow of events in the story, children made many compositions (Table 1).

Table 3. Analysis of animation operations per composition (in percent)

Animation operation	Experiment I	Experiment II	Experiment III
Show picture	0	0	53
Hide picture	0	0	4
Output Sound	13	0	10
Show text	-	0	15
Move picture	87	100	18

In this table we see that in Experiments I and II, mostly the 'move picture' operation was used. In composing a story, however (Experiment III), the 'show picture' was used most. We also found that the 'hide picture' operation was rarely used.

4 Conclusions

From our experiments, we see that the multimedia features of the composition-making system are most useful in illustrating a story or a narrative. Sound and text attachments and animation operations can be very helpful in expressing movement of characters and the progression of events in a narrative. We also found that many children are most expressive when they are given a focus of composition.

From these results, we propose that a system such as ours can be used in the classroom for children to make compositions about field trips and class excursions. For each trip or excursion, the teacher can set up the system appropriately by choosing relevant picture and sound libraries before children use the system. In this way, we feel that our system can provide a step forward from Silva [5]. Children are more actively involved in making compositions with our system than in exploring with 'They are catching sounds in the park!"

Acknowledgements

We would like to thank all the children who participated in the experiments, and the staff at the children's center for their cooperation. We thank Professor Yoshiyuki Kotani, and members of the Kotani-lab for their help and cooperation during this research. Some pictures used in the background of Experiment III were taken from [6].

References

[1] Brna, P., Martins A., & Cooper B., "My First Story: Support for Learning to Write Stories", Advanced Research in Computers and Communications in Education, pp. 335-341, 1999.

[2] Harviainen, T., Hassinen, M., Kommers P., & Sutinen, E., "Woven Stories: Co-authoring over the Internet", Advanced Research in Computers and Communications in Education, pp. 285-292, 1999.

[3] Ishii, Y., Indurkhya, B., Inui, N., Nose, T., Kotani, Y., & Nishimura., H., "A System Based on Rodari's 'Estrangement' Principle to Promote Creative Writing in Children", ED-MEDIA & ED-TELECOM 98,

Vol. 2, 1685-1686, 1998.
[4] Kawakami, S., Indurkhya B., Inui, N., & Kotani, Y., "A Story Making System for children", Advanced Research in Computers and Communications in Education, 359-360 1999.
[5] Silva, M.J., Silva, J.P., & Hipolito, J., ""They Are Catching Sounds in the Park!" Exploring Multimedia Soundscapes in Environmental Education", ED-MEDIA & ED-TELECOM 98, Vol. 2, 1274-1279, 1998.
[6] Yamawaki, K., & Miyamoto, E., "Yowamushi o-sama to to-zoku", Kyoiku Gageki, 1989.

Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space

Toshinori Yamasaki, Tetsuo Hattori and Yukihiro Matsubara
Faculty of Engineering, Kagawa University
Hayashi-cho, Takamatsu, Kagawa 761-0396 Japan
Yamasaki (hattori, matsubar)@eng.kagawa-u.ac.jp

The students acquire a visual literacy through learning the coloring systematically in the fine arts subject. This paper describes an extraction method for the aesthetic impression of the paintings based on the tone in the Muncell color space for fine arts subject. The impression, which the human being gets from the paintings, depends on the motif, the composition and the coloring. Here, we discuss the evaluation method of the paintings by the computer based on the tone that includes the lightness (intensity) and the saturation (vividness). We perform the evaluation experiment of the paintings that have a unique coloring. The evaluation result approximately resembles the impression of which human being is moved. This method is also useful for retrieving the image database using the ambiguous key words like the impression words.

Keywords: **aesthetic impression of paintings, color tone, color harmony, visual literacy, fine arts subject, image retrieval system**

1 Introduction

Fine arts subject educates the ability of the sense beauty, that is, a visual literacy through recognizing a form and a color. For training such a visual literacy, it is important for the students to understand the nature of color systematically. Visual literacy that is the aesthetic judgment ability becomes the basis of the expression and the appreciation activity in the fine arts learning. The students acquire the visual literacy by experience through repeated practice of painting the picture. On the other hand, there are the empirical rules about the composition and the coloring in the art. As for the color harmony, Ostwald, Muncell and Moon Spencer are well known.

Recently, the multimedia database spreads widely with the development of the network technology. In the multimedia database retrieval, it is useful that we can refer database using the impression words and the ambiguous feeling words in addition to the key words. Recently, an image database retrieving by impression words as beautiful, balmy is reported [1-5].

We report the extraction way of the aesthetic impression degree of the paintings based on the Moon Spencer's color harmony theory [6]. However, in the Moon Spencer's way, we can estimate the degree of the beauty as the numerical value but we cam not know the detail impression like the dark, light, bracing impression which each painting gives. In this study, we describe more concretely the way of extraction the aesthetic impression of the paintings based on the tone in the HLS Muncell color space.

2 The tone and the systematic color names

We call a suitable coloring the color harmony. In the color harmony theory, Ostwald, Muncell and Moon Spencer are well known. Also, a color system is established by JIS (Japanese Industrial Standards) and

PCCS (the Japanese Color & Coloring System).

Here, we use the tone in the Muncell HLS space for estimating the impression of the paintings more precisely. We express a color by the word, which shows the impression of the color like the light green, the dark green. There is a difference between bright and dark, strong and gentle, vivid and muddy in the same color, same hue. We call this difference the tone (Lightness and Saturation). The tone is a concept of the lightness L and the saturation S being compounds and shows an impression of the color, which doesn't depend on the hue well. As the tone has an each image, it is easy to connect the tone the psychological effect of the color. We can evaluate the feeling impression of the paintings by extraction the tone from the image data. In this paper, we adopt the PCCS tone for evaluating the impression of the paintings [7]. The PCCS defines the tone in the lightness L and the saturation S in the Muncell color space and gives color system as the tone and the hue. The PCCS classifies into 12 kinds of tones in each hue and packs the same tone of the every hue. Figure 1 shows the classification of the tone.

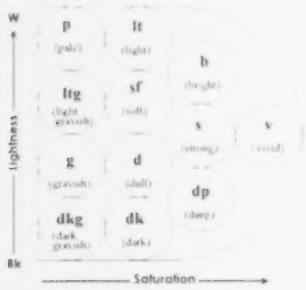


Figure 1 Tone (Lightness – Saturation)

Figure 2 Systematic Color Names

The tone image is defined by the systematic color names in the PCCS color system. The systematic color names is the color expression way that gives a modifier according to each fundamental color like white, red and blue. It sets a way of combining a fundamental color name and modifier. The modifier in PCCS includes an adjective, which shows the hue difference like the tinge of red, green. On the contrary, it has no word, which shows only lightness or a saturation. The bright impression includes not only the high intensity but also the vivid saturation. The mild impression means the high lightness and low saturation. Figure 2 shows the systematic color names of the tone space.

3 Evaluation of the aesthetic impression

After getting the image data through the scanner, we extract the impression feature of the paintings. Figure 3 shows the outline of our method. The resolution and the size of the image data is 120 [pixels/inch] and 640*512 [pixels] respectively. The image data is a full color, bit map.

The image data has RGB color component and doesn't connect with the color sense of the human being straight. Also, it is difficult to adjust the color tone in the color synthesis. Here, we convert the RGB to the HLS value in the Muncell color space, which fits for the color sense of the human being. Mucell color system shows the color as the three components, H (Hue), L (Lightness) and S (Saturation) and is used widely in the coloring. Figure 4 shows the Muncell HLS color space. We get the H[0,360], L[0,1], S[0,1] values through the conversion of the RGB[0-255] value.

BEST COPY AVAILABLE

The number of the colors in the image data is enormous for processing data by a computer. Here, we reduce the number of colors to the degree, which doesn't loose the color tone of the paintings. We divide the H, L and S to 10 and 14 respectively.

Hue (H)	Lightness (L)	Saturation (S)
R	8.5	14
YR	9	13.5
Y	9	13
GY	9	12
G	8.5	11
BG	8.5	10
B	8.5	10
PB	8	11.5
P	8	11.5
RP	8.5	12.5

Table 1 Maximum Values of L, S

Figure 4 HLS Muncell Color Space

Figure 3.Outline of the Extraction Process

The maximum value of the L and the S depends on the coloring material and each hue shown in table 1. Therefore, the value range of the L and S is different according to each hue. For example, the maximum L, S value of the Red and Purple hue is 8.5, 14.0 and 8.0, 11.5 respectively. Here, we normalize the L, S value 0-10 ranges.

From the above way, we estimate the number of the pixel in the S-L tone space through mapping the image data to the tone space. We can find the aesthetic impression of the paintings by estimating the position of the mapped pixel in the tone space because of the correspondence between the tone space and the impression modifier shown in figure 2. In this experiment, we evaluate the number of the colors, which accounts for 70 % of the color area. However, we cannot estimate the impression because the distribution in the tone space becomes apart. Here, we calculate one position of the tone space from several distributed positions using the weight coefficient of each tone position.

$S = W_i S_i, \quad L = W_i L_i \quad (1)$

Where $Wi = \sum(a_i / \sum a_i)$ a_i is the number of the occupied pixel in each color.

We estimate the impression of the paintings according to the tone index (S, L) defined in equation (1).

4 The evaluation experiment

The simple coloring picture is tested beforehand. As a result, the showy picture of the pure color and the gloomy picture are mapped over the v (vivid) and dkg (dark grayish) tone respectively. Typical paintings and poster works from renaissance to modern are tested in this experiment shown in table 2. Figure 5 and figure 6 shows examples of the paintings and the typical mapping result in the tone space respectively. We can evaluate the aesthetic impression of the paintings using figure 6 and figure 2. The extraction impression is listed as follows.

"Mona Lisa" (2) of Leonardo da Vinci is famous for gently smiling lady. This painting locates near dk (dark) in the tone and gives dark, mellow impression.

Monet's "Water Lily" (5) is said the mystic beauty of the surface of the water and is situated on the tone space near ltg (light grayish). We can say that the water lily has a cooled silent image.

Gogh's "Sun Flower" (8) is painted yellow strongly which he liked most. It is situated on the tone space near s (strong). From this result, we can evaluate that the impression of sunflower is strong, passionate painting.

Figure 7 shows the mapping result of the works in table 2. The above-mentioned results agree with the established reputation and the eye inspection of human being.

BEST COPY AVAILABLE

Table 2 Lists of Paintings and Design Pictures

	Painter	Style	Work	epoch
1	Leonardo da Vinci	Renaissance	Virgin of the Rock	1503
2	Leonardo da Vinci	Renaissance	Mona Lisa	1503
3	Rembrandt	Baroque	Night Watch	1642
4	Rembrandt	Baroque	Raising of the Cross	1633
5	Monet	Impressionist	Water Lilies	1903
6	Monet	Impressionist	Flower Pot	1903
7	Monet	Impressionist	Poppies	1873
8	Gogh	Modern	Sun Flowers	1888
9	Gogh	Modern	Self Portrait	1889
10	Signac	Impressionist	Saint-Tropez	1900
11	Renoir	Impressionist	Theater Box	1874
12	Renoir	Impressionist	Les Grands Boulevard	1880
13	Renoir	Impressionist	La Liseuse	1876
14	Klee	Modern	Baldgreis(Senecio)	1922
15	Matisse	Modern	Green Stripe	1905
16	Matisse	Modern	Red Room	1947
17	Munch	Modern	Screem	1893
18	Munch	Modern	Sick Chiled	1895
19	Poster	Design	Star Wars	
20	Poster	Design	Bug's Life	

Figure 5 Examples of the paintings

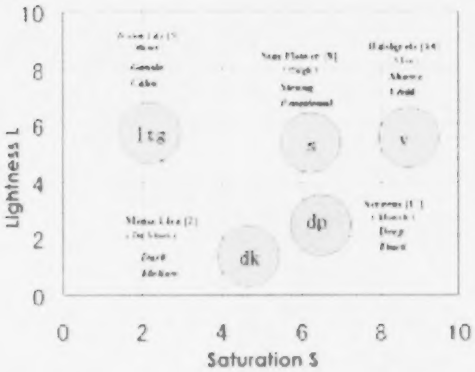


Figure 6 Mapping Result in the Tone (1)

Figure 7 Mapping Result in the Tone (2)

5 Conclusions

We proposed the way of evaluating the beauty and impressive sense of the paintings and design pictures based on the tone in the Muncell color space. We use the tone space, which can concretely express the color impression and a corresponding systematic color names. This method suits the aesthetic impression degree evaluation by the computer because the evaluation processing doesn't depend on the hue.

After getting the image data through the scanner, we convert each RGB pixel the tone space in HLS Muncell color space. We extract the location of the paintings in the tone space by calculating the coefficient of the occupied area. The aesthetic impression is estimated by the location of the used color in the tone space.

The famous paintings from renaissance to modern are tested for extracting the impression feeling. "Mona Lisa" of Leonardo da Vinci and Gogh's "Sun Flower" is estimated as matured darkly and strongly passionate impression respectively. These results tell us that the distinction by the computer coincide with an established reputation of the paintings.

The impression extraction by this way is useful for the students learning how to use color arrangement in their fine arts subject.

Acknowledgments

This research was supported by Grant-in Aid for Scientific Research on priority areas (12040229) from the Japanese Ministry of Education and Culture.

References

[1] K., Hachimura, " Retrieval of Paintings Using Principal Color Information," Proc. 13th ICPR, pp.130-134, 1996.
[2] A., Tojima and K, Hachimura, "Extraction of compositional feature from paintings and application for retrieval," Trans. IPS Japan, vol.40, no.3, pp.912-920, Mar. 1999.
[3] H., Kimoto, "An image retrieval system using impressional words and the evaluation of the system," Trans. IPS Japan, vol.40, no.3, pp.886-898, Mar. 1999.
[4] H. Nozaki and Y. Isomoto, "Information retrieval for fine arts database system," Trans. IEICE Japan, vol.E80-D, no.2, pp.206-211, Feb. 1997.
[5] E., Masuyama, "How to analyze the impression of paintings from the point of KANSEI engineering," Proc. JSISE Conf. '97, K3A32a4, pp355-358, Sep. 1997.
[6] T. Yamasaki, T. Hattori, " An Aesthetic Impression Extraction of Paintings for the Fine Arts Subject," Int. Con. Computers in Education (ICCE99), pp.329-332, 1999.
[7] Nihon Color Research Institute, "PCCS Harmonic Color Charts," 1999.

Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet

Min-Huei Lin , Ching-Fan Chen, Chen-Nan Chiang
Department of Information Management
Aletheia University
Tamsui, Taiwan, R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

The popularity of WWW (World Wide Web) produces lots of new instructions or substitutive cases to build a new future, therefore educational units need to develop various computer-assisted instructions. To ensure good learning effect, the instructive strategy adopted by most CAI systems is to provide tremendous amount of multimedia data in order to attract the learner and a complete process of instruction is like the scenario of a presentation. The purpose of this thesis is to discuss how the multi-tier developing architecture can let the multimedia learning resources be used and shared in WWW from a view of organization's requirements, such that teachers, measuring researchers, and learning researchers can perform different tasks according to their own specialties independently. We also propose and implement a multimedia presentation system to let various authors with various identities author and present their presentation, i.e. CAI systems, conveniently and correctly. We compare the general hierarchy of a multimedia presentation system with the multi-tier architecture proposed by us, and we can know how the tasks are divided and assigned to corresponding professionals to accomplish the whole teaching materials through working cooperatively. It is possible to have a suggestion to develop CAI software for educational department.

Keywords: **Multimedia Presentation System, CAI System, Multi-tier**

1 Introduction

Although there exists many arguments, object-oriented is still spread out in 1990's and it seems to be a possible survival direction in software crisis. Besides this, we can use component oriented to build a set of CAI systems via existing papers that can be divided into several areas, e.g. research of interface, learning methods of computer assisted instructions, application of virtual reality, networking exam, virtual classrooms (including distance instruction), individual researcher objects, and etc. For example, the processes of mental model research emphasize the use of information of objects, so researchers just make the analysis components of mental model, the key point of this study is the component of mental model, not the scenario of teaching and the interface of designation. Another example, fuzzy theory should be used in the research of learning analysis, the key point is to provide learning analysis for content of exam, and it can make the analysis component purely. From the two examples, we can find the generation in proper components analysis, so all we have to do is making the component of its own domain. Each researcher only concerns its own theme without being concerned with the entire system, then can reuse the resources and get the complete experimental environment. This thesis constructs the developing architecture of CAI through component oriented and logical dividing of multi-tier structure, and emphasizes that the discussion of developing architecture is the beginning of the series of research.

2 Multimedia presentation system

2.1 General Hierarchy of Multimedia Presentation System

On Internet, the way to play multimedia objects is hypermedia shown in the Fig.1. To display such a scene on homepages, we can divide the designation into two layers, frame layer and resource object layer. The resource object layer stores all the multimedia objects participated in playing, the frame layer records the objects that compose each frame, the schedule of playback, the arrangement of objects on screen, and the events that may change the playing flow of inter-frames.

A multimedia resource may be a picture, a text description, a video, or other materials that can be used in a multimedia computer. A topic is a resource carrier that presents the resource to the addressee. A frame is a composite object that represents related issues that a presenter wants to illustrate. A frame may contain push buttons, one or more topics to be presented, and a number of knowledge. A message with optional parameters can be passed between two frames (or back to the same frame) to trigger a multimedia presentation action.

In the two layers, we make some definitions by referring the various links defined in [7].
An inheritance* (successor or precedence) *link: is a property inheritance between two frames and is used in the process of knowledge collection of an activated frame before the logical inference of the frame proceeds.
A usage link: is a link that represents a message passed between two frames.
An aggregation link: indicates that a frame is using a resource.
A resource association link between two resources: indicates that the two resources are correlated.
A frame association link between two frames: indicates that the two frames are correlated.

2.2 Models of Presentation systems

In 1983, James F. Allen advocated in ACM• There exist thirteen temporal relationships between two intervals, namely, before, meets, overlaps, during, starts, finishes and the other six inverse relations as well as equal. The thirteen corresponding temporal operators constructed from the Allen's interval-based temporal logic are depicted in Fig. 2.

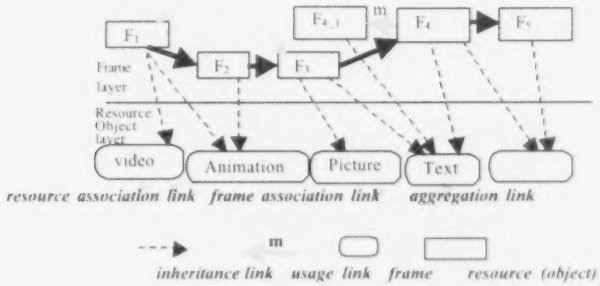


Fig.1 the way to play multimedia objects on Internet is hypermedia

Relation	Diagram	expressions	relation	Diagram	expressions
P before Q	P Q	P; ε(n);Q	P before Q	Q P	P‖ Q
P meets Q	P Q	P;Q	P meets Q	P Q	P‖ Q
P during Q	P Q	P‖ Q	P during Q	P Q	P‖ Q

Relation	Diagram	expressions	relation	Diagram	expressions
P finishes Q		P Q Q		Start-time	Q End-time

Fig. 2 Temporal Relationships (Allen 1983) and their corresponding temporal operators

2.3 Define the Playback of Multimedia Presentation

We define some notations used in our presentation system. The F_i denotes the frame in the frame layer. The O_i denotes the resource in resource layer. The $F_i.O_i$ denotes that the resource O_i is one component of the frame Fi. The m_i denotes a triggered message when users push a button, a hypertext or a hypermedia. The m_iF denotes that the frame F will be displayed after the message mi is triggered, and the m_kF denotes that the frame can be directly displayed not depend whether the message is triggered or not.

For example, a presentation displayed one frame by one frame can be described by the following expression $S = m_kF_1\ (m_lF_{21}+m_kF_{22})\ m_kF_3\ m_kF_4\ (m_lF_{51}+m_kF_{52})$. According to Fig.1, we know that the $F_1.O_i$ is an aggregation link, m_kF_1 is an inheritance link, and m_lF_1 is a usage link.

2.3.1 Define the Properties of scenario

A complete process of instruction is just like the scenario of a presentation, and can also be described by the expression $S = m_kF_1\ (m_lF_{21}+m_kF_{22})\ m_kF_3\ m_kF_4\ (m_lF_{51}+m_kF_{52})$.

2.3.2 Define the Properties of Objects

We denote a media object as O = (N, T, D, UM, OAL, PT), and describe the attributes of an object below:
O_i.N *(Name)*: is the identifier of the object.
O_i.T *(type)*: What multimedia device is used to carry out this resource (e.g. sound, video, text or picture).
O_i.D *(Duration)*: records the display time of the object.
O_i.UM *(Usage model)*: the situation about the usage of objects, such as the object is a background or a referent.
O_i.OAL *(object association link)*: describes the relationships between objects, and is specified like **O_i.FAL**={O_1(*association Keyword description*), O_2 (*association Keyword description*) ,..}, we use association keywords to describe the related relationships between O_i and O_1, the same as O_i and O_2.
O_i.PT *(Player Type)*: describes the way to play the object.

2.3.3 Define the Properties of Frames

A frame F_i is denoted as F_i =(N, O, FAL, L, P, UM), and the meanings of its attributes are listed below:
F_i.N*(Name)*: assign a unique name to a frame F_i.
F_i.O*(resource objects)*: the set of all the resource objects participated in the frame F_i, O = {O_i | $O_i \in$ O } .O is the set of all objects stored in database.
F_i.FAL*(frame association link)*: F_i.FAL ={(C_i, F_k) | $C_i \in$ {◈, ⊙ }, $F_k \in$ F }.The relationships between F_i and F_j are divided into inclusive and exclusive relationships; we denote them by ⊙ and ◈ respectively. The F_i⊙F_j represents the two frames are inclusive, that is, whenever the F_i is displayed, the F_j must be displayed also. The F_i◈F_j represents the two frames are exclusive, that is, whenever the F_i has been displayed, the F_j can't be displayed. F is the set of all frames.
F_i.L *(Layout)*: the spatial arrangement of the objects of F_i for the presentation. For example, the (X_{j1}, Y_{j1}) and (X_{j2}, Y_{j2}) are the position on the screen arranged for O_j, F_i.L = {O_1 (X_{11},Y_{11})(X_{12},Y_{12}), O_2 (X_{21},Y_{21})(X_{22},Y_{22}), ...}.
F_i.P *(Presentation)*: the duration of playback of all objects in the F_i. We use the 13 temporal relations proposed by Allen and use ε(n) to represent units of time. OP is the set of all operators used to describe the temporal relations between objects. P is a set composed of O_i OP O_j, P={(O_i, op, O_j) | O_i, O_j∈O,op∈OP}, OP = { ;,‖ ,‖ ,‖ ,‖ ,‖ , ε(n)}.F_i.P={∪P_i | P_i∈P}. For example, F_i.P={(O_1‖ O_2),($_1$‖ O_3),(O_3 ; O_4),..}.
F_i.UM*(Usage model)*: describes usage of frames, e.g. the frame is designed for teaching or for taking exams. For example, expression F_i.UM = exam means that the frame is an exam frame.

3Three-layer CAI architecture

3.1 Partition the CAI system into Components

The flow of instruction is from teaching course, taking examinations, speculating the advanced contents of instruction according to the result of examination, to achieve the goal of instruction. Generally, the teachers, educators or scholars take part in editing the CAI systems and the computer engineers are responsive for implementing the CAI systems, so they often spent lots of time on mutual communication. We analyze the CAI systems and partition the CAI systems into various components that are designed by various persons respectively, and these persons work together to achieve the whole function of the CAI systems. To partition the components clearly, we use the UML to describe the flow of CAI systems shown in the Fig.3, and we can know the following things:

- Step1 to step4 is for identifying the users.
- Step5 to step8 is for displaying the teaching of courses or questions of exams.
- Step9 to step11 is for analyzing after the exams are finished.
- Step12 to step14 is for designing the advanced courses after the fitting analysis is finished.
- Step15 is for exiting the CAI system.

In Fig.3, we can classify the partitioned components of CAI systems into four kinds listed below.

- The verification component for logging the usage of systems and maintaining the security of system. —is managed by system administrators or computer engineers.
- The course and exam component for instructing students in learning and taking exams. —is managed by teachers, educators or scholars.
- The fitting analysis component for the learning process of students. —is made by educators and scholars.
- The database component for storing the media objects and instruction materials. —is implemented by art designers or computer workers, and is managed by computer engineers.

3.2 Three-layer CAI architecture

From the CAI system described with UML shown in Fig.3, we can know that the course and exam component is the most important one and the other components are discussed in other area. In our system, we propose the Multi-layer CAI architecture to construct the CAI systems, and use the management of components to distribute the resources over the servers on Internet to achieve the goal of resource sharing.

We present a 3-layer CAI architecture model that expresses different points of view and is fully flexible and component oriented [2,3]. Based on the efficiency of systems, the model is partitioned into 3 layers--resource layer, presentation layer and evaluation layer. It raises the productivity of system development and improvement process, also promotes the individual skills and development of distributed computing environment.

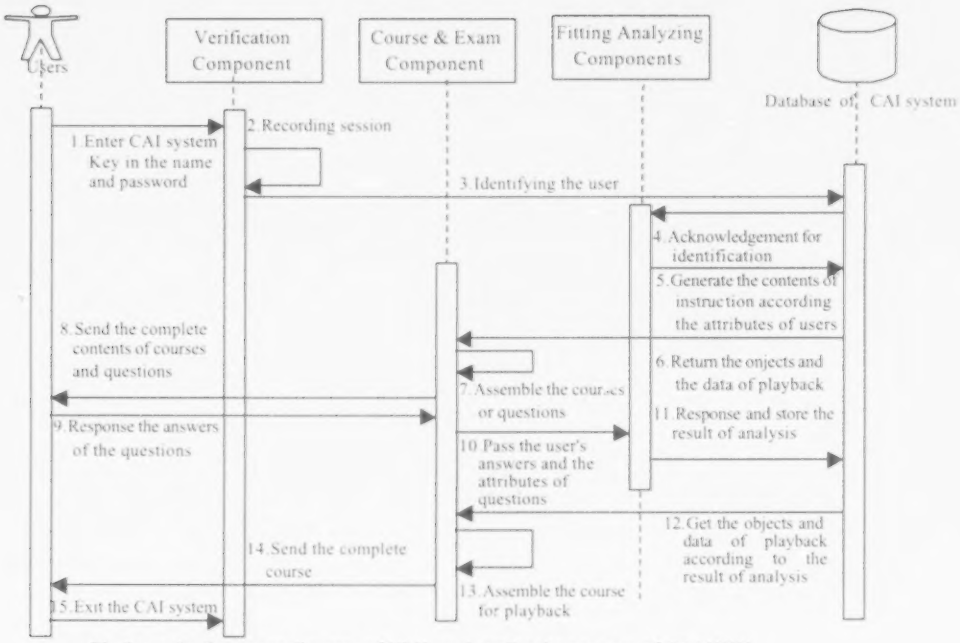


Fig.3 use the Sequence diagram of UML to describe the process of CAI [8][9]

3.3 Relationship between Three-layer CAI architecture and hypermedia

From the Table 1 and the frame and resource objects defined in our multimedia presentation system, we can analyze that to what layer the settings of various objects belong listed in Table 2[2][4]. In the components of scenario, we define the miFi that describes which frame should be displayed after the message is triggered, i.e. we can use the expressions to define the schedule of playback of the frames about designing exams and teaching. The components of plot or story just describe the flow of teaching courses defined by users.

From Table 3, we can design and implement the system on Internet more easily to let teachers or other education experts design their teaching materials or questions of exams conveniently and systematically.

4 Conclusion

Different researchers can benefit from this architecture by studying their own knowledge domain independently. Shortening the time spent on completely developing the whole system is to promote the successful rate of resolving the kernel problems. Researchers can't benefit from studying their own domain only; it's necessary for them to know our open architecture that can easily expand one system into various domains.

Users can acquire an easy-used and reusable system from defining components of multimedia and instructive units of CAI. Our architecture lets teachers have the suitable flexibility and lets various experts and scholars participate in the installation of CAI system. The educational authorities can take our architecture as a referenced architecture for developing the multimedia education. Our system is shown in Fig. 4. The prototype of our system has been completely implemented and published in some various conferences or journals. [1] [5] [9] [10]

Table 1. Three-layer CAI architecture [2][4]

Layer	Researcher	Participants
Resource	Researcher of Interface	Designer of animation , graphic, sound
Presentation	Researcher of learning theory	Teacher, Instructor
Evaluation	Researcher of evaluation	Manager, researcher of educational policy

Table 2. Explanation of part of components [2][4]

First layer (Evaluation layer)	
Components of fitting analysis	This component is made according to some theorem. After analyzing the data acquired from the process that the students take exams and learn, there are some various frames generated.
Components of evaluation and analysis	This component is made according to learning evaluation and learning retrieval of theorist or researchers.
Second layer (Presentation layer)	
Components of scenario	This component is made according to the researchers of learning theory or teaching materials.
Components of structure	This component is made according to learning environment.
Third layer (Resource layer)	
Components of exam	This part must include the parameter or properties which is used broadly
Components of background	Background is concerned to the interest and attention of learner.
Components of referents	To help users of different levels from different method a id presentation
Components of multimedia	The components make the CAI lively which may be somebody of cartoon

Table 3. Explanations of part of components

Explanation of part of components		Set the values of necessary item needed
First layer (Evaluation layer)	Components of fitting analysis	
	Components of evaluation and analysis	• F_i.O • F_i.Layout and F_i.UM= exam • F.Presentation and F_i.UM= exam
Second layer (Presentation layer)	Components of scenario	• S
	Components of structure	• F_i.Layout and F_i.UM=learn • F.Presentation and F_i.UM=learn
Third layer (Resource layer)	Components of exam	• O_i.UM = exam
	Components of background	• O_i.UM =Background.
	Components of referents	• O_i.UM = Referents

References

[1] Bal Wang , Ching-Fan Chen, Min-Huei Lin. " A Multimedia Presentation System on Web -- Dynamic Homepage Approach"., The Institute of Electronics, Information and Communication Engineers(IEICE) Transactions on Information and System, Vol.E82-D,NO.4,April 1999, pp. 729-736

[2] Min-Huei Lin, Ching-Fan Chen, Ian-Ru Li, " Building Component Oriented Multi-tier CAI Architecture in the Internet ", ICCE' 98 (The Sixth International Conference on Computers in Education) , Beijing,china,1998,pp.180~pp.186.

[3] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Wei-Yu Li , Ya-Ting Chuang. "A Three-Tier Multimedia Presentation System in Internet", ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 162-166.

[4] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Ian-Ru Li. "Building multimedia component oriented Multi-tier CAI architecture in the Internet".ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 158-161.

[5] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE' 99(International Conference on Computers in Education).

[6] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bal Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design –A Scheme to Promote the Effect of Web CAI" . ICCE' 99(International Conference on Computers in Education).

[7] Chung, C.-M.; Shih, T.K.; Kuo, C.-H.; Lin, W.-C. . "Supporting the reuse of multimedia presentations" , Information Sciences, Vol: 101, pp. 131-151.

[8] Min-Huei Lin, Zheng-Kui Huang, Bal Wang, , Ching-Fan Chen• "Using Object Oriented Method in Network CAI Model" • The 8th International Conference on Computer-Assisted Instruction.

[9] Min-Huei Lin, Zheng-Kui Huang, Bal Wang , Ching-Fan Chen.• "Management of the Object–Oriented Resources Application System – an Instance of Distance Education" • Distance Education. Vol. 12 , June 1999. pp.53-61.

[10] Bal Wang, , Ching-Fan Chen , Min-Huei Lin , Chien-Ming Pan , Jen-Shan Huang , Hsing-Ten Chein• "An Authoring Tool on Web" • •The 8th International Conference on Computer-Assisted Instruction.

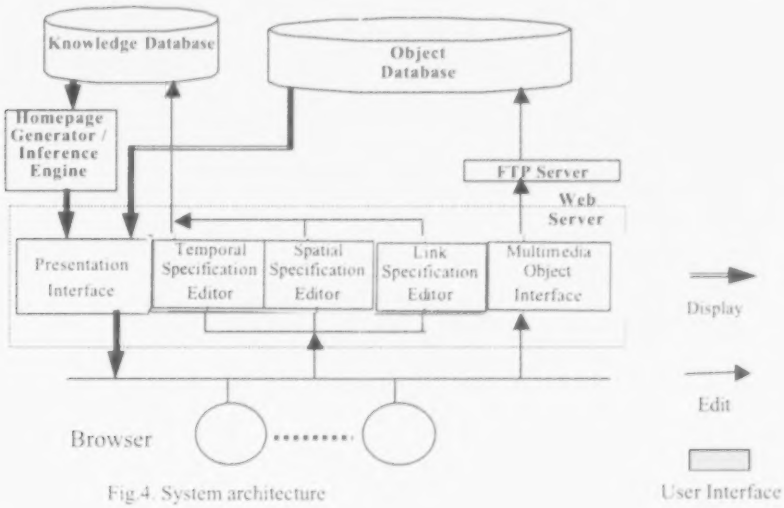


Fig.4. System architecture

BEST COPY AVAILABLE

CAI System Generator on Web -- using Automatic Trace Recording

Min-Huei Lin, Ching-Fan Chen, Si-Hao Hu, Ming-Hong Taai and Yung-Hsiang Chiu

Department of Information Management
Aletheia University
Tamsui, Taiwan
R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

By the prosperity of computer media, many companies treat electric media as their developmental base and use these electric media in more effective way. It goes without saying that the domain of teaching has developed on the Internet and many CAI systems have been already used in the teaching. The goal of our research is to create CAI systems by automatically recording the trace of editing. So in the thesis, we define the actions of users through image, audio, schedule, point and the module of event, and present the generated CAI systems dynamically on web.

Keywords: **CAI System Generator, Multimedia, Web**

1 The goal

Currently, many teachers and students use CAI systems as their teaching tools, and most teaching materials are designed by both teachers and system engineers. But teachers are generally in the passive position, and if they want to make teaching materials according to their own ideals, they have to learn how to use HTML to design homepages. Usually, students may not understand the meanings of teaching materials very well through the static homepages written in HTML. So we propose and implement an auto-recorded multimedia presentation system to let authors construct dynamic homepages of CAI systems directly through browser on web from automatically recording the trace of their editing.

2 Structure of system

We show the structure of our system in Fig. 1. In the auto-recorded system, we can catch the screen of process of users' operations, or insert sound or image information to the process. Then, these multimedia resources and related information are stored in Information Database and Media Database. The information of presentation schedule is recorded in information database. In the media database, contents of multimedia objects are recorded. In Fig.2, we can see the interactions among Image, Sound, Timer, pointer and Event. Image Module is to make necessary pick-ups for required images, decide what images are picked up in the Event Module Database and store their transition and filename in the forms. Sound Module is used to record sound, thereafter the sounds can be played at proper time by temporal scheduling. Pointer Module is to record the location of mouse pointer. When the transition has something wrong, we can make an adjustment in the coordination. In Timer Module, the time sequences are recorded in the form of Timer Pointer. The schedule designed through directly recording or specified by users is stored in the event database, and the generated multimedia objects will be presented according to the schedule built on the Timer Pointer. Event Module will react to all the other modules. It can decide what modules are going to work, and react to them. When users need to present teaching materials, the Java & HTML Generator will generate and send java code and HTML code to users' browser, then users can see the dynamic homepages. In Fig. 3, we can see a dynamically presented Web CAI system that is produced by recording and modified through the authors' edition and arrangement.

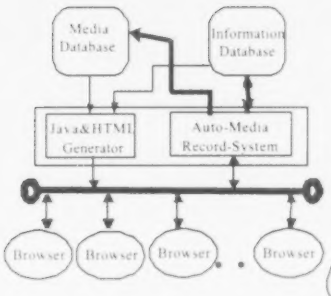


Fig.1 Structure of System

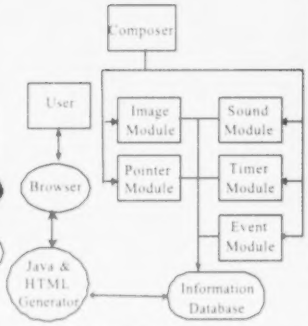


Fig.2 Modules of System

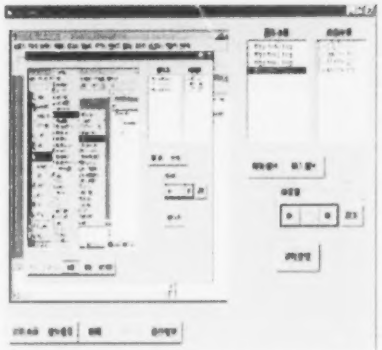


Fig.3 The interface of Auto-Recorded System.

3 Conclusion

We still continuously work on the pack technique of the multimedia file because the transmittance of image and audio are limited by the bandwidth of the Internet. However, teaching through Internet is an inevitable trend in the future, so how to make the best efforts between editing the teaching materials and let the learners learn as efficiently as possible are our goals.

References

[1] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE' 99.

[2] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bal Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design–A Scheme to Promote the Effect of Web CAI" . ICCE' 99.

[3] James F. Allen "Maintaining Knowledge about Temporal Intervals", Communications of the ACM, Vol. 26, No. 11, 1983.

[4] http://windowsmedia.com

CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL

Hiroaki Ogata, Yoshiaki Hada, Cheng Feng and Yoneo Yano
Dept. of Information Science and Intelligent Systems,
Faculty of Engineering, Tokushima University
2-1, Minamijosanjima, Tokushima 770-8506, Japan
Tel: +81-886-56-7498 Fax: +81-886-23-2761
E-mail: {ogata, hada, feng, yano}@is.tokushima-u.ac.jp
URL: http://www-yano.is.tokushima-u.ac.jp/ogata/

This paper describes an online markup-based composition learning environment system called **CoCoAJ** (Communicative Collection Assisting System for Java). It allows students and teachers to exchange marked-up documents via Internet, and its environment is very similar to a real world one in which people use pen and paper. In order to record and exchange corrected compositions with marks and comments, this paper proposes XCCML (eXtensible Communicative Correction Mark-up Language), that is based on XML (eXtensible Mark-up Language). XCCML facilitates teachers to analyze and reuse the marked-up documents for the instruction.

Keywords: **Computer assisted language learning, Collaborative writing, XML, Online document correction, Hypermedia.**

1 Introduction

Recently, teacher-centered instructional approaches in traditional writing classrooms are replaced with more active and learner-centered learning approaches with collaborative writing tools[2]. These tools can (1) change the way students and teachers interact; (2) enhance collaborative learning opportunities; (3) facilitate class discussion; and (4) move writing from solitary to more active and social learning. Writing compositions includes various sub-processes such as planning, transcribing, and revising, which do not need to occur in any fixed order [19]. In particular, the review process assisted with computer-based writing tools, has recently received much interest (see as examples [4, 9]).

Many researchers developed online markup systems employing some markup models. However, it is very difficult to analyze and reuse the marked documents that are collected through the writing classroom because the documents do not have a common structure. Therefore, it is necessary to define the generalized format for encoding and exchanging the marked-up documents in order that online markup systems are used easily and widely.

CoCoA (Communicative Correction Assistant system) has been developed for supporting foreigners and teachers to exchange marked-up documents by e-mail [14]. Its environment is very similar to a real one in which people use paper and pen. CoCoA allows teachers not only to correct the compositions sent from foreigners by E-mail, but also foreigners to see where and why the teacher had corrected them. CoCoA improves the opportunities that foreigners have for writing Japanese compositions and for receiving instructions from teachers. **CCML** (Communicative Correction Mark-up Language) [15] has also been proposed for the representation of marked-up documents, which is based on **SGML** (Standard Generalized Mark-up Language) [8]. With CCML, teachers and students can exchange marked-up documents via e-mail [16, 17]. In the experimental use of CoCoA, most of users commented that CoCoA was easy for them to understand the mistakes in documents because of the use of marks, and that the optional view of the original, marked or revised text was very useful. However, CoCoA cannot show users a hypermedia document including figures, tables, movies and links because it deals with only text.

This paper tackles how to correct hypermedia documents by the extension of CoCoA. This paper proposes **CoCoAJ** (CoCoA for Java) to do so. Also this paper describes **XCCML** (eXtensible CCML) for correcting

hypermedia documents, that are based on XML (eXtensible Markup Language). XCCML is combined CCML with HTML (Hyper Text Markup Language) that can represent hypermedia documents including pictures, movies, audios and so on.

We have been investigating technological support for Japanese language learning among overseas students. For example, CAI systems called Kanji Laboratory [7], JUGAME [23], GRACILE[23] and JULLIET[1] were developed to support Japanese language learning. However, an on-line mark-up supporting system for Japanese language learning has not yet been proposed. Usually, in a Japanese writing classroom, teachers have to individually review learners' documents using pen and paper[18]. It takes a lot of time for teachers to do this. Therefore, we have implemented CoCoA for writing Japanese composition.

2 Online markup models

There are some editing systems that support teachers to review and correct the students' drafts with online mark-up. Farkas & Poltrock [5] classified the mark-up models as followings:

(1) *Silent editing model*: This is the simplest model and it requires no special techniques. However, it is very difficult for the author to check the editor's work. This model is destructive because the editor cannot readily recover the original words once he/she has changed it.

(2) *Comment model*: This model employs pop-up notes, temporary footnotes, hidden text, and special symbols placed within the text. This model can work for special groups and ad-hoc situations. A system called XyWrite[10] was proposed with this model.

(3) *Edit trace model*: In this model, the editor works in the manner of an author, deleting, adding, and moving text as usual. The computer can compare the editor's new version with the original text, and allows the author to view the draft that contains the editor's changes. This model is apt to encourage heavier editing and less regard for the author's original text. Microsoft Word accepts this model.

(4) *Traditional mark-up model*: This adapts the traditional paper mark-up model to the computer screen. The symbols are both familiar and intuitive for editors and authors; for example, deletion, insertion, and move. For instance, Red Pencil allows the editor to apply a complete set of traditional editing symbols directly to a document. The editor uses "digital ink" to mark a traditional editing symbol along with the words. Moreover, MATE[6] allows the editors to use both digital ink and voice command toward pen and voice computing. In this model, authors and editors can interpret the editor's markings much more readily than in the edit trace model.

There are many systems that employ traditional mark-up which allows multiple users to mark-up an electronic document as if they were marking up a printed copy of the document. However, such systems do not globally come into practical and wide use in composition writing classes because of their special format. Moreover, it is very difficult to analyze and reuse the marked documents because the marked documents are unstructured. Therefore, the system should provide a generalized and structured format for encoding and interchanging marked-up documents via the Internet.

3 XCCML

Based on the experimental results, we propose XCCML for exchanging marked-up documents. XCCML is an application of XML, and it supplies a formal notation for the definition of generalized mark-up languages. XML is a device- and system-independent method of representing texts in electronic form. That is to say, XML is a set of mark-up conventions used together for encoding texts. A mark-up language must specify what mark-up is allowed, what mark-up is required, how mark-up is to be distinguished from text and what the mark-up means.

3.1 Features of XCCML

The main characteristics of XCCML are:

(1) Based on the experiment, XCCML presents six marks and annotation XCCML tags.

(2) The marks have three degrees of importance levels against respective corrections.

(3) The original text is generated through removing all the XCCML tags.

(4) The revised text is derived from the XCCML document.

(5) Because XCCML documents are text-formatted, it is easy to send them by e-mail.
(6) CCML documents easily make up full-text databases.
Needless to say, XCCML inherits its features from XML.

3.2 XCCML structure

As shown in table 1, XCCML documents consist of three parts: header, body and close. "Header" represents additional information about the document. For instance, "next" tag denotes the next version of the document. The marks for review are shown in the "Body" as XCCML tags. "Close" shows the editor's comments. In one sentence, "insert," "replace" and "delete" marks were used, while "join," "separate" and "move" marks were used over two sentences. The part between the start tag and the end tag denotes the learner's mistakes. The "string" attribute represents the revised part of the document.

Table 1: Marks and XCCML tags.

Correction	Mark	Tag
1. Insert	text	<Insert string="text"/>
2. Replace	text2	<Replace string="text2"> text </Replace>
3. Delete		<Delete> text </Delete>
4. Separate		<Separate/>
5. Join		<Join/>
6. Move	id id	<Movefrom refid="id"/> <Moveto id="id"> text </Moveto>

(1) Root tags

Tag name	Explanation	Attribute	Attribute's contents	End tag
XCCML	Beginning of XCCML tag	Version	Version number	</XCCML>
Head	Header information	None		</Head>
Body	Corrected document	None		</Body>
Close	Overall comments	None		</Close>

(2) Tags in header section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Title	Title of the document	String	Title name	None
Editor	People who corrected the document	Name	Name of the editor	None
		Email	Email address	
Author	People who write the original document	Name	Name of the author	None
		Email	Email address	

(3) Tags in body section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Insert	Insert words	String	Inserted words	</Insert>
		Level	Level of importance	
		Comment	Comment for the correction	
Replace	Change words	String	Corrected words	</Replace>
		Level	Level of importance	
		Comment	Comment for the correction	
Delete	Delete words	Level	Level of importance	None
		Comment	Comment for the correction	
Separate	Separate a paragraph	Level	Level of importance	None

		Comment	Comment for the correction	
Join	Join paragraphs	Level	Level of importance	None
		Comment	Comment for the correction	
Moveto	Moved position from the original spot	Fromid	ID	None
		Comment	Comment for the correction	
Movefrom	Original position of the words	Toid	ID	</Movefrom>
		Level	Level of importance	
Annotate	Comment for the correction	String	Annotation contents	None
		Level	Level of importance	

(4) Tags in close section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Comment	Overall comment	None	None	Necessary

3.3 Level of marks

We found that the marks do not have the same level of importance. We identify corrections on the following levels:

(1) Weak correction: The learner does not need to revise the document.
(2) Normal correction: The learner should correct the document.
(3) Strong correction: The learner must correct the document.

The strong corrections denote the important part of marks to be revised in the document. Using the importance level that the teacher had entered, the system provides the learner with the marks he/she wants to see. Therefore, the learner can avoid information overload from the reviewed documents. Every tag in table 1 has an attribute "level" that a teacher gives a number from one to three. Its default is two as normal correction.

3.4 Level of annotations

It is very important for a teacher to annotate the marked text for instruction in composition. For example, PREP Editor [12] is a word processor that allows writers and reviewers to create electronic margins, or columns, in which they can write and communicate through their annotations. We identify the following different kinds of annotations:

(1) Explanation: This is used for explaining the reason of a correction.
(2) Question: This is used for asking the learner a question; e.g., what do you want to write?
(3) Comment: This shows the educational view of the teacher with respect to the document.

4 CoCoAJ

CoCoAJ consists of CoCoAJ-Editor and CoCoAJ-Viewer. A teacher corrects the document of overseas students with CoCoAJ-Editor and the system saves the marked document in XCCML format. CoCoAJ-Viewer interprets the XCCML document, and shows the learner the marked document.

4.1 Learning processes using CoCoAJ

By using CoCoAJ, a learner receives instruction about a Japanese composition from a teacher with the following processes:

(1) The learner writes an original text with his/her familiar editor.
(2) The learner sends the document to his/her teacher with his/her own e-mail tool.
(3) CoCoAJ-Editor makes the document double-spaced. The teacher corrects the document with online marks and annotations. Then, the system allows the teacher to set the importance level to the marks in the document.
(4) After CoCoAJ-Editor saves the marked text as a XCCML document, the teacher sends it to the learner by e-mail.

(5) CoCoAJ-Viewer provides the learner with the marked text after interpreting the XCCML document. Then, the system allows the learner to select the importance level to see the important part of the marked text.
(6) CoCoAJ-Viewer automatically generates both the original text and the revised one from the XCCML document. After editing the revised text, the learner can send it again to the teacher and continue refining the text.
(7) CoCoAJ maintains the version of the document, if the learner wants to revise the same document.

4.2 System configuration

Figure 1 depicts the learning environment of CoCoAJ.

(1) XCCML parser: This module analyzes XCCML documents using the XCCML parser after reading them through the file management module. Then, it provides the results of correction according to the level of importance of marks.
(2) Correction module: This module inserts XCCML tags into the learner's document, according to the revision of the teacher. After saving the marked text, the teacher sends it by e-mail to the learner.
(3) Original text display module: This module generates the original text from the XCCML document by removing all the XCCML tags.
(4) Revised text display module: This module generates the revised text by applying XCCML tags.
(5) File management module: This module manages the versions of the documents. When the learner sends the teacher the revised document, the system creates a new XCCML document, inserts the "next" tag into the old XCCML document, and also enters the "previous" tag into the new XCCML document.

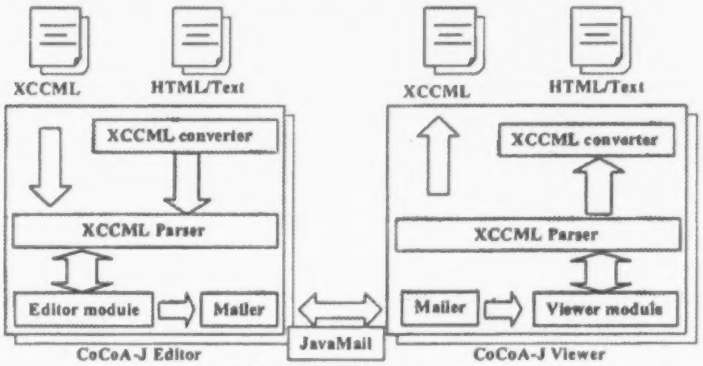


Figure 1: System configuration of CoCoAJ.

4.3 User interface

Figure 2 shows the screen snapshot of CoCoAJ-Editor. First, the learner writes a Japanese composition with a word processor and saves the document as HTML format. After that, the learner sends the document to the teacher by e-mail. By selecting a mark from the mark palette shown in the upper window, the teacher can revise the document. Moreover, the teacher can annotate the document using the annotation palette, and he/she can classify the marks according to the level of importance. The user can see the correcting document at the left side in the window and "*" means the user inserted the comment. The user can see the comments for the correction at the right side in the window. In this figure, the teacher substitutes "allow" with "allows" and gives a comment "*2". Also the teacher can see the original document and revised one by selecting window tag. After saving the marked document as a XCCML (see appendix A), the teacher can send it to the student by e-mail. Using CoCoAJ-Viewer, the learner obtains the same marked text that the teacher revised. By selecting the level of importance, CoCoAJ-Viewer provides only the marks over the level. The learner can reply to the teacher's comments and collaboratively write a composition with the teacher.

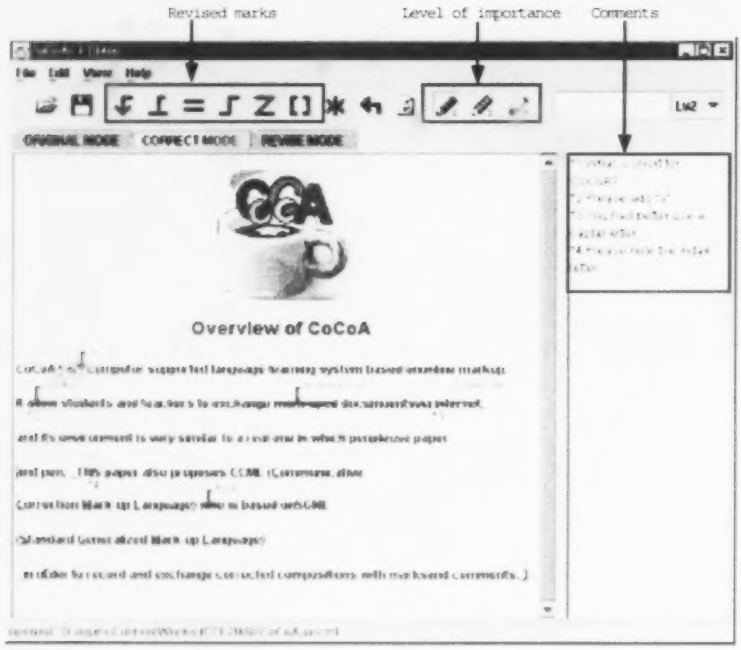


Figure 2: Screen snapshots of CoCoAJ-Editor.

5 Conclusions

This paper proposed a computer mediated language-learning system called CoCoAJ and XCCML for exchanging electronic marked-up documents. Now we are trying to propose XCCML to W3C (World Wide Web Consortium), and to show an XCCML document into Web browsers. After that, CoCoAJ will be able to be used for learning any language in an open-ended writing classroom. In our future research, we will investigate how to classify students' writing errors in their drafts, and how to assist a review process with AI technologies.

Acknowledgment

This research was supported in part by the Grant-in-Aid for Scientific Research (B) (2) No.09558017, No.09480036, and No.09230214 from the Ministry of Education, Science, Sports and Culture in Japan.

References

[1] Ayala, G. & Yano, Y. (1995). "GRACILE: A framework for collaborative intelligent learning environments", *Journal of the Japanese Society of Artificial Intelligence*, vol.10. no. 6. pp.156-170.

[2] Bonk, J. C. & King, S. K. (1995). "Computer conferencing and collaborative writing tools: Starting a dialogue about student dialogue," 1995 Proc. of Computer Supported Collaborative Learning.

[3] Brock, N. M. (1995). "Computerised text analysis: Roots and research," *Computer Assisted Language Learning*, vol.8, no.2-3, pp.227-258.

[4] Coniam, D. (1997) "A computerised English language proofing cloze program," *Computer Assisted Language Learning*, vol. 10, no. 1, pp.83-97.

[5] Farkas K. D., & Poltrock, E. S. (1995). "Online editing mark-up models, and the workspace lives of editors and writers," *IEEE Trans. in Professional Communication*, 38(2), pp.110-117.

[6] Hardock, G., Kurtecbach, G., & Buxton, W. (1993). "A marking based interface for collaborative writing," *Proc. of the ACM Symposium on User Interface Software Techonogy*, pp.259-266.

[7] Hayashi, T., & Yano, Y. (1994). "Kanji Laboratory: An environmental ICAI system for Kanji learning," *IEICE Trans. on Information and Systems*, E77-D(1), pp.80-88.

[8] Herwijnen, E. (1990). *Practical SGML*, Kluwer Academic Publishers.

[9] Kehagia, O. & Cox, M. (1997). "Revision changes when using word processors in an English as foreign languages context," *Computer Assisted Language Learning*, vol. 10, no. 3, pp.239-253.

[10] Kincade, D. & Oppenheim, L (1994) "Marking it up as we go along: Into editorial production's electronic future," *Journal of Scholarly Publishing*, Vol. 25, No. 3, pp.233-242.

[11] Matsumoto, Y, Kitauchi, A., Yamashita, T., Hirano, Y., Imaichi, O. & Imamura, T. (1997) "Japanese Morphological Analysis System ChaSen Manual," Nara Institute of Science and Technology Technical Report NAIST-IS-TR 97007. (in Japanese)

[12] Neuwirth, M. C., & Wojahn, G. P. (1996). "Learning to write: Computer support for a cooperative process," *CSCL: Theory and practice of an emerging paradigm*, Koshmann, T. (Ed.), Lawrence Erlbaum Associates, Publishers, pp.147-170.

[13] Ochi, Y., Yano, Y., & Hayashi, T. (1996). "JULLIET: Interactive learning environment for Kanji compounds learning," *Proc. of Educational Multimedia and Hypermedia 1996*, pp.539-544.

[14] Ogata, H. and Yano, Y. (1997). CoCoA: Communicative Correction Assisting System for Composition Studies, *Proc. of ICCE 97*, pp.461-468.

[15] Ogata, H., Yano, Y., and Wakita, R. (1998). CCML: Exchanging Marked-up Documents in a Networked Writing Classroom, *International Journal of Computer Assisted Language Learning*, Vol.11, No.2, pp.201-214.

[16] Ogata, H., Feng, C., Hada, Y., and Yano, Y. (1999). Computer Supported Proofreading Exercise in a Networked Writing Classroom, *Proc. of ICCE 99*, Vol.1, pp.414-417.

[17] Ogata, H., Feng, C., Hada, Y. and Yano, Y. (2000). Online Markup Based Language Learning Environment, *International Journal of Computers & Education*, Vol.34, No.1, pp.51-66.

[18] Sato, M., Kano, C., Tanabe, K., & Nishimura, Y. (1994). *Practical Japanese Compositions*, Bonjin-sya. (in Japanese)

[19] Scardamalia, M., & Bereiter, C. (1986). "Research on written composition," M. Wittrock (Ed.), *Handbook of research on teaching* (third ed.), Macmilian, pp.778-801.

[20] Schwind, B. C. (1995) "Error analysis and explanation in knowledge based language tutoring," *Computer Assisted Language Learning*, vol.8, no.4, pp.295-324.

[21] Shimano, H. (1986). *Handbook of proofreading*, Miki Publishers, Japan, in Japanese.

[22] Yano, Y., Miyoshi, K., & Hayashi, T. (1993). "Development of a game style environmental ICAI system for Kanji idiom learning," *Proc. of International Conference on Computers in Education '93*, pp.411-413.

[23] Yano, Y., Ogata, H., Sakakibara, R., & Wakita R. (1997). "CoCoA: Communicative correction assisting system for learning Japanese compositions", *Transactions of Japanese Society for Information and Systems in Education*, vol. 14, no.3, pp.21-28. (in Japanese)

Appendix A: **XCCML document in figure 4.**

```
<?xml version="1.0" encoding="Shift_JIS"?>
<!DOCTYPE XCCML SYSTEM "XCCML.dtd">
<XCCML>
<HEAD>
<Title string="Overview of CoCoA"/>
<Editor name="Hiroaki Ogata" email="ogata@is.tokushima-u.ac.jp"/>
<Author name="Yoshiaki Hada" email="hada@is.tokushima-u.ac.jp"/>
</HEAD>
<BODY>
<CENTER><IMG width="128" height="128"
src="image001.gif"/></CENTER><CENTER><H2>Overview of CoCoA</H2></CENTER> <H4>
CoCoA <Annotate level="3" comment="What is short for CoCoA?"/> is<Insert string="a" level="3"/>
computer supported language learning system based ononline markup.<BR/>
 It<Replace string="allows" level="3" comment="Please add &#34;s&#34;."> allow </Replace> students
and teachers to exchange<Replace string="marked-up" level="3"> mark-uped</Replace> document via
<Replace string="Internet" level="1" comment="You had better use a captal letter.">
internet</Replace>,<BR/> and its environment is very similar to a real one in which people use paper<BR/>
and pen. <MoveTo fromid="1" level="2" comment="Please note the initail letter."/>This paper also
proposes CCML (<U>C</U>ommunicative<BR/> <U>C</U>orrection <U>M</U>ark-up
<U>L</U>angua<Replace string="that" level="3">ge)</Replace> who is based on SGML<BR/>
 (<U>S</U>tandard <U>G</U>eneralized <U>M</U>ark-up <U>L</U>anguage)<BR/>
<MoveFrom toid="1" level="2">in order to record and exchange corrected compositions with marks and
comments.</MoveFrom></H4></BODY>
<CLOSE>
<Comment/></CLOSE>
</XCCML>
```

Design and Implement CAI Programs for Adult Literacy Learners

Pi-Chi Chen
Department of Information Management, I-Shou University
1, Section 1, Hsueh-Cheng Rd., Ta-Hsiang, Kaohsiung County, Taiwan 84008
E-mail: pchen@isu.edu.tw

This paper discusses adult learners' learning characteristics and how to integrate their characteristics with proper learning theories to make the CAI design more appropriate for adult learners. Three important issues concerning CAI design features are discussed: (1) learner control, (2) feedback and reinforcement, and (3) cooperative learning. Suggestions for CAI software designers about CAI design features and for adult literacy educators in implementing CAI programs are provided at the end of the paper.

Keywords: **Computer-Assisted Instruction (CAI), Adult Literacy Education**

1 Introduction

The computer has been attracting adult literacy educators' attention because it provides solutions to problems which have been plaguing adult education. For instance, it allows self-directed learning. Privacy is also possible. In addition, it provides flexible scheduling for adult learners. However, several limitations exist. One of the biggest problems with computer-assisted instruction to adult literacy education is the lack of CAI designed to meet the specific needs of adult learners. This paper discusses learning characteristics of adult learners, issues concerning CAI design features for adult literacy learners and provides suggestions for computerized adult literacy education.

2 Adult Learners' Learning Characteristics

Summarizing many adult educators' findings about adult learners' development and learning, the author generated a list of learning characteristics of adult learners. (1) Self-motivated: adults have a self-concept of being responsible for their own decisions and for their own lives. They want to be involved in making mutual decision about the learning process. (2) Experienced: adult learners want the learning experience to relate to their real-world experiences. (3) Practice-oriented: adults learn better by really doing something rather than hearing theory only. (4) Pragmatical: adults need to know exactly what the learning objectives are and how they will apply them in their daily lives. (5) Self-evaluated: adults like to know how they are progressing, but they tend to shy away from tests because of the fear of being humiliated if they do not do well. (6) Varied learning style: adults have adopted a particular learning style and it is not easy to change it. Thus adults want a variety of learning techniques utilized.

3 Issues Concerning CAI Design Features for Adult Literacy Learners

Learner control is particularly important for adult learners for three reasons: (1) adults need to control their learning, (2) they may need more time to make decisions about the learning topics and procedures, and (3) their learning may be ineffective in a learning situation with speed constraints [7].

Researchers have suggested effective instructional materials for adult learners should include feedback and reinforcement [2, 7, 9]. Chen [4] also asserted that positive and explanatory feedback had significant positive effects for adult learners' achievement and attitude toward instruction.

The rich resources of each adult's unique experiences and differing contexts should be focused on and integrated into the learning environment [11]. Steeples [11] concluded that, "Learner collaboration not only emphasize a positive, constructive approach to learning but it also allows the knowledge and skills of the participants to be shared with their peers and with others who have similar interests and concerns" (p. 452).

4 Suggestions

1. Design CAI for knowledge application. CAI for adult literacy education is still limited to specific learning subjects, such as language and mathematics. However the final goal is for the individual to be able to apply these skills to meet the needs for dealing with daily life. CAI designers should expand adult literacy learning subjects from the basic knowledge level to the advanced application level.

2. Develop daily-life-related simulation programs. To expand learning subjects from the basic knowledge level to advanced application level, a more complex learning environment is needed. A daily-life-related program could simulate real world environment, such as food markets, banks or hospitals, and allow learners to experience and solve problems happening in daily life. A tutorial section might also be integrated with the simulation program to provide instruction whenever needed.

3. Apply advanced computer technology. A simulated real environment can be displayed in a video segment or a Quick Time movie. The learner uses the computer to control the video to playback and retrieve information needed to solve the problems presented in the computer. A daily-life-related simulation program delivered by a multimedia system would motivate adult learners and improve their achievement.

4. Consider adult learners' vocabulary ability. Instructional developers must understand adult learners' vocabulary ability and develop easy-to-read text for adult learners improve their literacy ability in a progressive way. An option for audio to explain program usage methods and important information in plain daily-life language should be provided.

5. Develop CAI for both cooperative and individualized learning environment. When designing CAI software, neither individualistic nor cooperative learning should be viewed as the ultimate delivery system for adult literacy education. CAI programs that can be implemented in both individualized and cooperative learning environments would be more practical and effective for adult literacy learning.

6. Integrate varied software interactivity. The interactivity level of CAI should be carefully determined and designed after considering learners' characteristics, subject matter, and learning outcomes. When drill-and-practice learning mode is needed to help learners master some specific skills, semi-interactive CAI software might be a good design approach. If the learning outcomes are advanced knowledge application, CAI which provides high level of interactivity would be needed.

7. Apply multiple media with adult literacy teaching activities. When a learning environment provides varied learning media to facilitate students' learning, it is called a multimedia learning environment. If a computer-controlled multimedia is not available, adult literacy educators are encouraged to create a human-controlled multimedia learning environment for learners.

8. Let learners decide to learn individually or cooperatively. CAI designers are suggested to develop CAI which can be implemented in both individualized and cooperative environments. Adult literacy educators are also encouraged to let learners decide their CAI learning strategies. Learners can choose to learn individually, in pairs, or in groups of more than two.

9. Help learners obtain positive attitudes toward using computers. Teachers or trainers should avoid jargon when explaining how to operate a computer and access CAI program. Adult education organizations should offer a short pre-training program to help learners orient themselves to a computerized learning environment. Finally, adult learner grouping should pair learners who have never used computers before with learners who have had some computer experience.

10. Provide flexible learning schedule and learning location. CAI adult literacy educators should provide adult learners, who usually have many different obligations, with flexible learning schedule and choices of learning locations when implementing CAI programs for adult learners. This special feature of CAI—always providing organized and uniform instruction—should be fully used and enjoyed by adult learners.

References

[1] Askov E. N., & Brown, E J., "R.O.A.D to success: Evaluation of workplace literacy efforts", Adult Basic Education, Vol 2, No. 3, pp. 167-175, (1992).

[2] Askov, E. N., & Clark, C. J., "Using computers in adult literacy instruction", Journal of Reading, Vol 34, pp. 435-448, (1991).

[3] Boucouvalas, M., & Krupp, J., "Adult development and learning", in S. B. Merriam & P. M. Cunningham (Eds.), Handbook of Adult and Continuing Education (pp. 183-200). San Francisco: Jossey-Bass. (1989).

[4] Chen, P. C., "The effectiveness of computerized adult literacy education: a meta-analysis of literature from 1979 to 1994", Unpublished Ph.D. dissertation. Purdue University, West Lafayette, Indiana, (1996).

[5] Ewing, J. B., London, J., & Ramirez, S., "Adult education and computer literacy: A new challenge", Lifelong Learning, Vol 10, No. 3, pp. 21-23, (1986).

[6] Fletcher-Flinn, C. M. & Gravatt, B., "The efficacy of computer-assisted instruction (CAI): A meta-analysis", Journal of Educational Computing Research, Vol 12, pp. 219-242, (1995).

[7] Manheimer, R. J., "Older adult education: A guide to research, program, and policies", Westport: Greenwood. (1995)

[8] Merriam, S. B., "An update on adult learning theory", San Francisco: Jossey-Bass, (1993).

[9] Mills, H., & Dejoy, J., "Applications of educational technology in a self-directed learning program for adults", Lifelong Learning, Vol 12, No. 3, pp. 22-24, (1988).

[10] Shaw, D. S., "Computer-aided instruction for adult professionals: a research report"., Journal of Computer-Based Instruction, Vol 19, No. 2, pp. 54-57, (1992).

[11] Steeples, C. A., "Computer-mediated learning environment for adult learners: Supporting collaboration and self-direction", Journal of Educational Multimedia and Hypermedia, Vol 2, pp. 443-454, 1993.

[12] Woldkowski, R. J., "How to plan motivational strategies for adult instruction", Performance and Instruction, Vol 24, No. 9, pp. 1-6, (1985).

Designing for Interactivity

Johanna Klassen*, Douglas R. Vogel, and Emily Moody*****
**CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* pdklasse@cityu.edu.hk
***IS Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong, isdoug@is.cityu.edu.hk*
**** CELT Dept., City University of Hong Kong, 83 Tat Chee Ave., Kowloon Tong, Hong Kong,* Emily_Moody@hotmail.com

In education, 'interactivity' is the catalyst that has transformed the traditional classroom setting into an active media environment. Yet the standards for interactivity within education are by no means clear. Educators and multimedia designers are confronted with many questions concerning the effectiveness of interactive courseware as a learning tool. In this paper, the authors draw on their experience of producing the interactive courseware package *Virtual Language University*, an interactive multimedia package for language learning that has over 3,500 interactive tasks. Specific topics in the paper include screen design, navigation, effective task writing, choices in the type of user feedback, scoring and testing. Attention is given to decision-making procedures that deepen understanding, promote interactivity and encourage self-direction.

Keywords: **interactivity, multimedia, courseware design**

1 Introduction

In education, interactivity has transformed the traditional classroom setting into an active media environment. As Laurel indicates, interactivity is a necessary component for learning to take place. Learners only learn how to learn when they are actively and continually involved in the learning process [13]. Yet the standards for interactivity within education today are by no means clear. Educators and multimedia designers are confronted with questions concerning the effectiveness of interactive courseware as a learning tool, such as: how multimedia can be successfully integrated into the classroom, what level of interaction should be included, and which programs are most suitable. As this new area of learning evolves, those involved in interactive learning are discovering that developing material according to a multimedia interface is simply not enough [25]; [26]; [5]; [3]. Courseware designers are being challenged like never before to produce material that deepens understanding, promotes interactivity and encourages self-direction.

In this paper, the authors draw on their experience of producing an interactive courseware package to discuss the primary areas involved in designing a multimedia program in a Higher Education institution. A review of multimedia production discourse will be used to connect the discussion to broader issues within educational technology and interactive learning. Attention will be given to the decision-making procedures that add to an enhanced level of interactivity within computer-assisted learning.

2 Development Environment

2.1 Virtual Language University (VLU)

Virtual Language University (VLU) is an interactive learning program developed at the City University of Hong Kong. The courseware consists of four CD-ROMs and aims to provide a self-directed learning tool for students and academic staff interested in improving their English skills. The two-year long project was

funded by the Teaching Development Grant of the University Grants Committee. The development team that was responsible for creating the program was an eclectic international mix, consisting of a project manager, three computer programmers, a graphic artist, two scriptwriters and several student helpers. This team worked closely during every stage of the production, including the conceptual phase of brain-storming and scriptwriting, and the production phase of computer programming, video recording, and graphic design. The program was completed after an extensive review and piloting process that took several months.

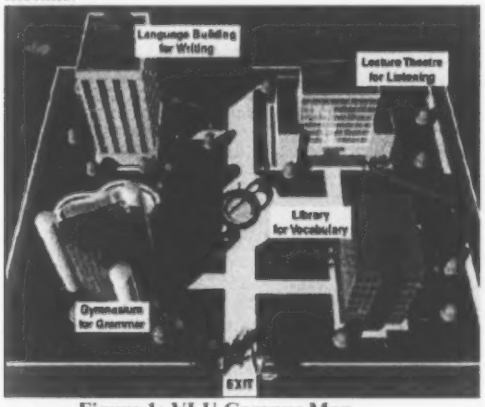


Figure 1: VLU Campus Map

Figure 2: VLU Lobby

Upon entering VLU, users are introduced to four units: Listening, Writing, Vocabulary and Grammar, metaphorically represented as four separate buildings in a virtual university campus (See Figure 1). The animated host, a friendly Dr. Einstein, provides first time users with a tour of the campus and explains how the program works. Once the users have selected a building (or unit) to work in, they are given a test and provided with feedback on weaknesses before being directed to the appropriate level: 1, 2, or 3, with 1 being the easiest (See Figure 2). For example, the Listening Unit consists of five multimedia lectures from University professors, which include video, graphics, sound and about 40 tasks per lecture. Users can control the forward, back and replay buttons of the lecture, and in this way monitor their own pace and approach in a "learner controlled" environment [5]. Within the Writing Unit, a video tutorial by an actual English teacher guides the students through complex writing structures, pausing for interactive tasks along the way. The other sections, Grammar and Vocabulary, provide ample practice for users to improve their proficiency in grammar usage and to expand their vocabulary. In total, there are over 3,500 interactive tasks in the program, all of which are programmed to give immediate or delayed feedback and a percentage score after each task. Users can also access their last two scores, as this information is automatically stored in the computer.

2.2 Project Development

Developing a multimedia product calls for a collaborative effort from various team members drawing from different backgrounds. The team usually includes a project manager (who is often the instructional designer), a subject-matter expert, scriptwriters, computer programmers, graphic artists, a videographer, an audiographer and administrative support [2]; [15]. The success of an interactive learning product depends very much on the ability of the team to work together; "As multimedia development demands the cooperation of many highly skilled and talented individuals, division of responsibilities, smooth communication, and strong commitment to the objectives of the project are essential to make a project successful" [15]. Depending on the size of the team, one person may take on several roles throughout the course of a project, or roles may overlap - as was the case for the production of VLU.

The project manager addresses the conceptualization stage [[9] and plans the instructional design. This involves a critical look at the educational needs, the interface design and a proposal for the delivery

content. The project manager will identify the instructional goal of the program, which should define, in general, what the program intends to achieve [2]. At the same time, s/he will determine the learning characteristics important to the design, such as the level of instruction, language, age and culture of the end users. The project manager is also responsible for outlining the schedule for the project and may facilitate a liaison with external specialists. S/he coordinates the efforts of the team, encourages positive interpersonal communications, and ensures that team members stay on track and complete their part by specified deadlines [2]; [15].

The scriptwriter works with the project manager to develop the content and design of the final product. S/he is responsible for selecting appropriate media, writing tasks, creating storyboards as well as developing ideas for graphics. Together, the project manager and scriptwriter construct the skeleton for the project, which is then brought to life by the programmers and graphic artists. The early phase is probably the most important stage of the production - and, if done properly, can save hours of time in unnecessary programming and tedious revisions.

Once the programmers and graphic artists have the scripts in hand, they can proceed with the production phase. They may use a number of authoring programs, systems or languages to implement the suggestions of the scriptwriter and project manager [2]. The graphic artist designs the program's graphics and animation, working closely with the scriptwriter to ensure everyone is thinking in the same direction. The videographer collects and digitizes video and photo images and the audiographer records the necessary sound elements. In the case of VLU, university professors were videotaped professionally. Academic lectures were given on different topics, such as "Exploring the Internet", "Organizational Behavior" or the "Poetry of Cavafy". The scripts for the lectures were first written by the professors and then transformed into an interactive format by the scriptwriter and project manager. The professors also acted as the subject-experts of the team, providing specialized feedback during the piloting of the program.

2.3 Scriptwriting

The key to good interactive multi-media packages is the nature and level of interaction between the users and the application. The level of interactivity is directly related to the successful creation of appropriately placed tasks that range in nature and content. During the scriptwriting stage, decisions concerning the number and type of tasks, the style of feedback, the sequence of questions, the different levels of tasks and the type of scoring are made. The decisions should first be organized into an outline form to give a broader perspective and to ensure there is an appropriate distribution among all the categories. It is also important for scriptwriters to maintain consistency throughout the scripts with the use of identical terminology, predictable sequences and the same command language.

Figure 3: Grammar

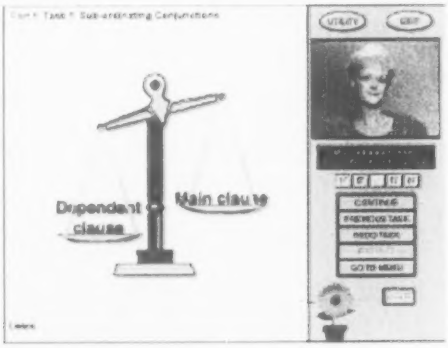


Figure 4: Writing

BEST COPY AVAILABLE

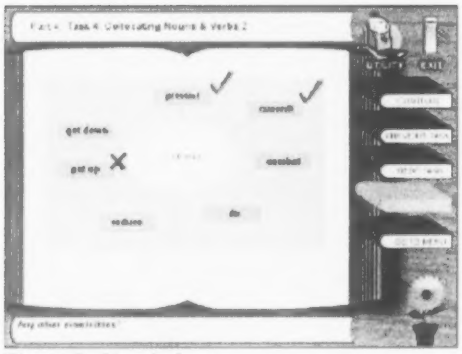


Figure 5: Vocabulary

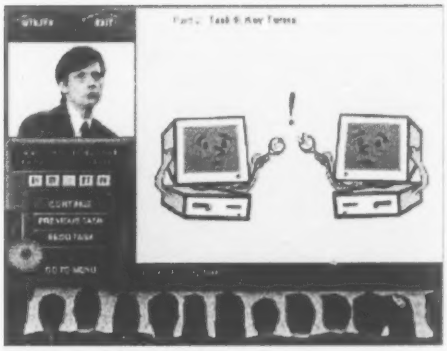


Figure 6: Listening

In VLU, tasks were written according to the instructional aim of each of the four units (See Figures 3-6). The main types of tasks that were used include click, drag, notepad writing and multiple choice. Multiple choice and click are the easiest to construct, both for the scriptwriter and programmer, but should be combined with other task types to ensure maximum interactivity. Each task is designed according to the learning objective of the unit. For example, in the Listening Unit, tasks are diagnosed as vocabulary, main ideas, key words, summary, predictions or inferences. When choosing the frequency and placement of tasks, Orr, Golas & Yao [17] advise including an option for an interactive task every three of four screens, or once every minute. Yet designers should avoid a strict adherence to any formula for interactivity, as it depends entirely on the content, style and complexity of the material being presented. "You cannot gauge the amount of active involvement in a technology product by the number of mouse clicks, and … similarly, one cannot assess learning by overall level of activity" [26].

The binary structure of the computer makes the process of task-writing an interesting and difficult endeavor. The scriptwriter is faced with the challenge of creating insightful, thought provoking tasks that elicit predictable, quantifiable responses. Where a teacher may be able to judge the validity of a multiple range of answers, a computer cannot. It is therefore up to the scriptwriter to predict all of the potential responses, a challenge especially for tasks that allow users to type responses in an open-ended format. During the piloting of VLU, for instance, it was observed that certain open-ended questions caused frustration among students who believed their answer to be correct - and if judged by a real-life teacher, may well have been. It is for this reason that questions with vague, complex or multiple responses must be constructed with great care.

How, then, can multimedia tasks be written without oversimplifying multifaceted and in-depth subject matter? This has been one of the leading criticisms of multimedia development as it expands to cover the more concept-based material within higher education. Users may get an unwarranted sense of having mastered a complex subject after correctly answering a complete set of computerized quizzes and close-ended questions [14]. One method of avoiding such a compartmentalization of information is allowing students to write down their own opinions on a profound subject matter using a computerized notepad. In VLU, this non-graded task is used to elicit predictions of what the lecture could entail, or personal opinions that the student may have. In this way, students are encouraged to contribute their own ideas and thus are able to build confidence in their analytical skills. The producers of the interactive multimedia package *Investigating Lake Iluka* argue that the notepad facilitates cognitive self-management by allowing students "to collect and manage information from a variety of different sources" [6]. This is substantiated by Laurillard [14], whose case study found that students appreciated "being forced, or perhaps enabled, to consider and develop their own analysis first, before seeing what the expert has written".

3 Design Issues

3.1 Screen design

Interactive media places users in a one-on-one relationship with a program that can be as intimate, or more intimate than, a face-to-face exchange [22]. For that reason, it is the task of educational multimedia producers to transform that relationship into a successful learning experience. In a user-controlled environment that enables students to turn off the program whenever they want, screen design becomes essential to maintaining learner motivation. Effective screen design allows for maximum learning from the materials while providing the learner with appropriate control of the learning process [16]. This could be compared to the teacher's role at the beginning of a traditional classroom setting. An effective screen design sets the stage for meaningful 'deep learning' to take place and motivates the student to stay engaged. The signs of a poorly designed screen are cluttered displays, complex and tedious procedures, inadequate command languages, inconsistent sequences of action and insufficient informative feedback [20]. Such designs can lead to anxiety, poor performance and dissatisfaction with the program. Some researchers recommend limiting the amount of text on screen to three lines in order to prevent information overload [4]. Users are most effectively able to concentrate on the multimedia material when the screen is made user-friendly with consistent commands and positioning of buttons. The importance of the screen design is corroborated by a number of researchers [21], [1]; [23]; [8].

The choices for screen design are endless, but the two basic extremes are simple and complex. There are both advantages and disadvantages for either consideration. The primary advantage of keeping the screen 'simple and uncluttered' is that it is less likely that users will suffer from immediate sensory 'overload.' As Stemler points out, multimedia instruction packages can become "nightmares when designers try to dump anything and everything into a single program simply because the capability is there" [21]. Most researchers agree with this approach [17]; [18]; [19].

In many cases, a thoughtfully designed complex interface will hold the user's attention longer. The use of a metaphor is one way of integrating a number of complex features with a simple visual structure and provides users with a sense of place, familiarity and ease of use. Within VLU, the metaphor of campus buildings is employed to distinguish between the four sections of the program: Grammar, Listening, Vocabulary and Writing. This metaphor is also useful for selection of the three levels of difficulty within the program. After diagnosis, the users take an elevator to the appropriate level of the unit they are working in.

3.2 Navigation

Unlike passive approaches to education, in student-centered learning, users navigate the path of their own learning. Because of this, the navigation design of a program determines the level of interactivity users will experience. There is a delicate balance between giving enough sense of direction to avoid anxiety, without over-directing users. It is important for users to always know where they are going. Too much freedom may result in students reviewing material or completing tasks that are not relevant to their purpose. According to the findings of Laurillard, learners working on interactive media lacking a clear narrative structure will display learning behavior that is generally unfocused and inconclusive. Learner control, one of the key benefits of interactive media, thus becomes pedagogically disadvantageous if it results in mere absence of structure [14]. While the users should be provided with sufficient choice through hypermedia links, there needs to be a balance between jumping around and sticking to one task [5]. According to Wild and Quinn, the ideal combination is "scaffolded reflection", that is, navigation that encourages thinking without losing the focus of the instruction [24].

There are several possibilities for how users access materials: sequentially, semi-directed, free choice or through pathways. Each of these methods can be designed to have extreme linear order or extreme non-linear order where users have little or no chance of deviating from a predetermined sequence. Thus,

package possibilities can range from strict, prescribed, sequential learning to complete freedom of choice. An alternative is a semi-directed program, allowing for the possibility of choice within certain situations.

Users can be given the option of skipping ahead only when a task is finished or they can be allowed to skip ahead at any time. Common procedure is to have the exit function or menu function available to users at all times. This implies that the navigation has minimal travelling; that is, express pathways so users arrive at their desired destination as fast as possible with little or no redundancy. In contrast, users may not be given the option of skipping at all but can only exit when a particular task/topic/section/unit is finished. Kristof & Satran suggest that users should not have multiple paths to any particular location because this causes confusion [11].

In VLU, users can chose to skip ahead to sub-topics at any time, yet are required to select the Main Menu to do so. Thus, while students can jump around to any building or level, they automatically enter a linear sequence once they have chosen a particular lesson (unless they click on the Main Menu, which is available at all times). This is particularly true for the Grammar section, where skipping ahead may mean missing important grammatical rules and explanations. In this section, students choosing to skip ahead will hear a friendly reminder from the animated host: "You are not advised to go to this task at this stage". Users are then given the option of proceeding anyway, or returning to the previous section.

3.3 User Feedback

Within the interactive format, the educational value of a program is directly linked to the style and quality of user feedback. The users can receive either immediate or delayed feedback to responses or actions. Immediate feedback lets the users have only one attempt at providing correct information, or making a decision. Delayed feedback, in contrast, allows the users to have a longer learning experience, an experience which requires completion of one or more steps before the users receive any feedback.

Feedback can also range from: i) individualized feedback which is based upon individual choice and performance, ii) to a more general response which addresses content considerations, iii) to a type of scoring (percentage, grade, written comments). Personal feedback can be created to address users by name and either make suggestions or critique decisions made. In VLU, the computer greets users by name as they enter the program. Because most users tend to respond positively to being addressed individually, this is usually seen as a positive option [9].

3.4 Testing

Users can also be tested before, during, or after using a package. The test that precedes the work done in the package can be used as a diagnostic tool for the user. By diagnosing weaknesses or strengths, students can be directed to enter the program at an appropriate level of difficulty. Considerations on the nature of the test include whether or not the test should be timed, whether students should be able to choose the subject matter of the test and how long the test should be. The answer to these questions will depend upon the type of material being tested. Analytic material probably requires no time limit, whereas non-analytic material may need to be timed. A secondary consideration would be how many times a user can take a specific test. How often should tests in general be given? Once per unit? One test per section or per topic?

If testing is used, diagnosis will be more reliable if several tests have been taken; therefore, a bank of tests is useful. It follows then that each test must accurately assess the skills being tested and all tests must be equal in difficulty. The generation of tests can be accomplished by having a single bank of questions with the computer randomly selecting the questions. This will ensure that users do not duplicate test materials.

Testing within VLU is an option provided to users once they have entered one of the campus buildings. The test length varies according to each section, but averages about 15 minutes per unit. For example, upon entering the Listening Test area, users are presented with a pop-up menu that asks them to select a test in

their area of interest: Environment, English, Politics and Business or Social Issues. In this way, students are able to control their learning experience and are not penalized for a lack of knowledge in a particular area.

3.5 Scoring

Another question designers will need to address is what kind of report users will receive after completing a test or set of tasks. Does the program require written comments, percentage grades, or is a simple pass/fail more appropriate? Reporting can be automatic after each task, or the report can be accessed upon request. One extreme is for there to be no access to scores until the entire unit/section/package is completed; the other is for automatic reporting to occur whenever a task is completed. The feedback or report can be a numerical or graphic representation. There can be results posted on the screen, or they can be printed, or even saved to a disk. Another design possibility is to have a progress report after users have used the program for a specified period of time. The progress report can incorporate individual feedback or re-direction to an easier or more difficult level. Teachers may also want to have a network reporting option that automatically sends them the students' reports [9].

Within VLU, users are provided with a percentage grade for each task as well as an overall grade for the section completed. This provides users with a clear indication of their areas of weakness, whether it be in specific grammatical structures, writing topic sentences, listening for key words or creating compound nouns. A rating of "good", "average" or "poor" is also given, with 80 percent or higher being good, 79 to 50 as average and below 49 as poor. With this method of reporting, users are oriented within the tri-level system of the program and provided with goals for motivating improvement.

Conclusions

As multimedia producers, our goal is to harness the power of emerging technologies to achieve our educational objectives. With proper planning and design implementation, producers can not only simulate the classroom setting, but enhance it - and thus contribute to an overall rise in the level of educational standards. As Kozma points out, our ability to take full advantage of new technologies depends on the creativity of designers and our understanding of the relationship between these capabilities and learning [10]. This becomes especially important as computer-based multimedia becomes a ubiquitous aspect to learning at all levels [12]; [2]; [7].

This paper has discussed some of the issues involved in designing interactive courseware, with an emphasis on the Higher Education environment. The authors have attempted to use the experience of VLU to identify some of the key challenges involved in the various stages of multimedia design: development environment, design, user feedback and piloting. One of the greatest challenges involved in multimedia design is integrating the freedom-of-choice that makes interactivity what it is, without straying too far away from the sensible guidance necessary for any valuable educational endeavor. Designers are being challenged to create a learning environment that combines learner controlled browsing within a system-encouraged structure. As demonstrated in VLU, this bipolar dynamic is evident in a'...ost every stage of the production process - from navigation to taskwriting to the integration of audio and visual effects. Every interactive learning production has its own set of problems and challenges, which is perhaps what makes multimedia design such an exciting and creative field to be working in. The lessons gained from VLU will continue to improve the program as it is exposed to more users and teachers, and as the development team generate new ideas for a revised version. It is hoped that these insights will contribute to the growing source of knowledge on multimedia design and ultimately lead to better products for students.

References

[1] Boyle, Tom. "*Design for multimedia learning*", London: Prentice Hall, (1997).

[2] Falk, D. & Carlson, H. "Multimedia in Higher Education: A practical guide to new tools for interactive teaching and learning", Medford, NJ: Learned Information, (1995).

[3] Gatlin-Watts, R., Arn, J. & Kordsmeier, W., "Multimedia as an instructional tool: Perceptions of college department chairs". Education Vol 120, No.1, pp. 190-196, (1999).

[4] Hannafin, M.J. & Rieber, L.P. "Psychological foundations of instructional design for emerging computer-based instructional technologies: Part II", Educational Technology Research and Development, Vol 37, *No.*2, pp. 102-114, (1989).

[5] Hanson-Smith, E., "Why multimedia?" CAELL Journal, Vol 7, No. 3, pp. 35-36, (1996-1997).

[6] Hedberg, J, Harper, B., Brown, C. & Corderoy, R., "Exploring user interfaces to improve learning outcome", In Beattie, K., McNaught, C., & Wills, S. (Editors) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 15-29, (1994).

[7] Heinich, R., Molenda, M., Russell, J., & Smaldino, S., "Instructional Media and Technologies for Learning", Englewood Cliff, NJ: Prentice Hall, 5th Edition, (1996).

[8] Ivers, K. & Barron, A. "Multimedia projects in education: designing, producing, and assessing", Englewood, CO: Libraries Unlimited, (1998).

[9] Klassen, J. and Milton, P., "Decision-Making in the Pre-production Stages of Developing an Interactive Multimedia Package", In Bradbeer, R. (Editor), Current Practice in Multimedia Education, Hong Kong: City University of Hong Kong Press, pp. 19-32, (1999).

[10] Kozma, R. "Learning with Media", Review of Educational Research, Vol 61, No. 2, pp. 179-211, (1991).

[11] Kristof, R., and Satran, A., "Interactivity by Design: Creating and Communicating with New Media", Mountain View, CA: Adobe Press, (1995).

[12] Lamb, A.C., "Multimedia and the teaching-learning process in higher education", In Albright, M.J. & Graf, D.L. (Editors) Teaching in the Information Age: The Role of Educational Technology, San Francisco: Jossey-Bass Publishers, pp. 33-42, (1992).

[13] Laurel, B. (Ed.) "The Art of Human-Computer Interface Design", Reading, MA: Addison-Wesley, (1990).

[14] Laurillard, D., "Multimedia and the learner's experience of narrative", Computers & Education, Vol 31, pp. 229-242, (1998).

[15] Liu, M, Jones, C. & Hemstreet, S., " Interactive multimedia design and production processes", Journal of Research on Computing in Education, Vol 30, No. 3, pp. 254-280, (1998).

[16] Milheim, C.L. & Lavix, C., "Screen Design for Computer-Based Training and Interactive Video: Practical Suggestions and Overall Guidelines", Performance and Instruction, Vol 31, No.5, pp. 13-21, (1992).

[17] Orr, K.L., Golas, K.C., & Yao, K., "Storyboard development for interactive multimedia training", Journal of Interactive Instruction Development, Winter, pp. 18-31, (1994).

[18] Overbaugh, R.C., "Research-based guidelines for computer-based instruction development" Journal of Research on Computing in Education, Vol 27, No. 1, pp. 29-47, (1994).

[19] Rambally, G.K. & Rambally, R.S., "Human factors in CAI design", Computers and Education, Vol 11, No. 2, pp. 149-153, (1987).

[20] Schneiderman, B. "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Reading, MA: Addison-Wesley, 2nd Edition, (1992).

[21] Stemler, L., "Educational Characteristics of Multimedia: A Literature Review", Journal of Educational Multimedia and Hypermedia, Vol 6, No. 3/4, pp. 339-359, (1997).

[22] Utvich, M., "Instructional Design: People and the Art of Interactive", Multimedia Producer, Vol 1, No. 9, pp. 1-5. www.kipinet.com. (1995).

[23] Vaughan, T., "Multimedia: making it work", Berkeley: Osborne McGraw-Hill, 4th Edition, (1998).

[24] Wild, M. & Quinn, C., "Implications of educational theory for the design of instructional multimedia", British Journal of Educational Technology, Vol 29, No. 1, 73-82, (1998)

[25] Wills, S. & Swart, R., "The book is dead, long live the book: Designing interactive publications", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 83-92, (1994).

[26] Woolsey, K. "Multimedia Opportunities", In Beattie, K., McNaught, C., & Wills, S. (Eds.) Interactive Multimedia in University Education: Designing for Change in Teaching and Learning, Amsterdam: Elsevier, pp. 93 -98, (1994).

Design of Multiple Metaphors in User-Interface

Yu-chen Hsu
National Tsing Hua University, Taiwan
arbia@ms55.hinet.net

As computer systems have become more sophisticated, several researchers have proposed the use of multiple models or metaphors to design computer systems and have argued that the provision of multiple metaphors would better match the characteristics of complex target systems. Multiple metaphors refer to the use of two or more distinct metaphors, each explaining various aspects of the target system. A multiple-metaphor interface means the combination of two or more metaphors to design the interface for a computer system. Although we see the strength of using multiple metaphors in interface design, not many guidelines for selecting and combining metaphors in creating a system are available. Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. In this paper, the theoretical basis for the use of multiple metaphors is discussed. The method in designing metaphorical interfaces is proposed as the author created the interfaces for a metaphor study. Issues of metaphorical interface design are discussed and detailed procedures in generating and combining metaphors in creating interfaces for a hypermedia system are presented.

Keywords: **Multiple metaphors, analogy, structural cues, interface design guidelines**

1 Introduction

Metaphor is traditionally a concept belonging to the fields of linguistics and philosophy. In 1980, Lakoff and Johnson [1] presented new ways of thinking about metaphor regarding everyday experience. They consider the essence of metaphor to be "understanding and experiencing one kind of thing in terms of another" (p. 5). They demonstrate that people's conceptual systems are metaphorical and people's actions every day are a matter of metaphor. In human-computer interaction, a metaphor is "present when terminology or concepts from a familiar non-computer domain are used to depict computer functions and objects in a user interface" [2]. Two components of a metaphor are the base domain and the target domain. The base domain is "the area of knowledge or expertise which a person already possesses," while the target domain is "the area of knowledge or expertise in which a person is trying to become familiar" [2]. When a computer user learns a new computer program, he calls upon his prior knowledge (analogies or metaphors) as the basis on which to form a new mental model. Designers can take advantage of users' existing mental models to present ways of conceptualizing computer functions and to design interfaces for computing systems [3]. Carroll, Mack, and Kellogg [4] describe the use of metaphor as a way to control the complexity of user interfaces by designing the actions, procedures, and concepts of new interfaces based on users' familiar actions, procedures, and concepts from previously learned interfaces. Metaphors used in this way are called interface metaphors.

Because humans learn new concepts or knowledge in terms of what they already know, almost all the computer interfaces in the world contain various types of metaphors taken from other domains. The current concern in computer interface design for ease of use, encourages the use of familiar objects and icon-based operations. Using these, computer users do not have to interact with command line syntax like they did before. This trend also facilitates the growth of the Internet [5]. Ratzan [5] argues that "metaphors may themselves suggest further implications, inferences or interactions of computer components. Metaphors help make sense of the online environment" (p. 47). Nevertheless, design guidelines derived from research findings on Internet metaphors are far behind their present demand in the practitioner field.

2 The use of multiple metaphors in interface design

While metaphor is useful for helping people to reason about new knowledge, mismatches between the base and target domains may occur, which lead to incorrect inferences. Carroll, Mack, Kellogg [4] claim that metaphor must provide incomplete mappings to their target domains. "If a text editor truly appeared and functioned as a typewriter in every detail, it would be a typewriter" (p. 69). Mismatches happen in situations in which the attributes and relations of a single metaphor can not be perfectly correlated with the attributes and relations of the target domain. This is especially true when the target domain is so complex that no individual model can fully explain anticipated behavior. In this case, the use of multiple metaphors to design interfaces may be a solution [6]. Benking and Judge [7] explain that three or more complementary metaphors may be used together in order to adequately represent some complex systems. Booth's [8] argument provides a basis for the use of multiple metaphors. He notes that people "appear to have blocks of knowledge relating to different domains and use parts of these knowledge blocks when they believe that it is appropriate" (p. 73). One kind of composite metaphor (multiple metaphor) is the use of complementary metaphors to represent functions of an interface, with each metaphor representing a function at a single level. Carroll et al. give an example of this kind of composite metaphor -- the integrated office system, which includes electronic mail, spreadsheets, text editing, and decision support, each with a different metaphor to represent it in the system.

In terms of the theoretical basis for multiple metaphors, Rumelhart and Norman [9] conducted a study on teaching new users to learn a text editor. They observed that students made errors because of their inadequate conceptualization of the various parts of the computer system. This resulted from the insufficient mental models students brought to the situation; they limited the kinds of analogies they might have employed. The authors note that no single metaphor can fully explain a complex piece of subject matter. Thus, they postulate an effective solution to eliminate student errors -- the provision of a more appropriate analogical framework, with different conceptual models to help students in their reasoning. They developed the "secretary," the "card file," and the "tape recorder" models, each explaining various aspects of the text editor, and claim that, although none of the models are perfect, as people grow more experienced in a domain, they become better at choosing appropriate models for a specific situation. In teaching this subject matter, it is effective to present a set of models, each with their own built-in context dependencies, as alternative conceptualizations of the target domain.

Collins and Gentner [10, 11] found that analogies allow people to create multiple mental models for use in reasoning about a complex system. They discuss Gentner's [12] analogy hypothesis and note that "a major way in which people reason about unfamiliar domains is through analogical mappings" (p. 247). They used analogies to map the set of transition rules from a known domain (the base) into the new domain (the target), thereby constructing a mental model that can generate inferences in the target domain. To test this hypothesis, they observed how subjects reason about evaporation and did an analysis of their protocols. The qualitative data suggests that subjects formed three different levels of interrelated mental models in reasoning about the target domain. These findings support the view that people learn the target domain by partitioning it into different component models, each mapped to a different base domain.

Multiple metaphors have also been employed in the field of artificial intelligence. Burstein [13] presented a model for students to learn a programming language. This involved the use of a box analogy, an algebra analogy, and a human processor analogy. In the example, the author used analogies in such a way that each analogy covered several levels of description, but served different functions. The use of multiple analogy models has been found to be more helpful in facilitating students who are learning the new domain in this case.

Spiro et al. [14] describe the danger of using single analogies in learning and instruction. They suggest that misconceptions are often caused by the reductive effect of analogies. "When analogies are used to 'start simple,' the knowledge ultimately acquired often stays simple. Well-intended analogies often result in oversimplified knowledge" (p. 502). They present eight situations in which the use of an analogy induces misconceptions or mismatches. One common characteristic of these eight situations is that users tend to depend too much on the properties of an analogous source domain in understanding the topic (target) domain. To solve this problem, they propose an antidote -- the use of integrated multiple analogies to represent complex concepts. They claim that by introducing new analogies which emend the missing or misleading aspects of the earlier analogy, the strength of the original analogy is retained, but its weakness is discarded. To give an example, muscle fiber function is proposed as the target concept, which is then explained by three analogies -- the rowing crew, the turnbuckle, and the Chinese finger-cuffs analogies. To integrate multiple analogies, they propose the technique of "composite imaging with selective contingent instantiation" (p. 522), in which three analogy models are created separately for the comprehension of the muscle fiber function with

the applicability of the elements in each analogy being context-dependent. Although the authors claim that this technique could be applied mentally or to computer graphic displays, its implications for the design of a composite metaphor are limited.

The advantage of using multiple metaphors in designing computer interfaces can be seen. However, there is no accepted standard for designing an interface with multiple metaphors. In the following section, the issues or problems of designing a multiple-metaphor interface will be discussed.

3 Issues to consider in the design of multiple (composite) metaphor interfaces

Judging from previous studies [15, 2] and my experience, I conclude a number of difficulties that designers or researchers would face in creating a multiple metaphor interface. Since the generation of a multiple metaphor interface involves the selection and combination of multiple metaphors, design considerations and problems will be discussed below within these two phases.

3.1 Selection of metaphor

When selecting metaphors to design interfaces for computer systems, the designer needs to consider several issues, which include the type of information, description level of metaphors, users' expert levels and prior knowledge, users' tasks, methods of task completion, and appearance of the interface.

* The *type and structure of information* of the target system influences how designers select metaphors. These attributes include the information content and structure of the target system. Designers need to consider the type of content information when choosing appropriate metaphors.

* In terms of *description level* of the target system, Booth [8] claims that "the level of description of a metaphor is concerned with the type of information that a metaphor might be expected to communicate" (p. 77). He takes an example from Moran's [16] Command Language Grammar and says that a metaphor can be aimed at the task level, the semantic level, the syntactic level, or the physical level. This characteristic increases possibilities, but also the difficulty in designing a metaphorical interface.

* When choosing metaphors, the designer should consider *users' prior knowledge* in their familiar domains as a basis for designing tools for learning new things. Stagger and Norcio [17] claims that, when designing multiple models for users to learn new knowledge, designers need to consider the expert level of the users and the tasks to be completed. As users gain expertise in the target area, their ability to manipulate multiple models increases. Since metaphors work by mapping previously acquired knowledge of users to the target domain that they are going to learn, some attributes (objects, relations, actions, effects) of the base domain must match with the attributes of the target domain. The selection of metaphors should be based on a user's familiar knowledge.

* Carroll et al. [4] explain three aspects to consider in designing a metaphor: the *tasks, methods, and appearance levels*. The task level describes users' goals and what they can do; an example is the information search in the present study. The method level describes how tasks are accomplished. The appearance level is the "look and feel of the task situation vis-à-vis the physical implementation of the domain" (p. 78). It includes aspects of the hardware and the presentation of screen objects.

In addition to consideration of the above criteria in selecting interface metaphors, designers also face some design problems described by Cooper [18]: 1) there are not enough metaphors; 2) the metaphors do not scale well; and 3) the ability of users to recognize them is questionable. As the number of metaphors increases in designing an interface, there are more constraints regarding the criteria of metaphor selection. Carroll and Thomas [3] suggest that when using two or more metaphors to design a system, one should not choose objects or procedures that are exclusively alternative to each other, so as to avoid interference and confusion. In another article [19], Carroll and Mack argue that good metaphors should also not provide completely transparent and comprehensive mapping, so that they may better enable users to learn.

3.2 Combination of metaphors

Once multiple metaphors are selected, designers need to identify an optimal way of combining the metaphors. This issue has not been well discussed by scholars, so there are not many guidelines regarding how to combine mult ple metaphors to create a computer interface.

Beyond the issues discussed above, designers face some additional problems in combining multiple metaphors. First, it is hard to draw the boundaries between different metaphors. Booth [8] raises this question for designers: "how [can we] signpost the boundaries of metaphors within a system so that users know when a metaphor is no longer relevant and when another metaphor is appropriate [?]"(p. 78) Second, although the idea of using multiple metaphors has been suggested for interface design by practitioners, the way to operationalize multiple metaphors to create interfaces is very difficult to carry out. Most previous studies used separate analogies to teach new knowledge, or they used separate metaphorical interfaces to help users to learn new computer systems. Methods for combining different metaphors in a system have not been explored. Smilowitz [2] was a pioneering researcher who tried to mix two metaphors in an interface in her experimental studies. Due to the challenging nature of this case, there were design deficiencies in her approach to combining multiple metaphors. Smilowitz tried to mix two metaphors within the navigation area in a hypertext system. But navigation tools are only a part of an interface. The design in her study limits users' perceptions of the metaphorical interface.

In light of the above difficulties, the application of structural cues taken from multiple metaphors may be a solution to integrate two or more metaphors in designing an interface. The next section is a brief review on structural cues in computer interfaces.

4 Hypertext structure cues

Dillon [20] presents a discussion on the structure in documents. He argues that the meaning of structure differs depending on different standpoints: from the perspectives of writers, readers, or from the consideration of reading/writing tasks. There is a difference in the structures of a paper and an electronic document. Compared to a paper document, a hypertext document does not have the same amount of information available to the readers, and its structures do not have equal transparency. In a hypertext system, the author can create numerous structures from the same information. Due to the lesser experience novice users may have with hypertext systems, "users' schemata of hypertext environments are likely to be 'informationally leaner' than those for paper documents" (p. 114). These reasons may explain why users easily become lost in hyperspace.

One way to solve navigation problems in hypermedia is to provide structure aids that inform users of what information is available, as well as where it may be located and how it may be organized. Hulley [21] discuss hypermedia and notes that "its structure needs to be made obvious to the users [,] and a means of browsing and navigating around it needs to be provided." In addition, he thinks that "the methods chosen for structuring information need to be the most suitable for the user's needs; they must support the tasks that the user wants to carry out and provide an interface which can be easily understood or learned" (p. 173). Thuring, Hannemann, and Haake [22] argue that the coherence of a hyperdocument has an impact on the reader's information processing. Well designed hypertext structures plus the presence of rhetorical cues may facilitate coherence; so designers should provide cues at both the node (within nodes) and net (between nodes) levels. Rouet and Levonen [23] describe the prototypical representation of hypertext as "a set of text units connected through multiple links, that is, a text network" (p. 15). Due to the navigation problems which a novice user may experience, they argue that novice users need analogies with conventional structures.

5 Procedures used to create multiple-metaphorical interfaces

From the literature review we know that a single metaphor does not cover everything in the interface. The use of two or more metaphors in designing an interface may be a solution for the problem of mismatch and may better represent the elements as well as the relations to the target system. In addition, structural cues or metaphors should be provided to hypermedia users for them to understand the way to navigate the system.

Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. Interface design in this area is more laborious because of this problem concerning the operational definition of metaphorical interfaces. Due to the problems designers or researchers may experience when combining multiple metaphors to create an interface, the

creation of a metaphorical interface by combining structural cues that are derived from two or more metaphors may be a useful way to help users to search within a hypermedia system.

In my metaphor study, I compared single versus multiple-metaphor interfaces on their effects in facilitating users' information search behaviors in a hypermedia system. There were three interfaces as the independent variable in the study, with the first interface containing less metaphorical elements, the second containing some metaphorical elements from a single metaphor, and the third (multiple-metaphor interface) containing more metaphorical elements from two metaphors.

A method was proposed to create the metaphorical interfaces based on existing design guidelines and the revision of design methods used by other researchers. In this strategy, the metaphors work as the source for the structural cues to be combined in creating a metaphorical interface. Metaphors were used as the basis for deriving navigational cues, but those cues were not treated illustratively. In other words, the cues are related structurally to the metaphors but do not necessarily represent elements of the metaphors in a pictorial way. The metaphors used provided a logic for the designs, which guided the choice of structural cues that distinguish the three interfaces by the varying degrees to which they appear. This approach leads to a more precise operational definition and manipulation of the variables.

A detailed review of the method for creating the three interfaces for the experimental study is presented in the following paragraphs.

5.1 Selection of context and task for the study

In the study information searches were chosen to be the user task in order to investigate the effectiveness of using metaphors as a navigational aid in designing a hypermedia system.

5.2 Selection of information content (information system)

After the task had been chosen, the information content was identified based on the scope and structure of the system, the depth and width of the information structure, characteristics of the information related to the target system, the familiarity of the content to the potential subjects, the availability of the system, its ease of implementation, appropriate metaphors for this information content, and software used to create the hypertext system. These issues were identified partially through a review of articles describing the processes that other designers went through to create metaphorical interfaces and the criteria they took into account [24, 25, 26, 27, 28, 29]. The web sites of some universities, the web pages of the Library of Congress and the National Science Foundation, a CD-ROM in science, a health database, geography information, the lives of musicians, world art and wars, and American history were reviewed. Some systems were good because they have structures embedded within them for information searching and navigation; but there were no appropriate metaphors for those types of content. For the other systems, there were appropriate metaphors that matched the content or elements, but the information structures were not useful for information searching.

The CD-ROM "The Enduring Vision" [30] was finally chosen as the content on which to base the hypertext system. It contains 33 chapters of American history. The same content as that in the CD-ROM can be found in the book The Enduring Vision, and the CD-ROM structure is similar to the structure of the book. This similarity between the book and CD-ROM was a positive factor which influenced my choice of the CD-ROM. It made the job of creating the three variances of hypertext easier, because the content did not have to be restructured to fit the book metaphor. Four chapters with a total of ninety-eight articles in nineteenth-century American history were selected from the program to create the hypertext system.

5.3 Selection of metaphors

The chosen hypertext system placed constraints on the variety of possible metaphors that could be used to design the interfaces. The issues taken into account at this stage included the subjects' prior knowledge concerning the metaphors, the characteristics of hypermedia systems versus the attributes of metaphors, the overall structures of metaphors in covering hypermedia systems, the appropriateness of metaphors for information searching, potential mismatches between the metaphors and the hypermedia system, existing metaphors used in other software, ease of representation, manifestations /appearances of metaphors, guidelines for metaphor design, and methods of combining multiple metaphors. In addition, the characteristics proposed by Lin [15] were also taken into consideration. These are: (1) the style of presentation of information, (2) the size of information units, (3) the degree of user control over the ordering of information, (4) routes of

traversing, (5) the visibility of linkages among units, (6) the implied internal structure of information units, and (7) the style of access to specific information. Some other design guidelines were also taken into consideration when I created the metaphorical interfaces. After several unsuccessful attempts (using different combinations of multiple metaphors such as timeline, map, journey, path, container, building…), the book and folder metaphors were ultimately selected, based on the above guidelines and the consideration of possible ways of metaphor combination.

One criterion in selecting multiple metaphors is that the chosen metaphors must be independent of each other. In other words, one metaphor can not be a secondary (subordinate) metaphor to the other one (the primary metaphor). According to Cates [24], a primary metaphor refers to the principle or first metaphor employed, and a secondary metaphor means a subsequent metaphor employed. The secondary metaphor "stimulates images and semantic expressions related to those stimulated by the primary metaphors which they are intended to accompany."(p. 98) If one metaphor is subordinate to the other, then they can be seen as the same metaphor.

The reason I selected book and folder metaphors is that each could map to different aspects of the hypermedia system, so they are complementary (see Table 1 for analysis of metaphor functions). Spiro et al. [14] propose the employment of multiple analogies in learning and instruction. They identify eight ways that analogies may induce misconceptions. Based on their framework, I analyzed the strengths and weaknesses of book and folder metaphors and used them in the design of three interfaces. Due to the scope of this paper, this analysis will not be discussed in the current paper.

Table 1: Analysis of metaphor functions and structural cues

	Elements related to content or to the hypermedia structure	**Metaphor functions related to hypermedia characteristics**
Book metaphor	• Books have structure. Each book page can be used to place an information unit (e.g. a web page) • A book has a cover, a table of contents, chapters, sections, and pages • Turn page/ page number • Open/close a book	• There is visibility of linkages among units • A book structure implies the internal structure of information unit in a hypertext system • A book has a particular style of information presentation and access to specific information • Book pages need to be accessed sequentially by page turning or by reading the table of contents (Lin, 1989, p. 48)
Folder metaphor	• Each folder can be used to place an information unit • Folder tabs with labels enable users to easily identify the content of a folder • Flexible ordering of information (Lin, 1989, p.46)	• Folder tabs allow random access to specific information units (Lin, 1989, p. 46) • Information units in different levels can be directly accessed

5.4 Combination of two metaphors and the creation of three interfaces (use of structural cues)

After each metaphor was selected, all of their objects and functions were analyzed using the POPIT model as shown in Table 2 [24]. The design problems which previous researchers faced in combining multiple metaphors in one interface (the creation of a composite metaphor interface) have been discussed in previous sections. In addition, Lakoff and Johnson [1] claim that "metaphors do not imply a complete mapping of every concrete detail of one object or situation onto another; rather they emphasize certain features and suppress others" (p. 96). It is also impossible to manipulate metaphorical elements in an interface from complete absence to presence.

In view of these difficulties, the three metaphorical interfaces were created in such a way that each interface contains various degrees of structural cues taken from one or two metaphors, with the cues ranging from minimum to maximum. Rather than call them the no-metaphor, single-metaphor, and multiple-metaphor

interfaces as in previous studies, they were called "the interfaces with different degrees of structural cues derived from single or multiple metaphors."

Table 2: POPIT Model (Cates, 1994)

	Book (Cates, 1994)	**Folder**
Properties	Book cover, pages, table of contents, chapters, sections, title	Tabs on the top of each folder, several folders can be put together, labels or keywords on the tabs
Operations	Open or close a book, turn page forward and backward	Folder tabs can be thumbed through, it allows random access, flexible ordering of folders
Phases	Turn pages, open, close, begin reading, find information/words, highlight	Select the folder, open the folder, select section by way of thumb tabs
Images	Book cover, layout of books	Same size and shape for each folder, tab in different location on the top, tabs have different colors
Types	Reference works, recreational books	Information storage

First interface (interface A with minimal cues)

There were a total of one hundred screens in this interface. Interface A contains a minimal degree of metaphorical concepts. In addition, the three interfaces in this experimental study needed to have similar structures and styles of information presentation for the sake of comparison and data collection. Since all computer interfaces contain some degree of metaphors taken from other domains, it is impossible to rule out metaphor elements totally. In the hypertext system, each article was organized hierarchically with its title listed in previous levels as hyperlinks. This made the title lists look more like the content lists of a book. For this reason, interface A still contains a small number of metaphorical elements, partially due to the nature of the information content.

Second interface (interface B with medium cues)

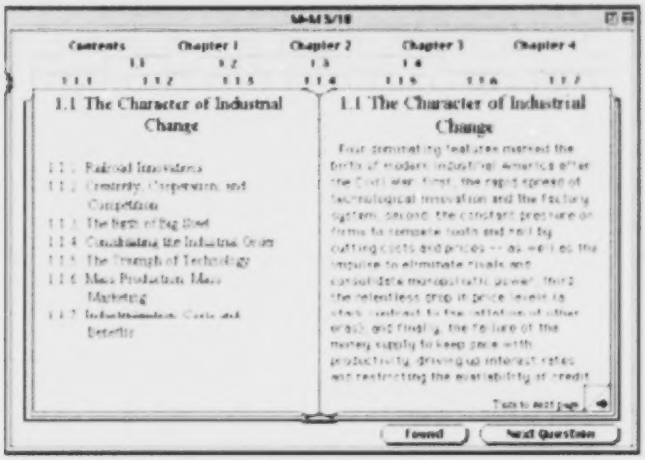
There were a total of four hundred and twenty seven screens in each of the interfaces, B and C. The same structural components and elements can be found in all three interfaces: 1) four levels in the system, 2) a main page as the first level with hyperlinks linking to the second and the third level, 3) articles in the second, the third, and the fourth levels with or without hyperlinks linking to the next level, and 4) titles and body text for each article. Based on the analysis, terms, images, structures, and operations were taken from a book metaphor to add to the design of the second interface. This causes the second interface to contain more structural cues from a book metaphor. All the information was presented in book format; for example, the text of each article was presented on double-sided pages, as in a real book. Users can click on the dog-ear to turn to the previous or next page. In addition, the title of each article was labeled with chapter, section, and subsection number to resemble the title of a book.

Third interface (interface C with maximum cues)

In order to compare the effects of the interface in which the structural cues were taken from only one metaphor with the interface in which structural cues were taken from multiple metaphors, a third interface was created (see Figure 1). Extra structural cues, including images, structures, and operations of a folder metaphor, were added to the second interface to create the third one. Whereas information presentation in a book metaphor is linear, the folder metaphor conveys the hypermedia attribute of flexible information access. The book metaphor worked as the main metaphor and was broader in its scope, while the folder metaphor was added to the design to supplement the book metaphor. Booth [8] describes the dimensions of a metaphor in terms of its scope and level of description. The scope describes the number of concepts that a metaphor addresses, and the level of description deals with the information types that a metaphor communicates. Similarly, Hammond and Allinson [30] describe four levels of information that a metaphor may convey: task information, semantic information, lexical information, and physical information. Using those concepts to examine the design in the present study, the book metaphor has a larger scope and it conveys four information levels: the hypertext structure, the layout, the terms, and the operations; but the scope and information levels of the folder metaphor are more restricted. The main function of the folder metaphor is to provide a flexible means of information access so that users can randomly access articles in different levels.

The structural cues taken from the book and folder metaphors include content lists, section titles and number, double-paged layout, book turning corners, folder labels with section numbers, physical layouts of book and folder metaphors, and so on. Those elements consist of textual and graphical structural cues, which were combined to create the metaphorical interfaces.

Figure 1. Screen-shot of the third level for interface C (multiple-metaphor interface)



6 Conclusion

Metaphors do not apply equally in the interface designs, and usually only the most salient points are drawn from a metaphor. The book and folder metaphors are not alternative choices; instead, they complement each other (in a non-exhaustive way). This is consistent with Benking and Judge's [7] view of using three or more complementary metaphors to explain complex systems. Due to the consideration of ease of manipulation in the experimental study, only two metaphors were chosen for the design of the interfaces. At each step in creating the interfaces, not only more possibilities, but also a few constraints were added to the design. The selection and combination of the structural cues did not result in perfect designs, but they were completed with much deliberation concerning the many design possibilities and tradeoffs.

Designing metaphorical interfaces involves many other issues that are beyond the scope of the present discussion. The compatibility between the metaphors to be combined may play an important role in appropriately conveying the functions of each of the interface elements. Interfaces that are created with incompatible metaphors could cause misunderstanding and hinder users' performances. The problems of selecting and combining multiple metaphors have been discussed in this paper, and the procedures for creating the metaphorical interfaces have been explicitly presented. There are many complex design issues involved in the creation of metaphorical interfaces. The design of a metaphorical interface relies on appropriate metaphor selection and combination in order to achieve optimal effects. Further research is needed to explore other possible ways to combine multiple metaphors to create user-friendly interfaces.

Due to the scope of this paper, the whole process of creating metaphorical interfaces can not be discussed in detail. However, it is the hope of the author that the method presented can provide interface designers and researchers with insight in creating metaphorical interfaces.

References

[1] Lakoff, G., & Johnson, M., Metaphors We Live By. Chicago, IL: University of Chicago Press, (1980).
[2] Smilowitz, E. D., Metaphors in user interface design: An empirical investigation. Unpublished doctoral dissertation, New Mexico State University, (1995)

BEST COPY AVAILABLE

[3] Carroll, J. M., Thomas, J. C., Metaphor and the cognitive representation of computing systems. IEEE Transactions on Systems, Man, and Cybernetics, SMC Vol. 12, No. 2, pp. 107-116, (1982).

[4] Carroll, J. M., Mack, R. L., & Kellogg, W. A., Interface metaphors and user interface design, In Helander, M. (Ed.), Handbook of Human-Computer Interaction (pp. 67-85). North-Holland: Elsevier Science Publishers, (1988).

[5] Ratzan, L. D., Maing sense of the Internet: A metaphorical approach. Unpublished doctoral dissertation, The State University of New Jersey, New Brunswick, (1998).

[6] Williams, M. D., Hollan, J. D. & Stevens, A. L., Human reasoning about a simple physical system, In D. Gentner & A. L. Stevens, Eds, Mental Models, pp. 134-154, Hillsdale, NJ: Lawrence Erlbaum Associates, (1983).

[7] Benking, H., & Judge, A. (1994). Design Considerations for Spatial Metaphors [On line]. Available HTTP:

[8] Booth, P. A., An Introduction to Human Computer Interaction. Alwrence Erlbaum Associates, Publishers, Hillsdale: C4, p65-101, (1989).

[9] Rumelhart, D. E., & Norman, D. A., Analogical processes in learning. In J. R. Anderson (Ed.), Cognitive Skills and Their Acquisition (pp. 335-361). Hillsdale, NJ: Lawrence Erlbaum Associates, (1981).

[10] Collins, A., & Gentner, D., Multiple models of evaporation processes. Proceedings of the Fifth Annual Conference of the Cognitive Science Society (pp. 16-20). San Diego: CA, (1983).

[11] Collins, A., & Gentner, D., How people construct mental models. In D. Holland, & N. Quinn (Eds.), Cultural models in language and thought (pp. 243-268). New York: Cambridge University Press, (1987).

[12] Gentner, D., Are scientific analogies metaphors? In D. S. Miall (Ed.), Metaphor: Problems and Perspectives (pp. 106-132). Atlantic Highlands, NJ: Humanities Press, (1982).

[13] Burstein, M. H., Concept formation by incremental analogical reasoning and debugging. Proceedings of the International Machine Learning Workshop (pp. 19-25). Monticello, IL: University of Illinois, (1983).

Development of 3D simulation programs for classical mechanics - Using Java 3D -

Yasuyuki NAKAMURA* and Hiroshi NAKANO**
School of Informatics and Sciences, Nagoya University
Nagoya, 464-8601, Japan
*Tel: *+81-52-789-4753 **+81-52-789-4801*
*E-mail: *yasuyuki@info.human.nagoya-u.ac.jp*
***nakano@info.human.nagoya-u.ac.jp*

1 Introduction

As LAN and Internet have diffused in recent years, environments of computers have been well filled and computers have become more popular among students. These developments make it possible for the style of education of physics to become various.

Recently many groups develop simulation programs for education of physics. We develop simulation programs for physics education using C language, XForms and Mesa library on Linux computer [1]. There are not only 2D but also 3D simulation programs. These programs are used in physics experiments for students [2,3]. One of the weak points of our system is a difficulty for opening our programs to the public. Only students attending the class can execute the programs.

On the other hand many programs coded by Java are also proposed and an education environment are prepared on the Internet. On World Wide Web (WWW), there are many programs coded by Java that are opened to the public [4,5]. Condensed Matter Theory Group of Kyushu University in Japan opens a virtual laboratory for the introduction of physics on WWW [6]. In the laboratory one can study physics with a simulation and an explanation for it. It is very good idea to open the programs to the public through Internet, but most of those programs are for 2D simulation. We think that 3D simulation is more exciting and is more helpful for understanding the motion of objects, because 3D simulation is more realistic.

Our aim of this study is to develop 3D simulation programs and open them to the public through Internet. We develop programs using Java in order for as many as people to utilize them and make use of Java 3D API for realizing 3D visualization. To our knowledge, there are still only a few programs proposed for education with use of Java.

2 Environment of development and execution

Our simulation programs are developed on an IBM PC/AT compatible computer. We adopt Linux as an operating system (OS) and XFree86 3.3.6 for X Window system. Java 2 SDK v 1.2.2 for Linux Production Release, Java 3D 1.1.3 API and Mesa 3.1 are used for developing applications. One of the reasons for adopting Linux is that Linux system has a reputation for its stability. Although applications are developed on a computer with Linux operating system, one can use any kind of computers and operating systems for execution of applications. This is merit and what we aim for in developing applications.

3 Example

We developed some programs with use of Java and Java3D by way of trial. One of them is a simulation of motions of ball in a box under gravitation, whose snapshot is shown in figure 1. We list below special features of these applications.

- We make use of Swing API for graphical user interface (GUI). Swing is provided as one of the standard APIs in Java2 and we can develop applications with common GUI operations in total independence of a kind of a computer and OS using Swing API.
- One can execute programs not only as an application on a local computer but also as an applet on a

browser through Internet. Java Plug-in is necessary for executing programs on a browser in the present. However this restriction will be solved in the future.

- Real-time simulations can be realized with use of thread class of Java. Furthermore, one can execute applications in slow-motion mode and in fast-forwarding mode.
- Java3D uses a tree structure for realizing 3D visualization. By changing branches and leaves, objects can be moved, transformed, replaced and so on.
- Java is a class-based object-oriented programming language. Therefore we can easily add or remove objects. Furthermore rules of motion can be specified to objects. Then we can realize various motions of objects.
- Since Java2 is prepared for Unicode and Locale, internationalized programs can be developed.

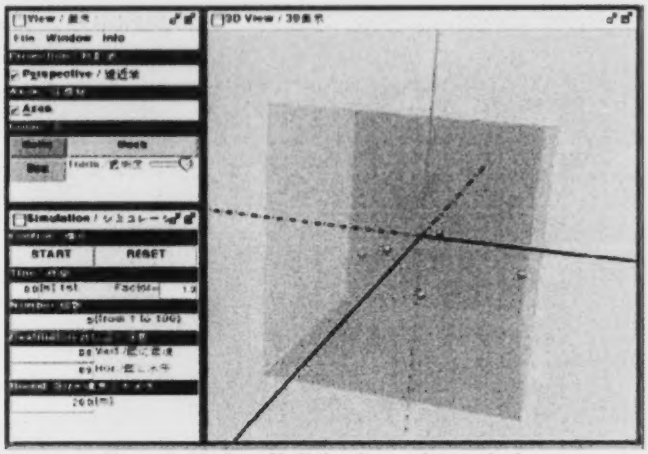


Figure 1. Motion of balls in a box under gravitation.

4 Conclusions

We propose an educational system for elementary physics with use of Java and Java 3D API. Our system offers 3D simulation programs with use of Java 3D. 3D visualization of the system of classical mechanics helps students to understand the behavior of the system and to have interests in physics. Since our programs are developed by Java, anyone who has an environment of Java can execute them on WWW. Therefore we can open our programs to the public and we can receive responses and evaluations for our programs. Note that one needs Java Plug-in for execution of our programs in the present. In the future, we want to increase the number of simulation programs and open those programs to the public.

This work is supported by the Japanese Grant-in-Aid for Science Research Fund from the Ministry of Education, Science and Culture.

References

[1] Yasuyuki Nakamura and Hiroshi Nakano, "Development of simulation programs for classical mechanics –Using UNIX system –", Computer & Education, Vol. 6, pp. 107-111, (1999).

[2] Butsurigaku Kiso III Home Page, http://kiso3x0.phys.human.nagoya-u.ac.jp/ (accessed on August 9, 2000)

[3] Yasuyuki Nakamura and Hiroshi Nakano, "A Computer Network System for Physics Education –Using Linux –", Proceedings of the Seventh International Conference on Computers in Education (ICCE' 99), Chiba, Japan, November 4-7, pp. 821-822, (1999)

[4] JAVA Physics Resource Mailing List, http://www.nep.chubu.ac.jp/~nepjava/applet.htm (accessed on August 9, 2000)

[5] Simulations on Physics, http://www2.tky.3web.ne.jp/~inaga/index.html (accessed on August 9, 2000)

[6] Virtual Laboratory, http://www.cmt.phys.kyushu-u.ac.jp/virtuallab.html (accessed on August 9, 2000)

Evaluating educational multimedia: a case study

Elizabeth A. Kemp and Raymond H. Kemp
Institute of Information Sciences and Technology,
Massey University, Palmerston North, New Zealand
E.Kemp@massey.ac.nz, *R.Kemp@massey.ac.nz*

Following constructionist principles, postgraduate students who were studying a paper on Human Computer Interaction were required to build educational multimedia systems and then to evaluate those produced by their colleagues. The experience of developing a multimedia system, together with lectures and access to general material on the topic, enabled them to provide valuable insights into important issues. Nonetheless, the students were not, on the whole, able to transfer all that they had learned when building their own systems into an evaluation framework. The provision of scaffolding was recommended to facilitate transfer.

Keywords: **Multimedia, Evaluation, Constructionism**

1 Introduction

What are the criteria that should be used to judge the effectiveness of interfaces for multimedia tutorial systems? In an experiment with a class of postgraduate students studying Human Computer Interaction (HCI), they were asked to develop their own framework for evaluation. To give them some notion of what to look for and what to expect, they first had to form groups and construct their own multimedia tutorial systems. This approach is based on the idea of constructionism [6]. By collaborating in a group to develop some appropriate product, it is suggested that learners can come to a better understanding of the principles of a subject rather than by just being given the information by a teacher. This is in line with the wry comment from Jonassen *et al* [9] that the people who learn most from instructional materials are the designers.

The students were required to work together with one or two other classmates to produce their own small scale multimedia educational systems. Using the knowledge and experience they had gained, they then had to individually evaluate the interfaces of the other systems. There was no detailed specification about how to carry out these activities. The students had, however, been exposed to the main issues through lectures and discussions. They also had appropriate readings made available to them. The intention, therefore, was to see what the students, themselves, considered appropriate ways of evaluation in the light of their background and their experience in developing multimedia software. An assessment was then made of how much they had learned when building systems and how well the knowledge was applied to evaluating the systems of others.

2 Previous work

Interface evaluation can be carried out for many different purposes. The distinction is usually made between formative evaluation where improvements to a system under development can be determined and summative evaluation which assesses the overall performance [8]. There are a range of methods that can be used depending on the purpose of the study. Preece [12] categorises these purposes as analytic, expert, observational, survey and experimental. Analytic techniques are used to determine the complexity of the interfaces. Expert evaluation involves inviting people experienced with interface issues to identify usability problems. Observational, survey and experimental studies all have in common the involvement of what Preece terms "Real users." Users can be observed using software, provide feedback about the system through interviews or questionnaires or take part in experiments to test the impact of various features of the interface.

A common method of evaluation that does not involve users is expert evaluation where, as noted above, people

with some knowledge of interface issues detect possible problems. This process can be conducted in accordance with the guidelines formulated by Nielsen and Molich [11]. The following aspects of the interface are all considered in what is referred to by these authors as a heuristic evaluation: simple and natural dialogue; speaking the user' s language; minimising user memory load; consistency; feedback; clearly marked exits; short cuts; good error messages; prevention of errors, and help and documentation.

An examination of the literature on multimedia reveals little mention of evaluation. Testing is usually discussed but not evaluation [4, 15]. Some important principles emerge, however. Alty [1, p33] points out that "A key question is when to use which media and in what combination to achieve the maximum effect." He also observes that success in multimedia depends more on the *combination* of media rather than on the provision of a rich set of media. Frater and Paulissen [5] note that interactive tutorials should allow the user to choose the starting point and allow the information to be accessed as often as required. They also offer this piece of advice. "Keep in mind that multimedia can make learning much more interesting when animation and sound files are used to explain the topic. Also a quiz is more fun when set up as a game" [5, p362]. Preece [12] points out that navigation, too, is an important consideration in hypertext/multimedia systems. Users, as she notes need to be able to know where they are, how they reached that point, where can they go next and how they get there. This as pect of interface design is actually covered by the first heuristic of Nielsen and Molich [11] which refers to "Simple and natural dialogue." This takes into account navigating through a system. Interface factors in interactive multimedia systems are also considered in Reeves and Harmon [13] and Tannenbaum [14].

One recent taxonomy in the literature provided by Heller and Marti.. [7] aims to help students on multimedia courses understand the forms of media as well as enabling them to evaluate the work of others. It has two dimensions - the media type and the means of expression (elaboration, representation and abstraction). This classification shows, for example, that text might be fully elaborated (large chunks of narrative), can be abbreviated (represented in bullet points) or might be abstract in nature such as text in a logo. Students are able to check whether a medium has been used in an appropriate fashion. As the authors state, though, the taxonomy takes no account of the effect of combining several media. Nonetheless, it is useful in focusing on the evaluation of each element. Detailed guidelines about how to use each medium, for example text, can also be found in Vaughan [15] and Collins [2].

3 Course structure

"Topics in Human-Computer Interaction" is a single semester paper for postgraduate students in Computer Science and Information Systems at Massey University. Most students have already completed a third year undergraduate paper "Human-Computer Interaction" in which the underlying theory is presented. These students will also have gained some experience in developing interfaces. The aim of this course is to consider issues of current interest such as computer supported co-operative work, innovative interfaces, different ways of evaluating the interface, multimedia systems and interfaces on the World Wide Web. Teaching is carried out through a mixture of lecturing, student seminars, discussion and demonstrations (of software such as Adobe Premiere and Macromedia Director). Students have available to them two books of readings which cover the material taught.

One assignment for this paper involved the students working in groups to develop a small multimedia system with an educational focus. The groups could choose any appropriate subject. Each student was then asked, individually, to evaluate the interfaces to all the other systems. A set of lectures had been given on the topic of multimedia including exposure to several life cycles for developing software of this kind. The topic of evaluation had also received considerable coverage in lectures and student seminars. Students were aware that interfaces can be evaluated for various purposes and in many different ways (for example by heuristic evaluation, interviews, questionnaires etc.)

Guidance on the life cycle that should be followed to develop the multimedia systems and the method of evaluation required was deliberately kept to a minimum. In the light of the teaching on the course and the material available to them, students were expected to make their own informed decisions. In particular, it was hoped that the students' own experiences in developing multi-media software would give them some insight into the criteria that should be employed when evaluating the interfaces to the other students' systems.

4 The student systems

Six groups each developed their own multimedia system. The systems were expected to offer instruction to their users and be interactive. A brief description of the systems follows.

Maori Language Tutoring

This system was designed to help students learn the Maori language. The study material was based on the philosophy that Maori be used wherever possible, with visual and aural stimuli to teach the vocabulary. Words were introduced via demonstrations using pre-recorded video clips. The system, however, also contained explanation in English for students who did not wish to completely immerse themselves in Maori. As well as learning new terms, students could choose to review vocabulary or test their comprehension. Maori music and designs were used in this system where the developers thought appropriate.

Learning the New Zealand Road Code

A written test on the New Zealand road code has to be passed before learner drivers can take their practical driving test. The aim of the road code system was intended to make the learning process more interesting. It was believed that by using animation, audio and video, the learning process would be enhanced. The system included tutorial material on aspects of the road code (for example, how to overtake or what to do when approaching a roundabout) as well as test material.

Earthquake Disaster System

The earthquake disaster system was developed to show people how to behave in the event of a serious earthquake. It included clips from a video developed by Civil Defence. Topics that were dealt with included planning for and coping with an earthquake. The opening screen showed a photograph of the devastation caused by a major earthquake. Music and animation chosen to reflect the theme of devastation accompanied the photograph.

Shape Recognition

The intention of the shape recognition system was to help children learn how to identify both two and three dimensional shapes in a lively and interesting way. Sound, animation and graphics were included in order to make the system appealing to children. Another goal of the developers was to make the system easy to use. There was a particular emphasis on the use of colour which was seen by the developers as making the system attractive to the intended users. The opening screen was designed to capture the attention of children with music and morphing shapes.

Introducing the Internet

This system, as its name implies, was intended to be introductory in nature. Its target group was school children who could find out about concepts such as email, newsgroups, file transfer protocol etc. This system made use of graphics and sound but also included lengthy textual explanations. As with the shape recognition system, there was an emphasis on the use of colour. Ease of navigation was also a major consideration.

Undergraduate Studies in Computer Science

This system allows students to find out about the staff and the papers they teach in a Computer Science department. Photographs of staff members were included. When browsing through the system, users were able to move from a staff page to obtain information about papers taught by the staff member. Contextual information about the location of the building where the Computer Science staff were housed was also provided. The opening screen of the system showed a picture of the university grounds. Other pictures could also be viewed.

5 Educational Issues

Although the course does not deal with issues of computer-based learning, this was the focus of the assignment and gave the students some context for the systems they produced. They were expected to choose an approach to teaching which was appropriate for the subject that was being taught and that they felt would be effective in a multi-media setting. They all propounded the philosophy of their systems during their presentations. It is interesting to compare the different approaches that the students chose for their systems and how this was reflected in the presentation styles.

The Maori language teaching system immerses the student in the subject and attempts to teach by example. As noted earlier, the system can be used without reference to English words or phrases. Maori, like various other languages such as Japanese is very much bound up in the culture of the people and so this approach seemed entirely appropriate. Maori songs, words and phrases in a commentary with accompanying visuals provided a backdrop that was both stimulating and educationally appropriate.

The road code system contains video clips produced by the students themselves which graphically illustrated both correct and incorrect procedures to be followed in various situations when driving. This could be regarded as teaching by presentation and illustration.

Like the road code tutorial, the earthquake disaster system has an emphasis on illustration using video clips and contains other factual information in an appropriate form.

Unlike the previous systems, the shape recognition tutor includes trial and error examples for the student to consider. It takes into account the answers the student gives and does not continue until it judges s/he has fully understood all the current concepts. It could be regarded as a mastery system from this point of view.

The internet system contains a great deal of information in a text-based format, but the presentation was enhanced with appropriate animations. Material is set out in an simple to follow form and subjects can easily navigate around the system to discover what they need to know.

The undergraduate studies in Computer Science system also allowed students to learn about the department of Computer Science in a discovery mode. In some senses this was the package that was the least like a tutorial system, since it just provided information in a non-instructional form.

The underlying objective of the assignment was to determine whether or not students had assimilated a fundamental principle of HCI - that issues concerning functionality should not be divorced from interface concerns. Given the experience of developing a multimedia system, it was hoped that students would take into account the educational aims of the system as well as the multimedia features. It was not the object of the exercise, however, to see whether effective learning took place. It was expected that some variation of expert evaluation would be followed. What was of interest were the criteria that students incorporated into their checklist. Issues it was hoped would be addressed (in the light of the literature on this topic) included the following:

- whether the interface reflected the educational objectives of the system;
- the suitability of the media selected;
- the user appeal of the systems;
- the interface concerns;
- evaluating the execution of the various media.

6 Results

Every student (thirteen in total) appraised all the systems developed by their colleagues. All the students provided a checklist of the criteria used for the evaluation - some were very detailed and others quite brief - from thirty items at one end of the scale to five at the other. The two students with the longest checklists evaluated whether the system fulfilled its objectives, the selection of multimedia components and the execution of the multimedia as well as detail of the interface such as the provision of feedback, ease of navigation etc. There were another three quite comprehensive taxonomies which covered many but not all of the relevant issues. Five students used Nielsen's [10, 11] guidelines for heuristic evaluation without adding to them to deal with the educational or multimedia aspects of the systems. The three students with the short checklists had incorporated rather broad categories such as ease of use, knowledge presentation, navigation, multimedia concerns and quality of knowledge which gave them reasonable but not complete cover of the relevant issues.

Expert evaluation can be carried out by anyone with appropriate skills and by more than one evaluator. In one case, two people evaluated the systems and combined their findings whilst on another occasion the student drew up the framework but did not carry out the heuristic evaluation himself. Some students scored the various items and averaged the results. This enabled systems to be ranked. Others did not attempt to provide an overall score for each system but left the findings to speak for themselves.

1. Did students check to see whether the interface reflected the educational objectives of the system?

In total, eight of the students included questions in their checklist which related to the educational nature of the system. Three of these explicitly mentioned the educational objectives of the systems under review before providing their assessment.

> *"This system is a multimedia tutor system designed to aid students in learning the Maori language. The system uses both visual and aural stimuli to teach words and concepts."*
> *"The system aims to provide information to undergraduate students."*
> *"It aims at helping children to learn a shape through playing which makes learning easy and fun."*

The eight students who considered the purpose of the system, that is its educational aspect, did not all ask the same questions. A variety of issues were covered as follows:

How does the system consider educational objectives?
Is the system suitable for intended users?
Who is the target audience?
Is the system aimed at the right audience?
Does the system have a reasonable informational content?
Is the quality of knowledge sufficient?

The evaluations included comments such as the following:

> *"Good way to teach a student with audio pronouncing the language and seeing the words on the screen."*
> *"Including some information on the properties of the different shapes and showing everyday examples of them would make learning the shapes a richer experience."*
> *"It does not really seem to be an educational system, more an informative system."*
> *"The current system does not seem to have a glossary page. A page for quick lookups and acronyms and jargon would probably be helpful."*
> *"It might have been good to have an option of telling users what the different shapes look like."*

Some of the students, however, not only evaluated the systems in accordance with their checklist but also in the light of their experience in appraising the programs. They mentioned, therefore, other important criteria in their assessments. One student centred her overall assessment around the suitability of a system for its purpose although this was not included in her criteria for evaluation. Two other students, also, mentioned educational issues such as whether the systems provided adequate content and comprehensible instructions.

> *"I had no idea what I needed to do and how the test was being processed."*

2. Did the students consider whether the mix of multimedia selected was appropriate for the stated purposes of the system ?

Only two students included in the guidelines for evaluation the need to consider whether suitable media were selected and used appropriately. One student asked the question "*Is the multimedia actually of use and not redundant?*" The other student checked that the mix of multimedia was used appropriately. This student noted not only occasions when a particular mix of media was ineffective but also when media was missing.

> *"The current system seems to rely too much on textual information. Improvements would be to make more use of video, diagrams and to provide more navigation options. These changes would give the user a more enriching learning experience."*

Many other relevant comments were made by the other students about an appropriate usage of multimedia, although they did not take the issue into account systematically.

"Of all the applications reviewed this has the most appeal due to its excellent usage of graphics and sound. The main area it could be faulted on is the large textual explanations given but these are offset by the following graphical examples."

"It uses multimedia such as sound and text making the system vivid and active."

Only one student fell into the trap of believing that a multimedia system had to incorporate all media. He would criticise a system that did not include video, for instance. No regard was paid to whether adding video would contribute to meeting the goals of the application.

3. Since educational systems have to be appealing to their users, did the students take this factor into account?

With regard to the appeal of a system, this issue was only expressly considered by four students. Related questions were as follows:

Is the system interesting and fun?
Does the user find the system visually appealing?
Has information been presented in an interesting manner?
Has the system an attractive presentation?

Comments made by these students include the following:

"Its creative design of the main menu ... and its appropriate use of the sound medium, make it enjoyable to use the system."
"There was no splash screen introduction. Whilst this may seem superfluous, good splash screens can be used to arouse a user's interest."

Three other students, however, did mention this issue. One of these was the student who did not carry out the expert evaluation himself. After watching the evaluation (according to Nielsen's guidelines as specified), he realised that the system he preferred obtained the lowest rating. He proceeded to base his overall assessment of the systems on whether they had an interesting and attractive interface. A second student also focused on the interest or lack of it in the programs. Of the Maori tutor, she said " *The welcome interface is impressive. The background and the music gives me some feeling of Maori culture.*" According to her, another system was a little bit boring.

An issue that relates to the appeal or attractiveness of a system is the appropriate use of colour. Four students included at least one item in their checklist concerning colour. Questions were as follows:

Are too few or too many colours used?
Is the colour in the system beautiful?
Does the use of colour help to make the displays clear?
Is the use of colour bad, normal, good or excellent?

One system was notable for its use of colour and several comments were made about this

"The very colourful shapes used are appropriate for the school based children as seen as being the intended users."
"The colour used in the system is beautiful."
"Good colour choice, relaxing."

This was not the only the system to make effective use of colour, however and one student observed in his conclusion that no-one made the mistake of using too many colours.

4. What typical interface factors were considered?

All of the students checked for at least one well-known interface concern such as consistency, clearly marked exits etc. Seven of them specifically included the guidelines for heuristic evaluation by Nielsen and Molich [11] or the updated version by Nielsen [10] in their checklist.

It was also expected when considering interface issues that the importance of navigation in interactive instructional systems should be recognised. It should not be just one more item in a checklist. Eleven of the 13 students took account of this issue.

"No stop, rewind or scroll bars for video."
"Gives reasonable freedom to navigate backwards and forwards."
"Not very flexible, very linear in its execution."
"It is very easy to get "lost" while navigating through the system. No "back" button provided."
"Clicking at various places in the window may move you to unexpected screens."
"With the test screens there is no title indicating this."
"Have no idea what I am supposed to do in the first screen."

Four of the students highlighted the importance of navigation. Three incorporated this into their framework as a high level criteria. A fourth not only checked how users moved around the system but whether or not the users would know where they were in the system.

5. Did the students evaluate the multimedia components of the system?

Four students evaluated the execution of the individual media. Two of these assessed the effectiveness of each component: video, sound, graphics, text etc. by rating them on a scale. The third student concentrated on text and icons. His section on text was quite detailed, checking the length of the sentence, whether it just focused on one issue, and whether there was sufficient white space around it. The fourth student checked that the multimedia was not "over the top".

"When the system explained the Maori words, text is well organised."
"I liked the use of Maori music with the splash screen."
"Liked the introduction - morphing shapes."
"Widely accepted icons are used to aid page-based navigation."
"The background music is excellent. The button clicking sounds great."
"Image excellent. When the system first starts, the animation is creative and attractive."

7 Discussion

Reflecting on the results of the assignment, it became clear that learning about multimedia evaluation took place at various points in time. Most of the systems developed by the students were stimulating to watch. As developers the students were clearly aware of the need to use appropriate media in suitable combinations [1] and of the requirement to navigate easily through the system [12]. Some of what they had learned was reflected in the checklists that they developed for evaluating the systems of others. There was a difference, however, between the criteria specified by students for evaluation and those actually used when making their overall appraisals. These sometimes took additional factors into account that had not been included in the stated checklist. The experience of evaluating the systems themselves, allowed further learning to take place. It will be the more complete list of factors that are considered in the remainder of the discussion since the experience gained from carrying out appraisals is important and should not be discounted.

Eleven students checked to see whether the interface reflected the educational objectives of the system and two of these also considered whether the mix of multimedia was appropriate for the stated purposes. All of the students considered at least one relevant interface factor (consistency, clearly marked exits, etc). Six of the students also realised the need to find out whether or not a system would appeal to users. Four students included assessment of media components in their appraisals, however none of their questions showed a deep understanding of media issues.

It was pleasing from an educational perspective that most of the students when carrying out their evaluations took account of the functionality of the system. This cannot be divorced from interface considerations as for many users the interface is the system and must deliver the appropriate functionality.

Interface issues, too, were seen as important by all of the students. Of these, 11 checked to see whether a user

could easily navigate around the program. This is an important issue in interactive multimedia systems and was recognised as such by the students. Eight of the students carried out a reasonably comprehensive evaluation of traditional interface concerns but for five it was rather rudimentary. This was surprising given the emphasis on the heuristic evaluation in the undergraduate and post-graduate courses.

Overall there were only two students whose evaluation was limited to just those interface issues covered by Nielsen [10, 11]. This meant that they excluded educational considerations, the appeal of the interface, an evaluation of the individual media and whether or not they were used in appropriate combinations.

A major weakness in the student evaluations' overall was the failure to consider whether the mix of multimedia selected was appropriate for the purpose of the system. Whilst the students did consider educational issues at a high level, they found it difficult to move to a detailed perspective, that is were suitable media selected and combined? This may involve greater knowledge of the potentialities and problems of the individual media than the students possessed. They tended, therefore, to have an overall impression of a system. This was reflected again in the failure of two thirds of the students to evaluate the exe cution of each media component.

Around 50% of the students did not take appeal/interest and fun sufficiently into account. This can possibly be attributed to the fact that they were not the intended users of the systems. If they had been drawing up a list of questions for users to answer they may have incorporated this. Nonetheless, it was an important omission as multimedia systems set out to interest and hold the attention of their users.

As the above discussion shows, students were particularly weak in considering what was to them the new area of multimedia. They did not appear to have the knowledge or experience to determine how to evaluate the media. They were given some exposure to these issues in lectures but do not appear to have followed them up. Whilst no one student came up with a complete checklist for evaluating multimedia systems, amalgamating the items in their checklists enables a comprehensive framework to be developed. See Appendix 1 for the main features of this. In future it may be preferable to provide students who have built a multimedia system with some scaffolding to help with the evaluation phase. Scaffolding [3] refers to supports that can be provided by a teacher to students. The main headings in the taxonomy outlined in the Appendix could be provided. The students could then be asked to develop appropriate questions for each area.

8 Conclusions

The students learned a great deal by building multimedia software and evaluating the systems of others. This was reflected in the perceptive comments of the students made in their written assignments. It was not always reflected, however, in the frameworks for evaluation that they developed, only two of which were comprehensive. Certain areas were handled well by the students, for example checking that each system was suitable for its purpose and the importance of navigation. Two significant issues, though, were only identified by a minority of the students – the need to choose appropriate media and to determine how well they had been produced. It appears that because the area of multimedia was new to the students, they needed more scaffolding in place to be able to learn from their own experiences. Instead of developing an evaluation framework from scratch, some initial information can be given to students in future that they then have to flesh out.

References

[1] Alty, J. L., Multimedia – "What is it and how do we exploit it?" In D. Diaper & N. Hammond. (Eds.), People and Computers VI, pp. 31-44, Cambridge: Cambridge University Press, (1991).

[2] Collins, A., "What different media do best", In The Six International Conference on Computers in Education, Beijing, (1998).

[3] Collins, A., Brown J.S., & Newman S. E., "Cognitive Apprenticeship: Teaching the craft of Reading, Writing and Mathematics", In L. B. Resnick (Ed), Knowing, Learning and Instruction, Hillsdale, New Jersey: Lawrence Erlbaum, (1989).

[4] England, E., & Finney, A., "Managing Multimedia", Harlow: Addison-Wesley. (1996).

[5] Frater, H., & Paulissen, D, "Multimedia mania : experience the excitement of multimedia computing", Grand Rapids: Abacus. (1993).

[6] Harel, I. (Ed.), "Constructionist Learning", Boston: MIT Press, (1990).

[7] Heller, R., & Martin, C. D., "A Media Taxonomy", IEEE Multimedia, 2(4), 36-45. (1995).
[8] Howard, S., & Murray, D. M., "A Taxonomy of Evaluation Techniques for HCI", In H. J. Bullinger & B. Shackel (Eds.), Human Computer Interaction. Interact' 87, pp. 453-459, Amsterdam: North Holland. (1987).
[9] Jonassen, D. H., Wilson, B. G., Wang, S., & Grabinger, R. S., "Constructivistic uses of expert systems to support learning". Journal of Computer Based Instruction, 20(3), pp. 86-94, (1993).
[10] Nielsen, J., "Enhancing the explanatory power of usability heuristic", Proc. ACM CHI'94 Conf. (Boston, MA, April 24-28), 152-158. (1994).
[11] Nielsen, J., & Molich, R., Heuristic Evaluation of User Interfaces. In J. C. Chew & J. Whiteside (Eds.), Proceedings of CHI' 90: Human Factors in Computing Systems, pp. 249-256, New York: ACM Press. (1990).
[12] Preece, J., "Hypermedia, multimedia and human factors". In C. Latchem, J. Williamson, & L. Henderson-Lancett (Eds.), Interactive Media, London: Kogan Page, (1993b).
[13] Reeves, T. C., & Harmon S., "Systematic evaluation procedures for interactive multimedia for education and training". In S. Reisman (Ed.), Multimedia Computing: Preparing for the 21st Century, London: Idea Group Publishing, (1994).
[14] Tannenbaum, R. S., "Theoretical Foundations of Multimedia", New York: Freeman, (1988).
[15] Vaughan, T., "Multimedia: Making it Work", Berkeley, Cal: Osborne McGraw-Hill. (2nd ed.). (1994).

Appendix 1

1. Does the system meet its objectives?
    - Who is the target audience?
    - Is the system suitable for the target audience?
    - Does the system include (in the case of educational systems) sufficient content?

2. Has an appropriate mix of multimedia been selected?
    - Have sound and text been used effectively together?
    - Have sound and graphics been used together effectively?

3. Will the program appeal to users?
    - Is the system fun?
    - Will the user find the system visually appealing?
    - Has the system a features that will pall over time e.g. an unusual sound or joke?
    - Has colour been used in an appropriate fashion?

4. Has the interface been properly constructed?
    - Is the interface consistent ?
    - Is help available when necessary?
    - Can users easily navigate around the system?
    - How does the user navigate around the system?
    - How does the user know where s/he is?
    - Is progression through the program logical?
    - Can the user start and stop as required?

5. Have the individual media been well-executed?
    - Is the text /graphics,/sound etc well produced?
    - Are the sections of text too long/too short?
    - Will the text be understood by the target audience?
    - Has text been expressed using elaboration, representation or abstraction?

Learner Control in Technology-mediated Learning within a Constructivist Model

Manuela Perez and Jun H. Jo
School of Information Technology
Faculty of Engineering and Information Technology
Griffith University, Gold Coast, QLD, Australia
PMB 50 – Gold Coast Mail Centre
QLD 9726 – Australia
Tel: + 61 7 5594 8266
Fax: + 61 7 5594 8066
E-mail: M.Perez@gu.edu.au and J.Jo@gu.edu.au

This paper explores current strategies on learner control within a technology-mediated learning environment, with a special emphasis on constructivism as the underlying learning theory. An adaptive learning model, based on constructivism is presented. The model addresses the issues of learner control and its implementation within a technology-mediated learning environment. The model's major components: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module are outlined and analysed. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible. We propose a system that is dynamic and merges the capacity to deliver educational material with the ability to analyse learners performance, based on navigational patterns and results, and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

Keywords: **Learner Control, Technology-mediated Learning, Constructivism, Technology-mediated Adaptive Learning Model.**

1 Introduction

Technology has impacted greatly on education. Since the introduction of technology, new delivery methods, as well as new challenges, have emerged. One of the most important delivery methods introduced has been flexible delivery or flexible learning as it is now preferably called. Flexible learning is learning that can be achieved at your own pace and independently of time and place. Several technology-mediated approaches, for example, Web Based Instruction (WBI) and Competency Based Instruction (CBI), have been used to provide the flexibility required to deliver flexible learning.

Technology-mediated learning is versatile. It can be used as the only means to deliver education or as an aid to traditional up-front teaching. Although technology has been embraced by education, there are areas of concern over its use, or more precisely, over its misuse. Areas of concern include: access to the medium, measurement of students learning, testing the validity of the Internet as an instructional medium and the cost of producing technology-based learning materials (Rickard, 1999; Eckert *et al.*, 1997). Selwyn (1996) points out that the Internet can become a trap for both teachers and students as it can go from the '*tool to the toy*' in education if its use is not properly guided and monitored. Phillips (1980) also expresses concern about the quality of on-line materials on the Internet. In spite of these issues the proliferation of courses designed and developed for a technology-mediated environment continues to increase.

This paper explores current trends on technology-mediated learning environments with an especial emphasis on learner control. The paper also proposes an adaptive learning model based on constructivism. The model addresses the issue of learner control and its implementation within a technology-mediated learning environment.

2 Technology and learning control

A technology-mediated environment offers the learner a number of choices and alternatives that were inconceivable in a traditional educational setting. Traditional education, both on-campus and distance learning, is highly structured, teacher centred, mostly one-way communication and directed to passive learners. In contrast, technology-mediated learning, within a constructivist approach, can be learner centred, unstructured to suit the learner's individual learning needs and context-based. It also allows the learner to take control of the learning process, promotes social discourse and collaboration and contributes to the personal growth of the learner.

2.1 Learner Control in Technology-mediated Learning

The definition of *learner control* often appears to be elusive. In its broadest sense, learner control refers to the level of self-determination that the learner has in making decisions about his/her learning (Doherty, 1998). Learner control is often being addressed in combination with other factors. For example, learner control and attitude towards the technology-based system used (Ivanoff and Clarke, 1996; Mitra, 1997) and learner control and epistemic beliefs (Jacobson, *et al.*, 1996). Learner control, within the scope of this paper, refers to the degree of autonomy that learners have in organising, pacing, sequencing and using the available learning resources. That is, the ability and power of adapting the technology-mediated environment to suit their individual specific learning needs. Control over their learning direction and pace is made possible by the many alternatives and choices that a technology-mediated learning system offers the learner (Bagui, 1998). The level of control that the learner needs to exert over the learning environment is not constant over time. Learners will engage in different levels of control depending on their individual learning style (Rasmusen and Davidson-Shivers, 1998), prior knowledge of the material or related material (Fitzgerald and Semrau, 1998), attitude towards information technology (Ivanoff and Clarke, 1996; Mitra, 1997) and past experience, initiative, intellectual and social maturity, metacognitive proficiency, and insights (Ewing *et al.*, 1998).

2.2 The role of the teacher in Technology-mediated Learning

Frank Wydra anticipated a learning environment in which the teacher's role focus changed from delivering instruction to designing the instruction (Wydra, 1980). By the hand of technology we may transform the teacher from the "*sage on stage*" to the "*guide at the side*" (Andrews, 1997). Within a technology-mediated learning environment, the educator's role, far from becoming redundant, metamorphoses into a more challenging and active one. The educator becomes the leader, designer and manager of the learning environment (Doherty, 1998). Other vital functions are initiating the learning process; supporting, encouraging and motivating the learner and mediating between the learner, the technology and the resources (*Ewing et al., 1998*).

The new role of the teacher, in technology-mediated learning, is a very demanding one. *Ewing et al.*, (1998) emphasise the great deal of effort that goes into planning and preparing technology-mediated learning materials and environments. The design and development of multimedia teaching material, especially for distance education, is a time-consuming process. For one hour of CBT software approximately 200 hours of development time are required (Kawalek, 1995). The educator's role does not stop after the planning, designing and preparation of the technology-based materials. It must also facilitate the learning, monitor learners' progress and evaluate the performance of the system, the learners' and his/her own in order to further improve the system. "*The need for the teacher does not go away*" in a technology-mediated environment with emphasis on learner control (Andrews, 1997).

3 Constructivism

The introduction of technology-mediated learning has called for a revision of learning strategies.

Constructivism is gaining momentum and has been heralded as the most appropriate learning theory for the technological classroom. Constructivism was introduced by Piaget's and Vygotsky's learning theories. Piaget's learning theory involves two cognitive stages: assimilation and accommodation (West *et al.*, 1991). During the assimilation stage the learner attempts to fit the environment with existing mental schemata. The accommodation stage is reached when the learner is confronted with a new experience, for which no schemata exists, or one exists but does not conform to the new experience. As a result, equilibrium occurs when, through an alternate process of assimilation and accommodation, the learner achieves cognitive stability. Externally in-coming experiences find a corresponding mental schemata and the learner is aware of this fact. In order to achieve high-level cognition the learner must be aware that learning has indeed occurred. Otherwise, learning will stop at the behaviourist level where it is ascertained by an external party, usually the teacher, or in the case of a technology-mediated environment by a computer program.

Vygotsky's learning theory differs from Piaget's in that he sees learning taking place within a social and cultural context. He argues that social interaction affects the way the learner sees the world. That is, it contributes to the way the learner constructs his/her schemata. Therefore, the quality of the learning will be determined by the quality of the social interactions or what Vygotsky terms *zone of proximal development* (Oliver, *et al.*, 1997).

In a learning environment the cultural and social interactions translate to interactions between teachers and peers. Within this collaborative learning environment the teacher becomes the facilitator of learning. The facilitator's role should be to design, promote and guide the learning but not to enforce it as learning is an individual process. Knowledge in this environment is socially constructed and has no absolute value but a socially agreed value.

4 The proposed learning model

The aim of the proposed model is to offer an adaptive learning system that caters for different types of learners and learning styles with an especial emphasis on learner control. The proposed model operates within a constructivist approach to learning (Ewing, *et al.*,) based on the following points:

1. **All learners are different**
2. **Learning is individual to each learner**
3. **A learner can learn at different speed levels in different situations**
4. **A learner can engage in different learning strategies simultaneously**
5. **Learners learn best with a context**
6. **Learners construct and re-construct knowledge as they seek to understand and explain their environment**

4.1 Proposed model learning variables and controls

The concepts of learner individuality and learner control are essential to constructivism. Table 1 below depicts the main variables involved in the proposed model in relation to learning control and learners' choices and options.

VARIABLES	CONTROLS	
	INSTRUCTOR	LEARNER
Learning Objectives	Overall	
Amount of information provided	Overall	
Amount of information used **Addition/removal of material**		Desirable
Material appearance and mode		Desirable
Pacing, time	(When necessary)	Desirable
Sequencing	(When necessary)	Desirable
Place, location		Desirable
Monitoring learners' individual progress	Overall	
Interaction and collaboration	Shared	Shared
Assessment	Overall	

Table 1. Control Variables and Controllers

The term ***desirable***, rather than ***overall***, is used in the learner control column because the proposed model's aim is to empower learners not to force them to take control. For example, a learner that possesses prior knowledge of a topic is more likely to exercise control over his/her learning than a novice learner is. The second is more likely to follow a linear approach to learning until he/she too acquires prior knowledge.

Learning objectives

Learning objectives within the model are explicit, clearly specified and achievable. The acquisition of non-anticipated learning objectives is possible within the system, especially, when the learner accesses more information that is required to complete a task. This is a positive feature of the model as far as the specified learning objectives have been reached.

Amount of information provided and used

The system contains all the information necessary to achieve the specified learning objectives or provides references to acquire it. However, the learner controls the amount of information that is actually used. A learner can discard a particular learning material piece in favour of another, which has been acquired from external sources, just because is easier to understand or is visually more appealing. Learners' performance can be improved by designing materials that can be adapted to satisfy different learning styles (Rasmussen and Davidson-Shivers, 1998).

Learning material appearance and mode

A genuinely adaptive technology-mediated learning system must allow learners to customise the appearance and mode of the material displayed. This may include: changing background and text colours and choosing between text, graphics, audio and video modes.

Pacing and timing

The learner has the autonomy of pacing his/her learning and scheduling his/her study time. However, in some instances this has to fit within the general time-frame allocated to the course or subject. The designer controls the general time-frame, if one exists.

Sequencing

Learning materials must be accessed in the order that most benefits the learners' learning style. The model is able to cope with the demands of linear as well as non-linear approaches to learning. Figure 1 displays an example of the progression or navigation path of a learner who prefers to be guided by the system. '*Learner 1*' uses all the material provided and in the order provided until she encounters difficulties and seeks the help of an instructor or other learners. Then, revises the previous lesson and again continues with the linear path provided. In contrast, '*Learner 2*' feels confident enough to discard material provided and adds material from external sources. Both learners achieve the corresponding learning objectives through the use of different learning strategies. Beginners often benefit from having a structured learning path (Eaton, 1996). A graphical representation or map of the entire unit or lesson must be made available to the learners to guide their navigation decisions (Barba, 1993).

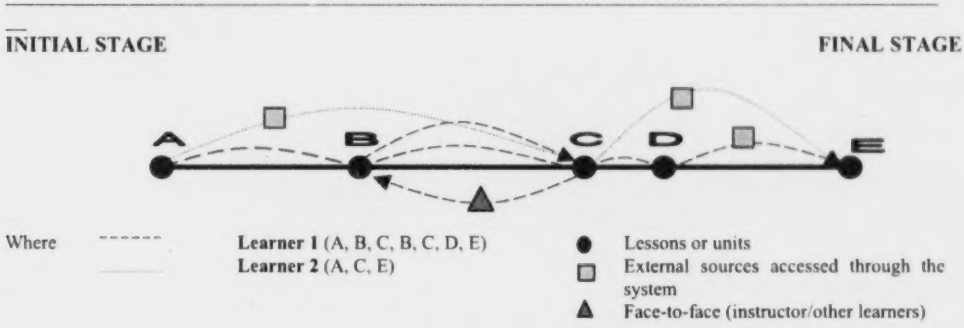


Figure 1. Learning Sequence Patterns – Linear and Non-linear

Learners must be free to use forward and backward navigation through the system as long as it does not compromise the learning itself. For example, if the completion of a task is the pre-requisite for another,

allowing the learner to move onto a task for which a pre-requisite has not been completed might result in a waste of time and unnecessary added frustration for the learner. For example, moving into algebra without knowing how to multiply.

Place and location
Technology-mediated learning offers the possibility of accessing and using learning materials at different locations. Using the proposed model, learners can now study at home, at appropriately equipped learning centres or at traditional classrooms.

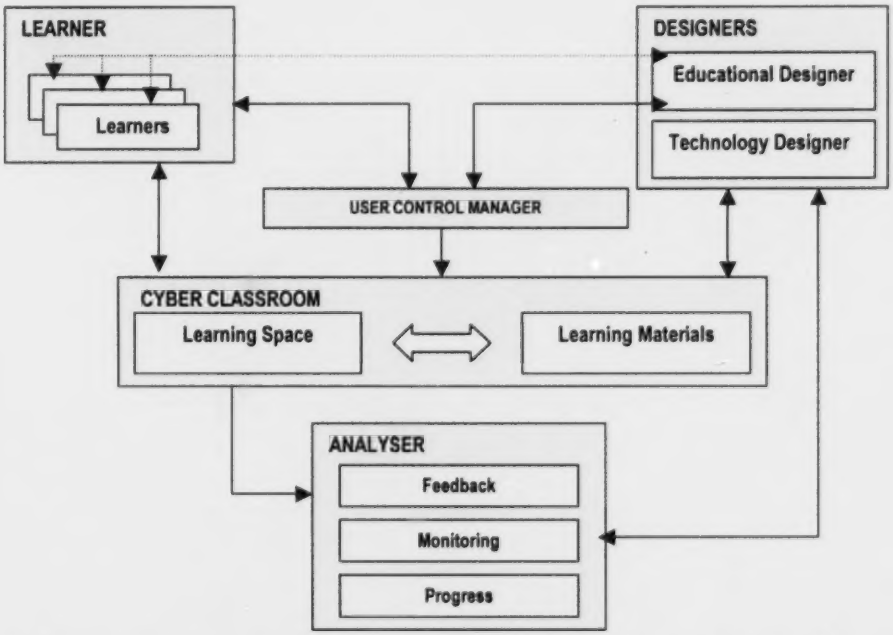
Monitoring learners' individual progress
Instructors are in control of monitoring the learners' individual progress. Based on the analysis of the learners' performance instructors can either guide or advise the learners through different strategies or modify the system.

Interaction and collaboration
The system must provide the capabilities to allow learners to interact with each other and with their instructors. This communication may occur, for example, through e-mail, and on-line forums. Physical, or face-to-face, communication is also a part of the model.

Assessment
Assessment is designed and administered by the instructor. This is to evaluate the students' learning performance and to provide feedback both to the educator and to the students.

4.2 Technology-mediated Adaptive Learning Model

The proposed model, the Technology-mediated Adaptive Learning (TAL) model, is composed of five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and Analyser module, Figure 2.



Where ⟶ Technology-mediated communication (web browsing, down/uploading, email, forum, database updates, ...)
⟶ Physical communication

Figure 2. The Technology-mediated Adaptive Learning (TAL) Model

4.2.1 Learner Module

The learner module comprises the learner group. Learners interact with the TAL system through the Learning Space. Communication with instructors and other learners occurs within the Learning Space or physically, as indicated by the dotted line in Figure 2.

4.2.2 Designers Module

The designers' module can be composed of an educator, instructional designer, multimedia designer and technicians. This module is concerned with three main areas: the educational design, multimedia design, and computer and Internet technology. The educational designer is in charge of designing quality learning materials within a constructivist approach. This includes being aware of the subject matter as well as the pedagogical theory in use. The multimedia designer and the instructional designer help the educator to appropriately formulate the teaching materials for CBI or WBI. The technology designer provides the means to make the learning materials available to the learner group through a technology-mediated environment. Good skills and tools for multimedia authoring and technical services are required in this module, which may cause production cost issues.

4.2.3 User Control Manager Module

The User Control Manager allows the learner to customise the learning space. Through this module the learner can select the display mode to suit his/her own learning needs and preferences, for example, text, graphics, audio or video mode. Pacing and sequencing of the learning material can also be controlled from this module.

4.2.4 Cyber Classroom Module

The Cyber Classroom module is composed of two sub-modules: Learning Space and Learning Materials module. The Learning Space is where the learning is delivered. This is generally a kind of display unit, such as a personal computer or a network terminal screen. It may also include equipment for sound and video. It must be easy to interact with and be self-explanatory. Within the Learning Space the learner has the option of accessing learning materials provided by the educator, such as lecture notes, or external resources such as Internet sites or libraries

4.2.5 Analyser Module

The purpose of the analyser module is three-fold. First, it gathers statistics on the performance and progress of learners. Second, it records learners' perceptions about the learning material presented and about the overall working of the system (learner feedback). Finally, it monitors and records students' navigation patterns into a database. These will provide an indication of the learners' preferred learning styles. This information can be used to provide advice for the learner and to improve the system (Chavero *et al.*, 1998) by evaluating the existing materials and options and formulating new ones. The optimal implementation of the system will be to incorporate an Intelligence module to automatically generate and administer changes, based on the information within the database.

The TAL model is being implemented in a couple of different programming languages and database tools.

5 Reviewing learner control, constructivism and the TAL model

5.1 The TAL Model and Learner Control

The main objective of the model is to provide a technology-mediated learning system able to support learner control within a constructivist approach. The learner control variables, identified in Table 1, have been built into the model. Learning objectives, amount of information provided, monitoring of learners individual progress and assessment are overall controlled by the instructor, while the amount of information used/added/removed, material appearance and mode, pacing, timing, sequencing, place and location are potentially controlled by the learners. Interaction and collaboration can be initiated by either party as the need arises.

5.2 The TAL model and Constructivism

The underlying pedagogical theory governing the TAL model is based on constructivism, and specifically on the constructivist elements represented in the table below. The model addresses all elements, however, its concrete effectiveness will only be determined after development and implementation, in practice.

TAL Constructivist Approach Checklist	
EXPECTED CONSTRUCTIVIST ELEMENTS	**TAL MODEL**
• All learners are different	The model allows for learner differences in needs, learning styles, and skills.
• Learning is individual to each learner	Learners can customise the learning materials to suit their learning styles and needs through the User Control Module.
• A learner can learn at different speed levels in different situations	Learners can control pacing and sequencing of learning materials.
• A learner can engage in different learning strategies simultaneously	Learners can engage in linear and non-linear strategies. Also they can learn independently and/or seek collaboration.
• Learners learn best within a context.	Learning materials (provided by the TAL model) are always presented within a context.
• Learners construct and re-construct knowledge as they seek to understand and explain their environments	This feature is intended within the model but only after implementation will it be ascertained.

Table 2. TAL Constructivist Approach Checklist

6 Conclusion

This paper has addressed current educational trends on learner control within technology-mediated learning environments. The roles of the learner and the teacher have been reviewed and analysed in the light of technology-mediated environments.

The TAL model, based on constructivism, was presented, and its major functions were explained. The model includes five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model presented, empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible.

From the designers point of view the model is a dynamic system that merges the capacity to deliver educational material with the ability to analyse learners performance (based on navigational patters and results) and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

References

[1] Andrews, E.A., A non-euclidean view of teaching, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[2] Bagui, S., Reasons for increased learning using multimedia, *Journal of Educational Multimedia and Hypermedia*, **7**(1), 3-18, (1998).

[3] Barba, R.H., The effects of embedding an instructional map in hypermedia courseware, *Journal of Research in Computing and Education*. **25** (4), 405-412, (1993).

[4] Chavero, J., Carrasco, J., Rossell M.A. and Vega, J.M., A graphical tool for analysing navigation through educational hypermedia, *Journal of Educational Multimedia and Hypermedia*, **7**(1), 33-49, (1998).

[5] Doherty, P.B., Learner control in asynchronous learning environments, *ALN Magazine*, **2**(2), (1998). URL:http://www.aln.org/alnweb/magazine/vol2_issue2/doherty.htm.

[6] Eaton. M., Interactive features for HTML-based tutorials in distance learning programs, *AusWeb96*, (1996). URL:http://elmo.scu.edu.au/sponsored/ausweb96/educn/eaton/paper.html

[7] Eckert, A., Geyer, W. and Effeldberg, W., A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[8] Ewing, J.M., Dowling, J.D. and Coutts, N., Learning using the World Wide Web: A collaborative learning event, *Journal of Educational Hypermedia*, **8**(1), 3-22, (1998).

[9] Fitzgerald, G.E. and Semrau, L.P., The effects of learner differences on usage patterns and learning outcomes with hypermedia case studies, *Journal of Educational Multimedia and Hypermedia*, **7**(1), (1998).

[10] Ivanoff, G. and Clarke, J., The use of the world wide web for teaching: things to consider before putting materials on-line, *Australian Communication Conference: Teaching Communications Skills in a Technological Era*, Monash University, Australia, (1996).

[11] Jaconson, M.J., Maouri, C., Mishra, P. and Kolar, C., Learning with hypertext learning environments: theory, design and research, *Journal of Educational Multimedia and Hypermedia*, 5(3/4), 239-281, (1996).

[12] Kawalek, J., in (Eckert, A., Geyer, W. and Effeldberg, W. (1997). A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada), (1995).

[13] Mitra, A., Categories of computer use and their relation with attitude toward computers, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Alberta, Canada, June, (1997).

[14] Oliver, R. and Omari, A. and Herrington, J., Exploring student interactions in collaborative world wide web learning environments, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[15] Phillips, R., What research says about learning on the Internet, *in* C. McBeath, C. McCoughlin and R. Atkinson (*eds.*), *Planning for Progress, Partnership and Profit, Proceedings EdTech '98*, Australian Society for Educational Technology, Perth, (1998).
URL:*http://cleo.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/p/phillips.html.*

[16] Rasmusen, K.L. and Davidson-Shivers, G.V., Hypermedia and learning styles: can performance be influenced? *Journal of Educational Multimedia and Hypermedia*, 7(4), 291-308, (1998).

[17] Rickard, W., Technology, education, and the changing nature of resistance, *EDUCAUSE, Educom Review*, Vol. 34 (1), 42-45, USA, (1999).

[18] Selwyn, N., The Internet and schools: An uneasy alliance? *Compute-Ed*, Vol 4, (1998).
URL: *http://www.education.uts.edu.au/projects/comped/Vol4/selwyn.html.*

[19] West, C. K., Farmer, J.A. and Wolff, P.M., Introduction to Cognitive Science and instructional design, *Instructional design: implications from a Cognitive Science*, pp.3-27, Allyn and Bacon, Sydney, (1991).

[20] Wydra, F.T., Learner controlled instruction, *Englewood Cliffs, Educational Technology Publications*, New Jersey, (1980).

Learning algorithm design through interactive simulation

Hoi-kau Yuen
Department of Curriculum Studies
The University of Hong Kong
Pokfulam Road, Hong Kong SAR, China
Fax: +(852) 2858 5649
Tel: +(852) 2859 2540
Email: hkyuen@hkucc.hku.hk

The teaching of algorithm design is a subject of great difficulty, however, its value has not been addressed in the curriculum of computer studies in secondary schools. The aim of this paper is twofold: to describe the method and design principles of developing the Traffic Light System Simulator (TLSS) and to discuss a learning example of using TLSS. The TLSS is a learner-centred simulation tool for learning algorithm design. It provides a daily life problem in a learning environment. In solving the problem, students are encouraged to think and construct their own possible solutions. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

Keywords: **programming, algorithm, simulation, learner-centred**

1 Introduction

"Algorithmics is the spirit of computing" advocated by Harel [4]. Computer programming mainly consists of three activities - problems identification, analysis; algorithm design to tackle problems; and algorithm representation in a computer coded language [16]. Algorithm is usually defined as a method, procedure, recipe or step-by-step process for doing a job, or a finite sequence of unambiguous, executable steps that will ultimately terminate if followed, in which "unambiguous" means at each step the action to be performed next must be uniquely determined by the instruction and the data available at that time. Yet algorithm design is usually more challenging and problems-bounded as it involves solving continuous problems during execution [16]. To design an algorithm is to find a step-by-step procedure for locating a clue for errors [5]. This design activity entails an exceedingly diverse activity and involves complex cognitive processes. Difficulties in discovering algorithms are prevalent in the learning of computer programming.

The teaching of algorithm design is a subject of great difficulty, its value, however, has not been addressed in the curriculum of computer studies in secondary schools. Algorithm design has been revealed as an activity that demands abstraction, analysis, and synthesis abilities from students [3]. Therefore, the learning of algorithm design contributes not only to the teaching of computer programming, but also the cognitive development of students [17]. This paper attempts to address the importance of algorithm design in computer programming by examining the development of the Traffic Light System Simulator (TLSS), a learner-centred simulation program for learning algorithm design.

The TLSS, comprising simulation, animation, sound, text, graphics and video, aims to stimulate learners' interaction and initiative by simulating the actual algorithm design activities in learning process. As the word "interaction" indicates in its compounded use with multimedia. Interactive multimedia enables learners' communications, exchanges and involvement. Effective use of interactive multimedia enhances learning motivation and retention. Multimedia also provides an authentic environment which is relevant to daily life. The aim of this paper is twofold: to describe the method and design principles of the TLSS development and to discuss a learning example of using TLSS.

2 The Development of TLSS

In the development of the TLSS, the prototyping paradigm was adopted. Prototyping is a process allowing the developer to create a model of software that will be completed in the future. Like all approaches in software development, prototyping begins with requirements gathering [12]. However Marques i Gralles [8] opines that the "development of an educational program always begins with an initial idea which seems to have the potential for enhancing particular teaching and learning processes". In other words, the development of TLSS, backed by Marques i Gralles' initial concept, has been supported by basic principles. The present model's principles are to apply the learner-centred approach as well as to nest with the understanding of teaching and learning algorithm design in secondary schools [18]. Grounded theory [3], which is a methodology for the systematic generation of conceptual models from qualitative data, was used to collect and analyse information from the interviews of teachers and students [20] during requirements analysis.

The label "grounded theory" means "the discovery of theory from data" [3]. Grounded theory is an approach of the handling of qualitative data and of the formulation of theoretical propositions in social sciences, and this methodology has been used successfully for conceptual analysis in a number of information system development projects [11].

Strauss [15] presents a "concept-indicator model" to direct the conceptual coding of a set of empirical indicators. It is a possible operation of concept formation from qualitative data. Indicators are labels for actual data, such as behavioral actions and events, observed or described in documents and in the words of interviewees or informants. By constant comparison of indicators to indicators and their related data or documents, the researcher is forced into confronting differences, and degrees of consistency of meaning among indicators. This generates an underlying uniformity, which in turn results in coded categories, coded relations, definitions and properties of categories and relations, and theoretical concepts.

In order to develop a system "grounded" from the teaching and learning of teachers and students, twelve teachers and ten students from various schools were interviewed. The following issues were addressed in the interviews: (1) to identify the difficulties of teaching and learning of algorithm design in secondary schools, (2) to examine the needs, skills, and interests of students in the learning of algorithm design, and (3) to identify a series of problems conducive for learners' further exploration and motivation. Data were analysed using the constant comparative method in grounded theory.

The following is a brief summary of some major findings supporting the TLSS development: (1) algorithm design is too abstract to some students, (2) students are lack of logical thinking skills, (3) some teachers think that learning algorithm design is very important, (4) some teachers think that algorithm design can be learned naturally, (5) students' existing mental model is an important factor of learning algorithm design, (6) most students cannot decompose problem into sub-problems, (7) there is a lack of teaching material in algorithm design, and (8) the curriculum is not related to daily life.

The results also reveal that teachers use either teacher-dominated method or subject-centred method. Teachers with teacher-dominated method "are serving the immediate needs of the dependent, authority centred, linear thinking students" [9]. Teachers in this case direct students' learning through a straightforward lecture of textbook and presentation. Teachers who teach with subject-centred method "are providing more information and use a greater variety of presentation method" [9]. The responsibility for learning is on students, while the teacher primarily provides opportunities for learning to take place. Most teachers adopt this subject-centred method. They teach with metaphors, examples, pictures or games. Apart from textbooks, they also prepare notes, laboratory sheets, and supplementary exercises as teaching materials.

The discovery method of instruction for teaching computer programming is one of the major focuses in educational computing research [14], and discovery learning occurs when a learner is motivated to act and allowed to formulate and test questions or answers [7]. A number of studies suggest to connect computer programming with logic, truth tables, switching circuits, gating symbols, flow charts, pseudocode and visual simulation enhance the teaching and learning of computer programming in secondary schools [1]. Other studies indicate that algorithm animation seems to be a useful tool for teaching algorithm [6].

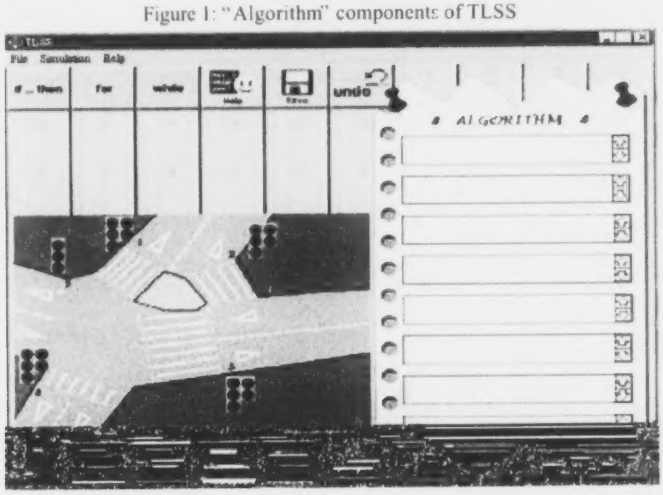
Further to these observations, this paper focuses on the learner-centred approach which facilitates active, multi-functional, inspirational, and situated educational experiences. The basic principles of learner-centred

approach can be summarised as: (1) problem-driven rather than structured analysis of the curriculum content; (2) attending to learners' needs, skills and interests; and (3) learning on a constructivist approach.

3 The TLSS Simulation

The TLSS embraces two distinct features. First, the system provides students with an authentic multimedia context that will motivate students to learn and explore [19]. The system allows continuous feedback and challenge to stimulate students to decompose the challenge, thus keeping students continue learning activities [13]. Second, students might benefit from actively constructing the algorithm than passively watching the algorithm. The system supplies a visualised simulation and an animated environment which students are actively immerse in creating, exploring, testing, and understanding their implemented algorithms.

Figure 1: "Algorithm" components of TLSS

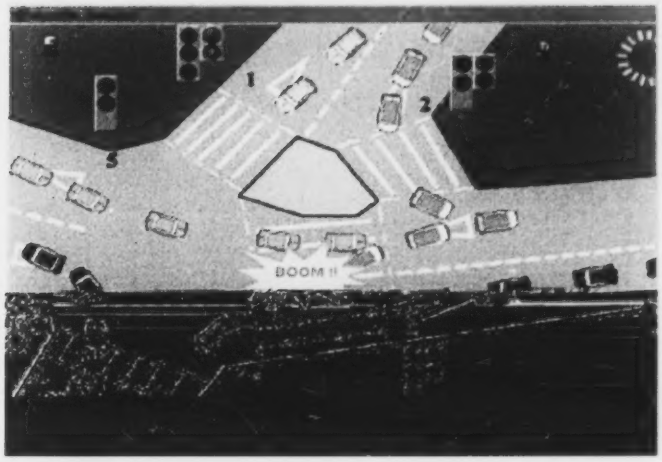


The TLSS provides a dynamic model of a traffic light system with simulated roads, traffic lights, vehicles, pedestrians and various traffic situations. It allows students to present and test their algorithm of controlling a traffic light system in animation. The system also represents students' algorithm in Pascal programming language to reinforce programming language learning.

The TLSS consists of two major components namely, "algorithm" and "simulation". In the "algorithm" component, users are asked to design an algorithm using "while", "for" and "if-then" to control five sets of traffic lights at a junction (Figure 1). Students are expected to begin by simple guided situations on resolving two traffic lights. Each "if-then" will be contained in statement 1 and 2 of a set of algorithm design. Implanting "if-then" statements may be relatively simple and direct for most students. Other components, "for" and "while", targeted at coupling the algorithm with variables and validity, complicates the activity. From the outset of the compilation, students will be given no explanation of the set, "if-then", "for/while", but be guided on a step-by-step traffic light simulated situations to generate in them understanding of the syntax. Students will use each set of algorithm, represented as statements ensuring the smooth running of traffic lights, to assign the colour of traffic lights and its time span. Incorrect input of algorithm or a change of the idea can be rectified by pushing the "undo" button. The "save" button enables students to retain their exercises. After compiling the algorithm, students can proceed to the "simulation" component by pushing the simulated button for execution of their design. Evolved will be an animated environment. Since the aim of the designed algorithm is to ensure the safety of pedestrians and vehicles, correctly compiled algorithm yields smooth running of traffic while incorrect algorithm gives rise to accidents. Accidents are categorised into car crash and car bumping into pedestrians. Figure 2 is a graphical presentation of a car accident in the simulation.

BEST COPY AVAILABLE

Figure 2: "Simulation" components of TLSS



If an accident occurs, users may return to the "algorithm" component to re-compile another possible algorithm and test it again. The activity allows students unlimited trials of designs and implementation. Because solutions to every situations are totally dependent on the success of the algorithm design, students' problems solving, engagement in critical thinking to reach for the success stage are crusts of the TLSS.

4 Shirley: A Learning Example

A preliminary version of the TLSS has been developed, and a group of secondary 5 students (Grade 11) with average academic ability were asked to use the TLSS for learning algorithm design and computer programming. The process of using the TLSS was observed. Because of the volume of data generated, the case of only one student, Shirley, was reported and discussed in this paper.

A sequential activity comprising a series of exercises to guide students to the final operation of all five lights is assigned (see Appendix). Each student, engrossing in the learner-centred approach, will freely discover problems and solutions on their own. Also, as featured in the approach, questions will dominate the exercise so that students can actively engross in the revelation of questions. Students are encouraged to try out patterns so as to simulate the "debugging" process of programming environment. Emphasis of the exercise will not only be the success of compilation, but on the process of compilation. The process of compiling a simulated TLSS demonstrates ways of how students can plan, debug and execute a computer programme.

Shirley, who has completed one-year programming learning practice in her secondary 4 (Grade 10) studies, started the activity by following the assignment instruction. She operated the TLSS and set the simulation off by pushing the button at the very first instance. By observing the simulated junction, Shirley tried to locate directions for the movement of cars and the operating sequence of traffic lights but of no avail. Shirley found that all traffic lights, cars and pedestrians were not working and in stand-by mode. Simulation could not be executed because algorithm was not compiled.

Having finished observation, Shirley returned to the menu and tried to familiarise herself with the available syntax of the simulation. She tried put the "If..Then" onto one of the boxes and observed the pattern of its appearance. The representation of "If..Then" as conditions to be fulfilled was acknowledged. Double-clicking the "statement 1" box, Shirley realised it was the first condition for the first part of the algorithm and the "statement 2" box was ignored. Returning to the assignment instruction, Shirley began to work on how she could survive for 20 seconds if lights 1 and 2 were simultaneously working. Without a second thought, Shirley inserted "red" and "20 seconds" for light 1 and the same for light 2. Two "If..Then" statements appeared after hitting the "OK" button. A simulated environment was followed where all pedestrians crossed the road at ease. Some pedestrians were standing on the traffic island. Shirley considered that it was due to some pedestrians were heading to light 3 area so they kept waiting on the island. The assignment question on the difference of the situation between the reality and the simulated

environment also reinforced Shirley's belief that some pedestrians were on different directions. Shirley failed to recognise the time of traffic light was determinant in affecting pedestrians' continuation of crossing the road. That misunderstanding gave rise to recurrent traffic accidents in other activities which required much longer time.

Having triumphed on the first part of the exercise, Shirley tried to make a car crash as required. For convenience, Shirley followed instructions strictly. She produced "light 2" as "red" for "20 seconds" and "light 5", "red", "20 seconds". A first car crash was experienced. It was too quick a crash and Shirley missed out the sequence, details and picture. Shirley could not answer the first question of how long it took for the first collision. Shirley decided to study and read carefully questions provided by instructions before finding out solutions. By returning again two times to the simulation, Shirley concluded that the crash took place after 8 seconds of execution. In order to remove the accident, Shirley had to find out a workable algorithm. Shirley tried to visualise the traffic pattern in her mind but was not successful. She then realised it was because the most important element of vehicles direction was not recorded. Pens and paper were ready before Shirley returned to the simulation again. She then looked for patterns of the traffic and pictured it onto the paper. She devised that light 2 should stay red long enough to allow light 5 cars to run. Although unsure about the result, she kept light 5 as red for 20 seconds and light 2, red, 40 seconds. The result was successful and Shirley proceeded to the third part of the exercise.

The third activity requested Shirley to run the car more than once. Suggestions on using "For" button was put forward. On devising "for i = 1 to n", Shirley did not understand the function of "n". No hints were given. She did not know where to put the "for" trunk at the infant stage. After several unsuccessful hits of trying to make the equation (e.g. "i" equals "10" and "n" equals "9"), Shirley took an hour break. Shirley returned and read carefully the instruction again. She decided to insert "for i = 1 to 5" and retained the previous lights 2 and 5. A first success was experienced. She concluded that "if" functioned as an executable command while "for" predicted the number of execution of the "if" command.

The fourth activity demanded Shirley to keep cars running forever. Shirley did not understand what was meant by the "for-loop" inside the "while-loop" as delineated in the activity. She tried to put the "If..Then" statements first, and then the "while-loop", the "for-loop". Consecutive errors led Shirley back to study questions carefully again. She devised the sequence of the "for-loop", the "while-loop", and the "If..Then" statements. Working out the sequence, Shirley realised that the "while" statement should always remain "True" because it kept the "If..Then" to continue for "n" times. The "If" just started the programme and "while" was a continuation command.

The fifth activity asked why car accidents occurred. The activity required Light 3 as red for 10 seconds while light 4, green 14 seconds. An alternative could be light 5 as green for 16 seconds. Shirley selected the first combination (light 3 as red for 10 seconds and light 4 as green 15 seconds) but a car accident occurred. After trying out a couple of combinations, Shirley shifted to the diagram she drew before. She worked out the flow of cars, wrote down seconds next to each light. She went back to four previous activities to devise solutions. She attended to her negligence of the importance of time element in activity 1. She finally could not contribute colours and time to lights as she could not work out the transition time of lights passing through red to green. Shirley believed there should be intermission for red-yellow and yellow lights. She recorded every combination and observed its execution. Shirley then tried to perform a monitor system by checking the time for accidents taking place like the guidance referred by activity 2. After almost 20 combinations, Shirley referred back to the question and decided to remove the "for-loop" and the "while-loop". No traffic accident occurred because there was no repetition of car flow. Shirley, however, was not satisfied with the result because reality traffic required continuous flow of cars. She tried to learn from experience in activity 2 that one light's stopping time should be longer than the other's flowing time. After almost 30 trial and errors, Shirley reached the conclusion that emphasis should be on the transition lights. Finally, Shirley gave up algorithms without reaching successful traits. The last activity requested the smooth running of cars by operating all traffic lights. Shirley did not proceed to this stage and the assignment was handed in.

5 Discussion

In the observation, we found that students using the TLSS were encouraged to participate in the thinking process of designing algorithm, such as imaging a goal, formulating a goal, inventing a product, finding alternatives, choosing the solution, generating more alternatives, making choice and evaluating choice,

which are essential elements in algorithm design [5]. In contrast with the teacher-dominated and subject-centred method, the learner-centred approach is based on the idea that "people learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand" [10]. In learning with the TLSS, students are involved in active exploration, problems solving and construction rather than passive teacher-directed lecturing. Such learner-centred simulation tool also generates in learners a long-term pursuit of examining the subject which leads to lifelong learning. Further exploration enhances creativity and critical thinking. However, some students, in particular the case of Shirley, revealed that teacher's guidance is also crucial to make such active learning successful.

The design of the TLSS is based on the learner-centred principles as well as grounded from the experiences of teachers and students. The primary goal of the TLSS is to provide a daily life problem in a simulation environment. In solving the problem, students are encouraged to think and construct their own possible solutions. Simulation, by definition, is not real. Most simulations are artificial systems that can in no way come close to the real situation in complexity and variety. In TLSS, the operation of the traffic lights is certainly different from real life. Thus, students must always be alert for the limitation of simulation. It is believed that the TLSS would inspire students to look beyond the traffic light simulation and transfer the insight to the learning of algorithmic thinking.

References

[1] Brown, D.W., Giving Students a Logical Step Up, *Computer Science Education*, 5(2), 12-17, (1990).

[2] Glaser, B. and Strauss, A., *The Discovery of Grounded Theory*, Chicago: Aldine, (1967).

[3] Guimaraes, M.A.M. & de Lucena, C.J.P., A System Environment for Teaching Introductory Algorithms, *SIGCUE OUTLOOK*, 23(3), ACM Press, 2-11, (1995).

[4] Harel, D., Algorithms: The Spirit of Computing, 2nd Ed., Addison-Wesley, (1992).

[5] Jonassen, D.H., *Computers in the Classroom*, NJ: Prentice-Hall, (1996).

[6] Kann, C. et al., Integrating Algorithm Animation into a Learning Environment, *Computers Education*, 28(4), 223-228, (1997).

[7] Keegan, M. (1995), *Scenario educational software : design and development of discovery learning*, NJ: Educational Tech. Pub., p. 67-75

[8] Marques i Graells, P., Designing Educational Software for Pupils in the 12-16 Age Group: What to Product and How?, *Educational Media International*, 30(3), 138-42, (1993).

[9] McBeath, R., Facilitating Transitions in Learning and Teaching, *Improving University Teaching: Twentieth International Conference*, 10-13 July 1995, Hong Kong, 420-428, (1995).

[10] Norman, D.A. and Spohrer, J.C., Learner-Centered Education, *Communication of ACM*, 39(4), 24-27, (1996).

[11] Pidgeon, N.F. et al., The Use of Grounded Theory for Conceptual Analysis in Knowledge Bicitation, *International Journal of Man-Machine Studies*, 35, 151-173, (1991).

[12] Pressman, R.S., *Software Engineering*, McGraw-Hill, (1992).

[13] Schank, R.C. & Kass, A., Goal-Based Scenario for Higher School Students, *Communication of ACM*, 39(4), 28-29, (1996).

[14] Seidman, R.H., New Directions in Educational Computing Research, in R.E. Mayer (Ed.) *Teaching and Learning Computing Programming*, NJ: LEA Publishers, (1988).

[15] Strauss, A., Qualitative Analysis for Social Scientists, Cambridge: Cambridge University Press, (1987).

[16] Thomas, R. A. & Upah, S.C. Jr., Give Programming Instruction a Chance, *Journal of Research on Computing in Education*, 29(1), 96-107, (1996).

[17] Van Merrienboer, J., Instructional Strategies for Teaching Computer Programming: Interaction with the Cognitive Style Reflection-Impulsivity, *Journal of Research on Computing in Education*, 23(1), 45-53, (1990).

[18] Whiteside, M. & Whiteside, J., The successful multimedia development team - expertise and interaction, in J. Keyes (Ed.) *The McGraw-Hill Multimedia Handbook*, NY: McGraw-Hill, (1990).

[19] Woolf, B., Intelligent Multimedia Tutoring Systems, *Communications of the ACM*, 39(4), 30-31, (1996).

[20] Yuen, H. K. and Richards, T. J., Knowledge Representation for Grounded Theory Construction in Qualitative Data Analysis, *Journal of Mathematical Sociology*, 19(4), pp. 279-298, (1994).

Appendix: Sample Activities

How can you survive for 20 second?

- **Objective:** By the end of the activity, students should be able to use "IF ..Then" statement by using trail and error approach. Use basic problem solving skills. The activity allows the students to explore the implementation of the "If..Then" statement.
- **Activity:** In this simulation, students only use "IF-THEN" statement to control the traffic flow. (Hint: Ignoring Lights 3 to 5 and congests for route 3 to 5, control Light 1 and 2 only. Observe the pedestrians' flow).
- **Questions for Discussion:** Why there are some pedestrians standing on the traffic island? Is there any difference between the reality and the simulation?

How can we make the car running more than once?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "for" button.
- **Activity:** Students should first use "for i= 1 to n", where n is any chosen number. We should predict what would happen before we run the game. No instruction will be given to students so students can make the simulation by their own. For instance, how many times of car flow occur if we set for i = 1 to 5 and put in one condition such as controlling light 1 & 2 as we tried before, inside the loop?
- **Questions for Discussion:** What is the function of the "if" statement in programming? What is the benefit of using this button?

How can we make the car running continuously?

- **Objective:** By the end of the activity, students should be able to get more familiar with the characteristics and function of the "while" button.
- **Activity:** Students are asked to control the car flow so that the car flow can run continuously. We can use the "while" statement to implement this task. "While" it is true, then do the following statement. Students are suggested to predict the effect of putting the "for-loop" inside the "while-loop" and the vice versa. They are asked to explain these effects.
- **Questions for Discussion:** What is the function of the "while" statement in programming? What are the differences between "if" and "while"?

Acknowledgements:

The research reported in this paper was funded by the CRCG research grants of the University of Hong Kong.

Making Exploration History Interactive for Web-based Learning

Akihiro Kashihara, Masanao Sakamoto, Shinobu Hasegawa, and Jun'ichi Toyoda

The Institute of Scientific and Industrial Research, Osaka Univ., JAPAN
8-1, Mihogaoka, Ibaraki, Osaka 567-0047, JAPAN
kasihara@ai.sanken.osaka-u.ac.jp

The main problem addressed in this paper is how to help learners reflect on knowledge that they have constructed in exploring existing hypermedia/hypertext based learning resources on the Web. Our approach to this problem is to provide each learner with a kind of reflection support proper to his/her exploration process. In this paper, we describe an interactive history that encourages learners to annotate their exploration history with the reasons why they have explored, which reasons have a great influence on knowledge construction in hyperspace. It also generates a knowledge map, which spatially represents the semantic relationships among the WWW pages visited by the learners. This paper also describes a preliminary analysis and evaluation with the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system produces good effects on learning such as integrating the contents of some nodes in more complicated hyperspace.

Keywords: Exploratory Learning, Hyperspace, Reflection, Interactive History

1 Introduction

Hypermedia/hypertexts generally provide learners with a hyperspace within which they can explore the domain concepts/knowledge in a self-directed way [3], [7]. The exploration often involves making cognitive efforts at constructing the knowledge from the contents that have been explored [12]. These cognitive efforts would enhance learning [2], [6]. However, learners often fail in knowledge construction since what and why they have explored so far become hazy as the exploration progresses. To what extent the learning has been carried out also becomes unclear [10], [12].

A possible resolution of this problem is to encourage learners to reflect on what they have constructed during exploration in hyperspace [11], [12]. The reflection also involves rethinking the exploration process that they have carried out since it has a great influence on their knowledge construction. In particular, exploration purposes, which mean the reasons why the learners have searched for the next node in hyperspace, play a crucial role in knowledge construction [8], [9]. For instance, a learner may search for the meaning of an unknown term to supplement what is learned at the current node or look for elaboration of the description given at the current node. Each exploration purpose would provide its own way to shape the knowledge structure. The reflection support accordingly needs to adapt to their exploration activities and the knowledge structure being constructed by the learners.

In this paper, we discuss a proper reflection support with a careful consideration of exploration process in hyperspace. This paper also describes an interactive history for learning with hypermedia/hypertext based learning resources on the Web. The interactive history system enables learners to annotate their exploration history with exploration purposes that have arisen during exploration. It also transforms the annotated exploration history into a visual representation called knowledge map. It spatially shows the semantic relationships among the WWW pages that the learners have visited [8]. Using the interactive history system, the learners can view and reorganize the exploration history to rethink their exploration process that they have carried out so far. They can also view the knowledge map to reflect on what they have constructed in hyperspace.

This paper also describes a preliminary evaluation of utility and effectiveness of the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system facilitates learning such as integrating the contents of some pages in more complicated hyperspace.

Before discussing the interactive history, let us first consider exploration process in hyperspace.

2 Exploratory Learning

In hyperspace, learners can explore in a self-directed way from one node to others by following the links among the nodes. The exploration often involves making cognitive efforts at constructing the knowledge structure from the contents that have been explored. In order to shape a well-balanced knowledge structure, it is necessary for the learners to recall what and why they have explored so far, and to properly direct the subsequent exploration [10], [12], [13]. However, these efforts may cause cognitive overload [6].

In this paper, we consider learners who attempt to learn domain concepts and knowledge in a constructive way. Some learners may not make the cognitive efforts of knowledge construction. In this case, they may only browse or surf in hyperspace. Supporting such browsing or surfing is out of our scope.

Table 1. Exploration Purposes and Visual Representation.

Exploration Purposes	Visual Representation
Supplement	Inclusion
Elaborate	Set or Part-of tree
Compare	Bidirection arrow
Justify	Vertical arrow
Rethink	Node superposition
Apply	Arrow

Starting node Terminal node

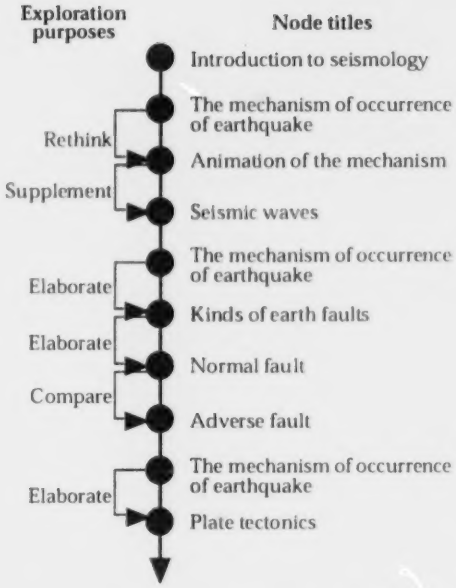


Figure 1. An Exploration History.

2.1 Primary Exploration Process

Learners generally start exploring hyperspace with a learning purpose. The movement between the various nodes is often driven by a local purpose called exploration purpose to search for the node that fulfills it. Such exploration purpose is also regarded as a sub purpose of the learning purpose. We refer to the process of fulfilling an exploration purpose as primary exploration process. This is represented as a link from the starting node where the exploration purpose arises to the terminal node where it is fulfilled.

An exploration purpose may have several terminal nodes with one starting node. Exploration purpose, represented as verb, signifies how to develop or improve the domain concepts and knowledge learned at the starting node. We currently classify exploration purposes as shown in Table 1, which are not investigated exhaustively.

An exploration purpose arising from visiting a node is not always fulfilled in the immediately following node. In such case, learners need to retain the purpose until they find the appropriate terminal node/s. While searching for the fulfillment of the retained purpose, it is possible for other exploration purposes to arise. The need to retain several exploration purposes concurrently makes the knowledge construction more difficult to achieve.

The exploration process can be modeled as a number of primary exploration processes. Let us give an example where a learner uses a hyperdocument on a WWW server with the learning purpose of understanding the occurrence of earthquake. In this example, he/she explores a number of nodes (WWW documents) with various exploration purposes. Figure 1 gives the exploration history, which shows the sequence of the nodes visited and primary exploration processes. For example, he/she visited the node *Animation of the mechanism* in order to rethink the description in the node *The mechanism of occurrence of earthquake*. He/she then visited the node *Seismic wave* since he/she did not know the meaning of the term used in the previous node.

2.2 Knowledge Structure

Exploring hyperspace in a self-directed way, learners make semantic relationships among the domain concepts and knowledge explored to construct a knowledge structure [12]. In hypermedia/hypertext systems with concept maps representing domain concepts to be learned, learners can derive such semantic relationships from the maps. Most existing web-based learning resources, on the other hand, do not specify the semantic relationships. In this case, learners need to explore WWW pages and to identify the semantic relationships by themselves for the knowledge construction.

The knowledge structure constructed is shaped according to learners' exploration process, especially the exploration purposes. Each exploration purpose provides its own way to make relationships among the domain concepts and knowledge explored and to shape the knowledge structure [8].

2.3 Reflection

Knowledge construction in hyperspace requires learners to reflect on their exploration process. Some work on analysis of exploration process in hyperspace has also shown that revisiting nodes to rethink the contents explored often take place [11], [13].

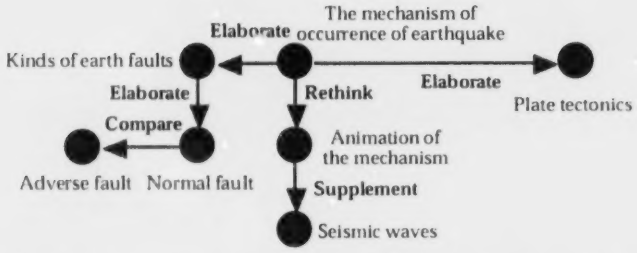


Figure 2. A Semantic Network Composing Primary Exploration Processes.

In reflection, it is important for learners to rethink not only the nodes visited but also the reasons why they have visited since these reasons have a great influence on how to shape a knowledge structure. In other words, they should pay attention to primary exploration processes included in the whole exploration process.

3 Interactive History

Let us now discuss what kind of reflection support is indicated by the above consideration.

3.1 Problems

There are the following important problems to be addressed towards a proper reflection support. The first problem is how to help learners retain the primary exploration processes that they have carried out. The retention may cause cognitive overload on exploration. It is also hard for computer to infer their exploration purposes, which arise in the learners' mind. These suggest that learners should be encouraged to note down the exploration purposes, starting nodes, and terminal nodes that compose the primary exploration processes.

The second problem is how to assist learners in reconstructing their exploration process. In reflecting on their exploration process, they would not only look at it but also reconstruct it such as modifying/deleting the primary exploration processes and adding new primary exploration processes. It is accordingly necessary to provide learners with a space where they can reconstruct their exploration process after exploring hyperspace.

The third problem is how to facilitate learners' reflection on a knowledge structure constructed. One way to resolve this is to spatially show semantic relationships between nodes explored. We represent a semantic network that comprises a number of primary exploration processes. Figure 2 shows a semantic network comprising the primary exploration processes shown in Figure 1. The semantic network does not obviously represent the contents included in the explored nodes, which may be summarized by the node titles. However, this summarized information would be substantially fruitful for learners to reflect on what they have learned.

In order to resolve the above problems, we have developed an interactive history that helps learners reflect on their exploration process and knowledge structure by means of an exploration history annotated with primary exploration processes. Let us next demonstrate the interactive history.

3.2 Overview

The interactive history system first displays an exploration history, which includes the nodes sequenced in order of time learners visited. In order to help learners note down primary exploration processes during exploration, the system provides them with a list of exploration purposes, and requires them to select one from the list when an exploration purpose arises. The learners are also asked when they find the terminal nodes. The interactive history system annotates the exploration history with the information noted down. The annotated history enables the learners to retain their primary exploration processes.

The learners are also allowed to directly manipulate the annotated exploration history to modify/delete the primary exploration processes and to add new primary exploration processes after exploring hyperspace. Such direct manipulation allows them to reconstruct their exploration process without revisiting hyperspace.

Although the annotated exploration history is represented as semantic network shown in Figure 2, it may be difficult to understand. It is accordingly transformed into a visual representation called knowledge map by means of visualization scheme that describes the correspondence of an exploration purpose to a visual representation.

3.3 Annotated Exploration History

In the interactive history system, learners can use a user interface as shown in Figure 3. They can also explore a hyperdocument on a WWW server with one learning purpose in the left window. When they want to set up an exploration purpose in visiting a node, they are required to click one corresponding to the purpose in the *Exploration Purpose Input* section of the right window. The clicked purpose is added to the *Exploration Purpose List* section. The node visited currently is also recorded as the starting node of the exploration purpose.

The learners can also add the object of the verb describing the exploration purpose. It means what to develop/

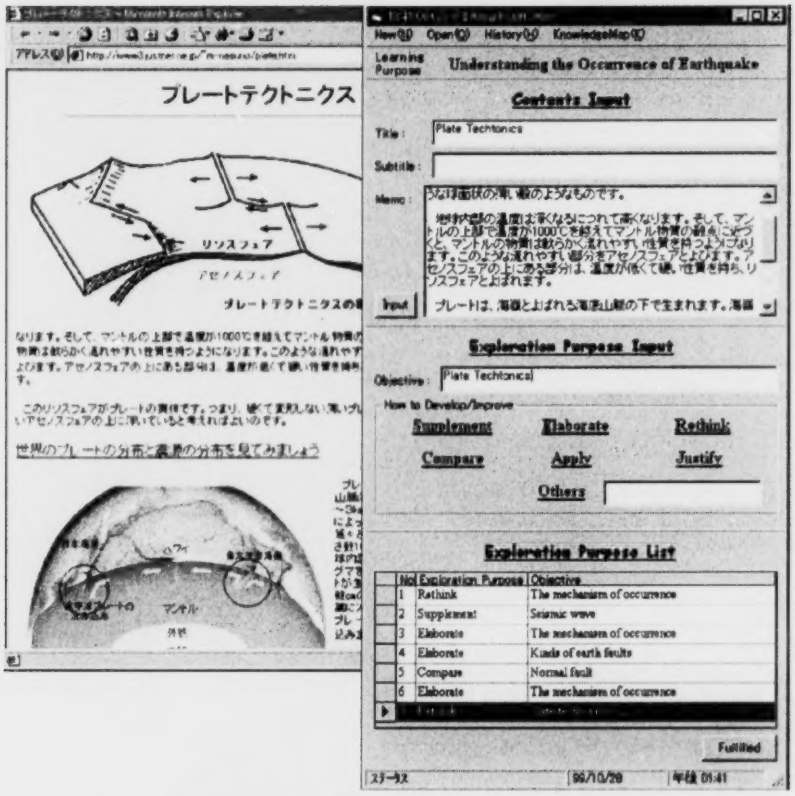


Figure 3. User Interface of Interactive History.

improve in the current node whereas the exploration purpose specifies how to develop/improve. When the learners do not add this object, the system adds the title of the current node, which is the title tag in the HTML file.

When the learners find a terminal node of the exploration purpose, they are required to mouse-select the exploration purpose in the *Exploration Purpose List* section, and to push the *fulfilled* button. The node visited currently is then recorded as the terminal node of the exploration purpose.

The system also provides another support for helping learners store part of the contents of the node visited currently with Cut&Paste function in the *Content Input* section although they may not always need this support. In hyperdocuments on WWW, in addition, the title tags of the nodes do not always represent the contents of the nodes. If the learners want to change the node titles, they can input new titles in the *Content Input* section, which new titles should represent the contents the learners explored in the nodes. The pasted information and the changed node titles are also used in the annotated exploration history.

Using the information inputted from the learners, the system generates the annotated exploration history as shown in Figure 4 so that the primary exploration processes can be viewed clearly. In the annotated history, the nodes learners visited are sequenced in order of time. Each node has the node title. The starting node of each purpose is linked with the corresponding terminal node/s. There may be some primary exploration processes without terminal nodes since they have not been found yet. The learners can look at the annotated exploration history on their demand during exploration. They can also click the nodes in the history to review the content information, which they have inputted with Cut&Paste function.

Learners are not always required to input the above information whenever they visit nodes. Nevertheless, inputting the information during exploration may be troublesome for learners. On the other hand, it enables the learners to make their exploration more constructive, facilitating their exploratory learning. This point is discussed later in detail.

3.4 History Manipulation

Directly manipulating the annotated exploration history, the learners can reconstruct their exploration process without revisiting hyperspace. Each manipulation is done by means of mouse-clicking/dragging parts of the primary exploration processes. There are three basic manipulations: deleting and changing exploration purposes/links between starting and terminal nodes, and adding new primary exploration process.

BEST COPY AVAILABLE

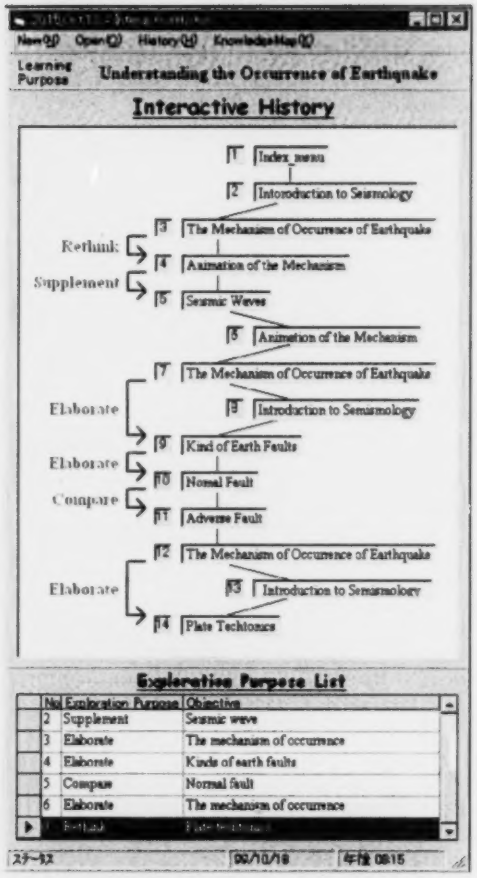


Figure 4. An Annotated Exploration History.

3.5 Knowledge Map Generation

In order to make the knowledge map understandable, we have adopted a visualization scheme shown in Table 1. This table shows the correspondence of an exploration purpose to a visual representation of the relationship between the starting and terminal nodes. For example, an exploration purpose to *Elaborate* is transformed into a set that visualizes the starting node as a total set and the terminal node as the subset. An exploration purpose to *Rethink* is also transformed into a visual representation that superposes the starting node on the terminal node. Following such correspondence, the system generates a knowledge map by extracting the primary exploration processes from the annotated exploration history. The knowledge map generation is executed on learners' demand before/after manipulating the annotated exploration history.

Figure 5 shows an example of the knowledge map that is generated from the annotated exploration history shown in Figure 4. Viewing this map, the learner can reflect on his/her knowledge construction. For example, he/she can recall that he/she rethought *The mechanism of earthquake occurrence* by exploring *The animation of the mechanism*. He/she can also recall that he/she compared *Normal fault* and *Adverse fault* to elaborate the description about *Kind of earth faults*.

3.6 Discussion

Let us now discuss several points to notice in utilizing the interactive history. The interactive history system requires learners to input information about primary exploration processes that have been carried out. Such inputting, in addition, requires a meta-cognitive skill that is indispensable for managing knowledge construction process in existing web-based learning resources. The interactive history system could distract learners, who do not have it, from their learning tasks in hyperspace. We believe, however, it is educationally important to train the learners to improve the meta-cognitive skill so that they can learn in the Web. The interactive history can be viewed as a potential tool for this training.

Before using the interactive history system, in addition, learners need to know how to interpret the visual repre-

BEST COPY AVAILABLE

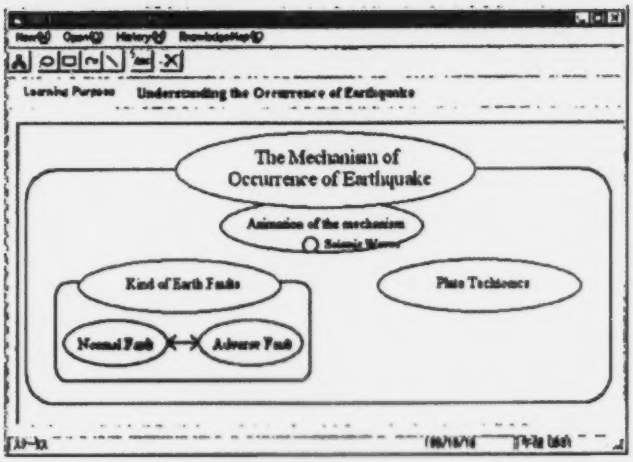


Figure 5. A Knowledge Map.

sentation used for the knowledge mapping. In order to explain it, the interactive history system demonstrates few examples of annotated exploration history and knowledge map before starting the actual learning support.

Let us next compare with related work on reflection support to consider the usefulness of the interactive history. The general browsers such as Netscape and Internet Explorer enable learners to revisit nodes with back buttons, and provide browsing history. However, these facilities do not always make the retention of their exploration processes easy [11]. As the retention support, there are several kinds of annotation systems that allow learners to take a note [1]. However, there is little discussion of what kind of annotation should be done for the success in exploratory and constructive learning. In the interactive history, we claim that the reasons why learners search for the next nodes should be particularly noted down.

Current work on adaptive hypermedia/hypertext systems has often provided spatial maps and concept maps as reflection support, which are originally used as navigational aid. Spatial maps display the nodes and links that compose the whole structure of hyperspace. These maps can visually represent the subspace where learners have already visited [4]. This subspace is represented as the partial structure of hyperspace. This visual representation can inform the learners where they are, what they explored, and to what extent they explored. However, the reasons why they visited the nodes are not clearly shown.

Concept maps consists of the nodes and links representing the structure of domain concepts to be learned. Each node is mapped on the corresponding node in hyperspace. The scope where the learners have already visited in hyperspace is mapped on the corresponding part of the concept maps. The learners can look at the partial structure of the concept maps to reflect on what they learned in hyperspace [5]. Such maps are more helpful for learners who have lower capability of exploring hyperspace in a constructive way since the direction of knowledge construction is visible to them. However, learners who have higher capability of the exploratory learning may identify semantic relationships among the domain concepts explored in a self-directed way, which relationships may be different to those defined in the concept maps [12]. In other words, they do not always construct the same knowledge structure as the structure of domain concepts that the designers of concept maps make.

The interactive history, on the other hand, provides the learners with a more proper support since it enables self-directed exploration and generates a knowledge map according to their exploration process. In addition, the interactive history can provide the reflection support even for most existing web-based learning resources of which concept maps are not prepared and even in ill-structured domains of which concept maps cannot be defined.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the interactive history system, we have had a preliminary experiment. The main purpose of this experiment was to analyze the utility of the system and to ascertain if the interactive history improves learning compared to learning without the system. We also prepared two web-based learning resources, which had comparatively simple and complicated hyperspace, and ascertained in which resource the interactive history system enhances its own utility and facilitates learning more effectively.

Table 2 shows the two learning resource, which describes the number of nodes, and the number of links per node, which was calculated except for navigation links such as *Next*, *Back*, and *Top*. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were five graduate and undergraduate students in science and technology.

We set four conditions, which were (1) learning in the learning resource 1 with the system (*Simple-With*), (2)

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	73	161
Number of Links per Page	1.2	2.2

Domain of learning resource1: Mechanism of earthquake
Domain of learning resource2: Life in Sea

learning in the learning resource 1 without the system (*Simple-Without*), (3) learning in the learning resource 2 with the system (*Complicated-With*), and (4) learning in the learning resource 2 without the system (*Complicated-Without*). Subjects were provided with Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource with the system, and learned the other without the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given a learning purpose for each learning resource. Under *Simple-With* or *Complicated-With*, they were also given the explanation about how to use the interactive history system, and were asked to try it in a sample learning resource whose hyperspace is simple. They were then asked to explore hyperspace with or without the system to accomplish the learning purpose. After subjects finished learning, they were given several problems about the contents for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, effects on learning were measured by the scores on both problems. The utility of the system was analyzed with the dispersion of pages visited, the number of revisit per page [11], the number of primary exploration processes executed, and the number of revisiting pages that were included in the primary exploration processes. Comparing the averages of them under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the utility and effectiveness of the interactive history system.

4.2 Results and Discussion

Table 3 summarizes the analysis of the utility. The average numbers of revisit per page on both *Simple-With* and *Complicated-With* were slightly higher than the average numbers of revisit per page on both *Simple-Without* and *Complicated-Without*. The average dispersion of pages visited on both *Simple-With* and *Complicated-With*, on the other hand, was lower than the average dispersion of pages visited on both *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* was large. These results indicate that the interactive history system makes learners' exploration more intensive, particularly in a more complicated hyperspace. We further analyzed the utility of the interactive history system on *Simple-With* and *Complicated-With* as shown in Table 4.

Table 4 shows the average number of primary exploration processes executed, the average number of starting and terminal nodes (pages), and the average number of revisting pages that are included in the primary exploration processes. The average numbers of starting and terminal pages on *Simple-With* and *Complicated-With* corresponded to about half of the average numbers of pages visited as shown in Table 3 (56% on *Simple-With* and 52% on *Complicated-With*). In other words, half of the visited pages were related to the primary exploration processes. The average numbers of revisiting the starting and terminal pages on *Simple-With* and *Complicated-With* accounted for 67 % and 78 % of the whole revisits shown in Table 3. The ratio on *Complicated-With* was particularly high. These results indicate that the interactive history system can direct learners' attention to primary exploration processes, particularly in a more complicated hyperspace. In other words, the system can encourage learners to rethink exploration processes. This would improve learning.

Table 5 shows the average score of problem-solving on each condition. As for the single problems, the average scores on *Simple-With* and *Complicated-With* were lower than the average scores on *Simple-Without* and *Complicated-Without*. As for the compound problems, on the other hand, the average scores on *Simple-With* and *Complicated-With* were higher than the average scores on *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* were large. These results indicate that the interactive history system can produce good effects on learning such as integrating the contents of some nodes by means of exploration purposes, particularly in a more complicated hyperspace.

5 Conclusions

This paper has claimed that exploratory learning in hyperspace requires learners to reflect not only what but also why they have explored, and that the reflection support needs to adapt to their exploration process and knowledge structure being constructed by them.

This paper has also demonstrated the interactive history with knowledge mapping as a proper reflection support. The interactive history encourages learners to annotate and manipulate the exploration history to rethink their exploration processes. It also generates a knowledge map from the annotated exploration history, which allows the

BEST COPY AVAILABLE

Table 3. Analysis of Utility.

	Total Number of Pages Visited (a)	Number of Pages Visited (b)	Dispersion (b/a)	Revisit (a-b)	Revisit per Page ((a-b)/b)
Simple-With	69	19.5	0.283	49.5	2.53
Simple-Without	72	22.3	0.31	49.7	2.23
Complicated-With	67.3	21.3	0.317	46	2.16
Complicated-Without	59.5	32.5	0.546	27	1.25

Table 4. Utility of Interactive History.

	Number ofPrimary Exploration Processes	Number of Starting and Terminal Pages	Revisit
Simple-With	9.5	11(56%)	33 (67%)
Complicated-With	8	11(52%)	36 (78%)

Table 5. Avarage Scores of Problem-Solving.

	Total	Single Problems	Compound Problems
Simple-With	60.5%	75%	66.7%
Simple-Without	66.7%	91.7%	50%
Complicated-With	51.8%	55.6%	50%
Complicated-Without	41.1%	66.7%	25%

learners to reflect on what they have constructed during exploration.

In addition, this paper has described a preliminary evaluation of the interactive history system. Although we need a detailed evaluation with more subjects, the results indicate that the system facilitates a rethink on primary exploration processes particularly in a complicated hyperspace. The system can also improve learning, particularly integrating the contents of some WWW pages.

In the future, we will have a more detailed evaluation. We would also like to classify exploration purposes in detail to represent learners' exploration process more precisely.

Acknowledgments

This research is supported in part by Grant-in-Aid for Scientific Research from the Ministry of Education, Science, and Culture of Japan. We also want to thank Dr. Noriyuki Matsuda for his valuable comments for implementation of the interactive history.

References

[1] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia, Journal of User Modeling and User-Adapted Interaction, 6, (1996) 87-129.

[2] Chan, T.W., Lin, C.C., Lin, S.J., and Kuo, H.C. OCTR: A Model of Learning Stages, in Proc. of 6th World Conference on Artificial Intelligence in Education '93 (1993), 257-264.

[3] Conklin, J. Hypertext: An Introduction and Survey, Computer 20, 9 (1988), 17-41.

[4] Domel, P. WebMap - A Graphical Hypertext Navigation Tool, in Proc. of Second International WWW Conference (1994), http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Searching/ doemel/www-fall94.html.

[5] Gaines, B.R. and Shaw M.L. G. WebMap: Concept Mapping on the Web, in Proc. of Second International WWW Conference (1995), http://www.w3.org/Conferences/ WWW4/Papers/ 134 .

[6] Kashihara, A., Hirashima, T., and Toyoda, J. A Cognitive Load Application in Tutoring, Journal of User Modeling and User-Adapted Interaction, 4, 4 (1995), 279-303.

[7] Kashihara, A., Kinshuk, Oppermann, R., Rashev, R., and Simm, H. An Exploration Space Control as Intelligent Assistance in Enabling Systems, in Proc. of International Conference on Computers in Education '97 (1997), 114-121.

[8] Kashihara, A., Uji'i, H., and Toyoda, J. Reflection Support for Learning in Hyperspace, Educational Technology, Vol.39, No.5 (1999), 19-22.

[9] Murray, T., Condit, C., Piemonte, J., Shen, T., and Kahn, S. MetaLinks - A Framework and Authoring Tool for Adaptive Hypermedia, in Proc. of World Conference on Artificial Intelligence in Education 99 (1999), 744-746.

[10] Nielsen, J. The Art of Navigating Hypertext, Communication of the ACM, 33, 3 (1990), ACM Press, 297-310.

[11] Tauscher, L., and Greenberg, S. How people revist web pages: empirical findings and implications for the design of history systems. International Journal of Human-Computer Studies, 47, 1 (1997), 97-137.

[12] Thuering, M., Hannemann, J., and Haake, J.M. Hypermedia and Cognition: Designing for Comprehension. Communication of the ACM, 38, 8 (1995), ACM Press, 57-66.

[13] Zeiliger, R., Belisle, C., and Cerratto, T. Implementing a Constructivist Approach to Web Navigation Support, in Proc. of World Conference on Educational Multimedia and Hypermedia '99 (1999).

Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

Jia-Rong Jerome Wen * Chia Chin Li and Jian Jie Dung***

**jerome@nknucc.nknu.edu.tw djj@icemail.nknu.edu.tw*

116,Ho-Pin 1st Road,Kaohsiung,Taiwan,R.O.C

***april@ficnet.net*

The information education in Taiwan has been progressing rapidly since the Network Technology was adopted on a large scale.Under the Nine-Year Consistent Courses policy the by Ministry of Education, the information education will be integrated into other subjects and all teachers need to use computer and Internet resources to assist teaching .The plentiful education web sites on Internet also provide the student with materials for assisting learning .The essay presents the development process of information Education in Taiwan ;through it, we point out the obstacles we meet when promoting information education in primary schools and high schools.Meanwhile ,through introducing two education web sites :Gas Station for Learning and Schoolfellows' English Adventure Land, which were constructed in different models ,we offer the workable models and strategies for promotiing distance education in primary schools and high schools.

Keywords: **Distance Learning, Nine-Year Consistent Coures ,Teaching Material Resources Center, Schoolfellows' English Adventure Land**

1 Introduction

1.1 Analysis of Current Situation

"Nine-Year Consistent Syllabus" implemented in 2001, all schools will no longer especially establish the subject of Information Education, but enlist it in the learning area of "Nature and Technology." Nevertheless, in order to train students to have the basic abilities to make use of technology and information, teachers have to emphasize the application of information in the teaching of different subjects. And all teachers of different subjects are expected to take computer as a tool of instruction, integrate via network the traditional teaching materials and the teaching materials on Internet, and provide students with broader and more diversified learning resources.[2][3]

1.2 Problems Faced by Distance Learning:

To apply information education to the teaching of various subjects will really be a consistent trend in the education of Taiwan in the future. However, when confronted with the important educational reform, the actual implementation encounters difficulties because of Taiwan's restricted environment for information education.

The ratio of the number of class computers to the number of the students of a class is such a wide gap.If teachers are requested to use the limited computer classrooms to apply information to the teaching of various subjects, obviously, it is not an easy job to promote this at the current stage.[5][7]

2 Distance Instruction and Distance Learning

After the Ministry of Education implemented "Foundation Establishment Plan of Information Education," the computer and network equipment of various schools are increased. Besides, it also promotes the establishment of "Information Education Software and Teaching Materials Resources Center" at primary schools, junior high schools, senior high schools and vocational schools, in order to enrich the network teaching materials for subjects of primary schools and high schools.[1][8]

Besides, the famous distance instruction network of primary schools and high schools in Taiwan is illustrated as follows (Table1):

Web Site Name	Address	Institute	Object
Gas Station of Learning	http://content.edu.tw	Ministry of Education	Grade 1 to 12 student
Schoolfellows' English Adventure Land	http://192.192.186.8/seal/	San Hsin Institute of Housework and Commerce	Grade 1 to 12 student
Pathfinder	http://pathfinder.ntntc.edu.tw/	National Tainan Teachers College	Grade 1 to 9 student
Computer Assisted Instruction	http://www.wcjs.tcc.edu.tw/	Wu Chi Junior High School	Grade 7 to 9 student
Teaching Resource	http://www.ctjh.tpc.edu.tw/ctjh/resource.htm	Chiang Tsui Junior High School	Grade 7 to 9 student

Table1: Virtual Classroom Web Site for Grade 1 to 12 student

3 Teaching Materials Resources Center Focusing on Systematic Subjects

3.1 Concept and Idea:

The Ministry of Education in Taiwan starts "Foundation Establishment Plan of Information Education" not only to establish hardware environment, train teachers, carry out promotion activities, etc., but also to establish Information Education Software and Teaching Materials Resources Center, simply called "Education Resources Center" or "Gas Station of Learning."(http://content.edu.tw)

3.2 Outline of Resources Center:

The Ministry of Education advises various school to develop the on-line teaching materials of different subjects. The center can effectively integrate the resources of all primary schools and high schools and develop a series of network instruction resources with its own characteristics. "Teaching Materials of Subjects" are divided into four divisions: primary school, junior high school, senior high school and vocational school. In each group there are: 14 subjects in primary school, 19 subjects in junior high school, 17 subjects in senior high school, and 21 subjects of 4 categories in vocational school (the divisions of senior high school and vocational school was established in January 2000). The information integrated and collected by web sites cover the education resources of the Chinese's Five Education: virtue, wisdom, physical, group and aesthetics.

Through a united interface of users, it decreases the learners' load in adaptation to learning environment. The establishment of "Education Resources Center" is expected to achieve the following objectives: [6]

- Strengthen the applied network resources for teachers and students, and make the educational environment more diversified .
- Lay a foundation for a lifelong learning environment.
- Strengthen the quality and quantity of the resources of information learning so as to reach the aims of sharing of resources
- Shorten the distance between city and village [1]

4 Schoolfellows' English Adventure Land Focusing on Self-Learning

4.1 Concept and Idea

Teaching Materials Resources Center mainly edits the teaching materials according to the contents of the systematic teaching materials of various subjects. Therefore, they are suitable for teachers to adopt in class and for students to review after class. However, in the age of information explosion, the knowledge in books can no longer satisfy most of the students' thirst for knowledge. Therefore, with network being the media, distance education must have more diversified contents. It also has to create an interacting relationship between school and students. It can hold various kinds of activities and offer substantial awards to encourage all the students to participate. Then an activated distance learning environment can be created beyond system. Kaohsiung municipal government is positively involved in the activity. The "Schoolfellows' English Adventure Land , SEAL "(http://192.192.186.8/seal/) established by the municipal government at San Hsin Vocational School is based on this idea. It has the following characteristics .(1)Diversified Contents and Scope.(2)Individualistic Learning Environment.(3)Internet Learning without Limitation of Time and Space. (4)Flexibility of Time, Holding of Activities.(5)On-Line Contest,Internet Pen Pal Society.(6)Teacher Mechanism--Student Groups Management and Inquiry of Students' Learning Process:,Self-Made Test Paper Management:

4.2 Evalutaion on SEAL

The working group of Seal held an investigation in December 1999, towards the junior and elementary school teachers that used this website to assist their teaching. The questionnaire adapted Likert's five point scale from extremely disagree(1) to highly agree(5). In the 73 effectively retrieved questionnaires, there're 67 English teachers and 6 are not English teachers.

The statistics results of the questionnaire, in the curriculum arrangement and management session, show that sample teachers think the arrangement of the curriculum in SEAL is appropriate and the related activities that go with the curriculum is successful. (M=4.10 ,SD=0.82) Sample teachers think that the recording of learning profile on the website of each student helps teachers to understand the student's learning style and problems.(M=4.26,SD=0.83) Sample teachers think that the idea of designing language games and holding on-line composition contest is appropriate. (M=4.16,SD=0.83 ;M=4.03 ,SD=0.93) About the learning interaction, most teachers thinks that English pen pal club will help to enhance the interaction between students, M=4.18 SD=0.93) . Most teachers think that SEAL is worth popularizing in assisting traditional learning. (M=4.59,SD=0.66)

5 Workable Model and Strategy

In the implementation of distance education in primary schools and high schools, besides the consideration of the contents of teaching materials, how to make use of the characteristics of Internet appropriately to activate instruction is an important topic that cannot be neglected for discussion. Focusing on the above-mentioned analysis, we propose a model and strategies for distance learning be carried out in primary schools and high schools:

5.1 Four Elements for Activating Web Site:

According to the discussion above,there are four elements to activate the web site teaching materials :the content, interactivity, learning profile and activity. We have to take these four elements into consideration when designing the learning web site. The detailed function of the four elements is as follow:

5.1.1 Content

Text, image, sound , photo , animation chip and other mutimedia components should be included in an excellent education web site.Through multiple information styles supplied , the student can obsorb knowledge easily

5.1.2 Interactivity

With more interactivity function the education web site is more attractive and effective .The interactivity machanism encourages the student to use higher -level cognition skill..

5.1.3 Learning Profile

The learning profile lets the student know what he has learned and what to learn .The porfile also provides the teacher information about the student.

5.1.4 Activity

Not only in classroom but also in virtual classroom, well-designed activities are very important to improve the effectiveness of learning . Besides, through holding an activity , the student can cooperate and compete with others .

5.2 Strategy for Promoting Distance Learning

From this point of view, we will suggest applicable strategies for school administrators,teachers and students.

5.2.1 As for school adminstrator:

✱ Establishment of Web Site by Full-time Professionals:
The school administrator should know there should be full-time professionals to put teaching materials on Internet, hold Internet activities and carry out the maintenance work of systems.

✱ Strengthening of Propaganda:
The education departments or general affairs units of schools should positively introduce such an environment in the learning of students, and positively hold activities of relevant kind.

5.2.2 As for teacher and related professional:

✱ Development of Excellently Activated Web Site:
A web site must have substantial contents , diversified activities as well as interactivity machnism and learning profile to make the web site become a dynamic and lively learning environment.

✱ Material Making:
Teachers need not learn the establishment of web site. Teachers' job should be an all-effort studying of suitable contents of teaching materials for the learning of students.

✱ Resource Assisted Teaching:
All the related teaching web sites need the teacher to use them .Many web sites are well constructed ; however,few teachers use it to assist teaching . The teacher can provide the web site constructor with feedback for promoting the funciton or the rescources of the web.

5.2.3 As for Students:

✱ Participate in activities :
Only students' participation can make web sites activated and meaningful; otherwise, web site is merely an empty shell in a waste of information development.

✱ Resource Assisted Learning:
The student can make good use of on-line material to assist learning after class ; meanwhile , the student's feedback also helps the web constructor refine the web .

6 Conclusion

After the implementation of "9-year consistent" new syllabus in primary schools and junior high schools, information will be applied to various subjects and the application of network resources will become broader. The information-application-oriented network learning functions can be facilitated more effectively. The "Plan of Teaching Materials Resources Center" undertaken by Ministry of Education integrates various schools' resource to establish a garden that provides teachers with instruction resources and students with learning resources.The Plan not only can reach the purpose of resources sharing, but also decrease the load of learning through united interface environment. Besides, the distance learning environment beyond system, as provided in "SEAL," is also a good example for primary school students and high school students to involve in distance learning.

In term of positive implementation of information education, it is important to cooperate with the existing instruction environment and choose a workable model. For the government, based on the principle of effective utility of resources, it is necessary for her to integrate the establishment and the sharing of instruction resources. For schools, they have to encourage teachers and students to use Internet positively to assist in their teaching and learning. For teachers, they might not be required to allocate teaching materials on Internet, but they have to use the existing Internet resources and teaching materials positively, adopt suitable instruction methods, and correctly use Internet to communicate with students or parents. For students, they should meet the instruction of schools, use the teaching materials on Internet to assist in their learning, and learn new knowledge themselves.

References

[1]Bates A.W.,"Technology, Open Learning and Distance Education",Routledge. (1995)

[2]Chin Nian-Shing , "The World Wide Web Integrated Learning Environment", Information & Education ,vol 64, Taichiung Home Economical and Commercial Vocational School . (1998)

[3]David H. Jonassen:,"Computers in the Classroom: Mindtools for Critical Thinking", Prentice-Hall. (1996)

[4]Hung Ming-Jou,"Teaching On Internet", Hua-chai Software. (1999)

[5]J. Mark Pullen (1999):Synchronous Distance Education and the Internet. George Mason University.

[6]The Preface of "Gas Station of Learning,http://content.edu.tw/new/intro1.htm(2000)

[7]Wang Chuan-Shi: "Experimental Research on Adoption of Information Technology in Subject of Chinese Language at Primary School.",Research Plan of Graduate School of Information Education of National Kaohsiung Normal University, unpublished.

[8]Wang Wen-Ke,"Research Approach of Education (new ed.)", Taipei City: Wu Nan. (1999)

MULTIMEDIA DESIGN FOR CHEMICAL VISUALISATION

Mun Fie Tsoi, Ngoh Khang Goh and Lian Sai Chia
Science and Technology Education, National Institute of Education, Nanyang Technological University, Republic of Singapore
E-mail: mfrtsoi@nie.edu.sg

In chemical or chemistry education, the ability to establish the connections among the three levels of understanding, namely, macroscopic, microscopic, and symbolic is an important task as this is fundamental to an understanding of chemical concepts. However, shortcomings such as limitations of textbooks in providing minimal images of macroscopic or microscopic events, time constraint and costs of laboratory experiments do exist, making achievement of the above essential task difficult for many students. Multimedia is one way to address these issues. As such, this paper concentrates on the pedagogical design for multimedia instruction in terms of instructional storyboarding and relevant learning principles. Visualisations such as computer graphics or animations and videos that elicit effective visual and verbal information processing will be illustrated using the topics of electrolysis, organic chemistry and acids, bases and salts.

Keywords: **Multimedia design; Interactive learning environment; chemical education**

1 Introduction

In the teaching and learning of chemistry, three understanding levels have been identified (see [1, 2] for more details). They are (a) the macroscopic level, which deals with sensory/ visible chemical phenomena such as laboratory observations and data; (b) the microscopic level, which deals with particles such as atoms, ions and molecules; and (c) the symbolic level, which represents the matter in terms of chemical formulae and equations. Students are required to demonstrate transfer between the phenomenon and its atomic or molecular events and symbolic representations.

However, this seems to be difficult for many students (see [3, 4] for more details). As such, multimedia CD-ROMs integrating various presentation modes such as sound, text, images, videos, graphics, and animations may be used to address this issue of the students' difficulties. Hence, this would call for an appropriate and practical multimedia design with an emphasis on dual coding of verbal and graphical information that would elicit effective visual and verbal information processing.

2 Multimedia Design

In multimedia design, one needs to consider the research in learning styles and "multiple intelligences" which imply that some students learn better through specific presentation modalities, such as visual, audio, or kinaesthetic. Essential design decisions such as determining the goal of the instruction and the pedagogical approach where learners are to be engaged not only in meaningful authentic tasks but also in constructing meanings with the visualisations employed need to be processed (see [5] for more details).

As such, important chemistry modules such as electrolysis, organic chemistry and acids, bases and salts are developed as part of a courseware with these design considerations in mind using C++ programming language and Director 6 to help students who take chemistry at the General Certificate of Education Ordinary Level.

3 Developing Visualisations

The first step in the development of visualisations in chemical or chemistry education is to identify the specific chemical concept or principle to be learnt for the particular subtopic. The next step will be to decide on the instructional use of the materials for purposes of expository teaching, demonstration, tutorial, group or individualised learning.

Subsequently, instructional storyboards will need to be constructed. Therefore, the following learning and design principles need to be taken into account. For example, integrating new knowledge with existing knowledge; organising system features logically and functional to facilitate the learning process; reducing the cognitive load on the learners through proper screen interface design and navigational procedures as well as employing the principle of progressive disclosure (see [6, 7] for more details).

Besides, the storyboard should contain as much information as possible on how the visualisations are to be displayed. Figure 1 shows the instructional storyboard on the addition reaction of alkenes while Figure 2 illustrates the translation of this storyboarding into the actual product. Notice also the emphasis placed on the different size, colour and shape of the atoms involved and the breaking of the chemical bonds in the animation which are essential in order to enhance the understanding of the meaning of "addition" in this organic chemical reaction.

As such, an understanding of the principles in using animation (see [8, 9] for more details) to address the three levels of understanding in chemistry is important so that relevant and appropriate animations can be employed in a concrete way to depict certain molecular events.

Figure 3 shows animations for the purpose of understanding the relative ease of losing electrons. The interactivity designed is functional in that opportunity is given to the user to discover and construct knowledge and understanding of the discharge of an anion with regard to its relative ease of losing its electrons.

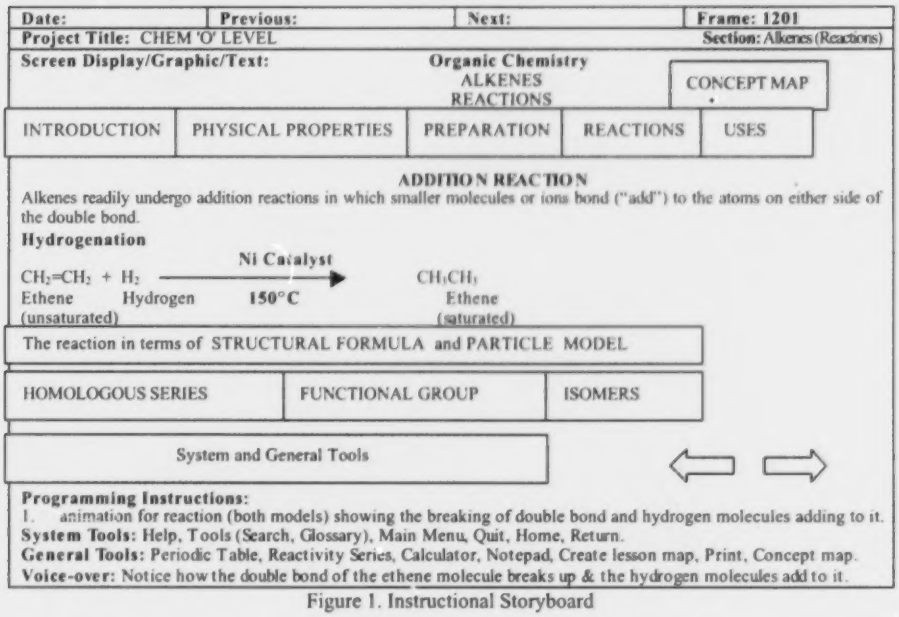


Figure 1. Instructional Storyboard

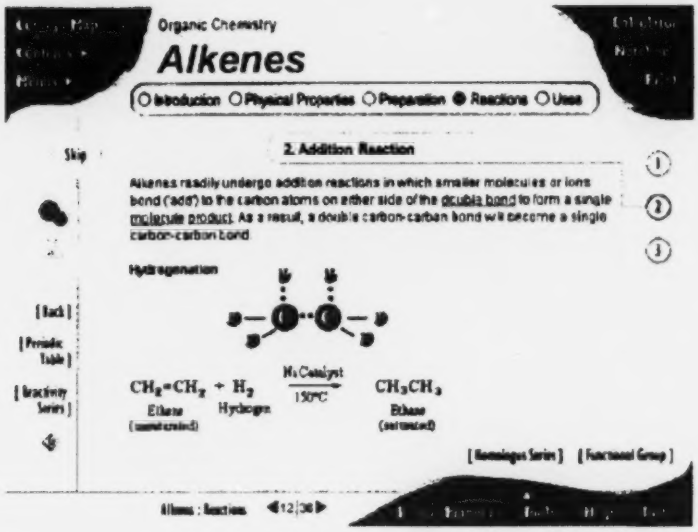


Figure 2. Organic chemistry user interface

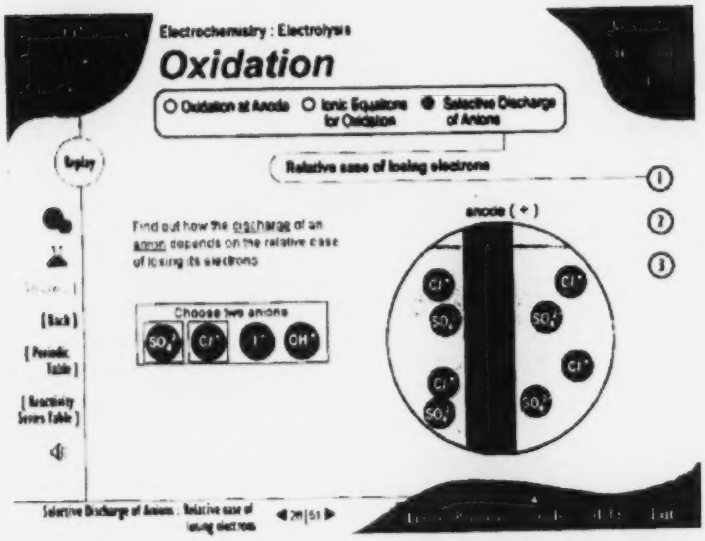


Figure 3. Electrochemistry user interface

4 Conclusions

The importance of content design will continue to be paramount even in the most advanced created multimedia technological environment. Animation, an example of computer graphics, can be used effectively to help learners to perceive and process information thereby increasing the depth and fluency of learning. Equally important is the pedagogical approach in the design of the multimedia courseware, which needs to be selected and understood.

BEST COPY AVAILABLE

From what we have observed, the development of visualisations in chemistry or chemical education is not a one-way process with arrows going in one particular direction through a flow chart, but rather an iterative process. Also, an overall multimedia design especially in the aspect of logical and functional consistency would be required. Despite the complex nature of chemistry multimedia courseware design, technological advances are providing dynamic new design and development opportunities. However, the development of sound pedagogy based on educational theories is still of primary importance. Essential issues, for example, the kind of methodology needed for the learning materials to be organised and structured; the type of navigation patterns to be employed; and how best the design and development process to be approached need to be fully addressed to realise the potential of such multimedia courseware.

References

[1] Johnstone, A. H., "Why is science difficult to learn? Things are seldom what they seem", Journal of Computer assisted Learning, vol. 7, pp. 75-83 (1991).

[2] Gabel, D. L., "Use of the particle nature of matter in developing conceptual understanding", Journal of Chemical Education, vol. 70, pp. 193-194 (1993).

[3] Herron, J. D., & Greenbowe, T. J., "What can we do about Sue: A case study of competence", Journal of Chemical Education, vol. 63, no. 6, pp. 528-53 (1986).

[4] Staver, J. R., & Lumpe, A. T., "Two investigations of Students' Understanding of the Mole Concept and its use in Problem Solving", Journal of Research in Science Teaching, vol. 32, no. 2, pp. 177-193 (1995).

[5] Wilson, B. G., Jonassen, D. H., & Cole, P., "Cognitive approaches to instructional design", in G.M. Piskurich (ed.), The ASTD Handbook of Instructional Technology, 21.1-21.22., New York: McGraw-Hill (1993).

[6] Gagne, R., "The conditions of learning", New York: Holt, Rinehart and Winston, 4th Edition, (1985).

[7] Shneiderman, B., "Designing the User Interface: Strategies for Effective Human-Computer Interaction", Reading, MA: Addison-Wesley (1997).

[8] Mayer, R. E. & Anderson, R. B., "The instructive animation: Helping students build connections between words and pictures in multimedia learning", Journal of Psychology, vol. 84, no. 4, pp. 444-452 (1992).

[9] Park, S. & Gittelman, S. S., "Selective use of animation and feedback in computer-based instruction", Educational Technology Research and Development, vol. 40, no. 4, pp. 27-38 (1992).

Multimedia Intelligent Tutoring System for Context-Free Grammar

Rhodora L. Reyes, Carlo Paolo T. Galvey, Marie Christine D. Gocolay, Eden M. Ordona and Conrado del Rosario Ruiz
Software Technology Department, College of Computer Studies
De La Sane University, Manila
2401Taft Ave., Manila
Tel: (632) 5244402, (632) 5364278
Email: ccsrlr@dlsu.edu.ph

CFG-MINTS is a multimedia intelligent tutoring system that teaches context-free grammar. The tutor model of his ITS is composed of a set of teaching strategies and an algorithm that determines which teaching action to be deployed given the goals of the system and the current state of the student model. The student model uses the Constraint-Based Modeling (CBM) approach in diagnosing the learner. CBM reduces the complexity of student modeling by focusing on the difference of the student' s solution to the ideal solution only and the analysis is reduced to pattern matching. The assumption here is that there can be no correct solution of a problem that traverses a problem state, which violates the fundamental ideas, or concepts of the domain. The system also includes features for simulating the created context-free grammar to aid in teaching.

*The paper was not available by the date of printing.

Multimedia Whiteboard Design in* WWW-Based Remote Cooperative Education System

Xueli Yu, Zongxia Du and Shiping Li
Taiyuan University of Technolygy, Taiyuan, Sahnxi, PRC
E—mail: xlyu@tyut.edu.cn

Computer Supported Cooperative Work (CSCW) is combined into the remote education, and the WWW-based Remote Cooperative Education System (RCES) is designed and realized in the paper. RCES adopts Browser/Serer model and makes users be able to run the client over the Internet without the need of installing special client software. And the real-time communication tool in RCES - multimedia whiteboard is also designed and realized which is also the major tool of CSCW. A set of Control Transport Protocol (CTP) is proposed to transmit the data and realized with Java and Java Media Framework (JMF). The new system enhances the interaction capability and realizes live transmit of multimedia data including graphics, images, audio and video etc.

Keywords: **CSCW, RCES, CTP, whiteboard**

1 Introduction

The theory of Computer Supported Cooperative Work appeared along with the progress of society, development of science and technology and raise of the complicated level of work. It provides a "being face-to-face " and What You See Is What I See (WYSIWIS) environment for the users scattered on different time and in different space and makes it possible for computer system to raise group work efficiency as well as traditional individual work efficiency. Since Engelbart first demonstrated CSCW in the 1960s, a variety of CSCW applications have developed at several research laboratories and universities. Education is an inherently cooperative activity involving at least one teacher and one student. Now, we combine CSCW into remote education, design and realize the WWW-based Remote Cooperative Education System (RCES). It adopts Browser/Server model and makes users can run the client over the Internet without the need of installing special client software.

Whiteboard is an important tool in the WWW-based RCES. The whiteboard provides a real-time interactive environment among people. In the traditional education, teacher and students face to face exchange their opinion through blackboard in classroom. While in the WWW based RCES on-line exchanging opinion and consulting are fulfilled through whiteboard over the Internet. Except the basic function, the whiteboard adds some functions such as drawing, loading images etc. The existing whiteboard system can roughly be divided into two kinds: systems based on Client/Server model and systems based on Browser/Server model. The whiteboard based on C/S model can solve well the interaction problem and provide powerful function for users. Its defect is that the users have to install the client software as server does. That limits the application scope of the system. Compared with it, the whiteboard based on B/S model can run over the Internet and the client doesn't need special software, but a

*Supported by the Foundation of Returned Overseas Students and Scholars in Shanxi Province browser such as IE or Netscape navigator is needed. Apparently B/S model gives a more convenient environment to the users. But its interactivity is less than C/S model and most present whiteboards based on B/S model only transmit the information such as texts, graphics, images, but do not support the transmission and playback of the time-based information such as audio and video.

We design and realize a new real-time communication tool in RCES—multimedia whiteboard that is also the major tool of CSCW. It absorbs the advantage of systems mentioned above. New system adopts B/S model

and makes users can run the client over the Internet without the need of installing special client software. In addition, we design a set of Control Transport Protocol (CTP) in order to transmit the data and implement it adopting Java and Java Media Frame (JMF). Compared with the present whiteboard, the new system enhances the interaction capability and transmits multimedia data lively including graphics, images, audio and video etc. And the live audio and video can be transmitted and played back on this new whiteboard to make the system more practical.

2 Control Transport Protocol Design

TCP/IP and UDP are the major protocols of the Internet and they are well supported by Java. The multimedia whiteboard runs over the Internet, so the system is mainly based on TCP/IP. When multimedia information is transmitted, Real-time Transport Protocol (RTP) is used, which is a protocol based on UDP so as to get better playback effects. In order to transmit and deal with the system information over the Internet, we design a new control protocol of application layer—Control Transport Protocol (CTP) that is special for the whiteboard system. We design it on the basis of the whiteboard function and build it in the request/response model.

Owing to assuring the accuracy of data transmission by TCP / IP, therefore, the design of CTP should be as succinct as possible under the promise that the function is guaranteed.

The CTP set can be represented as a multi-element set (D, F, n, a_1, a_2, … a_n). Here D represents the transfer direction. If data is transmitted from server to client, and then D="S", whereas D="C"; F represents the catalog of transfer data. For example, if a user wants to transmit the login data, and then F="login"; n represents the number of associated information and the concrete associated information is represented by a_1, a_2, … a_n. For a line, n=6, a_1="line", it is one of graphics styles. a_2 =color of paintbrush, it is an integer, a_3, a_4, a_5, a_6 are the starting and end point coordinate of this line. If the number of associated information is uncertain, and then n=-1, the subprotocol is ended with "ok". This protocol set can be expanded easily. For example, we want to transmit the polygon, we can add ("C","polygon", -1, the color of paintbrush, abscissa of starting point, ordinate of starting point, abscissa of the second point, ordinate of the second point, …abscissa of end point, ordinate of end point, "ok") to the CTP set.

Table 1 Control Transport Protocol Set

Tasks	Protocol
User applies* to join in a discussion room	("C", "join", 1, the topic of discussion room)
User applies to pause the communication	("C", "pause", 0)
Server demands** to refresh the room and the user lists	("S", "refresh", -1,the topic of room 1,the user 1's ID in the room $_1$,e the user 2's ID in the room $_1$, "complete", the topic o room $_2$,e the user 1's ID in the room $_2$…"complete", the topi of room $_n$ the user 1's ID in the room $_n$,"complete", "ok")
User applies transmit the graphics	("C", "draw", 6, graphics style***, the color of paintbrush, ab scissa f of starting point, ordinate of starting point, abscissa o end point, ordinate of end point)
Server demands transmit audio data	("S", "audio", 1, IP Multicast address)

Note: * The data from client is transmitted to server only;
** The data from server is transmitted to all clients in the same room;
*** The style of graphics includes line, point, oval and rectangle etc.

3 The method of solving key problems

The whiteboard is a major tool to help the cooperative education system to fulfill the cooperation. We have solved the key problems including technical problems about CSCW, problems occurred during multimedia transfer and so on. The method of solving key problems in the whiteboard is described as following:

1) The method of solving CSCW technical problems in the whiteboard

CSCW technical problem generally includes role-control, data consistency, conflict clearing, concurrency control and so on.

① Role control
Every user who logs in the system will play a role. In the education system, users are divided into 2 class: Teachers and students. By means of User ID, users get their roles and authority from existed user information database soon after they log in. Then according to their different roles and authority, related system functions are given.

② Data consistency
We use the method of Client/Server to solve the problem of data consistency. The whiteboard server maintains a set of global data and the data on each client PC are same as those on the server. When users operate with the data on client PC, this PC sends message to the server first. The server updates the global data and then informs the clients of the modification. At last, the clients update local data to keep the coherence of the whole system.

③ Conflict clearing
The conflicts in whiteboard mainly refer to data resource conflicts during transfer. They are due to the limited bandwidth and the high frequency outburst during data transfer. When several users send data at the same time or a certain user sends a mass of data, the congestion will occur in the web. Hence, data may be discarded or errors may be caused. Further, valid data have to be sent again and the congestion will be more serious. This problem is solved by way of data priority (PRI) when designing the system. That is to send the vital data first. Data PRI can be divided into 5 levels. They are listed in orders from higher to lower. i) Data such as users login information or screen-refreshing data, because these data will influence all users; ii) texts and graphics; iii) images; iv) audio; v) video. Data in higher level are always sent first.

④ Concurrency control
Concurrency control mainly indicates the conflict of shared resource used by users at the same time. Solving this problem is very important to fulfill cooperation; this factor must be taken into account in. Because the system belongs to distribute one, hence the concurrency control is very complex. Typical method of dealing with concurrency is the locking or time stamp. Relatively, the former is more simple and valid. The method of locking is adopted in the paper.

In our Server/Client system, synchronous block is created in each subprotocol of the protocol set. All operation of the subprotocol is performed in its synchronous block, so as to limit output stream or input stream that accesses to the web at random. As a result, when a thread processes a subprotocol, it can monopolize the shared resource and the other threads cannot access the resource. Thus a thread is able to process a subprotocol without disturbance from the other threads and system error can be avoided. The disadvantage is that efficiency of thread operation will be decreased. So the code in a synchronous block should be limited as little as possible under the promise of correct subprotocol operation.

2) The method of solving problems in the multimedia transfer

Multimedia information can be divided into 2 classes. One is information irrespective of time, such as text and graphics. The other is time-based information, such as audio and video. Because audio or video restrictively demands real time, discarding errors and ignoring lost data will achieve better effects. So audio and video information are transmitted by the way of UDP-based real-time transport protocol----RTP. It provides real time media transport services, such as live audio or video. These services include data type, sequence number, time stamp and transfer supervising. In fact, RTP itself cannot fulfill data-transmitting service without the help of protocols in lower level of the networks. The head of each RTP data packet includes time stamp and sequence number. With the time stamp, the receiver can resume the original data sequence. With the sequence number, the receiver can deal with lost, repeated or error data packet.

On the other hand, because the audio or video information is usually a large amount, and needs long time to transfer, it will take up too high bandwidth. In the situation of multi-users over the Internet, the method mentioned above cannot achieve good effects. We take advantage of IP Multicast Technique to save bandwidth, and the transferring and playing back audio or video smoothly in narrower bandwidth can be realized. IP Multicast Technique is a complement to the standard protocols of network level. It uses D-Class IP address

that possesses the same byte length as A-Class, B-class or C-Class address. And the scope of D-Class address is from 224.0.0.0 to 239.255.255.255 in decimals.

D-Class address is a kind of temporary address that is assigned and recovered dynamically. Each multicast group is corresponding to a dynamic D-Class address. After the multicast group finishes, its related D-Class address will be taken back to be used later. D-Class IP address is the multicast address for a whole group and the members in this group share the same D-Class IP address. So the information from the source node is sent only to members in this group. Furthermore, only one packet is sent to the site on the same route and the action of copying is performed only when needed. This process is different from point-to-point system (in point-to-point system, each destination site needs a copy). So we are able to save lots of bandwidth resource, increase the members on networks and eliminate the aimlessness of broadcast with the multicast way.

Because the standard JAVA API doesn't support transfer and playback of video information, the Java Media Framework produced by Sun Company can be applied. In fact JMF is a group of Java class library, which is created specially to remedy the incomplete support to multimedia in Java. JMF collects and plays multimedia data in Java applications or Java applets. JMF itself supports both RTP and IP Multicast Technique, so it is very convenient to transmit and play audio or video back with JMF.

4 Multimedia information flow

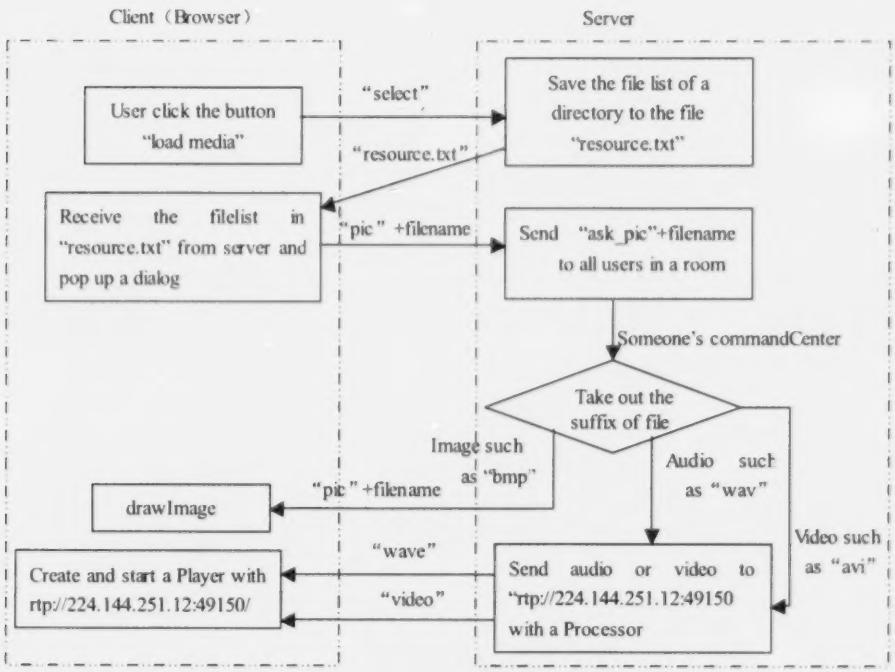


Fig.1 Multimedia information flow

Multimedia information flow is as shown in the figure 1. Taking the example of transmitting loaded multimedia information, the system flow is given out while users discuss using the whiteboard. When a user wants to load multimedia on the client, the client will send message ("C", "select", 0) to the server, which indicates the user wants to select loaded files. On receiving this message, the Sever sends a file list that is stored in a file named as "resource.txt" to the client. Then the client reads the file list out of that file and displays it in a new file-selecting dialog box. Hence the user can select the file that he wants to load and the message ("C", "pic", 1, filename) is sent to the server.

After the server receives this message, it sends the message ("pic"+ filename) to every user object that belongs to the server. Please note that this message is sent not to the client side but to the related user-information object in the server. According to the suffix of the file, the server knows it is an image, an audio or a video file that is needed by the client. If a picture is wanted, a message ("S", "pic", 1, filename) is sent to the client and the client calls drawImage () function to present the image by its filename. If the audio or video is wanted, the Server will create a D-class multicast address and send multimedia data to this address. Meanwhile the Server sends to each user in the room a message "audio"(in case of audio data) or a message "video" (in case of video data). Thus the clients are informed to join in the related multicast address so that the audio or video can be played back.

5 Conclusions

In order to test the performance of new system, we not only apply text, image, animation, and drawing graphic, but also apply most challenging time-based media – audio and video – to this system. The result is rather good (Testing condition is: rate of network is over 40 Mbps, one server and 5 concurrent users, on-line transferring and playing back audio and video).

Remote education is an application on networks that develops rapidly in recent years. With the never stopping development of network technique and multimedia technique, the users' demand on remote education will be higher and higher. We combine CSCW technique into remote education and make the system possess more and better mutual functions. Based on the past man-to-PC mutual mechanism, we add man-to-man mutual mechanism to the system. Now the educating process becomes more vivid, and better education effect is achieved.

The real-time communicating ability of most B/S model software in present cannot satisfy the users' demands. Taking this factor into consideration, we design and use CTP to transmit control message and non-time-based media information and combine RTP and IP Multicast Technique with CTP to fulfill the transfers and playback of multimedia information. Hence the real-time communication ability of the system is enhanced. Compared with the present whiteboard in B/S model, the system has stronger function in transmitting the multimedia. It can't only transmit the audio and video in files, but also can transmit the live audio and video to get better effects in education. The students can hear or see the teacher and communicate with him or her in real time.

Though most present software in B/S model are weaker than those in C/S model, the convenience that they possess provides a large latent market. Furthermore, with the development of the browser and other related techniques, the functions of software in B/S model will become more and stronger. In a word, the prospect of software in B/S model is promising.

References

[1] Liang ,Ting-Peng. When Client/Server Isn't Enough: Coordinating Multiple Distributed Tasks, Computer of IEEE, May 1994

[2] Mohammad Banikazemi. IP Multicast: Concepts, Algorithms, and Protocols http://src.doc.ic.ac.uk/computing/internet

[3] Nathaniel S. Borenstein, Computational Mail as Network Infrastructure for Computer-Supported Cooperative Work, Proceedings of CSCW 92, 1992, pp 67-74

[4] RTP: A Transport Protocol for Real-time Applications, RFC1889 http://src.doc.ic.ac.uk/computing/internet/rfc/rfc1889.txt

[5] Teege G. Object-Oriented Activity Support: A model for Integrated CSCW System. Computer Supported Cooperative Work. 1996, 5

Multimedia-Based Teaching Material For Learning Digital Signal Processing

Tetsuro SHIMAMURA*, Hiroshi SUDA,**
Masahiro UKIGAI, Yoshiro MIIDA****
** Dept. of Computer Science, Chiba Institute of Technology*
*** Dept. of Network Science, Chiba Institute of Technology*
2-17-1 Tsudanuma, Narashino, Chiba, Japan 275-0016
Tel: +81-47-478-0288
Fax: +81-47-478-0582
E-mail: simamura@miida.cs.it-chiba.ac.jp

In acoustic engineering, it is very difficult to understand a phenomenon of a wave inside of a media, because these phenomena are invisible. In education of digital signal processing, it is related to improve the educational effect, that the method to help understand to modelize these phenomena. In this research, the digital signal processing teaching material, which used the multimedia, was designed and developed.

Keywords: **Education of Acoustic Engineering, Multimedia, Digital Signal Processing**

1 Introduction

In Education of Acoustic Engineering, it is very important to promote better understanding about a wave or a sound. It is difficult for students to confirm the theory, because of them invisibleness. If a sound can be visualized, it is very easy to understand them. The concretely samples of acoustic engineering are closely connected with our daily life. So, it is very important to present the relative movies, music, or synthetic sounds. It becomes to better effects of education.

By the way, computers get speedier CPU and larger volume of hard disk, and software for presentation and visualized languages, which have a graphical user interface, is improved. These things made easy to visualize a difficult simulation, and to playback a movie and a sound. [1-3] In this research, the digital signal processing program that requires using it in the lecture to improve student's understanding is developed.

2 Theory

2-1 Discrete Fourier Transform (DFT)

The Fourier Transform is a method of converting a complex signal into a lot of sine wave groups. Analog signal that is continued cannot be treated in case of the Fourier transform on the computer. Therefore, discrete data will be treated. It is called Discrete Fourier Transform (DFT).

Figure 1 shows the process of DFT. A wave sampled by computer. The sampling condition has the sampling rate and the number of making to the quantum. The shape of waves that changes in detail cannot be read when the sampling rate lowers to the maximum frequency included in the input signal, and the shape of waves of the phantom is sampled. This phenomenon is called Aliasing error, and the appearance is shown in Figure 2.

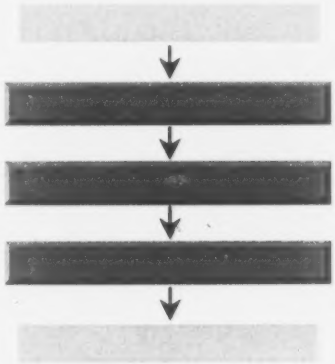


Fig1. Flow of Processing until signal analyzing

So as not to generate Aliasing error, when the frequency of the wave input to the computer is assumed to be f, the sampling cycle should be at least $2f$ or more.[4]

When one cycle of a certain continuous crimp is sampled by equal intervals, the data row of P piece($f_0, f_1, f_2, \ldots, f_{p-1}$) is obtained. When DFT is calculated by using this data row, f_N becomes the next expression.

$$f_N = \sum_{M=0}^{P-1} a_M e^{j(2\pi/P)MN} \qquad (2\text{-}1\text{-}1)$$

In general DFT, the next expression is used to obtain the coefficient($a_0, a_1, a_2, \ldots, a_M$) of the above expression.

$$a_M = \frac{1}{P}\sum_{N=0}^{P-1} f_N e^{-j(2\pi/P)MN} \qquad (2\text{-}1\text{-}2)$$

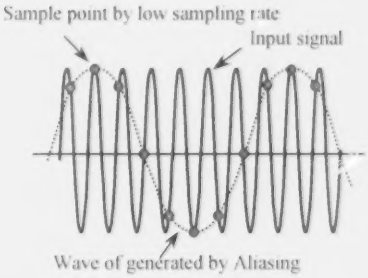


Fig 2. Appearance of Aliasing error

In the above expression, P shows the number of sampling for one wavy cycle and M shows the degree of a high note wave.

In this method, however, to obtain all the coefficient rows, addition and the multiplication by the complex number are needed. So, a lot of calculation time is required.

2-2 Fast Fourier Transform (FFT)

In this program, the method of decimation in time is used as a method of Fast Fourier Transform. It is one of the methods for the high-speed enabling processing.
The expression is the following.

Previously, a part of complex function value which is used frequently shows as expression (2-2-1).

$$W_P^{\ M} = e^{-j(2\pi/P)M} \qquad (2\text{-}2\text{-}1)$$

And the following relation exists because $W_P^{\ M}$ has the cycle of P.[4]

$$W_P^{\ M+P/2} = -W_P^{\ M} \qquad (2\text{-}2\text{-}2)$$

Therefore, the expression which uses the method is the following expression (2-2-3) and (2-2-4).

$$a_M = a_{EM} + W_P^{\ M} a_{OM} \qquad (2\text{-}2\text{-}3)$$

$$a_{M+P/2} = a_{EM} - W_P^{\ M} a_{OM} \qquad M=0, 1, 2, \ldots, P/2-1 \qquad (2\text{-}2\text{-}4)$$

At this time, the Mth coefficient a_M of DFT data that calculated by data-row including data of P, could be changed to 2 data-rows, which are the even data-row a_{EM} and the odd data-row a_{OM}. These rows are composed by $P/2$ piece. EM and OM, affixing characters of a, explain order of even-row and odd-row.

The principle chart in this method is shown in Figure 3. It shows, if the number of data is made involve piece of two by using this method, it is divided consequentially into two DFT groups.

By this method, the DFT calculation of the data of P piece decreases from times of P^2 to times of $(P/2)\log_2 P$. In addition, doing high-speed DFT becomes possible because the addition frequency also decreases the level.

3 Teaching Material Development

3-1 Development Background

The lecture of Acoustic Engineering in our department is lectured with the multimedia style by using the LCD projector and the notebook-sized personal computer. The multimedia contents that used by presentation are composed of the slide simulation program and the dynamic scene, etcetera. The lecture consists by the main explanation and a supplementary explanation. That is, the former uses the main slide and the latter uses the simulator teaching material of the phenomenon in Acoustic Engineering.

In a past research, we have developed the teaching material, which is multimedia-based for learning Fourier Transform. It is shown in Figure 3. Moreover, it actually uses in the lecture of our Department and an educational effect has been improved.

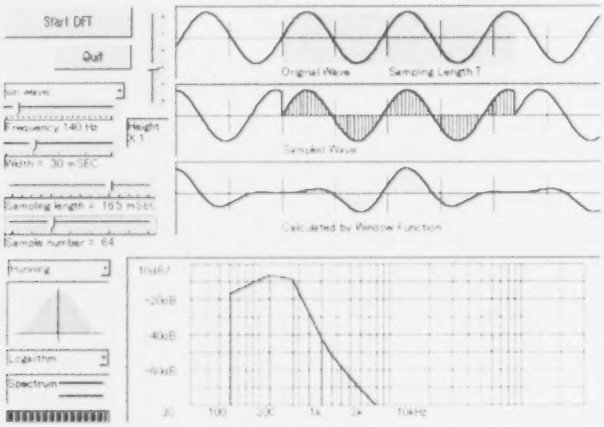


Fig 3. A program of DFT Analyzer

3-2 Execution Program

This program enhances the above-mentioned teaching material. That is, the analysis teaching material of sound to improve understanding voice-print analysis and filter is developed. The voice-print can be analyzed by applying DFT. The analysis result can judge the character of the voice. On the other hand, the filter is an application of DFT as well as the voice-print, too. We can extract an arbitrary frequency and do masking by using the filter. If these phenomena can be made visible, and the sound in that case is output, the understanding of the student will be improved.

For development of teaching material, the user interface part uses Microsoft Visual Basic (VB), and the FFT calculation part uses Microsoft Visual C++ (VC++). As this reason, the former has already had GUI(Graphical User Interface) parts and the latter can execute a numeric calculation at high speed.

This teaching material is required to be used with the projector with a remote-controlled mouse. Therefore, the following two points are important.

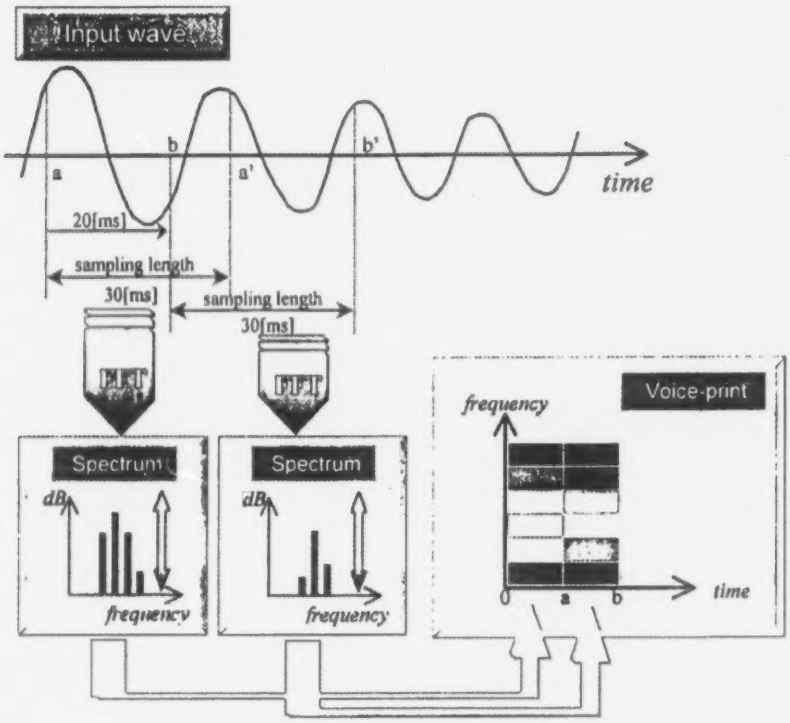
To reduce the load of those who operate it, the frequency of the click is reduced as much as possible.
To use by the lecture is considered, a detailed character and the image keep from using, and enlarge an important wave display.

It is necessary to design the screen based on the above-mentioned theory.

Figure 4 shows the flow of the program. First, it is necessary to cut out the input wave. The section samples it with about 30[msec], from a to a'. Next, the window-function and FFT must be processed to the obtained sampling wave. Then, it becomes spectrum of each frequency. Finally, in the obtained spectrum, a strong part is classified as white and a weak is classified as a black by each frequency element. And, the section shifts in 20[msec], and the part of the following 30[msec] is sampled and input again. The Frequency-Time graph obtained repeating these process is a voice-print. And digital filter extracts and masking a specific

frequency in the graph.

This program has a flexible setting in the above-mentioned process.



Appearance of Aliasing error

4 Conclusions

In this research, the multimedia-based teaching material of digital signal processing that used in the lecture of Acoustic Engineering was designed, and developed. In using this in the lecture of Acoustic Engineering, It is thought that this teaching material can help understanding the phenomenon, in digital signal processing. Moreover, it is possible to apply it also to large-scale education and the distant place education by developing this program for the network.

References

[1] Hiroshi Suda, Masahiro Ukigai, & Yoshiro Miida, "Multimedia-Based Acoustical Engineering Education", Journal of the Educational Application of Information Technologies, Vol.2, No.1, pp.13-18, (1999).

[2] Hiroshi Suda, Masahiro Ukigai, & Yoshiro Miida, "Education of Acoustic Engineering with Multimedia-Presentation Style", Proceedings of the International Conference on Computers in Education (ICCE'99), Kisarazu, Japan, November 4-7, pp.2-211-214, (1999).

[3] Harutoyo Ozawa, Hiroshi Suda, & Yoshiro Miida, "The Education System for Acoustic Engineering with Multimedia", Proceedings of the Electoronics, Information and Systems Conference Electoronics, Information and System Society, I.E.E. of Japan, Narashino, Japan, August 30-31, pp.453-456, (1999).

[4] Shuichi Arai & Yoshiro Miida, "Suuchi Keisan Hou", Morikita-Shuppan, (1991).

Agents in a WWW System for Academic English Teaching

Alexandra Cristea and Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621; Fax: +81-424-89-6070
E-mail:alex@ai.is.uec.ac.jp

This paper describes our research on building a free, evolutionary, Internet-based, agent-based, long-distance teaching environment for academic English. Here we will describe some of the design aspects of the system prototype, focusing especially on the adaptive features and the agents of the system.

Keywords: **Distance Education, CALL, Agent Technology**

1 Introduction

As distances constantly grow smaller and the Internet links more and more remote parts of the world, English gradually becomes the lingua franca for information exchange. In the academic field, in research and development, where international cooperation is a must, English is used frequently. Academic English is International English. Although accents are more or less variable, the spoken, but mostly, the written academic language has still its rules and etiquette. Academics usually know some English and have a more or less wide English vocabulary. However, especially in Japan, but in other non-English speaking countries as well, there exists the phenomenon that, although a person can read academic papers in English, when it comes to writing a paper by oneself, or to make an academic presentation in English, serious problems appear. Therefore, we embed these necessary rules and etiquette in our teaching environment. The main aim of our system is to help academics exchange meaningful information with their peers, through a variety of information exchange ways: academic homepages, academic papers, academic presentations, etc. As far as we know, this type of English teaching system is new. Some English teaching environments on the Web appeared, but, as in [1] or [11], they have two main defects: they are not free, and/or they are not automatic, but based on real human teachers at the end of the line. Good on-line dictionaries [12], [8] and several collections of English on-line books [2] exist, but those can only act as auxiliary helpers during the English learning process. Our aim is to have a system capable to function autonomously, without human interference, as a virtual, long-distance classroom, embedding the necessary tutoring functions within a set of collaborating agents that will serve the student. The course is called 'MyEnglishTeacher', because of its evolutionary nature, of adapting over time to the needs and preferences of individual users. These needs can be expressed explicitly, or can be implicitly deduced by the system, represented by its agents. We are currently in the process of adding more AI-based intelligent adaptation capabilities. Users can find in our virtual classroom situational examples of academic life, presented as Multimedia, with Audio and/or Video presentations, Text explanations and pointers to the main patterns introduced with each lesson, exercises to test the user's understanding, moreover, adaptive correction, explanation and guidance of the user's mistakes. The general guidelines for this system were proposed by our course design researcher in [3] and elaborated by us in [6].

2 Background

Virtual environments in education and distance-learning systems are the recent trends in education worldwide. This trend is determined by the current spread of the Internet, as well as by a real demand for better, easy-to-access, and cheaper educational facilities. Therefore, universities everywhere respond to the academic demand for technological and pedagogical support in course preparation, by developing specialized software environments [5]. As bandwidths grow, the traditional text environments gradually switch to multimedia and Video-on-Demand (VOD) systems ([17]). The problems in the current language

education systems, as well as the motivation of our research, as pointed out by our language specialist team member and [15], can be resumed as follows: the lack of learning activities for checking learners' constructive understanding (requiring the learner not only to memorize, but also to summarize, generate, differentiate, or predict); the lack of a variety of problem-solving tasks to motivate students to think about their reading; the learning process does not enable learners to become active participants; in the current Computer Aided Language Learning (CALL) systems, learners cannot key-in the target language's sentences freely; lack of explanatory feedback (telling the user why); lack of exercises related to the learner's individual characteristics; lack of considerations about the effectiveness of different physical attributes of the presentations, on the students' learning; lack of analysis of the interaction between learner and learning environment, with special focus on assimilation and accommodation. These problems could not be solved by traditional systems, mostly due to their lack of adaptability, or in other words, intelligence. In [19], it is stated: "there is the need to endow these systems with the ability to adapt and learn, that is, to self-improve their future performance". The objective of this research is to help learners achieve academic reading and writing ability. The course is intended for students whose starting English level is intermediate and upper-intermediate, who have some vocabulary of English, but not much practice in using it. The tutoring strategy used is to give the reader insight into his or her implicit or explicit learning strategies. The methodology applied is the communicative teaching approach, allowing communication and interaction between student and tutoring system, via agents. The interactive reading strategies applied and yet to apply include bottom-up theory, top-down theory, and schemata theory. The topics and stories used are mainly passages from textbooks, journals, reference works, conference proceedings, and academic papers, in other words, real-life academic products.

3 System features and modules

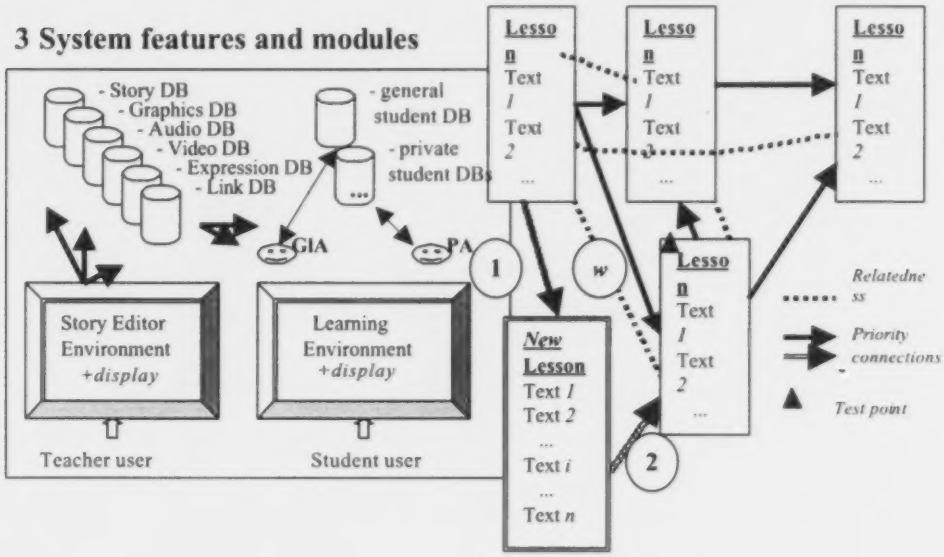


Fig. 1: The system modules and their interaction

Fig. 2: The subject link database

The system offers two interfaces, one for the teacher/tutor user, for course-authoring purposes, and the other one for the student user, who is supposed to learn. The information exchange from tutor to system contains input of lessons, texts, links between them, etc., but also asking for help in editing. The data from the tutor is stored in six different structured databases, including a library of expressions that appear in the text, a VOD database, a background image database, an audio database of listening examples, a full text database and a link database. The information exchange with the student is more complex. It contains usage of the presented materials, implicit or explicit advice, the student's advice requests, queries, searches, gathering of data on the student by the two agents, the Global Agent (GlA) and the Personal Agent (PA). Each of these agents has its own database on the student(s). The GlA stores general features on students, and the PA stores the private features of each student. User modeling follows many patterns, and has many applications. [7] proposes a fuzzy-based, stereotype collecting user model for hypermedia navigation. [18] elaborates on the Human Plausible Theory. ([4]) provides intelligent help for determining the cause of errors in software usage.

[14] has shown how prior belief (belief bias) can influence the correctness of judgment of the human (users). Other authors, like [10] have studied the relation between achievement goals, study strategies and exam performance. A realistic user model has to take into consideration the influences a system can achieve on the user, in order to allow an easy interpretation of the current state, as well as an easy and clear implementation of the user model.

4 The Authoring System Module (Story Editor)

Our most important goal is to design a meaningful, evolutionary feedback for the user. In order to build such a
system, an authoring tool is necessary for flexibility purposes: our colleagues researching the optimal material for academic English teaching should be able to add or delete freely the available resources. In a way, they are also clients/users, and should be restricted to build a courseware, which conforms to the capabilities of the system. In the following, these restrictions and their purposes are explained. These restrictions are necessary instruments for the two system agents to work with, as will be shown later in this paper.

Texts: Each video/audio recording has to have a corresponding TEXT (of dialog, etc.). For each text, it is analyzed if video is necessary, or if audio suffices, as audio requires less memory space and allows a more compact storage and a speedy retrieval. Each TEXT also has (beside of main text, etc.), the following attributes: a short title, keywords, explanation, patterns to learn, conclusion, and finally, exercises. Titles and keywords are naturally used for search and retrieval, but the explanation and conclusion files can be also used for the same purpose, as will be explained later on.

Lessons: One or more TEXTs (with video or not) make up a LESSON. Each LESSON also has (beside of texts, etc.) the following attributes: title, keywords, explanation, conclusion, combined exercises (generated automatically or not). Next, a text or a lesson will be referred as ' SUBJECT'.

Priority and Relatedness Connections: When introducing one or more subjects, the teacher has to specify the Priority Connections, i.e., to show the required learning order, with a directed graph (arrows). When there is no order, subjects will have the same priority, and build a set. The teacher (courseware author) should also add connections between related SUBJECTS, with indirect links. This means, the teacher has to add Relatedness Connections between subjects, for which no specific learning order is required, but which are related. These relations are useful, e.g., during tests: if one of the subjects is considered known, the other one should be also tested. The main differences between the priority connections and the relatedness connections is that the first ones are directional, weightless connections, whereas the latter are non-directional, weighted connections. After these priorities and links are set, the system will then automatically add more links via keyword matching, from explicit keyword files and keyword search within subjects. Priorities among the texts of a lesson are set implicitly according to the order of the texts, but can be modified, if necessary. The teacher / multimedia courseware author can decide if it is more meaningful to connect individual texts, or entire lessons, for each lesson. The way a new lesson is introduced, by asking the teacher to set at least the previous and the following lesson in the lesson priority flow, is shown in figure 2 (steps 1,2). As can be noticed from figure 2, priority connections, with no respective relatedness connection, can exist. This can happen when, e.g., common course design knowledge dictates that respective priority, but the learning contents of the lessons are quite different. These kinds of priorities are optimal student learning strategy related connections, not similar contents connections. These priorities help the system to place the current subject in the global subject map. Final priorities will be set by the system according to findings (teacher's input, keyword matching). This final result can be shown to the teacher or not, depending on the options under which the system is running. We are currently testing if it is wise to allow the teacher to have add/modify/delete rights. The final graph is used for the student, and it can be shown to the student upon request, serving as a map guide.

Numbering: SUBJECTS are numbered automatically in the order of their creation. Teachers are prohibited to use numbering. This is because otherwise, every time new material is brought, the numbering should be changed according to the new order of priorities. TEXTs are automatically numbered inside a lesson, and are referred from outside with two numbers: the LESSON number and the text number.

Test Points: The teacher should mark TEST POINTS (figure 2), at which it is necessary to pass a test in order to proceed (these tests can be at any SUBJECT level).

5 Student models and agents

The system gradually builds two evolutionary student models: a global student model (GS) and an individual student model (IS), managed by two intelligent agents: the personal agent (PA) and the global agent (GlA).

The reason for doing so is that some features, which are common to all students, can be captured in the GS. However, many studies have shown [17] that personalized environments and especially, personalized tutors, have a better chance of transferring the knowledge information from tutor to student. This is true even in the more general sense of a tutor and student, where the tutor can be man or machine, and the student likewise. In this work, we mean by agent a "computer system situated in some environment", "capable of autonomous action", "in the sense that the system should be able to act without the direct intervention of humans", "and should have control over its own actions and internal state" [13]. These agents' intelligence is expressed by the fact that each agent "is capable of flexible autonomous action in order to meet its design objectives", and that it is "responsive" (it perceives its environment), "proactive" (opportunistic, goal-directed), "social" (able to interact) [13], and of an "anticipatory" nature (having a model of itself and the environment, and the capability to pre-adapt itself according to these models) [9]. Next, the raw data stored for the two student models, the GS and IS, is presented.

The GS: The GS contains the global student features: the common mistakes; favorite pages, lessons, texts, videos, audios, grading of tests' difficulty (according to how many students do each test well or not); search patterns introduced, subjects accessed afterwards: if many IS use the same order, than they are recorded in the GS.

The IS: The IS contains the personal student features: the last page accessed; grades for all tests taken, mistakes and their frequency; if the student takes the test again and succeeds, his/her last grade is deleted, but his/her previous mistakes are collected for future tests; the order of access of texts inside each lesson; order of access of lessons (this can be guide to other students: "when another student was in your situation, he/she chose..."); frequency of accessing texts/ lessons/ videos/ audios, etc. - for guidance and current state check; search patterns introduced, subjects accessed afterwards (to link patterns with new subjects that the system didn't link before).

The PA: The role of the personal agent is to manage the information gathered on the user, and to extract from this information useful user guidance material. Each step taken by the user inside the environment is stored, and compared with both what was proposed to the user, as well as with what the user was expected to do (from the PA's point of view). The differences between previous expectation and current state are exploited, in order to be used for new guidance generation. Beside of analyzing the own user and extracting knowledge from the data on him/her, the PA is able to request information from the GIA, about, for instance, what other users chose to do in a similar situation to the current one of the PA's own user. Furthermore, the PA can contact other PA's with similar profiles (after a matchmaking process), and obtain similar information as from the GIA, only with more specificity. The PA can decide to turn to another PA if the information from the GIA is insufficient for a decision about the current support method. The PA decides, every time a user enters the system, what material should be studied during that particular session, and generates a corresponding list. Therefore, the course index is dynamic, not static. To this material, the PA will add or subtract, according to the interaction with the user during the session. According to [16], the PA is therefore an interface agent ("a computer program to provide assistance to a user dealing with a particular computer application" – in this case, a learning environment). However, the PA's job description is a little wider than this, as can be seen also in the following.

The GIA: The global agent averages information from several users, to obtain a general student model. The deductions of the global agent are bound to be non-specific. The GIA is necessary, because otherwise, the system will not profit from the fact that different users interacted with the system, and each new interaction can smoothen the path for following users. The GIA is to be referred before the PA starts looking for information from other PAs, process that can be more time-consuming. Therefore, the role of the GIA is to offer to the PAs condensed information, in an easily accessible, swiftly loadable form. From this description, it is clear that the GIA is subordinate to the PA (from the student user's point of view). The GIA cannot directly contact the student user – unless the PA explicitly requests it. If the GIA considers that its intervention is required, it still has to ask for permission from the PA. In this way, the generation of confusing advice is avoided.

From the described interactions between agents and databases, and between the agents themselves, it is clear that the agents of the system work in two ways. The first way is based on the embedded rule/knowledge systems, which try to foresee, prevent and solve conflicting situations. The second way is as evolutionary, learning objects, which can adaptively change their representation of the subject space, by creating and deleting links and changing weights. A next step in the system's agents design will be focused on adaptive problem, quiz and test generation. In short, this design is made necessary by the fact that a student, after failing to pass a test, has to be presented, after some more learning is done, with a new test, of similar difficulty and contents. As it is difficult for the teachers to generate as many tests as would be necessary for such repeated situations, this task is to be passed to the system's agents. A very important task of each of the agents is also to keep the consistency of the subject link database. The agents inform the teacher(s) if some subjects form loops (determined by the priority connections set by the teacher(s)), if some subjects become inaccessible; if a teacher is not available, they make corrections by themselves, and decide from the student (s) feedback about the appropriateness of those changes.

6 Conclusions

We have proposed in this paper an Evolutionary, Web-based, Academic English Teaching Environment, called "MyEnglishTeacher". Moreover, we have described the rationale, the design and implementation and the modules of our system: an authoring environment for the teacher user(s), which is generating the lessons, and a learning environment for the student user(s). We have further on presented each of these modules in more details. The learning environment is based on two intelligent agents, interacting with each other and the student user, in order to guide the student through a new course for academic English, which is under development in our laboratory. We have also explained in which sense our agents evolve and present intelligence. Our agents build and modify student models with the help of a double graph: a non-weighted, directional priority graph, and a weighted, non-directional, relatedness graph. In addition, we have explained how, from the authoring system courseware design requirements, we enforce the generation of structured content databases, to serve as a basis to the rule/knowledge bases, which will be used and added to by the two agents. We believe that with our system we are addressing more than one current need: the need of an English tutor for academics, which should also be easily accessible – i.e., on-line –, free, adaptive and user-friendly.

References

[1] Aspera PrivaTeacher, http://www.privateacher.com/

[2] Bartleby.com, Great books on-line, http://www.bartleby.com/

[3] Cristea et al,. (1999) "The Theoretical Framework for CALL Courseware Development", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 723-726.

[4] Collins, A. and Michalski, R. (1989) "The logic of plausible reasoning: A core theory", Cognitive Science, Vol. 13, 1-49.

[5] Collis, B. (1999) 'Design, Development and Implementation of a WWW-Based Course-Support System", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 11-18.

[6] Cristea et al, (2000) "An Intelligent language teaching tool for the Web", Proc. of ISSEI 2000, Bergen, Norway.

[7] Di Lascio, L., Fischetti, E. and Gisolfi, A. (1999) "A Fuzzy-Based Approach to Stereotype Selection in Hypermedia", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 285-320.

[8] Dictionary, http://www.dictionary.com/

[9] Ekdahl, B., Astor, E. and Davidsson, P. (1995) "Towards Anticipatory Agents", Woolridge, M., Jennings, N.R. (Eds.), Theories, Architectures, and Languages, Lecture Notes in Artificial Intelligence, Springer Verlag, 191-202.

[10] Elliot, A.J., McGregor, H.A. and Gable, S. (1999) "Achievement Goals, Study Strategies, and Exam Performance: A Mediator Analysis", Journal of Educational Psychology, Vol. 91, No.3, 549-563.

[11] EnglishLearner, http://www.englishlearner.com

[12] Jeffrey' s Japanese-English ó English-Japanese on-line dictionary. http://enterprise.dsi.crc.ca/cgi-bin/j-e/jis/dict

[13] Jennings, N.R. and Wooldridge, M. (1998) "Applications of Intelligent Agents", Agent Technology Foundations, Applications, and Markets, Springer-Verlag.

[14] Sa, W.C., West, R.F. and Stanovich, K.E. (1999) "The Domain Specificity and Generality of Belief Bias; Searching for a Generalizable Critical Thinking Skill", Journal of Educational Psychology, Vol. 91, No.3, 497-510.

[15] Levy, M. (1997) "Computer-Assisted Language Learning", Oxford Claredon Press.

[16] Maes, P. et al. (1993) "Learning Interface Agents", Proc. of the 11th Nat. Conf. AAAI, MIT/AAAI Press.

[17] Tomek, I. (1999) "Virtual Environments in Education", Frontiers in Artificial Intelligence and Applications Series, Eds. Cumming, G., Okamoto, T., Gomez, L., IOS Press Ohmsha, 3-10.

[18] Virvou, M., Du Boulay, B. (1999) "Human Plausible Reasoning for Intelligent Help", User Modeling and User-Adaptive Interaction, Vol. 9, No.4, Kluwer Academic Publishers, 321-275.

[19] Weiss, G. And Sen, S. (Eds.) (1996) "Adaptation and Learning in Multi-Agent Systems", Springer Verlag, Lecture Notes in Artificial Intelligence, Vol. 1042.

Natural Language-like Knowledge Representation for Multimedia Educational Systems

Eva Heinrich and Ray Kemp
Institute of Information Sciences and Technology
Massey University, Palmerston North, New Zealand
E-mail: E.Heinrich@massey.ac.nz R.Kemp@massey.ac.nz

The appropriate use of multimedia is becoming increasingly important in computer teaching systems. Not only are students stimulated by being presented with information in a variety of forms, but such an approach also more closely resembles the real world where they have to assimilate what they see and hear, abstracting out what is relevant. With the diversity and amount of multimedia material that may be present in these systems, a powerful form of knowledge representation is required to support navigation and knowledge retrieval. The (human or computer) tutor may wish to refer to document segments, to recap important points, provide feedback, give hints and so on. The student also may wish to refer to items previously seen or heard. The Flexible Structured Coding Language, FSCL, is a natural language-like, formalised description language which allows the formulation of rich yet structured sentences. These sentences are attached to segments of multimedia documents. FSCL provides an easily accessible approach for knowledge representation, precise and rich description of complex contents, correct and complete retrieval within the descriptions, and retrieval across data of different media types. FSCL can be extended to integrate ontologies, inference of knowledge and freeform querying performed by the learner.

Keywords: **Multimedia, knowledge representation**

1 Introduction

Computer-based educational systems have developed from standalone applications, using mainly text and graphics, which focused on teaching a restricted set of subjects or skills. Today's multimedia systems are often distributed across the web using a client-server approach and aim to integrate teaching material from multiple subjects areas. These systems collect feedback on the progress of the learner and attempt to provide material at the appropriate levels. An example of such a system is GENTLE [5].

Beside the technical challenges of managing such a system, a number of conceptual ones arise. One of these is knowledge representation and the related issue of knowledge retrieval. One problem with supplying a learner with a flexible learning environment is the need to provide a mechanism for locating appropriate information. This is a non-trivial task considering the vast amount of diverse material stored and the complexity of the concepts incorporated into the learning material. Another requirement is to give the learner a mechanism for questioning the system. This can be for retrieving specific material or for asking conceptual questions concerning the subject area.

To illustrate some of the requirements for a computer-based educational system, consider a small scenario. Imagine a web-based teaching module on the use of machinery. This module could consist of a number of multimedia documents: for example, a video showing an instructor demonstrating the use of the machinery, a set of images displaying various technical features of the machinery or a set of text documents explaining various procedures. These multimedia documents, annotated with appropriate knowledge representation mechanisms and generic domain knowledge, have to be stored. Based on this information a range of material could be retrieved: a segment of the video document showing the instructor demonstrating a specific task; additional information from images or text documents relating exactly to this task; the status of

the machinery at a specific position in the video inferred from the domain rules.

After a brief overview on current approaches to knowledge representation in computer-based educational systems, we consider how the Flexible Structured Coding Language, FSCL [9,11], may be applied to this problem. We will first describe FSCL in the form it is used in its original context of studies of human behaviour and then discuss the advantages of using FSCL in computer-based educational systems. We then suggest some modifications to FSCL to provide extended support for computer-based educational systems and conclude the paper by summarising the contributions this natural language-like approach to knowledge representation can give us.

2 Current approaches to knowledge representation

To access the appropriate information in a computer-based educational system, a knowledge representation scheme is necessary. This provides a meta-level description of the contents of the educational system. In this paper, we consider the format of this meta-level description, not its technical realization in a database or file system. Before we describe some common approaches to meta-level description, we want to briefly discuss why a meta-level description is necessary and why it is not possible to extract the information directly from the learning material.

The retrieval of information from documents directly has limited scope both on a technical and on a conceptual level. Technically, searching through text based documents is easy and allows for identification of keywords, phrases or sentences. Achieving the same level of retrieval for video documents is much harder. Techniques exist to automatically parse video documents to detect scene changes [8, 23] and objects [6, 17]. However, a number of problems still have to be overcome to provide sufficient access to video content [13].

Setting the technical difficulties in accessing video or audio documents aside, there are still conceptual considerations which will demand some meta-level description of content. Retrieving appropriate information from a collection of documents will, in many cases, require access to the semantics of these documents. Searching through these documents on a keyword (or object) basis is unlikely to produce satisfactory results [2]. The transition of factual ('she was smiling', a smiling face, a sunny picture) to conceptual (happiness, pleasant atmosphere) information has to be made to access the semantics of a document. This is not possible without some meta information or description of these documents.

A number of approaches are used to facilitate the access to the semantics of documents in preparation for information retrieval. Ontologies provide a modelling scheme for a specific domain creating a shared vocabulary for the description of contents [4]. Topic maps [22] create organising principles for information by defining topics, the associations of topics and the occurrence of topics in documents. Conceptual graphs [20,21] capture knowledge about a specific domain and make this knowledge accessible to deduction using first order logic.

In the analysis of data in the social sciences, a *description* approach is common. Codes or annotations, called descriptions, are attached to specific locations of multimedia documents to assist retrieval. These can contain any kind of factual or semantic descriptions of the documents' contents. Domain specific codes or freeform textual annotations are common in analysis programs like The Observer [16], Nudist [18] or its successor, NVivo [19]. All the approaches mentioned above have been proposed to overcome the technical and conceptual difficulties of accessing the information contained in multimedia documents and to facilitate the retrieval of appropriate information. In this paper, we propose the use of FSCL as a meta-level description mechanism. In the next section we introduce the main features of FSCL. We follow this by a discussion of its advantages for knowledge representation and retrieval, and indicate how FSCL can be combined with ontologies and conceptual graphs.

3 Knowledge representation using FSCL

FSCL is a natural language-like description language. It aims to combine the expressiveness and flexibility of natural language with the rigour of formalised approaches. The main components of FSCL are its *vocabulary*, *grammar* and *categories*. The vocabulary can be freely defined by the author of the teaching material. Any word can be used and the vocabulary can be extended at any point of time. Whereas the vocabulary is likely to be defined for a specific domain, the grammar is generic. It is designed to formulate 'subject - verb - object' and 'concept - object' sentences and combinations of these elements, including

conjunctions, prepositions, adjectives and adverbs. The role of the categories is to bridge the vocabulary and the generic grammar. The grammar is defined on the categories. Each word of the vocabulary has to belong to exactly one category. This construct allows for the structure of the description language to stay the same across applications in different domains. The categories of FSCL have been defined in accordance with the word classes of the English language. The categories are: Person/Thing, Activity, Concept, Conjunction, Preposition and Descriptor (which combines the word classes adjective and adverb).

FSCL has been incorporated into an information system to support the analysis of multimedia documents, called PAC [12]. Sentences formulated with FSCL can be, in a system like PAC, attached to a segment of a multimedia document. The sentences, together with document identifiers and segment specifications are stored in a database and later used for retrieval. Because the structure of the FSCL sentences is well known, it is possible to access the semantics of the information stored. The retrieval of information from FSCL descriptions is achieved using the Flexible Structured Query Language, FSQL [9].

FSQL provides three layers for querying: the first layer is based on the properties of FSCL and allows the correct and complete retrieval of information from the description sentences; the second layer provides for Boolean combinations within sets of description sentences; the third layer accesses the properties of the multimedia document segments attached to the FSCL sentences and facilitates time and position comparisons. More detailed information on FSCL and FSQL can be found in [9]. Specific information about information retrieval across multiple media formats is given in [10].

4 Advantages of using FSCL

The most convenient and expressive language available to us is natural language. Yet looking at knowledge retrieval with computer systems, natural language poses a range of well known and not yet fully solved problems. The main problem lies in the vast amount of implicit knowledge necessary to see words in the right context and to fully understand a sentence [21]. Various large scale projects are underway to attack these problems, like WordNet [15], an ontology for natural language processing, and the Cyc system [14], attempting to construct a 'complete' ontology of the world. Our approach is far less ambitious. We acknowledge that using full natural language for knowledge representation and retrieval would be highly desirable. Yet with the enormous difficulties associated with this approach we were looking for a much simpler solution. FSCL provides us with a number of advantages:

- We have a natural language-like notation. Any FSCL sentence can immediately be understood by a human reader. The importance of this is confirmed in the discussion of the five principles of knowledge representation by Davis *et al* [3].

- We have a language and can deduce the structure of our sentences. We have therefore more power than with the keyword approach commonly used in information retrieval, which suffers from low precision and low recall [21].

- We can build a powerful vocabulary by integrating the FSCL categories with ontologies.

- Of special interest to computer-based educational systems is that we can link our form of knowledge representation with multimedia documents.

FSCL has been successfully used to support the study of behaviour recorded in multimedia documents. It has given analysts the possibility to create rich descriptions of behaviour and to analyse the descriptions in a precise way [9]. We want to keep the main features of FSCL in formulating natural language-like, structured and flexible sentences attached to multimedia documents. Further, we want to adapt FSCL for a more general use in knowledge representation and retrieval. Our ideas in this direction are presented in the next sections of this paper.

5 Proposed extensions

We want to indicate several areas of possible changes and extensions to FSCL: changes to its categories and grammar forms; extensions to include ontologies; conversion of FSCL sentences to conceptual graphs to facilitate inferencing; and the introduction of freeform querying.

5.1 Changes to categories and grammar of FSCL

As described in section 3, the FSCL categories and grammar have been designed to formulate sentences of the forms 'subject - verb - object' and 'concept - object' in the context of studies of behaviour. To simplify the construction of the vocabulary, adjectives and adverbs have been combined in the FSCL category 'Descriptor' [9]. Adhering to the general FSCL principle of having a formal grammar on fixed, defined categories we are currently investigating a number of changes to FSCL to adapt it to a more general use in knowledge representation. The exact format of the changes has to be determined through applying FSCL in a range of web-based educational systems. Our current thinking centres around the following topics:

- We are investigating changes to the FSCL categories. Merging the categories Person/Thing and Concepts to a more general category, Noun, would address the potential conflict between abstract and concrete terms (see the discussion about the abstract term 'students' and the specific individuals in section 5.3). The category 'Descriptor' could be split up into separate categories of 'Adjectives' and 'Adverbs'. The grammar of FSCL had to change accordingly to accommodate the different roles of adjectives and adverbs within a sentence. The advantage over the current approach in FSCL would be that with this change adverbs could be positioned correctly as in natural language English sentences.

- In natural language, words occur in different grammatical forms in different roles in a sentence ('the instructor *starts* the motor'; 'the motor is *started*'). The current FSCL has a strict separation between its categories. While a word can be defined in its derivations in multiple categories (Activity: starts; Descriptor: started), it is not possible to create a semantic link between the different word forms. We are looking at introducing such a link together with a meta-level grammar to be able to detect semantic equivalence between sentences with word derivatives in different parts of speech.

- The grammar of FSCL could be extended to recognise a wider range of sentence structures. Clausal variations like imperatives ('Start the motor!') or questions ('Is the motor running?') can be introduced. Conditional sentences of the form 'if C then S' would support inference as outlined in more detail in the following section. A wider range of sentence structures recognised correctly by FSCL would increase the potential for knowledge retrieval and inference.

5.2 Extension to use ontologies

FSCL uses hierarchies to define the words of the vocabulary. These hierarchies are defined within the FSCL categories. They are used to group related words and to allow for a retrieval of information on different levels of granularity. These hierarchies, as they are currently used in FSCL, can be seen as simple forms of ontologies. While a number of issues have to be addressed to base FSCL on more substantial ontologies, none of these seems to pose a real problem.

- Users of FSCL define the vocabulary they need for their particular domain. The experience, so far, as reported in [9], show that users define their vocabulary as multiple hierarchies within each FSCL category. These hierarchies could be joined under the FSCL category name to build one ontology within each FSCL category.

- An ontology typically moves from the abstract to the concrete, from concepts to instances. The vocabulary in FSCL is organised in the same way. In a study on 'learning to read', e.g., individual students' names were grouped under the term 'students', individual teachers' names under the term 'teachers' [9]. A term like 'students' contains two components: it has an abstract component in describing a group of the population in general with the property of 'attending school to learn'; it has a concrete component in grouping together specific, named individuals. In the current uses of FSCL this distinction has not caused any problems.

- Not all FSCL categories contain vocabulary which necessarily should be structured as ontologies. While it can be of advantage to organise the vocabulary in the FSCL categories 'Conjunction' and 'Preposition' in hierarchies these words will not build ontologies as they not define 'categories of the world'. Yet the coexistence of ontologies and hierarchies in the vocabulary of FSCL should not create a difficulty.

5.3 Conceptual graphs and inference

FSCL is an easy to understand and effective scheme for an author to create their own vocabulary and use it

together with the grammar for describing the contents of a multimedia document such as a video. Currently, knowledge retrieval is performed using the complementary query language FSQL. FSQL addresses the grammatical structure of FSCL sentences, takes advantage of the hierarchy information built into the vocabulary, and offers Boolean, time and sequence query options. However, there is no deductive feature in this scheme which would allow us to be able to infer facts or relations that are not explicitly stated. For example, given the statements:

If anyone starts the motor then the motor is running

The instructor starts the motor

which describes the situation in a training video then we may wish to be able to answer the question:

Is the motor running?

To be able to function at this level, we need the power of a first order logic system. Conceptual Graphs, CG, [20] give us this power.

Our proposal is that the user should describe their domain in terms of FSCL. The statements in this language can then be automatically translated into a CG format. This process is quite straight forward since FSCL is unambiguous, allowing many of the problems of natural language translation to be circumvented.

When a query is made, or some information needs to be located within the document segment then an initial attempt can be made to do this by using FSQL. If this fails then the deductive power of the CG representation is invoked. Standard theorem proving techniques within CG would enable us to check the veracity of a statement. As a bonus, we would get a step-by-step justification of the result proved, similar to the explanation given in expert systems.

5.4 Freeform Querying

Based on a limited yet flexible vocabulary and on a limited grammar, as offered by FSCL and FSQL, a query system can be developed which allows the user to pose questions to the educational system. As the structure and the vocabulary of these questions is known, the educational system can 'understand' these questions. Questions can be mapped against a repository of previously asked questions. If a semantically equivalent question is stored, the corresponding answer is retrieved and presented to the user. If a semantically close question is stored, this previously asked question can be used to facilitate the answering of the new question. As questions and knowledge representation are constructed by the same underlying mechanisms a mapping from question to knowledge representation is possible. This can be used to assist the answering of questions based on the knowledge descriptions and to find the appropriate segments of the multimedia teaching material.

The approach presented here does not attempt to answer any natural language question but a restricted set. The vocabulary is restricted to allow the construction of meaningful questions in a particular domain. The grammar is restricted to allow the construction and comparison of meaningful questions based on the vocabulary. The grammar is generic as it is based on categories which are used to organise the vocabulary across domains. The restriction of vocabulary and grammar distinguishes this approach from the AskJeeves [1] search mechanism. The existence of a grammar distinguishes this approach from keyword based search mechanisms as used in library systems or by internet search machines.

The general idea is to provide the user with specific answers to questions. These answers are retrieved from a body of stored answers only if semantic equivalence can be guaranteed. If semantic closeness is detected the relevant questions with their answers are given to a human operator who then decides on the suitability of the match.

6 Conclusions

In this paper we have considered the need for a knowledge representation mechanism for computer-based educational systems. We have first indicated a number of commonly used mechanisms and have then discussed the Flexible Structured Coding Language, FSCL. We have suggested that FSCL provides an effective mechanism for knowledge representation and subsequent knowledge retrieval, based on the nature of FSCL as a natural language-like description language which allows for flexible, rich yet structured description of learning concepts. As extensions to FSCL we have suggested the integration of more substantial ontologies, the conversion of FSCL sentences into conceptual graph structures and the introduction of freeform querying.

References

[1] AskJeeves, http://www.aj.com/index.asp (accessed on February 2, 2000).

[2] Davenport, G., "Indexes Are 'Out', Models Are 'In'", IEEE Multimedia, Fall 1996, Vol. 3, No.3, pp.10-15, (1996).

[3] Davis, R., Schrobe, H. and Szolovits, P., "What is knowledge representation?" AI Magazine, 14:1, pp. 17-33, (1993).

[4] Decker, S., Erdmann, M., Fensel, D. and Studer, R., "ONTOBROKER: Ontology Based Acess to Distributed and Semi-structured Information", Proceedings of Eighth Working Conference on Database Semantics, Semantic Issues in Multimedia Systems, R. Meersman, Z. Tari and S. Stevens (Eds.), Kluwer Academic Publishers, Boston, (1999).

[5] GENTLE, www.gentle-wbt.com (accessed on April 10 2000).

[6] Gong, Y., Zhang, H. Chuan, H. C., Sakauchi, M., "An Image Database System with Content Capturing and Fast Image Indexing Abilities", Proceedings of the International Conference on Multimedia Computing and Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

[7] Grossmann, R., "The Existence of the World, An Introduction to Ontology", London: Routledge, (1992).

[8] Hampapur, A., Jain, R., Weymouth, T. E., "Production Model Based Digital Video Segmentation", Journal of Multimedia Tools and Applications, 1, 9-46, Kluwer Academic Publishers, Boston, (1995).

[9] Heinrich, E. A., "Multimedia Information System for the Support of Studies of Behaviour", Doctoral Dissertation, Massey University, Palmerston North, New Zealand, (1999).

[10] Heinrich, E. and Kemp, E., "Description and Retrieval across Multiple Media Formats", 4th International Workshop on Query Processing and Multimedia Issues in Distributed Systems, L'EXA'00, IEEE Computer Society Press (2000).

[11] Heinrich, E., Kemp, E. and Patrick, J.D., "A Natural Language Like Description Language", 10th Australasian Conference on Information Systems (ACIS), B. Hope and P. Yoong (Eds.), School of Communications and Information Management, Victoria University of Wellington, Wellington, New Zealand, pp. 375 – 386, (1999).

[12] Heinrich, E., Patrick, J.D., and Kemp, E., "A Multimedia Information System to Support the Analysis of Human Behaviour Recorded on Video", Computers in Psychology, Conference Proceedings, CTI Centre for Psychology, University of York, York, (1998).

[13] Jiang, H., Montesi, D., Elmagarmid, A. K., "Integrated Video and Text for Content-based Access to Video Databases", Journal of Multimedia Tools and Applications, 9, pp. 227-249, Kluwer Academic Publishers, (1999).

[14] Lenat, D.B. and Guha, R.V., "Building Large Knowledge-Based Systems; Representation and Inference in the Cyc Project", Addison-Wesley Publishing Company, Reading, Massachusetts, (1990).

[15] Miller, G.A., "WordNet: a lexical database for English", Communications of the ACM, 38:11, pp. 39-41, (1995).

[16] Noldus Information Technology, "The Observer Video-Pro, Version 4.0 for Windows". Wageningen, The Netherlands, (1998).

[17] Palhang, M., Sowmya, A., "Learning Object Models from Real Images", Proceedings of the First International Conference on Visual Information Systems, Victoria University of Technology, Melbourne, Australia, (1996).

[18] QSR Software, QSR NUDIST 4 Overview, http://www.qsr.com.au/Software/N4/qsrn4.htm (accessed on June 22 1998).

[19] Richards, L., "Using NVivo in Qualitative Research", Melbourne: Qualitative Solutions and Research Pty, (1999).

[20] Sowa, J.F., "Conceptual Structures: Information Processing in Mind and Machine", Addison-Wesley, Reading, Massachusetts, (1984).

[21] Sowa, J.F., Knowledge Representation; "Logical, philosophical, and Computational Foundations", Brooks/Cole, Pacific Grove, CA, (2000).

[22] Topic maps. ISO/IEC JTC1/SC34 - Document Description and Processing Languages http://www.ornl.gov/sgml/sc34/document/0058.htm, (accessed on February 8 2000).

[23] Zhang, H., Gong, Y., Smoliar, S. W. and Tan, S.Y., "Automatic Parsing of News Video", Proceedings of the International Conference on Multimedia Computing Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

On Supporting Semantic Indexing in a Mediabase System which Facilitates Collaborative Learning

Hideo FUNAOI, Kazuyoshi BABA, Masatoshi SUZUKI, Makoto, ITAMI, Kohji ITOH
Department of Applied Electronics, Science University of Tokyo
Yamazaki 2641, Noda-shi, Chiba, 2788510, JAPAN
Tel: +81-471-24-1501 (ext.4232)
E-mail: {funaoi, kazuyosi, masatosi, itami, itoh}@itlb.te.noda.sut.ac.jp

Our mediabase system "ShareMedia" can facilitates collaborative learning, especially, inductive knowledge acquisition. In ShareMedia, learners in a community add, collaboratively, structured query to the electric data, which is to be registered in the mediabase. Structured queries consist of query units. Pieces of electric data express concrete knowledge or cases. Then they can navigate and retrieve pieces of electric data express by use of the queries. In other words, they can compare and examine the pieces of electric data and know their relationships. Consequently, they can acquire knowledge inductively. However, it is difficult for them to select suitable query units for a structured query. In this study, then we applied Latent Semantic Indexing to the supporting method. In our method, pieces of electric data and query units are represented as a vector space. The vectors are decomposed by Singular Value Decomposition, and then new vectors will be created. The piece of electric data that a learner wants to index is also processed with the same method. Then, the new electric data vector is compared with the new query unit vectors, and suitable query units will be selected. As a result of evaluation, our supporting method was proved to perform well.

Keywords: **indexing, navigation, collaboration, hypermedia, mediabase**

1 Introduction

In the field of education, teachers and researchers are, recently, more concerned about collaboration. Because of it, Many Computer systems are developed to support collaborative learning. For example, CSILE[1,2] facilitates knowledge building in a community, Collaboratory NoteBook[3] supports scientific inquiry activities in high school.

The mediabase system "ShareMedia[4,5]", which we are developing now, is such a system that supports learner's activities of description and accumulation, sharing, searching, selection of knowledge. In detail, it can not only promote the process of learner's browsing accumulated cases or knowledge and discovering their relationships, but also train their skills to share and use such cases and information in a community. Though we now assume that learners in high school geography class use ShareMedia, of course ShareMedia can be used in another domain.

ShareMedia needs not to link between nodes explicitly, and requires only indexing retrieval indices to media representations (see chapter 2). Then, ShareMedia enables learners to retrieve flexibly based on the semantics or concept of data by use of retrieval indices. Through the functions mentioned above, ShareMedia facilitates collaborative learning in a junior high school geography class to acquire generalized knowledge from individual cases and knowledge inductively and to index semantic indices to them in order to enable such activities.
ShareMedia supports learning activities as follows:

1) In a small community (e.g. a classroom or a group), learners collect electric media as individual knowledge or concrete cases and add indices express their concept to them. Then, learners store their shared mediabase with the electric media.

2) The learners browse the shared knowledge and compare pieces of the knowledge, which are extracted with indices, many times. As a result of this activity, the learners can abstract the pieces of the concrete knowledge and understand the relationships between them.

3) The learners discover inductively generalities or rules, which exist in the relationships, and deal with them as hypothesis.

4) The learners apply deductively the hypothesis to pieces of individual knowledge and can acquire then as generalized knowledge if their propriety is confirmed.

2 Mediabase system "ShareMedia"

The current version of ShareMedia (Fig.1) was developed on UNIX environment (Solaris CDE ver.1.3) with JAVA Development Kit ver.1.1.7 and K-Prolog Compiler ver.4.0. ShareMedia consists of several components. Above all, media representations, semantic frames, semantic indices and retrieval requests are important. Their details are as follows:

2.1 Media representation

Media representations (Fig.1.a) are electric data of pieces of individual knowledge or concrete cases. They are represent as texts, images, pictures, movies, sounds and so on. In this paper, however, only text form is dealt with because of presumption of semantic frames with natural language processing. Learners index a semantic index mentioned below to the block of a media representation and store the shared mediabase of ShareMedia with the media representation. After storing, learners can chose media representations from the list of them. With semantic indices, however, learners can navigate them more flexibly.

2.2 Semantic frame

Semantic frames (Fig.1.b) are used as query units and are primitive units of concept or semantics of media representations. They have slots that express subject, object, means, moment and so on. For example, "utilize" frame has "who", "what" and "to what" slots and "be factor" frame has "what" and "of what" slots. Learners should decide their form by mutual agreement in order to use them effectively in learning activities and store shared mediabase with them consistently.

2.3 Semantic Index

Semantic indices (Fig.1.c) are structured queries to express concept or semantics of media representations. Learners select semantic frames that are suitable to a media representation, which the learners will store mediabase with. Then, the learners combine them and link their relative slots. Like this, semantic indices are created by combining semantic frames and are indexed to media representations. They are used when learners retrieve or navigate media representations.

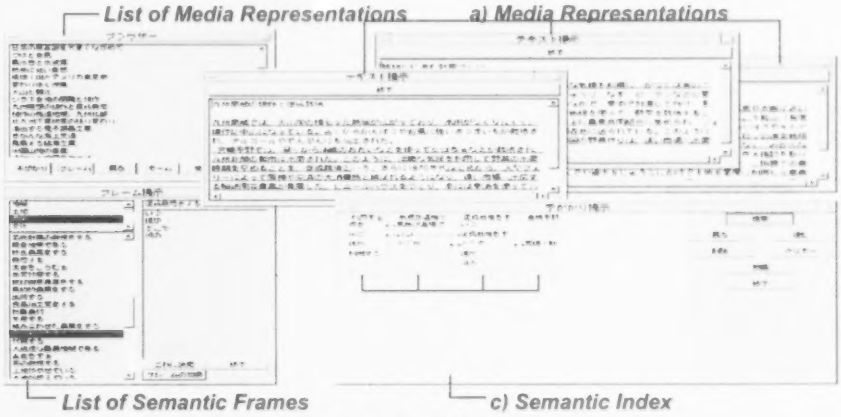


Fig.1 Interface of ShareMedia

BEST COPY AVAILABLE

2.4 Retrieval request

Retrieval request is used when learners retrieve or navigate media representations that are stored in shared mediabase. A learner creates it in the same way as semantic indices. Then, the learner submit it to ShareMedia, he will be presented media representations, which were indexed semantic indices that match the retrieval request. Owing to semantic indices and retrieval requests, learners can retrieve and navigate semantically.

These components mentioned above can facilitate learner's activities to navigate pieces of knowledge semantically, to understand their relationships inductively and to discover generalities, which exist in them, deductively. However, it is difficult for learners to select suitable semantic frames for a semantic index or a retrieval request.

3 Supporting learner's selection of semantic frames

In this study, we applied LSI[6] (Latent Semantic Indexing) to the supporting method for selecting semantic frames. Because LSI is one of statistical method, similarity of documents can be presumed without any dictionaries. In LSI, documents are dealt with a term by document matrix. Then, rows of it can be considered to be term vectors and columns to be document vectors. In addition, these vectors are decomposed by SVD (Singular Value Decomposition), as a result, terms and documents are abstracted.

In our method, media representations and semantic frames are represented as a vector space model. In training, the vectors are decomposed by SVD, and then new vectors will be created. In presumption, The media representation that a learner wants to index is also processed with the same method. Then, the new media representation vector is compared with the new semantic frame, and suitable semantic frames will be selected. Their details are as follows:

3.1 Training

Training needs a data set, which is a collection of combinations of paragraph and semantic frames. Here, paragraph is a part of media representation and contains one or more blocks, which are indexed parts of the media representation. And semantic frames are contained in the semantic indices, which were indexed to the blocks. First, Paragraphs are done morphological analysis with Chasen, which is one of Japanese morphological analysis tool. As a result, word lists of each paragraph are created.

Next, they are filtered in order to extract only the words, which have noun, verbal, and adjective morph. After filtering, they are sorted by frequent descending order. Based on them, a sorted list of all words is generated. On the other hand, based on the relation between the word lists and the semantic frames, sorted word lists of each paragraph collection, which relate each semantic frame, are created.

Then, word by semantic frame matrix is computed from these two type lists. This matrix can be divided to word vectors and semantic frame vectors. SVD decomposes them and creates new word vectors, new semantic frame vectors and the diagonal matrix of singular values. These vectors and matrix are used in presumption.

In addition, latent relationships will be available in presumption, because this decomposition abstracts the words and the semantic frames

3.2 Presumption

To presume the semantic frames that are suitable to a whole media representation or a block of it, the vector of these text strings is processed with new word vectors and diagonal matrix, which are created in training. As a result, new text vector is created. It is compared with each new semantic frame vector by computing cosine between them. The more cosine value is large, the more the semantic frame that corresponds to the new semantic frame vector is suitable to the text string. Then, a list of semantic frames, which are arranged by descending order of cosine values, is made. This list will support learners to select semantic frames, which is suitable to a media representation.

4 Experiment

4.1 Training data set

We prepared 304 media representations, 318 semantic frames and 318 blocks, which were indexed semantic indices by manual. A block, we call in here, is a part of a paragraph where semantic indices are indexed. A media representation contains one or more paragraphs. A block might extend through several paragraphs. Though media indices are indexed to blocks, we use paragraphs to training because of giving redundancy to the presumption. Media representations and semantic frames used in here were extracted from the Japanese geography area of Japanese junior high school geography textbooks. By making use of this data set, new word vectors, new semantic frame vectors and diagonal matrix were computed.

4.2 Evaluation

We use 93 blocks, which are used in training and chosen at random, in order to evaluate the presumption of our method. Each media indices, which were indexed to the blocks, have 3.63 semantic frames on the average. The method presumed suitability of each one of 318 semantic frames to each one of 93 blocks by computing cosine values

4.3 Result

We confirmed their propriety about top of 5, 10 and 15 semantic frames, which were arranged by descending order of presumed suitability to each one of 93 blocks (see, Table 1). In Table 1, "Suitable to Blocks" indicates the average number of frames which experimenter judged suitable to each block. In the same way, "Suitable to Paragraphs" indicates the average number of frames to each paragraph. "Indexed by Manual" indicates the average number of frames, which are indexed to each block by manual beforehand.

Table 1. Average numbers of semantic frames which experimenter judged suitable.

	Suitable to Blocks		**Suitable to Paragraphs**		**Indexed by manual**	
Top	average	precision	average	precision	average	recall
5	2.10	42.0%	2.78	55.6%	1.81	49.9%
10	3.13	31.3%	4.39	43.9%	2.44	67.2%
15	3.72	24.8%	5.32	35.5%	2.77	76.3%

4.4 Discussion

A glance at Table 1 will reveal that presumption of our method is good. For example, seeing top 10 row, the precision within the range of blocks is 31.3%, the precision within the range of paragraphs is 43.9% and recall is 67.2%. Take it into consideration, our method can extract many of semantic frames which should be indexed. In short, learners can easily extract many of necessary semantic frames by selecting from them, which our method presented.

To illustrate the performance more precise, however, we need to make another experiment, because this experiment used same data in both training and evaluation.

5 Conclusion

In this paper, we described the process that ShareMedia supports learning activities, abstract of main components of ShareMedia, our supporting method for learner's selection of semantic frames and it's performance. As a result of the experiment, our method proved to perform well. To judge the performance of our method more strictly, however, we need another experiment with data sets that differ in training and evaluation. And we will improve our supporting method based on the result of it.

References

[1] Scardamalia, M. and Bereiter, C., Technologies for knowledge-building discourse, Communications of the ACM, Vol.36, No.5, pp.37-41 (1993)

[2] Scardamalia, M. and Bereiter, C., Student Communities for the Advancement of Knowledge, Communications of the ACM, Vol.39, No.4, pp.36-37 (1996)

[3] Edelsen, D.C., Pea, R.D. and Gomez, L.M., The Collaboratery NoteBook, Communications of the ACM, Vol.39, No.4, pp.32-33 (1996)

[4] Kuroda, T., Funaoi, H., Takahashi, T., Uchida, A., Nagao, H., Itami, M. and Itoh, K., Evaluation of shared mediabase system that supports learning by comparison cases - on the effect of using shared indices in navigation, Japanese Society for Artificial Intelligence, Technical Report SIG-IES-9804-7, pp.39-43 (1999)

[5] Kuroda, T., Funaoi, H., Itami, M. and Itoh, K., Media database system that supports learning through comparing cases by using shared indices, Proceedings of 7th International Conference on Computers in Education, pp.308-311 (1999)

[6] Deerwester, S., Dumais, S.T., Furnas, G.W., Landauer, T.K. and Harshman, R., Indexing by latent semantic analysis, Journal of the American Society for Information Science, Vol.41, No.6, pp.391-407 (1990)

SimPCS: A Web-based PCS Learning Tool

Chyi-Ren Dow, Yu- Feng Hwang, and Jong-Shin Chen
Department of Information Engineering
Feng Chia University, Taichung, Taiwan 407
{crdow, baterma, and jschen}@pluto.iecs.fcu.edu.tw

With rapidly growing interest in the area of wireless communications in recent years, the wireless resource allocation problem has received tremendous attention. The demand has led to intensive research and studying efforts for personal communication systems (PCS). Many related courses have been offered and corresponding web-sites were developed. Unfortunately, most of the web-sites contained only static and pre-defined PCS information. The utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS by using only the conventional education materials. This work designs, develops, and implements a web-based PCS learning tool that meets the above criteria. The system provides the merits of personality, transparency, efficiency, scalability, portability, and flexibility. It offers simulation and data analysis so that the user can learn actively and understand easily the advanced issues of PCS.

Keywords: **Web-based learning, PCS, simulation, performance visualization**

1 Introduction

Computer-assisted instruction (CAI) programs based on Internet techniques, especially on the WWW, provide new opportunities in various applications. Due to the reason that the growing popularity of the World Wide Web, the characteristic of its portability, wide acceptance, and comprehensive availability can help us to solve many problems related to conventional CAI systems, which lack portability and local availability.

A PCS system is a wireless network that provides communication service with mobility to its subscribers. With rapidly growing interest in the area of wireless communications in recent years, many related courses (e.g., wireless communications, mobile computing, personal communication systems, etc.) have been offered and corresponding web-sites were developed. However, most of the web-sites contain only static and pre-defined information of PCS. Few web-based PCS learning tools have been developed to provide a highly interactive facility for users.

The wireless resource allocation problem has received tremendous attention in the last few years and the demand has led to intensive research and studying efforts for the related topics. Unfortunately, the utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS systems by using only the conventional education materials. Simulators can be used to identify various characteristics of PCS systems and to support decisions and understanding by giving the possibility of experimenting with different scenarios [24].

However, the simulation of a PCS scenario is time consuming for large-scale PCS systems. Therefore, scalability is an essential factor for the simulation of PCS systems. As well known, conventional sequential simulation techniques can not adequately fulfill such simulation requirements, necessitating the development of parallel simulation techniques capable of doing so. On the other hand, when very great amount of users use the simulation system at the same time, the load of the server will be quite heavy so that the performance decreases rapidly and the response time of a simulation experiment increases.

It is essential that a learning system should be capable of providing the flexibility of usage profiles and services for different users. Users can be classified according to the conditions of user's ability, frequency, and so on. It is expected that each user may have an adaptive interface and configuration to fit his/her requirement. Furthermore, in order to improve the performance of a simulation system, the technologies of parallel processing and caching should be applied. The user may reuse previous simulated results without doing a long-running simulation experiment again, thereby reducing the waste of computation resources of application servers. It not only reduces the waste of the computation resource but also provides real-time services for users.

In light of above discussions, we develop SimPCS, a web-based learning tool for PCS which integrates simulation and computing in a multimedia learner environment with various enhanced functionalities. The proposed system has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. The system can be used to help users to understand the concepts of PCS systems. By using the PCS simulation and data analysis, the users can understand the advanced issues of PCS environments (e.g. resource allocation, probability of blocking call, etc.).

The rest of this paper is organized as follows. Section 2 discusses the architecture of conventional CAI systems and related technologies applied to our system. Section 3 describes the proposed system architecture. The implementation of our system and a prototype are illustrated in Section 4. Section 5 discusses the usage profiles and case studies. Finally, conclusions are offered in Section 6.

2 Related Work

In recent years, training environments based on computational simulation are being used much more frequently and the importance of simulators is widely appreciated. They are used to support decisions and understanding by giving the possibility of experimenting with different scenarios. For a training environment, one thing that is commonly assumed is that the trainee has a reasonable amount of knowledge about the subjacent model and is capable of analyzing and learning from the simulation results [4]. Form a user's aspect, the tools must have characteristics of convenience, auto-analytic, assistant, resource sharing and so on [10,18,20]. The rationale behind the use of multimedia in education is that some media transmit certain kinds of information better than others. This makes it possible to give media an extremely important role in the context of education and learning [6]. The motivation for the use of simulation in an education is that it supports an active learning approach and maximizes the learner control [18]. The degree of available learner control defines the perceived level of interactivity of a course [19]. Learner control is seen as the control over learning strategy, manipulation of learning content and description of content [14]. The claims are that an active learning approach facilitates learning. Learners appear to be more engaged and have better motivations. Simulation enables learners to make their own errors, try to find these out, explore these and learn from these. Moreover, simulators are powerful in situations in which they otherwise would be difficult or impossible to give training or education. It is realized that simulation needs to be embedded in an instructional environment to fulfill an instructive role in a satisfactory manner [23].

In this way the content of a conventional CAI program, which is necessarily limited, can be strongly expanded. Web-based CAI programs differ from conventional CAI software [8,12-13,17,21] significantly and therefore require a specific consideration. It can be utilized on almost all of computer platforms. The materials of CAI systems can be shared since WWW is based on the network technologies. The learners can be free from restrictions of space or time. Conventional CAI programs can be stored on data media, installed, and used on stand-alone computers [1]. By contrast, WBT (web-based training) programs are based on Internet technology, in particular on WWW technologies. Generally, CAI programs can be subdivided into three layers: presentation, teaching, and domain data and knowledge. These combinations generate different types of architectures [6].

Many efforts have been made to improve the limitations of wireless communications [9,11]. In order to increase the system capacity, many advanced channel allocation schemes were proposed [13,21]. Another way to increase the system capacity is to split the cell into micro-cells. The micro-cell architecture is an efficient way to increase the total available channels but additional infrastructures are needed [21]. Many simulation languages and tools have been developed for the simulation of large-scale networks such as cellular mobile systems. Parsec, a parallel simulation language, can be used to develop simulations for complex systems and mobile wireless networks [16,22]. Other systems were developed that can simulate large-scale cellular mobile systems [2]. They used discrete event scheme to model cellular mobile systems

and proposed the synchronization schemes to avoid faults distributed computing environments. Lin [15] proposed a PCS handoff simulator that supports arbitrary PCS cell structure and can be used to evaluate the call blocking probability or forced termination probability.

3 System Architecture

In this section, we describe an overview of our system architecture and the functionality of each component. Figure 1 illustrates the system architecture layout from three different viewpoints, the interaction type, distributed teaching program, and system configuration. For the interaction type, the system provides methods of presentation, browsing, and simulation. The user can interact with the system through various interaction types. For the distributed teaching program, it describes the architecture of client-server and layers for distributed teaching. For the system configuration, it describes the detailed modules of the system.

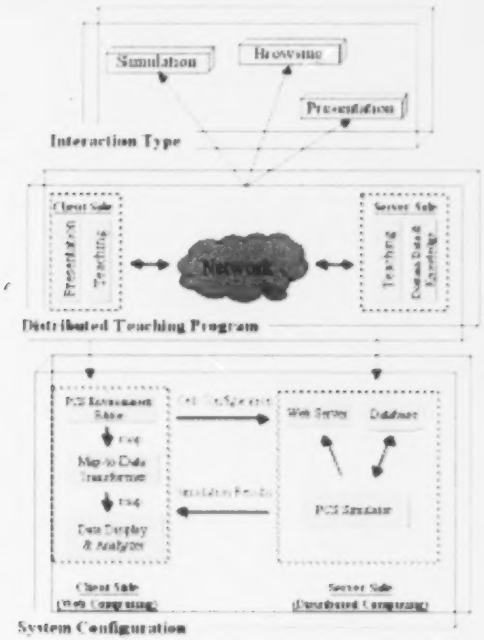


Fig. 1 System architecture

3.1 Interaction Type

SimPCS provides three interaction types including browsing, simulation, and presentation. The details of each interaction type are described as follows.

(1) Browsing:

Here, the user can determine the contents and the consequences of the presentation by accessing the contents through freely navigable hypertext. Internet users can browse the system through a Java-enabled GUI (graphical user interface). In order to reduce the response time of simulation, the caching mechanism is applied, which allows the user to quickly obtain the simulation results and without wasting the computational resources of the application server. Moreover, it provides basic functions to support analysis and display of performance information. The user can determine the contents and the consequences of the presentation by accessing the contents through borrowing.

BEST COPY AVAILABLE

(2) Simulation:

In the simulation system, the user can easily construct a PCS environment. Then, the user can assign the parameters related to the PCS environment. Next, the parameters are embedded to our parallelized simulation system. Finally, users can use visualization functions to analyze the characteristics and observe the performance variation of different factors. In addition, the system provides various virtual objects to let the user simulate a real environment. On the other hand, the techniques of parallel processing and caching are applied to the system to improve the efficiency of the system.

(3) Presentation:

In this case, the system presents the information in a linear manner just like slide show. The system provides static education materials such as slides, notes, simulation results, and other related information. The system can also be used to support distance learning of PCS environments.

3.2 Distributed Teaching Program

The distributed teaching architecture offers the best performance and the least network traffic of all web-based training architectures. The system we provide belongs to this architecture. On the client side, the presentation layer constitutes the interface between the user and the teaching layer. It is responsible for the presentation and management of usage profiles. It provides the flexibility of usage profiles and services for different level of users. The teaching layer handles user activities (mouse actions, inputs and so on), and then responses to the presentation layer. It is implemented in our system with JAVA programming language to process user activities. On the server side, the teaching layer is responsible for the simulation of PCS systems and processes queries. In order to improve the performance of simulation, the techniques of parallel processing and caching are applied. In the domain data and knowledge layer, the simulation data is saved in a database. It has considerable advantages: multi-stage queries to the data and knowledge layer can be completely created and executed on the server.

3.3 System Configuration

The system configuration consists of many modules. On the client side, the user can use any Java enabled browser. Internet users can communicate with the system through the GUI. The server side provides the ability of the simulation. The PCS environment construction system is used to minic a PCS environment. After constructing an environment, a map representing the environment is transferred to cell configurations. The cell configurations are sent to the PCS simulator and the map is sent to the performance data analyzer. The PCS simulator is used to simulate the behaviors of mobile hosts on the constructed PCS environment. After the simulation, the results are sent to the performance data analyzer/display. Then, the system analyzes the performance data and visually displays it on the map. The database server stores cell information and simulation results obtained from the application server.

The client side is java-based interface. It can enable the users access the system through a WWW browser. The client side consists of a PCS environment constructor and a performance data analyzer. The PCS environment constructor consists of a PCS environment editing module and a map-to-data transformer module. Their features are listed as follows:

(1) **PCS Environment Editor:** the PCS environment construction system is an iconic editor. It provides many iconic objects to represent different things such as a station, highway, or city. With these objects, the user can set up different parameters to change the cell configuration. For instance, the user can set up a station or a city in a cell and the system will automatically change the parameters of the cell such as the number of MHs and call arrival rate. This mechanism makes the simulator more practical.

(2) **Map-to-Data Transformer:** the transformer is used to transfer the map (constructed by PCS environment construction system) to readable parameters for the simulator.

On the server side, the simulation system consists of three components: a Web server, a database server and an application server. The Web server is in charge of communication with the client and manages the application server. The database server stores cell information and simulation results obtained from the application server. Because the database server provides a caching mechanism, the user may replay the

simulation results without wasting the execution resource of the application server. Therefore, simulation is more efficient. The application server is responsible for the execution of the PCS simulator. The application server can be a distributed computing environment (i.e. a network of workstations or a supercomputer). The PCS simulator on the application server can simulate large cellular mobile systems more efficiently with these powerful platforms.

The PCS simulator is used to simulate the behaviors of MHs on a specific PCS environment. The basic behavior of a base station (BS) is to provide channel allocation service and communication service for mobile hosts (MHs) within its service range (cell). The BS chooses a channel to serve when a MH needs a communication. If no channel is available, either a channel is borrowed from neighboring cells or call blocking occurs. For details, we refer readers to [5].

The client side and the server side can be used independently or together. This will facilitate other PCS simulators to embed to our system. Users can use the PCS environment constructor to construct a simulation environment. Then, they can use performance analysis/visualization tools to analyze results.

4 Implementation and Prototype

In this section, the classification of the system modules is discussed. SimPCS can be used to help instructors to create motivating lectures and allow the students to do experiments so they can understand relative wireless information in depth. Users may compose and simulate a PCS environment using various modules. Figure 2 illustrates the hierarchical relation of these modules.

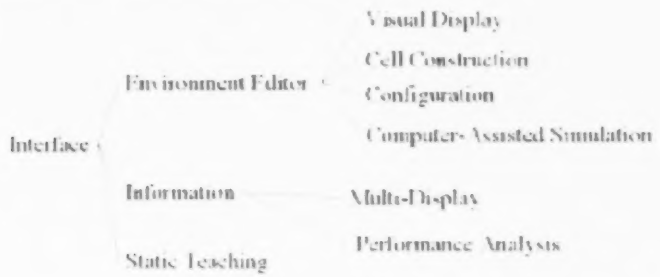


Fig. 2 The hierarchy of modules

(1) Interface module, is the front-end object for SimPCS. It offers the basic functionality required for an interactive program. Its main types of the widgets used to make a control are the pull-down menus and panels, which have the basic file operations and customization at this level. Figure 3 is a snapshot of our system. This layer is the root of all modules of our system. It consists of the environment editor, the information modules, and the static teaching module.

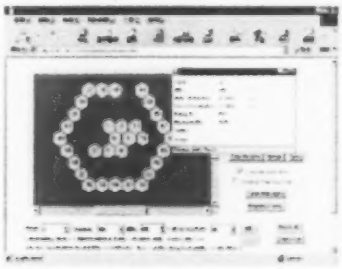


Fig. 3 A snapshot of the system

(2) **Environment editor module**: provides the establishment of a virtual environment. It enables the user to compose and establish complex conditions with virtual objects (e.g., house, river and road), to import and edit a map and save an established map.

BEST COPY AVAILABLE

(3) **Visual display module**: is an advanced feature of the system. It provides many iconic objects such as a station, highway, or city. With these objects, users can construct a mimic PCS environment. It enables users to simulate a PCS environment. Within the environment, the user can set up different parameters to change the cell configuration.

(4) **Cell construction module**: is responsible for establishing the cells in a selected area of the map. The user can directly select the cells on the map with the mouse. The module can create cells after constructing the environment. Figure 4 shows an example of cell distribution. The module also provides a mechanism of recombination. It uses the performance visualization grains to advance the visualization capability [4]. The technique facilitates to reorganize the performance visualization grains and support various presentations. The system can merge/split the performance visualization grains for specific geographical areas or cells.

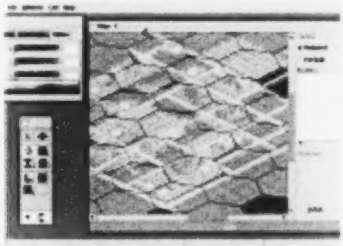


Fig. 4 Cell establishment

(5) **Configuration module**: offers the function of configuration of the objects. It allows users to set and configure the properties and limitations of the objects. The user can set call holding time and residence time of each mobile host. Figure 5 shows the dialog of configuration.

Fig. 5 Configuration

(6) **Computer-assisted simulation module**: as suggested by the name, provides the simulation of practiced conditions. It provides the user with methods to generate parameters of practiced conditions and transmit the queries and parameters form the user interface on front-end to the simulator which applies parallel/distributed computing techniques on the server. It also allows the user to choose several processors in order to run the programs simultaneously. The users can explore their behaviors after simulation.

(7) **Information module:** offers the information of simulation results, which consists of multi-display module and analysis module.

(8) **Multi-display module**: offers advanced presentation forms. It not only displays the static information (e.g. cells, channel, blocked call and so on) but also provides different presentation forms according to different configurations. Currently, two presentation modes are available to the users, color and numeric. In the color-oriented mode, the simulation results can be expressed by different colors. For instance, high blocking probability can be expressed by red color and low blocking probability can be expressed by green color. With this mode, the user can easily identify the area with high blocking probability. On the other hand, the numeric-oriented mode offers users the capability to see the details of each cell.

BEST COPY AVAILABLE

(9) **Performance analysis module**: provides the basic functions of performance analysis. SimPCS provides statistical analysis functions for the performance data. The main objective is to allow support the users in their efforts to understand the results and behaviors of simulation. The users can analyze the different results and behaviors of simulation according to different factors (e.g. new call blocking, forced termination). Figure 6 illustrates the different types of analysis of simulation results with histograms and pizza graphs.

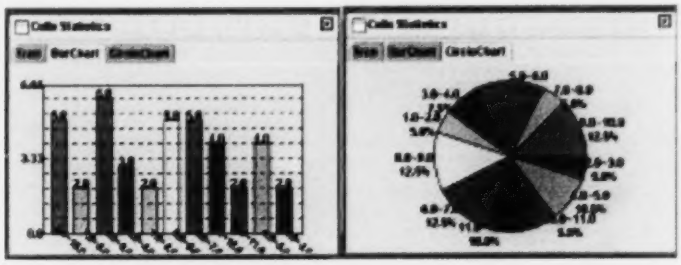


Fig. 6 Different types of analysis

(10) **Static teaching module:** is used to present static education materials. The information of PCS is presented in some manners just like slide show, notes, and simulation results.

After this brief description above, we can refer to the fact that actual prototype of SimPCS has been implemented with Java programming language in an object-oriented development environment.

5 Usage Profiles and Case Studies

This section gives different scenarios of using SimPCS for different users and discusses the services for them. Figure 3 depicts a snapshot of SimPCS for novice users. First, a novice user can select different parameter values such as number of rings(cells), number of channels in a BS, number of MHs in a cell, and the average call arrival rate of MHs. After the novice user selects the parameters, SimPCS accesses the pre-simulated (caching technique) data from the database system and presents the probabilities of new call blocking and forced termination, using the predefined PCS system model. The user can then use the visualization function to refine the presentation of the performance data. Figure 3 illustrates the snapshot of the system with statistical analysis.

The simulation system provides flexibility that means the simulator should provide different services for different users. The proposed performance visualization system classified target users into three groups: novice or first-time users, knowledgeable users, and expert frequent users. Each group will have a different usage jurisdiction. Figure 7 illustrates the relationship between users and operations.

(1) **Novice or First-Time Users** – True novice or first-time users know little of PCS systems nor do they want to understand the concept of PCS systems. These users will use a menu to select items to play with (i.e. ring of cells, number of channel, number of MHs in a cell, and call arrival rate). By choosing different the menu item and seeing the quick feedback on the screen, they will be exposed to an overview of PCS systems. The results have been stored in the caching mechanism on the database server, thereby, reducing system response time.

(2) **Knowledgeable Users** – Knowledgeable users understand concepts within PCS systems such as new call blocking, forced termination, call arrival rate, and so on. The proposed system allows knowledgeable users to execute the PCS simulation with their own parameters. These users tune the allocation of the resource by changing predefined parameters and observe the performance difference between their options.

(3) **Expert Frequent Users** – Expert "power" users are experts with the PCS systems and [illegible] develop and implement a PCS system to verify their research. The expert users will construct a PCS environment to mimic the real environment for evaluating performance. Since our prototype provide the capability to construct and mimic PCS environments, users can embed their simulation protocols into our system and use the analysis/ visualization tools to analyze the performance data.

BEST COPY AVAILABLE

Fig. 7 Available functions for users

6 Conclusions

This work designs, develops, and implements SimPCS, a web-based PCS training and learning tool, to provide users a more flexible learning environment and give users full user-control capabilities. SimPCS can be easily used through a web browser to achieve the goal of cooperative testing and learning. It can simulate large-scale PCS systems up to thousands of cells. SimPCS has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. SimPCS provides many user-directed features. It not only simplifies the complexity of programs but also supplies convenience for the users. Furthermore, the system provides the user with several editing components of the visualization system and many iconic objects to design the simulated environment by clicking the mouse directly. Although related investigations extensively perform simulation studies, relatively few web-based, large-scale PCS learning tools are developed as these models are rather time consuming. SimPCS uses the distributed teaching architecture, which offers the best performance and the least network traffic of all architectures. In addition, parallel processing and caching mechanisms are applied to improve simulation efficiency on server-side and offer a real or accelerated-time simulation.

Acknowledgment

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 89-2213-E-035-010.

Reference

[1] A. Bittorf, J. Bauer, M. Simon, and T. L. Diepgen, "Web-based training modules in dermatology," MD Computing 14 (5), pp. 371 – 376, (1997).

[2] C. D. Carothers, R. M. Fujimoto, and Y. B. Lin, "Simulating population dependent PCS network models using time warp," in Proceedings of the IEEE 45th Vehicular Technology Conference, July, (1995).

[3] M.A. de Juan, M.A. Leon, B. Martin-Calero, A. Mendoza, A. de los Ojos, J.R. Peran, and L.J. de Miguel, "Decision making based on a discrete event simulation tool," in Proceedings of 7th IEEE International Conference on Emerging Technologies and Factory Automation, pp. 335 – 341, (1999).

[4] C. R. Dow, J. S. Chen, Y. F. Huang, "Visualization of performance data on PCS systems," International Symposium on Multimedia Information Processing, Taipei, Taiwan, December 14-16, pp. 28-33, (1999).

[5] C. R. Dow and S. H. Hung, "A web-based parallel simulator for cellular mobile systems," ISCA 12th International Conference on Parallel and Distributed Computing Systems Conference, Fort Landerdale, Florida, USA, August, pp. 18-20, (1999).

[6] P. M. Greenfield, Electronic technologies education, and cognitive development. In D.E. Berger, P. Pezdek and W.P. Banks(eds.), "Applications of cognitive psychology: problem solving, education, and

BEST COPY AVAILABLE

computing.," Lawrence Erlbaum, Hillsdate, NJ, (1987).
[7] M. Haag, L. Mayleim., F.J. Leven, B. Tönshoff, and R. Haux, "Web-based training: a new paradigm in computer-assisted instruction in medicine," International journal of medical informatics, Volume: 53, Issue: 1, January, pp. 79 – 90, (1999).
[8] J. Hooper, J. O'Connor, R. Cheesmar, and C.P. Price, "Tutorial software for clinical chemistry incorporating interactive multimedia clinical cases," Clin. Chem. 41, pp. 1345–1348, (1995).
[9] S. Jordan, "Resource allocation in wireless networks," Journal of High Speed Networks, vol. 5, no. 1, (1996).
[10] A. Kaddouri, B. Khodabakhchian, L.-A Dessaint, R. Champagne,L. Snider, "A new generation of simulation tools for electric drives and power electronics," Proceedings of the IEEE International Conference on Power Electronics and Drive Systems, pp. 348 –354, (1999).
[11] I. Katzela and M. Naghshineh, "Channel assignment schemes for cellular mobile telecommunication systems," Personal Communications magazine, June, (1996).
[12] R. Klar and U. Bayer, "Computer-assisted teaching and learning in medicine," Int. J. Biomed. Comput. 26, pp. 7-27, (1990).
[13] C. Lalle, "A hypermedia system for parasite identification," Int. J. Biomed. Comput. 41, pp. 175–180, (1996).
[14] D.M. Laurillard, "Computers and the emancipation of student: giving control to the learner," Instructional Sci.,16, pp. 3-18, (1987).
[15] C. W. Lin and Y. B. Lin, "Development of a PCS handoff simulator," Master Thesis, Department of Computer Science, National Chiao-Tung University, June, (1997).
[16] W. Lin, C. C. Chiang, H. K. Wu, V. Jha, M. Gerla, and R. Bagrodia, "Parallel simulation on environment for mobile Wireless Networks," in Proceedings on Winter Simulation Conference, (1996).
[17] H. Pasterkamp, "Computer assisted learning of chest auscultation: the respiration acoustics laboratory environment," in: van Bemmel, Zvaronova (Eds.), Knowledge, Information and Medical Edu-cation, Elsevier, North Holland, pp. 244–251, (1991).
[18] M. Piccolotto and O. Rio, "A computer-based teaching tool for structural design," Materials Science and Engineering A196, pp. 109-120, (1995).
[19] L. Polwman, "An ethnographic approach to analyzing navigation and task structure in interactive multimedia: some design issues for group use.," In A. Monk, D. Diaper and M.D. Harrison (eds.), People and Computer VII. Cambridge University Press, Cambridge, UK, (1992).
[20] J.B. Pugliesi and S.O. Rezende, "Intelligent hybrid system for a training and teaching environment," ICCIMA '99. Proceedings. Third International Conference on Computational Intelligence and Multimedia Applications, pp. 148-152, (1999)
[21] F. Puppe and B. Reinhardt, "Generating case-oriented training from diagnostic expert systems," machine-mediated learning 5 (3,4), pp.199– 219, (1995).
[22] J. Short, R. Bagrodia, and L. Kleinrock, "Mobile wireless network system simulation," ACM Mobile Communication Networking Conference, November, (1995).
[23] K. Tait et al., "Sim/10 first intermediate report on authoring tools for simulation," DELTA project D1014 SAFE, (1989).
[24] P. van Rosmalen and J. Hensgens, " The use of computer simulations in training," Materials Science & Engineering - A - Structural Materials: Properties, Microstructure and Processing, Volume: 199, Issue: 1, August 1, pp. 109-120, (1995).

Students' thinking processes when learning with computer-assisted mass lectures.

Nopphol Pausawasdi* and Dr Lyn Henderson**
School of Education, James Cook University,
Townsville, Queensland 4811, Australia
Phone: 617 4781 6984
Facsimile: 617 4725 1690
*Email: *Nopphol.Pausawasdi@jcu.edu.au,*
***Lynette.Henderson@jcu.edu.au*

This paper presents findings from a research project that examined students' thinking during mass lectures that utilized interactive multimedia (IMM). The data were obtained from six second year Thai medical students via stimulated-recall interviews. The reported thinking (or mediating) processes engaged in by the students during the mass lectures that related to the academic content of the physiology subject are detailed and discussed. We identified 18 different types of thinking skills including generating, anticipating/predicting, linking, metacognition, analyzing, and categorizing. These ranged from a high usage frequency (generating) to a low usage frequency (categorizing). Being able to understand such student thinking may result in more effective use of IMM in mass lectures. The data are also compared with studies that provided students' reported thinking processes when studying with the WWW, IMM, and text-based material. The significant differences in the mediating processes between using IMM in computer-assisted mass lectures, where the students did not directly interact with the IMM, and hands-on use of IMM, the WWW, and text-based material are discussed.

Keywords: **Thinking skills, Computer-assisted mass lecture, IMM, medical education, Thai medical students**

1 Introduction

There is increasing use of IMM in mass lectures in universities for teaching and learning. Yet IMM supported lectures do not guarantee better content learning or higher-order thinking than do traditional instruction methods. There is much research and literature concerning instructional design, the characteristics of IMM, and learning: for instance, the use of educational technology [1] and the effects of colors [2], animations [3], and interactivity [4]. Research has neglected how students engaged with the new technology in lectures. The research by Nowaczyk, Santos, and Patton [5] examined student perceptions of various characteristics of multimedia such as color transparencies, video, and PowerPoint in tutorials and mass lectures. However, they did not investigate students' thinking processes about the academic content. The research by Faraday and Sutcliffe [6] examined visual attention and comprehension of multimedia presentations. Research by Putt, Henderson, and Patching [7] and Henderson, Putt, Ainge, and Coombs [8] examined learners' mediating process about the academic content of IMM and WWW courseware, respectively. However, these did not focus on an IMM mass lecture context.

Studies report that IMM can be effective in encouraging higher order thinking skills when learners work with IMM individually or, better still, in pairs or small groups [9, 10, 11]. However, in a mass lecture, the IMM is controlled by the lecturer. Learners play a passive-receiver role. Are they focused on the content? What sort of thinking about the content do they engage in?

Heeding current literature in the field [1, 12, 13], the study does not aim to ascertain whether learningwith

IMM supported lectures produces better learning or test outcomes than traditional lectures. Rather, it utilizes qualitative methodologies to ascertain the students' thinking skills as they learned in the authentic context of a lecture theatre. Thus the study sought to:

(a) identify and categorize the thoughts concerning the content of the IMM supported lectures that were reported by the students;

(b) compare the mediating processes reported in the computer-assisted mass lecture study with those reported in research which identified the reported mediating processes that occurred in three studies where students had hands-on use of IMM software, WWW courseware, and text-based materials respectively; and

(c) with respect to (b), evaluate our hypothesis that the type of interaction with the learning materials would be a significant factor, that is, the lack of direct manipulation of the learning materials would result in lower percentage frequencies of reported mediating processes (our study) compared with those reported in the other studies that had direct hands-on interaction.

2 Methodology

Much existing research data regarding the efficacy of computer mediated environments is anchored in the process-product paradigm. The paradigm is based on the assumption that instructional stimuli give rise to learning outcomes. Recognition of the simplistic nature of this general cause-effect paradigm when applied in education, led to the adoption of the mediating process paradigm that focuses on student thought processes that mediate, or come between, instructional stimuli (the IMM supported lecture) and learning outcomes [14]. Mediating processes can be viewed as the fine-grained eléments of cognition through which, and by which, learning outcomes are realized. Thus, learning outcomes are the function of the mediating processes activated by instructional tasks and other learning activities. Salomon [11] describes the contrast between analytic research that is focused on isolating effective instructional treatments and systemic research focused on understanding how instructional treatments work in practice. This study embraced systemic research focussing on the sorts of thinking that tertiary students engaged in during IMM supported lectures.

It is a qualitative study utilising stimulated recall interviews to ascertain students' thinking in authentic contexts. Learning is related to the quality and quantity of thinking undertaken by learners [15]. To categorize and tabulate students thinking skills, a process-tracing methodology is utilized. It involves appropriate self-reporting techniques through using a video to stimulate recall of cognitive processes engaged in during a learning/study session. The stimulated recall interview technique follows strict guidelines [14]. Triggered by such things as the students' non-verbal actions or what is appearing on the computer screen, non-leading questions are asked, such as: "You seemed to frown; can you tell me what you were thinking?" and, in order to confirm that the reported thought occurred during the learning session and not while being interviewed, "Did you think that then or just now?" Both the interviewer and students can stop the video when they believe something is significant and, for the student, when the video triggers a thought that he/she had had during the initial study session. This method has been used in different settings with different mediums and with individuals, pairs, and small groups [7, 8, 16, 17, 18].

2.1 Context, Participants and Data collection

The research context and methodology capitalize on authenticity [11]. The students' thinking processes were obtained in realistic, ecologically-valid situations as the data were collected from students working in their regular environment. Thus for the current study, the research was conducted with a physiology class in a mass lecture theatre, Faculty of Medicine Siriraj hospital, Mahidol University, Bangkok, Thailand. The lecturer used A.D.A.M., The interactive physiology-muscular system [19] in the one hour lectures. Two lecture sessions were video recorded. Six students volunteered to participate in the stimulated-recall interviews. There were four males and two females with ages ranging from 17 to 19 years. They were in the third semester of a six year Medical degree. The six participants self selected into 3 pairs, 2 male pairs and 1 female pair. Working in pairs was the favored study practice of these Thai medical students. The first male pair was interviewed after the first lecture session; the others after the second lecture session. The content of both lectures was the same topic and used the same IMM. All six participants attended both lectures.

The interviews were conducted with one pair at a time. The interviewer and each pair of participants together viewed a videotape of the lecture and a synchronized computer screen showing the A.D.A.M. IMM software that was used in the lecture. The video picture included the lecturer's verbal and non-verbal behaviors and the content of the computer-assisted lecture. The computer screen showed the A.D.A.M. IMM

software content which appeared on the videotape. Both videotape and computer screen facilitated the participant's recall and verbalization of their thinking during the lecture. The three stimulated recall interviews, one hour duration for each interview, were conducted immediately after the lecture sessions and were audio taped for later transcription and analysis.

3 Results

From the interview transcripts of the students' stimulated recall interviews, their thinking skills were identified, categorized, and then analyzed. Both authors together identified the thoughts from the first transcript. The others, they did individually. Then the data from each researcher were compared and discussed. Consensus was achieved when disagreement occurred. The data that were considered invalid, such as student's thinking that did not occur during the study session, the reports of students' activities that were not related to their thinking, and answers where the interviewer had led the student, were identified and discarded. Only students' thinking that occurred during the study session were identified as useable data.

The students' thinking data reported by participants were classified according to the mediating processes identified by Henderson, et al. [8]. The 18 mediating processes identified in our study are listed in Table 1 which provides a definition for each thinking skill and a clarifying example of each from the data.

Type	Description	Example
	Mental activity in which a student -	
Affect	reports feelings aroused by content during study	"He [the lecturer] clicked A. I was glad. My answer was correct."
Analyzing	Reduce, breaks down whole (e.g., problem, task) into parts	"I've learned that content. There were some new parts adding to it. The rest was old."
Anticipation	predicts or states expectations that problem, question, or textual feature will be encountered; wonders about: the possibility of an event, relevance of material, content	" He [the lecturer] was talking about timing. So, I thought ahead that it must higher. And when stimulated, a bit slower - it would be lower."
Applying	Considers the use of an idea, tactic in a different context.	"When I saw the clearer image, I thought they should use this technique in the textbook because it can't use animation."
Categorization	Sorts items, ideas, skills into different groups	"I thought I already noted this as asynchronous."
Comparison	identifies similarities, differences between two statements, concepts, models, situations, ideas, theories, points-of-view, etc.	"From the graph shown on screen, I thought it would appear in another way."
Confirmation	judges that ideas in text support one's own beliefs, practices, tactics	"When he [the lecturer] clicked, I just thought that one is correct."
Deduction	reasoning process by which a specific conclusion necessarily follows from a set of general premises	"I felt the image doesn't look real because the vesicle [4small bags within a larger bag] has just 4 bags and the water filled this space."
Deliberation	engages in "thinking" about a topic, prose segment, etc. (type of thinking not disclosed)	"I was thinking about the question."
Diagnosis	identifies strengths and weaknesses in idea, strategies, points-of-view	"I thought it made me understand better by cropping and enlarging the picture. So I can see it clearly"
Evaluation	makes judgments about the value, worthwhileness of textual materials, activities, in-text questions, own position or point-of-view	"I thought the topic shown at the top was good. It told me what I was going to learn."
Generating	formulates one's own questions, examples, ideas, or problems; interpolating; going beyond the data	"What does the handle look like? Stimulate by hands! Do we use hands to do that?"
Imaging	creates a mental image of an idea in text in order to gain a fuller understanding	"I thought about the real muscle and how it should look if I cut it"
Linking	associates or brings together two or more ideas, topics, experiences, tasks	"I thought about the frog's leg in the laboratory."
Metacognition	thinks about, reflects on, evaluates or directs own thinking	"I couldn't see the shrink in the first animation. I thought I need to focus more on the next one"
Recall	brings back into working memory an idea, opinion, fact stored in long-term memory	"This picture, I thought I learned it before."
Reflection	general indication of careful consideration or thought over past action and response; tries to establish the reason or causal link between the action and its response	"When this graph was shown, I thought the latent period is narrow. At first, I thought it would be wide and red like the previous one."

Strategy Planning	plans ways of processing or handling content material during study or learning sessions	"When I saw these, I would open the textbook. I did not wait. I would note the additional information in the textbook."

Table 1: Mediating Processes Identified in the Present Study

Note: Descriptions are adapted from Marland, et al. [14] and Henderson, et al. [8]; examples are from the current study.

The frequencies for each type of mediating process were tallied (Table 2). The data in Table 2 indicate the frequency of the 18 identified mediating processes. The data shows the different frequency of mediating processes between three pairs and the variation in the frequency of occurrence of mediating processes. These ranged from

Categories of classification	*Mediating Process (i.e., thinking skills)*	*Frequency (1st male pair)*	*Frequency (female pair)*	*Frequency (2nd male pair)*	*Total*	*Percentage (%)*
Content	Generating	3	19	11	33	14.5
	Anticipating/Predicting	1	10	20	31	13.7
	Linking	2	14	11	27	11.9
	Metacognition	11	7	6	24	10.6
	Evaluating	6	7	7	20	8.8
	Strategy Planning	0	6	10	16	7.0
	Recalling	8	3	4	15	6.6
	Affective	3	2	9	14	6.2
	Confirming	0	4	5	9	3.9
	Deliberating	1	2	6	9	3.9
	Diagnosing	6	1	2	9	3.9
	Imaging	0	0	7	7	3.0
	Reflecting	1	6	0	7	3.0
	Comparing	0	3	1	4	1.4
	Applying	1	1	0	2	0.9
	Deducing	1	0	1	2	0.9
	Analyzing	1	0	0	1	0.4
	Categorizing	0	0	1	1	0.4
	Total thoughts	45	85	97	227	100
	Mean number of mediating processes per pair from 3 pairs		76		based on responses	

Table 2: Frequency of Mediating Processes Related to Academic Content.

14.5% for "generation" to 0.4% for "analyzing" and "categorizing". A total of 227 mediating processes were identified from the transcripts. The mean number of reported mediating processes per pair was 76. The first male pair who were interviewed after the first lecture reported 45 mediating processes. The other male and the female pair who were interviewed after the second lecture reported 97 and 85 mediating processes, respectively. Familiarity with content and presentation probably influenced the higher number of thinking processes during the second lecture.

Mediating processes	*This study:* IMM in mass lectures (%)	*Study by Henderson, et al.. (1997):* IMM study (%)	WWW study (%)	Text-base study (%)
Generating	very high (14.5)	high (8.4)	very high (10.1)	Low (3.6)
Anticipating/Predict.	very high (13.7)	high (7.8)	very low (1.4)	high (5.9)
Linking	very high (11.9)	very high (11.4)	very high (11.5)	very high (10.4)
Metacognition	very high (10.6)	very high (19.8)	high (9.4)	very high (12.4)
Evaluating	high (8.8)	very high (18.0)	very high (26.5)	very high (18.6)
Strategy Planning	high (7.0)	very low (1.8)	high (7.7)	very high (16.8)
Recalling	high (6.6)	high (6.6)	very low (1.0)	low (4.1)
Affective	high (6.2)	very high (14.4)	high (9.4)	high (7.8)
Confirming	low (3.9)	Very low (1.8)	low (4.5)	very low (2.8)
Deliberating	low (3.9)	very low (1.8)	very low (2.8)	none (0.0)

Diagnosing	low	(3.9)	none	(0.0)	low	(3.1)	low	(0.26)
Imaging	low	(3.0)	very low	(0.6)	very low	(2.4)	none	(0.0)
Reflecting	low	(3.0)	none	(0.0)	very low	(0.003)	none	(0.0)
Comparing	very low	(1.4)	low	(4.8)	very low	(2.1)	very low	(1.5)
Applying	very low	(0.9)	none	(0.0)	none	(0.0)	none	(0.0)
Deducing	very low	(0.9)	none	(0.0)	very low	(1.4)	none	(0.0)
Analyzing	very low	(0.4)	very low	(2.9)	none	(0.0)	very low	(1.1)
Categorizing	very low	(0.4)	none	(0.0)	very low	(1.0)	very low	(0.005)

Table 3:Comparative students' mediating processes frequency between this study and the study by Henderson, et al. [8]

The data in Table 3 show the variation in the frequency of occurrence of mediating processes in our study and that by Henderson, et al. [8] which reports data from three different studies. In these three studies, the tertiary education students had hands-on control of the IMM software, the WWW courseware, and the text-based materials. (Our research was not aimed at arguing that one type of learning material [the IMM in mass lectures, the hands-on IMM study, the WWW study, or the text-based study] was better educationally. Our intention with the comparison frequency of thinking processes was that, if the quality and quantity of reported thinking skills was comparable with those reported in the other three studies, and if hands-on interactivity did not appear to be a crucial factor, then lecturers would feel a level of confidence in using IMM in mass lecture.)

Based on four level divisions used in the Marland, et al. [14], Putt, et al. [7], and Henderson, et al. [8] studies, the frequency of occurrence is divided into very high, high, low, and very low in order. In all studies, the 3% and 10% cut-off figures were arbitrarily chosen, whereas 5.5% (100/18), the cut-off for the "high" category, was the average percentage frequency across all 18 categories.

In Table 3, the categories of generating, anticipating/predicting, linking, and metacognition have the highest frequency ($f>10$) in this study. According to the study by Henderson, et al. [8], linking was rated very high in learning with the WWW, IMM, and text-based materials as well. However, while anticipating/predicting rated as very high in this study, it rated as low in the WWW study and high in the IMM and text-based studies. Evaluating was reported often in all four studies. It was rated as high in this study and very high in the other three studies. Interestingly, strategy planning was very low ($f<3$) in the IMM study, but it rated as high in this study and the WWW study and very high in the text-based study. Recalling rated as high in only the two studies that used IMM. Comparison of the results show that ten mediating processes (confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing) occurred in the low to very low frequencies in all four studies.

4 Discussion

The following discussion focuses on the comparison of mediating processes that were reported by students during their learning sessions. In the computer-assisted mass lectures, the A.D.A.M. IMM software was used as a teaching-learning tool. It played a major role in the lectures. However, the students were not in a position that allowed interaction with the IMM. They were a group of passive-receivers who possibly consumed the content provided by the lecturer via the IMM features. Therefore, the data obtained in our study concerns the reported mediating processes of students who learned with IMM without direct hands-on interaction. The comparison data between our study and that reported by Henderson, et al. [8] reveals factors that influenced students' mediating processes while learning with different mediums. Moreover, it also revealed the differences in the quantity and quality of the reported thinking skills when students had direct hands-on interaction versus receiver interaction.

The top frequency percentages for the four studies are 26.5% (WWW), 19.8% (IMM), 18.6% (text-based), and 14.5% (our study). The data reveal a higher percentage frequency of the most reported thinking skills in the studies where students had hands-on interaction control. If we add the percentages of all mediating processes in the "very high" category for all four studies then the differences are 63.6% (IMM), 58.2% (text-based), 50.7% (our study), and 48.1% (WWW). Nevertheless, even though the students in the hands-on WWW study had the fewest reported mediating processes in the very high frequency range, there was only a small percentage difference (2.6%) between it and our study. In terms of these criteria, the data generally tends to support our hypothesis. The students in the hands-on IMM study obviously reported more mediating processes than those in the IMM computer-assisted mass lectures. However, when the number of mediating

processes per person in all four studies is averaged, the results are 38 per person for our study, 16 per person for the IMM study, 36 per person for the WWW study, and 28 per person for the text-based study. The low hands-on IMM number was affected by having learner groups of more than two students; beside two groups of two students there was one of three and one of four students in the stimulated recall interviews [20]. Nevertheless the highest number was in our study where students did not have hands-on control. Moreover students in our study reported more types (18) of mediating processes during learning. Students in the WWW, IMM, and text-based studies reported 16, 14, and 13 different types of mediating processes respectively. The students in the WWW study did not report applying and analyzing. The students in the IMM study did not report reflecting, applying, deducing, and categorizing. Those in the text-based study did not report deliberating, imaging, reflecting, applying, and deducing (Table 3). Breadth, that is, the number and type of different mediating processes are relevant to engaging meaningfully with the content as is the number per individual. Thus hands-on control does not seem to be the crucial factor here. The following discussion examines these issues concerning our hypothesis by singling out various mediating processes for analysis and reveals that our hypothesis is tenuous.

The top four mediating processes in our study were generating, anticipating/predicting, linking, and metacognition in descending order. "Generating" encompasses one or more of the following: (a) formulation of one's own questions, examples, ideas, opinions, problems, and answers; (b) interpolation by adding new knowledge through the elaboration of existing knowledge within a given framework; and/or (c) extrapolation which adds new knowledge by extending an existing framework and going beyond the data. The reason for the very high percentage for generating is because of the cause-effect relationship between their thoughts and the animation features of A.D.A.M., which led the students to focus on the content [21]. Generating has a very high frequency (14.5 %) in our study, a high frequency (8.4%) in the IMM study, a very high frequency (10.1%) in the WWW study, and a low frequency (3.6%) in the text-based study. Therefore, direct hands-on interaction might have caused the lower frequencies of generating in the hands-on study. Students in the three studies reported by Henderson, et al. [8] might have engaged in the jobs they needed to do to control the IMM and the WWW materials and underline or take verbatim notes from the text materials. Thus resulting in less focus on the content. Students in the computer-assisted mass lectures just followed the lecturer's presentation, which may have allowed them to allocate more time to focus on the content.

"Anticipating/predicting" includes predicting, looking forward to, speculating about, and expecting the likelihood of encountering problems, types of content, and features of the medium. Anticipating/Predicting is the second highest ranked mediating process having a very high frequency in our study. It had a high frequency in the other IMM study. A possible explanation for this finding is that the lecturer was the only person who controlled the A.D.A.M. IMM software, thus the students anticipated and predicted what the lecturer decided to present and what would emerge in the A.D.A.M. presentation. Students in the IMM study had direct interactive hands-on control of the IMM. Therefore, it is possible that they automatically clicked the mouse to move to the next page, clicked for the answer to embedded questions, and clicked to control the animation without allowing time for anticipation or prediction. The very low score (1.4%) for the WWW study appears to be an anomaly. Perhaps the content, particularly the instructional design of the content, did not promote these thinking skills. Or perhaps the students used the hypermedia functions of the WWW and engaged in thoughts such as "I will click on this link" rather than wondered what content ideas would be presented embedded in that link. In our study, students in the computer-assisted lectures had to wait for lecturer interaction. Thus, during waiting, they had more time to anticipate or predict the coming content.

"Linking" had a very high frequency in all four studies. It is defined as the process of associating, or bringing together in the mind, two or more ideas, topics, contexts, personal experiences, words, and so forth. From this finding, linking occurred easily when text, picture, graphic, or animation that illustrated the concept prompted recall of an associated item in the student's memory. Therefore, it is not surprising that linking occurred very often in all studies because they contain those elements that influenced students to consider how the information related to their experiences. This also shows that, in comparison with our study, direct hands-on interaction did not influence the linking processes.

Mediating processes classified as "metacognition" are those in which students reported awareness of, reflecting on, evaluating, or directing their own thinking. This definition reflects a widely accepted view of metacognition as referring to students' knowledge about, and control over, their cognitive processes. The findings show that metacognition had the fourth highest frequency of mediating processes in this study. The students were able to engage with the content and thinking about their own thinking as it related to the content, and were less inclined to be sidetracked by the features of IMM, the lecturer, and

student-idiosyncratic factors [21]. Metacognition had very high and high frequencies in the four studies (see Table 3). In three studies the percentage frequencies were similar: our study (10.6%), the WWW study (9.4%), and the text-based study (12.4%). However, there was a significant gap between these and that for the hands-on IMM study (19.8%). A factor that possibly made the gap is that the hands-on IMM study contained embedded questions that forced students to interact in order to receive feedback and to be able to move to the next section. In our study, the A.D.A.M. software also offers the same feature, but the students did not have hands-on control. The text-based study also provided embedded questions, but did not provide feedback and also did not "force " the students to answer those questions. The WWW study did not provide embedded questions. This comparison shows that the different pedagogical instructional design in conjunction with the hands-on control is a crucial factor that influenced metacognition. Nevertheless, it is still significant that students engaged in metacognition, which is a type of thinking that is considered to be one of the highest types of cognitive processes [22].

"Evaluating" is defined as the mental process in which a judgement is made about the value or worth of some aspect of the content of the instructional material. Evaluating had a high frequency (8.8%) in this study. The percentage of reported evaluative thoughts about content is very high in the other three studies (18.0%, 26.5%, and 18.6%). The gap between our study and the other three studies is significant. The students in the other three studies used the learning tools by themselves. Thus, it would seem that hands-on experiences and, hence, control over their own pacing and navigated sequencing with the learning tools produced more evaluative thoughts. In computer-assisted lectures, the students may not have had enough time to evaluate the content as well as generate new ideas, link to their past experiences, or metacognise. Perhaps, the students in our study rationalized that if the lecturer had purposely selected out this particular IMM A.D.A.M. material then it was important. In the hands-on studies, the students had to make the evaluative decision as to what content was worthwhile or relevant to their individual goals.

"Strategy planning" refers to thought processes in which students plan ways of processing or handling instructional material or activities during study or learning sessions. There is a dramatic gap between the frequency percentage for IMM study (1.8%) and the other three: our study (7.0%), the WWW study (7.7%), the text-based study (16.8%). The students in our computer-assisted mass lecture study had to follow the lecturer's presentation. One could therefore assume that the frequency rate would be "very low"; but why then the very low score for the IMM study? There appear to be three explanatory factors. The first factor suggests, as is the case with lectures in general, in our study students planned how to deal with the information and process the content through note-taking, drawing graphs, and deciding whether to annotate the textbook or attempt to draw or describe the animations that they cannot control. The second factor is that the students in the IMM study when interacting with IMM, did not appear to spend time thinking about how they would process the material but instead just followed the linear sequence programmed as the "default" choice [8]. The third factor is that, in comparison with the IMM study, in which assessment was not a factor, the students in the computer-assisted mass lectures, the text-based, and the WWW studies knew that the content was assessable. This might have influenced the students' strategy planning.

"Recalling" is defined as bringing back into working memory ideas, opinions, and facts previously stored in long-term memory. It has a high frequency (6.6%) in both studies that used IMM while it was rated very low (1.0%) in the WWW and low (4.1%) in the text-based studies. The gap between the studies that used IMM and those that did not use IMM is substantial. It is possible that the features of the IMM products, such as animation and enforced embedded questions, encouraged students to recall their previous knowledge and experiences during learning.

It is interesting that confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing were rated as low or very low (see Table 3) in all four studies. The type of interaction (hands-on or receiver), the mediums and their features did not seem to influence these types of mediating processes. This implies that factors that should be considered are the content and whether its instructional design prompted these types of thinking skills.

5 Conclusion

It has been argued that IMM is more useful as a learning tool when used individually or with others rather than in mass lectures where students could be seen as merely passive receivers. Our study shows that hands-on interaction does not appear to be such a crucial variable. Indeed in our study, the quantity, quality and range in type of mediating processes were greater than, or comparable to, the other studies. Therefore, the authors argue that IMM can be used as a cognitive tool in mass lectures to enhance various thinking

shills. This study draws the attention of instructional designers and lecturers to the existence, types, and relative frequencies of mediating processes in which students engage with while learning with computer-assisted mass lectures. They were not passive receivers but active receivers. Our study highlights the need for instructional designers to plan educational materials that will activate desired mediating processes as part of student learning in computer-assisted mass lectures.

References

[1] Glenna, T. K. & Melmed, A. (1996). Fostering the use of educational technology: Elements of a national strategy. A Rand Report. Santa Monica, CA: Rand. [Also Online] http://www.rand.org/publications/MR/MR682/contents.html Accessed 31 March 2000.

[2] Chapman, W. (1993). "Color Coding and the Interactivity of Multimedia," Journal of Educational Multimedia and Hypermedia, pp.3-23.

[3] Rieber, L. (1991). Theoretical foundations of instructional applying of computer-generated animated visuals," Journal of Computer-Based Instruction, 18(3), 83-88

[4] Sims, R. (1998) Interactivity for effective educational communication and engagement during technology based and online learning, [On line] http://wwwtlc1.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/rs/sims1.html. Accessed 3 March 2000.

[5] Nowaczyk, R., Santos, L., & Patton, C. (1998). Student perception of multimedia in the undergrad classroom. International Journal of Instructional Media, 25(4), 367-382

[6] Faraday, P., & Sutcliffe, A. (1996). An Empirical study of Attending and Comprehending Multimedia Presentations. London: City University, pp 265-275.

[7] Putt, I., Henderson, L., & Patching, W. (1996). Teachers' thinking elicited from interactive multimedia professional development courseware. Educational Technology Research & Development, 44(4), 7-22.

[8] Henderson, L., Putt, I., Ainge, D., & Coombs, G. (1997). Comparison of student thinking process when studying with WWW, IMM, and Text-based material.

[9] Park, I., & Hannafin, M. (1993). Empirically-based guidelines for the design of interactive multimedia. Educational Technology Research & Development, 41(3), 63-85.

[10] Simpson, M. (1994). Neurophysiological consideration related to interactive multimedia. Educational Technology Research and Development, 42(1), 75-80.

[11] Salomon, G. (1998, February). Novel constructivist learning environments: Some issues to be concerned with. Paper presented at Thinking in Teaching and Learning Conference, Jerusalem.

[12] Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42(2), 21-29.

[13] Reeves, T. (1997). Pseudoscience in qualitative research. [Online] ITFORUM listserv. ITFORUM@UGA.CC.UGA.EDU Access date: 3 March 2000.

[14] Marland, P.W., Patching, W.G., & Putt, I. (1992). Learning from text: Glimpses inside the minds of distance learners, Townsville: James Cook University.

[15] Litchfield, B. C. (1992). Evaluating 0f inquiry-based science software and interactive multimedia programs. Computing Teacher, 19(6), 41-43.

[16] Galluzzo, G.R. (1984, April). A study of student-teacher thinking. Paper presented at Annual Meeting of American Educational Research Association, New Orleans

[17] Mostert, M.P. (1996). Contextualized thinking about teaching: Special educators' metaphorical representations of practical knowledge. In L. Bouton (Ed.), Pragmatics and language learning (pp. 189-213). Urbana-Champaign, Ill: University of Illinois.

[18] Norton, R.A. (1987 April). Divining and defining a problem space: An investigation of preservice teachers' interactive thinking. Paper presented at Annual Meeting of American Educational Research Association, Washington, DC.

[19] Branstrom, M. (1996). A.D.A.M. The interactive physiology-muscular system [CD-ROM], A.D.A.M. Software, Inc. and Benjamin & Cummings Publishing, Atlanta, GA

[20] Patching, B., Henderson, L., & Putt, I. (1994, February). Interactive and Thinking: A report on research in progress. Paper presented at Second International Symposium on Interactive Multimedia, Perth.

[21] Pausawasdi, N., & Henderson, L. (2000, June-July). Students' Engagement Behaviors in Computer-Assisted Mass Lectures. Paper presented at World Conference on Educational Multimedia, Hypermedia, and Telecommunication, Montreal.

[22] Osman, E. M., & Hannafin J. M. (1992). Metacognition Research and Theory: Analysis and Implications for Instructional Design. Educational Technology Research and Development, 40(2), 83-99.

The Automated Teaching Assistant: Automatic construction of teaching materials from course outlines

Chris Houser*, Shigeki Yokoi and Takami Yasuda****
**Kinjo Gakuin University, Omori 2-1723 Moriyama-ku Nagoya 463-8521 Japan, houser@kinjo-u.ac.jp*
***Nagoya University, Furo-cho Chikusa-ku Nagoya 464-8601 Japan*

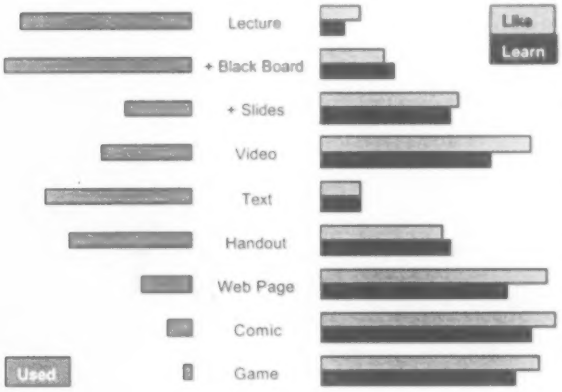
Keywords: **Lecture Preparation, Automation, Design of Teaching Materials.**

1 Educational Media: Yet Another Digital Divide

Instructors can use many media. Traditional teachers lecture while outlining on a black board; they assign readings from texts and printed handouts. Technological teachers lecture (or direct activities) while showing PowerPoint slides; they assign readings of web pages.

Instructors can use many media. Which do they in fact use? Which do students prefer?

We polled 200 students at three Japanese colleges. We asked students how often they saw, how well they liked, and how well they learnt from nine educational media. Responses were similar for all students across different colleges, different grades, and different majors. This graph summarizes their unified opinion.



The left side shows how frequently students saw each media. Common were traditional media (lecture, black board, text, and handout). Modern media were rare.

The upper bars on the right show how well students liked each media. The modern, rarely used were well liked. The lower bars show how well students thought they learnt from each media. Students claimed that well-liked media also taught the best.

In interviews, teachers claim they have no time to prepare multimedia slides and web pages, no time to learn PowerPoint. Students want multimedia; teachers don't prepare it. A digital divide separates a generation of computers from a generation of chalk.

How can we span this divide? These teachers brightened at the idea of a teaching assistant who would prepare these multimedia teaching materials, but only if the assistant could work from existing materials – typically typed course outlines – without supervision. They wanted a completely automatic teaching assistant.

So we created one.

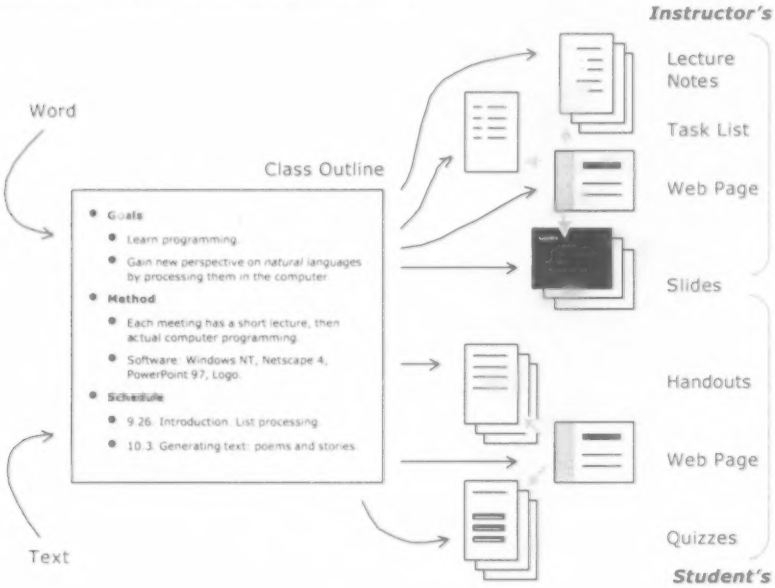
2 The Automated Teaching Assistant

The Automated Teaching Assistant (ATA) converts course outlines to multimedia teaching materials.

To use the ATA, instructors first prepare course outlines. They can use their favorite text editor or word processor, on any type of computer. Instructors then drag their saved file over the ATA program icon. The ATA reads the course outline and constructs a folder filled with teaching materials:

- syllabus (in the form of a class web page) [5]
- instructor' s notes (teaching plans)
- student' s handouts (outlines of each meeting)
- instructor' s task list (things to do, to prepare this class, sorted by date due)
- graphical slides visualizing each point in the outline [3, 4]
- web-based quizzes, tests, assignments, polls, class evaluations, and peer evaluations [1, 2]

The sketch below shows how a class outline is translated to teaching materials. Black arrows show the flow of information; **gray** arrows show hypertext links:



All these materials are automatically uploaded to the class's web server. Then students can view the materials from anywhere in the world. Instructors can travel to any classroom in the world with a working web browser, and give their lectures. There are no papers or floppy discs to carry, no worries about hardware and software compatibility, no need to install software, no fear that needed software will be missing.

The ATA is completely automatic: it has no commands or options. Teachers submit their outlines; seconds later the materials are all available on the internet. This automation contrasts sharply with the common manual production of multimedia materials.

If instructors were to create these teaching materials without the ATA, they would need to purchase and then study expensive and complex multimedia software, such as PowerPoint and DreamWeaver. In addition, they would have to learn at least some design theory, for they would need to learn how to make attractive and comprehensible slides, handouts, and web pages. (Although some instructors might find this an interesting diversion, others may resent it as time stolen from their research and content preparation.) Then, before every class, instructors must manually convert their lecture plans into slides and web pages. In our experience, this takes an average of four tedious hours to prepare each meeting. Most instructors, in fact, are unwilling or unable to spend this much time preparing lectures. So students are disappointed.

But if these instructors would use the ATA, it will cost them only seconds, but will greatly increase their student's satisfaction. The ATA is more efficient because it factors the *style* (layout and design) out of the

substance (logic and content) of teaching materials. Instructors need concern themselves only with the creation of the abstract content of their classes; They can delegate the tedious physical layout and distribution to the ATA.

Using the ATA, we prepare lectures in an average of 40 minutes. The ATA allows us to prepare in only 17% of the time – it speeds preparation five times.

References

[1] Houser, C., "Introduction to Interactive web pages Using CGI", *Proceedings of C@LLing Asia 99* (1999).

[2] Martin, L., *WWWAssign*, http://www.northpark.edu/~martin/WWWAssign (1999).

[3] Meyer, E., *Designing Infographics*, Hayden, Indianapolis, Indiana (1997).

[4] Rabb, M., *The presentation design book*, Ventana Press, Chapel Hill, NC (1993).

[5] Weinman, L., *Designing web graphics*, New Riders, Indianapolis, Indiana (1996).

The Criteria and Evaluation of Metadata/Keywords in Image Retrieval

Toru FUKUMOTO* and Kanji AKAHORI*
**Department of Human System Science*
Graduate School of Decision Science and Technology
Tokyo Institute of Technology
2-12-1 Ookayama, Meguro-ku, Tokyo, JAPAN
Tel/Fax: +81-3-5734-3233
E-mail: fukumoto@mail.club.ne.jp

Nowadays, a large amount of digital images are being stored worldwide in Internet. As an educational means, images stored in Internet have a big potential. Teachers can show the students pictures or images instead of actual things. The Internet is so rapidly expanding and becomes so complicated that the ways to retrieve images effectively from Internet database are now getting more difficult. In this paper we consider an image database about metadata type. We place a special emphasis on keyword itself in the metadata, and show the criteria of keyword, not the framework of them. Good keywords are needed in the database so that the retriever can get what he/she really wants. First we survey the necessity of metadata: especially keyword for image database. Next we consider and present the criteria for consistent and appropriate keywords, distinguishing subjective keywords from objective ones. And we examine and assess them. Furthermore we append a new item, importance, to our criteria.

Keywords• **Image Retrieval, Metadata, Criteria**

1 Introduction

Over the years large amounts of computer-aided images are being stored in Internet owing to widely available digital recording devices, such as digital cameras, scanners, and economical large size storage. For the effective management of those digital images, an image album or an image filing system has the subject of study and it has remarkably developed. And the Internet is so rapidly expanding and becomes so complicated that the effective retrieval methods of images from database becomes more and more important.

As an educational means, image presentation is very important. Because teachers cannot usually bring actual thing into classrooms, they show students the pictures or images instead. Or when the students use the Internet by themselves the images surely help them to learn fast and effectively.

There are 3 kinds of image database: feature type, sensitiveness type, and metadata type. Feature type (cited as [1] and [2]) is based on the colors or shapes of object in the images. When the retriever puts in color or shape, the system starts searching directly the database with color histograms or shape. In the case of sensitiveness type (cited as [3] and [4]), the retriever puts in sensitive words and the system exchanges them for color information and searches the database. In the case of metadata type (cited as [5]), each image in the database is already given metadata, which explains its characteristics by texts or digits, and the retriever searches the database using the metadata.

Our concern in this paper is of metadata type. Of this type, first, database creators define the structure or the framework of metadata. Second, database administrators attach metadata to images according to it in the database. Third, a retriever specifies texts as a key to the database. Finally the database system searches images using the metadata which is given by administrator and also using the texts which are keyed in by the retriever. Examples of metadata are keywords, texts, classification items and so on.

The metadata of image database system metadata needs consistency and appropriateness. If it often happens

that some of metadata are irregular or incomplete, the retriever cannot find images which he/she really wants. Especially of commercial systems, the reputation of the database is determined by the quality of metadata.

We place special emphasis on keywords in the metadata because they are the basic component of metadata. In Section 2 the necessity of metadata, especially keyword of image database, is discussed. In Section 3 the criteria of consistent and appropriate keywords is considered. In Section 4 the criterion, which we discussed in Section 3, is examined. In Section 5 our conclusion is presented and the future work is discussed.

By the way, we are not concerned here the structure or the framework of metadata. It needs another consideration. In ISO, the structure of metadata for multimedia contents description, MPEG-7 [6], is now being standardized. MPEG-7 will provide the distribution and utilization of multimedia contents with content-based retrieval. The application will be distance learning, a stream database, a personal TV, and so on. MPEG-7 will become International Standard at September 2001.

2 Metadata and Keyword

Good metadata is needed in the database so that the retriever can get what he/she really wants. In storing database with images, we give texts, especially words as metadata to them. These words can be defined as keywords. They are given to images and used when a retriever searches the database. Database system searches images based on keywords which he/she specifies.

Therefore when incompatible keywords are given to images in the database, a retriever cannot get images which he/she really wants, even if he/she puts in any compatible keywords. In next Section we show the criteria of good keyword, which discussed and experienced before in [7].

3 The criteria of keyword

We shall discuss the criteria of keyword in detail.

- Giving appropriate keywords

  A retriever depends only on keywords. Therefore the images need to be given beforehand the keywords which represent them precisely. For example, we should distinguish "people" from "doll" because he/she may really want the image of a doll, not of people. Or it depends on the retrievers of the database which is appropriate "car" or "BMW". The database administrator should expect how the retriever uses keywords when he/she gives keywords to the image.

- As many keywords as possible

  An image has a lot of views. For an example, in Figure• ; some people takes it for the figure of pond, some of others for monument. Obviously only a single keyword is not adequate to describe its whole concept.

  Therefore, a number of keywords should be given to an image so that it can precisely correspond to the keywords. The retriever can more easily obtain the images which he/she really wants.

- Distinguish subjective keywords from objective

  We can define a lot of keywords for one image. They may be divided into two types. One is objective; the other is subjective. In figure• ; objective keywords are, for example, "pond", and "monument". Whereas "summer" and "shine" are subjective factors, because they are viewer's impressions of this image. They are subjective keywords. The former is more general than the latter.

You might think that you need only objective keywords. However, a retriever's needs are generally divided into two types: subjective and objective. In Figure• ; he/she wants a summer picture. "Summer" is a subjective word. If the database does not have subjective keyword, he/she cannot find such an image. He/she must hit objective keywords instead of "summer". Accordingly there are subjective needs in so many cases that subjective keywords are to be needed. For this reason, both subjective and objective keywords are needed in an image database.

And subjective keywords are to be distinguished from objective ones. Here is an example. A retriever wants

an image of "sea atmosphere". In a database, one image represents the impression of sea, that is, "beach". The other image represents the sea itself. When he/she specifies a keyword "sea", the database system searches an image with keyword "sea". It hits two images: the sea itself and the beach. However, what he/she really wants is the sea image, not a beach one. So that a subjective keyword should be given a subjective marker in the database, to distinguish it from objective one. The retriever finds the image more easily and precisely by putting in the keywords with a subjective marker. Such is the criteria of keyword.

4 Examination and Assessment of the criteria

We examined above mentioned criteria to assess the effectiveness.

We arranged seven persons (5 males and 2 females; all adults). First of all, we showed them our criteria discussed in Section 3 as a book-style. We call it "keyword book". Next, we show them 20 images, one per one paper. The contents of them are sight, animals, texture and so on. We included pictures of various image types. We scanned, digitized and printed pictures by a color laser printer. Then we let them give keywords to these images. They gave keywords to the images referring the keyword book as many as they liked. We did not limit the number of keywords for each image.

Finally we let 3 specialists give keywords to same images separately. And we compared the former keywords (by 7 persons) with the latter keywords (by 3 specialists) so that we might assess the contents of both keywords. In the following section we discuss about the result of this examination.

4.1 Number of keywords and the appropriateness

The result of our experiment are presented in Table• ? Total number of keywords is 416 for 20 images. In average there are about 21 keywords for an image. The relationship of keywords and object in each image is roughly as many. The specialists added total 103 keywords to those given 7 persons.

It is the tendency that specialists give keywords to the small objects in each image. Especially there are a lot of objective keywords, which are given to images that has many objects. 7 persons and 3 specialists gave the same keywords to Figure• ? But to Figure • •7 persons gave only 5 keywords: while 3 specialists did 29. And the keywords by 7 persons are different from the ones by 3 specialists.

The keyword is for retrieval. We need not say that keywords should be given to as many as possible to improve the preciseness simply because the objects in the image are very small. Generally the more keywords the image is given, the easilier it can be searched out. But, on the contrary, from the point of appropriateness, we claim that the images should be added the information regarding the objects in it; for example, how large it is, or what impression a person has when he/she looks at it. This is to help the retriever to obtain the image which he/she really wants. The database should have such information. However, there is no information about them in our criteria.

It follows that an index is needed to show the importance of keywords or square measure of objects in the image: for example, the keyword "monument" and importance "3", or monument has one-fifth (of the image).

To the images that cannot be dis tinguished by the object such as texture and patterns, the keywords of 7 persons vary widely compared with ones by specialists. For example, in Figure • •7 persons gave "red", "water-drop" and "discomfort". The object in it is so hard to define that they are difficult to give keywords to this texture and pattern. In educational situation, this is a serious matter because students are not generally able to hit such keywords to retrieve them. In short, we point out that metadata type is of limited use when images are given in pattern or texture style. So that it seems reasonable to say that feature type retrieve is better for them than metadata type.

4.2 subjective/objective keywords

In Table• ? subjective keywords are 81, 21 % of total keywords. And the specialists gave 7 subjective keywords, which is 10 % of 7 persons' keywords. On the other hand, the specialists gave 96 objective keywords.

Regarding subjective keywords, there is little difference between 3 specialists' and 7 persons'. On the contrary, regarding objective keywords, 3 specialists' are different from 7 persons'. In addition to this, 7 persons' keywords are lacking of uniformity. There are only a small number of common subjective keyword that both 3 specialists and 7 persons.

Therefore it follows that there are limited words that express the character of images subjectively. The number of subjective keywords using these limited words is so small. On the other hand, regarding the objective keywords, 7 persons mostly attached them to even the objects which occupy the main part of the image, while 3 specialists gave them to even the small objects. We may say that that caused the increase of their keywords.

	Total	Subjective	Objective
Seven Persons	313	74	239
Three Specialists	103	7	96
Total	416	81	335

Table• •Number of Keywords

4.3 Discussion about our criteria

As mentioned above, we must modify our criteria because they will be to include the importance of each keyword.

• Appropriateness• The database administrator should expect how the retriever uses keywords when he/she attaches keywords to the image. As mentioned above, he/she distinguishes or identify "car" with "BMW". If the database is for general use, both general noun "car" and proper noun "BMW" are also given.

• Number of keywords• It needs the number of object that the image has and at least one subjective keyword which express the characteristics of image.

• Importance• It newly is appended our criteria. Importance: 3 is that the object is very large in the image or that it express the characteristics or the main theme of the image. Importance 1 is that the object is as small in the image as people try to find. The other object or character in the image is importance 2. For example, in Figure • ; keyword: keyboard, importance: 1; keyword: PC importance: 2 and in Figure• •keyword: cat, importance:3.

• Subjectiveness/objectiveness• objective keywords should be given for all object in the image and subjective ones are given to at least one word for the impression by the image. Each keyword is appended subjective/objective marker or one s coded to numerically.

5 Conclusion

In this paper, we considered and the criteria of metadata, especially keywords for image database and image retrieval. We emphasized importance of consistency and appropriateness. We examined the criteria by experimenting 10 testers and verified them. And we added a new measures, "Importance" to our criteria

When a lot of persons give keywords to images, such criteria are indispensable. In our future study, we will concerned and define the structure or the framework of metadata. Furthermore, We will integrate metadata type and feature type for pattern or texture.

In the future, we hope that multimedia retrieval with metadata will be much easier for all people. So the teachers will be able to utilize more accurate images in education, and the students will be able to easily retrieve images from Internet.

References

[1] Kazuhiko KUSHIMA et.al., "Content based Image Retrieval Techniques based on Image Features", Trans. IPS. Japan Vol.40 No.SIG3 (TOD1), pp.171-184 (1999).

[2] M.Flickner et.al., "Query by Image and Video Content: The QBIC System", IEEE Computer, Vol28 No.9pp.23-32 (1995).

[3] Haruo KIMOTO, "An Image Retrieval System Using Impressional Words and the Evaluation of the System", Trans. IPS. Japan Vol.40 No.3, pp.886-898 (1999).

[4] Shoji TANAKA et.al., "A Study Concerning Automatic Addition of Impression Keywords to Natural Images", Tech. Report of IEICE HIP96-20, pp.19-24 (1996).

[5] Yasushi KIYOKI et.al., "A Semantic Search Method and Its Learning Mechanism for Image Databases Based on a Mathematical Model of Meaning", Trans. IEICE Japan D-• Vol.J79-D-• No.4, pp.509-519 (1996).

[6] MPEG Web Page: http://drogo.cselt/it/mpeg (accessed on July 1, 2000).

[7] Toru FUKUMOTO, "The Keyword Attachment Reference for the Integration of Image Retrieval", Conference Proceedings of the 1999 Conference of Japan Society for Educational Technology, pp.169-170 (1999).

[8] Hiroaki OOBA et.al., "Image Retrieval by Natural Language", JSAI SIG-HICGT-9202-4, pp.25-34 (1992).

Figure• • an example of image

Figure • • image with one object

Figure• • image with many objects

Figure• • Texture

The Development and Evaluation of a Learning Support System for Converting Web Pages

KOYAMA Yasuhiro*, YOKOYAMA Setsuo, AKAHORI Kanji***
**Graduate School of Decision Sciences and Technology, Dept. of Human System Science, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo,*
TEL: 03-5734-3233
yasu@ak.cradle.titech.ac.jp akahori@ak.cradle.titech.ac.jp
***Information Processing Center, Tokyo Gakugei University*
yokoyama@cs.u-gakugei.ac.jp

In recent years, the use of the Internet for school projects has become popular, even in the primary level. One of the difficulties in the use of the Internet is the arrangement and integration of Web materials to meet the learner's goals. This paper presents a tool that will help meet this challenge. It will also describe how the tool was developed and what are the results of its evaluation. The features of this tool are the following: 1) learner can easily gather Web pages as thumbnail of a screen image; 2) learner can make a list of thumbnails; 3) thumbnails can be sorted, with comments added; 4) arranged thumbnails can be displayed by HTML. Further, the learner can make a presentation using thumbnails. The authors later conducted an experiment to verify the effectiveness of this tool in arranging Web pages. The developed thumbnail tool and the browser's bookmark tool were compared. The results showed that our developed tool was more effective than the bookmark tool, especially in following areas: (1) more recognizable contents of Web pages (2) easier operation, and (3) more user-friendly for students.

Keyword: **WWW, Exploring Projects, Screen Image, Thumbnail, Bookmark**

1 Introduction

In recent years, the use of the Internet for school projects has become popular, even in the primary level. In Japan, Ministry of Education will implement the integration of technology in K-12 starting 2002. Thus, students will need to have the skills needed when using the Internet for various school subjects. For project-based learning using the Internet, the popular tool for surfing and gathering online data will be the search engine. It enables the easy gathering of various online data. But not all online data is reliable and accurate. Also, if not updated, the data or information in web pages can become obsolete. So learners need a tool that will help collect, select, organize and integrate the web pages that meet their learning needs.

Currently, the tool that is available to learners is the bookmark tool. It enables users to save Web pages with its title. It also makes it easy to access the web site's URL. But the bookmark tool leaves much to be desired in terms of the organization and integration of online data. Because data gathering using search engines is a vast task, there is an immediate need for easy browsing. The bookmark tool is a tree-structured file system, which is not quite adequate for quick and easy browsing. Moreover, it is hard for learners to appreciate the significance of Web pages when they appear only as text names when bookmarked.

In addition to doing research projects, learners also engage in making presentations of their projects using the Internet. To help learners in this activity, the authors proposed a tool that will provide students an easy way of making a file for their presentation. So, the authors developed and evaluated a learning support system which will enable learners to arrange and integrate Web more effectively.

2 Conceptual Framework for Tool Development

To reduce the load on making our choice information , the following 2-part approach was taken:

(1) The centralized of system approach. In advance searches, the tool will automatically narrow down the search to the closest level possible (filtering approach). This means the goal is an intelligent tool that can select information and improve the precision of narrowing down the search.

(2) The centralized of human approach. By adding available information as hint, in order to reduce extraneous information. This a support to the select available information.

The overall goal of this 2-part approach is to enable an easy narrowing down of a search.

When gathering web pages for a school project using the Internet, the tool that was developed by the authors enables the capturing of web pages and viewing them as thumbnail images. The authors believe that thumbnail images are more effective in providing visual cues of the content of Web pages. And, by displaying thumbnails, learners can arrange Web pages holistically, that is, they can visualize the whole composition. The authors made the hypothesis that more visual information as that provided by thumbnail images will be more effective when arranging Web pages for a project or presentation.

For presentations, the popular tool is Microsoft PowerPoint. Compared to OHP presentations, the use of motion pictures and animation makes a presentation more dynamic. But for children who are beginning computer users, the use of such tools may not be easy or may require more technology resources than what is available. But, by converting web pages directly to a HTML coding for presentation, the learning curve will be lower. So the authors proposed to add the function of being able to integrate selected web pages into a HTML coding for presentation in the development of their new tool.

3 The development of the new tool

3.1 Overview of the new tool

The developed new tool enables users to arrange Web pages using thumbnail images (**Figure1**). The functions of the developed tool are: listing thumbnails, sorting, and scrolling. The added function of a memo or comment line is to enable the users to add new information or data. The developed tool will then automatically generate the HTML coding for presentations. Through the use of HTML, learner can easily make a presentation (**Figure4**). **Figure2** shows the system configuration. The procedure for the use of the developed tool is as follows:

1) Learner displays Web pages or self-produced HTML pages using Web browser.
2) Screen image of Web pages and page title are saved to a database.
3) Lists of thumbnail from the database are displayed. Learner arranges web pages on the display, and add own comments to thumbnail.
4) Finally, using the arranged materials, learner makes a simple presentation

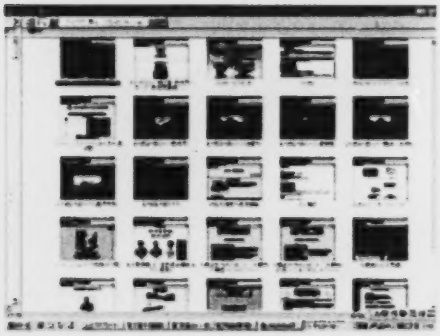


Figure1: A page showing the list of thumbnail images 1

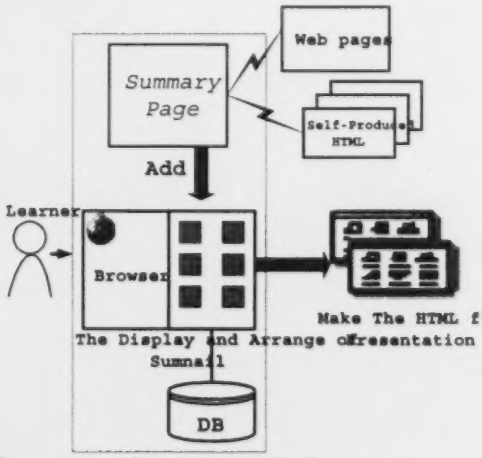


Figure2: System Configuration

3.2 The type of display Web page

In displaying the collected Web pages, the following 3 modes were used,
[1] Converting to thumbnail screen images
[2] Manipulating the original Web pages
[3] Making a presentation
The following sections explain further these 3 types.

3.2.1 Converting to thumbnail screen images

When selecting Web pages to put together, the user clicks a button to add a Web page. The web page is then converted to a thumbnail screen image (**Figure3**). Thumbnail screen images are Bitmap file made of large volume of data, so this Bitmap file is converted to a JPEG file. After that, the thumbnail is saved to the database.

3.2.2 Manipulating the original Web pages

By double clicking the thumbnail screen image, the learner can access the original Web page. It is just conceivable that learner will want to arrange the thumbnail web pages, and at the same time, have access to the original web pages. **Figure3** shows how the original web page and the lists of thumbnails are displayed at once. To change the display size, the learners can move from side to side, the display size control button located at the center of the display.

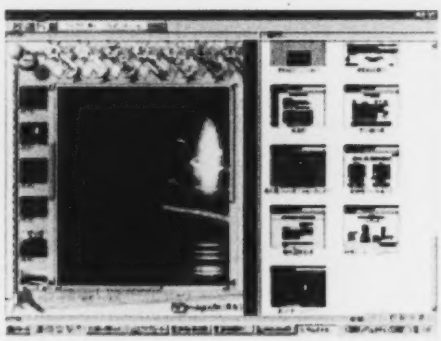


Figure3: A page showing the list of thumbnail 2

3.2.3 Making a presentation

Figure4 is the display of HTML for presentation. Arranged thumbnails are displayed in a sorted order. Learners can make a presentation using the display. Each Web page is composed of a link to the thumbnail, a link to the URL, and an area for comments or memo. The purpose here is to provide a function that will enable the easy arranging and integrating of Web pages for a presentation.

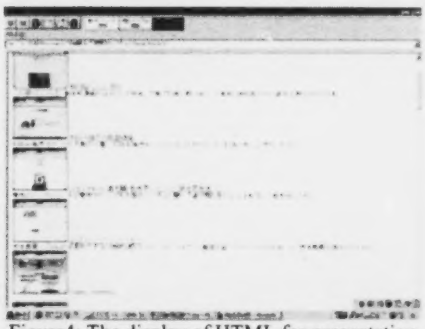


Figure4: The display of HTML for presentation

4 Evaluation of the tool

4.1 Purpose

The object of this evaluation is to verify the usability of the tool developed by the authors. Particularly, it will study the thumbnail screen images' usability for arranging Web pages. The subjects are the tool group using the developed tool and the bookmark group using only the regular bookmark tool. The groups were given the task to arrange Web pages about a specific theme. To collect data, the following were done:

(1) conduct a questionnaire survey. Subjects evaluated the operationality of the tool and were asked to give written comments of their experience of using the tool.

(2) In terms of arranging web pages, users compared the tool with the bookmark tool, and the analyses of the following data items were done.

1. work time
2. total number of times a URL is accessed
3. number of times a URL is re-accessed (the same Web page is accessed more than 2 times)
4. number of times thumbnails are sorted
5. number of times thumbnails are deleted

4.2 Method

The subjects arranged Web pages based on a theme using the developed tool and the bookmark tool. Thirty (30) Web pages were prepared in advance by the experimenter. To get a history of how they operated the tools (history of operation), a video record of how the subjects used the tool was made from a TV converter to a VHS video tape. After the experiment, the subjects answered the questionnaire. The experiment had the following stages

1. The use of the developed tool and the bookmark tool was explained to the subjects;.
2. The content of the task (theme of project) was explained to the subjects
   Theme A: the sights of Tokyo that you want to introduce to friends
   Theme B: the sights of Osaka that you want to introduce to friends
3. To eliminate order of effect, the subjects were divided into 4 groups (Table 1).

	Former	Latter
1Group	Theme A Using the tool	Theme B Using bookmark
2Group	Theme B Using the tool	Theme A Using bookmark
3Group	Theme A Using bookmark	Theme B Using the tool
4Group	Theme B Using bookmark	Theme A Using the tool

Table1: Subject groupings in the experiment

4.3 Results

To compared the developed tool and bookmark tool, questionnaire data was analyzed for significance using the t-test The results are given in **Table2**.

	Average	Result
Thumbnail screen image is more recognizable	4.17	**
The lists of thumbnail are more recognizable	4.17	**
Useful for arranging web pages	3.83	*
Recognizes the contents of a web page	4.33	**
Useful for school projects that use the Internet	4.67	**
Useful for making a presentation	4.42	**

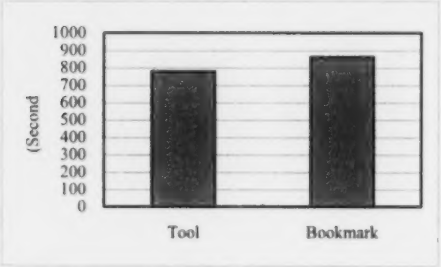
*p<.05,**p<.01 t-test (two-tail test) the average(max5)

Table2: The results of the questionnaire

T-test results show that web page titles with thumbnails are more recognizable than text-only web page title. And as to browsability, the lists of thumbnail are more recognizable than the tree structure of the bookmark tool. Inquiry as to "useful for arrangement" was significant at the 0.05 level. But as to the ability of operation in the questionnaire, couldn't get level of significance. Because the interface of sorting the thumbnails will not be enough to good for learner.

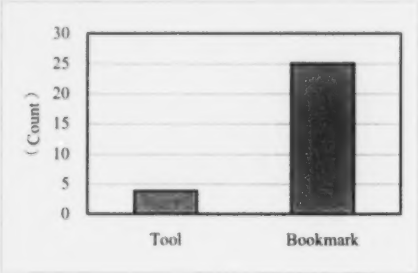
In the analyses of the history of operation (reference 4.4 (2)), the record shows that the thumbnail screen image is useful to learner when arranging web pages. The results are indicated in **Figure6-10**. From the results, the following items were verified:

* For shorter work time, the developed tool is comparatively more efficient than the bookmark tool (Figure6).
* By using the thumbnail screen image, the learner is able to better recognize the contents of the web page (Figure7,8).
* Lerner is comparatively able to estimate whether to use web pages or not (Figure10).



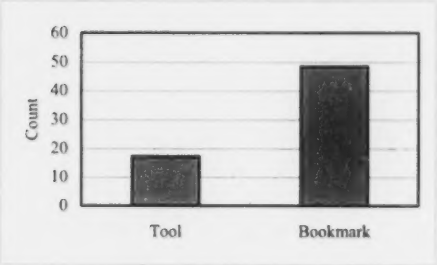
+p<.1

Figure6: Comparing the average of work time



**p<.01

Figure8: Comparing the average number of times of re-accessing URL



**p<.01

Figure7: Comparing the average of the total number of times of accessing URL

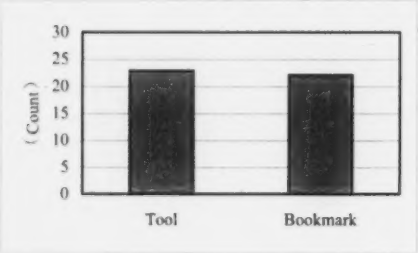
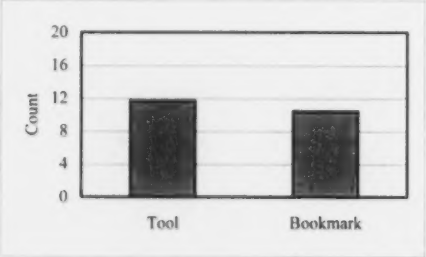


Figure9: Comparing the average number of times of sorting thumbnails



+p<.1

Figure10: Comparing the average number of times of deleting thumbnails

4.4 Analysis

The results of the evaluation procedures show that

1) based on the questionnaire, there were good results as to the functionality of the thumbnail screen images. And from the subjects' comments, "the lists of thumbnail is useful", "helps better recognize contents of the web page", and "the arrangement of web pages using the tool is convenient and useful".
2) based on the results of history of operation, work time, in terms of the number of times of accessing and re-accessing the URL and the number of times of deleting thumbnails, got good results in the given level of significance.

In terms of browsability, providing the user with a list of thumbnail is more useful than the bookmark tool. Accordingly, for arranging web pages, the list of thumbnail was better for integrating the collected data and for reviewing them. For arranging web pages, the results of the history of operation show that the developed tool is more useful than the bookmark tool.

5 Conclusions

In this research, a tool for learning to support the arrangement and integration of web pages was developed and evaluated. The results of the study can be summarized as follows:

1. Development of the learning supporting tool
   This research addressed the problem of selecting information for research projects using the Internet [1.Introduction], and examined how to resolve the problem by developing a tool that is both effective and user-friendly. The research also considered the interface of the tool and provided a conceptual framework [2.Conceptual Framework for Tool Development] in its development.
2. The evaluation of subjects about ease of operation and usefulness of the tool
   In the experiment phase of the paper [4.The evaluation of tool], a questionnaire was used to measure the as to ease of operation and usefulness of the tool., and got good results.
3. Verifying the efficiency of the tool for manipulating web pages
   When it comes to accessing and re-accessing URLs, the tool was more useful than the bookmark tool. For arranging web pages, the availability of a list of thumbnail images made it easier to integrate the selected web pages and to review them.

5.1 Future Studies

For future studies, the following are recommended:

1) Modification of the tool and adding more functions
2) A detailed analysis of the operation history

Acknowledgement

The authors would like to thank Dr. R. Santiago for her great assistance.

References

[1] Akai, K. and Koike, H., "Experimental Studies on Visual Search of Image Files" (in Japanese), The Special Interest Group Notes,: Information Processing Society of Japan(IPSJ), Vol.98, No.35, 98-H1-78, pp.27-32(1998)

[2] Ueda, M., "Development of a system of learning support using the Internet" (in Japanese),: Japan Society for Educational Technology(JET), 99-4, pp.9-16(1999)

[3] Mizobuchi, S. and Furuyama, T., "An analysis on the effect of indexes on WWW information selection process" (in Japanese), The Special Interest Group Notes of IPSJ,: Information Processing Society of Japan(IPSJ), Vol.98, No.116, 98-H1-81, pp.31-36(1998)

The Estimation of Music Genres Using Neural Network and Its Educational Use

Yasuhiko TSUJI*, Kanji AKAHORI*, Atsuhiro NISHIKATA*
Graduate School of Decision Science and Technology, Tokyo Institute of Technology
2-12-1, O-okayama, Meguro-ku, Tokyo, 152-8552, Japan
Tel: +81-3-5734-2991
Fax: +81-3-5734-2991
E-mail:tsuji@ns.cradle.titech.ac.jp,
akahori@cradle.titech.ac.jp,
nisikata@cradle.titech.ac.jp

To develop a learning support system of music genre, a neural-network-based system was developed that can estimate the genre of music from partial information of a standard MIDI file of music. Standard MIDI files of 120 music titles has been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal after the Neural network of the system had been trained. Comparison shows that, the system developed, has a higher judgment rate than that of subjects. Next, the weight of the links were examined by an expert, 5 of the nodes in the Hidden Layer could be extracted.

Keywords: **Music Education, Neural Network, Intellectual Learning Support, MIDI**

1 Backgrounds and Objectives

Recently, popular music, for example *Beatles* etc, is included in recent music textbooks of Elementary, Junior High and High Schools in Japan. So, it is thought that music education using popular music will increase more and more in course of time. When students learn popular music, music genre of the music is an important factor[1]. In order to learn the musical feature of each genre, it is thought to be very effective. Systematic genres studying of popular music, in which students seems to be interested, is thought to be a way of the students' music experience enrichment.

An "Automatic Composition MAGIC (Music system for Arrangement and Intelligent Composition) Considering Music Style" was developed [2] by Minamikata in 1989 is one of the researches in the research field that treats plural genres of popular music. This System supports composition and adaptation using heuristic rules divided by music taste of genre. It is said that rule-based system like this is effective when the system reproduces a already-known music taste or rule for the system, but there is an anxiety that generated music is conventional, and it is a problem for an unknown taste.

It can be said that the genre of popular music is the combination of different music. Now, many researches have done the grouping of music. Concerning Neural Network-based research, the research of Sakamoto (1999) grouped the music according to the sensibility information by using SD method [3]. If consider the flexibility and generality grouping by neural network differs from that of grouping by rules or multiple different analysis. So, it is said that moderate result can be expected for any unknown input by the process of grouping by Neural Network.

Based on the above research, we aim to develop the learning support system which can provide feedback on "Feature as the genre" of an unknown music with the Neural Network training of the music of various genres. Based on the above-mentioned background, we conducted this research in the following way. At the beginning, reserve experiment was done by an expert of popular music to confirm the factor for the estimation of the genre. Based on the obtained finding, we trained the Neural Network. Here the Neural Network was composed using the partial information as input signal and genre of the music as output or

teaching signal. In order to use this system for education purpose in the future, the meaning interpretation for each factor of the Hidden Layer of the trained Neural Network was identified by an expert of popular music. Then, the genre estimation experiment was done using the subjects who seemed to have general experience of popular music. Lastly, the estimated average result of the subjects and the estimated result of this system was compared to show the effectiveness of this system.

2 Estimation of Music Genres by Expert

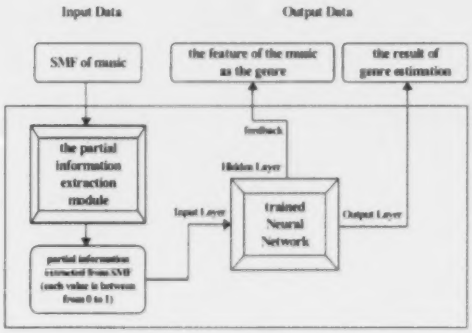
When music and genre are trained to the Neural Network, the problem is that we should take data to make an input signal from a long standard MIDI file. Therefore, we examine the mounting method of this system by knowing how the person judges the genre. For that, in the preliminary experiment we ask the expert about the factor of the genre estimation. The subjects had different musical instrument performance experience for ten years or more. The procedure was that they were made to listen ten in total of five genres. Also the factor to estimate the genre was interviewed. As a result, the following factors were found.

(1) The factor to estimate the genre is various according to the genre, and it's vague information.
(2) The factor to estimate the genre is local & partial information.

From (1), at first we got to the hypothesis that the estimation of music genre based on rules is very difficult and not proper. Under the above hypothesis, we propose to use Neural Network to deal with vague information in this research. As the input from (2), we judged that it was appropriate to extract partial information that seemed to be necessary for estimating the genre of music, and to assume it to be an input value of the Neural Network. The standard MIDI file (Hereafter, it is abbreviated as SMF) that is already a descriptive language was used as music.

3 Genre Estimation System

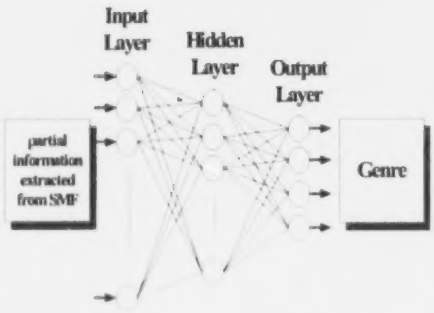
Figure.1 shows the composition of the genre estimation system. The flow of this system is as follows. When the user inputs SMF of music, the partial information extraction module extracts some partial information from the music. Then, it is put to the Input Layer of the Neural Network that has already been trained for music and the genre. The Neural Network feeds back the result of estimating the genre obtained from the Output Layer. Moreover, the feature of the music as the genre obtained from the Hidden Layer is planned to use as feedback in the future. If the module is developed, the user will be able to learn the genre.



3.1 Extraction of Partial Information from SMF

SMF of the General Midi correspondence was used in this research. SMF includes various musical information such as Note-On (time of starting to ring each music sheet), Note-Off (time of finishing to ring each music sheet), Velocity (the strength of each attack), Note Number (pitch), and Program Number (kinds of musical instruments and tones) etc. The following three information of these score information were decided to use in the partial information extraction module.

1. Kind and tone of musical instruments extracted from Program Number (henceforth, we call it "Musical Instruments and Tones", which is expressed by an array of 128 Boolean type variable. Each valuable shows whether musical instruments (tones) of Program Number 1-128, were used in that music or not.).



Distribution of Rhythm extracted from the statistics of position of Note-On per a bar (henceforth, we call it "Distribution of Rhythm", which is expressed by an array of 16 integer type variable. Each variable shows the frequency for which Note-On event is held at the rhythm in one bar in the SMF.).

Distribution of Pitch extracted from the note number (henceforth, we call it "Distribution of Pitch", which is expressed by an array of 12 integer type variable. Each variable shows the frequency for which each pitch of 12 music scales is used in the entire music of SMF.).

3.2 Composition of Neural Network

Figure 2 shows the composition of the Neural Network. We adopted the Back-Propagation algorithm as the learning algorithm of the Neural Network. For the input signal, we used a combination of the values.

4 Outline of Genre Estimation Experiment using this system

4.1 Method

By the above-mentioned methods, the genre estimation experiment by this system was performed. 120 music titles of SMF which are composed of 30 titles each in Japanese popular ballad, Jazz, Hard Rock, and Heavy Metal, tried to be learned by the Neural Network. In this research, the combination of the following partial information was learned as an input data.

Musical instrument and tone	128bit
Distribution of rhythm	16bit
Distribution of pitch	12bit
Musical instrument and tone, Distribution of rhythm (+)	128+16=144bit
Distribution of rhythm, Distribution of pitch (+)	16+12=28bit
Musical instrument and tone, Distribution of pitch (+)	128+12=140bit
Musical instrument and tone, Distribution of rhythm, Distribution of pitch (+ +)	128+16+12=156bit

The number of units of Hidden Layer in each Neural Network is assumed to 10-30. The number of units of Output Layer is as many as the number of genres that the Neural Network learns. In this case, it requires four units in Output Layer, because there are four genres.

4.2 Result

The result of training is shown in Table 1. In the Table 1, "NN" means Neural Network, and - in NN means the Neural Network whose input information is described above. The result of training, NN was converged about 650 learning times, and

NN	Input Layer	Hidden Layer	Output Layer	Judgment Rate	Judgment Percentage	Learning Time
	128	20	4	119/120	99.2	X
	16	10	4	97/120	80.1	X
	12	10	4	103/120	85.8	X
	144	30	4	120/120	100	About 650
	28	30	4	111/120	92.5	X
	140	30	4	119/120	99.2	X
	156	30	4	120/120	100	About 1100

NN was about 1100 learning times, but other NN were not converged within ten thousand learning times. So, the trained Neural Network was able to judge the genre of learned music at 100%.

From this, it is suggested that the Neural Network like - that has single partial information in Input Layer can't finish learning, But the combination of those partial information make it enable to learn. This result supports the findings of experts at the preliminary experiment in Chapter 2 whose also says that the factor to estimate the genre is various according to the genre.

4.3 An Analysis of Hidden Layer

The Hidden Layer in the Neural Network is analyzed here. There is a heuristic method that each cell's tendency in which it is likely to make active or inactive is found by an expert, and then the meaning of factor is obtained[4],[5]. We used that method here.We focused on the weight of the link between Hidden Layer and Output that is above 10. Each unit from No.1 to 5 are activated by following genres.

Unit No.1: Hard Rock
Unit No.2: Hard Rock, Jazz
Unit No.3: Hard Rock, Jazz, Japanese Popular Ballad
Unit No.4: Heavy Metal
Unit No.5: Japanese Popular Ballad

Table 2. Analysis of Each Factor in Hidden Layer

Unit	Name of Factor
1	Hard Tone Factor
2	Synthesizer Tone Factor
3	Jazz-Acoustic Factor
4	Rhythm Tendency Factor
5	Combination Factor of Electric Instruments and Rhythm Tendency

Finally, each unit was named by a music expert. The summarized result is shown in Table 2.

5 Experiment by Subject

To investigate at how much rate can the subjects, twenty-five female university students were asked to listen to eight music titles of 4 genres of SMF with MIDI sound randomly, and to judge the genre and the factor for each music.The judgment rate of all the subjects was 66.5%.

To compare the judgment of subjects with this system, Neural Network was trained with 119 titles, and was made to estimate the genre of subtracted one as unknown music.

As a result, both Neural Network and have a judgment rate of 100% for eight unknown music titles. From this, the judgment of this system is higher than that of subjects with general experience of popular music.

6 Summary of Results

In this research, development and evaluation of genre estimation system ware performed aiming for the development of learning support system of music genre. The results are summarized as follows:

(1) The preliminary experiment for experts with an experienced popular music was performed, and a result that says that the factor to estimate the genre tends to be local & partial information was obtained.

(2) From this finding, genre estimation system using Neural Network was developed.

(3) 120 music titles have been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal at the rate of 100% by training the Neural Network to identify these 4 genres.

(4) The judgment rate was 66.5% as the result of the estimation experiment for subjects with general experience of popular music.

(5) This system was made to estimate 8 music titles, as an unknown music, out of 120 which were used in the genre estimation experiment by subjects. As a result, the estimation rate of 100% which is higher than that of the subjects (66.5%) was obtained.

(6) Each unit of Hidden Layer in trained Neural Network was enable to be named, and the factors of each unit were able to be extracted by the expert of popular music.

From this finding of 6, providing feedback on the features of the music from Hidden Layer becomes possible by the way of observing the result of meaning explanation of Hidden Layer in which the Neural Network has the feature of the music as a genre, observing the state of fire, and observing the input units which have tendency to make active to the fired units in the Hidden Layer.

From the result described above, the possibility of the development of a learning support system using this system for music genre is shown. And, it was thought that the trained Neural Network of this system has the application possibility not only to the learning support system but also to the supporting composition and adaptation.

Acknowledgement

The authors would like to thank Mr. UZZAMAN MD. ANIS and Assistant. Taizan SUZUKI for their cooperation.

References

[1]Hiroshi UEDA, Kazumi AKAIWA etc.: Hajimeteno ongakutsuu:50 genres 500 CDs, Ongakunotomosha,1993

[2]Junichi MINAMITAKA, Mayumi INO, Kunio SATO, Shigenori MORIKAWA: Automatic Composition MAGIC Considering Music Style, Collected lecture papers of the 39-th National Convention of Information Processing Society of Japan, No.3, pp.2242-2243,1989

[3]Takashi SAKAMOTO, Yoshinobu KAJIKAWA, Yasuo NOMURA: Classification of Group According to Tune's Impression Using Nonlinear Distinction Analysis in the Music Sensibility Space, Transactions of Information Processing Society of Japan, Vol.40, No.4, 1999

[4]Hisayoshi ITO, Hiroki ITO, Kanji AKAHORI: An Analysis for the Neural Network Supporting Users' selection of Menu Items,IEICE technical report, (Educational Technology) ,Vol.96, No.500, pp.53-60, 1997

[5]Michio MATSUBARA: Evaluation of Global Processing of Students in Electric Circuit, Transactions of Society Japan Science Teaching, Vol.39, No.1, 1998

The Rhetoric of the web—A semiotic approach to the design and analysis of web-documents

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper seeks to discuss possible approaches through which semiotics and rhetoric can be applied to the World Wide Web seen as a multimedia; or, in other words, possible approaches through which Web-sites and Web-pages can be studied and designed from a semiotic point of view-The aim of the paper is thus to outline a coherent theoretical, methodological and analytical framework for the study and design of Web-documents based on semiotics and rhetoric. This paper has analytical, theoretical, methodological, as well as practical implications. It is of interest in relation to the analytical and theoretical understanding of the new and rapidly growing web medium, and in relation to methods of examining this phenomenon. The study shows the concepts and categories from the field of semiotics and rhetoric are highly relevant to the area of the web and it indicates that the concepts presented here can form the building blocks for a more general 'Semiotics of Cyberspace'. The observations from this study may also have an effect on conventional theory formation and understanding within semiotics, rhetoric, and communication research and media studies. However, it also has implications for the construction and design aspects since the design of Web-documents and Web-sites must be based on actual knowledge of the conditions and possibilities for communication and the construction of signs, codes and meaning in the new medium.

*The paper was not available by the date of printing.

Visual Presentation Format and Knowledge Discrepancy in Scientific Learning

Lih-Juan and ChanLin
Department of Library and Information Science, Fu-Jen Catholic University , Taiwan
510 Chung-Chen Road, Hsien-Chuang, 24205, Taiwan
Tel: +886-2-29031111-3226
Fax: +886-2-29017405
E-mail:lins1005@mails.fju.edu.tw

The effect of presentation formats and the students' prior knowledge on learning a computer-based physics lesson was investigated. Three hundred and fifty seven eighth-grade (novice learners) and ninth-grade (experienced learners) were randomly assigned to different treatments on a class basis. Having worked through the computer lesson, they were given a post-test to assess overall learning performance. A 2 (novice/experienced) X 3 (animation/still graphics/text) ANCOVA (controlling by covariants, physics and mathematics scores) was used to determine the effect of these two variables. It was found that in descriptive learning, the effect of knowledge discrepancy was significant ($p<0.000$); the effect of presentation format was insignificant ($p>0.05$); and the interaction between presentation format and knowledge discrepancy was significant ($p<0.05$). In procedural learning, the effect of knowledge discrepancy was significant ($p<0.000$); the effect of presentation format is significant ($p<0.05$); and the interaction between presentation format and knowledge discrepancy was also significant ($p<0.005$).

Keywords: **Computer Graphics, Animation, Prior Knowledge, Scientific Learning**

1 Introduction

The computer-based technology for implementing an interactive multimedia-learning environment currently exists. However, in spite of these advances in educational technology, the field of educational application still requires the development of a corresponding research-based theory for the design of computer-based instruction using words and graphical materials [1]. Along with recent innovations in computer graphics and animation, the use of various visual strategies has drawn significant attention. There has been research on the effects of different modes of presentation for conveying visual information [2] [3]. However, there is limited evidence of research that directly links instructional strategies to individual differences in preferred learning mode [1]. In evaluating the effects of visual presentation, several issues have been considered. It was assumed that not all people learn in a similar way, and in fact, the effect of the presentation formats (still graphics or animation) in facilitating learning might only apply for certain individuals. The present paper considers learning from different presentation formats within the context of different prior knowledge level of individuals. The design of computer graphics or the use of animation should take into consideration the knowledge discrepancy among learners as they process visual information.

1.1 Graphics and Animation

The use of computer graphics is relatively new in education. However, there has been much research evidence supporting the contention that student learning is affected positively by presenting text with graphics [4] [5]. Furthermore, computer animation offers potential power for presenting visual information to enhance learning [1] [6] [7] [8]. Although there has been widespread belief that animation is superior to

still graphics, in fact, studies reveal inconsistent findings. In various experimental studies that investigated animation in the context of computer-based instruction, some showed significant effects for the animation [9] [10]; whereas some showed no significant difference [11] [12].

Animation provides viewers with two different visual attributes: images and motion [8]. For scientific learning, images and motion are both essential elements for understanding and memorization. Mayer and Sims differentiate the functions of animation in describing textual materials and in helping students construct problem-solving procedures [5]. The motion provided by animation serves several different instructional purposes. In learning descriptive scientific concepts, animation can be used as mnemonic devices to facilitate memorization of principles and rules. However, in learning scientific procedural concepts, the spatial and procedural elements in animation play an important role in deciphering information [13].

In their study of the effects of animation used with different instructional texts, Large, Beheshti, Breuleux, and Renaud found that animation enhanced procedural texts but had no significant effect on descriptive texts [14]. ChanLin observed that instruction with animation was not equally effective for learning descriptive and procedural information [15]. Thus, to design animation effectively, it is important to consider the instructional attributes of the learning materials.

1.2 Prior Knowledge

One important characteristic of learners is their prior knowledge as related to the specific domain of the lesson. Constructivist learning occurs when the learner engages in each of these cognitive processes – selecting relevant images and verbal information, organizing them into respective visual and verbal mental models, and integrating them with each other and with existing knowledge [16]. The difference in cognitive processing depends on the amount of domain-specific knowledge students possess. Discrepancy in prior knowledge might influence the way given visual information is processed, and the degree to which related concepts and information are triggered and connected [5].

The use of animation in computer-assisted learning materials might have greater impact on students with specific prior knowledge than it has on those with higher or lower knowledge levels. Some researchers have identified knowledge discrepancy among learners as influencing effectiveness of visual presentation, although inconsistent findings exist among various studies. Mayer & Anderson found that inexperienced students were better able to transfer what they had learned from a procedural text about a scientific system when visual and verbal explanations were presented simultaneously [3]. Blissett & Atkin reported that individuals with less prior knowledge or lower-ability learners tended to find the learning demands confusing when animation was used [17]. Reid & Beridge found that the use of graphic information caused reading difficulties for less able students [18]. In these studies, the lower-ability students spent more time deciphering the pictorial and textual information. Students with less prior knowledge might devote a large amount of cognitive effort to building a visual representation of given concepts, whereas for high ability students building a visual representation that is based on the animation might be relatively easy [5]. Further study is required before any firm conclusion can be drawn.

1.3 Research Purpose

The purpose of this study was to investigate the effect of presentation formats in facilitating student achievement of different educational objectives. Specifically, the study attempted to determine:

(a) the effect of presentation formats (animation, still graphics, text) and students' prior knowledge (novice, experienced) on learning descriptive and procedural concepts,
(b) whether a specific presentation format (animation or graphics) would be effective for learners with different prior knowledge levels (novice, experienced), and
(c) whether the use of different visual presentation strategies would promote learning of different contents (descriptive, procedural knowledge)

2 Method

2.1 Subjects and Materials

The study consisted of nine classes from eighth-grade and ninth-grade students. A total of three hundred and

fifty seven students participated in this study. The ninth-grade students had more learning experience in mathematics and physics than the eighth-grade students because related geometrical concepts had already been provided in the ninth-grade curriculum. Therefore, the ninth-grade and eighth-grade students were classified as experienced and novice learners, respectively, due to the discrepancy in related prior knowledge and experiences used for application in the problem-solving activities.

During the learning time, students were assigned to treatments on a class basis, and learning their own instructional material independently. The material used for teaching physics was a computer-based learning program, covering lever problems, direction of force, resultant force, composition of forces, component forces, and equilibrium of force. Students learned the instructional materials individually. With an emphasis on using meaningful representations to encourage thinking, the lesson was designed with various scenarios for interaction. Several physics problems were embedded in the scenarios, with adventures for students actively involved in finding the solutions.

Basically, two major knowledge areas were covered: descriptive (knowing what) (Figure 1) and procedural knowledge (knowing how)(Figure2). Descriptive knowledge was referred to a recital of facts or the description of objects or events. In learning and application of the scientific concept, it was essential to provide the basic to-be-remembered information. For example, memorizing the definition of "Resultant" and "Force Vector" provided in the lesson was considered as a descriptive task. In order to enhance memorization of rules and facts, graphics and animation were used in treatment groups to provide memory cues to facilitate semantic connections in learning the scientific concepts (Figure 1). Different from descriptive knowledge, the procedural knowledge was referred to learning and construction of the problem solving steps or procedures involved in physics concepts. To perform a procedural task, learners needed to relate the rules and facts to formulate a sequence of problem solving steps. For example, given two force vectors acting on an object at an angle, students needed to formulate problem-solving procedures to determine one unknown force vector obtained from the resultant and a known force vector. To facilitate construction of procedural knowledge, graphics and animation were used in treatment groups to help students construct a conceptual model in solving the problem (Figure 2).

"Force Vector" is referred to the amount of force with a direction. When two forces acting on an object, then a single force vector forms, which is called "Resultant". One resultant can be formed from many different pairs of force vectors. Thus is you make a parallelogram out of it, you could say that the resultant is equivalent to the diagonal and the force vectors become the sides

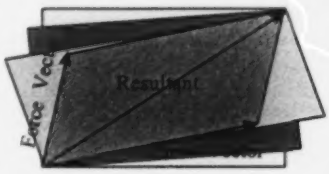


Figure 1. Examples of use of graphics for descriptive content

When a cart weighing 20 kg is pushed upward along a slanted surface with an angle of 37° from horizontal. How much force (Fw) is needed to move the cart upward? (Suppose the abrasion from the slanted surface is 0)

Rule 1: When the neighbor sides of a parallelogram are perpendicular to each other, the parallelogram is a rectangular

Rule 2: When the angles of a triangle are 37°, 53°, 90°, then, the sides against those angles will be 3:4:5.

Solution:

Step 1: The resultant F (20kg) can be formed by the following force vectors:
Fa is paralleled downward to the slant surface
Fb is perpendicular to the slant surface.

Step 2: F is 20kg, and the angle formed by Fa and the resultant F is 53° (90° – 37°) (According to Rule 1 and Step 1)

Step 3: Apply the Rule 2 to get Fa
Fa : Fb: F=3:4:5,
Fa = 3/5F=3/5 * 20=12 Kg

Step 4: If Fw is more than 12 kg, then you will be able to pull the cart upward

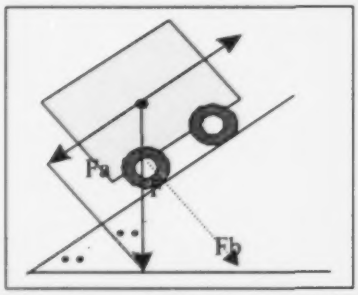


Figure 2. Example of using graphics for procedural content

BEST COPY AVAILABLE

2.2 Treatments

The lesson was designed in the following three versions:

(1) Treatment 1, Text (non-graphics group): In this version, only textual information was presented to explain scientific concepts. Students receiving this mode of instruction could interact only with the textual content. In a problem scenario, the verbal description was used to provide hints and the solution. Students needed to use their own abilities and related knowledge experiences to visualize the concepts in their mind according to the verbal description.

(2) Treatment 2, Still Graphics: In this version, static graphics with textual information was presented to explain scientific concepts. Students receiving this mode of instruction could interact with the textual content and the still graphics provided. Students could use the external graphic representation to help them visualize the concepts and construct the meaning for the textual materials.

(3) Treatment 3, Animation: In this version, the instructional materials contained textual instructions and animated graphics. Students receiving this mode of instruction could interact with the textual content and the animated graphics. Animation allowed students to comprehend the information through the graphic objects and motions provided by the visual stimuli.

2.3 Criterion Reference Test

After the computer-based learning, a criterion reference test was conducted to assess students' learning performance. The criterion reference test was created based on the content provided. It contained 25 testing items. Twelve of them were to assess students' learning of descriptive knowledge, for example, "What are the factors that might influence the direction of a force?" The other thirteen test items were to assess students' learning of procedural knowledge, for example, "If a bucket weighing 30 kg was pulled by two force vectors, one of which was 18kg, how much force is needed for the other force if the angle formed by these two force vector is 90° ". The Kuder-Richardson Reliability (KR21) for the criterion test items used in this study was 0.76

3 Results

Three hundred and fifty seven students participated in the study. Among the subjects, 183 were eighth-grade student (novice learners), and 174 were ninth-grade students (experienced learners). To determine the effect of presentation format and students' prior knowledge in descriptive and procedural learning, a 3 (Text/Graphics/Animation) X 2 (Novice/Experienced) ANCOVA was employed. Separate ANCOVAs were also used to test the effect of presentation formats on different knowledge level groups. Since in the Pearson correlation analysis, students' average physics, and mathematics scores were significantly correlated with post-test scores for both descriptive and procedural knowledge ($p<0.05$), these factors were used as covariates for controlling the initial differences among groups.

3.1 Descriptive Learning

For descriptive learning, the 2 X 3 ANCOVA indicated that the main effects were significant for prior knowledge level [$F(1,349) = 20.332$, $p = 0.000$], but insignificant for presentation format [$F(2, 349) = 2.034$, $p = 0.132$] (• •= 0.05 level). The interaction between the two variables was found significant [$F(2, 349) = 4.451$, $p = 0.012$] (Table 1).

Table 1 Effects of prior knowledge and presentation format (2 X 3 ANCOVA) for descriptive learning

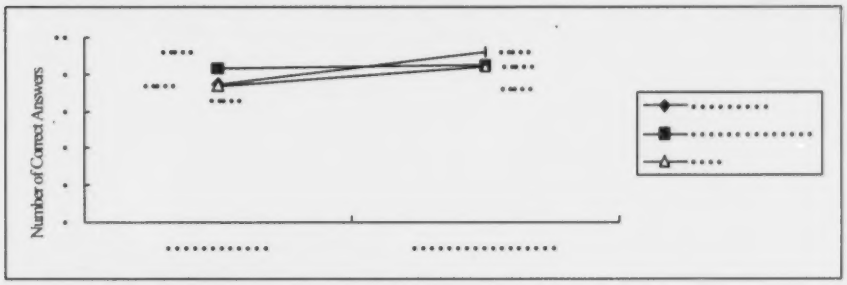
Descriptive Learning	
Effect of prior knowledge: F(1,349)=20.332• p=0.000*** Comparison of means: Experience (8.73); Novice (7.76) Experience > Novice, p=0.000***	Effect of presentation format: F(2,349) =2.034, p = 0.132 Comparison of means: Still Graphics (8.44); Animation (8.37); Text (7.93) Still Graphics > Animation: p>0.05 Still Graphics > Text: p>0.05 Animation > Text: p>0.05
Interaction: F(2,349)=4.451, p=0.012*	

*Significant level: 0.05; **Significant level: 0.01; *** Significant level: 0.001

Covariants: physics and mathematics scores

To test the treatment effect within different prior knowledge groups, separate analyses were conducted. An ANCOVA conducted for eighth grade students, who were novices in the content area, revealed a significant difference [$F(2,178) = 3.915$, $p = 0.022$] (• •= 0.05 level). Comparisons of adjusted means using LSD Test indicated that the still graphics group (n=44, M=8.364) performed better than either animation (n=48, M=7.502) or text group (n=91, M=7.412) ($p<0.05$). Another ANCOVA conducted for ninth grade students, who were experienced in the content area, revealed a marginal but not significant difference [$F(2,169) = 2.786$, $p = 0.065$]. Comparisons of adjusted means using LSD Test showed that students learning with animation (n=72, M=9.237) performed significantly better than the text group (n=32, M=8.448) ($p<0.05$), but did not differ from the still graphics group (n=70, M=8.514) ($p>0.05$). The difference between animation and still graphics was also insignificant ($p>0.05$) (Figure 3).

Figure 3. Interaction between treatment effect and knowledge discrepancy for descriptive learning



Comparison of adjusted means among different groups

3.2 Procedural Learning

For procedural learning, the 2 X 3 ANCOVA indicated that the main effects were significant for prior knowledge level [$F(1,349) = 13.381$, $p = 0.000$], and significant for presentation format [$F(2, 349) = 4.536$, $p = 0.011$] (• •= 0.05 level). The interaction between the two variables was also found significant [$F(2, 349) = 6.296$, $p = 0.002$] (Table 2).

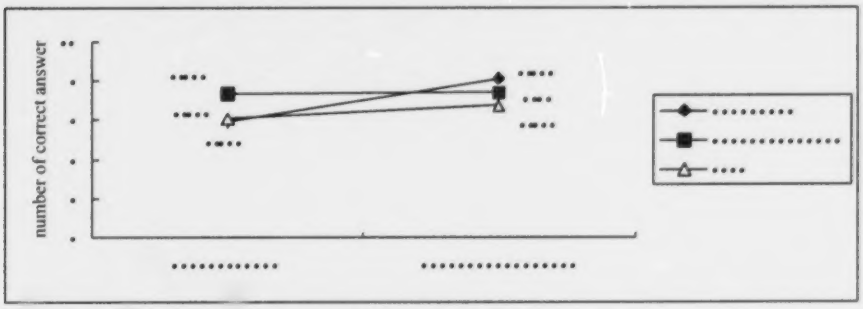
Table 2 Effects of prior knowledge and presentation format (2 X 3 ANCOVA) for procedural learning

Procedural Learning	
Effect of prior knowledge: F(1,349)=13.381• p=0.000*** Comparison of means: Experience (7.44); Novice (6.49) Experience > Novice, p=0.000***	Effect of presentation format: F(2,349) =4.536, p = 0.011* Comparison of means: Still Graphics (7.40); Animation (7.06); Text (6.44) Still Graphics > Animation: p>0.05 Still Graphics > Text: p<0.05* Animation > Text: p>0.05
Interaction: F(2,349)=6.296, p=0.002**	

*Significant level: 0.05; **Significant level: 0.01; *** Significant level: 0.001
Covariants: physics and mathematics scores

Among novice learners, the ANCOVA revealed a significant treatment effect [$F(2,178) = 4.462$, $p = 0.013$] (• •= 0.05 level) on procedural learning. Comparisons of adjusted means using LSD Test indicated that students in still graphics group (n=44, M=7.391) performed better than either the animation (n=48, M=5.977) or the text groups (n=91, M=6.105) ($p<0.05$). Among experienced learners, the ANCOVA revealed an insignificant difference [$F(2,169) = 1.980$, $p = 0.141$] (• •= 0.05 level). Comparisons of adjusted means using LSD Test showed that the animation group (n=72, M=8.146) was not significantly better when compared with either the still graphics (n=70, M=7.41) or text groups (n=32, M=6.766) ($p>0.05$). The difference between still graphics and text groups was also insignificant ($p>0.05$) (Figure 2).

Figure 2. Interaction between treatment effect and knowledge discrepancy for procedural learning



Comparison of adjusted mean among different groups

4 Discussion

In studying the effect of differing knowledge level and presentation format in learning computer-based materials, the following findings were obtained. The main effect of knowledge discrepancy was significant for both descriptive and procedural learning ($p<0.05$), indicating that the difference in knowledge levels influenced the performance of learning tasks. The main effect of presentation format was significant for procedural learning, but not for descriptive learning, indicating that presentation format (the use of animation, still graphic, and text) might influence different learning to different degree. Apparently, the use of presentation format can influence construction of procedural links, and thus has significant impact on solving procedural problems. In contrast to constructing problem-solving procedural learning, the effect of presentation format in descriptive learning for enhancing memorization of basic to-be-remembered information was not significant.

From the study, the significant interactions between presentation format and prior knowledge level in both descriptive and procedural learning revealed that the need of visual format differed when there was knowledge discrepancy among learners. The effect of treatment was significant ($p<0.05$) among novice learners in both descriptive and procedural learning implying that careful consideration in the use of presentation formats is more essential among novice students than experienced students. Novice learners possessing limited prior knowledge required the use of presentation strategies in assisting learning. With limited learning experiences, they performed better with still graphics in learning both descriptive and procedural content (compared with control group).

The follow-up comparisons among different presentation formats within each prior knowledge group revealed that animation was only better for experienced students in learning descriptive knowledge (compared with control group). Since experienced students had more learning experience in mathematics and physics than the novice students, they could relate geometrical concepts more automatically for performing the instructional tasks. The insignificant treatment effect might be explained by considering that domain-specific knowledge compensating for various presentation formats.

Similar to Blissett & Atkin's observation (1993), those with less prior knowledge or lower-ability learners tended to find the learning demands confusing when animation was used. It is postulated that novice learners might not be able to referentially process animated graphics and textual information for constructing semantic structure and problem-solving procedures simultaneously. Due to the limitations of their prior knowledge, they spent effort in deciphering visual information and adapting the presentation format. The element of motion in animation might require more extensive effort in constructing the connections between textual and graphical information in integrating knowledge. In this case, motion might not be suitable for students when the conceptual links among rules and concepts can be presented with sufficient clarity in a still-graphic form. In addition, the limited capacity of working memory in processing animation among novices might be worth noting.

5 Conclusions

In summary, this research points to the theoretical and practical benefits of the correct choice presentation format. The results of the study imply the need for considering the cognitive processes when using presentation formats. On the theoretical level, this study concludes that the use of presentation formats influences assimilation of scientific knowledge. On a practical level, this study raises the issue of differing mental processes among different learners. Animation should be used with some caution, and cognitive overload and spatial meta-cognition among novice students when performing the tasks is worth noting.

References

[1] McKay, E. "Exploring the effect of graphical metaphors on the performance of learning computer programming concepts in adult learners: a pilot study", Educational Psychology, Vol 19, No. 4, pp. 471-487, (1999)

[2] Large, A., Beheshti, J., Breuleux, A., & Renaud, A., "The effect of animation in enhancing descriptive and procedural texts in a multimedia learning environment", Journal of the American Society for Information Science, Vol 47, No. 6, pp. 437-448, (1996).

[3] Mayer, R. E. & Anderson, R. B., "The instructive animation: Helping students build connections between words and pictures in multimedia learning", Journal of Psychology, Vol 84, No. 4, pp. 444-452, (1992).

[4] Glenberg, A. M., & Langston, W. E., "Comprehension of illustrated text: Pictures help to build mental models", Journal of Memory and Language, Vol 31, pp. 129-151, (1992).

[5] Mayer, R. E. & Sims, V. K., "From whom is a picture worth a thousand words? Extensions of a Dual-coding theory of multimedia learning", Journal of Educational Psychology, Vol 86, No. 3, pp. 389-401, (1994).

[6] Baek, Y. K. & Layne, B. H., "Color, graphics, and animation in a computer assisted learning tutorial lesson", Journal of Computer-Based Instruction, Vol 15, No. 4, pp. 131-135, (1988).

[7] Rieber, L. P., "Animation in computer-based instruction", Educational Technology Research and Development, Vol 38, No. 1, pp. 77-86, (1990).

[8] Rieber, L. P., "Computers, graphics, & learning", Madison, Wisconsin: Brown & Benchmark, (1994).

[9] Alesandrini, K. L., "Pictures and adult learning", Instructional Science, Vol 13, No. 1, pp. 63-77, (1984).

[10] Rieber, L. P., Boyce, M. J. & Assad, C., "The effects of computer animation on adult learning and retrieval tasks", Journal of Computer-Based Instruction, Vol 17, No. 2, pp. 46-52, (1990).

[11] Caraballo, J., "The effect of various visual display modes in computer-based instruction and language background upon achievement of selected educational objectives", Unpublished doctoral dissertation, The Pennsylvania State University, (1985).

[12] Rieber, L. P. & Hannafin, M. J., "Effects of textual and animated orienting activities and practice on learning from computer-based instruction", Computer in School, Vol 5, No. 1/2, pp. 77-89, (1988).

[13] ChanLin, L., "Attributes of animation in learning scientific knowledge", Journal of Instructional Psychology, (Accepted in May, 2000).

[14] Large, A., Beheshti, J., Breuleux, A., & Renaud, A., "Multimedia and comprehension: A cognitive study", Journal of the American Society for Information Science, 45, pp. 515-528, (1994).

[15] ChanLin, L., "Visual treatment for different prior knowledge", International Journal of Instructional Media, Vol 26, No. 2, pp. 213-219, (1999).

[16] Mayer, R. E., "Multimedia aids to problem-solving transfer", International Journal of Educational Research, Vol 31, pp. 611-623, (1999).

[17] Blissett, G. & Atkins, M., "Are they thinking? Are they learning? A study of the use of interactive video", Computers in Education, Vol 21, pp. 31-39, (1993).

[18] Reid, D. J. & Beveridge, M., "Reading illustrated science text: A micro-computer based investigation of children's strategies", British Journal of Educational Psychology, Vol 60, pp. 76-87, (1993).

Acknowledgement

This paper was excerpted from a project supported by a grant from the National Science Council. Grateful acknowledgement is made to the National Science Council for financial support on this project. Thanks also go to the Fu-Ying Middle School for providing assistance needed in conducting the study

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

Xiagen Hu* & Scotty D. Craig**
The University of Memphis
University of Memphis, Department of Psychology, Memphis, TN 38152-6400
(901) 678-3608
*E-mail: *xhu@memphis.edu, **scraig@memphis.edu*

Xtrain is a program for scripting and presenting multimedia displays. This program was developed in the Advanced Learning Technologies Laboratory at the University of Memphis and has been used in variety of psychological experiments. This program can combine such multimedia formats as Microsoft agent, Macromedia flash, director and many others that are available for scripting under a GUI Windows environment. Furthermore, Xtrain offers a variety of options for testing styles.

KEYWORDS: **Conversational agents, multimedia applications, Xtrain, Microsoft Agent**

1 Introduction

The idea of embodied conversational agents has generated considerable interest in the realm of HCI recently. Unfortunately, for the most part this has been metaphorical, because computers could not support the needed software. In order for the computer to fully support embodied conversational agents, they would need software that could produce and control many human-like characteristics, such as conversational behaviors, with the ability to mediate the flow of conversation by the use of such things as facial expressions, hand movements and voice intonations [1].

Microsoft made one such attempt at this with their Microsoft Agent program. Microsoft Agent is an interactive interface with conversational capabilities that are embodied in an animated character agent. One example of this is the helper agent in newer versions of Microsoft products such as Microsoft Word and Microsoft PowerPoint. Microsoft Agent is also an optional program for windows 9x operating systems and is available for free download at the Microsoft site. It is compatible with all MS Windows platforms starting with Windows 95. Thus, this agent is readily available for widespread use [5]. The purpose off this paper is not to review Animated Agents for a review, see Johnson, Rickel, and Lester [4].

Furthermore, recent research has shown that the correct use of multimedia presentations can enhance the learning and memory from presented materials. Multimedia in this case refers to any type of pictorial information presented with textual information. However, this form of learning works best with pictorial information shown as an animation that is then coordinated with a narration of any textual information that would be needed [6]. Under the cognitive theory of Multimedia learning, there are three main rules that should be considered for scripting of a multimedia presentation: Spatial contiguity, Temporal contiguity, and Modality. The spatial contiguity effect states that relevant and related concepts should be presented in the same general area of each other (e.g. labeled words should be closer to the object they label than other objects on the screen). The temporal contiguity effect informs us that the various forms of media used during a presentation should correspond with each other by occurring at the same time. Lastly, the modality effect says that if two types of information are presented in the same type of modes, it will hinder learning. However, this can be overcome by presenting information in two modalities. So, printed text and animation on a computer screen would be a hindrance to learning, but a narration and an animation would not [7; 8].

Since Microsoft launched the first version of Microsoft Agent, users and developers have provided a lot of resources for use with the program (e.g., some information can be obtained

from http://www.msagentring.org/agentringmain.html). There are several innovated approached both in the use and the scripting of Agents. For example, mash.exe (http://www.bellcraft.com/mash/) provide a very useful scripting tool for agent programming. Many of these programs have been examined, including Mash, and while they have the ability to control Microsoft Agent, they are lacking the ability to synchronize the Agent program with other forms of multimedia.

The Advanced Learning Technologies laboratory at the University of Memphis developed Xtrain as a way to incorporate embodied agents (Microsoft Agent) and other forms of multimedia into instruction, research, and presentations. Psychologists have used products such as Mel©and Super lab©to run experiments, but these programs cannot incorporate newer technology. Xtrain provides ways to script many different kinds of presentations, including Microsoft Agent, audio and video clips, HTML, Macromedia flash files, Macromedia Director files, and many graphics file formats [2, 3].

This software program serves a duel purpose. It is both an authoring tool and presentation tool. These work together to form a powerful and versatile tool for the presentation of various multimedia displays as well as data collection.

2 Authoring tool

The authoring side of the program has two levels (a) overall organization of frames and (b) detailed construction of individual frames. The overall methodology is similar to the SuperLab program used in experimental psychology. The Presentation is organized in terms of a tree structure with each node in the tree as a pointer to presentation frames. Each frame consists of the smallest unit of information and the frames are logically contingent upon each other. Such tree structure serves as basic navigation guidelines. However, the navigation path can be quite flexible depending on the needs of the user. The tree structure can be created using a user friendly GUI. Each frame corresponding to the tree nods can be any of several formats such as text art, pictures with hotspots, video/audio clips, agent interactions, and animations.

Xtrain has extensive options for frame editing. The program has been arranged so that the different editing functions displayed as individual property tabs. Each tab corresponds to a specific multimedia format. A description of the property tabs will follow.

Property Tabs

2.1 Frame Property Tab

The Frame property tab allows the basic outline of the frame to be determined. From here frame duration is set, alone with the frame' s properties, and the frame type. The duration can be anywhere from self-paced to any amount of time desired measured in milliseconds. The type of multimedia desired can be selected under a Frame properties drop-down menu. Under the Frame type dropdown menu, the type of frame can be specified: Normal, Title, Review, Test, or Interaction.

2.2 Agent Property Tab

This is the general tab that is used to control the agent. Each frame can have up to three agent actions assigned to it. These actions are denoted as agent1, agent2, and agent3. However, these can be assigned as needed for example one agent can be given as many as three actions or three agents can be given one action each. These are selected from the available agents using the Agent dropdown menu. Just below this dropdown menu is a dropdown menu that specifies when the agent will be used. For example, "Action over frame" can be selected so the agent is active while the rest of the frame is running. Just below this are three additional tabs that specify (a) the agent's position on the screen, (b) what the agent will say in each frame, and (c) balloon formatting, if the agent has this option. These are the Action and Gesture tab, Speak and Play tab, and Balloon Setup tab, respectively.

Of these tabs, the Speak and Play tab is of the most importance. This frame in its most basic form allows for text to be entered into a text box. The agent reads this text using a text to speech engine. However, this text box can also contain simple markup within the text. This markup includes such speech parameters as volume, emphasis, pitch and speed. These markup tags can be inserted into the text by inputting the

desired values into the box beside the parameter name on the right portion of the tab and then double clicking the name. This list of parameters also includes a few special tags that can control the flow of the information delivery. These tags permit the agent to skip to a specific frame in the tree structure (Show Frame), or to go to specific frames in a selected Shockwave Flash movie (Go to Frame in Flash Movie). The remaining tag option is Insert Special action. This set of tags allows the user to start, stop, and restart a flash movie, and provides a tag that terminates the program at the end of a presentation. The Speak and Play tab allows for assignment of actions to the selected agent. These actions vary according to the abilities of the selected agent, and can be assigned either at the beginning or the end of the text the agent speaks.

Similar to other agent scripting tool, such as MASH, this agent property editor uses all available Microsoft agents controls. In addition, Xtrain utilizes the bookmark function of MS Agent to control the overall flow of the presentation. In fact it is the use of these bookmarking functions that make it possible to control Multimedia synchronization, such as with Flash animation, which is lacking in the other agent programs.

2.3 Text Display Tab

The text display tab is used to insert text to be displayed on the screen. Doing this involves clicking on the display area, typing in the text to be displayed, and then clicking update. The text will then appear in the display area in the same way that it will be displayed on the screen during the presentation.

2.4 Multimedia Tab

The Multimedia tab allows you to assign audio files, movie files, and wallpaper to the frame. The program supports wave files (.wav) and Enhanced Linguistic files audio formats. If an Enhanced Linguistic file is used Microsoft Agent can be made to appear to speak the file. The movie files available from this tab are AVI (.avi) and Mpeg (.mpg). A Bitmap (.bmp) image can be set as a background that either covers the whole screen or centered.

2.5 Pictures Tab

Using the picture tab, a picture can be added to the frame and manipulated. Xtrain supports two types of graphic files: Bitmap (.bmp) and GIF (.gif). The picture can be located at any point on the screen, centered, or can move from point to point. A hotspot option can be added to the picture to be used to give commands to the agent or to play audio files. Each hotspot can have information, such as text and tagged markup, to be sent to any selected agent.

2.6 Shockwave Tab

Under this tab, there are two options: Flash Movie and Shock Wave Movie. Flash movies and shockwave animations are among the most frequently used multimedia format. Xtrain uses activeX control from macromedia so both types of movies can be manipulated. By loading flash movie from this tab, detailed frame information can be examined so Agents can navigate through the movie. In addition, Xtrain uses FSCommand of flash movie to control Agent and the tree navigation.

2.7 Frame Summary Tab

The frame summary tab gives summary information both at the scripting phase and at the presentation phase. At the scripting phase, it gives a brief overview of the selections made in the other tabs for that frame. If the frame is a test frame, it also contains the correct answers to the questions given in the test frame. After viewing on the other half of this frame, responses are shown. If it was a test frame, the student' s responses are listed along with whether the response was correct.

2.8 HTML Tab

The program allows for the incorporation of html documents into presentations. This allows greater flexibility in terms of specialized displays. The format allows for html documents that are locally saved in the Xtrain directory to be displayed and navigated during presentations.

2.9 Test Tab

One other important feature of Xtrain is the testing option. During the scripting phase, frames can be assigned as testing frames on the frame property tab. These frames can be used to capture information from the user. They allow input in such forms as multiple-choice questions, short answer questions, and even essays. At the end of the presentation phase, input from the participant is automatically saved as an ASCII text file. The agent can also be programmed to give dynamic feedback, when the participant gives wrong answers.

3 Presentation Tool

The presentation of the scripted material is as easy as selecting the run drop-down menu and selecting the run entire session option. Alternatively, the Xtrain presentation file (.xtr) can be ran by double clicking its icon in the strain folder. This action occludes all other objects on the screen: only the scripted presentation and a control bar are visible. This control bar is a flash file that allows for the following actions: go back, continue, help, and progress. The presentation continues forward until it reaches the end of the presentation.

4 Summary

Xtrain is a program that is able to integrate multimedia files into one presentation format. The authoring side of the program takes advantage of many Windows' standards for ease of use. It provides a standard Windows interface window with icon buttons and drop-down menus, such as File, Edit, Window, and Help. These offer such options as open and save in the File menu, as well as, cut, copy, and paste in the Edit menu. Xtrain also offers a special drop down menu labeled Run. This menu offers the options of running the entire session or of previewing a selected frame. See Figure 1 for a view of the program. The frames are structured in a tree format that is located on the left of the screen. This tree is created via buttons labeled Brother, for frames on the same level, and Child, for frames on a branching level. Each frame can be scripted using nine different property tabs: Frame Property, Agent Property, Text Display, Multimedia, Picture, Shockwave, Frame Summary, HTML, and Test. These tabs may be individually associated with each frame. It is from these components that the script is produced to set the required tone for the information to be presented. Microsoft agent can also be used to control the flow between frames, so that if the need arises the agent can direct the presentation to any frame in the tree. Furthermore, if a Shockwave Flash file is used, the agent also has the ability to direct the flash movie to any frame within the movie. These options allow for maximum flexibility for the user when scripting a multimedia presentation. In addition to this freedom in scripting, Xtrain offers an easy presentation method that either selecting run entire session from the run menu or by simply double clicking on the created Xtrain file.

References

[1] Cassell, J., Bickmore, T., Billinghurst, M., Campbell, L., Chang, H., Vilhjalmsson, H., Yan, H., "Embodiment in Conversational Interfaces: Rea." Proceedings CHI' 99. Pittsburgh: ACM. (1999).

[2] Craig, S. D., & Hu, X. Xtrain: Expert training and data collection system. Presented at the 1999 meeting of The Society for Computers in Psychology. Los Angeles, California. (1999, November).

[3] Hu, X. "Xtrain 1.0 [computer program]." The University of Memphis: Author. (1998).

[4] Johnson, W. L., Rickel, J. W. & Lester, L. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. International Journal of Artificial Intelligence in Education, Vol. 11, in press, (2000).

[5] Microsoft. Microsoft Agent 2.0 [computer program]. (1998).

[6] Mayer, R. E. Multimedia learning: Are we asking the right questions? Educational Psychologist, 32, 1-19, (1997).

[7] Mayer, R. Using Illustrations to Promote Constructivist Learning from Science Text. Psychology of Science Text Comprehension. (Submitted).

[8] Moreno, R., & Mayer, R. E. Cognitive principles of multimedia learning: The role of modality and contiguity. Journal of Educational Psychology, 91, 358-368, (1999).

Proceedings

Content

▹ Full & Short Papers (Networked Social Learning)

A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community
Is a Learning Theory Harmonious with Others?-To form Effective collaborative Learning Groups with Ontological Engineering-
Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan
Online Education: A Learner-Centered Model with Constructivism
Peer Help for Problem-Based Learning
The Interactive Virtual Community
The network learning supported by constructivism

▲ HOME

A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community

Brian Hudson*, Ahmed El-Gamal, Amal Gouda**, Eric Knutsen***, Merja Ruotsalainen****, Antti Peltonen****, Minna Pesonen**** and Tarja Te rvola******

**Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria*

***Pedagogy and New Technologies Research Group, School of Education, Sheffield Hallam University, Sheffield S10 2BP, United Kingdom*

B.G.Hudson@shu.ac.uk

a.e.gamal@shu.ac.uk

a.gouda@shu.ac.uk

****Hope Valley Community College, Hope Valley, Derbyshire S33 6SD, United Kingdom*

knutsen@dircon.co.uk

*****Research Unit for Educational Technology, P.O.Box 2000 90014 University of Oulu, Finland*

Merja.ruotsalainen@oulu.fi

antti.peltonen@oulu.fi

mpesonen@oulu.fi

ttervola@ktk.oulu.fi

This paper outlines the background to the development of a European Masters programme in *Multimedia Education and Consultancy*. The development arises from an Advanced Curriculum Development (CDA) Project supported by the European Commission under the SOCRATES programme, which involves nine institutions in seven different European countries. The aims and outline of the Masters programme are described together with the pedagogical approach adopted. A key feature of the latter is a virtual learning environment that is underpinned by the use of the concept of "metaphor". This is intended to convey how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users. A pilot unit/module on *ICT in Open Learning Environments* is outlined together with some of the key features of the learning environment. This was trialled by a group of students based at locations in Finland, Austria, the Netherlands and the UK during the second semester of the academic year 1999-00. Evaluations are provided by a participating tutor, an observer and from two participating students. Finally some reflections are outlined which focus on the innovative aspects of this learning environment and of our experiences as teachers and learners in a multinational virtual learning community.

Keywords: **Collaborative Learning - Web-Based Learning - Networked Social Learning - Teaching and Learning Processes**

1 Introduction

This paper reports on experiences as teachers and learners in a multinational virtual learning community, which have resulted from our involvement in a pilot unit as part of the development of a European Masters

course. The pilot unit is entitled *ICT in Open Learning Environments* and our involvement has taken place between February and May 2000.

2 Background to the development

The background to the development is the Advanced Curriculum Development (CDA) Project *TRIPLE M: Masters in MultiMedia Education and Consulting* that is supported by the European Commission under the SOCRATES programme (29268-IC-2-97-1-AT-ERASMUS-CDA-1) over the period 1998 to 2001. The *TRIPLE M* project is co-ordinated by Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria and involves a number of departments and research units with experience and expertise in teacher education and the use of Information and Communication Technology (ICT). The current participating institutions in the *TRIPLE M* project are:

- Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria (Co-ordinating institution)
- Charles University, Prague, Czech Republic
- Hogeschool Arnhem and Nijmegen, Netherlands
- Liverpool Hope University College, United Kingdom
- Pädagogische Akademie Vienna, Austria
- Sheffield Hallam University, United Kingdom
- Umeå University, Sweden
- University of Oulu, Finland
- University of Santiago de Compostela, Spain

A sub-group of the TRIPLE M Consortium has formed the *European Association for Multimedia Education and Consultancy*™ (*EAMEC*™) with the intention of offering a validated Masters programme in for *Multimedia Education and Consultancy* from September 2000. Initially this will be offered as a part-time route with a plan to run the programme on a full-time basis from September 2001.

3 Programme aims and outline

The academic aims of the programme have been developed in response to the needs of the 'Information Society' phenomenon related to the rapid development of high technology use in all sectors of society. The programme aims to meet the needs of teachers in schools and further and higher education especially. Specifically the programme seeks to develop the profile of the 'problem solver'/team co-ordinator at the interface of pedagogical, technological and organisational/cultural dimensions of development. In summary the programme aims to support the development of individuals who are able to:

- demonstrate and communicate knowledge and critical understanding of pedagogical issues as applied to the use of multimedia in new learning environments
- critically understand the social, organisational and cross-cultural phenomena related to new learning environments in trans-national and cross-cultural contexts
- appreciate and be responsive to the social and cultural impact of the Information Society in relation to values and working practices
- act as effective mediators and facilitators at the interface between the needs of users and providers
- co-ordinate the efforts of multi-disciplinary teams in terms of problem analysis, design and implementation issues
- be aware of the staff development needs of new users and appreciate the support structures and strategies for continuing development
- demonstrate a critical understanding of (educational) research and its role in a context of rapid change
- remain open to critiques of the Information Society with particular regard to the social and cultural implications

The programme is made up of six units/modules that together make up 90 European Credits (ECTS). These are as follows:

- Open Learning Environments (*OLE* - 10 ECTS)
- Digital Media Applications (*DMA* - 10 ECTS)
- Communication and Consultancy (*CC* - 10 ECTS)
- Research Methodolgies (*RM* - 10 ECTS)

- Project Studies (*PS* - 20 ECTS)
- Dissertation (*DS* - 30 ECTS)

The four more structured units (OLE, DMA, CC and RM) all follow a common pattern of:

- Telematic-based Studies (50%) e.g. Web-based work and discussions, multi-point videoconferencing sessions, and
- Local and Independent Studies (50%) in national groups e.g. day workshops and tutorials plus independent study.

4 Pedagogical approach

The pedagogical approach involves Telematic-based Studies in Web-based work, discussions and multi-point videoconferencing sessions in multinational learning communities. It is seen as crucial that these studies are supported by Local Studies - in national groups e.g. day workshops, practical activity, project work, research activity and tutorials and Independent Studies including literature reviews, independent project work, research activity, writing etc.

The use of ICT as a medium for learning and communication is fundamental to the underpinning philosophy of the programme and is an integrated and all pervasive aspect of the pedagogical approach, both in terms of learning about it and as an essential part of the learning process. Students need to use the Internet as an essential part of the learning and communication process.

The platform for the net-based learning environment is *LC Profiler – Learning Community Profiler*. This is the product of *LCProf Oy*, which is a Learning Service Provider (LSP) and a 'spin-off' company of the University of Oulu. The services are based on the methodology and system developed at the University of Oulu in a range of domestic and EU R&D and education projects during the last 5 years (e.g. Telematics projects T3: Telematics for Teacher Training, SCHEMA: Social Cohesion through Higher Education in Marginal Areas). The implementation of the system is based on the principle of creating a distributed community of learners and supporting the tutors to enable them to create their own learning communities. This means that the tutors also belong to a unique learning community of their own, which aims to support ongoing professional development.

5 The role of metaphor

The concept of metaphor plays a fundamental part in the underlying design of the *LC Profiler* environment and also in signifying key functions to the user. In their paper Pulkinnen and Peltonen [1] use the concept of "metaphor" to "explain how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users". This paper is also one of the Core Readings for all students on the OLE unit/module. Their analysis combines ideas about knowledge, the structure of knowledge and learning with social aspects to do with the organisation of learning such as practical arrangements connected with "time, place and repetitive rituals". Their overall metaphor which captures the nature of the *LC Profiler* environment is of "a place of studying (virtual space) created with the help of ICT". The three "cornerstones" of their analysis of the learning environment are the individual whether as teacher or learner, the technology and the culture as fully outlined in Pulkkinen and Ruotsalainen [2]. They describe these as providing the "cross-disciplinary basis for the elements that are necessary for learning" and identify these elements as pedagogical functions, appropriate technologies, and the social organisation of education

6 The pilot unit/module

As part of the curriculum development process, two units have been piloted during the period from February to May 2000. These are *ICT in Open Learning Environments* (February to May) and *Digital Media Applications* (March to May). The former is based on an existing unit/module at the University of Oulu and forms the model for the development of the Masters programme as a whole. The full unit/module is worth 10 ECTS M Level credits for which 5 ECTS is available for successful completion of the telematics-based component. This was trialled as part of the TRIPLE M project with a group of about 25 Finnish, 9 Austrian, 4 Dutch and 2 UK students

The course outline is seen as one of the most important navigation tools, referred to as an "orientation metaphor". The introductory screen is shown below in Fig 1.

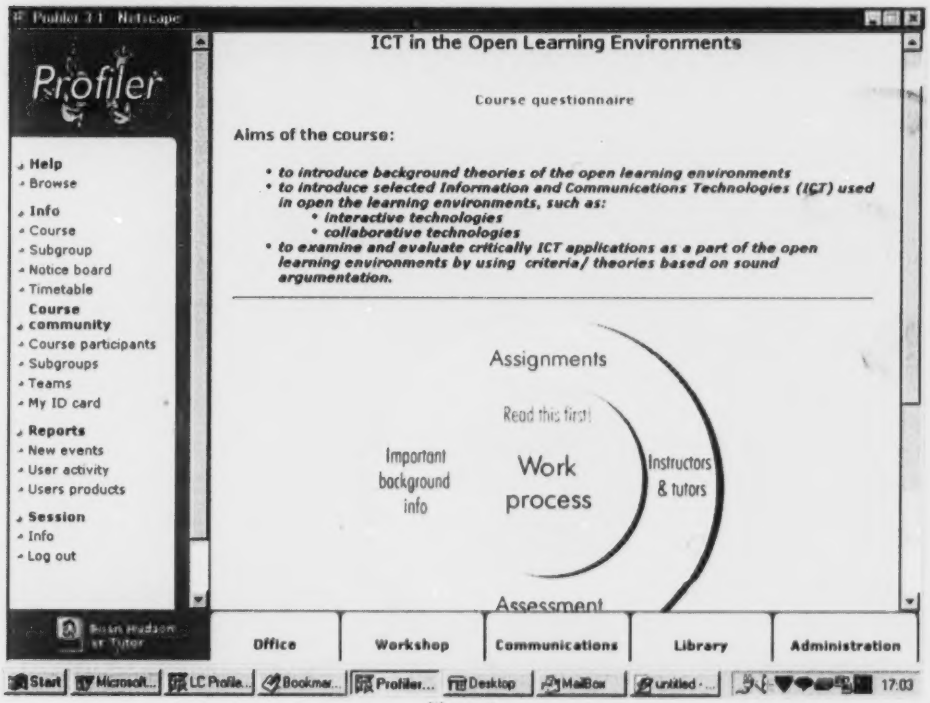


Figure 1

This screen includes a statement of the aims of the course and also conveys some of the metaphors that underpin the design of the system. (NB The use of the term "course" here is equivalent to the terms "unit/module" used previously and is a reflection of the diversity of the use of these descriptors across and within different systems) The most apparent metaphors are those which are to do with orientation to place or virtual working place. The Project Office, Workshop, Communications Centre, Library and Administration Centre refer to "working" and not to the technology and tools being used e.g. e-mail, chat, documents etc. This aspect is seen to be a particularly important issue in relation to signifying metaphors to users that refer to pedagogical practices. The metaphor of "project" is used to convey "the basic essence of learning" and the course flow orientates the user to time. This includes phases on the work process e.g. orientation, planning etc and also milestones, which are outlined in part in Figure 2.

BEST COPY AVAILABLE

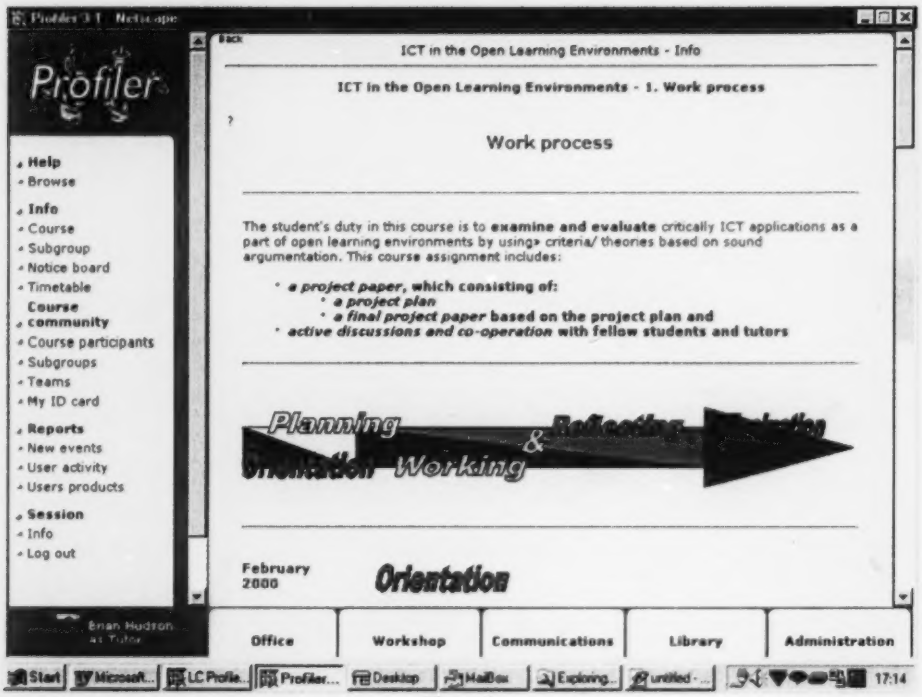


Figure 2

7 Experiences as teachers and learners

This section includes accounts and evaluations from a participating tutor (Brian Hudson), an observer (Ahmed El-Gamal) and from two participating students (Eric Knutsen and Amal Gouda).

As a particpating tutor I was immediately struck by the very clear sense of purpose that the course outline engendered with a very clear sense of the different phases, milestones and overall timescale. The active participation in discussions was not an option but a necessary requirement with comments being expected within fixed timescales and core readings, project plans of peers etc. As a result the level of communication on the course was very high - an analogy might be made with lighting a wood and coal fire - a little slow at the start but then bursting into flames from all sides!

Another key observation was of the role of the two main moderating tutors. Both could be characterised as being "on task" throughout the course of the unit/module. In general their responses to questions were very swift and they dealt with technical, pedagogical and social issues. The two tutors also interacted with each other in a very effective way by following up on each others comments, questions and prompts - so engendering a relaxed yet lively ambience around the discussions.

An example of the extent of the student discussions can be gleaned from the screen in Figure 3 below:

BEST COPY AVAILABLE

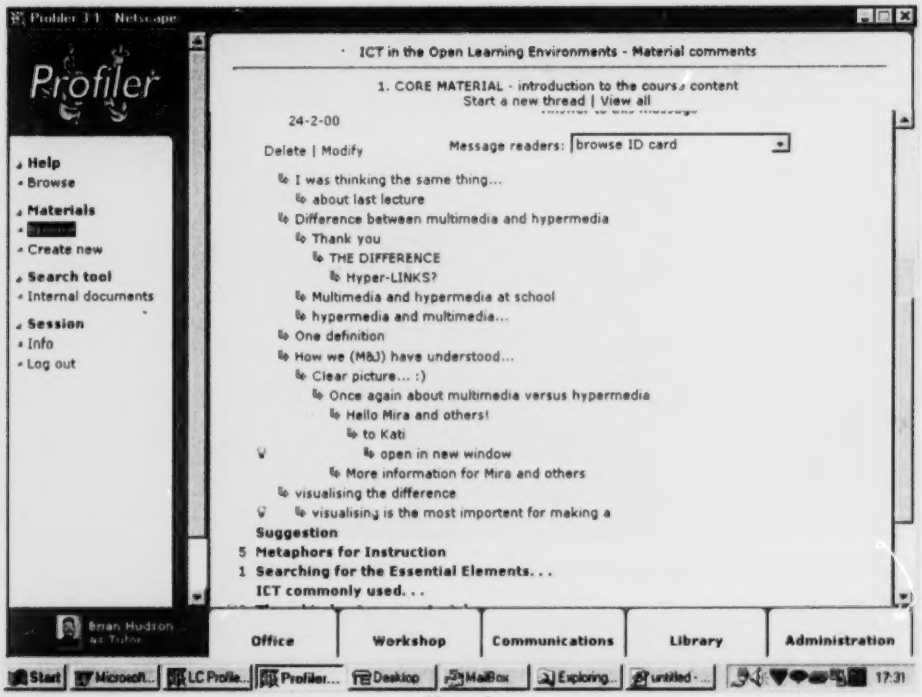


Figure 3

The particular thread started outlined above was started by student H on 24-02-00 with the comment:

Could some of you tell me what is the difference between multi- and hypermedia? Is there any difference, do they mean the same thing? The difference between these "words" was explained in the first core text but I just couldn't find the basic idea which might help to separate them.

These questions resulted in a rich, intense and well-informed discussion with around twenty contributions over a ten-day period, which seemed to conclude in an agreed consensus. Overall discussions were by no means restricted to technical matters but this particular thread was notable for its richness and intensity. A notable feature of this environment is the very clear way in which the threads are laid out and also the way in which the links are revealed when a thread such as the one above is opened.

Ahmed El-Gamal had the role of being a Local Tutor and was given access to *LC Profiler* as an observer. He is a staff member of Menofia University in Egypt on a PhD scholarship supported by the Egyptian Ministry of Education and Culture. He has chosen to cluster his comments around characteristics that he noticed about the learning environment in overall terms. This is a summary of his comments on these charactersitics:

Organization: The whole unit is well organized e.g. timetable, assignments, activities..etc. If there is any misunderstanding the student can post a question to the others.

Adaptability:Most of students adapted easily with this learning environment. Sometimes they have some technical problems e.g. the speed and the difficulty in using some tools, but they soon found assistace from the tutors and their peers.
Flexibility:It is a very flexible learning environment - students worked at different times in different countries, yet they have the opportunity to discuss the same topics.
Some students from different countries were able to create teams to conduct the same project.

Collaboration: Students collaborated with each other in solving some technical problems, clarifying some aspects in the references, developing teams and developing their project plans.

BEST COPY AVAILABLE

Conversation and discussion: Students were discussing different issues that were relevant to the course. All the participants have the opportunity to contribute to the discussion. They wouldn't end the discussion until they reached an agreement about the topic e.g. the discussion about the difference between Multimedia and Hypermedia was about 20 comments.

Social interactivity: Most of students have some social interactivity, by talking to the other students in the on-line café and by posting messages. Some friendships have been developed during the course.

Amal Gouda has studied to Diploma level in Educational Technology at Cairo University and is continuing her Masters studies at this time. She has chosen to group her evaluation around features of the studying process:

The studying process in OLE could be defined as an integrated process, which integrates the different resources and the different parts of the OLE to achieve the desired goals. The studying process in OLE is accomplished through the following parts:

Office: Every student can manage almost all his/her study through using the office and all the information about the course and other students are available on the office, in addition to the timetable and the framework of the course.

Workshop: Every student has developed his/her project plan and he/she has published it to the other course participants. This gave his/her opportunity to have the other students comments on it.

Communications: It gave the international students the opportunity to freely discuss different topics related to the course. It also allows them to discuss their project plans and the other students' project plans. Moreover, there are different categories for discussion e.g. questions and urgent message, general discussion about the study process..etc. In online café, the students can have a social chat with their peers.

Library: It has most of references that are related to the course, also it has a hyperlinks to enable students from browsing more materials. It was advised to write comments on these materials, in order to encourage the students to read them carefully.

Local studies: Every student met with his/her tutor many times to discuss the different topics and activities that seem to be unclear and to guide him/her through the course. The most important feature in the studying process in OLE is that it gave the opportunity to study and discuss different topics at any time during the day.

Eric Knutsen works in a secondary school and is in his first year of teaching as a teacher of ICT. He has chosen to respond to the aims of the course and to evaluate the extent to which these were met for him as a student:

- to introduce background theories of the open learning environments

This was done in a straightforward manner utilising the OLE of LC Profiler. It was useable as one would use a library in the traditional environment of a physical learning environment. The added value here was the amount of material referenced via the web. Using the expertise of the instructors on the course, I was able to make use of the varied written material and discuss other students' and my own opinions on the content. Being done in an asynchronous way, there was no need to be present physically or virtually for such discussion. Yet, I had the advantage of dozens of other opinions from which to draw my own conclusions. This took my learning beyond that previously possible via ...traditional learning ...

- to introduce selected (ICT) Information and Communications Technologies used in open learning environments, such as interactive technologies and collaborative technologies

One aspect of having been introduced to the background theory in the way it was done is the ability to review tens of project proposals and final project papers in light of the theory examined. This made the theoretical come to life, especially when undertaking my own individual work. This meant looking critically at the variety of components comprised with-in the environment being examined ...What made this a more lively introduction to the ICT was the regular use of LC Profiler and the success of the discussions taking place.

- to examine and evaluate critically ICT applications as a part of the open learning environments by using criteria/ theories based on sound argumentation

Given the foundation above ... it was straightforward to see the relevance of the theory when examining the OLE at hand. Especially of interest was the use made of LC Profiler as an OLE by all members of the course and the social interaction made possible by all areas of LC Profiler, not isolated to the on-line cafe. This even fed the theoretical side to my thoughts about my assignment.

8 Conclusions

The experience of participating in this pilot unit has provided a real example of the transformative potential of the use of ICT. This is in spite of several years experience of using the *First Class* conferencing software which seems quite limited by comparison with *LC Profiler*. In McConnell's [3] terms *First Class* can be seen to be simply an example of "unstructured groupware" or an "electronic space". Some experiences result in real and lasting changes - for myself this experience has transformed my own pedagogical thinking and practice. Whilst being a vital component, the learning environment of itself is not the main ingredient for experiencing this transformation, although many people at this time are looking for the "quick fix" and simple solutions. However it has been the experience as a participant in a community of practice (Hudson [4]; Lave, [5] and Lave and Wenger, [6]) that has been fundamental. This process takes time and is about changes within (the person) and developing new ways of relating to other people. In general terms such high levels of on-line communication also necessitate the need to develop a more relaxed attitude towards committing ideas into print, for seeing such comments as transient and not permanent and being accepting of the need for "repairs" to communication as one would in more traditional forms of communication.

References

[1] Pulkkinen, J. and Peltonen, A. (1998) Searching for the essential elements of Web based learning environments, *3rd International Open Learning Conference*, 2-4 December 1998, Brisbane, Queensland, Australia.

[2] Pulkkinen, J. and Ruotsalainen, M. (1998) Evaluation study of a telematic course for technology teachers (T3 Project). Paper to the *Teleteaching' 98 Conference of the 15th IFIP World Computer Congress*, 31 August - 4 September 1998, Vienna and Budapest.

[3] McConnell, D.: 1994, *Implementing Computer Supported Co-operative Learning*, Kogan Page, p37.

[4] Hudson, B. (1999) A social perspective on teaching and learning in the context of Computer Mediated Communication in teacher education, *Journal of Information Technology in Teacher Education*, 8, 2 (In press)

[5] Lave, J.:1996, Teaching, as learning, in practice, *Mind, Culture and Activity*, 3, 3, 149-164.

[6] Lave, J. and Wenger, E.: 1991, *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press.

Is a Learning Theory Harmonious with Others?

To form Effective Collaborative Learning Groups with Ontological Engineering

Akiko Inaba, Thepchai Supnithi, Mitsuru Ikeda, Riichiro Mizoguchi, and Jun'ichi Toyoda

I.S.I.R., Osaka University

8-1 Mihogaoka, Ibaraki, Osaka, 567-0047 Japan

inaba@ai.sanken.osaka-u.ac.jp

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. In this paper, we describe the outline of a system of concepts concerning learning goals expected to attain by learners through collaborative learning process with justification by the learning theories. We propose possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

Keywords: **Ontology, Collaborative Learning, Distributed Learning Environments**

1 Introduction

Our research objectives include constructing a collaborative learning support system that detects appropriate situation for a learner to join in a collaborative learning session, and forms a collaborative learning group appropriate for the situation dynamically. To fulfill these objectives, we have to consider the following:

1. How to detect the appropriate situation to start a collaborative learning session and to set up the learning goal,
2. How to form an effective group which ensures edu ational benefits to the members of the group, and
3. How to facilitate desired interaction among learners in the learning group.

We have discussed item 1 in our previous papers[10, 11], and this paper focuses on item 2. When we have clarified item 2 and extracted the desired interaction in the group, we would consider item 3.

There are many theories to support the advantage of collaborative learning. For instance, Observational learning[2], Constructivism[19], Self-regulated learning[9], Situated learning[15, 16], Cognitive apprenticeship[5], Distributed cognition[21], Cognitive flexibility theory[22, 23], Sociocultural Theory[25, 26], Zone of proximal development[25, 26], and so on. If we select a theory from these and form a learning group based on the theory, we can expect effective collaborative learning with the strong support of the theory. However, it is difficult to understand all theories because these theories are derived from a wide research area including pedagogy, sociology and psychology. Moreover, we can expect different educational benefits based on these learning theories, and observe various kinds of interaction between learners through collaborative learning process. Due to the diversity, it is difficult to list the learning theories effective to gain a specific educational benefit for a learner, and to compare the theories to form a suitable collaborative learning group for the learner.

Therefore, we have been constructing a system of concepts to represent collaborative learning sessions supported by these learning theories[12, 14, 24]. We call the system of concepts "Collaborative Learning Ontology". Although advantages of collaborative learning over individual learning are well known, the collaborative learning is not always effective for a learner. Educational benefit that a learner gets through the collaborative learning process depends mainly on interaction among learners. The interaction is partly influenced by relations among members of learning group, which suggests that how to form an effective group for the collaborative learning is critical to ensure educational benefit to the members. In this paper, we focus on "Learning Goal Ontology" which is a part of the Collaborative Learning Ontology.

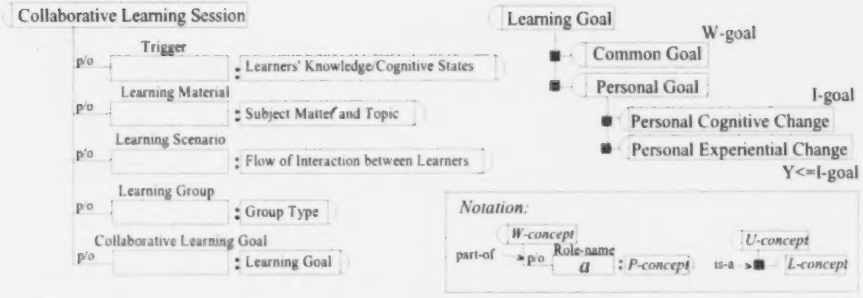


Fig. 1. Collaborative Learning Ontology

The concept "Learning Goal" is one of the most important concepts for forming a learning group because each learner joins in a collaborative learning session to attain some learning goals.

To help a learner obtain a specific educational benefit we can find several learning theories useful for the purpose and form different learning groups according to the theories. If the groups are merged into one, we may form a better learning group which is guaranteed its effectiveness by multiple learning theories. So, we also discuss the combination of learning groups supported by different learning theories.

This paper is organized as follows: we first show briefly the structure of our "Collaborative Learning Ontology" and "Learning Goal Ontology". Then we summarize advantages and remaining tasks: how can we narrow down candidates of learning groups into one? Finally we propose a new learning group formation formed by combining multiple learning theories.

2 Learning Goal Ontology for Collaborative Learning

Through a survey of studies on collaborative learning, we picked up concepts to represent a collaborative learning session. As a result, we set up five primitive concepts to characterize the session: Trigger, Learning Material, Learning Scenario, Learning Group, and Learning Goal. Fig. 1 shows the conceptual structure of Collaborative Learning Ontology.[1] Here, we concentrate on the concept "Learning Goal" which is one of the most important concepts for forming a learning group, because each learner joins in a collaborative learning session to attain some learning goals. The "Learning Goal" can be specified as two kinds of goals: "common goal" as a whole group and "personal goal" for each learner. The concept "personal goal" can be specified as two kinds: the goal represented as a change of a learner's knowledge/ cognitive states, and the goal attained by interaction with other learners.

We classify the goal of the first person (*I*), that of the first person to interact with the second person (*You*), and that of the whole group as I-goal, Y⇐I-goal, and W-goal, respectively. I-goal, which is described as G:I, represents what a learner is expected to acquire. Y⇐I-goal, which is described as G:Y⇐I, represents what a learner is expected to acquire through the interaction. W-goal expresses the situation being set up to attain Y⇐I-goals and we describe the goal as G:W. W-goal is a common goal characterizing the whole group.

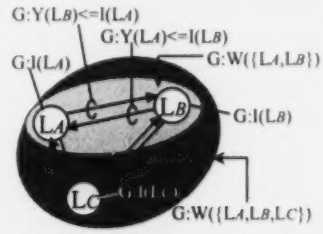


Fig. 2. Learning Goal Ontology

Fig. 2 represents learning goals in a group where three learners: L_A, L_B and L_C are participating. Learner L_A has an I-goal which is attained through this collaborative learning session and this goal is described in Fig. 2 as G:I(L_A). Both L_B and L_C have I-goals, and they are represented as G:I(L_B) and G:I(L_C) respectively. G:Y(L_B)⇐I(L_A) is a Y⇐I-goal between L_A and L_B observed from L_A's viewpoint. In other words, it means the reason why L_A interacts with L_B. Concerning this interaction between L_A and L_B, there is also a Y⇐I-goal observed from L_B's viewpoint. That is, it is the reason why L_B interacts with L_A. This Y⇐I-goal is represented as G:Y(L_A)⇐I(L_B). Both G:I(L_A) and G:Y(L_B)⇐I(L_A) are personal goals of

[1] Notation: the schemata define the W-concept and the U-concept. The W-concept has entity a, which is an instance of the concept P-concept, as a part. The entity a plays a specific role (Role-name) in the W-concept. The concept P-concept has a semicircle on the right sides. It means the concept is defined in other schema. The L-concept is a specification of the U-concept, and the U-concept is a generalization of the L-concept.

Table 1. W-goals

		W-goal	Definition	Src.
Singleton W-goal	M-P x S-S	Setting up the situation for Peer Tutoring PT	Setting up the situation where a learner teaches something to another learner.	[6, 7]
		Setting up the situation for Anchored Instruction AI	Setting up the situation where a learner diagnoses another learner's problem and then solve it (Problem-based Learning)	[4]
	S-P x M-S	Setting up the situation for learning by Cognitive Apprenticeship CA	Setting up the situation to learn knowledge or ski as an apprentice	[5]
		Setting up the situation for sharing (Meta-) Cognitive function between learners SC	Setting up the situation to share cognitive or meta-cognitive function between learners based on Sociocultural Theory	[25, 26]
		Setting up the situation for sharing Multiple Perspectives CF	Setting up the situation to evoke a learner's reflective thinking based on Cognitive Flexibility theory.	[22, 23]
	M-P x N-S	Setting up the situation based on Distributed Cognition DC	Setting up the situation where full participants, whom knowledge bases are different each other, discuss problems	[21]
		Setting up the situation based on Cognitive Constructivism CC	Setting up the situation where full participants discuss problems	[19]
CW-goal		Setting up the community for Legitimate Peripheral Participation LPP	Setting up the the community of practice for peripheral participant	[15, 16]
		Setting up the situation for Observational Learning OL	Setting up the situation to share other learners' learning processes	[2]

Note: ** means an abbreviation for the W-goal.
e.g., The W-goal "Setting up the situation for Peer Tutoring" is abbreviated as "PT".

L_A. G:W($\{L_A, L_B\}$) is a W-goal of the learning group ($\{L_A, L_B\}$). G:W($\{L_A, L_B, L_C\}$) is a W-goal of the learning group ($\{L_A, L_B, L_C\}$).

We have identified goals for collaborative learning for each of the three categories, and constructed I-goal Ontology, Y⇐I-goal Ontology, and W-goal Ontology with justification based on learning theories.[2] We can expect learners to acquire not only new knowledge concerning problems they solve, but also cognitive skills, meta-cognitive skills, and skills for self-expression through the collaborative learning session (I-goals). Each I-goal has several phases of development. It is difficult to understand from a theory what educational benefit is expected to a learner, because of lack of unified systematic terminology to represent a variety of phases. So, we adopt the terminologies used in two established findings: Rumelhart & Noman's work[15] on knowledge acquisition and Anderson's one[1] for skill development. The process to acquire a specific knowledge includes three qualitatively different kinds of learning[15]: Accretion, Tuning, and Restructuring. Concerning development of skills, there are also three phases of learning: Cognitive stage, Associative stage, and Autonomous stage[1, 8].

The learner is expected to achieve these I-goals through interaction with other learners. For example, to achieve the I-goal "Acquisition of Content-Specific Knowledge (Accretion)", some learners could take the Y⇐I-goal "Learning by being Taught[5]", while some learners could take another Y⇐I-goal "Learning by Observation[2]".

Table 1 shows the W-goals. The W-goals are classified into four kinds (*i.e.*,Three kinds of singleton W-goals and one Composite W-goal) according to their structures. To form a learning group means to pick up learners who join in the group as members and to assign a specific role in the group to each member. The formation should have rationale supported by learning theories. The structure of learning goals expresses the rationality. A W-goal, which is a learning goal as a whole group, provides the rationale for the interaction among the members. It means that a W-goal specifies a rational arrangement of Y⇐I-goals. Fig. 3 shows a typical representation for the structure of a W-goal. It would be more easily to understand a learning theory by preparing the structure to represent the theory and filling in each component of the structure with suitable concepts according to the theory.

A learning theory generally argues the process that learners, who play a specific role, can obtain educational benefits through interaction with other learners who play other roles. The theories have common characteristics to argue effectiveness of a learning process focusing on a specific role of learners. So, we represent the focus in the theories as Primary Focus and Secondary Focus.

Primary Focus (P): a learner's role that is mainly focused in the learning theory. The learner who plays this role (P-member) is expected to gain the main educational benefit.

[2] The details of the ontologies are described in our previous paper[14]. Here, we show the outline of the ontologies.

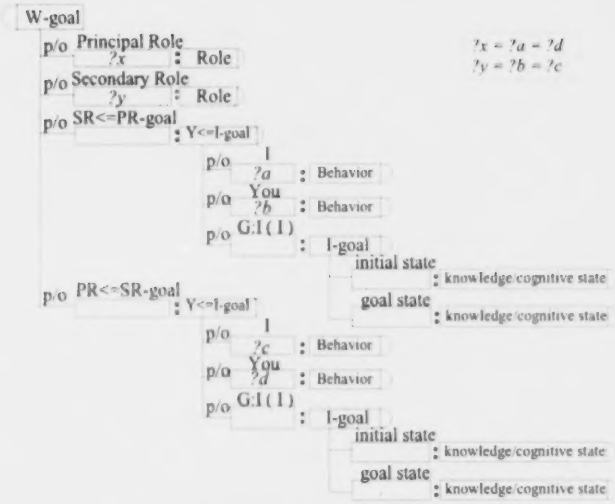


Fig. 3. Conceptual Structure of a W-goal

Secondary Focus (S): a learner's role that is weakly focused in the learning theory. The learner who plays this role (S-member) is needed as a companion to enable a P-member to attain his/her learning goals.

We classify the W-goals into the following four kinds depending on the number of the components P and S.

Singleton W-goal: Each Singleton W-goal can exist independently.

Multiple-P x Single-S: The W-goal of M-P x S-S type can have multiple P-members and single S-member.

Single-P x Multiple-S: The W-goal of S-P x M-S type can have single P-member and multiple S-members.

Multiple-P x No-S: The W-goal of M-P x N-S type has only one role for its members. In this group, each learner plays a role of companion for the other learner, while he/she gains main educational benefit.

Composite W-goal: The CW-goal includes another group as its component S.

For example, in the situation of Peer Tutoring, there are two roles: *Peer Tutor* and *Peer Tutee*. Main educational benefit is tuning of content-specific knowledge by externalizing a learner's knowledge[6,7]. So, P is identified as *Peer Tutor* and S is identified as *Peer Tutee*. From the viewpoint of assigned task, the role of main problem-solver is *Peer Tutee* who wants to get a new knowledge to perform assigned tasks, while the role of helper is *Peer Tutor*. The number of members who play *Peer Tutee* (S) should be single, the number of members who play *Peer Tutor* (P) can be multiple, and the W-goal **PT** is identified as a M-P x S-S type.

A group attaining a W-goal(W_i) can have another group, which has another W-goal(W_j), as the component S of the W-goal(W_i). We call the W-goal(W_i) "**CW-goal**" which means a composite W-goal. Fig. 4 shows the conceptual structure of the CW-goal Observational Learning[2]. The learning group has *Observers* as its component P.

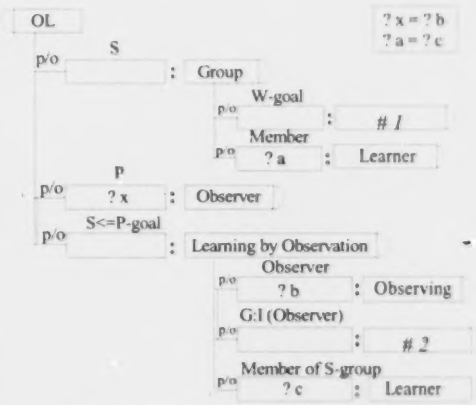


Fig. 4. An Example of CW-goal: OL

The *Observers* require a group (*i.e.*,its component S) as an object to observe meaningful interaction. In the figure, the W-goal, which is set in #1, depends on what I-goal is set in #2. For example, if accretion of content-specific knowledge is set in #2 as *Observer*'s I-goal, the W-goal **PT** is recommended as S's W-goal (#1).

A W-goal has two kinds of goals of interaction as follows:

S⇐P-goal: a Y⇐I-goal which means how and for what purpose the P-member interacts with the S-member.

P⇐S-goal: a Y⇐I-goal which means how and for what purpose the S-member interacts with the P-member. In the collaborative learning session, all members of learning group are expected to get some educational benefits. So, the S-member also has an I-goal, and the P⇐S-goal should be effective to attain the I-goal.

The entities of these goals refer to the concepts defined in the Y⇐I-goal Ontology. The conditions, which are proper to each W-goal, can be added to the concepts, if necessary. Each of the Y⇐I-goals referred to by S⇐P-goal and P⇐S-goal consists of three components as follows:

I: a role to attain the Y⇐I-goal. A member who plays I role (I-member) is expected to attain his/her I-goal by attaining the Y⇐I-goal.

You: a role as a partner for the I-member.

G:I: an I-goal which means what the I-member attains.

Each W-goal can be expressed by a set of Y⇐I-goals and I-goals. We can identify a group formation to start an effective collaborative learning session with these goals.

3 Advantages and Remaining Tasks of Learning Goal Ontology for Forming an Effective Learning Group

In a traditional classroom, sometimes a teacher divides students into several subgroups, and then the students start collaborative learning in the subgroup all at once. Such collaborative learning does not ensure educational benefits for every student, because it depends on a student's knowledge/ cognitive state whether collaborative learning is effective or not, and progress in learning differs from student to student.

So, we have been proposing a network-based new learning environment to support individual learning and collaborative learning dynamically. In the environment, each learner is solving problems individually with an ITS. When the ITS detects a desired situation for a learner (triggered-learner) to shift from individual learning mode to collaborative learning mode, the ITS forms an effective learning group for the learner, and then the members of the group start a collaborative learning session. In the group, not triggered-learner but every member should be ensured to attain individual learning goals through specific interaction with the other members. To encourage the interaction, every member is assigned a specific role in the group. When the members attain their learning goals, they close the session and return individual learning mode. We call the idea of dynamic group formation *"Opportunistic Group Formation (OGF)"*.

With our Learning Goal Ontology we can represent the several group formations whose effectiveness is ensured by learning theories. It means that the ontology brings the following benefit: When a personal goal for a learner (*i.e.*,I-goal or Y⇐I-goal) is decided, we can identify learning theories which propose learning groups to facilitate that the learner attain the personal goal. And then, we can form a specific group and identify roles assigned to the members of the group according to the theory.

If there are many theories to enable a learner to attain a specific personal goal, we can form many learning groups supported by the theories as candidates. Then, we have to narrow down the candidates to one. How can we select one?

Each learner plays a specific role in collaborative learning session. Every role has necessary conditions which should be satisfied by a learner who plays the role. The conditions will work as constraints to narrow down the candidates. If there are still some candidates after checking the conditions for role assignment, there are no rules for conflict resolution between all possible learning theories.

One might want to select one of the most profitable theory-based learning groups for a learner to attain a personal goal. Every theory expresses a different learning situation. The differences between theories do not mean the differences of the degree of effectiveness, but diversity of means to attain a goal. So, it is hard to compare a theory with the others on the effectiveness for helping a learner attain a personal goal.

There is another solution of the problem for narrowing down the candidates to one. Are learning theories exclusive each other? If the candidates can be integrated into one, a stronger learning group will appear: a learner is expected to attain a personal learning goal through some kinds of interaction, and each interaction is justified by a learning theory.

4 Is a Learning Theory Exclusive or Harmonious with Other Theories?

In actual learning environment, teachers often adopt the style of collaborative learning. If the group includes a member L_A whose knowledge base and/or experiences are relatively poor, it would be difficult for L_A to discuss with other members and to solve a problem collaboratively. L_A is expected to grow into a senior through practice in the group. This type of learning group is similar to the group based on the theory "LPP" which describes a process in which a newcomer grows into a senior[15, 16]. Fig. 5 shows typical learning group formation the W-goal "LPP" where three learners: L_A, L_B and L_C are participating. As a whole group, all members solve a problem collaboratively, and L_A is regarded as a **Peripheral Participant** and $\{L_B$ and $L_C\}$ are regarded as **Full Participants**.

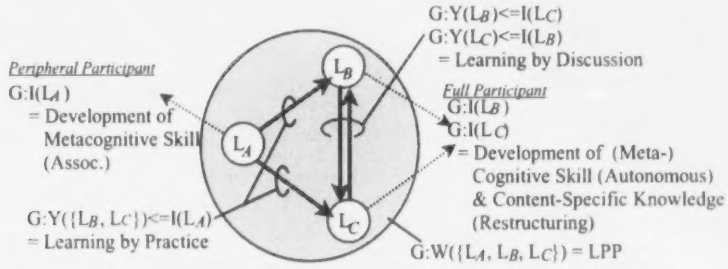


Fig. 5. An Example of Group Formation: LPP

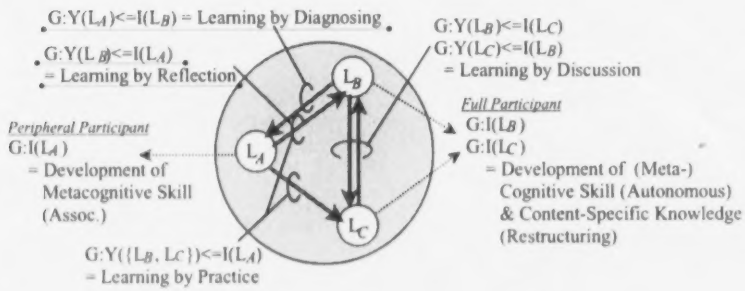


Fig. 6. An Example of Actual Learning Group

In this case, many skillful teachers will arrange for an excellent learner (*e.g.*, L_B) to help L_A in the group. For example, when a new student comes to our laboratory, a senior student may work as a tutor for the new student. Fig. 6 shows this type of learning group formation. We can find additional Y⇐I-goals between L_A and L_B in Fig. 6 as compared with Fig. 5. The teacher will expect different types of interaction between L_A and L_B, which bring additional educational benefits to them. This type of group formation can not be interpreted by a single learning theory.

In a learning group supported by "LPP", can all Peripheral Participants grow up into full participants? According to the theory "LPP", a learner (*i.e.*, Peripheral Participant) can acquire knowledge on the community and develop his/her (meta-) cognitive skills only by the learner's own practice. It is not assumed the other learners (*i.e.*, Full Participants) help the Peripheral Participant grows up. It seems that there is a gap between the Peripheral Participant and the Full Participant. Especially concerning the development of (meta-) cognitive skills, a Peripheral Participant can observe not the process in which

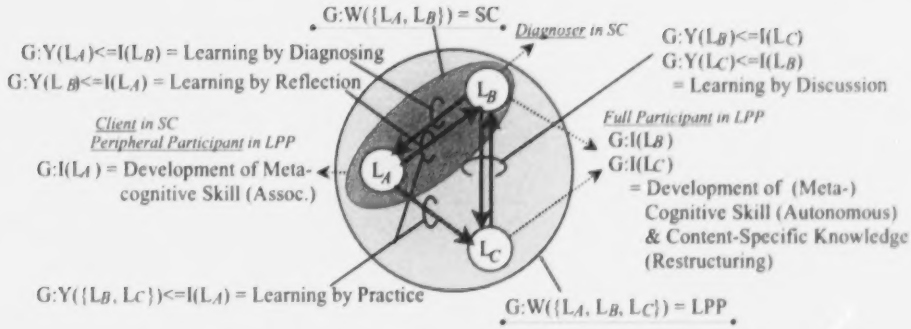


Fig. 7. An Example of Combined Learning Group: W-goal LPP & SC

a Full Participant uses the skill, but input and output for using the skill. It is difficult to learn the process by observing only input and output.

Concerning the W-goals, both W-goals "AI"[4] and "SC"[26] assume to have a "poor learner" who engages to solve a problem and a "helper" for the learner. The W-goal "AI" has a **Problem-Holder**, who has a difficulty in solving a problem, and an **Anchored Instructor**, who diagnoses the Problem-Holder's problem and gives advice to him/her. Similarly, the W-goal "SC" has a **Client**, who externalizes his/her own thinking process, and a **Diagnoser**, who diagnoses the Client's thinking process and evaluates the process. In both W-goals, a "poor learner" is expected to attain his/her I-goal, by a "helper"'s advice. Each of these W-goals can be combined with one of the other W-goals. That is, if it is difficult for a learner to attain an I-goal, we can combine the W-goal "AI" or "SC", and one of the other W-goals to help the learner attain the I-goal.

In the case of Fig. 6, we can interpret the group as a combination of two groups. One group ($Group_i$) consists of two Full Participants ($L_B$and L_C) and one Peripheral Participant (L_A). The W-goal of $Group_i$ is "LPP". Another group ($Group_j$) consists of a Client (L_A) and a Diagnoser (L_B), and the W-goal of the group is "SC". Fig. 7 shows the combination of two groups. In this learning group, $L_A$is expected to participate in the session more easily thanks to the help of L_B. For L_B, it is an opportunity for diagnosing L_A's authentic problems and helping $L_A$to participate in the collaborative learning session. Through the experience, we can expect $L_B$to develop his/her cognitive skill in two ways. For L_C, he/she will be able to get the same educational benefit with participating in the group shown in Fig. 5, because his/her activity is equal between the both groups.

For the combination of theory-based learning groups, the role of ontology is to clarify principles of combination. In combined groups, it should be guaranteed that all members can attain their own learning goals. At this stage, we store possible patterns of combining some theory-based learning groups as a pattern library. The ontology should not only represent the patterns, but also the principles which express the design rationale why the groups can be combined into one. When we can clarify the principles, an intelligent educational support system will be able to infer an effective learning group formation based on the principles opportunistically: The group formation is not picking up an appropriate one from the static pattern library. In this paper, we have described the possibility of combination the W-goal "AI" or "SC", and other W-goals. We have to consider the other types of combination.

5 Conclusions

We have discussed Learning Goal Ontology which will be able to make it easier to form an effective collaborative learning setting and to analyze the educational functions for a learning group. By considering the personal and common goals, we have identified three kinds of learning goals; I-goal, Y⇐I-goal and W-goal. In this paper, we described the outline of Learning Goal Ontology, and summarized advantages and remaining tasks for the ontology. We proposed possibility that theory-based learning groups can be combined into one in order to help a learner attain his/her learning goals and showed an example of effective learning group formation which is formed by combining multiple theory-based learning groups. With the ontology, it will be possible to compare and synthesize the learning theories to design the collaborative learning settings.

At this stage, we mainly focus on the learning goals. Future work includes to construct ontologies on remaining concepts in Collaborative Learning Ontology. Advantage of collaborative learning includes emotional factors: *e.g.*,motivation, familiarity. It is also our future work how to treat these factors.

References

1. Anderson,J.R. "Acquisition of Cognitive Skill", Psychological Review, vol.89(4), pp.369-406, (1982).
2. Bandura, A. "Social Learning Theory", New York: General Learning Press, (1971).
3. Bransford, J. D., Vye, N., Kinzer, C., & Risko, R. "Teaching thinking and content knowledge: Toward an integrated approach", In. B. Jones & L. Idol (Eds.) Dimensions of thinking and cognitive instruction. Hillsdale NJ: Erlbaum. pp. 381-413, (1990).
4. Cognition and Technology Group at Vanderbilt. "Anchored instruction in science education", In: R. Duschl & R. Hamilton (Eds.), Philosophy of science, cognitive psychology, and educational theory and practice. Albany, NY: SUNY Press. pp. 244-273, (1992).
5. Collins,A. "Cognitive apprenticeship and instructional technology", In: Idol, L., & Jones,B.F. (Eds.) Educational values and cognitive instruction: Inplications for refoem., Hillsdale, N.J.: L. Erlbaum Associates, (1991).
6. Cooke, N.L., Heron, T.E., & Heward, W.L. "Peer tutoring: Implementing classroom wide programs", Columbus, OH: Special Press, (1983).
7. Endlsey, W.R. "Peer tutorial instruction", Englewood Cliffs, NJ: Educational Technology, (1980).
8. Fitts,P.M. "Perceptual-Motor Skill Learning", In: Melton,A.W. (Ed.), Categories of Human Learning, Now York: Academis Press. pp.243-285, (1964).
9. Flavell, J. H. "Metacognitive aspects of problem-solving", In L.B. Resnick (Ed.), The nature of intelligence. Hillsdale, NJ: Erlbaum. pp.231-235, (1976).
10. Ikeda, M., Hoppe, U., & Mizoguchi, R. "Ontological issue of CSCL Systems Design", Proc. of AI-ED 95, pp.234-249, (1995).
11. Ikeda, M., Go, S., & Mizoguchi, R. "Opportunistic Group Formation", Proc. of AI-ED 97, pp.166-174, (1997).
12. Inaba, A., Ikeda, M., Mizoguchi, R., & Toyoda, J. "The Learning Goal Ontology for Collaborative Learning", http://www.ai.sanken.osaka-u.ac.jp/~inaba/LGOntology/, (1999).
13. Inaba, A. & Okamoto, T. "The Intelligent Discussion Coordinating System for Effective Collaborative Learning – What is the role of artificial intelligence in supporting collaboration? –", AIED 97: Workshop Notes IV, pp.26-33, (1997).
14. Inaba, A., Supnithi, T., Ikeda, M., Mizoguchi, R., & Toyoda, J. "How Can We Form Effective Collaborative Learning Groups? – Theoretical justification of "Opportunistic Group Formation" with ontological engineering –", pp.xx-xx, (2000).
15. Lave, J. "Cognition in practice: Mind, mathematics and culture in everyday life", Cambridge University Press, (1988).
16. Lave,J. & Wenger, E. "Situated Learning: Legitimate peripheral participation", Cambridge University Press, (1991).
17. Mizoguchi, R., & Bourdeau, J. "Using Ontological Engineering to Overcome Common AI-ED Problems", IJAIED, 11, (2000).
18. Mizoguchi,R., Ikeda,M., & Sinitsa,K. "Roles of Shared Ontology in AI-ED Research", Proc. of AI-ED 97, pp.537-544, (1997).
19. Piaget, J., & Inhelder, B. "The Psychology of the Child", New York: Basic Books, (1971).
20. Rumelhart, D.E., & Norman, D.A. "Accretion, Tuning, and Restructuring: Modes of Learning", In: Cotton, J.W., & Klatzky, R.L. (Eds.) Semantic factors in cognition. Hillsdale, N.J. : L. Erlbaum Associates., pp.37-53, (1978).
21. Salomon, G. "Distributed cognitions", Cambridge University Press, (1993).
22. Spiro, R. J., Coulson, R., L., Feltovich, P. J., & Anderson, D. K. "Cognitive flexibility: Advanced knowledge acquisition ill-structured domains", Proc. of the Tenth Annual Conference of Cognitive Science Society, Erlbaum, Hillsdale, NJ, pp.375-383, (1988).
23. Spiro, R. J., Feltovich, P., J., Jacobson, M., L., & Coulson, R. L. "Cognitive flexibility, constructivism, and hypertext: Random access instruction for advanced knowledge acquistion in ill-structured domains", http://www.ilt.columbia.edu/ilt/papers/Spiro.html (1995, accessed on March 2000).
24. Supnithi, T., Inaba, A., Ikeda, M., Toyoda, J., & Mizoguchi, R. "Learning Goal Ontology Supported by Learning Theories for Opportunistic Group Formation", Proc. of AIED99, (1999).
25. Vygotsky, L.S. "The problem of the cultural development of the child", Journal of Genetic Psychology, vol.36, pp.414-434, (1929).
26. Vygotsky,L.S. "Mind in Society: The development of the higher psychological processes", Cambridge, MA: Harvard University Press, (1930, Re-published 1978).

Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

Gin-Fon Nancy Ju, Soochow University
70 Lin-Shi Rd. , Taipei , Taiwan, R.O.C.
E-mail : gju@mail.scu.edu.tw

This research was to investigate the current situation of computer network usage, frequency and purposes between university students and occupational groups in Taiwan. The research also analyzed the influences of its related factors on computer network usage, such as computer experience background, the attitudes toward computers, personality, aptitudes, critical thinking ability, academic achievement and so on. The subjects of university students were sampled from the Soochow University. The subjects of occupational groups were sampled from various occupations. The Computer Experience Background Scale and the Computer Attitude Scale were conducted by author for this research. Lai' s Personality Scale, Differential Aptitude Tests and Critical Thinking Appraisal are three published tests selected appropriately by the author and used for the research purposes. Academic achievement in the research was based on the students GPA.

According to the computer network usage of university students, 150 students were sampled in 1997. The network usage was classified into three types of purposes: (1) information searching, (2) BBS, (3) e-mail. The findings were that the students used computer network for searching information the most frequently, then for BBS, for e-mail the least frequently. Besides, the male students significantly used computer network more frequently than the female students, especially for the usage of information searching and e-mail purposes. About computer experience background and the attitudes toward computers, the students who have more computer experience background and who have more positive attitudes toward computers significantly used computer network more frequently where the influences from computer experience background was larger than the influences from computer attitudes.

Since the subjects from the university students can be arranged and administered by the Lai' s Personality Scale, Differential Aptitude Tests and the Critical Thinking Appraisal, and their GPA can be retrieved from the university, therefore, the relationship between computer network usage and personality, aptitudes or critical thinking ability were analyzed. The findings of the Lai' s Personality Scale were that the students who were more objective, less depressed, and less nervous significantly used computer network for information searching purposes more frequently. The students who were

more social types of personality significantly used computer network for BBS purposes more frequently. The students who were more worry and distress significantly used computer network for e-mail purposes more frequently. The Differential Aptitude Tests was found that the aptitudes of arithmetic and abstract reasoning were significantly positively correlated with the frequency of computer network usage for BBS purposes. None of critical thinking abilities was significantly related to the computer network usage. The students' GPA was not found to be significantly related to the computer network usage either.

Since we sampled 110 university students for the same survey again in 2000, the changes of the computer network usage by time sequence were investigated in this research. It was found that no matter the usage of information searching, BBS, or e-mail purposes, the university students in 2000 have significantly more frequency in using computer network than the students in 1997. The university students in 2000 yielded significantly more computer experience background than did the students in 1997 too. However, for the attitudes towards computers, the university students in 2000 did not make significantly difference from the students in 1997. These results indicated that university students always respected the importance of computers in their lives. They significantly used computer network more and more by years. As a matter of fact, computer network will be the main tool to get survived in the future hi-tech world.

For surveying computer network usage of occupational groups, 115 adults were sampled in 1999. It was found that they significantly used computer network for information searching and e-mail more frequently than for BBS. No gender effect was found to be related to the usage of computer network. In addition, the more computer experience background the occupational groups have, the more significantly frequently they used computer network. However, their attitudes toward computers were not significantly related to the computer network usage. The results of age stages showed that the elder people significantly used computer network less frequently than the younger people.

General speaking, the occupational groups used computer network for e-mail purposes significantly more frequently but for BBS significantly less frequently than did the university students. The occupational groups significantly yielded more computer experiences than did the university students. It has to be mentioned here that since we sampled university students and occupational groups in different years, these results might confounded with the time effects. Further research and experimental design were suggested to verify these problems.

Reference

[1] Sternberg, R. J. "Diversifying Instruction and Assessment." Educational-Forum 59, p47-52. 1994

[2] Watson, G. & Glaser, E. M. "Critical Thinking Appraisal." The Psychological Corporation, Harcourt Brace Jovanovich, Inc. 1980

Online Education: A Learner-Centered Model with Constructivism

Kam Hou VAT
Faculty of Science & Technology
University of Macau, Macau
fstkhv@umac.mo

This paper describes the initiative to construct a WWW-enabled course and project support environment for undergraduate education, aimed to uphold the constructivist's ideas of active learning. The system is intended to create learning experiences that invite students to construct knowledge and to make meaning of their worlds of learning. In particular, we discuss the educational framework of our design through the Problem-Based Learning (PBL) approach, from the perspectives of the architect of the intellect. We also describe the incremental prototyping process of software development, through scenarios of participatory design of our students in Software Engineering at the author's affiliated faculty. The paper concludes by discussing the challenge of implementing the fully functioning constructivist WWW-based environment through blending the art and science of teaching into creative cognitive designs.

Keywords: **Constructivism, Problem-Based Learning (PBL), Learner-Centered Philosophy**

1 Introduction

With the advent of the World Wide Web (WWW or Web) towards the end of the 20th Century, the use of this Internet-based hypermedia technology in education has become the trend of today. The Web is aimed to facilitate learning in different disciplines, and is becoming the major driver to construct numerous experimental Web-based support environment in campuses around the globe. However, online education in the form of Web-based instructions (WBI) or Web-enabled learning environment, without an anchoring philosophy of education, could easily become a technology-rich educational wasteland. The theme of this paper is to investigate how the insights of our educational visionaries [5] could be designed into our Web-based support environment, to suit the unique schemata of individual learners. Actually, such designs require rigor in identifying certain essential elements of the constructivist architecture. And they represent challenges to the learning in our daily classrooms, which has typically involved having students repeat newly presented information on tests or in reports. Constructivist teaching practices help learners internalize, or transform new information, which in turn makes further understanding possible. Therefore, as instructional designers, the guiding question in tackling our Web-based design is this: How do we create a technology-enhanced learning environment that engages students in the types of activities that will take on their initiative and responsibility for their own learning?

2 Project Background

In the spring of 1999, a group of junior students in Software Engineering, initiated an informal study group (ISG) [15] with the author's facilitation. The ISG's mission is to help students develop their team-based technical interest in preparation for their graduation project. And we started exploring the ongoing development of Web-based distributed applications with online education as one of our first discussion topics. During the discussion, the author, as an instructor, expressed his difficulties in traditional classroom setting, to recognize students' intellectual and motivational problems, to explain to them a difficult part of the subject matter, to provide clear tasks, and to coach students in specific problem-solving activities. These issues indeed go far beyond the classroom walls. As students, they expressed their need for a learner-centered atmosphere whose focus is put on the needs, skills, and interests of the learners, and whose goal is

to encourage active exploration and construction in the course of learning activity. Likewise, we developed the initial dea of creating an environment where anyone is free to learn, to construct and refine new meaning in one's own learning, and to have enough channels to ask for help, when necessary, in the form of some extended service of a good teacher. We continue our expedition into Web-based technology to turn out the project ideas of creating a) a course support environment for active learning, and b) a project support environment for problem-based learning (PBL). The former has been given the project name **REAL** [13] to imply a Rich Environment for Active Learning, while the latter, **SUPER** [14] to denote SUitable and Practical Educational Resources for group-based project work. And in either project, we have not ruled out the familiar face-to-face classroom interactions between teacher and students, as one of the essential aspects of the learning process.

3 Pedagogical Intakes

In selecting the pedagogy of our Web-based environment, we have borrowed from the legacies of our educational visionaries in blending the art and science of constructivist teaching. John Dewey's designs embedded learning in experience [3]. He advocated field studies and immersion in experiences to stimulate learning. Jean Piaget's work influences constructivist educators through designs of discovery learning [9]. Students manipulate subject matter and objects representing the subject matter as they interpret their findings. He believed that learners' internalization leads to structural changes in how they think about something as they assimilate incoming data. Today, constructing meaning on the basis of one's interpretation of data is the heart of science inquiry, problem-based learning models, and case studies. Lev Vygotsky's theory [16] suggests that we learn first through person-to-person interactions and then individually through an internalization process that leads to deep understanding. This belief in the social process of idea making permeates today's interactive classroom led by skillful teacher questioning. Reuven Feuerstein's mediated learning theory [4] refutes the concept of an unchanging intelligent quotient (IQ) and leads to intense examination of how the classroom affects students' metacognition. He believes that the discovery process requires intervention from the teacher to guide learning. On examining the varied work of the master architects, and trying to crystallize the essential elements of the constructivist architecture, we see an array of tools emerging. They include a learner-centered curriculum; enriched environments; interactive settings; differentiated instruction; inquiry, experimentation, and investigation; mediation and facilitation; and metacognitive reflection.

4 Instructional Design

We expect the instructional design of our Web-based support should increase student participation and communication through re-designing the delivery of college lectures to incorporate more student online activities and instructor's feedback before, during and after the contact session. The environment is expected to develop students' abilities to generate problems, to engage in collaboration, to appreciate multiple perspectives, to evaluate and to actively use knowledge. From the designers' standpoint, we have included the following enabling ideas:

a) *Enable students to determine what they need to learn through questioning and goal setting.* It is believed that students should work to identify their knowledge and skill deficits, and to develop strategies in the form of personal learning goals for meeting those deficits. The emphasis is to foster a sense of students' ownership in the learning process. If teachers, through the Web-based support environment, can guide the students in identifying what they already know and what they need to learn, then knowledge gaps and mistakes can be viewed in a positive way such as another opportunity to learn. And students can assume more responsibility in addressing their own learning needs during any instructional unit.

b) *Enable students to manage their own learning activities.* It is believed that students should be enabled to develop their learning plans, which should describe priorities, instructional tactics, resources, deadlines, roles in collaborative learning situations, and proposed learning outcomes, including presentation and dissemination of new knowledge and skills, if applicable. Traditionally, these instructional events are arranged by teachers to be obeyed by students, in order to accomplish a specified set of pre-determined objectives. Yet, it is not advantageous for students to learn to be self-directed. To manage their own learning activities, students must be guided and supported by the teacher, through the Web-based environment, slowly taking on more and more responsibility of their own learning.

c) *Enable students to contribute to one another's learning through collaborative activities.* It is believed that

students should be encouraged and supported to discuss and share their personal findings. Particularly, we should enable students to become co-builders of the course/learning resources through evaluating and refining the entries their peers put into the Web-based depository. Collaborative group-based learning seems appealing to achieve the purpose. Students, nevertheless, must be educated to recognize what they are trying to learn in group-work, value it, and wish to share that value with others. Teachers can provide this sense of accountability and belonging by structuring students' work in the support environment with such concept as computer-supported cooperative work (CSCW).

It is convinced that the efficacy of the learning environment is a function of many complex factors, including curriculum, instructional methodology, student motivation, and students' developmental readiness. Trying to capture this complexity onto the design of our Web-based environment, is more an ongoing iterative process than a one-time activity. So we develop scenarios of situated learning support applicable to both individual course taking and group-based project work. These scenario-based supports are then incorporated into the environment incrementally, subject to our students' participatory testing.

5 Scenario-Based Support

Imagine attending a class where the instructor, after giving an introduction of what the course is entailed, invites you to visit his/her course support environment on the Web. On entering the Web-based environment, you are offered the privilege of creating your own personal space in the form of a customizable Web page guarded by your self-assigned identifier and password. Within your personal Web space, you are furnished with some tools to start your Web-life. These include a communications facility to keep one another in touch (email and newsgroup); a calendar planner to track your appointments or commitments (meetings or homework due dates, or project deadlines); and a frequently-asked-questions (FAQ) tool to send for instructor's help when encountering difficulty in housekeeping the personal space. Also, there are pathways to other service modules:

a) Course Information. This module provides such information as the course description, pre-requisite requirements, evaluation policy, references list, and other details such as time and location of the lectures. It also includes links to the instructor's contact details, his/her teaching/research profile, and the course schedule showing timetable for class with links to the study materials before, during and after contact sessions. Also included is the announcement service representing the most up-to-date information sent to the students from the instructor.

b) Course Resources. This module comprises the study materials prepared by the instructors, and the contributions representing students' submitted or reported work of interest to other students. Study materials can further be cataloged and managed as different resources: study notes, tutorial handouts, supplementary lecture details, or Web-links in the Internet. It could also include FAQs of the course: homework, quiz's, tests, examinations, and projects.

c) Course Assessment. This module keeps track of students' performance. The score each student obtained after completing a specific activity is recorded with enough details for evaluation at the end of the course. Students are encouraged to propose their own study plan to earn the accumulated score required, to complete the course. This service is designed into the Learning Contract [7] component to individualize the learning process for any individual learner. Typically, a student is required to write a formal agreement, which details what will be learned, how the learning will be accomplished, the period of time involved, and the specific evaluation criteria to be used in judging the completion of the learning.

d) Course Inquiry. This module fulfills several requirements of the teacher-student inquiry interaction. These include: a) a sense of dedicated space for an extended collaboration between teacher and student; b) an incremental delivery of inquiry results from teacher to student; and c) visibility of the inquiry interactions to avoid duplicating effort, and to encourage discovery of related interests. When an inquiry is initiated by a student, a request Web page is generated which is specific to that interaction and to which the teacher and student return frequently for their interaction. This request Web page (meeting space on the Web), contains the relevant material required for the specific inquiry interaction, say, contact details of the student and the teacher in the form of Web links or email addresses. Each request Web page supports several types of interaction: posting comments, recording actions, uploading/downloading files. These can be carried out at any time in any order. This feature is designed to support the often-time extended discussion and incremental result delivery of the teacher-student collaboration. Also, since the completed

request Web page could be visible to any registered student or teaching staff within the Faculty intranet, this increases the general awareness of the teacher's activities in consulting students, and avoids duplicating efforts of other staff in dealing with similar questions from students. More importantly, when users browse the inquiry activities over the Web, they are always exposed to information as to who was involved in what, and eventually they will learn about one another's specialties and interests. Hopefully, they will form communities centered about specific knowledge and interest; such are considered as important assets of any educational institute.

Now, on visiting the Web-based support environment and reading the latest announcement for the next lesson, you are aware that the next lesson is about group-based project work. According to the instructor's message, group project work is an essential component of any academic degree; many professional societies worldwide emphasize project and group work as preparation for professional practice. Also, you are to follow the problem-based learning (PBL) approach to work in teams. And you will be introduced to the teaming process and the PBL support of the Web-based environment.

6 Problem-Based Learning (PBL)

It is understood that project work is recognized as having many educational and social benefits, in particular providing students with opportunities for active learning. However, teaching, directing and managing group project work is not an easy process. This is because projects are often: *expensive* demanding considerable supervision and technical resources; and *complex* combining design, human communication, human-computer interaction, and technology to satisfy objectives ranging from consolidation of technical skills through provoking insight into organizational practice, teamwork and professional issues, to inculcating academic discipline and presentation skills. In preparing our students to get started with group-based project work, we have oriented towards the PBL learning model. According to the literature [1, 2], the modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management.

6.1 PBL Pedagogy

The PBL approach focuses education around a set of realistic, intrinsically motivating problems to fit the interests and needs of the learners. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how [10]. When applied to the course setting, PBL should encourage students' active participation, and develop in them self-directed learning and problem-solving skills while they interact, discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and final reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

6.2 PBL Activities

Students, on being presented with a problem or scenario, are made aware that initially they will not possess enough prior information to solve the problem at hand or to clarify the scenario immediately. These problems are often ill-structured, but devised according to concrete, open-ended situations. They are reminded that they must identify, locate, and use appropriate resources, and ask questions referred to as "learning issues" on the various aspects of the problem. These learning issues should help them realize what knowledge they require to construct a solution, and thus focus their learning efforts and establish a means for integrating the information they acquire. Often, they are encouraged to perceive themselves as managers of their own in terms of time, material resources, and the complexity of the problems that can be handled one at a time by the group. It is expected that the PBL students have to iterate through some relevant stages of activities: analysis, research, and reporting, with discussion and feedback from peers and the instructor at each stage.

• *Analysis.* Throughout this stage, students organize their ideas and prior knowledge related to the problem, and start defining its requirements. This helps them devise a specific statement of the problem. Meanwhile, they are encouraged to pose learning issues, defining what they know and what they do not know. This helps them assign responsibilities for research, eliciting and activating their existing knowledge as a crucial step in

learning new information.

• *Research.* Throughout this stage, students collect necessary information on specific learning issues raised by the group. They may conduct library searches, seek sources on the Internet, collect data, and interview knowledgeable authorities. More importantly, students teach themselves as they research their learning issues. It is intended that when they come to realize the complexity and texture of the problem, they may often see that information is a means to the ends of managing problems effectively.

• *Reporting.* At this stage, students report their findings to the group. Individual students become "experts" and teach one another. Subsequently, their discussion may generate a possible solution, or new learning issues for the group to explore further. Final solutions are constructed, and the facilitator's feedback should help students clarify basic information, focus their investigations, and refine their problem-solving strategies, besides addressing whether the original learning issues were resolved and whether the students' understanding of the basic principles, information, and relationships is sufficiently deep and accurate.

6.3 PBL Teamwork Experience

It is important that PBL students are taught how to work in teams and positively experience the team process because the team skills they acquire are applicable throughout their future careers. The PBL team process requires each team composed of 3-5 students, to be assigned a supervisor (instructor) and a client if applicable. The client's role is to clarify the project, and to resolve ambiguities as they arise, whereas the supervisor's is to guide, motivate and provide feedback to the team. Also, one of the team members is designated the team leader for the duration of the project, whose role is to coordinate the team activities, and to ensure effective team communications. The leader also has to interface with the supervisor, arrange meetings with clients when necessary, and facilitate meeting through setting agendas, taking minutes, and allocating tasks. Each team member has to help set the team goals, accomplish tasks assigned, meet deadlines, attend team meetings and take a turn editing a document to be submitted at the end of each major stage of project development.

Meanwhile, PBL students are made aware of the difficulties in teamwork throughout the project period. These include setting realistic project goals, carefully allocating tasks to team members, managing time, and communicating and managing shared group documents. Teams have regular meetings to which they invite their supervisor, and in which they organize themselves to manage the project. Students are often reminded of setting appropriate agendas before meeting, assigning enough time to the agenda items during meeting, restating the decisions made at the meeting, and converting decisions into action items after meeting. They are also advised on clearly separating the social and work aspects in meetings, and assessing each meeting for doing it better next time. Moreover, it is suggested that teams plan their project around major deadlines of individuals in the team thereby acknowledging the other commitments team members may involve.

Deadlines represent the milestones set down for the PBL students to submit project documents and to receive evaluation. Each team member is assessed by their supervisor and their team peers. The supervisor's evaluation is based on what each team member adds to the meetings and what the instructor perceives each member's contributions to the team to be. The peers' evaluation is based on a confidential rating sheet, to be completed by each team member at the end of each major phase of the project. This rating sheet should include each team member's contribution for that phase with explanatory comments. And the overall project assessment is made up of the group grade and the individual grade. The former is the same for each group member and is based on the quality of the documents produced and the product developed. The individual component is based on the quality of the student's contribution to the documents and the product, their participation in group-meetings, their commitment to the team process, and their professional attitude developed.

7 Scenario-Based PBL Support

Imagine you have just attended the second lesson on PBL and group project work. And you realize that the PBL support available in the Web comprises both the learning and performance aspects. These are actually a series of strategies and Web-based solutions that use instructional design principles to improve students' work-based performance according to the real-life PBL activities. And you are invited to visit the PBL-specific Web site to register as a PBL-user. The registration process invites you to fill in a Web form including a simple questionnaire for teaming purpose. You are now allowed to enter the PBL-support environment with your PBL identifier and personal password returned after the registration.

And for exploratory purpose, you have just navigated to the PBL Web page for the Software Engineering course *SFTW 300 Software Psychology* (Figure 1). Here you are presented with a number of projects to express your preferences to join through filling in another Web form activated by clicking the link "Join a Team" in the same page. You can then find out which team and project have actually been associated with you by clicking the link "Identify Your Team" also in the same page. On knowing which project to engage, you could click the suitable PBL Space link, i.e., "S300F99P3" in this case, to navigate to the suitable PBL Space (Figure 2). The PBL Space is assigned for each PBL group for project management on the Web. It contains links to the project itself, the PBL Group (including its members' links), the PBL Client, and the PBL Supervisor. Each of such links is associated with a set of related links for information and support of the project. Among the numerous support links in the PBL Group, you can find the *Work Space* link, which leads to the "Group Work Space" (Figure 3) Web page. This page contains links to individual group members and to specific PBL support, as well as to the project interim progress. Clicking on the individual member's link (PWS) leads to the "Personal Work Space" (Figure 4), where each group member's progress in terms of PBL activities (analysis, research, reporting, implementation) is tracked.

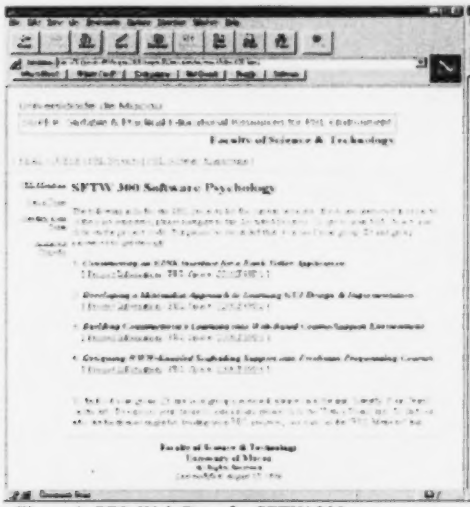


Figure 1: PBL Web Page for SFTW 300

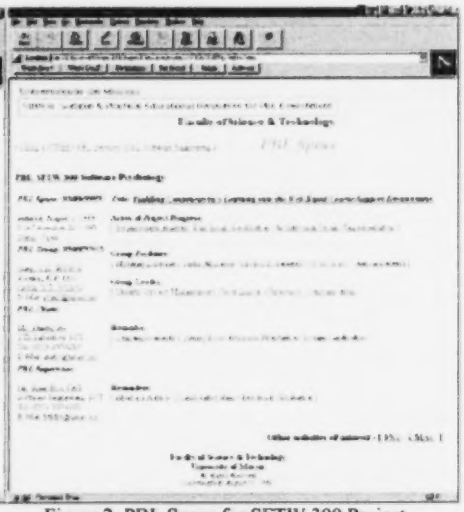


Figure 2: PBL Space for SFTW 300 Project

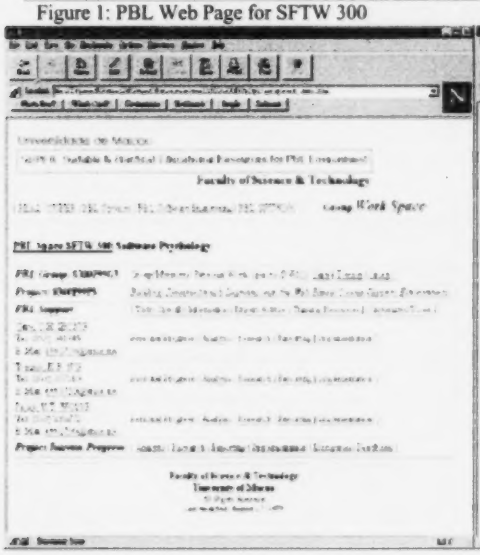


Figure 3: Group Work Space for a SFTW 300 Project

Figure 4: Personal Work Space for a SFTW 300 Project

BEST COPY AVAILABLE

8 Software Development

Our database-driven Web-based support environment has been developed as a series of distributed applications, by employing a mixture of object-orientation, client/server, and Internet (Web browsers, Web servers – HTML, HTTP, FTP) technologies, to deliver the desired support functionality. Such applications are largely event-driven because of the intensive graphical user interface (GUI) programming (e.g., handling the points and clicks) and/or because of the message exchanged between clients and servers over the Web. The specific types of individual Web applications constructed can be categorized into such classes as: a) static HTML-based, b) server-side (CGI-based) and c) client-side (Java-based or JavaScript-based). And the major steps followed to develop the distributed applications could be abstracted as follows:

a) Analysis. Establish users' requirements of what information are needed by whom and when, in terms of functionality, performance, security, operability, and management of the distributed applications. And develop an object model that shows conceptually how the information will be organized, accessed, manipulated, and presented in terms of objects.

b) Architecture. Partition the architecture concerns into: *data architecture*, determining what data sources (HTML, files, databases) will be needed, where they will be located, and how they will be accessed; *software architecture*, determining what will be written as CGI/Java code, what will be constructed as modules called by CGI/Java, where will the various objects/modules reside, and how they will be invoked (CORBA, RPC); *infrastructure architecture*, determining the servers where the home pages and the objects/modules will reside, the type of gateways that will be employed, the type of middleware that will be needed to invoke remote services and objects (CORBA, ActiveX, RPC, SQL), and the type of computing platforms (PC Windows, UNIX, Linux, Windows NT) used.

c) Implementation and Deployment. Build the HTML pages (including the Java-powered pages) by coding HTML or using filters that generate HTML from other data sources (e.g. Word documents). Then develop and test the software modules and objects. If necessary, purchase the appropriate infrastructure components. Fourth, test, install and deploy the system, followed by maintenance and the iterative re-design process.

9 Prototyping Process

The Web-based support in our online environment is developed incrementally through a user-driven iterative prototyping process, which involves our instructional designers, teachers, and students in the participatory development. This involves creating a series of function prototypes used to clarify the objectives of the system in light of design exploration between the designer and the users (teachers and students), so that the users gradually understand what can be achieved with the technology. Our knowledge of requirements, design and implementation may be incomplete in any one cycle; however, there has been progressive build-up of a structure, which will lead to the desirable system. Specifically, we have referred to the Dynamic Systems Development Method (DSDM) [12] for project guidance, which walks us through four main phases of the DSDM life cycle.

The *feasibility study* phase is to define the high level functional requirements of the environment, which refer to the educational support issues. This phase should produce an outline prototyping plan and establish the main non-functional requirements, such as the hardware and software to develop and deliver the system. The *functional prototype iterations* phase is to clarify the detailed requirements for the system. Its output includes a series of prototypes that demonstrate the main system functionality. These early visual prototypes are mainly used to clarify the system objectives between the designers and users. The *design prototype iterations* phase is to refine the functional prototype into a robust product after a more situated evaluation of system requirements. It involves satisfying all the non-functional requirements; i.e., producing a system that will work effectively on the target hardware in the organizational setting. It is understood that all the possible components of the system do not have to be developed in unison. Some may move on to the design and build phase while others are still at the functional clarification stage. The *implementation* phase involves placing the system in the user environment, carrying out any required training, reviewing the system and assessing further developments. The output should include a delivered system, user manuals/training, and project review document.

10 Conclusion

It is experienced that the conventional approach to education remains the instructivist one, in which knowledge is perceived to flow from experts to novices. This transmissive view of learning is most evident in the emphasis on lectures, in the use of textbooks to prescribe reading, and in the nature of tutorials and assessment methods. It assumes that the process of good teaching is one of simplification of the truth in order to reduce student confusion. Yet, this simplification could deny students the opportunity to apply their learning to dynamic situations. We question the transferability of the instructivist learning and ask how much of that which is assigned to academic learning ever gets applied to actual scenarios, when there is such a rapid surge in knowledge commonly associated with the birth of the "Information Age." This is a transference problem. Actually, the content product of learning is assuming a less important role relative to the process of learning as the life of information content shortens and the need for continual learning increases. In designing the Web-based support of our learner-centered environment, we have tried to reoriented towards a meaningful direction by reducing the obsession with knowledge reproduction. And PBL represents one such relief from the constructivist pedagogy. Greening [6] describes it as a vehicle for encouraging student ownership of the learning environment. There is an emphasis on contextualization of the learning scenario, providing a basis for later transference, and learning is accompanied by reflection as an important meta-cognitive exercise. Also, the implementation of PBL is done via group-based work, reflecting the constructivist focus on the value of negotiated meaning. Besides, it is unconfined by discipline boundaries, encouraging an integrative approach to learning, which is based on requirements of the problem as perceived by the learners themselves.

Undeniably, constructivism is a philosophy of learning that is having a major effect on the way that education is conducted today. In this paper, we have tried to spell out the working characteristics of constructivism [11], which have actively shaped the design of our Web-based support. These include: 1) Meaning is not transmitted. Instead, learning occurs as a process of adjustment of existing concepts. 2) Understanding is based on interaction among a complex weave of factors, such as the learners' goals and existing concepts, the content of the learning experience, the context where the learning occurs. 3) Puzzlement motivates learning. This sense of dissatisfaction emerges from experiences that threaten existing conceptual structures. 4) Social negotiation and viability are the principle forces involved in the evolution of knowledge. They ensure that learning is anchored both by the learning community and by the need to test constructions against reality. The effects of such testing are the adjustments in the structure of concepts held by the learner. So, one thing is evident: constructivist learning experiences can exert high cognitive demands on learners [8], and not all learners could respond well to the challenge. We believe the constructivist ideas assembled here make up what we might call pragmatic constructivism. Namely, constructivism could be viewed as a toolbox for problems of learning. If a particular approach does not solve the problem, try another. In keeping with this flexibility, active, social and creative learning can play out in rather different ways, depending on the circumstances. Although the term constructivism suggests a single philosophy and a unique potent method, there is not such thing as a one-size-fit-all. Rather, our suggestion is to look at constructivism like a Swiss knife with various blades for various needs. That is also the learner-centered philosophy behind our Web-based support for online education.

References

[1] Albanese, M., and Mitchell, S., " Problem-Based Learning: A Review of Literature on Its Outcomes and Implementation Issues," Academic Medicine, Vol. 68, No. 1, 1993, pp. 52-81.

[2] Barrows, H., " How to Design a Problem-Based Curriculum for the Pre-Clinical Years," New York: Springer, 1985.

[3] Dewey, J., " Experience and Education," New York: Macmillan, 1938.

[4] Feuerstein, R., " Instrumental Enrichment: An Intervention Program for Cognitive Modifiability," Baltimore: University Park Press, 1980.

[5] Fogarty, R., " Architects of the Intellect," Educational Leadership, Vol. 57, No. 3, 1999, pp.76-78.

[6] Greening, T., " Scaffolding for Success in Problem-Based Learning," Medical Education Online, 3(4) 1998, pp.1-15. http://www.utmb.edu/meo/

[7] O' Donnell, J.M., and Caffarella, R.S., "Learning Contracts," In M.W. Galbraith (Ed.), Adult Learning Methods. Malabar, Florida: Krieger Publishing Company, 1990, pp. 133-160.

[8] Perkins, D.N., "What constructivism demands of the learners?" In T.M. Duffy & D.H. Jonassen (Eds.), Constructivism and the Technology of Instruction: A Conversation (pp. 161-165). Hillsdale, NJ:

Erlbaum 1992.
[9] Piaget, J., "Piaget's Theory," In P. Mussen (Ed.), Carmichael's Manual of Child Psychology. New York: Wiley, 1970.
[10] Ryan, G., "Student Perceptions about Self-directed Learning in a Professional Course Implementing Problem-Based Learning," Studies in Higher Education, Vol. 18, 1993, pp. 53-63.
[11] Savery, J.R., and Duffy, T.M., " Problem-Based Learning: An Instructional Model and its Constructivist Framework," Educational Technology, 35(5) 1995, pp. 31-38.
[12] Stapleton, J., "DSDM: Dynamic Systems Development Method – The Method in Practice.," Addison Wesley, 1997.
[13] Vat, K.H., "REAL: Towards a WWW-Enabled Course Support Environment for Active Learning," Faculty Technical Report, FST/SE-1999-01, University of Macau, Macau.
[14] Vat, K.H., "SUPER: Towards a WWW-Enabled PBL Support Environment for Software Engineering Education," Faculty Technical Report, FST/SE-1999-02, University of Macau, Macau.
[15] Vat, K.H., "Training E-Commerce Support Personnel for Enterprises through Action Learning," In Proceedings of the 2000 ACM SIGCPR Conference, Chicago, Illinois, USA, Apr. 6-8, 2000, pp.39-44.
[16] Vygotsky, L.S., "Mind in Society: The Development of Higher Psychological Processes," Cambridge, MA: Harvard University Press, 1978.

Peer Help for Problem-Based Learning

Susan Bull and Jim Greer
ARIES Laboratory, Department of Computer Science,
University of Saskatchewan, Saskatoon, SK S7N 5A9, Canada.
bull@cs.usask.ca, greer@cs.usask.ca

This paper describes the I-Help peer help network, where helpers and helpees are paired according to the contents of their user models. Although originally designed for large groups, in this paper we suggest ways in which I-Help may be used in a small group, problem-based learning curriculum. The use of I-Help will be very different in this context: it is not expected to be necessary for all students. However, some learners may experience difficulties with some aspects of problem-based learning, such as: scheduling of meetings; involvement in discussions; understanding roles; acquiring skills for problem-based learning; different interaction preferences; differences in cognitive styles. We describe how I-Help may be used to alleviate some of these difficulties, in particular: by putting groups into contact with other groups; or putting individuals into contact with someone outside their group who can advise, or who is facing similar problems, and would like to explore the issues jointly. At the same time, group cohesion is not disrupted.

Keywords: **peer help, problem-based learning, student modelling.**

1 Introduction

Problem-based learning (PBL) is used in many academic subjects (e.g. architecture, business, education, engineering, law, medicine). The first implementations were in medical education, and PBL is still used in many medical sciences courses today. We therefore focus on medical education in this paper, though many of the arguments are applicable to a range of subjects.

Medicine is a difficult subject to teach and learn: the knowledge to be acquired and integrated is broad and very complex. This knowledge is useful only if it can be applied to problems presented by real patients. Such problems are ill-structured, specified with partial information, and often complicated by diverse interacting factors. While acquiring basic domain knowledge is a fundamental activity in medical education, integrative problem-solving is also a fundamental goal.

PBL attempts to focus learning around authentic patient problems or cases, which bring together many interacting issues of a multidisciplinary nature. A core aspect of PBL is that problems should be only partially specified. PBL involves the student in a practical activity, carried out in small groups (usually 4-8, facilitated by a tutor) in which students identify and research their own learning issues [17]. Typically a group will meet to discuss a case, identify learning issues, and then research these individually using a variety of resources (e.g. print-based, web-based and people). They then meet again to report and discuss the case further.

Investigations into the benefits of PBL have produced mixed results, possibly in part because traditional assessment mechanisms are less appropriate measures of the goals of PBL [13,30]. It is stressed that there is, as yet, no evidence that a PBL curriculum is more successful than a traditional approach [27]. Nevertheless, PBL has been embraced by some as the preferred approach to medical education, advantages cited including: the self-directed nature of PBL [27]; a greater tendency towards a deep approach to learning [21]; and positive student attitudes [6]. Others suggest that acquisition of basic domain knowledge may not be well supported in PBL. Learners may later recall less factual knowledge, since they are spending time learning other skills in addition to content [30], and they may lack depth of knowledge [18]. Explanations generated by PBL students can be less coherent, and more frequently incorrect [23]. Learners may also become bored with the PBL process [29]. It has also been recognised that PBL may simply not suit all students' ways of learning [10]. While the peer help system described in this paper can assist in a number of areas, it is this latter aspect that we focus on here.

This paper is neither a critique nor an endorsement of PBL. However, we emphasise that in PBL (as in traditional education), there is a need for tools to support peer interaction for situations where learners need assistance. In this paper we describe how the I-Help (Intelligent Help) system can be used to support students who have difficulties with the PBL approach by putting groups into contact with other groups, or an individual into contact with another learner who may advise or collaborate.

Section 2 of this paper introduces existing examples of computer support for PBL, and describes other systems which mediate peer help. The advantages of I-Help in large groups are described in Section 3. Section 4 discusses how the large group implementation of I-Help may be adapted to support PBL students when they are experiencing problems with the PBL approach. Conclusions are presented in Section 5.

2 Computer support for problem-based learning and peer help

Computer support for group interaction in PBL has been implemented for the asynchronous distance education context; the synchronous distributed learning context; and the co-present small group situation. Kamin et al. [15] describe a combined Web/CD-ROM program containing a video patient case, for use by a group of third year medical students and tutor. It is designed to facilitate asynchronous PBL during a clinical course component, requiring independent and collaborative involvement. Cameron et al. [5] discuss a distributed problem-based learning project using conferencing software together with a web page, to support synchronous sessions aimed at enabling 'authentic PBL' to occur amongst distributed first/second year medical students and a tutor. Koschmann et al. [16] introduce a method of conducting PBL meetings between students and tutor in a face-to-face context, using connected individual laptops and a large shared display. This approach is close to that found in PBL meetings not supported by computers, but offers some advantages: parallel polling (to ascertain each group member's views before they hear the ideas of others); and a record of contributions.

Computer support for PBL may, or may not include actual cases within the program: students may be collaborating about computer-presented cases, or interacting through the computer environment about externally introduced cases. External cases may be provided by the tutor off-line, or may be drawn from a database of patient cases (e.g. PATSy [19]). Systems to support PBL may help to structure and focus PBL discussions. However, even where such systems are available to a student, we believe that additional support is needed by some learners, to help them cope with the PBL situation if they feel uncomfortable with some aspects of it.

While it is acknowledged that many learners benefit from collaborative work, it is also the case that collaboration will not suit all learners; or a particular instantiation of a computational or non-computational collaborative learning environment may not suit a learner who could potentially gain much from collaborative interaction. Thus more flexible means of facilitating peer interaction would be useful. This kind of support will differ from that provided by systems such as the above: students who find the PBL approach difficult may find it useful to be put into contact with a peer who can share experiences about specific aspects of PBL.

An increasing number of peer help systems are attempting to organise learner interactions according to the student models of the individuals concerned – i.e. they have a matchmaking component; or by learner selection of available helpers. The matchmakers in such systems can take account of a variety of factors, but they most often look at students' relative proficiencies in the target domain. A few examples are given below.

An example of a peer help environment is that of Yu et al. [31], where more advanced learners act as mentors. Mentors are selected according to their knowledge, with reference to the following criteria: students who have successfully completed the course; students with high grades in other courses; students who have finished assignments; students who have successfully completed the computer-based tasks about which others need help; teachers and teaching assistants. The assumption is that the group of mentors and the student group do not overlap (though Yu et al. suggest extending the system to allow student-student help). Students select mentors based on availability (mentors may be involved in up to three help sessions); and the current problem (mentors may only help on one problem area at a time).

The above example has the advantage that learners choose to receive help when they need it, and are not forced into a collaborative context if they prefer not to participate. Further, they are guaranteed a knowledgeable helper. Nevertheless, there are drawbacks to this approach outside the setting for which it was designed. The set-up is very rigid: currently only externally acceptable (i.e. tutor-selected) individuals may be mentors. This does ensure that helpers are knowledgeable, but it does not require that they are good helpers. It also does not take account of the fact that students may benefit educationally from giving help, as well as receiving it.

Hoppe [14] proposes integrating knowledge from individual student models to support group learning – i.e. to parameterize group learning. One of the benefits is that peer helpers may be selected for help sessions: a knowledgeable helper can be partnered with a less knowledgeable student. In Hoppe's work this occurs as follows: a learner issues a help request; a menu of potential suitable helpers is offered; the learner selects their choice of helper; the selected helper receives the help request; the helper accepts or rejects the request. This approach is claimed to avoid personal conflicts, as helpers are neither assigned, nor must they interact directly with the helpee if they wish to refuse. It also allows all participants the opportunity to be helpers, as long as they know about the topic. It does not guarantee, however, that selected helpers will be proficient at helping.

Ogata et al. [22] extend this notion of peer help networks, taking into account pre-existing social networks amongst individuals, claiming that these are at least as consequential in a help context, as more official organisational structures. Ogata et al.'s approach allows users to register their proficiencies and social networks, and it also automatically traces user relationships by logging email exchanges. This provides additional information on personal networks, and also on abilities of the user: if an individual answers a question posed by a peer, the helper is assumed to be knowledgeable. These relationships are taken into account when matching potential helpers with those requesting help.

The above approaches allow peer interactions to be initiated by a learner, as required. Helpers are contacted, and may choose to take up or reject interactions. The first example [31] does not require extensive student models, but is quite restricted. The second example [14] expects student models to be in place, though overlay models are sufficient to indicate knowledge levels of individuals. The final example [22] does not require detailed models of knowledge, since it relies on social closeness and self-evaluations together with assumptions about competence based on question keywords in a help request, that has been responded to by the individual being modelled. However, what is not present in these approaches is an ability to match students according to their preferences of interaction method, or individual cognitive style, or to take into account a helper's ability to *help*. Such issues may be just as important for peer interaction to be successful.

The following section describes I-Help: an environment based on multiple user models, to match students who have help requests with potential peer helpers. I-Help aims to accommodate a broader range of characteristics that might be important when pairing learners. Suggestions of how I-Help might be usefully applied in PBL are then given in Section 4. This includes the more common face-to-face PBL context, and use alongside software to support group interaction in PBL, such as described at the beginning of this section.

3 I-Help

I-Help is the integration of several information/help sources brought together through the metaphor of a help-desk [12], designed originally for large student groups. The two principal components are an asynchronous public discussion forum [3], and a one-on-one private discussion facility which may be used synchronously or asynchronously. In the case of the private discussions, multiple distributed user models are used [20] to match students who can help each other in their learning. Each user has a personal agent which uses its owner's student model as a source of information for negotiating help sessions with other users, through their respective personal agents [28]. (Some examples of agent personas are shown in Figure 1.) The following illustrates the sequence of events for a help request. (For an example see [11]).

1. A student contacts their agent to issue a request for peer help;
2. The student's agent negotiates with the agents of other learners, to find appropriate helpers;
3. The top five user-matches are emailed that there is a help request waiting for them in I-Help;
4. To ensure maximum immediacy of response, while not duplicating effort, the first helper to accept the request starts a one-on-one discussion. Requests to other potential helpers are thereby cancelled;
5. Upon completion of discussion, each learner receives an evaluation form through which they evaluate their partner, for student modelling purposes.

The I-Help student model is composed, as stated above, in part from peer evaluations given at the end of a help session by both helper and helpee, about the knowledge of the other participant. The student model also comprises self-evaluations of knowledge level in each of the domain areas. In addition, helpees rate the utility of the help received. Social issues are also considered: learners can add users to their 'friends' list–i.e. people with whom they will preferentially interact, be they 'real friends' or people they do not know, but who have been helpful to them in the past. Students may also add individuals to their 'banned' list–people with whom they wish to have no further dealings. Much information for the student model is easily captured, since it is user-given. It is continually updated as peers evaluate help sessions once they are completed.

Also modelled are individuals' cognitive styles. The identification of cognitive style is based on Riding and Cheema's classification [26], which comprises two dimensions: wholist-analytic and verbal-imagery. The wholist-analytic dimension refers to the extent to which an individual usually *processes* information in *wholes* or separate *parts*; the verbal-imagery style relates to the degree to which an individual tends to *represent* information during thinking in a *verbal* or *image* form. In I-Help this information is provided through a front-end questionnaire. The questionnaire is very short, designed for students who may not themselves be interested in the outcome. The aim is to encourage learners to provide at least some information. While recognising that this is not ideal, partial cognitive style information is considered preferable to no information at all.

Five question types were identified, requiring different cognitive style combinations of helper and helpee:

1. *How does this fit with other things?*
   The first choice of helper for this type of question is a wholist, regardless of the cognitive style of the helpee, because wholists will tend to be better equipped to provide a broader overview.
2. *What are the details of...?*
   For this question type an analytic helper is preferred, regardless of whether this matches with the cognitive style of the helpee, because analytics tend to grasp the details of a topic more readily than wholists.
3. *Can you recommend any good materials for...?*
   The aim is to match individuals on the verbal-imagery dimension, since a verbal learner will more likely recommend materials helpful to another verbaliser, and an imager will do likewise for another imager.
4. *Miscellaneous question*
   This category covers any questions not included in the above. The default is to match all learners on the wholist-analytic dimension. If possible, learners are also matched on the verbal-imagery dimension.
5. *Questions requiring simple answers*
   No cognitive style matching is undertaken for straightforward questions requiring a simple answer, as cognitive styles are likely to have little impact here.

When submitting a help request, the learner indicates the question type from the above selection.

In addition to self and peer user-given information, learner models are updated automatically based on observations of eagerness (browsing and active posting behaviour in the public discussion forums, and amount of help given in private discussions). Furthermore, personal agents note which cognitive style matches seem most successful for different question types, and update the user model accordingly. (This also helps to overcome potential inaccuracies in the initial self-report.) Figure 1 illustrates the sources of information for the student model (open arrowheads), and the differences between private and public discussions. In the private discussions a learner interacts directly with a single peer in each dialogue, to give and receive help. Public discussions take place in forums – there is no direct interaction between two people (solid arrowheads).

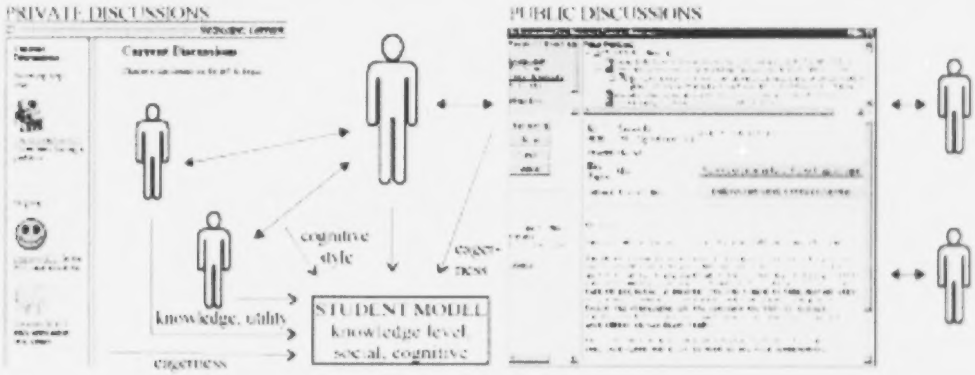


Figure 1: I-Help public and private discussions

In seeking partners, a personal agent tries to balance all relevant information (knowledge level of helpers; helpfulness of helpers; eagerness to help; preferential friends; exclusion of banned people; appropriateness of cognitive style). By default these issues are given equal weighting, but the learner may re-rank each component, as is important for them. For example, some learners may have more flexible cognitive styles. For such students, style may be a relatively unimportant factor. Other students will have more difficulty adapting to someone else's way of learning, and will assign greater importance to cognitive styles – perhaps even preferring this kind of match above the requirement that a helper should be very knowledgeable.

A variation on the peer help scenario involves permitting students to choose the kind of interaction they want, based on the S/UM system [4]. In addition to peer help, students may seek: peer feedback about work drafted or completed; collaborative learning; cooperative learning (i.e. X learns A & Y learns B, followed by tutoring or reporting). In addition to peer help, this allows students who wish to learn collaboratively or cooperatively the opportunity to find the most suitable partner. When a user sends an interaction request, they specify the kind of interaction they are seeking. Their agent negotiates a match with someone who also wishes to interact in that manner, and who has appropriate characteristics (e.g. a helper should have greater proficiency in the topic than the helpee; a collaborative partner should have a similar, non-expert, knowledge level).

In summary, the utility of I-Help increases with the number of users, as good matches become more feasible. Much of the user modelling is performed quickly and naturally by users (self- and peer-evaluations), and these models by themselves are sufficient even early during interactions, before additional system modelling has occurred. Student models contain content, cognitive and social information, which can be ranked in order of importance by learners. Further, I-Help can easily be applied across a broad set of courses: all that is required is a course description (in the form of course component labels) to be provided by the course tutor. Knowledge levels represented in user models, to contribute to matchmaking, are then related to these labels. Apart from reducing the load on tutors, from students requesting information, there are three major educational benefits:

- Students receive help when they have difficulties;
- Students learn through encountering the possibly conflicting viewpoints of others;
- Students will necessarily reflect on an issue when giving help on it.

Thus it is not only those receiving help, who benefit.

4 I-Help in problem-based learning

Due to the nature of PBL, students undertake a lot more research than traditionally educated learners, relying less on teacher-recommended texts. Many students use electronic resources more heavily than other resources [8], and they also use general library resources more extensively than their traditional counterparts [2]. I-Help provides additional human resources, forming a natural extension of this situation, and is likely to be useful to many students in PBL during the research phase. However, in this paper we focus on supporting those students who are uncomfortable with some aspects of the PBL approach itself.

Since PBL is focussed around small pre-established peer groups it is less obvious how I-Help might be applied, as opposed to in larger, traditional classes for which it was originally designed. Nevertheless, as illustrated in the following description, there are a number of situations in which I-Help could be useful in PBL.

There are a variety of potential difficulties to take into account in a PBL course. For example:

- It can be difficult for some students to find time to meet outside scheduled class hours;
- For a group to function effectively, individual team members should all be involved in group discussions;
- Students may not fully understand their role in the group;
- Students may lack the skills to make group interactions work;
- Students have different interaction preferences;
- Students have different cognitive styles.

Considering the first two of these issues, the public discussion forum of I-Help is a useful tool to keep all students in contact with their own group's discussions, but also allowing interaction between particular group members, should help or clarification be needed by some participants, on some group issue. At the same time, all students remain up-to-date with all interactions, at a time that suits them, thus freeing up part of meeting times for questions and group issues less easily handled through computer interaction.

Perhaps more unusual in the PBL context: there may be occasions when students could usefully interact *across* groups. As suggested above, it is not the aim to exclude any group members from any interaction important for group progress, but there may be situations where individuals from different groups could help each other, on issues perceived as not directly relevant to either group as a whole. For example, in some PBL contexts the various roles are divided amongst group members, often rotating. In such situations it might be helpful if individuals from different groups who are performing the same role (e.g. scribe; group leader; information analyst), could interact – especially if it is early in the rotation, and there is less group experience on which to draw. It will also be helpful for students finding their role difficult, who are part of a group whose members do not appreciate the learner's problems. Their personal agent could locate a helper who has successfully fulfilled the responsibilities of the role in the past, or find another student with similar problems, with whom they can

jointly explore aspects of the role. Where the whole group acknowledges a lack of understanding of any role, one of the group members may seek outside assistance on behalf of everyone.

I-Help's user models must therefore be extended to include information about student roles. I-Help must know the current role of individuals, in order to put students in touch with others facing the same tasks; and it should also remember the roles that individuals have previously held, and whether they were competent, and whether they are willing to offer help to novices in these roles. I-Help may then be used to pair individuals in interactions relating to role responsibilities, keeping such interactions amongst those for whom the discussion is currently relevant and/or helpful. As more students come to perform each role, previous help session archives may be accessed as help resources. In this manner, it is hoped that more students may develop an understanding of how to meet their various responsibilities, resulting in improved group functioning.

It has been commonly noted that many students entering the medical sciences do not possess the skills necessary for effective group interaction in PBL – e.g. discussion, decision making, conflict management, leadership, group feedback processes [24]. Although I-Help does not teach these skills, its ability to match students with others who are in a similar position, or who are able to help, provides a form of support not usually available. If a single individual has problems, the other group members may be able to compensate while also supporting the learner's development of the skill concerned. However, where group members recognise a general deficiency, they may use I-Help to put them in contact with a group that functions effectively with regard to the particular skill. They may be invited to observe, as the efficient group models the behaviour during their next meeting, or one of the effective group members may describe how their group tackles these issues. This will be especially useful where there are no resources (e.g. time, staff) for skills training.

Again the I-Help student model must be extended, to accommodate information about group interaction skills. This will involve all groups in a group evaluation process in order that they may provide skills information for the user model, which in itself will be a useful reflective activity. The main difference in the structuring of the model in this case is that skills information will relate to *group* functioning, and not to specific group members. Thus I-Help must also know which students belong to which groups. Skills information need then only be given by one learner.

A potential difficulty encountered by a student who might otherwise do well in PBL is that other group members may have different interaction preferences: some students gain much from brainstorming or spontaneous discussion, while others prefer to reflect and organise their thoughts before communicating. The combination of face-to-face meetings and the public discussion forums helps to cater for all students, while the possibility also exists to arrange collaboration, cooperation and feedback through the private discussions.

Students also have different cognitive styles. Some individuals understand verbal descriptions well, while others need pictures, diagrams, or demonstrations. Some learners deal well with abstract concepts and detail, while others tend towards a more general overview. Although a mixture of cognitive styles might sometimes be complementary in a group setting, and have a positive effect on group performance, some cognitive style combinations may lead to difficulties for some individuals. For example, if most members of a group are analytic, a wholist learner may have difficulty gaining the overview perspective they require to integrate information. Such an individual might find the situation very difficult as a learning experience. It is also possible that the other group members will not understand their difficulty. This is a problematic situation since all group members should be involved in group communications for a group to feel comfortable and function well. Full participation is essential in some groups to avoid resentment by other group members if they feel that one person is not contributing. I-Help private discussions should not, then, be used as an alternative to group interaction, as the group may suffer as a result. However, for students who have problems adapting to the way the other group members work, I-Help may provide a much-needed 'lifeline' by matching them with a student with a similar cognitive style, to support their PBL activities in a 'more comfortable' fashion. Thus they will continue to interact with their group to the best of their ability given the difficulties they experience, but they may also work with another learner outside the group context if they feel this to be useful. This need not detract from the group experience as a whole, since the learner may report back any findings. Taking the above example, such an individual's contribution may now be greater, since they will be able to provide the overview that the analytics lack. Therefore their group contribution may be stronger than any earlier contributions where they had not had this additional learning opportunity, and were interacting only within the confines of the particular group's interaction dynamics.

This section has suggested a number of ways in which I-Help might be useful in PBL. It is not suggested that all PBL students should use it (though the public forum is likely to be generally useful), but that I-Help could arrange peer support in cases where an individual is having difficulties with some aspect of the PBL approach.

Although it does not address the problem of group learning for an individual who prefers to learn alone, or in a different kind of group situation, it does at least provide them with some support that they would otherwise not have.

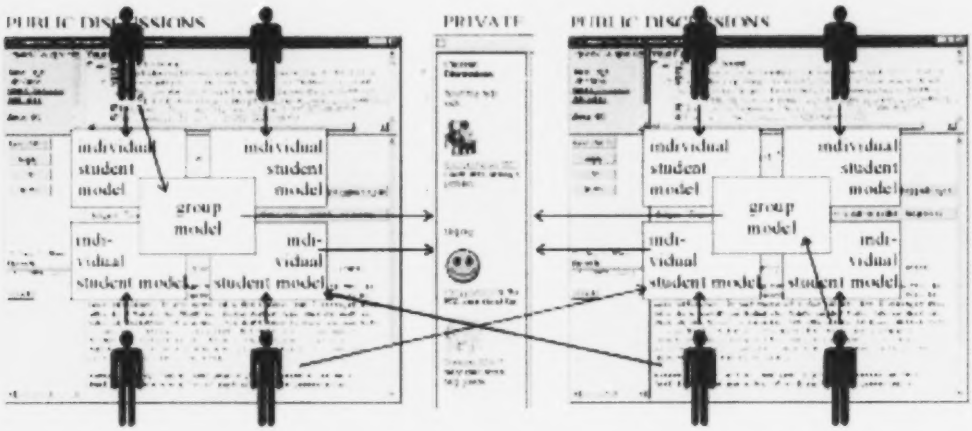


Figure 2: I-Help in problem-based learning

To introduce I-Help to the PBL setting, some additions to the user models are necessary. However, these are very easy to implement, having simplicity in common with the present representations. Currently I-Help user models contain: a quantitative measure of knowledge levels in the various domain areas; a quantitative indication of helpfulness; a quantitative measure of eagerness; a list of friends; a list of banned people; identification of cognitive style; a list of preferred interaction types. The additional information proposed above comprises: a list of roles successfully performed previously (to be added by the individual); the current role of the student (also added by the individual); a list of group membership (provided by one group member); a list of group skills (based on group evaluation, the result of which is entered by one group member). Thus minimal extensions could provide essential support to learners having difficulties in PBL. Provision of this information by students should also encourage them to think about factors that help to make group interaction successful.

Figure 2 illustrates how I-Help can support learners in a PBL setting. Students and peers provide student model information as occurs in large group uses. I-Help also performs some user modelling as described previously. The main difference with I-Help in PBL is that interactions for each group are focussed primarily around public discussions, with each person communicating with other members of their own group. There is less use of the private discussions. Where private discussions do occur, matching takes place according to the student models of individuals in the manner described in section 3. In addition to individual models, in PBL group models are required in order that groups may also be brought together where difficulties are recognised by the group as a whole. Information for the group model is obtained from one of the group members.

5 Conclusions

I-Help was initially designed to promote peer help amongst a group of learners in a large class situation. Some minor extensions to the system were suggested, to enable it to be effective also for students in PBL. Despite many successes claimed for this kind of collaborative interaction, not all students will function at their best with this type of curriculum. In this paper we focussed on PBL in medical education, but the arguments should be equally applicable to other academic disciplines and small group contexts, as long as the overall student numbers are large enough to enable sufficient choices of appropriate partners for cross-group interaction.

In addition to large and small group formal educational settings, I-Help might also be used beyond the classroom to support medical practitioners. For example, while some contexts have adequate funds to implement elaborate means of telemedicine (e.g. the U.S. Army [1]), remote areas which might benefit from access to various forms of telemedicine often find that the low population density does not provide sufficient demand to justify the expenditure required [25]. In rural locations a system like I-Help would provide a low cost means of obtaining expert help at least for some cases. Furthermore, practitioners requesting assistance do not themselves need to know who is the best person to contact. Similarly, I-Help might be useful in putting into contact physicians who

would like to hear experiences of other practitioners. For example, where ethical considerations are important to a case, such as conflicts between medical advice and parental beliefs [7]. I-Help might also be used alongside diagnostic decision support systems in cases where physicians remain unsure about hypotheses, since the advice offered by such systems may sometimes be misleading [9]. Experience with I-Help at university should encourage more individuals to register once they graduate and specialise.

Acknowledgements

This work is funded by the Canadian Telelearning Network of Centers of Excellence, Project 6.28. We thank the ARIES Lab members, in particular: G. McCalla, J. Vassileva, R. Deters, J. Cooke, L. Kettel and J. Bowes.

References

[1] Berry, F.C. "Telemedicine and the army", ARMY Magazine, April 1996.

[2] Block, K.J. "Problem-Based Learning in Medical Education: Issues for Health Sciences Libraries and Librarians", Katharine Sharp Review 5, 1997.

[3] Bowes, J. "Knowledge Management through Data Mining in Discussion Forums", MSc Thesis, Department of Computer Science, University of Saskatchewan, 2000.

[4] Bull, S. "A Multiple Student and User Modelling System for Peer Interaction", in R. Schäfer & M. Bauer (eds) 5 GI-Workshop, Adaptivität und Benutzermodellierung in interaktiven Softwaresystemen, Universität des Saarlandes, 61-7, 1997. On-line proceedings: http://w5.cs.uni-sb.de/~abis97/proceedings/

[5] Cameron, T., Barrows, H.S. & Crooks, S.M. "Distributed Problem-Based Learning at Southern Illinois University School of Medicine", in C. Hoadley & J. Roschelle (eds), Computer Support for Collaborative Learning, Stanford University/unext.com, 86-93, 1999.

[6] Camp, G. "Problem-Based Learning: A Paradigm Shift or a Passing Fad?", Medical Education Online 1(2), http://www.med-ed-online.org/ , 1996.

[7] Coward, H. & Hartrick, G. "Perspectives on Health and Cultural Pluralism: Ethics in Health Care Education", Workshop on Cognitive and Social Science Foundation for Medical Education and Training in the Information Age, Dunsmuir Lodge, Victoria, 2000.

[8] Deretchin, L.F., Yeoman, L.C. & Seidel, C.L. "Student Information Resource Utilization in Problem-Based Learning", Medical Education Online 4(7), http://www.med-ed-online.org/ , 1998.

[9] Friedman, C.P., Elstein, A.S., Wolf, F.M., Murphy, G.C., Franz, T.M., Heckerling, P.S., Fine, P.L., Miller, T.M. & Abraham, V. "Enhancement of Clinicians' Diagnostic Reasoning by Computer-Based Consultation", Journal of American Medical Association 282(19), 1851-1856, 1999.

[10] Gillespie, R.S. "Problem-Based Learning Redefines Medical Education", IMpact (Summer), American College of Physicians, 1995.

[11] Greer, J. & Bull, S. "Computer Support for Collaboration in Medical Education", Clinical and Investigative Medicine, in press.

[12] Greer, J., McCalla, G. Cooke, J., Collins, J., Kumar, V., Bishop, A. & Vassileva, J. "The Intelligent Helpdesk: Supporting Peer Help in a University Course", in B.P. Goettl, H.M. Halff, C.L. Redfield & V.J. Shute (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 494-503, 1998.

[13] Hmelo, C.E., Gotterer, G.S. & Bransford, J.D. "A Theory-Driven Approach to Assessing the Cognitive Effects of PBL", Instructional Science 25, 387-408, 1997.

[14] Hoppe, H.U. "The Use of Multiple Student Modeling to Parameterize Group Learning", in J. Greer (ed), Proceedings of World Conference on Artificial Intelligence in Education, AACE, Charlottesville VA, 1995.

[15] Kamin, C.S., Deterding, R.D., Wilson, B., Armacost, M. & Breedon, T. "The Development of a Collaborative Distance Learning Program to Facilitate Pediatric Problem-Based Learning", Medical Education Online 4(2), http://www.med-ed-online.org/ , 1999.

[16] Koschmann, T.D., Kelson, A.C., Feltovich, P.J. & Barrows, H.S. "Computer-Supported Problem-Based Learning", in T.D. Koschmann (ed) CSCL: Theory and Practice of an Emerging Paradigm, Lawrence Erlbaum Associates, Hillsdale, NJ, 1996.

[17] Koschmann, T. & Stahl, G. "Learning Issues in Problem-Based Learning", Panel at CSCW'98, 1998. http://www.cs.colorado.edu/~public.conferences/1998/cscw98/cscw_workshop.html

[18] Lee, R.M.K.W. & Kwan, C-Y. "The Use of Problem-Based Learning in Medical Education", http://www-fhs.mcmaster.ca/mdprog/pblart.htm , 1999.

[19] Lum, C., Cox, R., Kilgour, J., Morris, J. & Tobin, R. "PATSy: A Multimedia Distributed Web-Based Resource for Aphasiologists in Research and Education", Aphasiology 13(7), 573-579, 1999.

[20] McCalla, G., Vassileva, J., Greer, J. & Bull, S. "Active Learner Modelling", in G. Gauthier, C. Frasson & K. VanLehn (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 53-62, 2000.
[21] Newble, D.I. & Hejka, E.J. "Approaches to Learning of Medical Students and Practising Physicians: some empirical evidence and its implications for medical education", Educational Psychology 11(3-4), 1991.
[22] Ogata, H., Sueda, T., Furugori, N. & Yano, Y. "Augmenting Collaboration Beyond Classrooms through Online Social Networks", in G. Cumming, T. Okamoto & L. Gomez (eds), Advanced Research in Computers and Communications in Education, ICCE '99, IOS Press, Amsterdam, 277-284, 1999.
[23] Patel, V.L. & Groen, G.J. "Reasoning and Instruction in Medical Curricula", Cognition and Instruction 10(4), 335-378, 1993.
[24] Peterson, M. "Skills to Enhance Problem-Based Learning", Medical Education Online 2(3), http://www.med-ed-online.org/ , 1997.
[25] Puskin, D.S., Mintzer, C.L. & Wasem, C. "Telemedicine: Building Rural Systems for Today and Tomorrow", in P.F. Brennan, S.J. Schneider & E. Tornquist (eds), Information Networks for Community Health, Springer, New York, 1997.
[26] Riding, R. & Cheema, I. "Cognitive Styles–an Overview and Integration", Educational Psychology 11(3-4), 193-215, 1991.
[27] Spencer, J.A. & Jordan, R.K. "Learner Centred Approaches in Medical Education", British Medical Journal 318, 1280-1283, 1999.
[28] Vassileva, J., Greer, J., McCalla, G., Deters, R., Zapata, D., Mudgal, C. & Grant, S. "A Multi-Agent Design of a Peer-Help Environment", in S.P. Lajoie & M. Vivet (eds), Artificial Intelligence in Education, IOS Press, Amsterdam, 38-45, 1999.
[29] Wilson, B.G. & Cole, P. "Cognitive Teaching Models", in D.H. Jonassen (ed), Handbook of Research in Instructional Technology, Scholastic Press, New York, 1996.
[30] Woods, D.R. "Problem-Based Learning: Helping your Students Gain the Most from PBL", McMaster University, 1996.
[31] Yu, Y-T., Shan, H-L., Chou, C-Y. & Chan, T-W. "WWW-Based Mentoring System", in Z. Halim, T. Ottman & Z. Razak (eds), Proceedings of ICCE, AACE, 381-389, 1997.

The Interactive Virtual Community

Pen-Choug Sun, Chien-chang Lee, Chun-Wen Hsu, Shower-Long Hong and Jui-Chun Tai
Management Information system Department Alethia University
32 chen-li street, Tamsui, Taipei County, Taiwan, R.O.C.
Tel: (02)26212121 ext 5531
e-mail:pcsun@email.au.edu.tw

Because of the advanced technique of Internet, The virtual community is available and becomes popular on Internet. In this study, we focus on the interactive mechanism of a virtual community. We discuss the object-oriented interface and the environment. In the interactive virtual community, people can establish his own personalized space. He can be both system manager and user in the same time.

Keyword: **Virtual community, Interactive mechanism, Object-oriented.**

1 Introduction

Gradually, the V.C. (V.C.) is more and more popular on Internet. We firstly discuss the definition of the V.C. and the reason why it becomes popular. Most of the interfaces of the virtual communities seem too difficult for users to use. Some of them are not user-friendly. Some of them do not provide personalized features. We establish a V.C. called "Virtual University" which has the extensive mechanisms between people. We establish an interactive interface which allows the members of the V.C. communicate freely and independently.

2 The Definition of the V.C.

a. The circumstances of the V.C.: The V.C. gathers the people having same interests, inclination, favorite, or same domain to exchange information. The BBS (Bulletin Board System)can be regarded as the earliest version of the V.C.. In the chat room of Internet, users can communicate with each other on a web browser in real time. There are some famous web-site of specific topic and particular services. For example, Geocities and HotGroup supply personal homepage space, ICQ is a famous tool on internet for real-time message. More new function is added to the V.C. such as chat room, the essence board, message board, the message of searching people, etc.

b. The characteristics of the V.C.: For most of the V.C., they focus on a particular subject. They allow the members use some functions to exchange their viewpoints with others. They also encourage the members presenting their ideas and experiences. They always try their best to collect resources such as good company and the relative products to their members. And through these valuable resources and good environment, the V.C. can become a virtual company and gain profits.

The V.C. provides the users a place for communication, social contact and publishing. The user used to visit a homepage just for information. There is not any connection between visitors. But, in the V.C., people visit a web-site not only because the information but also the friends. It gathers a group of people and provides them opportunities to talk to each other. It saves the record of users and change temporal visitors into its loyal citizens. Until now, the functions of the V.C. on Internet do not make a lot of progress when being compared with BBS. For the users can't alter the environment as they like, they feel not enough emotion to participate the group as they in a real community.

3 The system framework

'The Virtual University' is not a simulation of a real college but an interactive platform. It allows users set

up any kind of subjects as they like on it. We lean three subjects in college such as 'school work', 'club' and 'love' lesson. The club lesson and love lesson are a multi-user game. New member had to register. The system shows its facilities in a map. The user adds any object to the environment according his authority. The supervisor of management just acts as an observer and the helper of users.

4 The sketch of interactive system

At present, almost web-site can only provide poor interactive function to the users. The user has no authority to reallocate the objects of the environment. He lives in a society with no right. The text-based communication always causes unnecessary misunderstanding of others. An ideal V.C. should more or less like a real society. In our system, system supervisor provides interactive objects and tools to users. Then members use these objects to build up the whole V.C.. Time and time, generation and generation, the information is extremely huge and dramatically powerful. Only the society which is controlled by users can really last long. There are three characteristics of our platform:

a. A visual Object-oriented personalized interface: Our graphic-oriented system use picture interface to show emotion and transfer message. User can have his user-ID and his picture. The picture which is constructed by user shows the user's face.

b. The user's authority to build the environment space: The society contains many sub-societies. Each sub-society has one system manager. The manager administrate manages all objects of his area and maintain the rule of the society. The user has the authority to change the environment. As Fig-1 shows, we distinguish members into two kinds. The personalized interface is here to let the member create picture of his own. The object manager system and Fuzzy system can adjust the flow of the game.

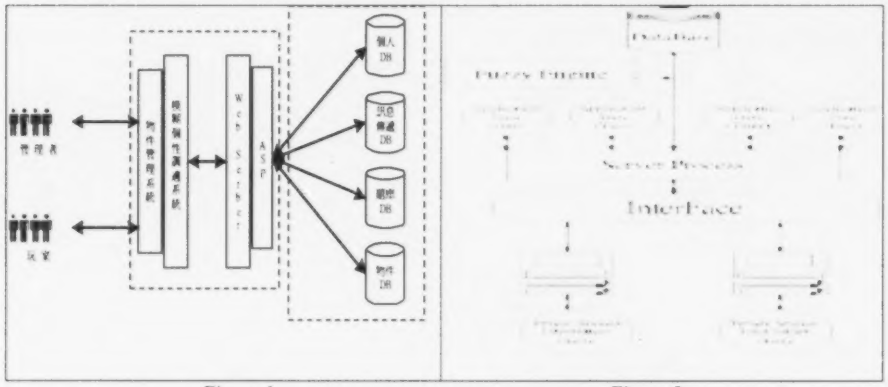


Figure 1 Figure 2

c. The real-time interactive communication: The game-based environment allow users travel around. The users can learn, entertainment, explore and interact with other users. As fig-2 shows, we apply ASP's(Active Server Page) Session and Application object, and adopt Fuzzy to create model.

5 Conclusion

In the future, There will be plenty of people in the V.C.. It means that will be a lot of commercial potential in the V.C.. Undoubtedly, the graphic-oriented V.C. with virtual reality will be the main stream of the market. We purposes a prototype of perfect platform of the V.C. and open ours arms welcome the leading character of the coming age - the V.C..

6 Reference

[1] John Hagel Ⅲ, Arthur G. Armstrong wr, "Virtual community-EC"
[2] http://www.ecpress.com.tw/virtualociety
[3] http://www.kenet.net.tw/keynet.htm
[4] http://tech.is.net.tw/business/1999/1019.html
[5] http://cashrobbers.hypermart.net/speech/s1118.htm

The network learning supported by constructivism

Song-Min Ku
E-mail:sppman@icemail.nknu.edu.tw

1 Introduce

Network learning gives a chance to educators to rethink and investigate the learning modules and styles. Therefore the educators can rearrange learning strategies and develop new learning environment to validate the learning strategies and ideas. Although network learning cannot affect the learning completely and fully, at least network learning offer the environment to fulfill the ideas of constructivism.

2 Setting up the network learning environment

2.1.To provide multiple and abundant materials:

The network learning resources provide the objective and existed knowledge, the multi-angle and multi-level experiences to give learners various stimulations. In other words give the learners a chance to create multiple constructions, the same learner create different level construction at distinct time.

2.2.Give learners the authentic problems:

The important mission when teachers proceed with the instruction of constructivism is to arrange and provide the abundant and fitted learning environment, to offer and assist learners to construct knowledge actively and successfully.

2.3.Encourage learners raise various solving methods for the problems:

Promote learners to think of the problems by multi-angle ways. In order to encourage learners to discuss, think, argue and learn cooperatly, thus the learning have to be proceeded with dialog and communication.

2.4.Clear learning goals and concepts:

In internet world no place is too far away to be reached. If let learners grope or learn alone, it's usually happen that learners disorientate in the internet world. Thus if there is no clear goal, learning activity will be one pattern of browse and the emphasis will be neglect. Let learning activities concentrate at the learning goals or concepts, learners will get more complete knowledge, understand the key points, thus increase learning effects.

2.5.Learners can present viewpoints fully:

The internet world is a multi-person and pluralistic environment . In addition to self-learning, learners can see the learning portfolios of others. The learners review the cognition of others by self-viewpoint, furthermore to imitate and learn the others, and self-viewpoint can also be referred by others. Learners develop one kind of self-thinking in the environment of arguing with others again and again. Thus learners are no more silencers, but the learners are encouraged to present their viewpoints or opinions.

2.6.Adaptive courses:

There are individual differences between learners, learning processes or learning strategies of learners are different from others. Thus the design of courses should be considered about the individual

difference,adapted to learning situation of learners. Arrange different course to match the learning situation and abilities of learners, thus learners got the individual learning.

3 Conclusion

It's convenient to search information and data in World Wide Web. The convenience is important factor to encourage learners to construct the self-knowledge. In the process of learners participating and learning actively, learners will feel that they have got self-learning goal.

In constructivism it's important factor that learners participate actively in learning process. Thus learners must participate self-learning activity positively. Learners should search and find knowledge what they want actively.In network learning environment the learning activities are emphasized the" internal control" directed by learners, and requesting learners to learn by their strategies in the process of learning activities.

4 References

[1] Chih-Yu Chan(1996),"Cognition and Knowledge: Constructivism VS. Acceptance", Journal of Education Research, 49,25-38.

[2] Chi-Hsien Lin(1999),"The design and application of network leaning environment", Journal of Information and Education,67,34-48.

[3] Kuei-Fa Chiu,(1996). "Situation learning concept and computer aided learning: The study of learning community " Taipei: Shih Ta Press.

[4] Kuei-Fa Chiu,(1996). "The study of network learning: The another space of education research", The 12th Science Education Seminar, Roc. December.

[5] Kuei-Fa Chiu,(1997), " The development of network learning environment supported by education", Environment education and information network seminar, May.

[6] Shih-Ju Chang(1997),"The meaning of internet hypertext and hypermedia applied in instruction with constructivism", Journal of Information and Education, 58 ,39-48.

Proceedings

Content

▸Full & Short Papers (Others)

A Code Restructuring Tool to help Scaffold Novice Programmers
An Assessment Framework for Information Technology Integrated Instruction
An authoring shell with intelligent reuse
An Educational Application of Integrated Route Information Service on the Internet
Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming
Design and Implementation of A N-Tiered Heterogeneous Virtual School Adminstration System
Design and Implementation of a WWW-Based School Official Memorandum System
DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment
Empowering Secondary School Teachers to Effectively Exploit Internet Resource for the Enhancement of Teaching and Learning
Examining problems of student teachers to build a web-supported environment
Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective
Initial Evidence for Representational Guidance of Learning Discourse
Learning from the Learning of other Students
Localization of a feature extraction area for touch-type training using a camera
Present State and Future Direction of Woman Informatization Education in Korea
Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives
Space Plan for Effective Educational Software Utilization in Korea
The web of the Teacher Professional Development
Using Learning Object Meta-data in a Database of Primary and Secondary School Resources

▲HOME

A Code Restructuring Tool to help Scaffold Novice Programmers

Stuart Garner
Edith Cowan University
Pearson St., Churchlands 6018, Western Australia
E-mail: s.garner@ecu.edu.au

This paper concerns a new software tool called CORT (code restructuring tool) that has been developed by the author to help students learn programming. The paper begins by discussing the difficulties that students face when learning to program and the use of part complete solutions as a teaching and learning method that reduces the cognitive load that students experience.

CORT has been developed to support this use of part complete solutions and its features are outlined. When used by a student, a part complete solution to a given programming problem is displayed in one window and possible lines of code that can be used to complete the solution are displayed within another window. The lines can easily be moved between the windows in order to complete the solution and the solution then transferred to the target programming environment for testing purposes.

Finally, the use of CORT with both undergraduate and postgraduate students at Edith Cowan University is described, preliminary feedback from students indicating that CORT is easy to use and that they perceive that it is helping them in their learning of programming. Four different methods of using CORT have been identified and these will be the subject of future research.

Keywords: **Scaffolding, Programming, Flexible Learning**.

1 Introduction

Learning to write computer programs is not easy [3, 18] and this is reflected in the low levels of achievement experienced by many students in first programming courses. For example, Perkins, Schwartz et al [17] state that:

> *Students with a semester or more of instruction often display remarkable naivete about the language that they have been studying and often prove unable to manage dismayingly simple programming problems.*

and King, Feltham et al [8] state that:

> *even after two years of study, many students had only a rudimentary understanding of programming*

Over the years since the advent of high level programming languages in the 1960s, much has been written about the problems that students have in learning programming and many ideas and initiatives have been put forward for improvements in the teaching and learning process with varying degrees of success. In practice, the ways in which teaching and learning takes place in the domain of programming have changed little and many students still find the learning of programming a very difficult process. The challenge of learning programming in introductory courses lies in simultaneously learning: general problem solving skills; algorithm design; program

design; a programming language in which to implement algorithms as programs; and an environment to support the program design and implementation [6]. In addition, students need to learn testing and debugging techniques to validate programs and to identify and fix problems that they may have within their programs.

Additionally, we are moving ever more rapidly to use more student centred and flexible learning methods within the teaching and learning process. This means that our instructional design for programming courses needs to take notice of these moves and utilise these methods. Fortunately technological improvements have also been significant over the last few years enabling us to more easily produce engaging courseware that can help students studying in a flexible learning mode. As courseware designers, we can produce electronic scaffolds to help students in their learning processes when they are studying on their own with limited access to a human tutor.

2 Use of Worked Examples in the Teaching and Learning of Problem Solving and Programming

There are several methods used in the teaching and learning of programming and one of these is to utilise worked examples. Several researchers have experimented with the use of worked examples in place of conventional instruction and found strong advantages. In the domain of algebra, Sweller and Cooper [19] suggested that students would learn better by studying worked examples until they had "mastered" them rather than attempting to solve problems as soon as they had been presented with, or familiarised themselves, with new material. In their research, students studied worked examples and teachers answered any questions that the students had. Students then had to explain the goal of each problem together with the steps involved in the solution and then complete similar problems until they could be solved without errors. Sweller and Cooper found that this method was less time-consuming than the conventional practice-based model and that students made fewer errors in solving similar problems than students who were exposed to the conventional practice-based model of instruction. There was no significant difference between the "worked example" group and the "conventional" problem solving group when they attempted to solve novel problems and it was therefore concluded that learning was more efficient and yet no less effective when this worked example method was used.

Worked examples are heavily used within the "reading" method of learning programming. According to Van Merrienboer et al [22, 23] the reading approach emphasises the reading, comprehension, modification and amplification of non-trivial, well-designed working programs. However, they also suggest that presenting worked examples to students is not sufficient as the students may not "abstract" the programming plans from them, a plan being a stereotyped sequence of computer instructions as shown in figure 1.

"Mindful" abstraction of plans is required by the voluntary investment of effort and the question then arises as to how we can get students to study the worked examples properly. In practice, students tend to rush through the examples, even if they have been asked to trace them in a debugger, as they often believe that they are only making progress in their learning when they are attempting to solve problems.

Lieberman [10] suggests that students should annotate worked examples with information about what they do or what they illustrate. Another suggestion is to use incomplete, well-structured and understandable program examples that require students to generate the missing code or "complete" the examples. This latter approach forces students to study the incomplete examples as it would not be possible for their completion without a thorough understanding of the examples' workings. An important aspect is that the incomplete examples are carefully designed as they have to contain enough "clues" in the code to guide the students in their completion. It is suggested that this method facilitates both automation, students having blueprints available for mapping to new problem situations, and schemata acquisition as they are forced to mindfully abstract these from the incomplete programs [24].

In one study, two groups of 28 and 29 high-school students from grades 10 to 12 participated in a ten lesson programming course using a subset of COMAL-80 [24]. One group, the "generation" group, followed a conventional approach to the learning of programming that emphasised the design and coding of new programs. The other group, the "completion" group, followed an approach that emphasised the modification and extension of existing programs. It was found that the completion group was better than the generation group in constructing new programs. It was found that the percentage of correctly coded lines was greater and that looping structures were more often combined with correct variable initialisation before a loop together with the correct use of counters and accumulators within the loop. It would appear that the completion strategy had indeed resulted in superior schemata formation for those students within that group. In addition, the completion group used superior comments in connection with the scope and goals of the programs, indicating that they had developed better high-level templates or schemata. It was noted in the study however that both groups were

equal in their ability to interpret programs and that this might indicate that students in the completion group do not understand their acquired templates. It is then suggested that future completion strategies should include the annotation of the examples by students with details of what they are supposed to do and details of the templates (plans) that are being used.

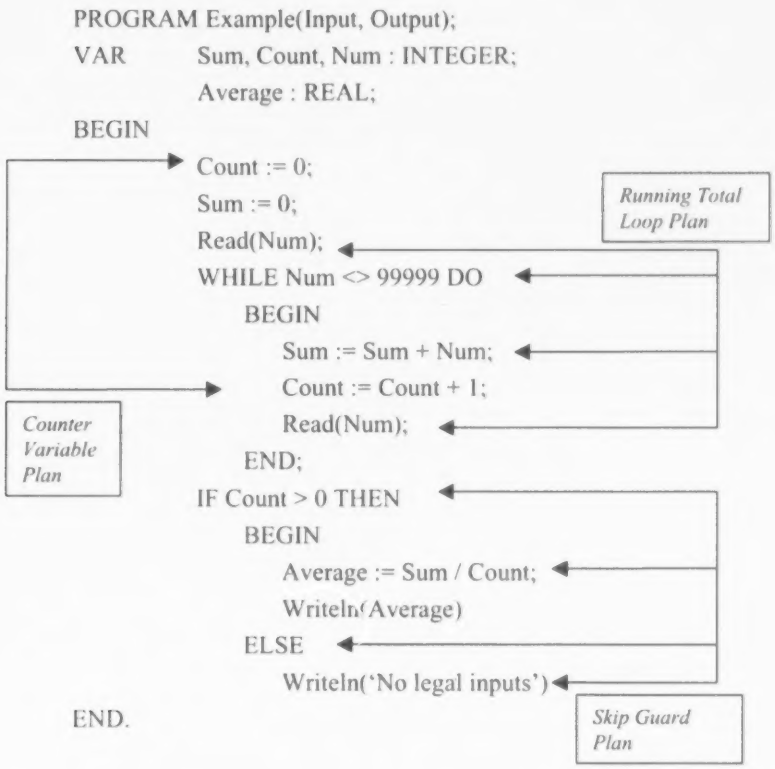


Figure 1

A side effect of the research was also noted. The drop-out rate from the completion group was found to be lower than for the generation group, particularly for female students with low prior knowledge. It was suggested that perhaps the generation of complete programs is perceived as a difficult and menacing task and that the completion strategy overcomes this difficulty.

The stimulation of the "mindful of abstraction" of schemata in students can possibly be improved further requiring them to also annotate the solutions with details of the scope and goals of the solutions and to answer questions on the inner workings of the solutions. The "degree" of completion of the solutions is an important aspect within the completion strategy and in some later work [23] examples are given of completion assignments that might be used early and later in a programming course. In an early part of a course, an example may indeed be complete and include explanations and a question on its inner workings. In the latter part of a course, the example may be largely incomplete and include a question on its workings and an instructional task. Between these two extremes, examples will have varying degree of completeness and in all cases, the incomplete examples are acting as scaffolds for the students.

3 The Cloze Procedure

A scaffolding tool called CORT (Code Restructuring Tool) has been produced that allows students to fill in lines of missing code from programs and this method is based upon the cloze procedure. The term is derived from "closure", a Gestalt psychology term referring to the human tendency to complete a familiar but not quite

finished pattern [2]. The use of cloze was first used to measure comprehension in English readability [9] however it has also been used in the teaching and learning of programming as a way of measuring student understanding of programs [7, 20]. Such program comprehension tests are constructed by replacing some of the "words" or tokens by blanks and requiring students to fill in the blanks during a test. The use of the cloze procedure in testing was found to correlate well with conventional comprehension, question – answer, type quizzes and is also much easier to create and administer, see for example the work of Cook, Bregar et al [2].

Other researchers have experimented with the testing of program comprehension by omitting complete lines of code from programs and requiring students to fill in those lines [5, 13, 14, 15, 16]. Norcio found that students were more likely to supply correct statements if they had been omitted within a logic segment rather than from the beginning of a segment. This is consistent with the chunking hypothesis [12] that specifies that the first element of a chunk provides the key to the contents of the entire unit. Ehrlich looked at the differences between experts and novices in filling in missing lines within various programming plans and, as expected, found that the experts filled in the lines correctly taking into account the surrounding plan whereas novices had more difficulty.

In the various experiments in program comprehension using the cloze procedure, the students had to fill in the lines of code without being given a selection of lines to choose from. In some work done in an area unrelated to programming, students were expected to create an essay using a file of statements, only some of which were relevant to the topic [4]. The students were expected to copy and paste only the statements which they believed to be relevant and then to link them with their own text and it was suggested that learners would consolidate their understanding of the topics by having to actively evaluate all possible statements. The file of statements was acting as a scaffold to student learning.

Although the literature suggests that the cloze procedure has only been used in measuring program comprehension, it appears that it could prove useful as a way of scaffolding student learning of programming. An incomplete solution to a programming problem could be given to a student together with a choice of statements that might be used in the solution. The student would then have to study the incomplete solution and the choice of statements and decide which statements to use and where to put them. CORT uses this idea making the mechanics of placing the statements into the incomplete solution very straightforward for the student and eliminating typing errors and therefore also syntax errors.

4 The Code Restructuring Tool (CORT)

CORT has been designed to support the "completion" method of learning to program and it was decided that the following features would be required in the first prototype:

- Support for part-complete solutions to programming problems. Such solutions help in schemata creation and also reduce cognitive load.
- A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution. This provides scaffolding for students.
- A facility so that students can add and amend lines of code. This would allow scaffolding to be reduced and for students to add more of their own code.
- For visual programming, a facility for students to easily view the target interface. The interface should be annotated with the various object names thereby reducing any split-attention effect and helping reduce cognitive load [1].
- A facility to access tutor created questions concerning the programming problems being attempted and for students to enter answers to those questions. This will promote reflection and higher order thinking.
- A facility to easily transfer a completed solution from CORT to the target programming environment.
- A facility to easily transfer programming code from the target programming environment back into CORT for further amendment.

4.1 The CORT Design

The user interface of CORT has been designed taking into consideration the three issues that have been suggested by Marcus [11] as being fundamental to interface design, namely development, usability, and acceptance. The interface for CORT is shown in figure 2.

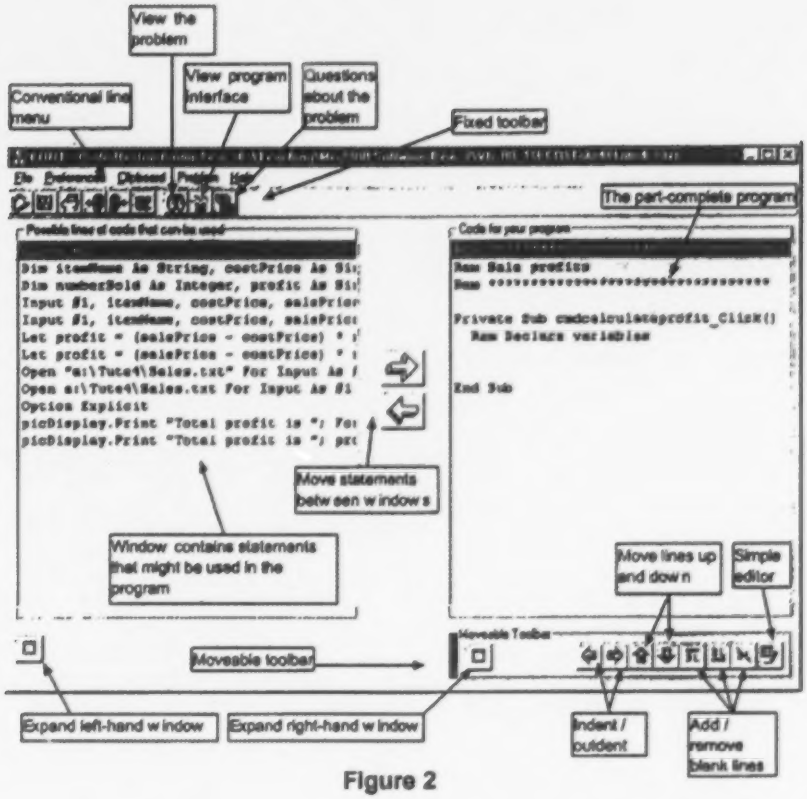


Figure 2

The ways in which the CORT design supports the list of required features are described in the following table.

Feature	Support in CORT Design
Support for part-complete solutions to programming problems	The part-complete solutions are automatically loaded into the right hand window and possible statements into the left hand window. Students load these from a file.
A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution	Two buttons in the middle of the screen will move lines between the windows. One line, or several lines can be selected and moved across.
A facility so that students can add and amend lines of code	A simple editor is provided so that students can add their own lines or amend existing lines.
For visual programming, a facility for students to easily view the target interface	Access to this feature is via a button on the fixed toolbar.
A facility to access tutor created questions on the workings of the programming examples and to enter student answers	Access to this feature is via a button on the fixed toolbar. Student answers are automatically saved.
A facility to easily transfer a completed solution from CORT to the target programming environment	This is provided by a button on the main toolbar. A single click will copy the contents of the right hand window to the Windows clipboard ready for pasting into the Visual BASIC programming environment.

BEST COPY AVAILABLE

A facility to easily transfer programming code from the target programming environment back into CORT for further amendment	This is provided by a button on the main toolbar. A single click will paste the contents of the Windows clipboard into the right hand window, overwriting what is there.

4.2 Use of CORT by Students

A student would typically use CORT as follows:

1. A student loads in a CORT file and the two windows display a part-complete solution to a problem together with possible lines to be used. There is a facility available for the contents of the two windows to be printed out.
2. The student can view the problem statement and the Visual BASIC solution interface by clicking on the appropriate buttons on the fixed toolbar. The problem statement may have already been provided to the student in the form of a handout, however there is also a facility to print it from within CORT.
3. The student moves certain lines from the left hand window to the right hand window in an attempt to complete the solution. Lines can be moved up or down, and indented or outdented in the right hand window. Some problems have too many lines in the left hand window, some of those lines being incorrect.
4. If necessary, the student can invoke a simple editor to amend, add or delete lines of code.
5. The student clicks on the appropriate button to copy the contents of the right hand window to the Windows clipboard.
6. The student invokes Visual BASIC and loads the file that contains the interface for the solution. This is in effect the Visual BASIC solution to the problem without the lines of code and was created by the tutor.
7. The student pastes the contents of the Windows Clipboard into the Visual BASIC editor and tests the program to determine if it works correctly. Use is made of the trace and debugging facilities of Visual BASIC. These facilities provide an insight to the workings of the notional machine.
8. If the student finds a problem with the working of the program, they can return to CORT and make the changes to the code there.
9. The student repeats steps 3 to 8 until they have a working program.
10. The student answers the tutor's questions concerning the programming problem that they have just attempted.

4.3 Initial Student Feedback

CORT has been used for one semester with both undergraduate and postgraduate students in the Faculty of Business and Public Management. The particular units are in the area of software development and the language that the students learn is Visual BASIC.

Each week the students have to undertake completion programming exercises using CORT and after each problem they were asked to comment on the use of CORT for the particular problem that they had just finished. The data was collected on-line through the Web and below are some of the comments that were received:

1. It's very helpful. I can see the interface of the program before actually running it.
2. I think CORT is a very useful tool to play around the codes. It saves me time copying and pasting.
3. Considering the increased workload as the semester progresses it is a bit of a relief that the exercises are much easier with the "fill in the gap" type format in CORT.
4. Without CORT, it's sure that I'll have a lot trouble with this particular problem, which focuses on arrays (a difficult topic). Thanks CORT...
5. CORT was useful in that the part solution helped to understand the logic of VB code
6. CORT is useful . However, I have used the unit text to try to understand the indentation format when writing the code. The directional keys are great for editing the code to meet the required format.

7. This was a challenge! I think that CORT is useful so long as I am not tempted to simply manipulate code until the program runs. If I were having to write programs from scratch I would use CORT so as to format and manipulate code and modules or sub procedures etc.

5 Conclusions

As can be seen from the above, the initial feedback on the use of CORT has been favourable. We have found that students can undertake two or three small programming problems within a one hour tutorial whereas without CORT they could only undertake one such problem. Also, without using CORT students often never manage to successfully complete their assigned problems and this certainly affected their motivation.

By using CORT, students do not have to be concerned with the design of programming interfaces which considerably reduces the cognitive load in the initial stages of learning programming. Also, the reduction of "split attention affect" by labelling all the objects with their names has been very popular with the students.

The above has described a preliminary study of the use of CORT and it has been undertaken to determine its suitability and to fine tune some of its features. CORT can be used in several ways and four distinct methods have now been identified. These will be the subject of further research. The four methods are as follows:

1. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are no extra lines displayed in the left hand window.
2. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are also additional lines displayed in the left hand window that are not required within the program. The extra lines are similar to the required lines, however they are incorrect and act as "red herrings".
3. **Some** of the lines that are required to complete a program are made available in the left hand window of CORT. Other lines that are required for the program completion need to be keyed in by the student.
4. **None** of the lines that are required to complete a program are made available in the left hand window of CORT. All of the lines that are required for the program completion need to be keyed in by the student.

References

[1] Chandler, P. and Sweller, J. (1991). Cognitive load theory and the format of instruction. Cognition and Instruction 8: 293-332.

[2] Cook, C., Bregar, W., et al. (1984). A Preliminary Investigation of the use of the Cloze Procedure as a Measure of program Understanding. Information Processing & Management **20**(1-2): 199-208.

[3] du Boulay, B. (1986). Some Difficulties in Learning to Program. Journal of Educational Computing Research **2**(1): 57-73.

[4] Edward, N. (1997). Development of a cost effective computer assisted learning (CAL) package to facilitate conceptual understanding. CAL97, University of Exeter, UK.

[5] Ehrlich, K. and Soloway, E. (1984). An Empirical Investigation of the Tacit Plan Knowledge in Programming. Human Factors in Compter Systems. J. Thomas and M. L. Schneider. Norwood, New Jersey, Ablex: 113-133.

[6] Fowler, W. A. L. and Fowler, R. H. (1993). A Hypertext Approach to Computer Science Education Unifying programming Principles. Journal of Multimedia and Hypermedia **2**(4): 433-441.

[7] Hall, W. E., III and Zweben, S. H. (1986). The Cloze Procedure and Software Comprehensibility Measurement. IEEE Transactions on Software Engineering **May 1986**: 608-623.

[8] King, J., Feltham, J., et al. (1994). Novice Programming in High Schools: Teacher Perceptions and New Directions. Australian Educational Computing(Sep 1994,): 17-23.

[9] Klare, G. R. (1974-75). Assessing Readability. Reading research quarterly(10): 63-102.

[10] Lieberman, H. (1986). An Example Based Environment for beginning Programmers. Instructional Science **14**(3): 277-292.

[11] Marcus, A. (1992). Graphic Design for Electronic Documents and User Interfaces. New York, ACM Press.

[12] Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity to Process Information. Psychological Review(63): 81-97.

[13] Norcio, A. F. (1980a). Comprehension Aids for Computer Programs. American Psychological Association Annual Meeting, Montreal.

[14] Norcio, A. F. (1980b). Human Memory Processes for Comprehending Computer Programs. Cybernetics and Society, Cambridge, Massachusetts.

[15] Norcio, A. F. (1981). Chunking and Understanding Computer Programs. Human-Machine Systems Symposium, Boston, USA.

[16] Norcio, A. F. (1982). Indentation, Documentation and Programmer Comprehension. Human Factors in Computer Systems, Gaithersburg, Maryland.

[17] Perkins, D. N., Schwartz, S., et al. (1988). Instructional Strategies for the Problems of Novice Programmers. Teaching and Learning Computer Programming: Multiple Research Perspective. R. E. Mayer, Hillsdale, NJ: Erlbaum: 153-178.

[18] Scholtz, J. and Wiedenbeck, S. (1992). The role of planning in learning a new programming language. International journal of man-machine studies **37**: 191-214.

[19] Sweller, J. and Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction **2**(1): 59-89.

[20] Thomas, M. and Zweben, S. (1986). The Effects of Program-Dependent and Program-Independent Deletions on Software Cloze Tests. Empirical Studies of Programmers: 138-152.

[21] van Merrienboer, J. J. G. (1990). Strategies for Programming Instruction in High School: Program Completion vs. Program Generation. Journal of educational computing research. **6**(3): 265-.

[22] van Merrienboer, J. J. G. and Krammer, H. (1987). Instructional Strategies and tactics for the design of Introductory Computer programming Courses in High School. Instructional Science **16**(3): 251-285.

[23] van Merrienboer, J. J. G., Krammer, H. P. M., et al. (1994). Automating the planning and construction of programming assignments for teaching introductory computer programming. Automating Instructional Design, Development, and Delivery (NATO ASI Series F, Vol. 119). R. D. Tennyson, Springer Verlag, Berlin.: 61-77.

[24] van Merrienboer, J. J. G. and Paas, F. (1990). Automation and Schema Acquisition in learning elementary computer programming. Computers in Human Behavior(6): 273-289.

An Assessment Framework for Information Technology Integrated Instruction

Chuan-Shih Wang* and Chia-Chin Li**
The Institute of Information and Computer Education, National Kaohsiung Normal University
116, Heping 1st Rd., Kaohsiung, Taiwan, R.O.C.
** jason@icemail.nknu.edu.tw **april@ icemail.nknu.edu.tw*

Information technology integrated instruction is the education tendency in the future, and it is also an important issue in the development of education in Taiwan. An assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference. This article proposes an framework for assessing information technology integrated instruction. The framework includes kernel and periphery parts. Kernel part refers to the whole teaching process, including information technology, curricula, learning materials, instructional strategies, learning activities, and evaluation. Periphery part refers to the surroundings situation, including teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

Keywords: **information technology integrated instruction, technology integration, educational technology, evaluation**

1 Introduction

The rapid development of information technology (IT) has not only brought about major effect on economy and industry but also made a great impact on society and education. In particular, the prevalent use of computers and the rapid development of the Internet have gradually changed our life style and pattern, with their impact on education being unprecedented. Many educators and policy makers believe that technology can be a catalyst for educational reform [3,4,10]. They suggest that the use of technology in classrooms will shift the roles of teachers and students. Teachers will act more like facilitators by helping students access information, process it, and communicate their understanding [4].

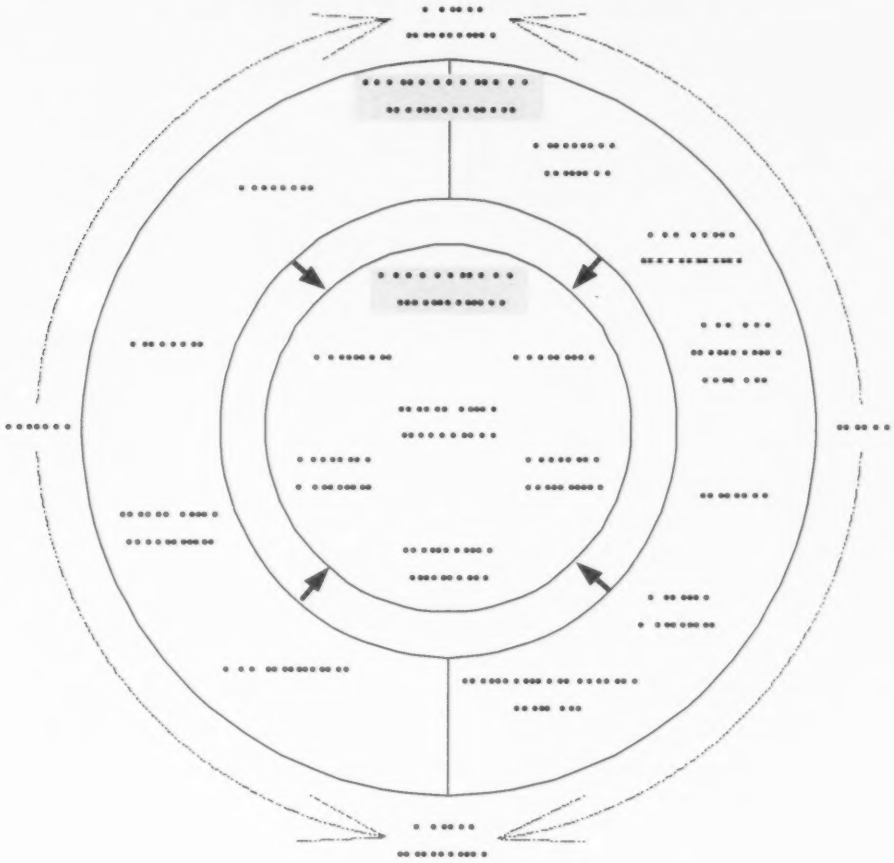
Beginning the 2001 academic year, Taiwan will implement phase-by-phase the nine-year integrated curriculum for its elementary and junior high schools [11]. To cultivate students' basic ability to "apply technology and information", the new curriculum will have to emphasize integrating IT into the teaching of various courses. Amid this major reform of curriculum, the Computer Center of the Ministry of Education has planned for the integration of information curriculum with other areas of learning [7]. At the same time, it has selected 18 elementary and junior high schools in which teaching experimentations will be carried out [1]. Therefore, an assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference.

2 The essence of information technology integrated instruction

The United States has implemented IT integrated instruction for years. Many educators are now actively using technology along with effective teaching strategies to integrate technology into their curriculum [9]. In contrast, IT integrated instruction is still a newly heard noun in Taiwan. Many teachers are unfamiliar with it, and some think of it as another name for computer-assisted instruction (CAI). Information technology has

developed rapidly, and the role of IT in education has changed over these years, from being an auxiliary to teaching to being an indispensable tool of education. Therefore, IT integrated instruction is distinguished from CAI.

In IT integrated instruction, information technology is an indispensable tool in the teaching environment because it is integrated into the curriculum, learning materials, teaching and learning [2]. Moreover, the traditional curriculum, materials, and teaching are transformed through the characteristics of information technology: the subject-based curriculum and materials become student-based; the teacher-driven teaching activities become student-centered. Information technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. It is not something one does separately; it is part of the daily activities taking place in the classroom [3].



F

igure 1. The assessment framework for information technology integrated instruction

Figure 1 depicts the assessment framework of IT integrated instruction. The assessment framework consists of two major parts: Kernel Part and Periphery Part. The kernel part primarily assesses the whole teaching process. Because the implementation of IT integrated instruction will bring about changes to teaching, the aspects to be assessed in this part should include not only the use of IT in teaching but also other perspectives of teaching: curricula, learning materials, instruction strategies, learning activities, and evaluation. The periphery part primarily assesses the teaching environment, learning resources, information equipment, personnel qualities, and administrative as well as professional support. All these factors will influence the outcome of teaching. In particular, IT integrated instruction is in need of supportive and coordinated environmental conditions. There are many perspectives of the periphery part that are related

with IT integrated instruction, and ten of them are carefully identified and included for assessment: teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

3 Assessing the kernel part

The kernel part refers to the whole teaching process, and Table 1 shows the perspectives and emphases to be assessed. The aspects of the kernel part are illustrated in the following paragraph.

Table 1. Emphases of the kernel part to be assessed

Perspective	Emphasis
Information technology	The use and role in instruction
Curricula	Subject-based separate curricula or Student-centered integrated curricula
Learning materials	Sequential or problem-based
Instructional strategies	Traditional expository approach or constructivist approach
Learning activities	Teacher-driven or student-centered
Evaluation	Traditional paper-and-pencil testing or multiple assessment

3.1 Information Technology

Information technology may refer to equipment or products, such as computers, network, peripherals, etc. It may also refer to the methods or processes in which the equipment of IT is used to help with the solution of problems. It is the purpose of implementing IT integrated instruction not only to enable students to use the equipment or products of IT but also to use the IT equipment to solve practical problems in learning and life.

In this perspective, we care about how IT is used in teaching and what role IT plays in teaching. The level of the use and role in instruction is developed:

- Nil (level 0): IT is not used and plays no part in teaching.
- Isolation (level 1): IT is used to teach students how to use IT (e.g. keyboarding, drill-and-practice, word-processing activities). There is no or little connection between IT and instruction content.
- Supplement (level 2): Teachers use IT to assist instruction and students use IT to aid learning occasionally. IT is viewed as a supplement to existing instructional program.
- Support (level 3): IT is needed to complete most learning activities. IT serves as a support to instruction.
- Integration (level 4): Students and teachers can use IT in every-day learning/teaching naturally, confidently, and actively. IT is expansively viewed as tool, process, method to find solutions to authentic problems in any time anywhere.

3.2 Curricula

For elementary and junior high schools, the curricular idea should be life-centered and be in compatible with the development process of students' physical and mental abilities; respect character development, inspire individual potential; cultivate civic qualities, respect the value diversified culture system; enhance science knowledge and skill, meet the requirements of modern life. The design of curriculum should be based on students, on practical experience, and devoted to cultivating the basic abilities required of modern citizens [11]. Therefore, the curriculum should be designed as student-centered integrated or interdisciplinary curriculum, not subject-centered separate curriculum.

IT is used as a tool to help students solve the problem. IT literacy should not be taught as an isolated subject, nor should activities with IT be isolated from other activities in the classroom [12]. Therefore, Taking the students to the computer lab once a week for 40 minutes is not necessarily integration [3]. The teachers should commit to designing student-centered integrated curriculum and integrate IT into the curriculum.

3.3 Learning Materials

Textbooks are the main materials for elementary and junior high schools and the primary learning materials of students. In traditional education, textbooks were unified, having only one version. They were based on subject systems and separate from students' living experience. Besides, it was difficult to innovate them,

they could not meet society's requirements for rapid transformation. In 1996 Taiwan implemented a policy which would partially allow publishers to edit and provide textbooks for elementary and junior high school so long as they are approved by the Ministry of Education. On February 3, 1999, VIII (2) of National Education Act was empowered, which unequivocally directs the full use of ministry-approved textbooks for elementary and junior high schools. A new epoch for textbooks was thus heralded in. Teachers should be able to exert their professional autonomy, and students should be allowed a flexible, autonomous learning leeway.

The presentation of learning materials should not be limited to static traditional books, but the characteristics of computer multi-media should be used to present these materials. Static words and pictures, animated pictures and films, voice, acoustic effect and music in combination would make teaching materials lively and motivate students to learn. Besides, they can help students to understand abstract concepts or knowledge and enhance learning effectiveness. If hyperlink technology is used, nonlinear learning materials can be designed so that what students see can be highly individual and not the same. As such, the content of learning materials is flexible, adaptive to individual difference, and compatible with the spirit of individualized learning.

In addition to textbooks, there are many resources on the Internet that can be used as learning materials. These resources can provide "instant", "living" information [8]. Teachers not only can search for information to be included in teaching materials but also can use the real-time information on the Internet to conduct teaching. Students not only can search for information on the Internet but also can conduct independent learning any time, any place by using the learning materials on the Internet.

The use of information technology can make learning materials diversified and lively, make their content flexible and integrated with life. Not only can teachers easily motivate students to learn, but students also can learn happily in a rich teaching situation.

3.4 Instruction Strategies

The teaching strategy of the traditional expository approach is teacher-centered. Students learn what is taught by the teacher, but are given a limited room for thinking, discussion, presentation and exploration. The teaching effectiveness is ostensibly good, and students' performance on examination seems impressive. Yet this approach contradicts the essence of education. In a series of meaningless learning process, what students learn is segmented memory that is extraneous to their experience and cannot be applied in practical situations of their daily life. Nor can they enjoy learning.

Constructive teaching strategy is student-centered. The teacher would first arrange a teaching situation to arouse students' motivation for learning and then would conduce students to explore and think. Through the interaction with peers, the students can gradually integrate the new knowledge into their own system of knowledge and make it an essential part of this system. By this constructive teaching, students must actively learn, while the teacher can only play the role of facilitator, auxiliary, and consultant.

When students use teaching software and browse for Internet resources, they must explore and think actively and construct their own knowledge through the interaction between machine and person and through social interaction. Therefore, the teacher is a "coach" for the student rather than a provider of knowledge. Self-directed learning is an attainable goal for both the student and teacher when IT is integrated in the various content areas [6]. That is, IT integration is most likely to occur in learner-centered classrooms in which the teacher acts as a facilitator [3].

3.5 Learning Activities

Traditional lecture-based and teacher-driven activities can no longer satisfy the needs of modern education. It is not only monotone, also lacks interaction between peers. Learning activities should be student-centered so that the learner can actively work to explore knowledge, clarify concepts, and gradually construct his/her system of knowledge. In addition, project-based and cooperative learning activities should be adopted to allow the learner the opportunity to produce high-level interaction with his/her peers. These activities not only can cultivate a respectful, responsible, and confident attitude and the abilities to express, communicate, coordinate, think, and create but also can increase learning effectiveness.

In cooperative learning activities, students can use computer to communicate and discuss, or use a certain

support cooperative work software to facilitate collaboration. Finally, multi-media would be used to present the learning effectiveness of students. Cooperative learning is not limited in local class. It can also be applied across schools, countries, and culture. Therefore, IT enriches the learning activity.

3.6 Evaluation

The traditional evaluation approach primarily depends on paper examinations and determines learning outcome by the scores on the test sheets. This type of evaluation measures only a dimension of knowledge, unable to reflect the 'wide spectrum of learning process. Future evaluation will become diversified; performance evaluation may be conducted along with paper evaluation; students' self-evaluation, peer evaluation and juried evaluation may be conducted along with teacher' s evaluation; in addition to evaluating learning outcome, the learning process should be evaluated; in addition to quantitative evaluation, qualitative evaluation should be adopted; in addition to evaluating cognitive domain, the evaluation of affective and skill areas should be included. Only such a comprehensive evaluation can re flect the learning process, not only be able to understand what the student has learned but also be able to understand how the learning has occurred.

IT integrated instruction is helpful to the implementation of diversified evaluation. For example, the electronic portfolio is an ideal means of integrating IT into the instruction. It gives the student and teacher an alternative form of assessment. Furthermore, electronic portfolios motivate students to produce quality work, and they also increase students' self-esteem by showcasing their best work [6].

4 Assessing the periphery part

The periphery part primarily refers to the surrounding situations. Table 2 shows the perspectives and emphases to be assessed. The following illustration is based on perspectives.

4.1 Teachers

The teacher is vital in leading teaching activities. Without sufficient information literacy and professional ability, he or she cannot apply information technology on teaching, let alone implement IT integrated instruction. Regarding professional ability, the teacher should be able to integrate IT, in addition to assessing software and digital materials. The attitude is another emphasis of assessment. If the teacher has a positive attitude toward computer, he/she can readily introduce and apply computer on teaching; if the teacher can accept the change in teaching status and role, the implementation of IT integrated instruction would not cause a great impact.

4.2 Students

Students are the chief character in education. In teaching, students should take the initiative to construct their own knowledge. In implementing IT integrated instruction, students can obtain from the process related knowledge and skill and steadily strengthen their information disposition. Gradually students should be able to use, naturally and confidently, computer equipment in active learning and to construct their system of knowledge.

4.3 Information specialists

Teachers are not information specialists. In extensive application of IT to teaching, they will definitely encounter many technical problems that can not be solved by them. In this case, information specialists can support teachers in solving such problems. It is much easier for information specialists with education background to integrate IT with education and guide classroom teachers to implement IT integrated instruction.

4.4 Administrators

Whether administrators feel important about IT integrated instruction is intimately related with the implementation of IT integrated instruction. In addition, if the classroom teacher can gain sufficient administrative support, he or she will be more willing to implement IT integrated instruction.

4.5 Classroom Settings

Generally speaking, teaching activities are conducted indoors. Therefore, the IT equipment in classroom is indispensable to the integration of IT into teaching [14]. The computer and peripherals should not be outdated. The operation system and application software installed in the computer should be appropriate for the use by students and suit the needs of teaching. Moreover, for a class of more than 10 students, a large display device or broadcasting teaching equipment is needed. Finally, it matters whether they are managed properly or whether the fair use by students is ensured.

Table 2. Emphases of the periphery part to be assessed

Perspective	Emphasis
Teachers	Information literacy and professional competency Attitude toward information technology and instructional change
Students	Information literacy Attitude toward information technology
Information Specialists	Professional competency Support for teacher
Administrators	Attitude toward information technology integrated instruction Support for teacher
Classroom Settings	Number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripherals (e.g. printer, scanner, digital camera) Broadcasting teaching facilities Management
Computer Laboratories	Number of computer labs, number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripheral (e.g. printer, scanner, digital camera) Broadcasting teaching system Management
Campus Instruction Network	Structure of campus network and network type Domain account File server and database server CD cabinet (perhaps made possible through software simulation)
Internet	Method and speed of Internet connection Actual connection speed Internet server (e.g. web server, proxy server, DNS server, mail server) The mechanism to filter out inappropriate information.
Digital Materials	Digital materials that can be used on the Internet Digital materials created by the teacher
Instruction/Learning Software	Quantity Adaptation

4.6 Computer Laboratories

In a situation in which IT is integrated into teaching, sometimes it is required that one person have one machine. Computer laboratories can justly meet this requirement. Therefore, the management of computer laboratories is an important assessment item and can decide whether the computer equipment can sufficiently support classroom teachers [14]. Moreover, computer laboratories can also provide the most appropriate places for teachers' advancement and students' training of information skill. The equipment in the computer laboratories should not be outdated. Furthermore, there must be a broadcasting system, enabling students to know the whole content of teacher's lecture in a ready manner.

4.7 Campus Instruction Network

The planning and erection of campus instruction network aims not only to construct an instruction network on campus but also to enable every classroom on campus to connect to the Internet through the campus

network. After the campus network is erected, File Server and CD cabinet (perhaps made possible through software simulation) should be erected, in which the teaching software owned by the school is stored so that all the teachers of the school can access to it readily and can apply it to teaching. In addition, the establishment and management of network account is equally important, ensuring the safety of information [14].

4.8 Internet

There are unlimited, un-exhaustive teaching resources on the Internet. If computers can not be connected to the Internet, the application of IT to teaching is compromised. Therefore, it is very important to provide information settings of the Internet. In addition, it is needed to erect Internet-related Server, in particular, Web Server must be erected so that teachers' teaching information and the learning outcome of students can be stored on it to facilitate examination and simulation by teachers and students. Besides, Internet is full of erotic and violent information which is unsuitable to students. It is extremely important to build a mechanism to prevent students from seeing those inappropriate content [14].

4.9 Digital Materials

Digital materials may be presented through information equipment and be used in teaching activities. Therefore, plentiful digital materials should be able to help integrate IT into teaching of various subjects. Therefore mny on-line materials on the Internet can be used for teaching purpose. To decrease the amount of time required for browsing and facilitate the use of the materials by teachers and students, on-line index and search systems are also required. In addition, if on-line materials are not appropriate for teaching needs, classroom teachers may create their own materials to be presented on information equipment or use materials created by colleague teachers with the approval from the original designer [14].

4.10 Instruction/Learning Software

Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) software is a help to teaching and learning. With more software, teachers are better equipped to apply IT to teaching. This software should be stored on the CD cabinet or File server on the campus network so that teachers can readily use it whenever needed. In addition, if existing teaching software available on campus is evaluated, further information can be provided to teachers [14].

5 Conclusions

That teachers and students can extensively use computers for teaching or learning purpose to heighten teaching qualities and learning effectiveness is the ultimate goal of the infrastructure construction of information education [5]. In other words, integrating computer into teaching of various subjects is the ultimate goal of the Ministry of Education in promoting information teaching [13]. What IT integrated instruction means is not merely to assist teaching by computer but work to integrate IT into curriculum, learning material and learning activities. At this point, the role of teachers begins to transform, from that of a main character to that of a support character. Therefore, the implementation of IT integrated instruction not only harmonizes with the u ltimate goal of information education but also prompt the reform of education so that learning becomes more effective, efficient, and meaningful.

IT cannot be successfully integrated overnight. It needs to take years to complete the process. The process should be carried out in order, stage by stage. Taiwan's IT integrated instruction is germinating. The assessment framework set forth in this article can be used not only to carry out practical evaluation but also serve as reference for development. Teachers' in-service education, pre-service training, administrative support, enriching IT equipment, developing appropriate digital materials and teaching software should be taken to strengthen the perspectives of the periphery part and to diversify the surroundings so that teachers can realize the benefits brought about by IT on education, Accordingly, teachers can apply IT to teaching, gradually infuse IT into learning activities, curricula, learning materials, and adopt student-centered teaching strategies and multi-facet evaluation. All this can lead to the fulfillment of the meanings of IT integrated instruction.

References

[1] Chang, H. Y., "1999 review of implementation of infrastructure construction plan for information education by the Ministry of Education", Ministry of Education Computer Center newsletter, No. 8810, pp. 1-8, (1999).

[2] Chiu, K. H., "Concepts and methods of computer-integrated instruction", Taiwan Education Review, No. 479, pp. 1-8, (1990).

[3] Dias, L. B., " Integrating technology: Some things you should know", Learning & Leading with Technology, Vol. 27, No. 3, pp. 10-13, 21, (1999)

[4] Dexter, S. L., Anderson, R. E., & Becker, H. J., "Teachers' views of computers as catalysts for changes in their teaching practice", "Journal of Research on Computing in Education", Vol. 31, No. 3, pp. 221-239, (1999).

[5] Han, S. M., "Infrastructure construction of information education – acceleration", Information and Education, No. 68, pp. 14-16, (1998).

[6] Hanfland, P., "Electronic portfolios: Students documenting their best work", Learning & Leading with Technology, Vol. 26, No. 6, pp. 54-57, (1999).

[7] Her, J. K., "Viewing the prospects of information education in elementary and junior high schools from the promoting strategy of information education of the Ministry of Education", Information and Education, No. 68, pp. 2-13, (1988).

[8] Lee, C. M., Wu, C. J., & Lin, M. C., "Erection of information education software and material resources center", Information and Education, No. 68, pp. 21-28, (1998).

[9] Levine, J., "Planning strategically for technology integration", Proceedings of Technology and Teacher Education Annual 1998 (SITE ' 98), Charlottesville, VA, pp. 293-295, (1998).

[10] Mehlinger, H., "School reform in the information age", Phi Delta Kappan, No. 77, pp. 400-407, (1996).

[11] Ministry of Education, "Tentative Guideline for Nine-year Integrated Curriculum for Elementary and Junior High Schools (first learning stage)", http://teach.eje.edu.tw (accessed on April 13, 2000).

[12] Sprague, D. & Dede, C., "If I teach this way, am I doing my job: Constructivism in the classroom", Learning & Leading with Technology, Vol. 27, No. 1, pp. 6-9, 16-17, (1999).

[13] Tu, A. P. & Lin, H. H., "Accelerating the infrastructure construction of Taiwan' s information education: Alternative for expanding internal demand – special interview of Chen Li-hsiang, director of computer center of the Ministry of Education", Information and Education, No. 68, pp. 29-32, (1998).

[14] Wang, C. S., "Criteria for assessing information situation of information technology integrated instruction", Information and Education, No. 77, pp. 36-47, (2000).

An authoring shell with intelligent reuse

Kam W. Li * Jill Slay * Warren James *
** School of Computer and Information Science*
University of South Australia, Mawson Lakes Campus,
Mawson Lakes, SA 5095, Australia
Tel: 61-8-83024714
Fax: 61-8-83023381
Email: li@cs.unisa.edu.au jill.slay@unisa.edu.au warren@cs.unisa.edu.au

Common authoring shell that enable reuse of teaching materials allows teachers to search for existing teaching materials on the web and computer system. The authoring shell will give a list of materials that will match the word(s) for searching. Sometimes none of the matched items will be reported but sometimes hundreds of matched items will be found. It is difficult for teacher to browse all matched items before making decision to reuse the material or not under such situation. To facilitate the reuse of teaching materials, we expect an authoring shell should be more intelligent—able to identify the purpose of the teacher in searching for a material. It should provide a list listing closely related materials when there is no matching and filter off those materials that are not related to a teacher's intention. In this paper, we shall discuss how it is possible to achieve this.

Keywords: **Reuse, authoring, intelligence**

1 Introduction

There is a lot of authoring tools available that assists teachers in producing online course. Common authoring tools being used by educational organizations to produce online course/lesson are Authorware, Toolbook, WebCT, BlackBoard, COCA and Hypercard … etc. Most of these tools can help a teacher to create and manage web-based courses even though the teacher may not have any programming or web-based design experience. These tools are not domain specific and therefore can be used in various knowledge domains. Usually these tools do not explicitly specify the pedagogy or the teaching strategies. Thus, a teacher at authoring will not be bounded by specific pedagogy or teaching strategy in using these tools. But this also means that a teacher must plan and implement the pedagogy and teaching strategy by himself/herself before using the tool. Even though most of these tools allow a teacher to search and retrieve teaching materials, they do not actively support the reuse of teaching materials over multiple teaching strategies by giving suggestions to teacher.

IAS, Intelligent Authoring Shell, is a generic authoring shell prototype. Our initiative in building IAS is to enable reuse of teaching materials for multiple teaching strategies. By using IAS, the production of online adaptive course with multiple teaching strategies can be more cost-effective. It is named with "intelligent" because it will suggest closely related reusable materials to a teacher at authoring.

2 Hypothesis for reusing teaching materials

There are two basic ways in tackling reuse of teaching materials. One of the ways is based on ontology. In 1996, Mizoguchi and his fellows discuss using task ontology in building Intelligent Tutoring System where "Task ontology is a system/theory of vocabulary for describing inherent problem solving structure of all the existing tasks domain-independently" [12]. Laresgoiti [11] also examine the use of ontologies as "vehicles for reuse". They use application ontology, domain ontology, basic technical ontology and generic ontology to describe the physical world of education. Similarly, Murray [13] has also discussed using special purpose ontologies over object to describe pedagogical knowledge. In 1998, Mizoguchi and his fellows Chen [2] have extended the use of task ontology into domain ontology, teaching strategy ontology, learner model

ontology and interface ontology into their SmartTrainer authoring tool. Using ontology has the advantages on re-engineering the structure of knowledge in education and each knowledge domain. This will facilitate the use of information technology onto education. However, using ontology in authoring has a potential problem—most users, teachers are not familiar with ontology. Unless the operation of ontology is transparent to teacher at authoring, it is reasonable that teachers may be reluctantly to use such authoring tool. Using ontology aims to standardise the terms to be used so that everyone using ontology will have the same understanding on the term being used. However, in education, teachers are encouraged to provide innovative teaching in order to promote teaching and student's learning. Therefore, there exists problem between standardisation and innovation.

Another way to solve material reuse is by using a database repository to store teaching materials information. Sarti and Marcke [14] have discussed using database repository method in storing information about "Domain", "Structuring", "Instructional" and "Presentational" perspective inside DISCourse. Cybulski and Linden [3] also suggest using repository method to store the information about various kind of "artefact". They have identified some attributes for the artefact: artefact number, URL, type, label, content description, keywords, file type, file size and preview [4][5] in building their MATE tutoring system. Using a database has the advantages that teaching materials can be decoupled from the teaching strategies. Besides, it allows flexible courseware configuration over LAN and web. Since there are many good off-the-shelf database tools available, relatively it is much easier to store, retrieve and maintain teaching materials within the system. The disadvantage in using database are the additional cost in setting up and maintaining a database system and inherit the limitations from using database softwares.

Instead of using ontology, we have decided to use database system method to store useful information. Unlike methods used in MATE, we use learning objectives as the key to reuse on teaching materials. Most teachers are familiar with the concept of learning objective and there is a rich educational research literature surrounding them. Even though we know that there are still controversial arguments over using of learning objectives, we believe that there are more pros than cons in using learning objectives, particularly under the criteria of "effective learning" -- student using minimum time and/or effort to produce maximum learning outcome.

Basic learning objective has two main components: an *object* and a *keyword*, the letter drawn from a learning objective. An *object* is a concept, or skill, or entity that is described in a learning objective. For example, in a learning objective *"Define Newton's First Law"*, Newton's First Law is the *object*. *Keyword* is the verb being using in the learning objective. Refer to previous example, "*Define*" is the *keyword* of the learning objective. There has been a lot of educational research on *keyword* (also named as learning objective taxonomy). If each teaching material is tagged with at least one learning objective, then from the *object*, we can search for the existence of a related teaching material. Also, from the *keyword*, we can know the purpose of that teaching material. In our IAS, teaching material is a multimedia file corresponding to the "atomic artifacts" as defined by Cybulski et al.

Besides using learning objective over reuse at teaching material level, we can also extend the usage of learning objective to learning activity level and lesson level. Learning activities in IAS are activities such as introduction, exercise and conclusion that are defined inside a normal lesson structure. Lessons in IAS are set of learning activities that are organized for particular teaching strategy such as lecturing, case study, drill and practice ...etc. The fundamental difference between our IAS and Cybulski's MATE system is; in MATE; learning objective is just a statement indicating the usage of teaching materials. In our IAS, learning objective is the key for us to build "*domain*", "*structuring*", indicator for usage, and "*glue*" to link teaching strategies and other educational theories into tutoring systems.

3 Design of IAS

In our IAS, we have built following modules: keyword (taxonomy) module, strategy design module and course design module. Reuse of teaching materials occurs in course design module. Keyword module and strategy design module provide the basic environment that help to provide intelligent suggestions to a teacher at authoring. Figure 1 shows the structure of our IAS.

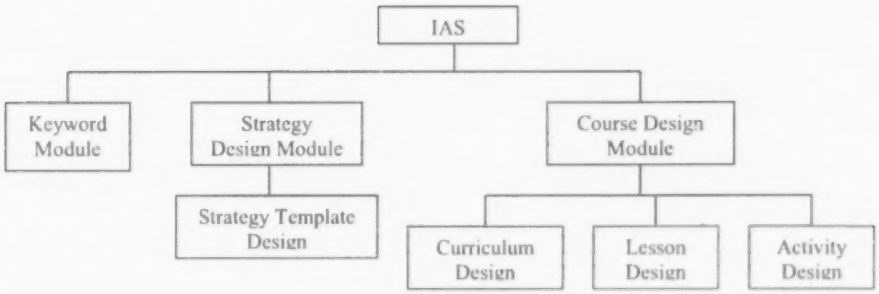


Figure 1 Structure of IAS

3.1 Keyword (Learning objective taxonomy) module

We have built this module to facilitate entering of learning objective taxonomy (*keyword*) into our IAS database. In building this module, we have used Bloom's taxonomy [1] as reference as it is a well-known taxonomy being used in education. In general, learning objectives [6] can be grouped as general objectives and specific objectives. General objective is composed of a set of specific objectives. Each specific objective can be composed of a set of sub-specific objectives or directly related to a lesson or an activity. Bloom has classified learning objective taxonomies into three different domains: cognitive domain, affective domain and psychomotor skill domain. Under each domain, taxonomies are further classified into different levels. For example, within cognitive domain, taxonomies are classified into *knowledge*, *comprehension*, *application*, *analysis*, *synthesis* and *evaluation*. These different levels form the class hierarchy with *knowledge* be the lowest class while *evaluation* is the upmost class.

In building this module, we are aware that Bloom's taxonomy is not the only taxonomy available. There are Harrow's taxonomy [7] on psychomotor skill, Krathwohol's taxonomy [10] on affective domain, Steinaker's taxonomy on experiential learning etc. Therefore, this module allows teacher to enter sets of taxonomy from other educational theory school such as experiential learning or "learn by doing". This feature will allow educationists to research and create their own set of taxonomy such as task ontology. We have also added a comment field for each keyword so that the definition of each keyword can be added. This will not only help teachers to arrive a common understanding of the keyword, but also in learning keywords from different educational theory school. Figure 2 shows the data hierarchy being used in this module.

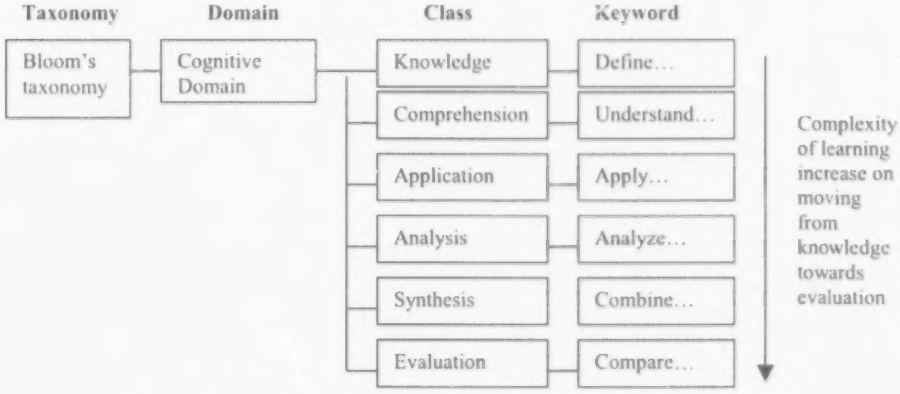


Figure 2 Bloom's hierarchy of learning objectives on cognitive domain

3.2 Strategy design module

From education, there are many teaching strategies such as lecturing, feedback lecturing, concept attainment, drill and practice, role-play, gaming, debate etc. Therefore, it is impossible to pre-design all teaching

strategies into our IAS. Besides, as mention before, teachers are encouraged to create teaching strategy or modify existing strategy in order to provide innovative teaching. Therefore, it is not reasonable if an authoring shell cannot allow a teacher to create his/her own teaching strategy. In IAS, we have a strategy design module that allow teachers to create their own teaching strategies. Using the strategy design module, we have pre-designed some teaching strategies such as lecturing, concept attainment for the purpose of demonstration and testing.

In IAS, a teaching strategy is composed of a set of activities with different activity type. Each activity type may consist of sub-activity type. For example, a lesson using concept attainment [8] as its teaching strategy usually contains introduction, example, counter-example, analysis and conclusion. A lesson using lecturing as its teaching strategy contains introduction, presenting new knowledge, example(s), exercise(s) and conclusion. Example is composed of sub-activities: description, question, answer and explanation [9]. Therefore, in designing a teaching strategy, a teacher will be asked to construct the structure for the teaching strategy by entering and arranging the activity types in order. Figure 3 shows a teaching strategy structure for lecturing.

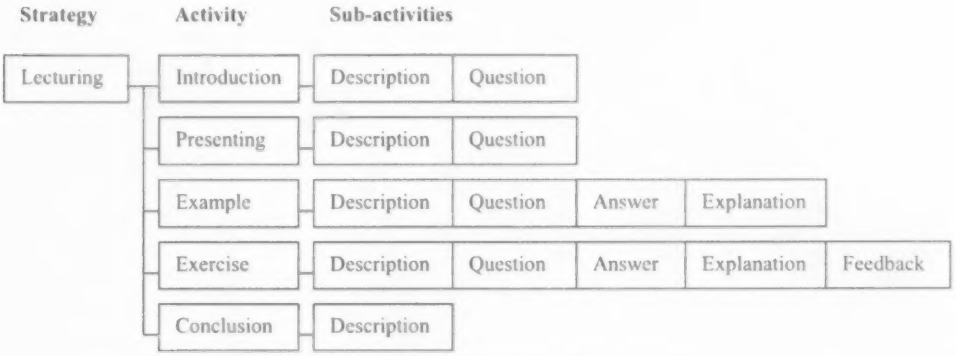


Figure 3 A teaching strategy structure for lecturing

In designing the structure of a teaching strategy, the author can enter information or rationale about using this teaching strategy. This will help other teachers in learning/knowing how to use the teaching strategy "properly". Author of teaching strategy is also asked to relate his/her teaching strategy to the domain and class of taxonomy that is unlikely applicable. With this information available, IAS can give suggestion to teacher what kind of teaching strategy are available and possibly applicable according to the keyword being used in learning objective.

3.3 Course design module

In designing a course, a teacher will be involved in designing the curriculum for the course, designing the lesson and the learning activities within each lesson. Since IAS is just an authoring shell, we will not consider the design of teaching materials. Authors can use most off-the-shelve multimedia authoring tools to create those teaching materials. In IAS, course design module is the module where most of the reuse of teaching materials takes place.

3.3.1 Designing the curriculum

In designing the curriculum, a teacher is required to construct a hierarchy of learning objectives for the course. A teacher will enter details for a learning objective including the keyword and object.
To enter a learning objective, a teacher will be requested to enter the object of the learning objective. With the object defined, a list of existing learning objectives with the same object will be displayed for selection. If a teacher want to put in a new learning objective, then a teacher will need to specify the keyword. Along with the keyword, the taxonomy, domain and class will be identified. Instead of keying in the keyword, a teacher may select keyword start from selecting the taxonomy, then domain and class. Information about the keyword will be displayed as required.

In entering a learning objective, it is possible for IAS to provide some basic logical checking over the

sequence of learning objective using the keyword class hierarchy. For example, it is not logical to arrange "apply for-loop" before "define for-loop" because, according to Bloom's taxonomy, "apply" is a keyword in class *application* while "define" is a keyword in class *knowledge*. Higher order classes usually require lower order classes as prerequisite. An illogical order of learning objective hierarchy will increase student's difficulty in learning. Therefore, such a checking feature can help to improve quality of a course.

After the learning objective hierarchy is built, an object hierarchy is also constructed using the objects from each learning objective. With this object hierarchy, we can identify the relation between each object. This relation will be useful in deciding which teaching materials may be appropriate for reuse. Besides, this will also assist us in searching and retrieving materials for the object.

3.3.2 Designing the lesson

In IAS, each lesson belongs to only one specific learning objective and each lesson has only one teaching strategy. However, a learning objective may have multiple lessons, hence multiple teaching strategies. With only one specific learning objective per lesson, it will be easy to replace a lesson with another lesson that has the same learning objective, thus provide multiple teaching strategy to student at learning. For example, if learning objective "Define for-loop" has two lessons designed using lecturing and concept attainment individually, then a student can decide to learn the learning objective using either lecturing or concept attainment or even both. Single learning objective per lesson also has the benefit that any modification of a lesson will not affect the other learning objectives.

In creating a lesson, a list of existing teaching strategy for the same learning objective will be available to teacher for selection. Besides, that, another list of appropriate strategy (with no activities defined) will also be available for a teacher to create his/her new lesson. This appropriate strategy list is generated according to the unlikely appropriate strategy for the class of domain keywords as mentioned in the "Strategy design module". For example, in knowing that the lesson is about learning a concept, IAS will give suggestion to the author indicating lecturing and concept attainment is recommended. Since IAS only provides suggestion rather than making the decision for the author, the author still can select other "less appropriate" teaching strategies available. With this feature, a teacher is allowed to use innovative teaching in preparing online courses.

3.3.3 Designing the learning activities

After a lesson is created, the author will follow the structure of teaching strategy to design learning activities. A learning activity may have sub-activities. For example, an example contains sub-activities description, question, answer and explanation. For activity that does not have sub-activities, author will be asked to enter the link (URL of the teaching material) to the activity.

In designing the learning activities for a lesson, basically it will use the information about the object and the keyword. From the preliminary analysis on reuse [9], we know that teaching materials in activities such as example and exercise are highly reusable. Therefore, in suggesting reusable learning activities, IAS will include activity type as a factor for consideration. The suggestion criteria available are based on activity type, keyword, object and learning objective (keyword + object). Suggestion criteria based on activity type will use activity type as filtering element. For example, if the activity at authoring is an example, then IAS will only list those activities that are examples only. Suggestion criteria based on keyword will list materials will the same keyword. However, this will give a large number of suggestions that are irrelevant due to the irrelevant object. Suggestion based on object only will give better results than using activity or keyword only because it always return closely related materials with same object. However, there are situations where IAS can not find the exact matching of keyword. Under this situation, IAS will give suggestion according to the "distance" from the object to other object on the object hierarchy as defined from the curriculum designed module. This will enable the most relevant activity/material will always be suggested. Suggestion criteria based on learning objective (keyword + object) will not only list materials/activities that have the exact matching on learning objective but also the activities/materials in the order of their relation in learning objective hierarchy (curriculum). This will reduce author's time in searching for reusable teaching materials, particularly when the database has thousands of teaching materials available.

4 Conclusion

An authoring shell that supports reuse of teaching material should not only allow the author to search for the

existence of the material and retrieve it if available. An authoring shell can be more "intelligent" by providing suggestions to author at authoring. Even if the searching cannot find the exact matching, an intelligent authoring shell should be able to produce a list of materials that are closely related to the searching. Our IAS is design not only to enable material reuse but also to assist author in reusing teaching material.

In our IAS, we have included a Keyword Module and a Strategy Design Module to provide the background for the intelligence. In the Course Design Module, an author can design the course curriculum, lesson within the course and activities for each lesson. IAS will provide intelligent suggestions to the author at each stage of design.

There are still a lot of works that we are going to do in order to improve the performance and intelligence of IAS. For example, we are going to find out whether there is an optimal suggestion criterion. Besides, we are also investigating the possibility for the IAS to continuously optimise its suggestions by itself according to a teacher's selections at authoring and students responses at learning. We know that Keyword Module and Strategy Design Modules cannot provide the complete background for the intelligence to be required. We still need to explore other modules such as pre-requisite knowledge module into consideration to enhance the performance of IAS.

References

[1]Bloom, B. S., M. D. Englehart, et al., "A Handbook of educational objectives: The cognitive domain", New York: David McKay, Inc., (1964).

[2]Chen, W., Y. Hayashi, et al., "An Ontology-based Intelligent Authoring Tool", ICCE'98, Beijing, China, China Higher Education Press Beijing, (1998).

[3]Cybulski, J. L. and T. Linden, "Composing Multimedia Artefacts for Reuse", http://www.dis.unimelb.edu.au/staff/jacob/publications/plop-98/pre-workshop-draft.pdf (accessed on February 1, 2000).

[4]Cybulski, J. L. and T. Linden, "Designing Multimedia Development Environments with Reuse in Mind", http://www.dis.unimelb.edu.au/staff/jacob/publications/acis-99/paper.pdf (accessed on April 2000).

[5]Cybulski, J. L. and T. Linden, "Assisting Web Site Development with Reuse and Patterns", http://www.dis.unimelb.edu.au/staff/jacob/publications/www-99/draft.pdf (accessed on March 1, 2000).

[6]Gronlund, N. E., "Stating Objectives for Classroom Instruction", Macmillan Publishing Company, (1985).

[7]Harrow, A. J., "A Taxonomy of the Psychomotor Domain", David McKay Company, INC., (1972).

[8]Joyce, B. and M. Weil, "Models of Teaching", Prentice Hall, Inc., (1986).

[9]Kam Wing, L. and J. Warren, "Reusing of teaching materials for an intelligent tutoring system with multiple teaching strategies", ICCE'98, Beijing, Springer-Verlag (1998).

[10]Krathwohol, D., B. S. Bloom, et al., "A Handbook of educational objectives: The affective domain", New York: David Mckay, Inc., (1968).

[11]Laresgoiti, I., A. Anjewierden, et al., "Ontologies as Vehicles for Reuse: a mini-experiment", http://ksi.cpsc.ucalgary.ca/KAW/KAW96/laresgoiti/k.html (accessed on May 16, 1999).

[12]Mozoguchi, R., K. Sinitsa, et al., "Task Ontology Design for Intelligent Educational/Training Systems", http://www.ei.sanken.osaka-u.ac.jp/pub/miz/miz-its96.html (accessed on August 1, 1999).

[13]Murray, T., "Special Purpose Ontologies and the Representation of Pedagogical Knowledge", http://www.cs.umass.edu/~tmurray/papers/ontology/ontology.html (accessed on August 1, 1999).

[14]Sarti, L. and K. V. Marcke, "Reuse in Intelligent Courseware Authoring", http://www.pitt.edu/~al/aied/sarti_vm.html (accessed on August 1,1999).

An Educational Application of Integrated Route Information Service on the Internet

Tun-Wen Pai*, Chao-Lin Liu and Chih-Yao Yang***

**Dept. of Computer Science, National Taiwan Ocean Univ., Keelung 20224, Taiwan,*
E-mail: twp@cs.ntou.edu.tw
*** Dept. of Computer Science, National Chengchi Univ., Taipei 11605, Taiwan*
E-mail: chaolin@cs.nccu.edu.tw

With the rapid growth and transfusion of information technology into community, the Internet offers a possible new education dimension. It provides a vast and integrated resource for individuals by network connecting and web interaction without time and location limitations. This paper presents an educational web system of integrated route information service (IRIS) that recommends and guides students to learn in-depth information of popular tourist spots and to travel those spots via the multimodal public transportation systems. As a result, the issues of environmental protection in terms of air pollution and traffic jam are overcome by making use of the proposed system, and the learner is also able to further understand local cultures and transportation information of his living area. The proposed IRIS educational service is categorized as a combination of transmission and consultation typology based on the controllability of information providing and distributing. The design of the system and its efficient algorithms for providing the service through the Internet will be discussed within the framework of the typology.

Keywords: **web application, transmission, consultation, Integrated Route Information Service**

1 Introduction

Traffic congestion and air pollution have become major headache for most large cities around the globe. Millions of people waste their time in jammed traffic and keep making air polluted by exhaust emission everyday. Driving in jammed traffic can also make people very annoyed and tired, inevitably reducing people's productivity and devastating state of mind when they finally arrive at their destination. As a result, educating people to utilize public transportation systems has become a target for all modern countries, and the Internet is one of the best approaches to convey the information and to achieve the goal.

The congestion problem can be tackled from both the demand and the supply sides. From the supply side, one may build more roads to increase the total capacity for traffic. This approach, however, may not be practical for many countries and definitely will ravage the natural environment. Land is a kind of limited resource, so we cannot construct more roads at the speed that people can buy more cars.

There are several conceivable strategies to cope with the traffic congestion and air pollution problems from the demand side. For instance, we may reduce the traffic volume and air pollution by legislatively banning a portion of registered vehicles from entering cities on specific days as what Singapore employs or aggravating car taxes for the aged cars as Japan does. Another strategy to reduce the traffic demand is to encourage people to commute by public transportation systems. Convenient public transportation systems provide not only an economical way for people to commute but also a chance for us to alleviate the air pollution problem that results from excessive use of passenger vehicles.

A popular way to encourage and educate people to use public transportation systems is to provide complete route information and to improve the predictability of travel times in an efficient and effective approach. Most noticeable measure is the introduction of bus priority routes in many cities [2]. By granting buses

exclusive rights to run on chosen routes, people can estimate the travel times on buses more precisely, thereby offering an incentive for people to take advantage of buses. Typical multimodal public transportation systems provide a complex route network for people to move around the cities. The route network covers the served area such that people can virtually walk to their destinations within minutes after departing from a nearby bus station. Complex route network, however, is very difficult for people to figure out what routes of buses they should take to get to their destinations. Taking the public transportation systems in the Taipei metropolitan area for example, more than 200 bus routes serve the metropolis, and the number of bus routes is still growing. A railroad route crawls through the metropolis, and five subway routes connect very busy area in the metropolis. Searching the best way, or even just a good way, to travel via such multimodal public transportation systems can be very challenging to ordinary people.

Providing route information is certainly an important step toward promoting the use of public transportation systems. People will not use the transportation systems effectively unless they have a good idea of the service provided by the systems, and people will stop using public transportation systems if they cannot use the systems effectively. We are motivated by this observation to build an information service that can help people find out their ways in such multimodal public transportation systems in order to solve the problems of environmental protection.

To this aim, we build a web service that provides Integrated Route Information Service (IRIS) to commuters and travelers. We collect route information of buses, subways, and trains that serve the Taipei metropolitan area, and maintain the collected data with a standard database management tool. Users of IRIS can request recommendations through Internet for how to use public transportation to travel from one location to another in the metropolis. Using informed-search methods [3], IRIS searches for paths and recommends selected paths to users via web connection in a real time manner. The recommendations may provide one or more ways to travel between the chosen locations, each of which may require users to transfer among different modes of public transportation systems, e.g., from buses to buses, from buses to subways, and from subways to buses.

IRIS system is considered as a travelers' guiding center that provides the information of sight-seeing spots and complete travel advisories in transportation. The techniques we employ to build the IRIS for Taipei city can be applied to provide similar services in any other metropolis. In a longer run, we can expand the database of IRIS to make IRIS a part of the intelligent transportation systems that will modernize the transportation systems in Taiwan or other countries[4].

2 Taipei public transportation systems

There are three basic types of public transportation in Taipei: trains, buses, and rapid transit system. Taiwan Railway Administration (TRA) operates traditional train system that runs through the heart of the metropolis, and there are a half dozen of stops in the area. We can obtain train schedule from both the booklet published by the TRA and its web site [10]. The Taiwan High Speed Rail Corporation [9] and the central government plan to build a high-speed train system that will connect major metropolis on the island, but the system will not start to operate in the near term.

Several bus companies, including publicly and privately owned ones, jointly operate the Taipei bus systems. These companies serve more than 200 bus routes in the city, and these routes altogether have about 2500 stops distinctively. Various sources of bus-route information are available nowadays. Traditionally, people obtain bus-route information either from booklets or from signboards at bus stops that contain such information. Those booklets can be purchased from any book retailer island wide. Recently, the Internet brings us a convenient media for distributing bus-route information. The Taipei city government provides on-line bus-route information on its web site [6,7], and there are personal web sites that provide free route information as well.

The Taipei Rapid Transit Corporation (TRTC) operates the Taipei Rapid Transit system (TRT). People may find information related to the TRT from both brochures published by the TRTC and its web site [8]. The TRT system consists of five different color-coded routes and there are four special locations where people may transfer between subways, traditional trains, and buses. They include Panchiao, Lungshan Temple, Sungshan and the Taipei Main Station that lie at the intersection of the red and the blue lines.

A traveler obtains the complete information through Internet for each type of public transportation

respectively, however, he may not be able to conclude the best vehicle combination for a specified original/destination pair for himself. Therefore, he may result in giving up the usage of public transportation and drive his own vehicle instead, and perhaps the air condition will be devastated in a further step. In the following section, we introduce the methodology of collecting public transportation information for each type and propose an efficient and intelligent algorithm for an optimal combination via Internet access in real time. A traveler can access the web site to learn the best way to arrive his destination by public transportation system.

3 Route-information database

3.1 The raw data

Information from multiple sources can cause data inconsistency problem. Both TRA and TRTC provide authoritative information about the routes that are under their control. Since TRT and traditional trains typically do not change routes, it is easy to take care of route information about these systems. Bus routes, in contrast, can change from time to time due to a variety of reasons such as road construction and demonstration events, etc.. Also, route-information sources, both web sites and books, typically do not reflect the route change in a timely manner. Our experience indicates that chance is high that bus-route information provided by different sources does not completely agree with each other.

Fortunately, bus companies generally do not change bus routes randomly. Usually, bus stops are relocated to nearby locations. Providing information that becomes out-of-date because of such minor route changes might cause nuisance, but the routing information should remain valuable. Therefore, we adopt the route information that is recorded in a booklet [5] in building our route-information database.

We maintain route information about buses, TRT and trains in a similar way. Tables for all routes contain the departure, intermediate, and destination locations in the metropolis. Routes served by different systems are marked by an attribute, *type*, in the route table. Each route table contains the type, the route number, and names of the departure, intermediate, and destination stops. The intermediate stops are *ordered* according to when a passenger may pass the stop from the departure stop, so a stop will have an *order* attribute in the database. Since regular routes that connect a particular pair of locations, A and B, typically provide round trip service, we treat routes that go from A to B and that go from B to A as two different routes.

We construct stop tables based on these route tables for convenience of reference. Each stop table contains what routes are available, the order of the stop on these routes, and if TRT and traditional trains are available at the stop. For further processing of the raw database, we also include information about the longitude and latitude for each stop in the database, and which will play an important role for geometrical information retrieval or WAP application in the near future.

3.2 A hierarchical map

We preprocess the raw database for the route-planning algorithm. Let X and Y be different stops, we use the following terms in the discussion.

(1) Stop route and *stop size*: In practice, a stop is a small area in the metropolis, and typically one or more routes may allow passengers to get on and off at a stop. The stop route, denoted $SR(X)$, is the set of the routes that serve the stop X, and the stop size of a stop X, denoted $SS(X)$, is the number of routes that serve the stop X. Notice that the routes can be either bus, TRT, or traditional train routes.

(2) Stop distance: The stop distance between X and Y, denoted $DS(X,Y)$, is the minimal number of intermediate stops that we would pass if we travel from X to Y via public transportation.

(3) Geographic distance: The geographic distance between X and Y, denoted $DG(X,Y)$, is the Euclidean distance between X and Y.

As we inspect the stop tables, it becomes clear that some stops are relatively more convenient in terms of ease of transferring between routes and are denoted as hubs. These *hubs* should be seriously considered as transfer centers when there is no direct route connecting the traveler's origin and destination. The Taipei Main Station, for instance, provides a great chance for people to transfer to routes that eventually lead to their destinations.

To take advantage of this observation, we introduce an attribute in the stop tables to reflect that if a stop is considered as a hub according to its easiness of transferring. To this end, we consider stops that have TRT and train services as hubs. Currently, we set the hub attribute if the stop size of the bus stop is greater or equal to 15. Therefore, in addition to TRT and train stops, we have about 70 hubs for Taipei area in our database.

We annotate tables for each stop X with information about the *nearest hubs*, denoted $NH(X)$. A nearest hub of a stop X is a hub that can be reached by taking a particular route in $SR(X)$ from X. Clearly, if a stop is itself a hub, then the stop is also the nearest hub for all routes in $SR(X)$. Except this trivial case, we define the nearest hub B of a stop X on a specific route based on the following criteria that are listed in the descending priority.

(1) $DS(H,X) \geq DS(B,X)$ for any hub H
(2) If $DS(H1,X)=DS(H2,X)$, then $B=H1$ when $SS(H1)>SS(H2)$ and $B=H2$ when $SS(H2)>SS(H1)$
(3) When there are still multiple candidate, we let $B=H1$ if $DG(H2,X) \geq DG(H1,X)$.

Usually, the first criterion suffices for determining a nearest hub on a route from X because most routes pass a hub or two. When a route from X does not pass any hub, transferring to other routes will be considered, and this is when we may need these criteria.

To speed up the route-planning algorithm, we have done some preprocessing on the raw database. We add into each stop table the routing information between the stop and its nearest hubs. This extra information will be helpful when we need to transfer via nearest hubs. Also, we compute routing information between any TRT and traditional train stations, and save the results in the route-information database. This information can be very useful at runtime, but does not require a large space to save, so it is worthwhile to carry out this preprocessing offline.

Technically speaking, the route map in our database has two levels. The lower level consists of all stops, and the higher level consists of only hubs in the metropolis. To utilize this hierarchical organization, we compute the best ways to travel from hubs to hubs offline, and save such information in the database. We will see how the route-planning algorithm harnesses such an effort next.

4 The route-planning algorithm

Although the route-planning algorithm does not necessarily provide the fastest solution for traveling from origins to destinations, the algorithm does attempt to do so based on a few heuristics. First, the algorithm strongly biases for the use of TRT and traditional trains.* It typically takes less time to commute by TRT or trains than by buses between two locations. The algorithm also prefers solutions that require less transfer and less number of intermediate stops. Therefore, the algorithm prefers a routing method that needs only one transfer to one that needs two transfers. In the algorithm we define and compute at runtime the set of stops $R(X)$ that are directly reachable from a stop X via $SR(X)$.

The algorithm requires information about the desired origin and destination. At this moment, both origin and destination are names of stops, so the algorithm does not have to worry about cases where no connecting routes are available. There is an easy way to expand the algorithm to allow street addresses as input for origin and destination since our stop tables already have the information about the longitude and latitude of each stop. The skeleton of the algorithm follows.

Algorithm RoutePlanning(origin O, destination D, route-info database)
1. If O is equal to D, there is no need to commute.
2. **Direct link**: If the intersection of $SR(O)$ and $SR(D)$ is not empty, there are ways to go from O to D directly, and the algorithm recommends such direct paths. If both O and D are TRT stops, recommend the TRT first.
3. **One transfer**: If D is in $R(R(O))$, we may go from O to D with one transfer, and the algorithm recommends these paths.

---

* For simplicity, we will not distinguish between TRT and traditional trains henceforth.

4. **Transfer via hubs**: Recommend the path from *O* to its nearest hubs *NH(O)*, from *NH(O)* to *NH(D)*, and then from *NH(D)* to *D* .
5. **Sorting and listing**: Sort and list the possible route combinations based on stop distance *DS*(*O*, *D*) and stop size of transferring node *SS*(*X*).

Whenever the algorithm finds multiple solutions to the query, it orders the solutions by the total number of intermediate stops. This designed decision is based on the assumption that more intermediate stops may lead to a longer total travel time. This principal may apply to solutions found at any step. For instances, at the second step, the algorithm may find multiple bus routes that directly connect *O* and *D*, and these routes will be listed in the order of increasing number of intermediate stops between *O* and *D*.

When there is no direct way to commute from *O* to *D*, the algorithm continues to the third step. This step dictates that commuting from *O* to *D* needs one transfer if there is at least a stop *Z* in the set of *R(O)*, and *D* is in the set of *R(Z)*. We can thus infer that it takes just one transfer to go from *O* to *D* if the intersection of *R(O)* and *R(D)* is nonempty. This method may be a good heuristic, but is not flawless. Recall that *R(Y)* represents the set of stops that are directly reachable from *Y*. The fact that the intersection of *R(O)* and *R(D)* is nonempty implies that there is a route from *O* to an intermediate stop *Z* and another route from *D* to *Z*. There is no warrantee to find direct routing method from *Z* to *D*, which is what we really need. There must be a stop *X* that can be directly reached by a route, say *RA*, from *O*, and must also be directly reachable by another route, say *RB*, from *X* to *D*. The algorithm will frequently find many related one-transfer solutions, and some of them appear to be better than others. Consider commuting from *A* to *B* in the example shown in Figure 1. Since there is no direct way to go to *B* from *A*, we must transfer at *T1*, *T2*, or *T3*. This might appear to be a contrived example, but it is not. In reality, bus routes often pass a portion of business districts, so they tend to have a few consecutive common stops. Examining these three alternatives for transfer, we see that the traveler can only transfer from *R1* to *R2* at either *T1* or *T2*. The traveler will have two choices, *R2* and *R3*, if s/he transfers at *T3*. Therefore, *T3* appears to be a better choice for transfer because it provides better chance for the traveler to catch the next bus sooner. Due to this observation, our algorithm lists as better alternatives those stops that have larger stop sizes for transfer.

When there are neither direct nor one-transfer routes that connect *A* and *B*, the algorithm reaches the fourth step. At this step, the algorithm applies the information contained in the database about nearest hubs of *A* and *B* to find desired solutions. Recall that we have computed the best routes from *A* to its nearest hubs *NH(A)* and the best routes from *NH(A)* to any other hubs including the nearest hubs *NH(B)* of *B*. The remaining task is to find a route from *NH(B)* to *B*. This is not a difficult task in practice since we can find at least a stop *X* in *NH(B)* such that *B* is in *R(X)*. Figure 2 illustrates that, to commute from *A* to *B*, we can commute from *A* to one of its nearest hubs, *H1*, then to one of *B*'s nearest hub, *H3*, and finally to *B*. In this case, the route-information database will contain the best way to commute from *H1* to *H3* is via *R1*, and the best way to commute from *H1* to *H3* is via *R1* and then transfer onto *R6* at *D*.

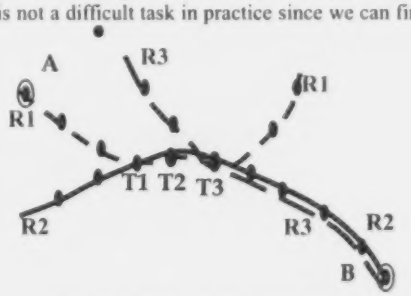


Figure 1: T3 is a better transfer location

5 User interface

In addition to provide intelligent public transportation information, the IRIS system collects general travelling information at Taipei, and it also provides information about popular tourist spots including natural beauty, cultures (museum/memorial/temples and historical sites/festival/folks art /aboriginal art/towns and city), amusement parks, shopping and entertainment, food and beverages, real-time weather report, real-time traffic surveillance, and related travel services. All these services and introduction are categorized and constructed in

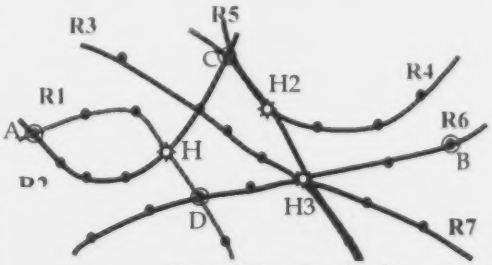


Figure 2: Transfer via hubs

the way of friendly and graceful page design. Unlike the consultation typology of public transportation querying system, the design pattern of travelling information leans to one-way communication of media technology. The activities of users are pure reception, and the pattern of communication is categorized as a transmission typology.

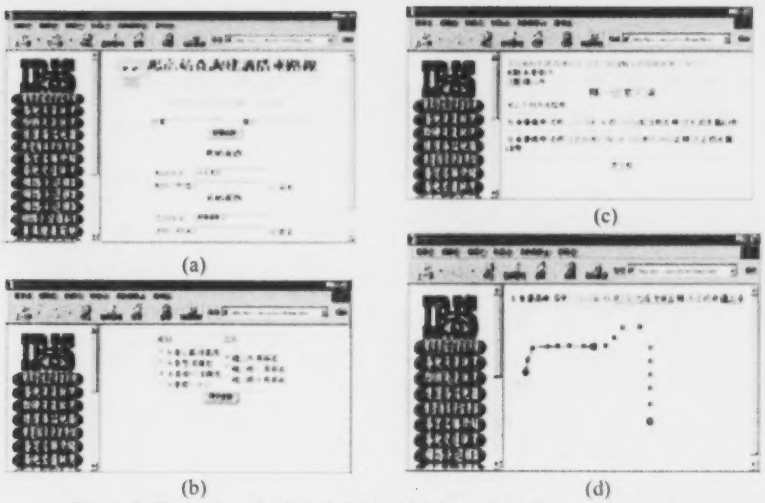
To obtain the quickest route information of an area or spot, users can click one of following items listed to acquire the correlative information: route information (complete stop information for each bus/TRT/TRA route), stop information (complete bus-route information for each bus route), local area route information(complete transportation information for each local area), popular tourist spot route information(complete transportation information for each tourist spot), original/destination Integrated Route Information(complete route information from original to destination). All these items are designed as a format of consultation typology and users have to make a request to the information providing center for specific message to be delivered. For examples, in the application of original/destination Integrated Route Information, users are allowed to type partial text of original/destination information through the main interface, and the IRIS system will base on the input contents and response an interface with option selection buttons for complete inputs. After analyzing the selected original/destination location buttons, IRIS system will verify the data, execute the matching programs, and show the results by listing route numbers and transfer stops in different color text, and the system also provides the map information of selected route and stops respectively. The querying processes and results are displayed in Figure 3. Listing the results with text may allow the system to provide more alternative routes at a time, but showing the routes on the map gives travelers a clearer picture of the recommended routes. The system is welcome to access and evaluate through the web address http://iris.cs.ntou.edu.tw/.

6 Conclusions

The proposed educational service is categorized as a combination of transmission and consultation typology. The part of general travelling information of IRIS system which provides and controls information distribution serves as a transmission communication pattern. When the learner makes a request and system provides an integrated information immediately, the system performs as a consultation typology since the information is produced by the system but the learner retains control over what and when the information is distributed. The objective of the proposed web services is to provide an integrate and optimal solution for tourists, however, there are still some future work left to be completed in this project. As we have reported, the IRIS system prioritizes alternative solutions based on heuristics that take into account the number of intermediate stops and times of transfers. Although these may arguably be good rules of thumb for selecting fast routes, a traveler might prefer routes that minimize the total distance that s/he would travel. To provide such alternative, the system would have to know the actual distance traveled by the bus for moving between two consecutive stops. In a longer run, the IRIS system may allow travelers to determine if the system should prioritize alternative solutions by the monetary cost, frequency of buses, and even predicted travel time.

The path-planning algorithm reported in Section 4 prefers the travelers to transfer at a stop that has a larger stop size. This designed decision is based on easy of transferring to another bus. Travelers may have other concerns though. A traveler might prefer to transfer at previous stops because it is more likely to have a seat if one can get on the bus earlier. A flexible system should allow travelers to choose her/his way for prioritizing the alternative solutions.

In addition to the future work, we have started to build a path-planning algorithm based on uninformed-search algorithms[3]. However, these algorithms might not provide satisfactory performance for ordinary shortest-path applications when the network is large. Nevertheless, these algorithms might provide satisfactory performance for constrained shortest-path applications in a median-sized city like the one we are tackling. Considering the fact that uninformed-search algorithms are far easier to construct than the informed-search algorithms, uninformed-search algorithms might be a viable way to the bus scheduling problems. We will report findings of our exploration in an extended version of this paper.



(a) (b) (c) (d)

Figure 3: Examples of original/destination Integrated Route Information

References

[1] Bordewijk, J.L. & Van Kaam, B. Towards a new classification of Tele-Information services, *Intermedia*, 14(1), 1986.

[2] N. Koga. Public transportation priority system using optical bus detectors. In *Proceedings of the IEEE/IEEJ/JSAI International Conference on Intelligent Transportation Systems*, pp. 135-138, Tokyo, Japan, 1999.

[3] S. Russell and P. Norvig. *Artificial Intelligence: A Modern Approach*. Prentice Hall, 1995.

[4] 交通部運輸研究所智慧型運輸系統網站，*台灣地區發展智慧型運輸系統綱要計劃*。<http://www.iot.gov.tw/its/HTML/MasterFinal/P_IDX1.HTM>

[5] 台北市政府交通局指導發行，*縱橫台北—北市大眾運輸系統搭乘指南*，November 1998.

[6] Bureau of Transportation of Taipei city government, http://www.busline.tcg.gov.tw (accessed on May 2000)

[7] Taipei City Bus Adminstration, http://tcba.tcg.gov.tw (accessed on May 2000)

[8] Taipei Rapid Transit Corporation, http://www.trtc.com.tw (accessed on May 2000)

[9] Taiwan High Speed Rail Corporation, http://www.thsrc.com.tw (accessed on May 2000)

[10] Taiwan Railway Administration, http://www.r ailway.go v.tw (accessed on May 2000)

BEST COPY AVAILABLE

Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming

Jun MORIYAMA
Department of Information and Technology Education,
Faculty of Education, Shinshu University
6 Nishinagano, Nagano City, Nagano, 380-8544, JAPAN
Phone: +81-26-238-4175
Facsimile: +81-26-232-5144
E-mail: junmori@gipwc.shinshu-u.ac.jp

The purpose of this study was to clarify the cognitive effects of collaborative learning on Junior high school students' Logo programming. Two experiments were implemented: *Experiment1* was an analysis of the relationships between interaction in pair activities and students' reflection. The effects of pair learning on students' promoting abilities of programming were analyzed in *Experiment2*. As the results of *Experiment1*, students' self-monitoring and self-control were supplemented each other through the interaction. Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

Keywords: **Collaborative Learning, Junior High School Students, Cognitive Effects, Logo Programming**

1 Introduction

In Japan, education about computer programming was placed in *Fundamentals of Information* of *Industrial Arts* at junior high school level from 1989. From 2002, programming, sensing and control will be placed in *Information and Computer* of *Technology* as an elective learning content (*Course of Study* published in 1998)[5]. Many technology teachers in Japan thought that teaching programming was not only for professional higher education. They didn't made points of understanding the function of software upon a computer system, but acquiring the problem solving skills through the programming activities.

Historically, many researchers suggested that one of the methods for acquiring the problem solving skills was collaborative learning. It was necessary for students to communicate and interact with someone who had same goal in collaborative environment (Deutsch 1949)[1]. In the recent past, it was supported that the experiences of solving the problem through the interaction made the processes of planning and decision making clearly each other, and would promote their self-control and self-monitoring when they would solve another problem all by themselves (SATOU 1996)[3]. In the case of learning about programming, KAGE (1997) suggested that 12-year old pupils showed vigorous verbal interaction, which led them to more sophisticated problem solving [4].

From these findings, it was predicted that acquiring the problem solving skills brought to promote students' programming abilities as a result of cognitive effects of collaboration.

The purpose of this study was to clarify the cognitive effects of collaborative learning on students' programming. For this purpose, two experiments by using Logo programming (Japanese Edition) were implemented. The aim of *Experiment1* was to clarify the relationships between interaction of collaborative learning processes and learners' reflection. The effects of collaborative learning on students' promoting abilities of programming were analyzed in *Experiment2*.

2 Methods

2.1 Experiment1

2.1.1 Subjects

Twelve 3rd grader Jr. high school students (6 males and 6 females) were divided into 6 pairs.

2.1.2 Instruments

"The Reflection Scale of Thinking Process on Computer Programming: RSTC"(MORIYAMA et al 1996) [2] and the modified LUTE (Link-UniT-Element) model (MORIMOTO et al 1997) [6] were used for measuring the level of reflection and analyzing the interaction, respectively. The RSTC was constructed from 4 factors as in Fig.1. Factor1 was the reflection of understanding the problems and enterprising how to make the program adequately. Factor2 was the reflection of designing the program and coding. Factor3 was the reflection of self-monitoring on each parts of the program on the local level. Factor4 was the reflection of self-monitoring on the whole program and renewal of problem representation.

Factor1 (6 items)	**Factor2** (6 items)	**Factor3** (5 items)	**Factor4** (3 items)
Semantic understanding of the problem	Setting up the keywords	Predicting the result of running	Analyzing the bug
Imaging the command and grammar	Division of the program	Testing walk through the list	Renewal of problem representation
Comprehending the image of program	Setting up the functional unit	Checking the clerical error	Seeking the bug
Rhetorical understanding of the program	Connecting the functional unit	Checking the syntax error	
Seeking the semantically-related knowledge	Coding the functional unit	Checking the logical error	
Seeking the rhetorically-related skill	Checking the sequences of each commands		

Fig.1 The Reflection Scale of Thinking Process on Computer Programming: RSTC

The modified LUTE model was shown in Fig.2. There were categories for analyzing interaction of collaborative learning in this model, and this model had three abstract levels: element, unit and link level. The items of element level were categories for functions of protocols. The unit and link level categories were for phases and contexts in their programming activities.

Element Level (5 categories)	**Unit Level** (6 categories)	**Link Level** (6 categories)
Proposed	Phase of Analysis	Link for Formation of plan
Agreement	Phase of Plan	Link for Modification of plan
Question	Phase of operation	Link for Implementation of plan
Opposition	Phase of Edit	Link for Check of Implementation
Supplementary explanation	Phase of Checking the program list	Link for renewal of plan
	Phase of Checking the result of running	Link for renewal of implementation

Fig.2 The modified LUTE (Link-UniT-Element) model

2.1.3 Procedures

Subjects were asked to make the Logo program which draw the "*House*" constructed from triangular shapes, square patterns, circles and lines in pair. Their activities were recorded on a VTR. After they finished the task, they answered RSTC individually. Their protocols were extracted from the VTR and were categorized by using modified LUTE model. The level of reflection and the relative interaction in the collaborating pair were analyzed by ANOVA on mean scores of frequencies of link level categories and Coefficient of Correlation (r) between the RSTC scores and frequencies of the element and unit level categories.

2.2 Experiment2

2.2.1 Subjects

Sixty 3rd grader junior high school students (30 males and 30 females) were divided into 2 groups learning Logo programming. One was collaborative learning group (pair), and the other was individually learning group.

2.2.2 Instruments

The achievement tests and the RSTC were prepared. The achievement tests included both the coding test and the debug test. The coding test asked to make a program drawing "*Scarecrow*" on an answer sheet. The debug test asked to find three types of error, clerical error, syntax error, logical error from the program list which drew "*Spaceship*".

2.2.3 Procedures

The procedure was shown in Fig.3. At first, subjects had a coding test which draws the easy "*flag*" as a pre-test. Next, subjects were asked to make the program, which draws the "*House*" such as *Experiment1* and answered RSTC in every group as a middle-test. Finally, they had the achievement tests and answered RSTC individually as post-tests. The effects of collaborative learning on students' promoting abilities of programming were analyzed by using ANOVA and Coefficient of Correlation (r) between the RSTC scores and the Achievement tests' scores.

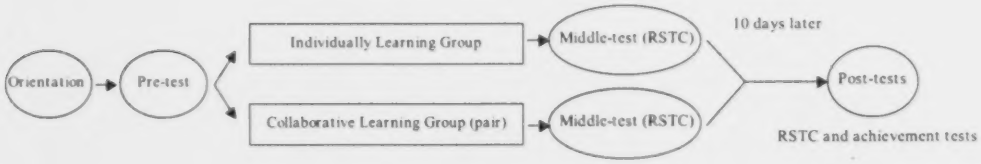


Fig.3 The procedure of *Experiment2*

3 Results and Discussion

3.1 Experiment1: Students' Reflections and Collaborative Programming

3.1.1 Contexts of Collaboration in the Pair Activities

There were differences of period of keyboard operation time in pair activities. In this analysis, long-operated learners were called *Learner A*, and the others (short-operated) were called *Learner B*. Mean scores of frequencies of link level categories were shown in Table.1.

Table.1 Frequencies of link level categories

Link Level Categories	Mean Score (S.D.)				ANOVA
	Learner A to B	*Learner B to A*	*Learner A to A*	*Learner B to B*	
Link for Formation of plan	1.75 (1.04)	2.00(1.77)	1.63(1.41)	3.50(2.73)	*n.s.*
Link for Modification of plan	3.35(2.12)	2.50(1.93)	0.25(0.46)	0.13(0.35)	$F(3,24)=8.397$, $p<.01$
Link for Implementation of plan	1.88(2.70)	15.63(5.80)	5.88(3.40)	2.75(2.49)	$F(3,24)=21.732$, $p<.01$
Link for Check of Implementation	3.75(1.49)	1.13(1.36)	1.00(1.07)	0.13(0.35)	$F(3,24)=13.055$, $p<.01$
Link for renewal of plan	0.38(0.52)	0.38(0.74)	0.13(0.35)	0.63(0.52)	*n.s.*
Link for renewal of implementation	0.63(0.92)	1.25(1.28)	0.25(0.46)	0.00(0.00)	*n.s.*

Results from Two-way Repeated Measures ANOVA showed that there were significant main effects of Links for Implementation of Plan from *Learner B* to *A* [$F(3,24)=21.732$, $p<.01$], and Links for Check of

Implementation from *A* to *B* [F(3,24)=13.055, p<.01]. Also, Links for Modification of Plan with interaction (*B* to *A* and *A* to *B*) were increased than that of individually links (*A* to *A* and *B* to *B*) [F(3,24)=8.397, p<.01]. These data indicated that the role of operation (*Learner A*) and the role of planning (*Learner B*) were shared in pair activities. However, it was suggested that consensus decision making through the interaction was important for building up their programming plans.

3.1.2 The Relationships between the Interactions and the Reflections

Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories were shown in Table.2. According to these data, when *Learner A* (operator) proposed something to operate, the reflection of designing the program (Factor2) was promoted in own thinking process [*r*=0.88, p<.01]. However, when *Learner B* (planner) proposed, the reflection of self-monitoring on each parts of the program (Factor3) was promoted in *Learner A*'s thinking process[*r*=0.88, p<.01]. Furthermore, opposition by *Learner A* correlated the reflection of self-monitoring (Factor3) in *Learner B*'s[*r*=0.71, p<.05]. Also, *Learner A*'s reflection of designing (Factor2) was promoted by the opposition of *Learner B*[*r*=0.77, p<.05]. These results indicated that the verbal communications on their interaction brought out their self-monitoring and self-control each other.

Table.2 Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories

Element Level Categories		Factor1		Factor2		Factor3		Factor4	
		Learner A	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*
Proposed	*Learner A*	0.41	0.26	0.88**	0.41	0.52	0.13	0.06	0.06
	Learner B	0.04	0.45	0.37	0.25	0.88**	-0.33	0.50	0.31
Agreement	*Learner A*	0.00	-0.10	0.31	-0.34	0.52	-0.66	0.26	-0.20
	Learner B	0.44	0.35	0.67	0.55	0.28	0.08	0.36	0.07
Question	*Learner A*	-0.32	0.56	0.27	0.28	0.56	-0.11	0.78*	0.23
	Learner B	0.40	-0.52	0.56	-0.29	0.00	0.02	0.03	-0.31
Opposition	*Learner A*	0.03	-0.30	0.27	0.08	0.13	0.71*	0.42	0.19
	Learner B	0.12	0.19	0.77*	0.23	0.52	0.27	0.68	0.00
Supplementary explanation	*Learner A*	0.72*	-0.35	0.61	0.13	0.03	0.40	-0.15	-0.01
	Learner B	-0.01	-0.34	0.32	-0.13	0.14	0.40	0.45	0.08

n=8, df=6, **p<.01, *p<.05

In addition, Coefficient of Correlation (*r*) between the RSTC scores and frequencies of unit level categories showed that, operation by *Learner B* as a planner conduced to *Learner A*'s self-monitoring on whole program[*r*=0.85, p<.01]. Also, task analysis by *Learner A* as an operator encouraged *Learner B*'s designing of the program[*r*=0.75, p<.05]. It was evident that one's reflective thinking was precipitated by the observation of the other's behavior which was supposed to be his own behavior.

These results of *Experiment1* suggested that students' meta-cognition (self-monitoring and self-control) were supplemented each other through the interaction of collaborative pair learning.

3.2 Experiment2: Effects on students' promoting abilities of programming

3.2.1 Acquisitions of Programming Abilities

In the pre-test, there are not significant differences between the pair learning group and the individually learning group [F(1,56)=0.65, *n.s.*]. Students who could get high scores were called *higher students* and the others were called *lower students* in this analysis (both 50% and n=30). In the middle-test, mean score of RSTC in the pair learning group (0.77) was higher than that in the individually learning group (0.56) [F(1,56)=32.40, p<.01]. This result supported findings of *Experiment1* because collaborative pair learning could promote students' reflections of thinking processes.

Mean scores of debug test were shown in Fig.4. Results from the ANOVA showed that the debugging scores of syntax error in the pair learning group was higher than that in the individually learning group [F(1,56)=4.75, p<.05]. But, there were not significant differences on the debugging scores of clerical and logical errors [F(1,56)=2.06 and F(1,56)=0.89, both *n.s.*]. These results indicated that collaborative pair learning could form students' debugging abilities against syntax errors, at least.

Mean scores of coding test were shown in Fig.5. The result from the Two-way Repeated Measures of ANOVA showed that there was significant interaction between *High-Low student* condition and *pair-individually* group condition [F(1,56)=10.46, p<.01]. Furthermore, from the results of Simple Main Effects Tests, the score of *lower students* in the pair learning group was promoted to the same level as *higher students* in both groups [F(1,56)=12.56, p<.01]. These results indicated that the coding abilities of Low-Ability students could be pulled up through the interaction with High-Ability students.

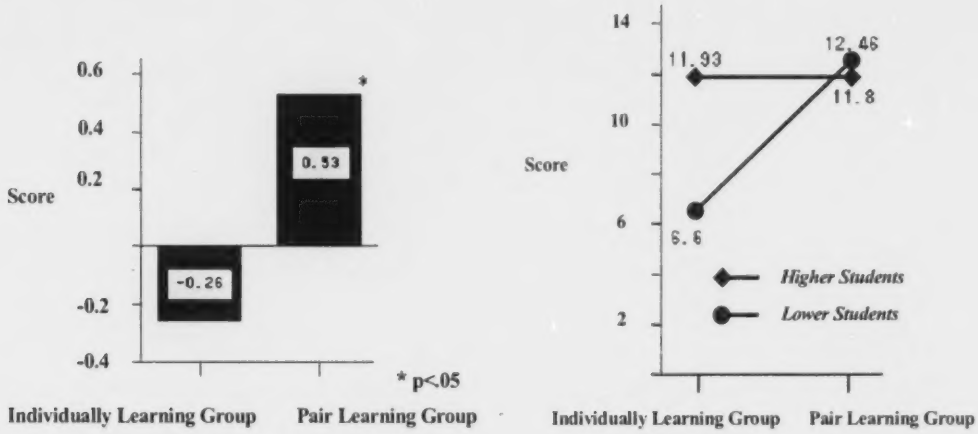


Fig.4 Mean scores of debug test (syntax error)

3.2.2 Acquisitions of Cognitive Strategies

Coefficient of Correlation (r) between the RSTC scores and the achievement tests were shown in Table3. According to these data, there were significant correlation between the coding test and the RSTC items: "Division of the program"(r=0.31, p<.05), "Coding the functional unit"(r=0.41, p<.01), "Connecting the functional units"(r=0.40, p<.01) and "Selecting the commands for each functional units"(r=0.40, p<.01) . Also, There were significant correlation between the debug test and the RSTC items: "Division of the program"(r=0.29, p<.05), "Checking the sequences of each commands"(r=0.33, p<.01). It was indicated that promoting these reflections were responsible for the development of the programming abilities. Furthermore, these items suggested the reflections of cognitive strategies for task division.

Table 3 Coefficient of Correlation (r) between the RSTC scores and the achievement tests

Items of RSTC	Achievement Tests	
	Coding Test	Debug Test
Division of the program	0.31 *	0.29 *
Coding the functional unit	0.41 **	
Connecting the functional units	0.40 **	
Selecting the commands for each functional units	0.40 **	
Checking the sequences of each commands		0.33 **

**p<.01, *p<.05

Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

4 Conclusion

In this study, it was clarified that students' meta-cognition and cognitive strategies could be acquired through the collaborative learning at junior high school level, also that the RSTC was useful for measuring students'

reflections in their programming activities. These findings will contribute to the researches of developments of collaborative learning systems.

For the future, learning processes and cognitive effects of more widely collaborative learning environment, for example, distributed programming by using CSCL system or long distance education for programming by using Internet, must be analyzed.

References

[1] Deutsch, M, An experimental study of the effects of cooperation and competition upon group process, *Human Relation*, 2: pp.199-232, (1949)

[2] Jun MORIYAMA et al, Structural Analysis of Thinking Processes on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 38-4: pp.255-262, (1996) (In Japanese)

[3] Kouji SATOU, Motivation for Learning and social context, *Cognitive Science 5: Learning and Development*, Tokyo University Press: pp.221-247, (1996) (In Japanese)

[4] Masaharu KAGE et al, Effects of Media and Learner Collaboration on Programming Education in Children, *Japan Journal of Educational Technology* 21-2: pp.93-105, (1997) (In Japanese)

[5] Ministry of Education, Science, Sports and Culture, Government of Japan, *Course of study for lower secondary schools in Japan*,(1989) (In Japanese)

[6] Shiro MORIMOTO et al, An analysis of Collaborative Discovery Learning Processes Based on Hierarchical Schema, *Cognitive Science* 4-2: pp.3-17, (1997) (In Japanese)

Note:

This study was revised and enlarged version of the following papers published in Japan:

Jun MORIYAMA, An Analysis of Collaborative Learning Process on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 41-4: pp.187-196, (1999) (In Japanese)

Jun MORIYAMA et al, Development of the students' abilities for Computer Programming through the Collaborative Learning, *Proceedings of the 42nd Annual Conference of Japanese Society of Technology Education*: p.21, (1999) (In Japanese)

Design and Implementation of A N-Tiered Heterogeneous Virtual School Administration System

Huang Gooshyon
Tamkang University Information Center
151 Ying-chuan Road, Tamshui, Taiwan 251
Tel: +886-2-2621-5656-2681
E-mail:georgehw@mail.tku.edu.tw

There are two types virtual school administration systems, web-based or voice-based, which are currently used by students. They are systems with different access mechanisms but same business logic, and require two times of resources for development and maintenance. Whenever the business logic of the systems changes, both of the systems need to be implemented. As the wireless communication grows more popular, the school has been considering adding a wireless interface to the system. However, with current architecture, the only way to add a wireless application protocol (WAP)-based system is to implement an additional system from scratch. Since the voice-based system and the web-based system have the same business logic, they can be integrated into one. We can dedicate an application server for the business logic, which interacts with the web-based interface and the voice-activated interface with a set of application programming interface (API). With the extraction of the business logic and the business logic API, developers for the voice-activated interface and the web-based interface can implement the interfaces without specific knowledge of the business logic of the system. With this design and architecture, the system can be further expanded to support a WAP-based interface and other interfaces easily.

Keywords: **Internet, wireless, virtual school, heterogeneous**

1 Introduction

The Internet is widely used for school education, especially virtual school education [2][3][4]. The advantage of the Internet is its capability of supporting multimedia and its attractiveness to the user. For the virtual school education, the students study via the Internet. They do not have to be in the classrooms of a school and can learn at anywhere at anytime. However computers and communication networks are needed to support virtual education through the Internet. The cost of the computers and setting up the communication networks is very expensive. Thus, the systems are not available everywhere. Furthermore, system interfaces must be developed in order to allow the users to access the computers and the networks. The purpose of these system interfaces is to provide an easier way for the students to access the systems and to allow the students to interact with the instructors real-time. Those systems interface do not need to be attractive and colorful since its main goal is to provide a mechanism for the students to access information real-time. For a web-based system, the homepage can be design in a way to reduce the network traffic and system load. However, not every student can access the computers and the networks due to his financial situation or the load of the system. For the students who cannot access the computers and the networks, the telephone (the voice activated based interface) provides another popular access media. Therefore there are needs for systems to support both telephone (voice- based) and web browser (web-based) interfaces [1]. The web-based system is more visual and more user friendly, however, the voice-based system is more convenient, more affordable, and requires no hardware investment from the students. As the technology evolves, the wireless communication is gradually taking over the traditional wire line communication. To support the wireless communication the system will need to be expanded to support the wireless application protocol (WAP)-based interface [10].

Originally, a couple of the school administration systems we had can be accessed via a regular telephone or via a web browser but not both. They were basically two different systems, though they support the same business logic. Both of them have their own user interface and system logic and were designed, implemented, and maintained separately. To support them two sets of resources are needed. The original system architecture is shown in Figure 1. Developers for both of the systems handle both the business logic's and the user interface's design and implementation. Whenever the business rule changes, both of the systems need to be modified and updated. It is very costly and difficult to keep both of the system consistent.

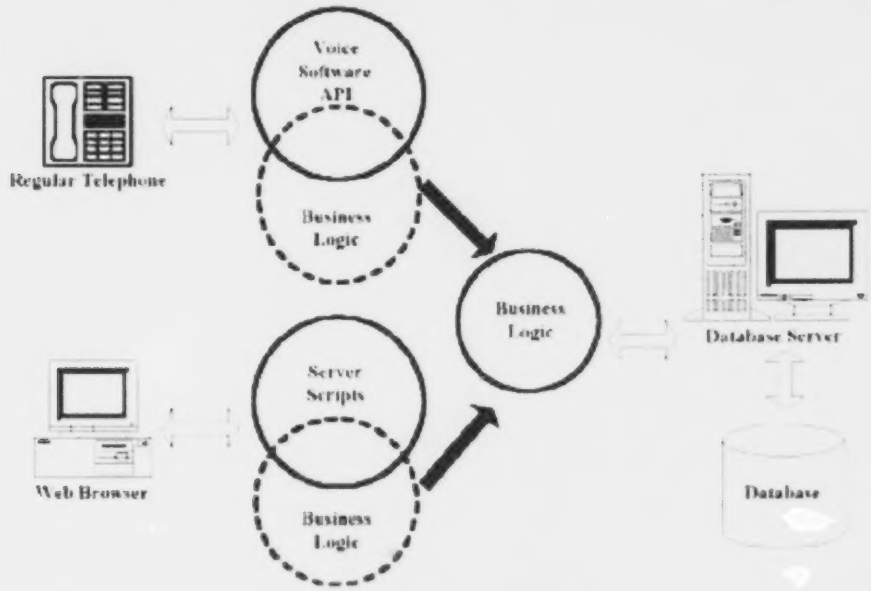


Figure 1. Logic view of voice system and web system

To reduce the maintenance cost of the two systems and to make them easier to be upgraded and expanded, we have proposed to integrate the two systems by extracting the business logic module out of them and migrate it into an application server. The remaining of the systems is migrated into a web server and a voice server respectively. By doing this, we dramatically reduced the cost of maintaining the system. After the architecture change, whenever there is a business change, only the application server is affected. We reduced the maintenance cost by 50%. No more concerns about the consistency of the systems. With the modification of the system architecture, we make it more scalable and expandable. The system can be easily expanded to support other access media without making changes to the application server. For example, to support a WAP-based interface, a WAP server can be easily introduced and integrated into the modified system architecture.

2 System Architecture and Implementation

2.1 Architecture

The administration system is an N-tiered system.

- Data Services Tier: The database services and implementations.
- Business Logic Tier: The business rule of the system.
- Translation Tier: Translate the I/O between application server and gateway server. For the voice-based system, the gateway server is the voice server. The purpose of the voice server is to translate PSTN and HTTP between application server and usual telephone. For the web-based system, the translation tier is transparent; it does not do anything. For the WAP-based system, the WAP Gateway is the gateway server. The purpose of WAP Gateway is to translate the WSP/WTP and HTTP between WAP telephone and web server.

BEST COPY AVAILABLE

- Presentation (UI) Tier: The input and output of the web-based system is HTML. The input and output of the voice system is the key press and voice of usual telephone. The input and output of the WAP-based system is WML [10].

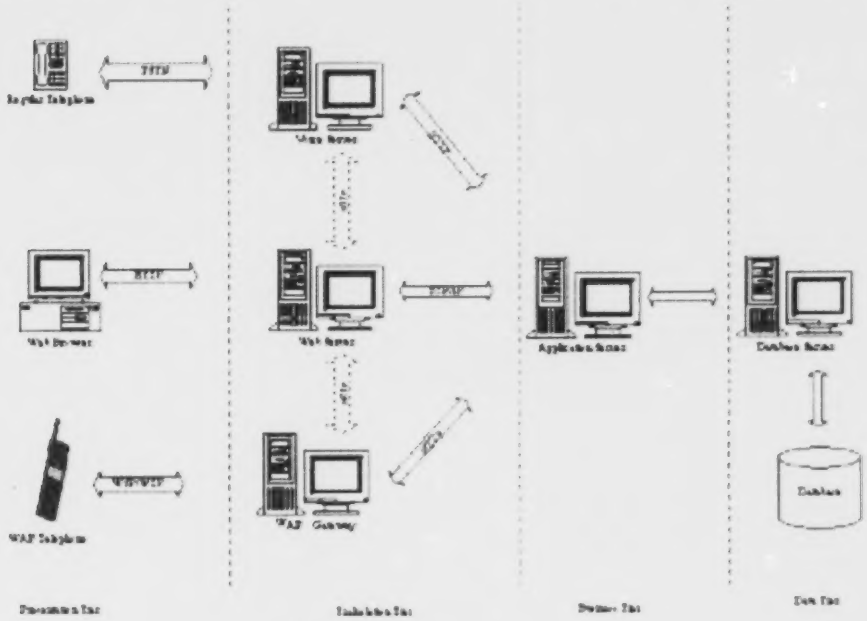


Figure 2. System Architecture

In the Architecture, the application server is the most important part. The application server needs to process business logic and interact with voice server, web server, and WAP Gateway. Because the protocol between the application server and the voice server and the WAP Gateway is HTTP protocol, we can set the application server and the web server in the same machine. The developers of the application server are more responsible, because they must handle business rule, HTML and WML. The developers of the other systems implement User Interface and do not have the knowledge of business rule of the system, because the developers of the application server handle the business rule. The application server sends different output format to different systems by parameters. Under the Architecture, after building the web system, the other systems are easily to build.

2.2 Architecture of the Voice System

Because taking business logic out of the voice system, the function of voice system is coherent. It translates the output of web server to telephone. The output format of web server is HTML. So the voice server has to simulate to web browser, shown as in Figure 3.

Figure 3. The communication methods are between voice server and web server.

BEST COPY AVAILABLE

3 Case Study

The Enrollment System of the Tamkang University [7] is designed and implemented following the architecture of this paper, shown as in figure 4. The system has been deployed and used by thousands of concurrent users [8].

3.1 Hardware Structure

We used thirteen Pentium based servers to implement the system. Six of them are used as the web servers. One machine is used as the UNIX Gateway. One server is used as the alert and automating email server. Four voice servers are used to support the voice activation. Finally, all student enrolment information is stored in one database server. The network hardware are two 100 MB/sec switch hub.

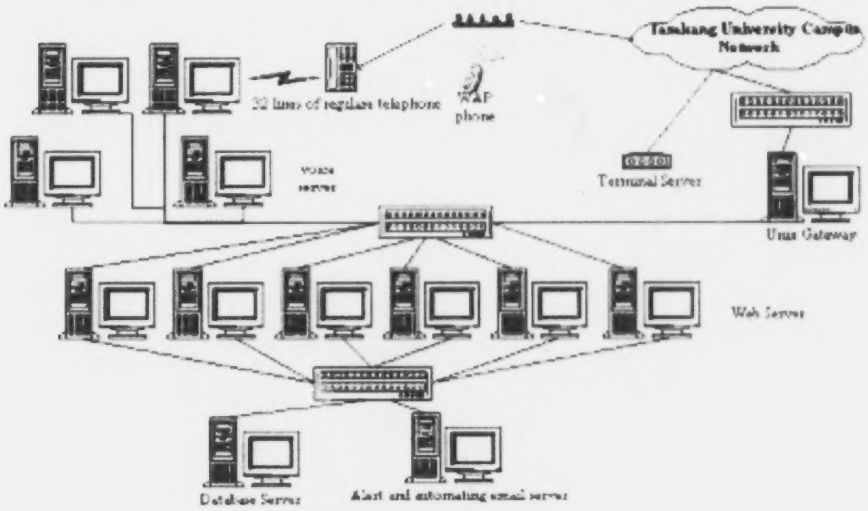


Figure 4. System Hardware Structure

3.2 System Software

OS: Microsoft NT4.0 is used for the web servers, voice servers, and the alert and automating email server. Free BSD 3.0 is used for the UNIX Gateway [8].
Web server: Microsoft IIS 4.0.
Database: Microsoft SQL Server 6.5.

3.3 Load Balancing and Scalability

To make the system suitable for all schools, we also took into considerations of the cost of hardware and the scalability of the system. A set of low-end servers can be grouped together to replace a high-end server[6]. To achieve this, a DNS server is needed for the load balancing work. The simple round robin methodology is used for the load balancing. With the current flexible four-tiered architecture, servers can be added into the system to share the performance load whenever the system load is heavy[9].

3.4. Security

Two security strategies are used to increase security:

1. Packet filter: It only allows IP packets through port 80 to access the web server, the packets of the other ports can not pass through. The web system can avoid being attacked by the other machines.
2. Supports multi-protocol: TCP/IP protocol is used between the web server and outside systems. IPX protocol is used between the web server and the database server. The web server should be hacked, the database server is kept away Internet and the database is still safe.

3.5. Network Management and Monitoring

The alert system has the following features:

1. Monitoring the system: It sends to keep-alive message to web servers, voice servers, and database servers in every period.
2. Network management system: Checks network traffic between web servers, voice servers and database server.
3. Auto Backup the data of database server.

3.6. User Interface Design

One of the most important criteria of the virtual school administration system is to let students access and retrieve correct information real-time. The user interface must be simple to reduce network traffic and system download time. The homepages for the web system and WAP are simple and straightforward to improve system performance. The look and feel of the WAP homepage depends on the WAP telephone the user users. An Ericsson r320 model WAP homepage is shown here as a sample WAP homepage. We can compare the home pages for the web system and WAP system.

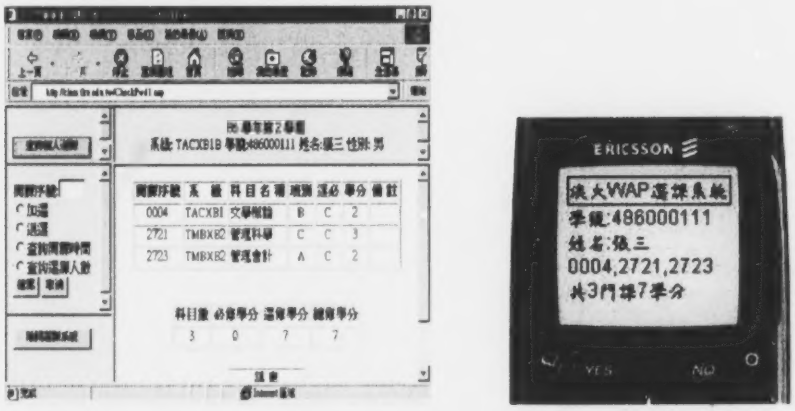


Figure 5. The display of the homepage of WAP-based system

3.7 Log statistics and analysis

Duration of enrollment period, the system generates the log automatically everyday for statistics and analysis, as shown in Table 1.

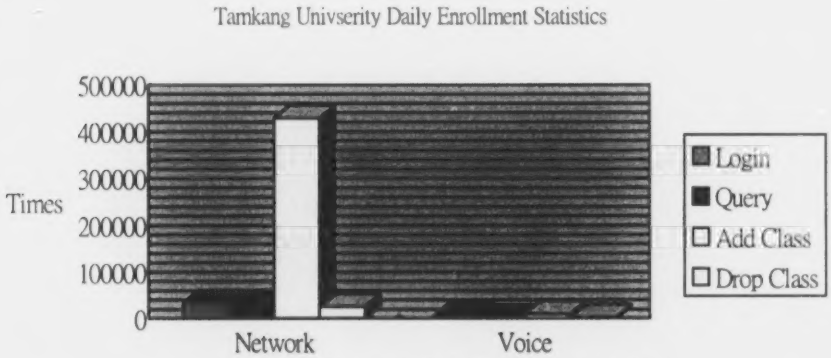


Table 1. Tamkang University Daily Enrollment Statistics

By comparison, the load of the web system is much heavier than the load of voice system. Since the voice system has 32 telephone lines, it can only support 32 concurrent users. In the peak hour of the enrollment (the first hour of each grade enrollment), the load of the web server is high.

We expect the voice system and the WAP system to be fully loaded during the peak hour. A dedicated business logic-processing server is used for the voice system and the WAP system. Since the telephone lines of the voice system and the WAP system are limited (up to 32 lines), a dedicated web server for the business logic processing of the voice system and the WAP system is sufficient.

4 Conclusions and future development

The development and maintenance resource of the heterogeneous systems depends on how many access media. The more access media, the more resource it needs. My proposal has the following advantages:

- Resource Reducing: Because the business logic is centered, heterogeneous systems need one business-logic process only, the resource of development and maintenance is less than usual systems.
- Expandability: With the N-tiered system architecture design, the business logic system was designed and implemented to support different UI systems. Different UI access method can be easily added into the system.

In the system, the application server interacts with voice server and WAP Gateway on HTTP protocol., so the application server must have functions of the web server. We can develop a new structure of the application server for voice-based system and WAP-based system, and the application server interacts with the voice server and WAP Gateway on TCP/IP.

References

[1] C. Chou and C. T. Sun, "A Computer Network-Supported Cooperative Distance Learning System for Professional Communication Education", IEEE Transactions on Professional Communication, Vol. 39, No. 4, pp. 205-214, (1996).

[2] Colin McCormack & David Jones, "Building a Web-Based Education system", John Wiley & Sons, (1998).

[3] Dwyer, D., Barbieri, K.& Doerr, H. M., "Creating virtual classroom for interactive education on the Web", Computer Networks and ISDN Systems 27, pp. 897-904, (1995).

[4] Nian-Shing Chen, "Web-based Learning Environment", Information and Education, Vol. 64, April, pp. 2-13, (1998).

[5] C. T. Sun, C. Chou & B.K. Lin, "Structural and Navigational Analysis of Hypermedia Courseware", IEEE Transactions on Education, Vol. 41, No. 4, CD-ROM, November, (1998).

[6] Chen-Chung Liu, Gwo-Dong Chen, Kuo-Liang Ou, Baw-Jhiune Liu & Jorng-Tzong Horng, "Managing Activity Dynamics of Web Based Collaborative Applications", International Journal of Artificial Intelligence Tools, Vol. 8, No. 2, (1999).

[7] Gooshyon Hwang & Chao-Tsong Fangtsou, "Introduction of Tamkang University Enrollment System", Ministry of Education Computer Center Newsletter, Vol.8802, (1999)

[8] Jack Chou, "NT Dynamic Web Server Design", Unalis Company, (1997)

[9] J.J.P. Tsai, S.J. Yang & A. Liu, "An Integrated Architecture for Distributed Real-Time Systems Analysis", in IEEE Second World Conference on Integrated Design and Process Technology, Austin TX., pp. 152-159, (1996) Dec. 1996

[10] WAP Forum, http://www.wapforum.org/what/whitepapers.htm (accessed on July 1, 2000)

DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment

Ying-Dar Lin, Wen-Chun Sun, Chien Chou, Huan-Yun Wei
Department of Computer and Information Science
National Chiao Tung University
Hsinchu, Taiwan
Tel: +886-3-5712121-56667
Fax: +886-3-5712121-59263
E-mail: ydlin@cis.nctu.edu.tw

With the rapid growth of both computer technology and the Internet, conventional models of testing are gradually being replaced by CAT (Computer Assisted Testing) systems. However, the major problem in most CAT systems is the difficulty in refreshing and supplying test items. This paper presents a novel network CAT system, DIYexamer (Do-It-Yourself Examer). It has three features that differentiate it from existing CAT systems: student DIY items, item-bank sharing, and automatic assessment of item discriminability. DIYexamer accepts test items contributed form teachers as well as students, and allows limited item sharing between item-banks possibly maintained by different organizations. An algorithm is applied dynamically to assess the discriminability of items in item-banks in order to filter out less qualified contributions, hereby assuring the quality of stored items while scaling up the size of item-banks.

Keywords: **computer assisted testing, test evaluation, test acquisition, discriminability, distant learning**

1 Intorduction

With the continuing development of computer technology and the Internet, educators now have new alternatives for creating, storing, accessing, distributing and sharing learning as well as testing materials. Should testing be performed on or learned from computers, and then a computer can best assess the work, Bugbee (1996)[1]. Hence, assessing the learning achievements and attitudes of students via computers or networks becomes a challenging task for many educators and researchers.

A. Computer-assisted Testing Categories

Computer-assisted Testing (CAT) or Computer-based Testing (CBT), the use of computers for testing purposes, has a history spanning more than twenty years. The documented advantages of computer administered testing include reductions of testing time, an increase in test security, provision of instant scoring, and an individualized adaptive testing environment [2][3][4][5]. As listed in Table 1, three categories of CAT are currently employed: standalone packages, test centers and networked systems.

TABLE 1: Categories of CAT

	Network support	Item generator	Random item selection	Item source	Item quality assessment	Item-bank sharing	Test result analysis
Standalone package	No	Built in item-bank	Yes	Fixed	No	No	Yes
Test center	Yes	Expert	Yes	Limited	Yes	No	Yes
Networked system	Yes	Built in item-bank	Yes	Fixed	No	No	Yes

1) Standalone package: This type of computer software package is typically stored on disks or CD-ROMs. Some packages have built-in item-banks, while others require teachers to input test items. These CAT packages generally do not have network capabilities.
2) Test center: The test centers or lab services require dedicated computer terminals for testing purposes. Students are required to complete the computer-based tests at the centers. Well-known applications of this type of service are Graduate Record Examinations (GRE) and Graduate Management Admission Test (GMAT), as provided by Educational Testing Services (ETS) [6].
3) Networked system: This enables students to perform an examination through an Internet connection. Concurrent testing of multiple users, automatic score calculation, and automatic test result analysis are supported by a networked system. The major advantages of networked systems are the convenience of examinations and test result calculation. However, the major flaws are the limitation of the amount of items and no item discriminability assessment.

B. Problem Statement

Regardless of which CAT system is employed, a critical issue in developing CAT is the construction of a test item-bank. Traditionally, asking teachers and content experts to submit items generates the item-bank. Three major drawbacks of the traditional method can be observed:
1) Limitation of item amount: Teachers and content experts tend to have similar views on the test subject. That is, in a given field vital subject matter might be confined. Therefore, although more teachers and content experts are invited to contribute test items, the total number of distinct items remains low.
2) Passive learning attitude: Students are conventionally excluded from the creation of tests. In a typical computer-assisted testing system, teachers generate tests, the system presents test sheets and students then complete the tests. That is, within the system of testing, they play a passive role, and are not afforded the opportunity to conduct "meta-learning" or "meta-analysis."
3) No guarantee on item quality: Permitting students to generate tests may be a possible solution to the aforementioned problems. However, this raises a new problem: quality assurance and ensuring that the tests are worth storing and used for further tests. Even when the whole item-bank is contributed by teachers and content experts, ways to dynamically assess and filter test items are needed.

The rest of this paper is organized as follows. The three distinct features of DIYexamer are introduced in section 2. Section 3 describes how the DIYexamer was implemented and its functionalities for administrators, teachers, and students. The discriminability calculation formula is then presented in section 4. Finally, the accuracy of discriminability discretion of DIYexamer and conventional methodology are compared through a real-life test in section 5.

2 The Diyexamer Solution

The DIYexamer[7] is a Web-based multi-server system that allows students to contribute test items, and provides an effective means of verifying the discriminability of these items. Three main ideas are as below:

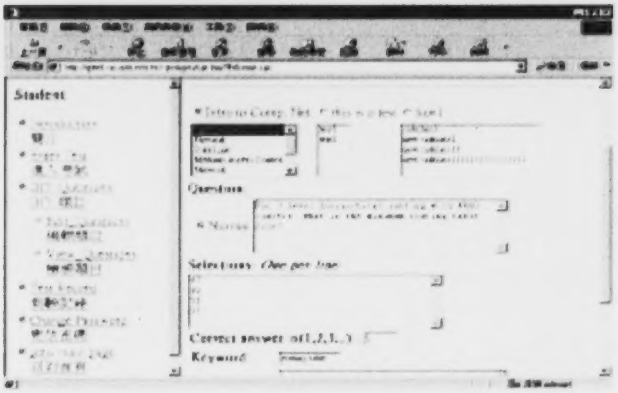


Fig 1: Students generate items into the item-bank

1) Item DIY by students: DIYexamer allows students to generate test items into the item-banks online as Fig 1. Teachers can query these items generated by students as Fig 2. In addition to rapidly increasing the total number of items in an item-bank, this feature also encourages students to develop *meta-learning*, i.e. *creative learning*. In order to submit tests, students must thoroughly study the learning materials, develop higher-level overviews of the materials, and practice cognitive and creative thinking.

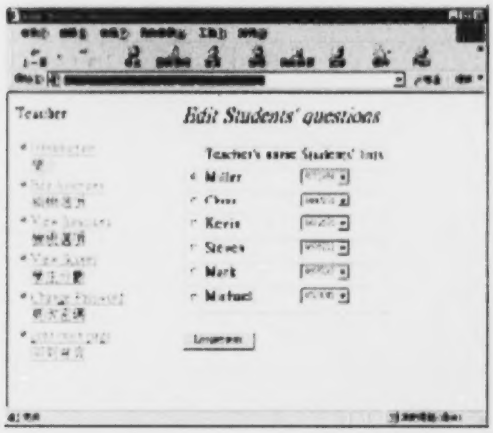


Fig 2: Student DIY items as queried by teachers

Fig 3: Average item discriminabilities of item-banks

2) Assessment of item discriminability: DIYexamer provides an item-discriminability assessment method to ensure the quality of the stored items. In addition to ensuring the internal consistency of existing test items, this method also continuously and dynamically screens additional new items in the item-bank. Fig 3 shows the average item discriminabilities of several item-banks.
3) Item-bank sharing: DIYexamer, a scalable multi-server system, connects many item-banks stored in different servers. Therefore, via the Internet, more items can be accessed and shared. The sharing is limited and controlled in a sense that a server issues a request, describing the criteria of a test item it requests, to another server. A server does not open up its item-bank for unlimited access.

Additional advantages have been identified and include the facts that since DIYexamer provides a real-time on-demand generation of test-sheet function, cheating is avoided. Also, DIYexamer provides an item cross-analysis function to which the degree of difficulty for each test as well as the entire test base can be accurately measured.

3 Diyexamer System Implementation

A. DIYexamer Network Architecture

DIYexamer is a WBT (WWW-Based Testing) system. An important feature is the sharing of item-bank via network connections. According to Fig 4, several DIYexamer servers form a *scalable test union*. Therefore, each server can access other servers and thus achieve item-bank sharing. A remote server can also join the test union to share additional test-bank resources, and leave the test union without affecting other servers.

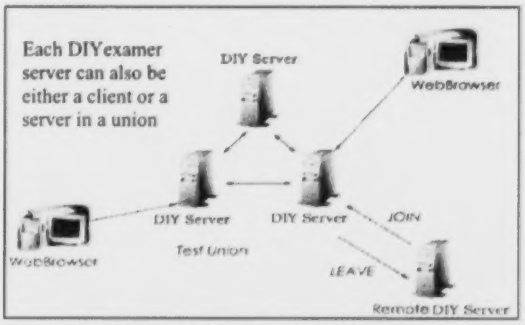


Fig 4: Network Structure of DIYexamer

B. Internal System Model

The internal architecture of DIYexamer (Fig 5) is divided into three layers. Interface layer is responsible for providing web interface for users. Test Profile Layer (TPL) selects items to form a test sheet, computes scores, and calculates the discriminability of selected test items. Test base Sharing Layer (TSL) accesses both local and remote databases via a network. Three functions of TSL are listed in Table 2:

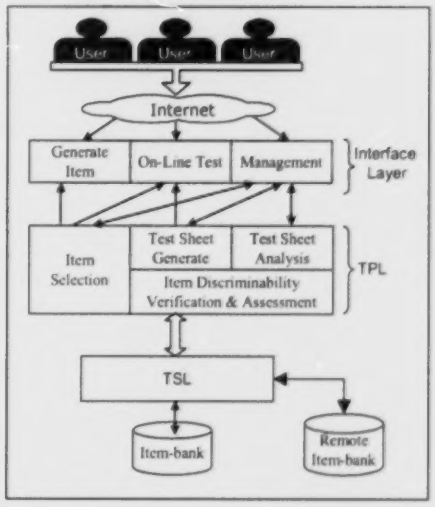


Fig 5: Structure of DIYexamer

TABLE 2: Functions of TSL

Function	Description
Add new items	New items and corresponding answers are categorized to specific chapters and stored in the local item-bank.
Access local item-bank	Accessing local while generating test sheets and calculating discriminability.
Connect to remote item-bank	Item-bank sharing through a connection to a remote item-bank.

Environments and development tools used to construct DIYexamer are listed in Table 3. Perl is used to write CGI programs to create user interface as homepage. Apache, an open source web server software, is responsible for front-end. The back-end, item-bank, is handled by Postgres.

TABLE 3: Environments and development tools

Function	Tools
HTTP Server	Apache 1.3.3 [8]
Programming Tools	Perl 5.003 [9]、CGI.pm-2.56 [10]、Gd.pn-1.14[11]
DBMS	Postgresql 6.5.3 [12]
O.S.	Red Hat Linux release 6.1[13]

C. Functionalities for administrators, teachers and students

DIYexamer provides a web interface for users to remotely control and operate the system. Three types of users are supported: administrators, teachers, and students. Corresponding functionalities are listed in Table 4.

TABLE 4: Functionalities for different users

	Administrator	Teacher	Student
System and Database	• Examine system status • Join a test union • Leave a test union • Create personal accounts • Create group accounts • Modify accounts • Modify item-bank • Redact course division • Backup database	• React course division	
Item production		• Create tests sheet • Select test items • Edit test items • Read test items	• Edit test items • Read test items
Test	• Network Invigilate	• Input scores of homework	• On-line test
Analysis	• Analyze tests • Analyze test items	• Analyze tests • Analyze test items • Analyze subjects and divisions	• Analyze tests
Inquiry		• Inquire tests • Inquire test items generated by students • Inquire students scores	• Inquire personal scores

4 Discriminability Assessment Of Diyexamer

A. Method of Traditional Discriminability Assessment

A criterion against which the quality of test items is judged is the assessment of discriminability. An item is regarded as with high discriminability when competent students correctly answered it, while less competent students incorrectly answered it, and vice versa. When computing item discriminability, those students with relatively high and relatively low scores are taken as samples. Those students whose scores fall in middle range not

considered. Next, item discriminability is computed according to the performance of these sampled students when answering each item.

In the traditional discriminability assessment method[14], those in the top 30% and the bottom 30% rank groups are chosen as samples. The top 30% scorers are defined as "high-rank group (H)", while the bottom 30% scorers are defined as "low-rank group (L)". The formula for calculating the discriminability of an item is as follows:

$$\text{Discriminability} = \frac{\text{The number of students in H that answered correctly}}{\text{The number of students in H}} - \frac{\text{The number of students in L that answered correctly}}{\text{The number of students in L}}$$

In the traditional method, two major drawbacks can be observed. The first one has something to do with whether the 30% is in terms of *count of students* or *range of scores*. The sampled students fall in the top 30% and the bottom 30% rank groups, i.e. in terms of *counts*. However, it is possible that these scores differ only slightly from the average score especially when scores are not wide-spread distributed, where many scorers should not be considered in computing the discriminability. Second, the effect on discriminability assessment by each student in either group is assumed to be the same. However, those students that received different scores have different degrees of tendency to correctly or incorrectly answer an item. For example, a sampled student who received 97 points should have higher referential value than a sampled student who received 80 points.

B. Method for DIYexamer's Discriminability Assessment

When selecting sample students, only those whose scores have large gap with the average score should be considered. Accordingly, those with the top 30%, in terms of range, scores are defined as "high-score group (H')", while those with the bottom 30% scores are defined as "low-score group (L')".

To show the different criteria and effects of choosing samples in the traditional method and DIYexamer method, Fig.6 depicts the score distribution in a test. In this example, the highest score is 92, the lowest score is 34, and the average score is 69. The "high rank score group" and the "low rank score group" are chosen according to these two methods. Take student X as an example, the score of X is 66, which differs only 3 points from the average score. The associated information of X should have little, if not none, referential value in computing item discriminability. However, X is chosen as a sample in the high rank group in the traditional method. This fallacy results from using rank group, in terms of count, as the criterion of choosing samples. In DIYexamer, X is not chosen since score group, in terms of range, rather than rank group is used. Only those with large gap with the average score are chosen as samples.

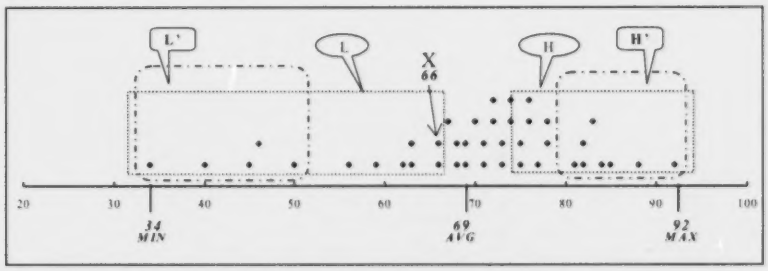


Fig 6: Comparison of samples taken in the traditional method and DIYexamer method

For different samples to have different impacts on discriminability, a referential value with respect to an item is generated for each student selected as a sample. We first define the item discriminability as the average of all associated referential values, as shown below:

$$\text{Discriminability} = \frac{\text{Sum of the referential values of sampled students}}{\text{Number of sampled students}}$$

Since the referential values depend on students' scores, the referential values are computed according to the ratio of correct and incorrect answers of the sampled students. The ratios of correct and incorrect answers are defined as follows:

$$\text{Ratio of correct answer} = \frac{\text{Number of items answered correctly}}{\text{Number of items on the test}}$$

$$\text{Ratio of incorrect answer} = \frac{\text{Number of items answered incorrectly}}{\text{Number of items on the test}}$$

TABLE 5: Principle to compute the referential value of a student with respect to an item

Student	Answer	Item discriminability	Referential value to compute discriminability
Competent (With high ratio of correct answer)	Correct	High	Ratio of correct answer
	Incorrect	Low	Ratio of incorrect answer
Less competent (With low ratio of correct answer)	Correct	Low	Ratio of correct answer
	Incorrect	High	Ratio of incorrect answer

According to Table 5, the referential value of a student correctly answered an item is the ratio of correct answer of the student. Alternately, the referential value of a student incorrectly answered an item is the ratio of incorrect answer of the student. This policy comes from the fact that an item should have increased discriminability if correctly answered by a competent student, while rendering decreased discriminability if correctly answered by a less competent student. In this way, a competent student contributes large referential value to a correctly answered item and small referential value to an incorrectly answered item, and vice versa.

C. Algorithm for DIYexamer's Discriminability Assessment

The test result of a student is used if the score falls in either the high or the low score group. A referential value is computed for each item the student answered. The discriminability of an item is the average of all of the associated referential values.

To calculate for each item, information must be recorded in the database. First, the highest and the lowest scores (i.e. Gmax and Gmin) of all students who answered the question item are recorded to calculate Gh and Gl. Gh and Gl are used as thresholds to determine whether a student is eligible to affect the rating of an item. Second, the number of students with referential values (i.e. n) and the sum of referential values (i.e. Accumulator) are recorded. The calculation formula and the corresponding definition of used parameters are listed below. Algorithm of DIYexamer's discriminability assessment summarized in Fig 7.

Accumulator: sum of referential values
n: number of students with referential value
T: number of correctly answered questions in this test
F: number of incorrectly answered questions in this test
Gmax: highest score of all students answered this question
Gmin: lowest score of all students answered this question
Gh: high threshold for ratio of correct answer
Gl: low threshold for ratio of incorrect answer
Ans: A Boolean variable indicates whether a student correctly or incorrectly answered the question

```
if((T/(T+F)>Gh) or (T/(T+F)<Gl))
{
 if (T/(T+F)>Gmax)
   Gmax = T/(T+F)
 else(T/(T+F)<Gmin)
   Gmin = T/(T+F)
 Gh = Gmax-(Gmax-Gmin)*30%;
 Gl = Gmin+(Gmax-Gmin)*30%;
 n = n+1;
 if (Ans==Correct)
   Accumulator = Accumulator + T/(T+F);
 else (Ans==Wrong)
   Accumulator = Accumulator + F/(T+F);
 Discrimination = Accumulator /n;
}
```

Fig 7: Discriminability assessment algorithm

5 Evaluation Of The Discriminability Assessment In Diyexamer

The fairness and performance of DIYexamer was evaluated. We conducted an experiment where 10 students took the test on-line using DIYexamer with 10 items. Table 6 summarizes the test results. Fig 8 shows the score distribution of the experiment. Discriminability for each item is computed using both the traditional method and the DIYexamer method. However, the discriminability originally falls between -1 to 1 using the traditional method, while falling between 0 to 1 using the DIYexamer method. To compare these two methods, both two ranges of discriminability are then normalized to 0 to 10, as shown in Fig 9.

According to Fig 9, the item discriminability differs in these two methods because the samples taken are different. The low-score group consists of student 1, 2, and 3 by the traditional method, while only 1 and 2 by the DIYexamer method. In this case, student 3 got 4 points, which differs from the average score (i.e. 5.2 points) by only 1.2 points. Since student 3 should have little, if not none, impact on the assessment of discriminability, student 3 is in fact not a proper sample.

Observe that, in Table 6, student 1 who is a less competent student and has incorrectly answered all items except item 1, and student 10 who is a very competent student and has incorrectly answered item 1. Thus, item 1 can be concluded as of low discriminability. Comparing the assessment results in these two methods, the computed item discriminability of item 1 is very low in the DIYexamer method but not as low in the traditional method.

Comparing item 3 and item 1 in Table 6, item 3 should have higher discriminability than item 1 because competent students tend to answer item 3 correctly and less competent students tend to answer item 3 incorrectly, which is not true for item 1. However, item 3 and item 1 have the same discriminability, i.e. 5, by the traditional method. In this case, the actual discriminability is more accurately reflected in the DIYexamer method than in the traditional method.

TABLE 6: Result of the test experiment

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Number of correct answers(score)
student1	1 (correct)	0 (incorrect)	0	0	0	0	0	0	0	0	1
student2	1	0	0	1	0	0	0	0	0	0	2
student3	0	1	1	0	1	0	0	1	0	0	4
student4	1	1	0	1	0	0	0	1	0	1	5
student5	0	1	0	1	0	0	1	1	0	1	5
student6	1	1	1	0	0	1	0	1	1	0	6
student7	0	1	1	1	1	0	0	1	1	0	6

Empowering Secondary School Teachers to Effectively Exploit Internet Resources for the Enhancement of Teaching and Learning

Y. T. Yu* and B. C. Chiu**

**Department of Computer Science, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong. Email: csytyu@cityu.edu.hk*

***Curriculum Development Institute, Education Department, HKSAR, 24 Tin Kwong Road, Kowloon, Hong Kong. Email: scdodp1@ed.gov.hk*

There are great potentials for the use of computers in the enhancement of teaching and learning in secondary schools, but in some subject areas, the realisation of these potentials is critically limited by the lack of appropriate educational software. Custom development of this kind of software is often not a viable alternative, since such a task is well known to be non-trivial and time-consuming that is frequently beyond the capacity of individual secondary school teachers. As computer science researchers and educators, we are aware that vast amount of teaching resources are freely available on the Internet. Such resources are often used by tertiary educators for enriching their teaching, but largely under-utilised by secondary school teachers. This paper reports our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources for use in their schools. Our approach is enabling in that it fosters participants' lifelong learning beyond the contents of the present course, and is applicable to a broader context than ours.

Keywords: **Teacher education, lifelong learning, program visualisation, algorithm animation**

1 Introduction

For a long time, educators and computer scientists have been exploring the use of computers in education [9]. The rapid drop in hardware price and the tremendous improvement in computing power in recent years have rendered computers more affordable to schools, teachers and students. Hardware is no longer the bottleneck that hinders the integration of information technology (IT) into the school curriculum. There are increasingly great potentials for using computers to enhance teaching and learning at all levels of education. In some subject areas, however, the realisation of these potentials is severely limited by the lack of appropriate educational software.

The development of good quality CAI software is well known to be a non-trivial and time-consuming task that calls for the combined expertise of programmers, experienced educators, graphics/multimedia designers, and others [10]. Such a task is often beyond the capacity of individual teachers in primary and secondary schools, due to their limited time, technical expertise and perhaps monetary resources. More fundamentally, it would not be realistic to require every teacher to develop their own CAI software from scratch for use. This is even true for most university educators. As Resmer [13] argues, "if every professor in a university had to write their own textbook, typeset it, print it, publish it, bind it, and distribute it before their students could use it, [textbooks] would not be a viable learning resource". Likewise, for widespread and effective use of computers in education, there is a need for teachers to be well informed of the source of available

educational software.

The Internet promises to be a source of many valuable teaching resources that are frequently available freely or at affordable costs. There are many advantages of exploiting Internet resources for use in teaching. Apart from cost savings, software tools on the Internet are more likely to be kept up-to-date as technology advances, and their evaluation versions could be put to trial use before making actual purchases.

By nature of their work, many university educators are accustomed to the exploitation of Internet resources for both research and teaching purposes [14]. In contrast, these resources have largely been under-utilised by secondary school teachers due to various reasons. Firstly, many teachers are not aware of the existence of such resources on the Internet. One example is the use of visualisation and animation tools that are great aids to program understanding. Although the existence and effectiveness of these tools have been well known to computer science researchers in the field, our experience is that few secondary school teachers are aware of this.[1] Secondly, teachers might not know where these resources are, even if they are aware of their existence. Blind searches on the Internet are likely to be inefficient and sometimes not productive, in terms of the time taken to retrieve useful materials. Thirdly, the use of some resources requires a level of technical competence that a typical secondary school teacher might lack. Finally, some software tools have to be adapted to suit the needs of individual teachers, and without any support or assistance, such tasks could be daunting.

In this paper, we report our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources. Our approach is enabling in that it fosters participants' self and lifelong learning beyond the contents of the present course. We believe that our approach is actually applicable to a broader context than ours and therefore would be of interest not only to secondary school computer teachers, but also to teacher educators and teachers of other disciplines at all levels.

The rest of this paper is structured as follows. Section 2 introduces the context and goals of our short course. Section 3 provides the background of the subject area: computer programming and visualisation tools. Section 4 describes how we exploit Internet resources for use in the course. Section 5 describes the implementation of the course and the feedback from participants. Section 6 discusses our approach. Section 7 concludes this paper.

2 The Teachers Update Course

2.1 Background and objectives

Our university has been organising the Teachers Update Course (TUC) annually as a service to local secondary schools. It aims at refreshing practising school teachers with updated knowledge on the subject areas they teach, and offering advice and assistance on the teaching and learning of the subjects. It serves to show our university's concerns to secondary education, to share our professional expertise, and to promote communication and cooperation between our university and secondary schools.

TUC consists of a series of half-day short courses that encompass many subject areas such as Use of English, Mathematics, Computer Studies, Physics, and others. This paper reports our experience in the design and delivery of the course on Computer Studies. Participants of the course were mainly secondary school teachers of computer subjects such as Computer Studies and Computer Literacy.

2.2 The local secondary school context

In Hong Kong, school teachers are often heavily loaded with both teaching and non-teaching commitments. Typically, a teacher has to conduct six to seven lessons per day, each lesson lasting for 35-40 minutes. In

[1] One author of this paper previously taught a class of student teachers in a Postgraduate Certificate in Education programme who were major in Computer Studies, and none of them were aware of the existence of program visualisation and algorithm animation tools. Similarly, none of the practising computer teachers who participated in the Teachers Update Course described in this paper were aware of such tools.

addition to such work as lesson preparation, setting and marking tests and examinations, most teachers have to share school administrative work as well as leading students to participate in extra-curricular activities.
In recent years, the Government of the Hong Kong Special Administrative Region (HKSAR) has undertaken numerous initiatives to promote the integration of IT into the school curriculum [3]. Since teachers of computer subjects are usually more acquainted with the use of computers than other colleagues, they are often busily involved in the setting up and management of the IT infrastructure of their schools, and they are generally expected to assist other teachers in solving various problems in using IT.

Increasingly, there are pressures for teachers of all subjects to apply IT in their teaching activities. Many teachers have to spend a great deal of time after school hours to attend in-service IT training courses [8,9]. However, one common problem they encounter is the limited availability of appropriate educational software, and few of them have the time and expertise to develop their own courseware. Moreover, budgets are limited in schools for the purchase or development of courseware.

2.3 Goals and strategy

During the planning and preparation of the short course on Computer Studies, the following goals were formulated in an effort to maximise the usefulness of the course to the participants:

- *The course had to provide materials that are directly relevant to teaching in schools.*

  The course in the previous year was intended to broaden the computer knowledge of school teachers by providing updated information on multimedia and their applications. As such, the course was organised in the form of a condensed lecture of part of an undergraduate subject, supplemented by demonstrations of the applied research work of our staff in the area. Although the subject materials were interesting, many teachers subsequently indicated a preference of topics that are more directly related to their own teaching in schools. Simply acquiring further knowledge in the computing field was not as welcome as knowing something directly useful for solving the problems they encountered in their teaching.

- *The course had to offer practical assistance to teachers.*

  Considering the heavy workload of secondary school teachers, any teaching resources must be easy to use and demonstrably useful, or they would not be used at all. In selecting the course materials, preferences were given to those that are easily and practically applicable in the secondary school context. This strategy is also in response to the feedback by teachers in the previous year of their desire to learn something that is "more relevant [to their teaching]".

- *The course should motivate teachers' interests and empower them to pursue further via self-learning.*

  The course was a short one and naturally limited in the amount of teaching materials we could possibly provide. Even with a much longer duration, it would still be impossible to inform the teachers everything they had to know about the topic. Moreover, even for the same topic, there are considerable variations in their needs (for example, due to different teaching styles or their students' background). The same technique useful to one teacher might not work for another. What is more important is to foster their ability to pursue the topics further beyond what we offer, whenever they have the need to do so. Therefore, from the outset the course was designed to "have an empowering or enabling effect on the participants" [9]. We hoped that the course could enable school teachers to acquire what they need via self and lifelong learning.

Setting the right goals was important, but the real challenge was how to achieve these goals within a few hours of contact with the participants. We now outline our strategy as follows. Firstly, we selected a topic that would likely interest most computer teachers: computer programming and algorithms. This topic is clearly directly related to their teaching. Secondly, we collected useful information and software tools for the enhancement of teaching and learning of this topic. Most of these resources were originated from overseas and would be hard to access were they not put on the Internet. Thirdly, among them, we selected only those information and software tools that were judged to be practically useful in the local secondary school context. Finally, we demonstrated to teachers how they could have found and utilised these resources on their own through the Internet.

In retrospect, we believe that although the first step (topic selection) is important in ensuring the relevance

of the course, it is our approach in the remaining steps (use of the Internet resources) that would have more profound influence to the participants. Our approach will be discussed in detail in Section 6. Meanwhile, we briefly introduce the subject area in Section 3 and then elaborate on what we did in the course in Sections 4 and 5.

3 Computer programming and visualisation tools

3.1 Computer programming as a common major part of many computing curricula

Computer programming and algorithms is usually considered a significant and fundamental component in undergraduate computer science education [6]. In most universities, introductory programming and the design of elementary algorithms are the first courses that a computing major undergraduate student has to take (unless these courses were exempted due to credit transfer or advanced standing). Elementary programming courses are also frequently offered as electives to non-computing students with a broad variety of backgrounds [10].

At the secondary school level, computer programming is historically the major component of a typical computer subject. Although the emphasis of learning programming has now been reduced as compared to the past, there is, arguably, still a place for it to be included in the secondary school curriculum. In Hong Kong, both the Computer Literacy subject (offered to almost all junior secondary students) and the Computer Studies subjects (offered as electives to senior secondary students) include programming as a major part of the curriculum [2].

3.2 Difficulties of teaching and learning computer programming and algorithms

The teaching of computer programming and algorithms presents a great challenge to educators at both the secondary level and the tertiary level [15]. To understand a computer program or an algorithm, the student needs to have a good understanding of the internal execution model of computers, as well as the dynamics of variables, data structures and control flows in the algorithm [7]. Such concepts are abstract in nature and could be difficult to even novice programmers [16], let alone non-computing major undergraduates and secondary school students. Indeed, according to our survey to secondary school teacher participants of our short course, about 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.

There is usually considerable overlap between the contents of a computer subject in a secondary school and those of a first year course on computer programming in a university. As such, the difficulties encountered by secondary school teachers are in many ways similar to those faced by the professors in universities, as far as the teaching of basic computer programming and elementary algorithms is concerned.

Nevertheless, usually only the academically more capable students will enter universities. As a whole, the secondary school student population is less mature in intellectual development and more diverse in their academic ability. Compared with university students, many of the secondary school students tend to be less motivated and less capable of independent learning; they normally require more guidance in their studies.

Secondary school teachers are generally less well informed and possess far less resource under their disposal than university educators. To our knowledge, a great deal of research has been done in many universities to address the difficulties in learning computer programming and algorithms [1,5,6,7,12,15]. Unlike universities, however, secondary schools seldom have the resources and expertise to perform similar work to solve their problems. In fact, they might not be aware of such research activities. Our approach in the course is to facilitate the use of university resources on the Internet by secondary school teachers to solve their own problems.

3.3 Program visualisation and algorithm animation

Program visualisation refers to the use of graphical artifacts to represent both the static and dynamic aspects of a program [11]. Algorithm animation portrays the dynamics of the execution of an algorithm by means of animation tools [7]. Educators and researchers have long believed that visualisation and animation are useful in helping students understand the abstract concepts and dynamics involved in computer programming and

algorithms [15]. It is believed that visualisation and animation tools help the learners by displaying in concrete form the mental model of the execution of computer programs. Indeed, many universities worldwide have been actively researching and experimenting with the use of visualisation and animation tools. As a result, a variety of such tools have been developed for different purposes [1,5,6,7,12,15]. Many experimental results have been reported that favour the use of such tools for enhancing program understanding [6,7,15].

4 Exploiting Internet resources for useful educational software tools

Despite years of active research, program visualisation and animation tools are still not widely used in secondary schools, and few such tools designed for teaching and learning are available commercially.2 As discussed in Section 2.2, it is often impractical for secondary schools to develop their own tools.

As computer science researchers and educators, we are aware that many program visualisation and algorithm animation tools have been developed as results of research work in various universities. Even though some tools have been developed mainly for demonstrating the research ideas and therefore might not have as many features as commercial software, most have been designed for teaching and learning. More importantly, they are usually available for free and easy access through the Internet for educational purposes. To our judgment, there are great potentials of utilising such tools in enhancing teaching and learning in secondary schools.

The idea of utilising research tools on the Internet for enhancing secondary school education is obviously appealing and has many advantages over acquiring similar tools by other means. We shall discuss these further in Section 6. However, before being convinced of the practicality of this idea, we had two concerns. Firstly, although these tools had been successfully applied in the tertiary education context, would they be useful in secondary schools as well? Secondly, would secondary school teachers be competent enough to make use of these tools that have originally been designed for use by tertiary educators who are technically more proficient?

To develop this idea further, we set out to evaluate the practicality of using Internet resources as teaching and learning aids in secondary schools. As program visualisation and algorithm animation do not fall into our own research areas, we started our search from only the scarce information that we had. Beginning with the Web sites of two well known researchers in these areas that we incidentally came across and made note of a few years ago, we followed links over links, and so on. It turned out that there was little difficulty in the search of relevant Internet resources. The more tedious and time-consuming task was to evaluate the contents of these resources one by one. Even so, within a few weeks' time, we were amazed to have collected and evaluated almost a hundred sites of related interest! These resources range from the innovative use of common spreadsheet software by researchers in the University of Helsinki [12], to ambitious laboratory projects such as the DYNALAB project of Montana State University [1], and university students' research projects such as Jeliot [5].

We selected and evaluated the resources according to several criteria: (1) relevance in content and level to the syllabus of secondary school computer subjects, (2) accessibility, (3) flexibility (customisability), (4) software and hardware requirements, (5) difficulty in technical content, (6) ease of setup and customisation. After evaluation, we decided to recommend about 30 web sites. The contents of these web sites range from ready-made animations of common algorithms, to downloadable program visualisation tools that support both forward and backward execution [1], and even online animation of user-defined algorithms using customisable 'actors' in a 'theatre-like environment' [5].

Through the process of selection and evaluation, we are increasingly convinced of the practicality of our approach. Many of the tools we found could be effectively used by people with some elementary knowledge of computer programming and concepts of program visualisation. Our participants were computer teachers who clearly possess knowledge of the former but not necessarily the latter. Therefore, part of our short course was to explain the program visualisation concepts and how they could be useful to aid program

[2] Although most commercial program development environments do provide some limited facilities such as the display of the contents of variables during program execution, these are primarily designed to aid software development (particularly to aid debugging) by programmers. These facilities are not targeted to beginner learners and usually not well suited for the purpose of teaching and learning.

understanding.

5 Course implementation and feedback

Our course began with discussions on the common problems in developing CAI software. Then we introduced various sources from which useful CAI software could be obtained freely or at nominal costs for topics in computer subjects in general. These sources included higher educational institutions, students pursuing higher education, professional educational bodies, textbook publishers and others. The use of these Internet resources was more straightforward and requires no further elaboration other than the provision of pointers.

Next, we introduced the concept of utilising program visualisation techniques for the enhancement of teaching and learning, and the corresponding selected Internet resources. For ready made animation tools that were straightforward to use, we simply provided pointers and made two representative demonstrations, leaving the participants to try and pursue the tools at their own pace after the course.

A few selected tools, however, were introduced in much more detail. These tools have one or more of the following characteristics: (1) they were technically more advanced; (2) they could be used in several ways to suit different educational purposes; (3) they had features that were particularly useful or illuminating; (4) their designs were based on notions that were innovative and less obvious to understand but practically very useful. Fortunately, the participants were mainly computer teachers whom could be safely assumed to possess the necessary programming skills and concepts to perform the required customisations. Were we to simply show the links of these resources, it could be difficult for them to tap the potential benefits of these tools effectively.

The participants were so interested in the selected Internet resources that the course was substantially overrun. At the end of the course, participants were requested to complete a questionnaire about their background (for planning of future courses) and about how well they felt the course had been organised (for evaluation of the present course). Some of the statistics obtained are as follows:

1. About 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.
2. About 90% of the respondents agreed (with 26% strongly agreed) to the statement that "I will try to make use of the course materials at school when appropriate". None disagreed; the rest were undecided.
3. About 87% of the respondents agreed that the course was useful to them; none disagreed and the rest were neutral. The same number of respondents agreed that they were satisfied with the course. Some felt that the course could have been improved by extending the duration to allow more time for further discussions.
4. All respondents agreed that the demonstration of the Internet resources for teaching was the most useful part in the course.

6 Summary and discussions

6.1 Characteristics of our approach

We began with the ideas that program visualisation tools are useful for learning computer programming, but such tools are not widely known, of limited availability and hard to develop by secondary school teachers themselves. Yet Internet resources abound that could be effectively exploited for use in secondary schools. As researchers in the university, by nature of our work we are usually better informed with the availability of such resources and the advancement of the latest technologies. In planning and designing the short update course for teachers, we positioned ourselves as mentors in the search of relevant teaching resources. We aimed at offering practical assistance to secondary school teachers by providing the source of relevant information on the Internet, by demonstrating the potential benefits of utilising such information, and by guiding them through the solutions to the technical problems that might arise in utilising such information. We attempted to motivate the interests of participants, to help them overcome the initial barriers (that is, to make "jump start") so that they could eventually help themselves exploit the vast potentials of Internet resources via self and lifelong learning. Incidentally, in so doing, we have exemplified our course as an alternative model of "teaching in the information age" in which teachers serve more like a mentor than an

authoritative knowledge provider.

Our approach is characterised in several ways which distinguish it from that of a traditional teacher education course. Firstly, our goal was modest yet pragmatic in trying to address a specific but real problem that a typical secondary school computer teacher encounters daily: the difficulties of teaching computer programming. Secondly, we demonstrated to the participants how Internet resources could be effectively and practically utilised for addressing their problems. What is even more distinctive is the recommended use of tools developed by researchers with the latest software technologies of the field for use in tertiary education. We have argued that both tertiary educators and secondary school teachers share many common problems that call for similar solutions. Secondary school teachers could learn a great deal from the experience of educators in universities when dealing with their common problems. Finally, the course was designed to be enabling and empowering, with the explicit a priori goal that participants could pursue the subject further via self and lifelong learning.

6.2 Reflections and discussions

On completion of the course with encouraging feedback from the participants, we reflect on the factors contributing to our success. We note that a key factor is our decision to take advantages of the use of selected Internet resources, especially those from universities worldwide. Firstly, these resources are easily *accessible* to teachers and students alike, as long as they are connected to the Internet. The ease of access also minimises the problems that might occur in the distribution and installation of custom developed or commercial software. Moreover, the use of educational tools on the Internet is *cost-effective*. Many of these tools have been demonstrated to be effective through their use in universities. They are typically designed by computer scientists for demonstrating the advantages of applying their research ideas in education, and have subsequently been experimented and evaluated for continuous enhancements, with such evaluations adequately documented in their research papers. More importantly, they are available freely or at affordable costs. Cost is often a critical factor determining whether an educational software tool will be widely used in secondary schools, as resources at their disposal are usually fairly limited.

Some of the software tools we recommended were developed as prototypes with source codes publicly available [12]. They are usually based on sound theoretical principles and accompanied by technical or educational papers describing the theory and implementation in detail. Teachers may customise these tools to suit their specific needs that might vary due to differences in teaching styles, objectives, and students' backgrounds. They may choose to use the whole or part of the tool, or write small program components to be integrated with these tools. For computer teachers who are acquainted with and probably interested in writing programs, such "lightweight customisation" is usually easier and more feasible than building a complete CAI system from scratch. Customisation by users is not normally adequately supported by commercial software that comes with no source code and only limited documentation such as operational guides.

Technologies and knowledge have been advancing very rapidly. On the Internet, new resources keep emerging as results of continuous research by academics who explore the latest technologies for the enhancement of teaching and learning. An example is the experimentation of using 3D visualisation, multimedia and virtual reality technologies in education as they emerge [4]. Teachers who are well informed of such activities through self-learning on the Internet will be in a better position to make use of the latest research results and technologies for continuous improvements to their teaching and learning in ways that are not otherwise possible.

The use of research tools for teaching and learning is not without problems. However, most of these problems would not be deterrent; they could be solved or avoided. Other problems are present in the use of other sources of educational software anyway. For instance, research tools are often imperfect, with some functionality not fully implemented; but as long as the implemented features are considered useful, the tools can be used in part rather than in full. There might be a lack of instant technical support, but many researchers who develop the prototypes are keen to collect feedback, as these might be crucial for their continuous research work. Inevitably, frequent revisions might occur to these tools for research purposes, but if the teacher finds an earlier version useful, that version could be downloaded and kept for use instead of relying on its availability at the source.

7 Conclusions

University educators possess the necessary resources, expertise and freedom to fulfil their roles of performing experimentation and researches, and producing prototypes to demonstrate the usefulness of their innovative ideas. In comparison, secondary school teachers are too occupied with teaching activities and other professional commitments. Most teachers cannot afford the purchase of expensive commercial software for teaching, nor do they generally have the capacity of developing appropriate educational software on their own. Success of integrating IT in the school curriculum is critically determined by the availability of easy-to-use and adaptable tools that satisfy the diverse needs of teachers and students of a variety of backgrounds in different contexts.

The Internet has provided a medium on which tertiary educators can make their resources and experience publicly available to be shared by all, including secondary school teachers. Around the world, numerous tertiary educators have gladly done so as part of their service to the community. Unfortunately, such resources are largely under-utilised by secondary school teachers, due to reasons such as the lack of knowledge and technical competence. For computer teachers, these barriers are relatively easy to overcome, as long as appropriate support and assistance is provided. For teachers of other disciplines, more help might be required. Ultimately, secondary school teachers have to learn, adapt and use these resources by themselves, and to keep themselves updated via self and lifelong learning to respond to the rapid changes that the world has been undergoing.

In this paper, we have reported our experience in the design and delivery of a short course that has progressed towards this direction. Our course also exemplifies itself as one possible model of "teaching" as "facilitating the self and lifelong learning of the participants". Most tertiary educators have now become regular users of Internet resources for enhancing their teaching and learning. It should not be long before secondary school teachers have to follow suit. What we have contributed is but a small part of the continuing collaborative effort to empower teachers to use IT effectively in secondary schools, and ultimately to better education of our younger generations.

References

[1] Boroni, C. M., Eneboe, T. J., Goosey, F. W., Ross, J. A. and Ross R. J. (1996). "Dancing with DynaLab – Endearing the science of computing to students". In *Proceedings of the Twenty-Seventh SIGCSE Technical Symposium on Computers Science Education (SIGCSE'96)*, 135-139, Philadelphia, USA, February 1996.

[2] Curriculum Development Council (1993). *Syllabuses for Secondary Schools, Computer Studies (Secondary 4-5)*, Hong Kong Government Press.

[3] Education Manpower Bureau (1998). *Information Technology for Learning in a New Era: Five-year Strategy 1998/99 to 2002/03*. November 1998, HKSAR.

[4] Gloor, P. A. (1998). "Animated algorithms". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (eds), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[5] Haajanen, J., Pesonius, M., Sutinen, E., Tarhio, J., Terasvirta, T. and Vanninen, P. (1997). "Animation of user algorithms on the Web". In *Proceedings of IEEE Symposium on Visual Languages (VL'97)*, 361-367, Isle of Capri, Italy, September 1997.

[6] Kalayar, M., Ikematsu, H., Hirashima, T. and Takeuchi, A. (1999). "Intelligent learning support system for algorithm learning". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 840-843, Chiba, Japan, November 1999.

[7] Kann, C. and Lindeman, R. W. (1997). "Integrating algorithm animation into a learning environment". *Computers and Education*, **28**(4): 223-228.

[8] Kong, S.-C., Au, W.-K. and Pun, S.-W. (1999). "A case study on the implementation of information technology education pilot scheme in Hong Kong". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 27-34, Chiba, Japan, November 1999.

[9] Law, N., Wan, J., Lau, M. F., Lee, R. and Yuen, A. H. K. (1999). "Towards a model of IT training for inservice teachers". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 51-58, Chiba, Japan, November 1999.

[10] Mulholland, P. and Eisenstadt, M. (1998). "Using software to teach computer programming: Past, present and future". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[11] Price, B.A., Baecker, R.M., and Small, I.S. (1993). "A principal taxonomy of software visualisation". *Journal of Visual Languages and Computing*, **4**(3): 211-266.

[12] Rautama, E., Sutinen, E. and Tarhio, J. (1997). "Excel as an algorithm animation environment". In *Proceedings of Annual Joint Conference Integrating Technology into Computer Science Education (ITiCSE' 97)*, 24-26, Uppsala, June 1997.

[13] Resmer, M. (1999). "IMS – Distributed learning standards". In *Proceedings of 7th International Conference on Computers in Education (ICCE' 99)*, **2**: 567-570, Chiba, Japan, November 1999.

[14] Sloane, A. (1997). "Learning with the Web: Experience of using the World Wide Web in a learning environment". *Computers and Education*, **28**(4): 207-212.

[15] Stasko, J. and Lawrence, A. (1998). "Empirically assessing algorithm animations as learning aids". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[16] Yu, Y. T. and Poon, P. L. (2000). "An approach for evaluating the quality of software developed by novice programmers". In *Proceedings of the 4th World Multiconference on Systemics, Cybernetics and Informatics (SCI' 2000) and the 6th International Conference on Information Systems Analysis and Synthesis (ISAS' 2000)*, **2**: 485-490, Florida, USA, July 2000.

Examining Problems of Student Teachers to Build a Web-supported Environment

Shihkuan Hsu* and Hsiou-huai Wang**
Center for Teacher Education, National Taiwan University
1, Sec. 4, Roosevelt Road, Taipei, Taiwan 10617
**Tel: +886-2-23692364 ext. 214*
E-mail:skhsu@ccms.ntu.edu.tw
***Tel: +886-2-23692364 ext. 215*
E-mail:wanghs@ccms.ntu.edu.tw

Student teaching is an important part of teacher training programs. With the emerging and the widespread use of the Internet, it is important to consider how this crucial stage of teacher development can be facilitated by the use of the technology. In order to create for a user-oriented and research-based web environment, this project was designed to explore problems that student teachers experience. During the internship year, student teachers filled out a self-report critical problem questionnaire five times in two periods, one in each semester. The student teachers were asked to pick one critical problem that they had tried hardest to solve in the day or the week. In the survey, they wrote down the ways to solve the problem as well as the resources they used in the process. The results showed that peer student teachers were those whose help were mostly sought. Over 90% of the means to solve the problem was face-to-face. It is summarized that student teachers may need three types of proximity for problems: Professional, emotional and physical. To provide rich interpretation to the problems, it is suggested that an experience database with focused case study discussion forum may be of help to student teachers' problems.

Keywords: **Student teacher, Student attitude, Teaching experience, Internet use**

1 Introduction

Student teachers are in the process of becoming a teacher. Fresh from the university, student teachers are often full of ideals and enthusiasm. Entering the real world of teaching, however, they are likely to experience problems and difficulties that can be termed "reality shocks" (Wubbels, Creton, Hooymayers & Holvast, 1982). With the Internet technology becoming more accessible and versatile, there are an increasing number of web-based projects to assist student teachers (Georgi & Crowe, 1998). Instead of building the technology first and assessing the student teachers later, this project intends to design a research-based and student teacher-oriented web environment.

This study proposes to examine the needs of the student teachers and use the results as basis to construct a web environment. During a one-year internship, a class of 76 student teachers were asked to participate in the survey and interviews for their problems and difficulties, as well as the resources they used to resolve their problems. The analysis of the problems will be used to develop the guidelines and the structure of the website.

2 Theoretical Background

2.1 The problems of the student teachers

Numerous studies have been done to understand the problems and "reality shocks" that student teachers encountered. In an extensive review, Veenman's (1984) collected 91 research studies in the last two decades.

His summary of the findings suggested eight categories of problems, including managing student, motivating students, dealing with individual differences, evaluating students' work, communicating with parents, organizing class work, obtaining supply and teaching material, and tackling individual student's problems. Chen & Chen (1999) critiqued the previous researcher-designed surveys and used student teacher's journals as a means to understand their problems. They collected 800 student teachers' journals and used Multidimensional Scaling to analyze the data. The major categories of student teacher's reality shock included status uncertainly, students' attitudes and disciplines, conflicts between the decision maker and the doer, the negative-reinforcement style of management, the working ethics of teacher and staff, as well as the relationships among school members (Chen & Chen, 1999).

While many studies addressed the problems that student teachers encounter, most of them focused on why the problems occurred and how to solve the problems for them. Very few, on the contrary, investigated how student teachers solved their problems. Questions regarding whom student teachers asked for help and what resources they used in solving their problems were seldom discussed. The purpose of study, therefore, is not to postulate another possible cause of the problems, rather, is to find out what resources student teachers use to solve their problems, and how technology can help expand this access.

2.2 The problems with the technology

The use of Internet technology for teacher training has received growing attention. E-mail is perhaps still the most widely used means to encourage communication between the supervising teacher and student teachers (Nabors, 1999). More recent developments include more sophisticated design such as electronic portfolio to promote reflection and performance-based assessment (Georgi & Crowe, 1998). Morley's (1999) project uses WebCT, an Internet-based interface, for course syllabus, class notes, hyperlinks, as well as bulletin boards for faculty and students in pre-service method courses. The National Science Council in Taiwan in recent years has funded several projects in building web-supported environment student teachers in areas such biology, math, science and technology (Guo, 1999).

When new technology is added to student teaching, however, some precautions are warranted. As an add-on, the help it provides may not be critical to the user's needs nor adopted by the user in a long run. Examples can be observed in many websites where only few messages are found in the discussion area. As Hsu & Bruce (1998) observed, teachers in distance education often fail to communicate with their distance students because their pedagogical strategy with the new technology does not supply the necessary cues that is acquainted by the students in their face-to-face environment. Therefore in this project we want to explore student teachers' current situation before designing the website.

3 Methods

A total of 35 student teachers from 11 subject areas of junior and high schools participated in this one-year study. The participants were all recent graduates from university or graduate schools of the same university. To sample the student teacher's experiences with problems and difficulties across the internship year, the critical problem survey involved two rounds of sampling periods, once in the end of the fall semester and once at the end of the spring semester.

During the first semester, student teachers were asked to fill out a questionnaire once a week for five weeks. Every week they had to pick one most critical problem in the past week. Three open-ended questions were designed to elicit the most critical problem that demanded the most of the student teachers' time and energy to solve. The three open-ended questions were: 1) What is the most critical problem you have experienced during the week? 2) How do you resolve the problem? And what resources do you use? 3) At the end of the week, was the problem resolved? If not, how would you like it to be solved?

In addition to the open-ended questions, there was a chart where student teachers had to check boxes for the people they had talked to regarding to the problems they were trying to resolve. The choices included the cooperating teacher, the supervising teacher, the student teachers in the same subject area and different subject area from the same university, the student teachers in the same school but from different university, the family, the roommate, none, and others. They were also asked how many times they have made the contact and by what means the communication was made. The choices included face-to-face, phone, e-mail, and others.

The questionnaires were first mailed out to the student teachers. After the initial data collection, it was found that the returned rate was too low. Therefore additional short telephone interviews with 25 students were arranged. The interview also provided a little more in-depth background for their problems and difficulties. At the end of the spring semester, the same questionnaire was filled out daily for five days with the help of telephone interviews. Regular attendance to the student teacher's monthly meeting and small group discussions also informed the interpretation of the data collected.

4 Results

4.1 Student teacher's problems

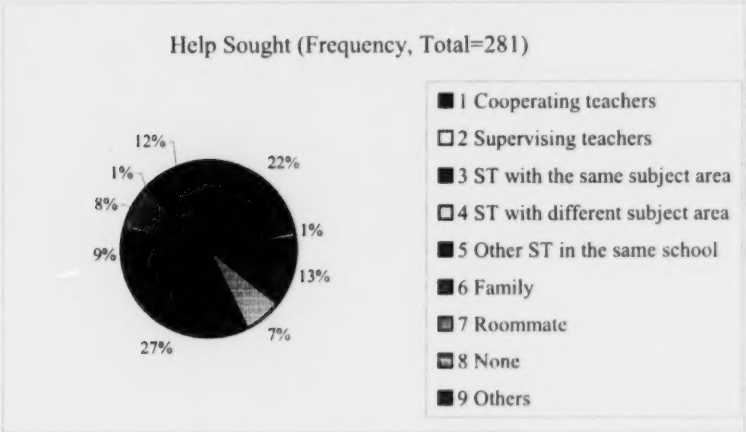
The results of the self-reported questionnaire and the transcript of the interview were coded by two researchers and two research assistants. The coding scheme originally used was Chen & Chen's (1999) findings of six categories, but the emerging themes of the data yields to the following four major categories in student teachers' problems. 1) Ambiguity of the status, including conflicts with the cooperating teachers for competing authority in the class; conflicts with school administrators in terms of task assignment; and conflicts with the school culture in terms of the feeling of unfit to the school physical environment, goals, and life styles. 2) Lack of professional knowledge, including subject knowledge, teaching skills, class management skills, and skills for student discipline problems. 3) Relationship with cooperating teachers, administrators, and students; including problems in making their needs known; and in dealing with small groups and gender issues. 4) Confusion in teaching as career goals, including conflicts between the ideal and reality.

4.2 Ways to solve the problems

When stressed by a problem, student teachers did not always know how to solve it. They usually consulted people for solutions. Categories of people whose help were sought after were coded from both the questionnaire and the interview. 1) Cooperating teachers, to ask for assistance or professional suggestions on classroom management and teaching skills. 2) Other teachers of the same subject area, for content knowledge and student discipline problems. 3) Other student teachers, to seek answers and condolence from others about conflict with the cooperating teacher and students' disciplines; also for relationship and cultural adjustment. 4) Solving the problem by oneself, such as trying out ones' own new ideas, making more effort to learn new things, adjusting attitude, accepting the reality, or simply enduring it.

Depending on the nature of the problem, other resources were sought for specific information. For legal issues, for example, some student teachers sought help from higher up authorities. In terms of technology, a few student teachers used the Internet to find teaching material and lesson plans. Not every problem had a solution, however. During our talk during the interview and in informal settings, quite a few students indicated that they often choose to passively accept the situation or to give up thinking for solutions. The following figure is a summary of the results from the questionnaire about the help the student teachers sought (see Figure 1). The results showed that about 47% of talks were with the other student teachers, where 27% were from the student teachers in the same school. About 22% of help was received from the cooperating teacher, and another 17 % were from family and roommate. Only 1% was from their supervising teachers. Among all the communication means, 92% were face-to-face, 6% were by phone, and 2% were by e-mail.

Figure 1 People whose help student teachers sought from



5 Discussion

According to the analysis, the problems of student teachers ranged from personal to professional. The solutions, although ranged from professional guidance to personal camaraderie, are limited to face-to-face communication. To contemplate what will help student teachers in solving their problems, it may be useful to postulate what they needs are. 1) Professional proximity. Being a novice, a student teacher may eager to know how others would have done differently. Those who are authoritative in professional fields, such as cooperating teachers, are likely to be pursued for instructional and managerial guidances. 2) Emotional proximity. Besides professional guidances, student teachers need to find emotional support to feel that they were not alone. It is also safer to talk to peers for issues of role adjustment and interpersonal relationships in schools. 3) Physical proximity. Those who are physically close (66%) are more readily to help. Therefore, when physical gatherings are not available, the help seeking channels can become seriously impeded.

Based on the above findings, we can begin to think about the design of a web-supported environment. The employment of a student teacher website should have features that provide additional or alternative support that take the above three types of proximity into account. The complexity of the problems and the limited access to solutions suggested that a case method that the user can criss-cross for multiple interpretations may be appropriate for learning in a complex knowledge domain (Spiro & Jehng, 1990). The following components are proposed in the website to be built. 1) A student-teaching case database. To provide experiences of other student teachers in a form of journals, including description of and reflection on various aspects of student teaching. This database is both outlined and keyword searchable. Hyperlinks to other similar cases can be also built. Student teachers can access to a peer's life lessons without having to have an appointment with him. 2) Guidelines and suggestions. Also included in the database are written guidelines and suggestions from academics, experts, experienced teachers and student teachers on the same topics as the above case database. Links to other web resources regarding professional information will also be added. Student teachers can reach specific information for guidance without much effort. 3) Focused case study discussion forum. To provide threaded bulletin boards on selected cases from the database. With shield identity, student teachers can find emotional support without being exposed. The cases can be rotated on weekly bases and among different subject matters. 4) Annotated video components of teaching. Also included in the database can be video clips of exemplar teaching of cooperating teachers as well student teachers' teaching. Written comments can be added by both the cooperating teachers and supervising teachers. This is a good place to engage a productive conversation among the triad of the student teacher, the cooperating teacher, and the supervising teacher.

It is hoped that with the aid of the technological power, the student teachers will have better chances to solve their problems and they should feel more empowered in their first full-time exposure to the real world of teaching.

References

[1] Chen, F. C. & Chen, H. L., "The experience of probation teacher's reality shock--The first season analysis." Proceedings of the Conference on the Exemplar and Practice of Educational Internship. Taipei, Taiwan, April 30-May 1, pp. 51-74, (1999).

[2] Georgi, D. & Crowe, J., "Digital Portfolios: A Confluence of Portfolio Assessment and Technology." Teacher Education Quarterly, Vol. 25, No. 1, pp. 73-84, (1998).

[3] Guo, Y. W., "Planning and promotion of the research on improving the science teacher quality." National Science Council Monthly, Vol. 27, No. 8, pp. 866-880, (1999).

[4] Hsu, S. & Bruce, B., "The missing borders: Pedagogical reflections from distance education." Teaching Education, Vol. 10, No. 1, pp. 47-54, (1998).

[5] Morley, L., "Expanding preservice teachers' tools for effective teaching." Paper presented at the Annual Conference on Technology in PE and Sport. Chattanooga, TN, USA, July, (1999).

[6] Nabors, M. L., "New functions for "Old Macs": Providing immediate feedback for student teachers through technology." International Journal of Instructional Media, Vol. 26, No.1, pp. 105-107, (1999).

[7] Spiro, R. J. & Jehng, J. C., "Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter." In D. Nix & R. Spiro (Eds.), Cognition, education, multimedia. NJ: Lawrence Erlbaum Associates, (1990).

[8] Veenman, S., "Perceived problems of beginning teachers." Review of Educational Research, Vol. 54, No. 2, pp. 143-178, (1984).

[9] Wubbels, Th., Creton, H. A., Hooymayers, H. P., & Holvast, A. J. C. D., "Training teachers to cope with the 'reality shock'." Studies in Science Education, Vol. 9, pp. 147-160, (1982).

Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective

Jill Slay* and Kam W. Li*
**School of Computer and Information Science*
University of South Australia, MAWSON LAKES, SA 5095, Australia.
Jill.Slay@Unisa.edu.au. li@cs.unisa.edu.au

Western research recognises [1] within the CS academic community pressure on its curriculum and teaching methodology brought about by the "evolutionary" nature of the discipline. This continuing need to avoid obsolescence in curriculum, which is produced by changing needs of industry and advances in research, is accompanied by other international and more local issue issues. Current research identifies several techniques which may be used to motivate and support CS learning in such an environment. This paper examines the implications of these findings to Asia, and particularly to mainland China, based on the personal reflections of this researcher on her own studies in China.

Keywords: **Computer Science Education, Cross-Cultural**

1 Areas of concern in Westérn CS education

Some modern issues of concerns in CS education [1] include attrition due to poor motivation/learning difficulty at CS1 level, dealing with students from a wide range of backgrounds with different learning styles and teaching the problem-solving and lifelong learning skills demanded by industry and research

2 Physical solutions

2.1 Providing Motivation Through Active And Participatory Learning

Active [2] and participatory learning [3] are techniques that are proposed to help motivate learners. Some methods which can be used include providing opportunities in "modified lectures" for paired response to questions posed by the lecturer or students discussing the notes they have taken during the lecture and helping to correct misunderstandings. Others have used role-play to demonstrate structures and protocols eg. arrays, linked lists or token passing protocols.

2.2 Learning programming through pattern recognition

In dealing with the learning of programming at the basic level, many researchers have examined the issues of teaching CS1. There is much interest in the use of patterns in aiding students' comprehension of basic programming and the integration of this knowledge [4 Clancy & Linn].

Clancy and Linn comment on the fact that design patterns are of great importance in software engineering and OO design and that to, to some extent, programming knowledge consists partially, at the cognitive level, as patterns (or schemas). However they show that, while the use of patterns is helpful in integrating knowledge, new programmers do not naturally infer patterns and sometimes find it difficult to understand "expert patterns". Clancy and Linn [4] and Johansson [5] advocate the use of a wide-range of contextualised examples and case studies to support the teaching of basic programming skills.

2.3 Adapting pedagogical styles to deal with social, cultural and gender issues

Research shows that students from different cultures or of different genders display different attitudes to computers and learning. In a two-year study of female and international CS students at Carnegie Mellon

University [6] issues which arose included the perception by some female students that the 'purpose' of computing needed to be defined within introductory CS courses. While they displayed a high-level of interest in the computing process they needed to be able to contextualise this process "within a larger purpose". They also displayed a lower level of "attachment" to their computers than did male students on the same course and expressed some relief as they discovered that CS education covered a wide-range of topics

Other research [7] [8] points out that there is a link between culture and learning style. Assertions made in this research indicate that Chinese students (studying overseas) would find it easier to understand and apply theoretical principles within programming than would a similar group of Western students. In their study, Fisher, Margolis and Miller [6] discovered that international female students on their course showed the least "attachment" to computers or computing and used pragmatic reasoning (such as employability) for their choice of major.

The conclusion here is that some allowance has to be made for cultural and gender preferences within the teaching of CS. While it is possible to provide an inclusive focus within lectures, there is, however, some may be a more pressing need to be able to adapt tutorial material for different styles and preferences.

2.4 Problem-solving for lifelong learning

It has been noted [9] that many students who have difficulties across the first year of CS as a whole do not know where to start with a task, regardless of the subject area.

Some effort has been made to incorporate training in problem solving skills and techniques in to early CS education to deal with this problem . This ranges from the use of Edward de Bono's tools for lateral thinking to the development of Polya's approach of Understand, Design and Review [9] for problem solving and offering courses in these techniques within, or parallel to, early programming subjects

2.5 Web-Mediated solutions

With the problems imposed by large classes, and the large range of individual approaches needed to deal with some of student learning issues raised above, CS academics have been some of the first to develop and use web-mediated learning environments for enhancing student learning in CS.

As I have pointed out ([8], [9]) the Web provides a vehicle for the development of the learning environment and teaching can be structured to develop lifelong learning skills and to cater for the expectations and learning styles of students from different cultures and backgrounds.

Early Australian examples of this style of teaching in CS education are many. Recent Australian examples of the use of the WWW in CS education abound. Boalch [10] provides an examination of the use of the WWW as a support medium for the delivery of a first year unit in Information Systems at Curtin University. He provides an evaluation of site utilisation and user feedback in the case where subject information and course details were provided on the WWW for students.

The Eklunds [11] examine the use of the WWW to supplement traditional IT teaching. They provide case studies of two examples of the re-structuring of traditional forms of IT course for Web-delivery. Jones [12] of Central Queensland University gives details of case study involving the design, presentation and evaluation of an undergraduate unit in Systems Administration taught completely via the WWW to on-campus and distance students.

3 Reflection on CS Education in Mainland China

The following two stories are taken from some interpretive tales which I wrote after two separate periods of studying and teaching in China. They draw a picture of the role of the computer on campus in Nanjing 1995) and in Jinan (1998).

A Visit To The Computer Centre 1995

I managed to pay a visit to the University Computer department (I was a Computer lecturer myself at the time in Australia). This was a definite culture shock. The computers, 386s and old at the time, were

kept in a special air-conditioned and carpeted room. People wore white coats and slippers if they wanted to use them. Most students (and only the best study computers) were doing basic Basic programming. I tried to investigate whether they used Windows, or anything modern, but the lecturer was only interested in the length of computer courses in Australia. There seemed to me to be no parallels in our courses at all. The students seemed only to learn Basic programming *[I wondered what job this would qualify them for!]* . It seemed to that things like word processing *[the Chinese have a special keyboard and it takes 5 keys together to create one character]* were a matter for female secretaries and did not enter the arena of the university. I tried to explain the issue of the 'computer as a tool' but I could see that the body language was saying 'Crazy Westerner!' when I tried to put across the concept of teaching less-able, or even all students, to use computers. Computers are for the young and highly intelligent in China.

A Visit to the Internet Centre 1998

It was surprised to find the computer was still as remote as ever from the everyday life of the average student. Computers, 486s by now, still lived in splendid isolation in carpeted rooms, and students still wore special slippers to use them. Still no Windows and still basic Basic.

I had imagined that the cutting edge of technology would be a little different to that which we had at home. I was a little surprised though to find out the process which I had inadvertently become involved with. I worked for six weeks with some highly creative young teachers to try and develop an intranet from an old CAD classroom (486s with no hard disks), one modern Pentium in a building several hundred metres away, one modem and a collection of legal and not-so-legal software. The Internet Centre turned out to be a heavily guarded room about the size of an average Western kitchen with a little row of computers along one wall, filled with a large collection of discarded technology and useful pieces of wire.

Major problems for the Chinese academics was their lack of ability in reading English as the 'install' dialogue boxes sped past on the screen. The problem for me was that I read Chinese much more slowly than they could read English. All the online-help in the world did not help us, installation was a slow process! We often laughed at the problems because we were all engineers and computer scientists. Not really the type of people who are famed for their linguistic abilities, but the monopoly of the Internet by the English language is certainly a problem in China.

I left before the networking was done. I did manage to complete a bilingual virtual library and an English home page for the Institute (with the help of some young teachers) and to teach a couple of them to use FrontPage. I gave lectures to many of the final year students and their teachers. Certainly no lack of enthusiasm here – just a lack of technology and English teachers!

3.1 Chinese Teaching Practice and Computer Based Education.

The combination of a Confucian philosophy and commonly accepted teaching models means that, in universities and colleges, all subjects are taught lecture-style to large groups. However to a Western none of the common CS teaching problems established above is observed in daily teaching and research.

From a Western perspective motivation remains very high among students as they strive to master modern hardware and software. Gender issues and the ability to attract female students do not appear to be a great concern and classes appear to display a balance between males and females. Learning problems do not appear to be the major difficulty experienced and researched in the West.

The major problem appears to be curriculum. The Chinese system has been one that has relied on a national curriculum in all sectors of education and changes in the software and hardware used and taught have not been allowed. During April 1998 (China Daily, 1998) the Ministry of Education announced major adjustments in the University system with corresponding changes to the High School curriculum and schoolbooks, which provide some hope that this issue will be addressed.

A national curriculum which has not kept pace with changes computing practice in Chinese industry and commerce, and even the home, has caused a demand for Western computer manuals in Chinese translation and the increase in number of private providers offering training in modern computer applications and the Internet. Many young teachers and their students are becoming competent users of modern software (eg Windows 98/NT, Office97, object-oriented software) which is not available within the Higher Educational system by turning to these private providers. This leads to disaffection and difficulties for both teachers and their students.

3.2 The Future

As well as the obvious improvements to connections, access speeds and call charges which are currently being made by CERNET, wider issues to be faced are the development of Chinese language software and WWW pages to improve the take-up of the Internet in China as a whole. This is being carried out in an environment of large-scale educational reform which will need to take into account the effect of the Internet on accepted Chinese teaching practice and pedagogy.

4 Conclusions

It is hard to imagine that, even within the next ten years, the Chinese economy might begin to develop and maintain a systemic hardware and software infrastructure within higher education. While it is easy to envisage the limited availability of the Internet for research students, and especially in the nationally funded universities and those around Beijing, the provincial lecturer has the doubly difficult task of persuading the older and therefore more powerful academics to accept new technology and to make drastic changes to their teaching style to incorporate it.

I have proposed elsewhere [9] that an effective conceptual framework for the development of an online learning environment might be one which is based on expected pedagogical outcomes. Therefore one model for China would be to concentrate on the development of online teaching content which would be a resource for guided and collective discovery learning (see above). This might begin with the development of Chinese language link pages to English language resources such as comprehensive virtual libraries and databases.

Academic staff development in technology is both very easy and very difficult. Young Chinese academics are as adept as their Western counterparts in their understanding and use of cutting-edge technology. Their progress is however hampered by their English language skills. This is especially apparent when one is made aware of the lower standards of English language required for technical subjects and the datedness (or nonexistence)of the technical vocabulary taught at university level. This appears to be one of the most pressing problems for the Chinese universities to grapple with and solve.

CS education research has shown a need for pattern recognition, motivation and problem solving skills as aspects of life-long learning. These can be supplied through the medium of web-mediated adaptive tutoring which can be used to augment face-to-face teaching but great efforts will need to be made to use these effectively within the current Chinese pedagogical framework.

References

[1] Tucker, A.B. "Strategic Directions in Computer Science Education". ACM Computing Surveys, **28**(4), (1996).

[2] McConnell, J.J. "Active Learning and its use in Computer Science." Integrating Technology into C.S.E. Barcelona, Spain, (1996).

[3] Jenkins, T. "A Participatory Approach to teaching Programming." *ITiCSE*, Dublin Ireland, (1998).

[4] Clancy, M.J. & Linn, M.C. "Patterns and Pedagogy." SIGCSE, New Orleans, USA. (1999)

[5] Fisher, A., Margolis, J. & Miller, F. "Undergraduate Women in Computer Science: Experience, Motivation and Culture". SIGCSE97. (1997)

[6] Cobern, W.W. "World view theory and science education research." NARST Monograph No. 3. Manhattan, KS: National Association for Research in Science Teaching. (1991)

[7] Slay, J."Unpublished Ph.D thesis". Perth,WA: Curtin University of Technology. (2000)

[8] Slay, J. "Using the WWW to Create an Effective Cross-Cultural Learning Environment. Hong Kong Web Symposium 98, Hong Kong University. (1998)

[9] Slay, J., "Using the World Wide Web to Create Foundations for Lifelong Learning - An Australian Perspective." Teleteaching, IFIP World Computer Congress98, Vienna. (1998).

[10] Boalch, G. "WWW as an Educational Support Medium: An Australian Case Study." Paper presented at AusWeb96, Gold Coast, Australia, (1996).

[11] Ecklund, J. & Ecklund, P. " Integrating the Web and the teaching of technology: Cases across two universities." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

[12] Jones, D. "Solving some problems of University Education: A Case Study." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

Initial Evidence for Representational Guidance of Learning Discourse

Daniel D. Suthers
Department of Information and Computer Sciences, University of Hawai'i at Manoa
1680 East West Road, POST 303A, Honolulu, HI 96822 USA
Tel: 1-808-956-3890
Email: suthers@hawaii.edu

Little work to date has addressed the effects that problem/solution representations have on collaborative learning processes. This paper outlines empirical and theoretical reasons why the expressive constraints imposed by a representation and the information that a representation makes salient may have important effects on students' discourse during collaborative learning. It then reports initial results from a pilot study. Students worked together in pairs on hypertext-based "science challenge" problems. Pairs used either free text, matrix or graph representations of evidence, with two groups assigned to each kind of representation for a total of six groups. Analysis of discourse transcripts suggests that these representations have quite different effects on the extent to which students discuss evidential relations.

Keywords: **Collaborative Learning Discourse, Representational Tools**

1 Introduction

Decades of research into cognitive and social aspects of learning have developed a clear picture of the importance of learners' active involvement in the expression, examination, and manipulation of their own knowledge, as well as the equal importance of guidance provided by social processes and mentorship. Recently these findings have been reflected in software technology for learning: systems are now providing learners with the means to construct and manipulate their own solutions while they are being guided by the software and interacting with other learners. My work is within this spirit, providing representational tools in support of collaborative learning. *Representational tools* may range from basic office tools such as spreadsheets and outliners to "knowledge mapping" software. Such tools help learners see patterns, express abstractions in concrete form, and discover new relationships [4, 8]. These tools can function as *cognitive* tools that lead learners into certain knowledge-building interactions [3, 7].

For a number of years, my colleagues and I have been building, testing, and refining a diagrammatic environment ("Belvedere") intended to support secondary school children's learning of critical inquiry skills in the context of science. The diagrams were first designed to capture scientific argumentation, and later simplified to focus on evidential relations between data and hypotheses. This change was driven in part by a refocus on *collaborative* learning, which led to a major change in how we viewed the role of the interface representations. Rather than viewing the representations as medium of communication or a formal record of the argumentation process, we came to view them as resources (stimuli and guides) for conversation [12, 17]. Meanwhile, various projects with similar goals (i.e., critical inquiry in a collaborative learning context) were using radically different representational systems, such as hypertext/hypermedia [6, 9, 13, 22]; node-link graphs representing rhetorical, logical, or evidential relationships between assertions [11, 14, 19, 20] containment [1], and evidence or criteria matrices [10].

Both empirical and theoretical inquiry suggests that the expressive constraints imposed by a representation and the information (or lack thereof) that it makes salient may have important effects on students' discourse during collaborative learning. Specifically, as learner-constructed external representations become part of the collaborators' shared context, the distinctions and relationships made salient by these representations may influence their interactions in ways that influence learning outcomes. However, to date little systematic research has undertaken to explore possible effects of this variable on collaborative learning, except for [5].

This paper motivates and describes our research and reports initial results from such a study.

2 Representational Guidance

The major hypothesis resulting of this work is that variation in features of representational tools used by learners working in small groups can have a significant effect on the learners' knowledge-building discourse and on learning outcomes. The claim is not merely that learners will talk about features of the software tool being used. Rather, with proper design of representational tools, this effect will be observable in terms of learners' talk about and use of *subject matter concepts and skills*. We have begun investigations to determine what features have what kind of effect. This section develops an initial theory of how representations guide learning interactions, and applies this analysis to make specific predictions concerning the effects of selected features of representational tools. The discussion begins with some definitions.

Representational *tools* are software interfaces in which users construct, examine, and manipulate external representations of their knowledge. Our work is concerned with symbolic as opposed to analogical representations. A notation/artifact distinction [16] is critical to the theory, as depicted in Figure 1. A representational tool is a software implementation of a representational *notation* that provides a set of primitive elements out of which representations can be constructed. (For example, in Figure 1, the representational notation is the collection of primitives for making hypothesis and data statements and "+" and "-" links, along with rules for their use.) The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational *artifacts* in the tool. (For example, in Figure 1 the representational artifact is the particular diagram of evidence for competing explanations of mass extinctions.)

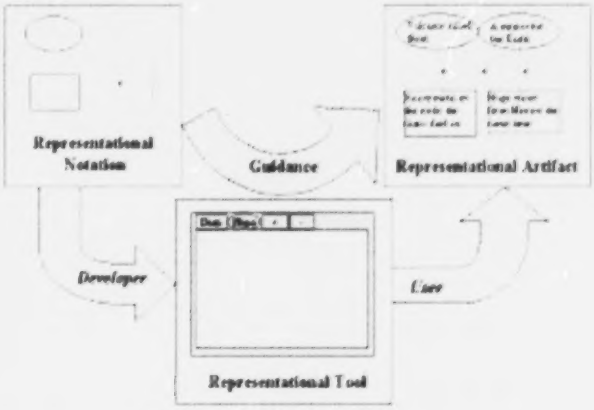


Figure 1 Representational Guidance

Learning interactions include interactions between learners and the representations, between learners and other learners, and between learners and mentors such as teachers or pedagogical software agents. Our work focuses on interactions between learners and other learners, specifically verbal and gestural interactions termed collaborative learning discourse.

Each given representational notation manifests a particular representational guidance, expressing certain aspects of one's knowledge better than others do. The concept of representational guidance is borrowed from artificial intelligence, where it is called *representational bias* [21]. The phrase *guidance* is adopted here to avoid the negative connotation of *bias*. The phrase knowledge unit will be used to refer generically to components of knowledge one might wish to represent, such as hypotheses, statements of fact, concepts, relationships, rules, etc. Representational guidance manifests in two major ways:

- *Constraints*: limits on expressiveness, i.e., which knowledge units can be expressed [15].
- *Salience:* how the representation facilitates processing of certain knowledge units, possibly at the expense of others [8].

As depicted in Figure 1, representational guidance originates in the notation, but affects the user through both the tool and artifacts constructed in the tool.

The core idea of the theory may now be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to articulate emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. Representational guidance constrains which knowledge can be expressed in the shared context, and makes some of that knowledge more salient and hence a likely topic of discussion. The discussion now turns to three predictions based on differences between representational notations.

2.1 Representational notations bias learners towards particular ontologies

The first hypothesis claims that important guidance for learning interactions comes from ways in which a representational notation *limits* what can be represented [15, 21]. A representational notation provides a set of primitive elements out of which representational artifacts are constructed. These primitive elements constitute an ontology of categories and structures for organizing the task domain. Learners will see their task in part as one of making acceptable representational artifacts out of these primitives. Thus, they will search for possible new instances of the primitive elements, and hence (according to this hypothesis) will be guided to think about the task domain in terms of the underlying ontology.

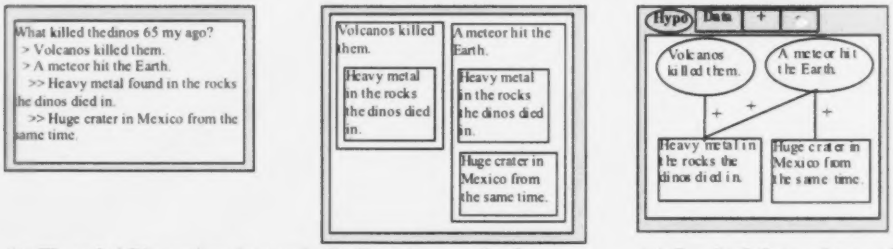
For example, consider the following interaction in which students were working with a version of Belvedere that required all statements to be categorized as either *data* or *claim*. Belvedere is an "evidence mapping" tool developed under the direction of Alan Lesgold and myself while I was at the University of Pittsburgh [18, 19, 20]. The example is from videotape of students in a 10th grade science class.

S1: So data, right? This would be data.
S2: I think so.
S1: Or a claim. I don't know if it would be claim or data.
S2: Claim. They have no real hard evidence. Go ahead, claim. I mean who cares? Who cares what they say? Claim.

The choice forced by the tool led to a peer-coaching interaction on a distinction that was critically important for how they subsequently handled the statement. The last comment of S2 shows that the relevant epistemological concepts were being discussed, not merely which toolbar icon to press or which representational shape to use.

2.2 Salient knowledge units are elaborated

This hypothesis states that learners will be more likely to attend to, and hence elaborate on, the knowledge units that are perceptually salient in their shared representational workspace than those that are either not salient or for which a representational proxy has not been created. The visual presence of the knowledge unit in the shared representational context serves as a reminder of its existence and any work that may need to be done with it. Also, it is easier to refer to a knowledge unit that has a visual manifestation, so learners will find it easier to express their subsequent thoughts about this unit than about those that require complex verbal descriptions [2]. These claims apply to any visually shared representations. However, to the extent that two representational notations differ in kinds of knowledge units they make salient, these functions of *reminding* and *ease of reference* will encourage elaboration on different kinds of knowledge units.



(a) Threaded Discussion: *limited representation of relation.*

(b) Containment: *Implicit representation of relations.*

(c) Graph: *Relationship as object of perception.*

Figure 2. Example of Elaboration Hypothesis

For example, consider the three representations of a relationship between four statements shown in Figure 2. The relationship is one of evidential support. The middle notation uses an implicit device, containment, to represent evidential support, while the right-hand notation uses an explicit device, an arc. It becomes easier to perceive and refer to the *relationship* as an object in its own right as one moves from left to right in the figure. Hence the present hypothesis claims that relationships will receive more elaboration in the rightmost representational notation.

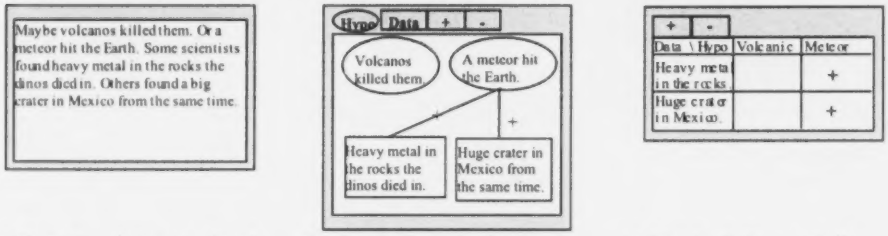
The opposite prediction is also plausible. Learners may see their task as one of putting knowledge units "in

their place" in the representational environment. For example (according to this competing hypothesis), once a datum is placed in the appropriate hypothesis container (Figure 2b) or connected to a hypothesis (Figure2c), learners may feel it can be safely ignored as they move on to other units not yet placed or connected. Hence they will not elaborate on represented units. This suggests the importance of making missing information salient.

2.3 Salience of missing units guides search

Some representational notations provide structures for organizing knowledge units, in addition to primitives for construction of individual knowledge units. Unfilled "fields" in these organizing structures, if perceptually salient, can make missing knowledge units as salient as those that are present. If the representational notation provides structures with predetermined fields that need to be filled with knowledge units, the present hypothesis predicts that learners will try to fill these fields.

For example, Figure 3 shows artifacts from three notations that differ in salience of missing evidential relationships. In the textual representation, no particular relationships are salient as missing: no particular prediction about search for new knowledge units can be made. In the graph representation, the lack of connectivity of the volcanic hypothesis to the rest of the graph is salient. Hence this hypothesis predicts that learners will discuss its possible relationships to other statements. However, once some connection is made to the hypothesis, it will appear connected, so no further relationships will be sought. In the matrix representation, all undetermined relationships are salient as empty cells. The present hypothesis predicts that learners will be more likely to discuss many relationships between statements when using matrices.



(a) Text: *No relation is saliently missing.*

(b) Graph: *Partial salience of missing relations.*

(c) Matrix: *Salience of all missing relations.*

Figure 3. Example of Salient Absence Hypothesis

2.4 Predicted Differences

Based on the discussion of this section, the following predictions were tested in the study reported below. The symbol ">" indicates that the discourse phenomenon at the beginning of the list (concept use, elaboration, or search) will occur at a significantly greater rate in the treatment condition(s) on the left of the symbol than in those on the right

Concept Use: {Graph, Matrix} > {Container, Text, Threaded Discussion}. The Graph and Matrix representations *require* that one categorize statements and relations. This will initiate discussion of the proper choice, possibly including peer coaching on the underlying concepts. The Container, Text, and Threaded Discussion representations provide only implicit categorization. Students may discuss placement of information, but this talk is less likely to be expressed in terms of the underlying concepts.

Search for Missing Relations: Matrix > {Container, Graph} > {Text, Threaded Discussion}. The matrix representation provides an empty field for *every* undetermined relationship, prompting participants to consider all of them. In Graphs or the Container representations, salience of the lack of *some* relationship disappears as soon as a link is drawn to the statement in question or another is placed in its container, respectively. Threaded Discussion does not specifically direct searches toward missing relationships.

The Elaboration hypothesis was not tested independently of the Search hypothesis in this study.

3 An Initial Study

This section reports on an initial study that was conducted to identify trends suggesting that there is a phenomenon worthy of further study; and to refine analytic techniques. Specifically, the study examined how the amount of talk about evidence and the amount of talk about the epistemological status of propositions (empirical versus theoretical) differed across three representational tools, and provided qualitative observations to guide further study.

3.1 Design

Six pairs (twelve participants) were distributed evenly between three treatment conditions in a simple between-subjects design. The three treatment conditions corresponded to three notations: Text, Graph, and Matrix. These notations differ on more than one feature, such as ontology, whether inconsistency relations are represented, and visual and textual notations. I intentionally chose this research strategy (instead of manipulating precisely one feature at a time) in order to maximize the opportunity to explore the large space of representations within the time scale on which collaborative technology is being adapted.

3.2 Method

3.2.1 Participants

Middle-school boys were recruited by my assistant (Cynthia Liefeld) from soccer practice. Two pairs of participants were run in each of the three conditions. Each pair consisted of boys who knew each other, a requirement intended to minimize negotiation of a new interpersonal relationship as a complicating factor.

3.2.2 Materials

Software. Three existing software packages were used: Microsoft Word (Text), Microsoft Excel (Matrix), and Belvedere (Graph). Groups using MS Word were not prohibited from using its typographical devices such as different typefaces, styles, lists, etc. We did not restrict participants' appropriation of typographical devices for organizing information, but neither did we encourage any particular use of the textual medium. Groups using MS Excel were provided with a prepared matrix that had the labels "Hypotheses" and "Data" in the upper left corner, and cells formatted sufficiently large to allow entry of textual summaries of the same. Participants were specifically told to enter hypotheses as column headers, data as row headers, and to record the relationships in the internal cells. The Graph condition used Belvedere. The version of Belvedere used (2.1) provides rounded nodes for hypotheses, rectangles for data, and links for consistency and inconsistency relations between them. Hypothesis and data shapes are filled with textual summaries of the corresponding claims.

Science Challenge Problems. Participants were presented with "science challenge problems" in a web-browser. A science challenge problem presents a phenomenon to be explained (e.g., determining the cause of the dinosaur extinctions, or of a mysterious disease on Guam known as Guam PD), along with indices to relevant resources. For example, one can obtain lists of articles posing possible explanations of the phenomenon, reporting empirical findings from fieldwork or laboratory work, or explaining basic domain concepts. These are relatively ill-structured problems: at any given point many possible knowledge units may reasonably be considered. The materials we used were modified from the classroom versions of science challenge problems developed by Arlene Weiner and Eva Toth.[1] The experimental version excluded hands-on activities, links to external sites and activity guide.

[1] Available at http://lilt.ics.hawaii.edu/belvedere/materials/index.html.

Computer Setup. The computer screen was divided in half as shown in Figure 4. The left-hand side contained the representational tool -- any one of Text, Graph (shown), or Matrix. The right hand side contained a web browser open to the entry page for the science challenge materials.

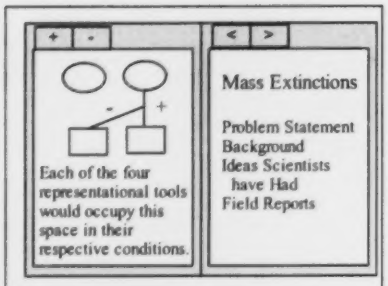


Figure 4. Screen Layout for Studies

3.2.3 Procedure

Participants were seated in front of a single monitor and keyboard. After an introduction to the study and signing of permission forms, participants were shown the software and allowed to practice the basic manipulations such as creating and linking nodes or filling in matrix cells. This training did not involve any mention of concepts of evidence or of the problem domain.

Participants were then presented with the problem statement in the web browser on the right. The problem solving session was initiated when they were instructed to identify hypotheses that provide candidate explanations of the phenomenon posed, and to evaluate these hypotheses on the basis of laboratory studies and field reports obtained through the hypertext interface. They were instructed to use the representational tool during the problem solving session to record the information they find and explore how it bears on the problem. Participants were responsible for deciding how to share or divide use of the keyboard and mouse. The procedure described in this paragraph was repeated, first with a "warm-up" problem, and then with the problem for which data is reported below (Guam PD). Sessions were videotaped with the camera pointed at the screen over the shoulder of one of the participants.

3.3 Results

Analysis was based primarily on coding of transcripts of participants' spoken discourse, and secondarily on participants' representational artifacts.

3.3.1 Coding and Analysis of Discourse

Pilot study videotapes from the six one-hour problem-solving sessions were transcribed and segmented. A segment was defined to be a modification to the external representation or a single speaker's turn in the dialogue, except that turns that expressed multiple propositions were broken into multiple segments. Segments were coded using the QSR Nud*ist software package.

The following codes provide the dependent variables of interest. *Epistemological Classification* codes discourse about the epistemological status of a statement, including classification as empirical (e.g., "that's data"), theoretical (e.g., "that's a hypothesis, isn't it?") or discussion of the choice (e.g., "do you want me to go data or hypothesis?"). In the present study we only wanted to see whether the tools differed in their prompting for making this choice, so did not discriminate these subcategories. Sub-dimension *Evidential Relation* is applied to segments where participants discuss or identify the nature of the evidential relationship between two statements. The codes are *Consistency* (e.g., "it's also for," "that confirms"), *Inconsistency* ("so that's against," "with this one, no, conflicts, right?"), or *Equivocal*, applied when participants raise the question of which relationship holds, if any, without identifying one specifically ("is that for or against?," "it can neither confirm nor deny"). In some cases, evidential relationships were apparently being expressed in terms of the representational primitives provided by the software (e.g., "connect these two"). These utterances were also coded with the appropriate Evidential Relation category, but marked with the Level code (discussed below) so that such "tool-level talk" could be distinguished during the analysis. Topic sub-dimension *Other Topic* codes segments not coded as one of the above topics. The "other" codes include *On-task* (e.g., "are we done with this?"), *Off-task* (e.g., "what's for lunch?"), or *Unclassifiable* (e.g., "uh," mumbles, etc.).

The remaining coding dimensions are used to select out relevant segments for particular analyses. *Mode* indicates whether the segment is coded for its *Verbal* content or for an action taken on the *Representational* artifact. The final two dimensions only apply to verbal segments. *Level* is applied only to Epistemological and Evidential Verbal segments, and indicates whether an utterance made direct use of epistemological or evidential concepts (e.g., "supports," "hypothesis": *Conceptual*) or was expressed in terms of the software

(e.g., "link to this," "round box": *Tool-based*). *Ownership* indicates whether the participant was merely reading text that we provided (Recited) or expressing their own ideas (Non-Recited).

Coding was performed by two of my assistants (Chris Hundhausen and Laura Girardeau). Questions of interpretation, problematic segments, etc. were discussed among the three of us during meetings, but the coding itself was done independently. Inter-rater reliability was computed using the Kappa statistic across all of the categories described above, producing a value of 0.92 (n=1942).

Table 1. Summary of Verbal Coding

Verbal segments tested: nesting indicates subset selection; % are of "Not Off-Task"	**Text**		**Graph**		**Matrix**	
	N	*%*	*N*	*%*	*N*	*%*
Non-Recited	778	*n/a*	626	*n/a*	537	*n/a*
..Not Off-Task	694	100	613	100	508	100
....Evidential Relation	4	0.58	32	5.22	100	19.69
.....Consistency	3	0.43	21	3.43	54	10.63
.....Inconsistency	1	0.14	6	0.98	35	6.89
.....Equivocal Evidential	0	0.00	5	0.82	11	2.17
.....Conceptual	3	0.4	9	1.47	43	8.46
.....Tool-Based	1	0.1	23	3.75	57	11.22
....Epistemological Classification	39	5.62	57	9.30	36	7.09
.....Conceptual	19	2.74	33	5.38	7	1.38
.....Tool-Based	20	2.88	24	3.92	29	5.71

Selected results of coding are shown in Table 1, focusing on segments coded as Mode=Verbal, and showing both counts and percentages for each of the three treatment groups. Percentages are taken relative to Non-Recited on task utterances, shown in the second row. Counts and percentages for Evidential Relation are broken down in two orthogonal ways: by whether the relation was Consistency, Inconsistency, or Equivocal; and by whether the talk about evidence was Conceptual or Tool-Based. Epistemological Classification was broken down by Conceptual or Tool-Based. Due to the small sample size we did not perform statistical testing in this preliminary study.

3.3.2 Qualitative observations

The document created by one Text group contained no expression of evidential relations, and the transcript of verbal discourse for this group contained no overt discussion of evidential relations. All of the discussion of evidence in Text occurred in the other group at the end of the session (the longest session in the pilot study), at which time they also added several expressions of evidential relations. A document produced by one of the Graph groups is notably linear, in spite of the fact that Graph is normally considered a nonlinear medium. A pattern of *identify information, categorize information, add it to the diagram, link it in* is typical of interactions in this transcript. This pattern of activity, which leads to the linearity of the graph, is consistent with the competitor to the Elaboration hypothesis: participants may feel that the primary task is to connect each new statement to something else, after which it can be ignored. Finally, the Matrix artifacts were especially striking because participants were not specifically instructed to fill in all the cells, yet they did so. The transcripts illustrated participants' systematic identification of evidential relations as they worked down the columns, and in one case their appropriate use of the table to rule out a hypothesis that they had proposed.

3.4 Discussion

Recall that the Search hypothesis predicts that participants will be more likely to seek evidential relations when using representations that prompt for these relations with empty structure (Text < Graph < Matrix). The row labeled "Evidential Relation" is relevant to the Search hypothesis. This row counts, for each treatment group, the percentage of verbal segments that were coded with any one of the three evidential values (Consistent, Inconsistent, Choice). The results appear to be consistent with the Search hypothesis: Text=0.58% < Graph=5.22% < Matrix=19.69%. This trend holds even when limited to Conceptual expressions of evidential relations: Text=0.43% < Graph=1.47% < Matrix=8.48%. Note however that a substantial portion of talk about evidence in the Graph and Matrix conditions is tool based (about two-thirds

of Graph and half of Matrix evidential utterances are tool-based). This is as expected, since these tools, unlike Text, provide objects that may be referred to as proxies for evidential relations.

The breakdown of Evidential talk according to the type of relation shows the influence of the exhaustive prompting of Matrix. In Text and Graph, participants focused primarily on Consistency relations, a possible manifestation of the confirmation bias. Treatment was more balanced in Matrix, with almost half of the talk about evidential relations being concerned with inconsistency or equivocal relations. This may be because Matrix prompts for consideration of relationships between all pairs of items: participants are more likely to encounter inconsistency or indeterminate relations when considering those they may have neglected in the Graph or Text conditions.

Addressing the Concept Use hypothesis, we found that 5.62% of Text, 7.09% of Matrix and 9.30% of Graph utterances were concerned with the classification of new information as *data* versus *hypothesis* or their equivalents. We believe that Text would have been lower, except that the instructions for all three conditions directed participants to consider and record hypotheses and empirical evidence. Text participants, like others, complied with these instructions, for example, by labeling propositions as "Data" or Hypothesis." Graph's greater proportion of epistemological classification talk is explained by its most explicit use of visually distinct shapes to represent data and hypotheses.

4 Conclusions

Overall, the results are encouraging with respect to the question of whether there is a phenomenon worth investigating. Differences in the predicted directions were seen in both talk about evidence and about the epistemological status of statements. However, this sample data cannot be taken as conclusive. Caveats, all of which are being addressed by ongoing work, include the small sample size (hence no test of significance), the lack of a learning outcomes measure, and the need for a more direct test of the claim that representational state affects subsequent discourse processes. Furthermore, analyses based on frequencies of utterances across the session as a whole fail to distinguish utterances seeking evidential relations from those elaborating on previous ones (i.e., between the Search and Elaborate hypotheses), or to show a causal relationship between the state of the representation and the subsequent discourse. A more sophisticated coding is required to test whether the representation or salient absence of a particular (kind of) knowledge unit influences search for or elaboration on that unit. All of these deficiencies are being addressed in a study underway at this writing. Pending the results of this study, plans for future work include attempts to replicate selected results in distance learning situations, both synchronous and asynchronous. This line of work promises to inform the design of future software learning environments and to provide a better theoretical understanding of the role of representational guidance in guiding learning processes.

References

1. Bell, P. (1997, December). Using argument representations to make thinking visible for individuals and groups. In Proceedings of the Computer Supported Collaborative Learning Conference '97, 10-19. University of Toronto.
2. Clark, H.H. & Brennan, S.E. (1991). Grounding in Communication. In L.B. Resnick, J.M. Levine and S.D. Teasley (Eds.), Perspectives on socially shared cognition (pp. 127-149). American Psychological Association.
3. Collins, A. & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. Educational Psychologist, 28(1): 25-42.
4. Goldenberg, E. P. (1995). Multiple Representations: A Vehicle for Understanding Understanding. In D. Perkins, J. Schwartz, M. West, & M. Wiske (Eds.), Software goes to school: Teaching for understanding with new technologies (pp. 155-171). New York: Oxford University Press.
5. Guzdial, M. (1997, December). Information ecology of collaborations in educational settings: Influence of tool. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.
6. Guzdial, M., Hmelo, C., Hubscher, R., Nagel, K., Newstetter, W., Puntambekar, S., Shabo, A., Turns, J., & Kolodner, J. L. (1997, December). Integrating and guiding collaboration: Lessons learned in computer-supported collaborative learning research at Georgia Tech. In Proceedings of the 2nd

International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.

7. Lajoie, S. P., & Derry, S. J. (Eds.). (1993). Computers as Cognitive Tools. Hillsdale, NJ: Lawrence Erlbaum Associates.
8. Larkin, J. H. & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. Cognitive Science 11(1): 65-99. 1987.
9. O'Neill, D. K., & Gomez, L. M. (1994).The collaboratory notebook: A distributed knowledge-building environment for project-enhanced learning. In Proceedings of Ed-Media '94, Vancouver, BC.
10. Puntambekar, S., Nagel, K., Hübscher, R., Guzdial, M., & Kolodner, J. (1997, December). Intra-group and intergroup: An exploration of learning with complementary collaboration tools. In Proceedings of the Computer Supported Collaborative Learning Conference '97 (pp. 207-214). University of Toronto.
11. Ranney, M., Schank, P., & Diehl, C. (1995). Competence versus performance in critical reasoning: Reducing the gap by using Convince Me. Psychology Teaching Review 4(2).
12. Roschelle, J. (1994, May). Designing for cognitive communication: Epistemic fidelity or mediating collaborative inquiry? The Arachnet Electronic Journal of Virtual Culture.
13. Scardamalia, M., Bereiter, C., Brett, C., Burtis, P.J., Calhoun, C., & Smith Lea, N. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.
14. Smolensky, P., Fox, B., King, R., & Lewis, C. (1987). Computer-aided reasoned discourse, or, how to argue with a computer. In R. Guindon (Ed.), Cognitive science and its applications for human-computer interaction (pp. 109-162). Hillsdale, NJ: Erlbaum.
15. Stenning, K. & Oberlander, J. (1995). A cognitive theory of graphical and linguistic reasoning: Logic and implementation. Cognitive Science 19(1): 97-140. 1995.
16. Stenning, K. & Yule, P. (1997). Image and language in human reasoning: A syllogistic illustration. Cognitive Psychology 34: 109-159.
17. Suthers, D. (unpublished). Designing for Internal vs. External Discourse in Groupware for Developing Critical Discussion Skills. Presented at the CHI95 Research Symposium, May 6-7. 1995, Denver CO. Available: http://lilt.ics.hawaii.edu/lilt/papers/chi95learning.ps
18. Suthers, D. & Jones, D. (1997, August). An architecture for intelligent collaborative educational systems. Paper presented at AI-Ed 97, the 8th World Conference on Artificial Intelligence in Education, Kobe.
19. Suthers, D., Toth, E., and Weiner, A. (1997, December). An integrated approach to implementing collaborative inquiry in the classroom. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 272-279). Toronto.
20. Suthers, D. and Weiner, A. (1995, October). Groupware for developing critical discussion skills. Paper presented at CSCL '95, Computer Supported Cooperative Learning, Bloomington, Indiana.
21. Utgoff, P. (1986). Shift of bias for inductive concept learning. In R. Michalski, J. Carbonell, T. Mitchell (Eds.) Machine Learning: An Artitificial Intelligence Approach, Volume II (pp. 107-148). Los Altos: Morgan Kaufmann.
22. Wan, D., & Johnson, P. M. (1994, October). Experiences with CLARE: a Computer-Supported Collaborative Learning Environment. International Journal of Human-Computer Studies.

Learning from the Learning of other Students

Stuart Garner
Edith Cowan University
Pearson St., Churchlands, 6018, Western Australia
email: s.garner@ecu.edu.au

This paper concerns the use of dialogues in student learning and how such dialogues can be captured for subsequent use by other learners. The process of learning by observing another person's learning is known as vicarious learning. The paper begins by discussing the movement towards more flexible types of learning and the belief by many that traditional dialogue has been omitted from a lot of today's courseware. Dialogue can be considered as one of the stages in the learning cycle and to support it there is a need to create tertiary courseware, this being the third stage in the cycle. Some of the research that has taken place into vicarious learning is described and this has shown that it has some benefit to learning and also produces positive feelings in students of being part of a learning community. Finally the vicarious learning resources that have been produced within a software development course at Edith Cowan university using a dynamic screen capturing tool are discussed together with a possible dissemination system.

Keywords: **Distance Education, Flexible learning, Vicarious Learning, Programming**

1 Introduction

Universities and colleges today have record numbers of students and yet the cost being spent per student is steadily decreasing as budgets are cut and universities become ever more competitive. One of the consequences of this is that many managers are turning to the Internet as a means for delivering courseware to students in a supposedly cost-effective manner. Students are also demanding more flexible learning with learners being able to learn when they want (frequency, timing, duration), how they want (modes of learning), and what they want (that is learners can define what constitutes learning to them) [14].

The situation has therefore arisen that students spend more time away from a traditional campus and technology is being used to provide the necessary flexibility with computer networking empowering connectivity and communication, allowing synchronous and asynchronous one-to-one and one-to-many communication [13]. However, such technology does not necessarily support some of the learning situations that are necessary in higher education. Laurillard [6] points out that learning in many educational contexts, particularly in higher education, requires learning about descriptions of the world, knowledge derived from someone else's experience, and from understanding someone else's arguments. She states that:

> *We cannot claim to have sorted out once and for all what students need to be told if they are to make sense of topic X. No matter how much detailed research is done on the way the topic is conceptualised, the solution will not be found in new ways of putting it across. The new way of telling may sort out one difficulty, but it may well create others. All we can definitely claim is that there are different ways of conceptualising the topics we want to teach. So all we can definitely conclude is that teachers and students need to be aware of those differences and must have the means to resolve them.*

The main way this has been done in the past has been by students participating in dialogue with fellow students and their tutors. We do have email and synchronous "chat" available to support dialogue to some extent but it may well be argued that this is insufficient to support the above.

2 The Learning Cycle

Dialogue can be considered as a crucial part of the learning cycle [9]. The cycle is shown in figure 1.

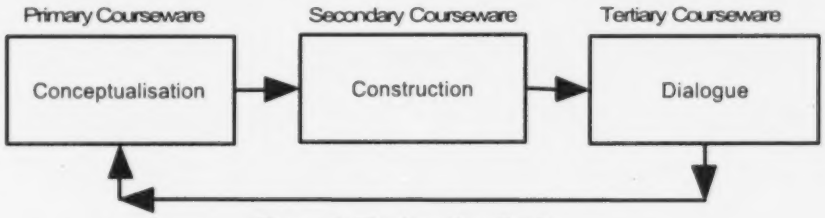


Figure 1: The learning Cycle

It can be considered to comprise:

- conceptualisation which comes from interacting with the primary content and relates to a learner's current state of understanding.
- construction and the use of knowledge occurs with the use of secondary courseware tools such as concept mappers. It involves picking out particularly relevant material, putting the information together in ways which have meaning for the learner, and relating old and new material into a coherent whole.
- dialogue which involves the testing of understanding and can possibly be facilitated with tertiary courseware.

Mayes et al [9] suggest that the third section of the learning cycle, dialogue, can itself be broken up into three stages, these being discussion, reflection and reification. Mayes et al agree with Laurillard that discussion is fundamental to effective education and that a deep understanding is promoted far more effectively and efficiently during discussions. Reflection has always been thought to be an important aspect of learning and can be considered as the testing of new knowledge against the schemata that hold our existing knowledge. And finally reification is a term put forward by Mayes et al and concerns the structuring of newly acquired knowledge into a new object of thought integrated with other knowledge.

The question then arises as to what sort of tertiary courseware can be produced and utilised to support the dialogue aspect of the learning cycle bearing in mind that the material will have to be used in flexible learning environments. One particularly interesting line of research has been into recording of discussions and making them available to other students in a flexible mode. This concept is known as vicarious learning where this is defined as [2]:

> *The potential benefit to learners of being able to observe or 'listen in' on experts or their peers as they discuss a new topic.*

The following can be considered to be vicarious resources:

- Frequently asked questions (FAQs). Here students can learn from the answers to typical questions posed by other students.
- Listservers. These promote vicarious learning as students receive the text dialogues that take place between various subscribers. The term "lurker" is often used for the person who does not participate in dialogues but prefers to simply observe.
- Bulletin boards. These provide the means for asynchronous dialogues and again can be used by "lurkers".
- Chat rooms. These provide the means for synchronous dialogues.

3 Research into Vicarious Learning

Research initiatives are in two main areas, the first attempting to determine if vicarious learning is of benefit to students and the second looking at how such dialogues might be made available as tertiary courseware for re-use by other students.

There are several interesting questions that might be worthy of investigation in the first area. Cox et al [2] suggest that we need to determine who are useful models for the vicarious learner, experts or novices. It might be better to observe experts as skilled behaviour would hopefully be modelled in a clear way, although this is not of course always true as many experts find it difficult to make their knowledge explicit. It could be argued that student – student dialogues would be better to observe as the observing student would be better able to identify with other students. Also the students participating in the dialogue might use more appropriate language and also ask questions of each other that they may not have wished to ask their tutor. Cox et al also point out that observing unskilled behaviour may also prove to be of benefit as the observing student would determine from the dialogue what sort of errors to avoid without having to make those errors themselves. Also of course, the dialogue type to observe may depend on the type of student who is the observer. It might be more appropriate for a strong student to observe experts and for a weak student to observe novices.

In one particular piece of research on vicarious learning [7] benefits were found that were both cognitive, with an increase in knowledge and understanding in the particular curriculum area, and social with exposure to peer discussion creating positive feelings of being part of a learning community.

Lee et al [7] carried out research within an on-line Masters level course in Computers in Teaching and Learning. They created task-directed discussions (TDDs) in order to capture good learning dialogues amongst students and to overcome the "barriers of silence" that might otherwise occur. Over 30 hours of discussions among students, and between students and a tutor (the expert), using the TDDs were videoed.

An architecture called the Dissemination System (DS) was created from primary instructional materials and integrated clips taken from the videos. The DS allows a multimedia database of video and audio clips, text transcriptions, and annotated graphics to be integrated with primary expository teaching material and delivered via the Web. The system was then used in an experiment to investigate the vicarious resources in a controlled laboratory setting.

The experiment used a section of the course on Models of Learning with Technology. Two sets of learning materials were created, the first comprising primary learning materials (approximately 45 web pages) and the second comprising both primary learning materials and an integrated set of vicarious learning resources. The vicarious resources had been obtained from the videoed dialogues and comprised 108 video clips, 13 audio clips, 43 text transcriptions, and 27 audio annotated graphics. The resources were accessible by either clicking on highlighted keywords or by a search mechanism.

Two groups of students took part in the experiment, one using only the first set of learning materials whilst the other used the second set of learning materials which included the vicarious resources. The conclusions that Lee et al drew from the experiment were that there were some benefits in learning and substantial positive changes in attitudes and discussion behaviour for the students who used the vicarious learning resources. The researchers also make the point that although some people claim that learning can only take place when students are personally engaged in discussion, the evidence suggests that observing peer dialogues can, on the contrary, provide a useful source for learning, both cognitively and socially. The researchers have in fact suggested that such vicarious learning may sometimes be more beneficial than being a participant, depending on the state of the learner [11].

The web based materials used in the experiment are available at http://www.hcrc.ed.ac.uk/Vicar/TT/. They are fairly slow to download from the Web but realistically they could be put onto a CD ROM for use with distance learners. The audio dialogues that are available are played whilst a static graphical image is displayed to the learner. Such a dialogue concerns the graphic being displayed and I felt that something was lost in this type of dialogue and that it would have proved to be more useful and meaningful if objects on the graphic could have been "pointed to" in order to draw the observer's attention to the important aspects of the graphic.

4 Creation of Vicarious learning Resources with Dynamic Screen Capturing Tools

During the summer school of 1998 at Edith Cowan University, I made use of Lotus ScreenCam for student-tutor dialogues within a Software Development unit. Between lectures and laboratory sessions, students had

no contact with me as I was off campus, however I did have access to email at home enabling students to send me ScreenCam movies of any programming problems that they were having. In addition to movies, students would also send the programming code enabling me to use this when making a "reply" movie. An example of a screenshot taken from a movie, which was sent to me by a student, is shown in figure 2.

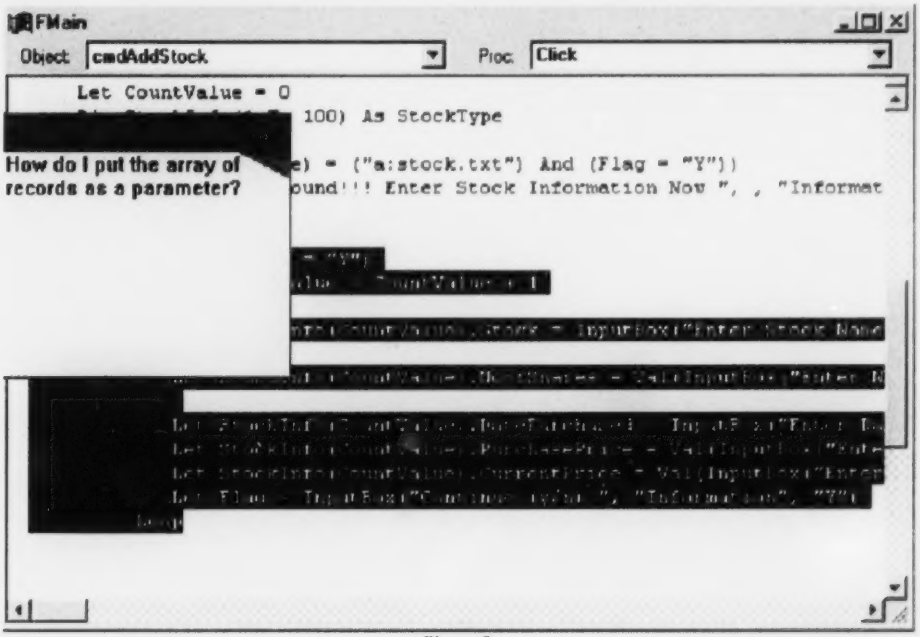


Figure 2

The movie had several text captions and concerned a problem that this student was having with passing arrays to subprograms in Visual BASIC. A screenshot taken from the movie, which I made and subsequently sent back to the student, is shown in figure 3.

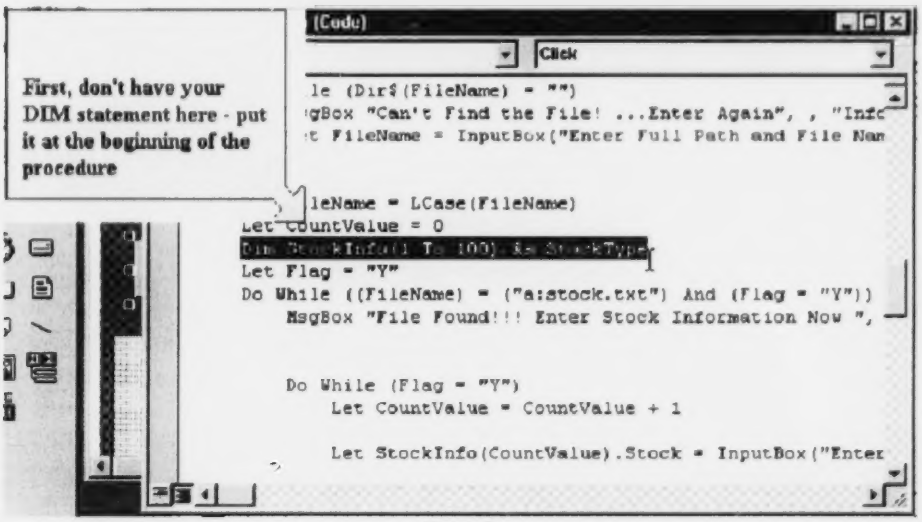


Figure 3

The screenshot in figure 3 includes a text caption that has nothing to do with the original student problem. It

is the sort of comment that I would make if I were looking at the code that a student had produced in a laboratory session. In the rest of the movie, I was able to make suggestions on how to overcome the original problem and I also included a captioned comment about the lack of comments within the student's programming code. By using ScreenCam, I had been able to engage in a richer asynchronous dialogue with the student than I would otherwise have done by conventional means. In addition, as a side effect, I was building up vicarious learning resources for use in future semesters.

In addition to capturing asynchronous dialogues as described above, Lotus ScreenCam can be used to provide rich feedback to students on their assignment work. Simple "low-tech" audio tapes have been used in student feedback [1] and it is suggested that such feedback adds a social dimension to the commentaries with the tutor being able to talk personally to each student, whereas written comments lacked context and sounded impersonal.

I produced a set of such movies for the small group of campus-based students that were involved in the 1998 summer school session mentioned earlier. Each week the students attempted a small programming problem and handed in the relevant programming code together with a small text -captioned movie explaining their program. I then made a feedback movie for each student. Each feedback movie had audio commentaries to keep the production time to a minimum and the movies were placed onto ZIP disks that had been provided by the students. I was able to go through the programming code on the screen, highlighting areas of interest with the cursor whilst making comments and in addition run the student programs with a variety of data whilst passing comments about both the good and the bad points of the programs.

The sets of movies that the students handed in and that I produced have now become another vicarious learning resource for use by students in subsequent semesters. Each week, students are given a small programming problem to attempt and they can then use the movies to view the student – tutor interactions for a similar programming problem. In practice, students have commented on how useful they have found these resources. Feedback was elicited on-line and some of the comments follow:

- I found it helpful and interesting in giving clear visual instructions or explanations.
- All the other students solutions were very helpful. And they were informative.
- Only used the movies once, but they do provide a good resource for students experiencing difficulty.
- Pick up other students mistakes.
- Always forgot how to get to them
- Probably slack, but using the sound was too much hassle.

5 Delivery Mechanisms for Vicarious Resources

The last two student comments above indicate that there is a need for some form of technological delivery mechanism for the vicarious resources that have been produced that is simple and easy to use. Students need to be able to quickly find movies that are appropriate for the programming problem that they are attempting and then view the movie. We have experimented using the Web to deliver the movies however this has been a problem as movies with audio are of the order of 1MB in length per minute and take too long to download. Realistically it is necessary to make the movies available on CD ROM and we will be using a Windows Help file as a way of delivering the movies. There are several Help file authoring tool available and one that I have used extensively is ForeHelp [4]. A Help file can be produced with the usual contents and index pages with little effort and programs can be launched seamlessley thereby permitting the running of ScreenCam movies.

6 Discussion

It would appear that the use of vicarious learning resources by students can benefit learning and also provide positive feelings of being part of a learning community. However the creation of such resources needs to be done very carefully so that they are relevant and of interest to learners. If a synchronous dialogue is to be recorded by the use of video or audio then it is important to use task directed discussions [7] to ensure that a relevant dialogue ensues. Asynchronous dialogues usually take place by email or bulletin boards, however

they can be made richer if a dynamic screen capturing tool is used. Finally the vicarious learning resources that have been collected need to be made available to other learners and to this end Lee et al created a web based dissemination system. Another approach is to use a Windows Help file for disseminating such resources assuming that delivery is to be by Wintel hardware only.

In the future I intend to look at capturing synchronous dialogues using a dynamic screen capturing tool. These would be both student – student and student – tutor where the two participants sit in front of a PC whilst having a dialogue concerning a program that is being displayed.

References

[1] Anson, C. M. (1997). In Our Own Voices: Using Recorded Commentary to Respond to Writing. New Directions for Teaching and Learning, Spring 1997(69), 105-113.

[2] Cox, R., J. McKendree, et al. (1998). Learning vicariously from educational dialogue and discourse. 20th Annual Conference of the (US) Cognitive Science Society, Madison, Wisconsin.

[3] Domingue, J., & Mulholland, P. (1997). Teaching Programming at a Distance: The Internet Software Visualization Laboratory. Journal of Interactive Media in Education (http://www-jime.open.ac.uk), 1, 1-28.

[4] ForeHelp User' s Guide (1995). ForeFront Incorporated

[5] Garner, S. (1997). Cost Effective Multimedia Production for Frequently Updated Courseware. Paper presented at ASCILITE 97, Curtin University, Perth.

[6] Laurillard, D. (1993). Rethinking University Teaching: A Framework for the Effective use of Educational Technology, London Routledge.

[7] Lee, J., F. Dineen, et al. (1999). Vicarious Learning: cognitive and linguistic effects of observing peer dialogues. American Educational Research Association (AERA '99), Montreal, Quebec.

[8] Lotus Corporation. (1997). White Paper (Technical) http://www.lotus.com/home.nsf/welcome/screencam, (accessed on June 23, 1999)

[9] Mayes, J., J. McKendree, et al. (1996). The Vicarious Learner: Rethinking the use of dialogue in teaching and learning, http://www.hcrc.ed.ac.uk/gal/vicar/VicarPapers/vicar.html (accessed on Aug 4, 2000).

[10] Mayes, J. T., & Neilson, I. (1996). Learning from other People's Dialogues: Questions about computer-based answers. In B. Collis & G. Davies (Eds.), Innovating Learning with Innovative Technology . Amsterdam: North-Holland.

[11] McKendree, J., K. Stenning, et al. (1998). "Why observing a dialogue may benefit learning." Journal of Computer Assisted Learning **14**: 110-119.

[12] Neville, L. (1995). Sense-making and Sensitivities: New Pedagogies? New Practices? New Acceptance of Old Ways of Learning? Australian Educational Computing (May 1995), 15-19.

[13] Nikolova, I. and B. Collis (1998). "Flexible learning and design of instruction." British Journal of Educational Technology **29**(Jan. '98): 59-72.

[14] Van den Brande L (1993). Flexible and distance learning John Wiley, Chichester, UK

Localization of a Feature Extraction Area for Touch-type Training Using a Camera

Masayuki Arai, Hiroyoshi Watanabe, Kenji Oguri* and Shigeo Takei
School of Science and Engineering, Teikyo University.
**Graduate School of Informatics, Teikyo Heisei University.*
1-1Toyosatodai Utsunomiya-shi Tochigi, 320-8551 Japan.
E-mail:{arai, hiro, oguri,takei}@ics.teikyo-u.ac.jp

This paper proposes a method to localize a feature extraction area for touch-type training using a camera. The feature extracted from pictures of a trainee's face is used for recognition of one's eye direction. The recognition of a trainee's eye direction enables us to give a trainee warnings and appropriate advice, and these warnings and advice assist a trainee to learn touch-typing quickly. The goal of this study is constructing a system which supports touch-type training using a camera. In this paper, a method to localize a feature extraction area using a horizontal direction's histogram and a vertical one mutually is proposed. These histograms are made from the sum of darkness values of pixels. Experimental results of the proposed method with trainees' black-and-white still pictures are described.

Keywords: **Touch-type training, Camera, Feature extraction, Histogram, Pattern recognition, Eye directions**

1 Introduction

In this paper, we propose a method which localizes a feature extraction area to recognize a trainee's eye direction for touch-type training. By the recognition of a trainee's eye direction using camera, it is possible to warn and give advice when a trainee looks at improper places. These warnings and advice must be effective for trainees to learn touch-typing quickly.

The capability of typing quickly is very helpful in studying and using IT (information technology). Nowadays the capability is becoming more and more important because many people use computers for calculating, writing, reading and so on, and the keyboard is the most common device to input characters. Users can type on a keyboard and train themselves in their own manner, because the keyboard is easy to use. However, typing in one's own manner has a speed limit which is much lower than typing in a proper manner. Furthermore, users' own training ways are not adaptable, that is, using their own typing style, the users would be able to type certain words or sentences quickly, but not so many.

Some training methods are proposed[1]-[3] for the purpose of learning touch-typing. Although the details of the methods vary, the methods have a common point. The point is that after a trainees roughly learn key positions, they should look at a display and should not look at a keyboard in order to learn touch-typing quickly.

The goal of this study is constructing a system which supports these touch-type training methods using a camera. The system warns and gives appropriate advice to a trainee automatically when one looks at improper places. In this paper, we deal with classification of eye directions into the following three classes: Looking at the display is the first class, looking at the keyboard is the second, looking at other places (not the display or the keyboard) is the third. Especially, in this paper, we propose a method to localize a feature extraction area for the classification using histograms of a trainee's face pictures. These histograms are made from the sum of darkness values of pixels.

2 Touch-type training system using a camera

2.1 Structure of the system

The supposed touch-type training system is as follows.
Hardware: A personal computer with a CCD camera.
Software: A touch-type training program and an eye direction recognition program

2.2 Process of an eye direction recognition program

Extracting an eye area from a picture of a trainee's head

Taking a picture of a trainee's head or the upper half of one's body using a camera which is placed on top of a display in the middle, and extracting an eye area from the picture.

Extracting features and classifying an eye direction

Extracting features from the picture of a trainee's eye area, then classifying the eye's direction into three classes.

Warning and advising

Warning with sound and giving appropriate advice when a trainee looks at improper places. Warnings concentrate one's attention on the training, and giving advice is effective for fast learning.

Some other research proposed methods on the process (1) and produced good results [4]. In this paper, we deal with the process (2) on the supposition that the process (1) is already done. To be applicable for most of touch-type training methods, the process (2) classifies eye directions into the following three classes: Looking at the display, the keyboard, other places (not the display or the keyboard).

3 Feature extraction and classification

Figure 1 shows vertical and horizontal histograms used for the classification of eye directions. The histograms are made from the sum of darkness values of pixels. Some research used the histograms, and reported that they are effective for the recognition of eye direction [5].

A vertical direction's histogram in an eye area has basically two peaks: the upper peak is the eyebrows; the lower one is the eyes. We expect those two peaks are key features for the recognition of eye direction, whether it be up or down.

On the other hand, a horizontal direction's histogram also has two peaks. Those peaks are expected to be key indicators for the recognition of eye direction, right and left.
In this study, a template matching method is used for the classification of eye directions using vertical and horizontal direction's histograms.

4 Localization of a feature extraction area

To obtain high classification rates, we must extract features from the area available for the classification, or reduce noise which is unavailable for the classification from a feature extraction area. For these purposes, we propose a method to localize an eye area.

4.1 Localization in a horizontal direction

Most vertical histograms have two peaks. The lower peak is basically at a line of the two eyes as shown in figure 2(a). Thus we localize an extraction area at the lower peak, and get a horizontal direction's histogram from the area as shown in figure 2(b). The histogram is expected to be a key feature for the recognition of right-and-left eye direction.

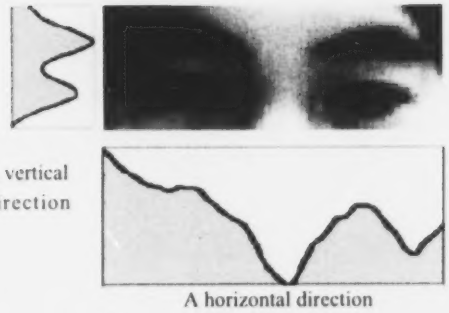
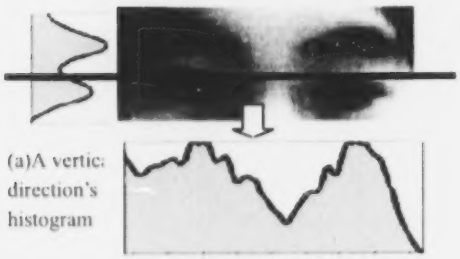


Figure 1. Histograms in an eye area.



(b) A localized horizontal direction's histogram

Figure 2. Localization in a horizontal direction.

4.2 Localization in a vertical direction

We localize a feature extraction area in a vertical direction using the localized horizontal direction's histogram (shown in figure 2(b)).

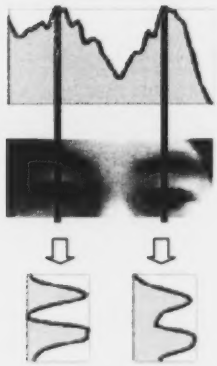
Peaks of the localized horizontal direction's histogram (shown in figure 3(a)) are basically at the two eyes (figure 2(b) is equal to figure 3(a)). Hence, we get vertical direction's histograms as shown in figure 3(b), using the horizontal direction's histogram as shown in figure 3(a). These histograms are expected to be key features for the recognition of up-and-down eye direction.

4.3 Experimental results

We made experiments to evaluate the proposed method of localization as follows:

- First, taking twenty-four still pictures of the trainees' heads (Three pictures were taken of each of eight trainees from each class(described in sect.1). The pictures were black-and-white, 256 picture elements and 72dpi.)
- Then, extracting an eye area by hand.
- Finally, localizing feature extraction areas as mentioned above.

Table 1 shows experimental results of localized areas by the proposed method. In table 1, the center of eye(s) means an iris in case an eyeball was shown in the picture, or the center of an eye's outline in case an eyeball was not shown in the picture.



(a)A localized horizontal direction's histogram (equal to fig.2(b))

(b)A localized vertical direction's histogram

Figure 3. Localization in a vertical direction.

A localized area	A horizontal direction	A vertical direction
the center of two eyes	2	10
the center of an eye	13	12
others	9	2

Table 1 Experimental results of localization

The reasons why the localized area was not at the center of two eyes are the following:
- 70% of the total were caused by inclined heads.
- 30% of the total were caused by noise such as glasses or hair.

5 Conclusions

In this paper, we propose a method to localize a feature extraction area using histograms for touch-type training. The feature is used for recognition of a trainee's eye direction.

Experimental results show the method has some problems when the following conditions exist: a head is inclined, noise such as hair or glasses are shown in the localized area.

To solve these problems, we have the following plans:
- Localization is carried out after adjusting inclined heads.
- Selecting one eye in case the localized area is at the center of only one eye.

References

[1] G. Ohiwa, "Keyboard Training for Information Education," IPSJ Technical Reports, Vol.CE-44-3, pp.11-18, 1997 (in Japanese).

[2] T. Masuda, "The method to master touch-typing in three hours," Nihon Keizai Shimbun, Inc., 1994 (in Japanese).

[3] T. Kawashima, "Method of touch-type training," Proceedings of 39th IPSJ Conference., 4Y-8, 1988 (in Japanese).

[4] M. Kosugi, "Human-face search and location in a scene by multi-pyramid architecture for personal identification," IEICE Transaction on information & systems., Vol.J77-D-II, No.4, pp.672-681, 1994 (in Japanese).

[5] T. Matsumoto, T. Ezoe, K. Wakaki, B. Mallinson, "A Method for the Objective Assessment of Learning Concentration in Computer Aided Instruction", Proceedings of ICCE99, pp.918-919, 1999.

Present State and Future Direction of Woman Informatization Education in Korea

In-Hwan Yoo* Chul-Hyun Lee* Soo-Bum Shin* and Tae-Wuk Lee*
**Dept. of Computer Education, Korea National University of Education*
**San 7, Darak-li, Kangnae-myun, Chongwon-gun, Choongbuk, Korea 363-791*
**E-mail:{bluenull, leesleek, ssb, twlee}@knue.ac.kr*

An informatization society, where high added value can be created through networks is different from an Industrial society where physical labor predisposes discrimination between men and women. As knowledge and information are regarded as the most important resources in an Informatization society, intelligence and emotional ability are given more importance than physical superiority. In light of this, the roles and positions of women are being newly evaluated, and the direction of the women's informatization movement has emerged as a new topic of the era. Korea places a strong emphasis on education and the percentage of women who attend University is also high. Contrary to this, the percentage of highly educated women who become working members of society is very low. These days, this problem has been recognized and education in woman informatization has actively proceeded. Taking various kinds of women's organization as the principal axis, woman informatization projects are actively unfolding. Government has also explored supporting plans in various aspects. This study explores the present state of women's informatization education and it's future direction.

Keywords: **Woman Education, Informatization Education**

1 Introduction

An Informatization Society is expected to be the 3F era: Female, Feeling, and Fiction. Productivity of culture and emotions is more important than labor productivity. Instead of labor productivity, sensitivity and intuition unique to women are expected to contribute a lot to the development of an emotional business that has high added value.

As the roles and position of women are newly evaluated, the direction of the women's informatization movement is emerging as an important topic. As it becomes necessary to have women's informatization education in Korea, a new movement has emerged. In light of this, this study will explore the present state and future direction of informatization education of women in Korea.

2 Present State and Problems of Woman Informatization Education in Korea

The studies on women and the informatization society have been introduced in Korea since the end of 1980. Until now, works on the development of women in an informatization society have been produced intermittently. The Korean Women's Association and National Women's Convention has dealt with "Woman and Informatization Society," and attracted the attention of the society of women overall. However, systematic, continuous and comprehensive studies on women and informatization have been insufficient. Also insufficient are the studies on the concrete policy alternatives for informatizing all women in accordance with national informatization.

2.1 Present State of Women's Informatization Education

Korean Women's Development Institute (http://kwdi.re.kr/)
·Government investing research institute ·Constructs public database first in Korea in 1995. ·Systematizes the professional information related to women and provide it by PC communication network ·Construct total distribution management system on woman information and Internet service in 1997
FemiNet Korea (http://www.feminet.or.kr)
·Established in 1996 with the purpose of 「Woman Informatization」 ·Study on woman informatization, education, information culture business, operation of web-site ·Campaign on home informatization
Women Link (http://www.womenlink.or.kr)
·As professional woman movement organization, promote woman informatization ·Explore business to urge woman participation ·Plan the construction of DB on woman information
Asian Pacific Women's Information Network Center, Sookmyung Women's University (http://apwin.sookmyung.ac.kr/)
· Explore woman informatization project most actively among woman organizations attached to universities ·Construct Web-site in 1997 and provides information related to woman ·Hold international seminars · Obtain professionalism by connecting with other inside institutions attached to university including cyber institute ·Obtained the position of Chair of UNESCO · Play a role as main organization in woman informatization in Asia-Pacific regions including Korea and Japan.

<Table 1> Web site of representative women institutes

First, in the case of education, several women's organizations and social education centers for women hold basic computer training and some job training programs and lectures to expand the mind-set for informatization. However, the lectures are sporadic and temporary, and job training programs are limited to extremely small areas, and the content of training focuses on PC utilization, since it doesn't have the fundamental environment necessary.

Among informatization education at government levels, the women's professional training project of the Ministry of Information and Communication has been most systematically promoted. To solve the manpower problems and to nurture women professionals in the multi-media and content fields, the Ministry of Information and Communication has carried out various supporting projects since 1998. The main projects are shown below:

2.1.1 Support Educational Institute Attached to Women's Universities

This project is to support educational institutes attached to Women's Universities with educational expenses. Women university students and unemployed women will be intensively trained in the fields of information communication including S/W programming, system engineering, networking, and game · animation · media in prestigious education institutions exclusively for women, to get a job or open their own business.

2.1.2 Support 'The House of Working Women'

It also supports the education expenses of the House of Working Women. Homemakers and ordinary women can take training courses in the field of information and communication to get a job in the House of Working Women which has its own childcare center.

2.1.3 Support the Foundation of the Business Incubation Center of Women's Universities

To solve unemployment and to activate the foundation of businesses by women professionals, it supports the establishment of the Business Incubation Center in women's universities. With this project, about 16,000 students and homemakers have obtained information training in 1998, and about 250 woman professionals have established their own businesses.

2.1.4 Present State of Information Service and DB Building on Woman Informatization

Centered on a few women organizations and women research centers attached to universities including the Korean Women's Development Institute, FemiNet Korea, Asia-Pacific Women's Information Network Center, Sookmyung Women's University, women-related DB building and information services have been actively promoted. All these institutes have created the environment for women informatization based on the construction of N/W as an information infrastructure, and launched related education, culture and promotional projects.

In detail, 9 women's organizations out of 117, and 5 women's research centers out of 12 attached to universities that can operate social education programs besides the Korean Women's Development Institute, have operating Web Sites. Following are 4 organizations whose activities are the most active.

2.2 Problems in Woman Informatization Education in Korea

In Korea, accessibility to information devices is extremely different between genders. This difference of opportunity results in that of informatization and further causes severe inequality between genders as it becomes an informatization society.

A survey on Internet users by a Korean newspaper showed that the ratio of males to females among Internet users has largely changed. While the ratio of males to females from 1st to 3rd survey was 9:1, the 4th survey showed that female users had largely decreased the ratio discrepancy to 8.15: 1.85. Compared with the gender ratio among world Internet users (6.64 :3.36), that of Korea is found out to have a severe imbalance as ever[4].

Following is the concrete explanation of the problems of woman informatization in Korea[2].

First, the index of woman informatization is relatively low. Especially, that of homemakers was very low. Considering that the household is the basic unit of the nation, and responsible for enforcing social values through the supervision of the homemaker, it is a very severe problem.

Second, the number of women in higher professional training programs is decreasing, even though information training for woman at the regular or temporary training institutes is increasing quantitatively. As well, the professional training courses by temporary training institutes focus on the simple practice-oriented short-term training, reenacting the isolation phenomenon of women labor.

Third, in spite of the quantitative increase in informatization training for women, the number of women working in the information industry is being reduced. Information communication requires professional training in most fields, and it is necessary to make working environments in which women can continue to work and get in-service training even after getting married and having children.

3 Development Direction of Woman Informatization Education

With the advent of the informatization society, job areas divided by gender lost meaning, and accordingly women manpower can contribute to the development of society more and more. Unless fixed ideas on gender roles are discarded and replaced with a flexible way of thinking, the information estrangement of woman will become larger, and result in the loss of one axis of social development[6].
We will explore the development direction of informatization training of woman in the 21st century from this aspect.

3.1 Primary and Middle School Education

We would like to present the desirable direction of informatization education for girl students as follows:
First, school education should implement systematic education of information and provide as many opportunities as possible to allow girl students access to informatization education. Schools should also guide interest and instill a sense of closeness in information technology fields through the information technology related future course guidance after graduation.

In addition, the curriculum should be reorganized to make the most of information devices in each subject. Especially, careful attention should be given to organizing the education courses, so as not to isolate girl students, including elective courses only for girl students. Going one step further, information technology should be actively utilized in girls' elective courses including housekeeping and home economics courses, which will result in natural information education.

Second, the interest of girl students should be attracted to information through various activities including information contests for girl students. Excellent students should be picked out early and guided. Before determining whether the low index of woman informatization is inborn or learned, it is judicious for the government to give the highest consideration to the informatization of girl students in the education system.
Third, information education should be presented to the parents of those girl students who guide them at home. After all, home is the starting point and the last stop of education. An Information-oriented mind-set for students can be decisively affected by their parents. Especially, the informatization education of the parents of primary students has a high possibility to produce positives effect for the students. Accordingly, it will have a profound meaning in terms of education to provide informatization education which parents and students can participate in together.

Fourth, industrial-educational cooperation should be constructed for the education of girl students. Informatization education requires high-priced equipment and high quality personnel due to its character. It is difficult to say that hardware and software infrastructure for informatization education has been established in Korea. However, universities and industries have both foundation facilities and human resources, and as a result, the personnel trained at universities can be regarded as the consumer and beneficiary. Accordingly, the industrial-educational cooperation will result in an effective system for improving the quality of the informatization education and those institutes.

3.2 Policy Direction for Woman Informatization Education

We would like to present the desirable policy direction for the informatization education of women.

First, it is necessary to carry out education of women's problem at an early stage. Informatization education of women is to overcome the imbalance and irrationality that has emerged from gender discrimination. Accordingly, early education of women's problems should be carried out to enable them to overcome the sense of gender discrimination from the juvenile period, and help them with fundamental problem-solving.

Second, it is necessary to select the institutions or women organizations that can act as an axis of informatization education for women, and to allow them to play pivotal roles in that education. At present, many women's organizations have actively carried out and yielded some fruit. However, in reality, there is no center of woman informatization education that can collect the capabilities of many women's organizations. Informatization centers should be selected, networks by region and by institution should be created, and systematic and reasonable informatization education of women should be carried out. This network should also be expanded as an international organization through the Internet.

Third, it is necessary to rearrange and complement the education courses to connect school education to life-time education. For this purpose, education courses for the informatization education of girl students should be rearranged, which should result in systematic and hierarchical life-time education.

4 Conclusions

Due to the special nature of the information industry, women's labor power of processing and creation of knowledge has retained a new evaluation. Women's delicate nature, intellectual power, and creativeness herald the creation of new value. The emergence of new jobs and concepts of working places opens the new horizon for the possibility of the woman labor force. What is important here is, however, not to be satisfied with this possibility, but to turn this possibility into reality.

Educational fever in Korea is relatively high. The rate of women who go to universities is very high. Compared with those of advanced countries, however, less women with high education have made their way into the society, and as a result, the education for women remains as the consumptive type of education.

It is time to discard the view that the informatization education of women is just one area of expansion of

women's right. Korea has to recognize the importance of utilizing the tremendous number of potential women laborers as real available manpower, and to put a large investment and sufficient support into this.

References

[1] Asia-Pacific Women's Information Network Center, Sookmyung Women's University, http://apwin.sookmyung.ac.kr (accessed on July 30, 2000).

[2] Bong Suk, Son, "Information society and solidarity of women in Asia – Present status and assignments of woman informatization", FemiNet Korea(1998).

[3] FemiNet, Korea, http://www.feminet.or.kr/(accessed on July 30, 2000).

[4] Hankyoreh Newspaper, http://www.hani.co.kr/(accessed on July 30, 2000).

[5] Korean Women's Development Institute, http://kwdi.re.kr/(accessed on July 30, 2000).

[6] Tae Hee, Whang. "Women newspaper", Women newspaper office(1998).

[7] Women Link, http://www.womenlink.or.kr(accessed on July 30, 2000).

[8] Woman Newspaper, http://www.womennews.co.kr/(accessed on July 30, 2000).

[9] Young Whan, Yu, "Exploration on means to improve girl students' informatization ability. – Present status and development direction of woman informatization in Korea –", Korean Women's Development Institute(1998).

Reflections on Educational Technology from Female Asian Faculty's (FAF) Perspectives

Doris Lee*, Amy S.C. Leh, Mei-Yan Lu*** and Mei-Yau Shih******
**Pennsylvania State University -Great Valley, School of Graduate Professional Studies 30 East Swedesford Rd., Malvern, PA 19355, USA, YDL1@psu.edu*
***Instructional Technology, California State University, San Bernardino, San Bernardino, CA 92407, USA, aleh@csusb.edu*
****Instructional Technology, San Jose State University, San Jose, California 95192-0076, USA, meiyan@email.sjsu.edu*
*****Center For Teaching, University of Massachusetts Amherst, Amherst, MA 01003, USA, mshih@acad.umass.edu*

Four panelists in this panel session will briefly present their perspectives on how the instructional technology field has influenced current Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Presenters will address their challenges as female Asian faculty in Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Suggestions and solutions will be discussed during the panel session.

Keywords: **Faculty development, Corporate training, In-Service teacher education, Pre-service teacher education, reflection, and perspectives**

Introduction

Each panelist will offer their unique perspectives in the field of instructional technology. Our focus questions are:

1) Has instructional technology field influenced current:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S. C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

2) What are the challenges do female minority faculty encounter in:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S.C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on In-service teacher education (Dr. Amy S.C. Leh)

Technology advancement is altering our society and our education. New technology standards grant opportunities, and policy reflect the change currently happening in our education. In September of 1997, the National Council for Accreditation of Teacher Education (NCATE) released a report addressing the importance of integrating technology into instruction. New technology standards clearly indicate that teachers must be competent of using technology in their teaching. Moreover, the Department of Education (DOE) has spent millions of dollars on grants to support teachers' training. The grants have brought many

university faculty members, school district administrators, and school teachers together to work on the task –technology integration. In the annual conference of Association for the Advancement of Computing in Education (AACE) 2000, Tom Carrell, director of PT3 grants addressed the influence of technology on our education and the need for organizational change. Some schools, for example, decided to only hire teachers who are competent of the use of technology.

At present, training teachers the use of technology has become a strong nation-wide movement and in-service teachers are expected to become technology literate through in-service training. The strong demand of teachers' training has invited many international scholars to participate in the movement of training US teachers the use of technology. The international scholars were mostly born outside of the United States, came to the USA for their higher education, e.g. Ph.D. degree, and are currently university faculty members at US universities.

The international faculty' participation brought new blood and tremendous strength into US in-service teacher education due to their educational experiences in both the USA and their native countries. Their experience with both educational systems allows them to compare how students learn in two different nations and to employ the strengths of each nation in the USA. For example, how an Asian student learns math is different from how a student in the USA. Asian students' math practice involves word problems (concepts) while the USA students' practice focuses on page after page calculation. An Asian Mathematics faculty, who was differently trained, might use a variety of effective teaching strategies due to the exposure to different ways of learning. Similarly, international Instructional Technology faculty may provide different perspectives in in-service teachers training. Because they are foreigners in the USA, they encounter challenges, especially international female faculty. Reports show that the percentage of female faculty in higher education is low. Some reports even indicate that they encounter more challenges than male faculty, e.g. in promotion. In this case, international female faculty would be minority within a minority and consequently encounter greater challenges. Below are examples of challenges:

"I felt that my viewpoints were not valued." (from an international male faculty)

"I felt that I was transparent in many meetings. They didn't seem to see my presence." (from an international female faculty)

"She [an international female faculty] couldn't get tenured because she was a foreigner." (from a US female faculty)

"You [an international female faculty] are double minority. You're female and foreign..You need to be firm and stand up for yourself." (from a US female faculty)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Corporate Teaching (Dr. Doris Lee)

Today, employees in the corporate settings operate in a rapidly changing, high tech environment. Each employee, in order to accommodate the increasingly rapid rate of technology change, must continually re-tool and upgrade his or her skill sets through life-long learning. The delivery medium for life-long learning, most likely, will use instructional technologies. Instructional technologies refers to computer technologies that can integrate texts, graphics, audio, video, animation, or film clips for the creation of instructional or training packages. Recently, instructional technology also includes the use of the World Wide Web, WWW, in which instruction can be delivered over public or private computer networks and can be displayed by a web browser. Dr. Doris Lee, one of the panelists has taught corporate trainers for more than 10 years in the areas of instructional technologies and design and development of computer-based and web-based training. Based on such an experience, Dr. Lee's discussion in this panel will focus on the impact that the instructional technologies have on corporate training, and what are the challenges and perspectives that she faces as a female instructor for corporate trainers. Below details her experiences and views on these topics.

Generally, most corporations believe that the use of instructional technologies would provide an additional tool to the face-to-face training, can be designed to integrate multiple options including video, audio, and text to accommodate employees' preferred learning styles, and is valuable in providing consistent and current training to employees. In addition, the use of instructional technologies to deliver training can be time and place independent and therefore, costs associated with employees' travel and classroom training can be reduced. However, some companies express concerns in using instructional technologies. These concerns include employees' lack of computer and/or Internet skills, the design and development issues, and the software and hardware limitations.

To convince my students, who are corporate trainers, to consider all the important organizational factors and design issues while using instructional technologies is the biggest challenge. Most of the corporate trainers are female and work in a male-dominate environment. It is imperative for a female faculty to emphasize the importance of front-end analysis even if the analysis is not desirable by their male supervisors. When a company is considering using instructional technologies, a female trainer should never feel intimated to ask important questions including human, machine and political readiness. Questions such as, are the employees comfortable with computers and are they ready to learn, need to be asked. Next, technology readiness is another factor. Hardware, software, and the availability of a technical support staff are some examples of the areas that need to be evaluated. Also, financial readiness pertains to budgeting for upgrades to hardware and software, the purchase of courseware, and developing staff. Plus, political readiness concerns the support of instructional technologies by upper management, middle management, employees, and the training department. Finally, skill readiness looks at whether the staff involved with supporting and developing the training has the skills necessary to do so.

Reflection on educational technology from female Asian faculty's (FAF) perspectives on Pre-service Education (Dr. Mei-Yan Lu)

Educational technology has played a major role in influencing pre-service education. For example, In the 60s, 70s, it was the audio-visual education. In the 80s it was computer assisted instruction (CAI), BASIC programming and Logo programming. In the 90s, it was multimedia, web-based learning.

As a female Asian faculty who has taught in major teacher training Institutes, I would like to share some of the unique challenges for preparing future teachers (per-service teachers) the past 16 years.

Challenge no. 1: Most pre-service teachers are young female white adults. Many of them do not have experiences in working with Asian faculty. For example, a typical K-12 school in San Jose, California, has mainly white teachers/administrators, in many cases, 100% white teachers/administrators while many of their students are from a diverse cultural background. Sometimes, a school student body is from 72 different language and cultural background.

Challenge no. 2: Most teacher preparation institute has mainly white faculty. For example, in the College of Education at San Jose State University which graduate, on the average, 600 credential teachers annually, has about 110 full time faculty. Out of the 110 full time faculty, only 6 are Asian faculty (Chinese, Japanese, and Korean).

Challenge no. 3: Most Asian female faculty are "foreign born". The fact that we are different can offer unique perspectives to our students and colleagues. However, sometimes, our background and cultural differences can be barriers as well. For example, the accent issue. Some students and faculty complain that Asian faculty have heavy accent. However, they rarely complain the European Born faculty who has heavy European accent. Many times, they found European accent charming, while Asian accent distracting.

Challenge no. 4: The field of educational technology generally does not pay attention to solutions and strategies in designing instruction for audience from diverse cultural background. For example, in 1999 AECT convention, there were only two presentations in the entire conference program addressed the issue of designing for international and diverse cultural audience. As one of the popular instructional media – World Wide Web and distance learning is gaining more attention, we as instructional designers/faculty should pay more attention to the international audience.

My goal is to prepare technologically competent teacher candidates that are also culturally sensitive to work with diverse student population. With this goal in mind, I like to recommend:

1. Increase the representation of diverse student body in the field of educational technology both within the United States and outside of the United States.
2. Recruit more faculty of color. Therefore, students will have opportunity to work with both faculty and students from different cultural background.
3. Look beyond the "accent" issue. The point that I am trying to make is that more of the main stream Americans have no trouble "comprehend" accented English. They just do not like the way it "sound". In addition, people who speak with an accent are capable of speaking more than one language and be able to function effectively in another culture. Why not take their unique experience and learn how to design instruction for an international audience?

4. Encourage more educational technologists to research the cultural issues in designing instruction such as in the area of World Wide Web and distance learning.

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Faculty Development (Dr. Mei-Yau Shih)

The use of instructional media in the classroom has long been identified as a "fourth revolution" in education (Ashby, 1967). It has the potential to reshape the role of the instructor from a knowledge conveyer to a guide and coach, while students take a more active role in the learning process. No longer are the textbook and instructor the sources of all knowledge; instead, the faculty member becomes the director of the knowledge-access process (Heinich 1996 et al,). Instructional technology refers not only the actual use of technological tools it also stresses the importance of the process of developing overall goals and strategies for enhancing teaching and learning. At its best, technology-based learning can help teachers support a wider range of learning styles, facilitate active learning in the classroom, use faculty time and expertise more effectively, and familiarize students with technology that will be vital for their futures in the world of work.
In our experience, university faculty are both greatly excited and daunted by the promise and power of teaching technologies. Our students have grown up in a "high technology" environment and are well adept at the use of TV, videotape, computers, and the Internet as information exchange tools. Many faculty, on the other hand, struggle to learn new technologies and to see how they might be useful to them as teachers (Shih & Sorcinelli, 2000). . The higher education is encountering the new trends of the changing student body, teaching practices, and the new roles and identities of faculty in universities. It is imperative, therefore, to remains a holistic view while helping faculty develop their technological skills with an understanding of the educational values and systems where the teaching and learning take places.

The perspectives from a foreign born female faculty developer, whose first 20 years of educational training differs massively from the majority of US university faculty on educational technology, reflect not only a personal challenge, they also underscore the important tasks of any faculty develop who serves as the chang agent in helping the transformation of teaching practice with instructional technology. These tasks include, first, effectively represent the instructional technology to faculty to help them see the integration of technology involves more than physical setup and technical support; it requires some curricular modifications and instructional strategy shifts; second, take in the cultural and educational differences in educational systems to design the strategies in energizing faculty and inspiring them trying innovative ways of teaching, and made them conscious about their purposes in the classroom; third, establish credibility and earn trust of the faculty to represent effectively the benefits of using technologies for teaching and learning; forth, remain alert and sensitive to the campus culture to help enhance the collegiality on campus, and maintain a supporting network of "exemplars" who would be eager to take risks and become "mentors" to colleagues who express interest in instructional technologies. Of most importance task as an Asian, female developer working for rising faculty technological skills is to help faculty recognize the diversity in college classroom, to make them conscious of the various student learning styles, ages, genders, race and ethnicity, and digital have's and have-not's issues in classroom. Effectively carry out these tasks is the means to the ends to help best researchers use and understand the instructional technologies to become a better and effective teacher in the 21st century.

REFERENCES

[1] Ashby, E., (1967). "Machines, Understanding, and Learning Reflections on Technology in Education." The Graduate Journal, 7, pp. 359-373.

[2] Heinich, R., Molenda, M., Russell, J. & Smaldino, S. (1996). Instructional Media and Technologies For Learning. 5th Edition. Englewood Cliffs, New Jersey. Prentice-Hall, Inc.

[3] Shih, M. Sorcinelli, M.D.. (2000). "TEACHnology: Linking Teaching and Technology in Faculty Development." To Improve the Academy. V(18). POD Network. Anker Publishing Company, Inc. Bolton, Massachusetts.

Space Plan for Effective Educational Software Utilization in Korea

Soo-Bum Shin* Chul-Hyun Lee* In-Hwan Yoo* and Tae-Wuk Lee*
**Dept. of Computer Education, Korea National University of Education*
**San 7, Darak-li, Kangnae-myun, Chongwon-gun, Choongbuk, Korea 363-791*
****E-mail:{ssb, leesleek, bluenull, twlee}@knue.ac.kr***

Need of the ICT(Information & Communication Technology) based education has been emphasized and importance of educational software is being recognized, but it is not being utilized effectively. To solve this problem, we surveyed present conditions, recognition, and obstructive factors of educational software utilization for teachers of elementary schools, junior high schools, and high schools, and school inspectors who use educational software in their schools by questionnaire and interview. On the basis of the surveyed matters, we suggested a plan to utilize educational software effectively in the teacher, educational software, support system, and environment side.

Keywords: **Educational Software, Effective Utilization**

1 Introduction

1.1 Purpose

The key target of the educational informationalization business in Korea is to improve methods and quality of teaching and learning by using various educational software. For this, total 3,400 educational software have been developed and distributed in Korea from 1985 to 1998, and software purchase expenses of 1 million won per school have been supported from 1998 to use software developed by private hands.

Although lots of software are being distributed to each school like this, rate of teachers who have used educational software is lower than expected and schools continuously appeal lack of educational software. But definite and objective factors of why educational software is not used properly have not been found.

Therefore, a realistic and practical plan for effective educational software utilization should be prepared for teachers in their schools by finding problems and actual conditions based on development, distribution, and utilization of present software and gathering opinions of demanders and suppliers of educational software.

1.2 Content and Methodology

This study surveyed the followings by questionnaire and interview[1].

First, Present conditions of educational software utilization. Second, Recognition of educational software utilization. Third, Obstructive factors to educational software utilization.

The subjects of questionnaire were 1568 teachers of 128 schools(8 schools of each two elementary school, junior high school, academic high school, and vocational high school under the Education Administrations of national 16 cities/provinces were selected). Especially, for the above Third matter, interview was added for school inspectors in charge of educational informationalization, chiefs of the information department and teachers in charge of the task in the 9 Education Administrations.

2 Concept and Category of Educational Software

The educational software may be wholly utilized in the education and educational support field.

Jeong Taek-hee et al. define educational software as 'data or program that are directly inputted to a teaching-learning course and mediate interaction between teachers and learners to achieve the educational object'[2].

This study focused on data or educational software made for teaching-learning and set the concept of educational software as "software with teaching-learning purposes of a diskette, CD-ROM, and web type, containing educational matters made with each kind of authoring tools or programming languages". Also, presentation and digital encyclopedia type, which are being used a lot in the field, are included in it.

3 Analysis of Educational Software Utilization

The questionnaires were recalled from 84 schools among 128 schools which received them and the recall rate was about 65.6%. But among them, 6 schools respond unfaithfully, so questionnaires for just 78 schools were handled, the response rate was about 56.7% consequently.

3.1 Present Conditions of Educational Software Utilization

As a result of questionnaire, it was surveyed that 67.8% of respondents have used educational software during the class. But it is just 1 time use and most teachers responded that they did not utilize it now.

Enough	Over 70%	Over 50%	Under 50%	Under 30%	Almost not utilizing	No response	Total
34(4.6)	32(4.3)	66(9.0)	0(0)	65(8.8)	471(63.9)	69(9.4)	737(100)

<Table 3-1> Degree of educational software utilization

The results of surveying reasons for not utilizing(for intending not to utilize) educational software are as <Table 3-2>.

Place	Reason for not utilizing
1	There is no proper educational software.
2	It is not suitable for curricular characteristics.
3	It is thought that there is no special need.

<Table 3-2> Reasons for not utilizing educational software

3.2 Will of Utilization of Educational Software

It was found that respondents who responded that they had a plan to utilize educational software were far more than respondents who had responded that the had not to the question, "Will you use educational software in future?". So it shows that the will of teachers to utilize educational software was significantly high.

Yes	No	No response	Total
453(61.5)	61(8.3)	223(30.2)	737(100)

<Table 3-3> Will you utilize educational software in future?

The reasons for having a plan for software utilization are first, increase of educational efficiency, and second, improvement of teaching quality, and other responses were attraction of students' interests, improvement of a visual effect, and playing a role of a teaching helper.

3.3 Obstructive Factors to Educational Software Utilization

The fact that there is a will to utilize educational software but it is not utilized involves many suggestions. This study considered it as an obstructive factor to educational software utilization and surveyed it by interview. The reason for using interview instead of questionnaire was for consideration of the field conditions which cannot be expected by questioners.

3.3.1 Hardware

(1) Inadequacy of Hardware Environment: To utilize educational software, specifications of hardware should be good. A student has a computer as the level of a computer per 15.8 students including from 286 grade to pentium grade and as the level of a computer per 19.1 students in case of efficient over pentium grade for utilization in Korea. This can be sufficient basis to raise consistent voice for field teachers, 'hardware environment is inferior'.
(2) Inferior Maintenance System: Computer produces various maintenance conditions such as from software error to exchange of computer mainframe. But present condition is that teachers are not sufficient to decide correctly and cope with these conditions.

3.3.2 Educational Software

(1) Lack of Utilization Capability of Educational Software in a Class: There were many opinions that they fall in utilization as an intention of educational software developer is not the same as the intention of teacher in a class. And, it was appeared that it is difficult for the software to connect with curriculum as reconstructing of educational software is difficult.
(2) Lacked Information about Educational Software: When teacher wishes to utilize educational software in a class, information to guide him are so insufficient. This functions as a factor to refuse the utilization of educational software by teacher as well as work excess of teacher.

3.3.3 Teacher

(1) Lack of Utilization Ability and Absence of Practical In-service Training: To utilize educational software effectively, teacher must have the ability to connect the contents of educational software with instruction contents. In-service training can be an appropriate method to improve this ability. But In-service training executed now includes mainly learning of fundamental ICT or development of educational software rather than utilization of educational software.
(2) Lack of a Study Time of Teaching Materials: To apply the educational software on a class in the school field, teacher must confirm the hardware environment, understand the contents and type of educational software by checking, and has an ability to reconstruct the contents of class. He must check various things himself as there are no sufficient existing information for utilization and there is nearly no place to ask. However, it was appeared that teacher did not utilize educational software as his task is so much for these works.

4 Utilization Plan of Educational Software

We examined recognition of teachers, actual condition of utilization, and obstructive factor about educational software as mentioned above. In this study, we will prepare a plan to settle obstructive factors educational software effectively and practically on the basis of this.

4.1 Hardware

We will suggest the plan for hardware as the consideration of 2 conditions such as exchange of the existing old computer and new installation. And other various conditions must be considered for current educational software. In consideration of these condition, gradual plans of the following 3 steps are necessary.
First, basic utilization must be induced by distributing multimedia PCs in classroom primarily. Second, multimedia room must be installed by each school with the first step together. It is because that multimedia room can be utilized for storage of educational software, role of file server, and development of educational software. Third, installed hardware is required to maintain certainly and to reinstall. To ensure the continuous maintenance and reinstallment for hardware can give sense of stability to the school and extend efficient utilization of educational software.

4.2 Educational Software

To utilize educational software efficiently, most of all, educational software with good quality must be developed and distributed in the school field. In addition to the development of educational software with good quality, P.R. about developed educational software is necessary urgently. We suggest plans in

consideration of these conditions as follows.

First, DB on the development educational software must be provided by the level of Ministry of Education. DB must arrange and construct contents to be a standard of selection such as subject, type, and characteristics about each educational software when teachers wish to utilize educational software. Second, educational software must be manufactured with easy type for utilization in a class and its development breaks from the form of collection. And it must be manufactured as a form with easy change of structure according to the class intention of teacher. Third, educational software must receive financial support to evaluate the quality of educational software, which is developed by a private enterprise, and to purchase and use it if it is excellent educational software.

4.3 Teacher

First, in-service training about practice of educational software must be performed. In U.S., State of California performs a in-service training to raise practicable ability educationally in the second step, the level of teaching, of teacher training course[3]. In Korea, the school field also indicates problems of the existing training and requires the training of this level. To supplement problems of the existing training and change it for practical training, first, what part is considered to be the most difficult for teachers must be examined when they intended to use the educational software. And we must analyze hardware problems and software problems met in running educational software and must perform a training about countermeasures against these error conditions to teachers. Especially, we must improve the ability of educational software selection as we let them evaluate educational software and let them apply it on a class during in-service training course.

Second, we must give study time of teaching materials to teacher for utilizing educational software as aiming at efficiency of work by arranging school management and administrative structure. And on the basis of studied contents, we must make a mood to study teaching materials for teacher by giving advantages such as allowance and promotion marks to teacher who carries out developmental class.

4.4 School Support System

In our country now, policies applied on education are made by policy investigators after examination of various facts and then are instructed collectively. To be sure, they provide results of study to the other school by study exemplary school, but practical results of study are not gained due to the lack of source of revenues and manpower. It is also applied in suggesting efficient settlement plan about educational software. To settle these problems, the study composed by following 4 steps must be performed continuously.

First, investigate facts indicated as problems in the school field concentratedly. Second, understand practical problems by analyzing investigated contents. Third, prepare settlement plans for practical problems. Fourth, apply this on the system.

4.5 Reorganization of Curriculum

Great vast digitalized data are being produced due to the development of ICT and the acquisition is possible easily. If students want and try, they can utilize base environment, which has already been prepared, to be able to acquire great information than teachers. Under these environments, it is required to learn method and experience to produce valuable information by utilizing knowledge than committing to memory of knowledge simply. This shows that it is required to reconsider what we teach in the school field. But as current curriculum is knowledge-centered curriculum and ICT is accessed with only simple support level for progress of class, difficulties of teachers have been added a load. Therefore, to aim at efficiency of practical education, curriculum must be reorganized for integrating ICT into education. This means that ICT must not play only a supporting role of education but be a base of education[4].

5 Conclusion

As modern society became informationalization society and knowledge based society, the amount of information increases rapidly and its life is short. Students must live in these society conditions and school must grow society adaptability of students. Currently computer is discussed on the same level of reading,

writing, speaking. In these flow, the importance of educational software has increased. Utilization of educational software enables not only to progress efficient class but also to extend ICT applicable ability of students. But the utilization of educational software is greatly lower than necessity of educational software. To settle this problem, it is required of curriculum and teaching method met with information society and ICT must be not supporting means of education but a base of education. And, first of all, an important thing is field teachers. Systematic support is required to utilize educational software for field teachers and effort of teacher itself is required.

References

[1] Lee Tae-wuk., "Study about Efficiency Plan of Development · Distribution · Utilization of educational software", Education policy study. Ministry of Education(1999).

[2] Jung Taek-hee et al., "Study about quality management plan of educational software", Study report RR 90-18. Seoul: Korean Educational Development Institute(1990).

[3] Technology-Based Performance Standards For Educators, http://ctap.k12.ca.us/grants/teachstds.html (accessed on August 14, 2000).

[4] Davjd F. Salisbury, "Toward a New Generation of Schools:The Florida Schoolyear2000 Initiative", Educational Technology. July. P. 7, (1992).

The web of the Teacher Professional Development

Hsu, chia-ling*,She Hsiao – Ching, and Lin,Min-Sheng*****
**Tamkang University clhsu@mail.tku.edu.tw*
***National Chiao-Tang University sheposei@ms14.hinet.net*
****National Taipei University of Technology mslin@ee.ntut.edu.tw*

1 Introduction

The education reform is one of the main issues in Taiwan. It provides an opportunity for the universities to open a teacher education program. In teacher education program, it emphasis on pre-servise, internship, and in-servise teacher training. Therefore, the lifelong learning and teacher professional development become very important for teachers. In, addition, the Department of education in Taiwan listed the lifelong learning as one of the main objectives since 1986. The government also declared the year of 1997 as the lifelong learning year (Yang, 1996). Hence, the result of this study, the TPD web site, is to enrich the lifelong learning environment for teachers to improve their professional knowledge.

Today is an age of information. The computer and Internet are changing our daily life. These new communication technologies will replace the traditional communication technologies (Hsu & Hsu, 1998). The traditional computer education emphasized the tutoring function. Although the CAI provides the learner control and independent study, it is lack of the opportunity to the students to explore their learning and to experience the discovering the results. On the other hand, the Internet connects all computers and all the information to be a big information sharing system. Moreover, people who are using Internet in education can learn the lesson in anytime at anyplace with any kind of computer system. The Internet changes the learning style from the physical, aerial, closed system into a virtual, long-distant, and opened learning environment. The resoult of this study is a teacher professional development website system. There is information for the pre-education students, for the interns, and for the in-servise teachers.

One of he main characters in the information society is changing quickly. Teachers are asked to improve their teaching knowledge and skills while they are studying in the teacher education program, or practicing their teaching skill in the internship training, or attending workshop in their daily teaching job. The process of the teacher professional development begins from the pre-servise education, and then into the internship education, and finally the education for the in-servise teachers(chang & Hsu, 1996). In the pre-servise education, students start to study a set of the education professional knowledge, and start to form their attitute, education vision, and education commitment in order to develop the special characters of the educator for these students (Jaoun, 1984). The teacher education program contains the teaching theory-based courses, the teaching method-based courses, and the teaching internship-based courses (Yang, 2000). During the teaching internship program, the students learn with the in-servise teacher and the professor. The students get into the school system to learn all kinds of the knowledge and skills in school based environment (chen, 1995). For the in-servise teachers, though, they are accumilating lots of teachiing experence, they need to reflash their teaching knowledge and skills (Lee, 1996). Therefore, for those in-servise teacher with different kinds of teaching needs, the education program should consider the teachers needs and encourage them to work togather to help each other in order to meet their teaching needs (Moursuond, Bielefeldt & Underwood, 1997). Hence, this study is based on the theory of the teacher professional development to development a virtural communication environment for teachers in order to achieve the goal of the teacher professional development.

The TPD web site will provide the information for all kinds of teachers. There are two purposes of this study. One of the puropose of this study is to enrich the literature of the teacher professional development. The other purpose of this paper is to build up a network-learning environment for those who are in pre-teacher program, internship, and on job training to improve their professional ability.

2 Conclusions

The result of this study is to build up a teacher professional development web site(http://www.tep.tku.edu.tw/3ic). It contains pre-servise education program courses, the information for the internship teachers, and the lifelong infromatioin for the in-servise teachers. There is a virtural classroom to provide the teaching manegement function to teachers. In addition, it contains the communiction function to various of teachers by using disscussion groups or BBS. The function of the questionnare is to provide a tool for action research. When teachers use this function to create the questionnare and send it by e-mail or web, the system will collect and analysis the data.

This study is based on the theory of the teacher professional development to develop a web site. The result of this study is not only to build up a teacher professional development web site but also to enrich the literature of the co-operative learning model. By developing this virtural lifelong learning web system, the future studies on the co-operation between different kinds of teachers are needed.

3 References

Hsu, F. C. & Hsu, C. L.(1998). The behavior for Media choice in Taiwan. Proceeding of the International Information Management Conferrence. pp.469-479.

Chang, Y. F. & Hsu, C. L.(1998). System Development for Teacher Professional Development, *Instructional technology & media*, No. 40, pp.3-11

Yan, K. S.(1998). Lifelong Education Policy and Strategy in Taiwan. Paper present at Educational Technology and Lifelong Learning.

Joan, C. W.(1996). Teacher Professional Development –Theory and Practice. Taipei. Wu-nan.

Chen, M. Y.(1997). Teacher Profession-Teaching Concept and Practice. Kaochun. Li-wen

Moursund, D., Bielefeldt, T., & Underwood, S. (1997). Computer Technology and Professional Development: Suggestions for schools. Http://www.iste.org/Resources/Projects/RoadAhead/Pd.html

Using Learning Object Meta-data in a Database of Primary and Secondary School Resources

Daniel D. Suthers
Department of Information and Computer Sciences
University of Hawai'i at Manoa
1680 East West Road, POST 303A, Honolulu, HI 96822 USA
Tel: 1-808-956-3890
Email: suthers@hawaii.edu

The Learning Object Meta-data (LOM) is an emerging standard for annotation of educational entities (digital or nondigital) that are relevant to technology-supported learning. The annotations describe educational, legal, and technical characteristics of these resources. The IEEE Learning Technology Standards Committee sponsors development of this standard. In this paper we describe an application of the LOM to the construction of a database of resources available to schools in Hawai'i, and report on both successes and issues encountered. Recommendations are made concerning modifications to the LOM and adoption of the LOM by others working in primary and secondary school contexts.

Keywords: **Standards, Meta-data, Resource Databases**

1 Introduction

Internet technology for learning, including web-based resources, networked groupware and remote sensing have the potential to bring teachers and students together with a greater diversity and quantity of human, natural and technological resources than was previously possible. Educators and students can now access an enormous variety of web-based expository materials, images, activity plans, simulations, etc., and interact with people from many walks of life over the Internet. Already pressed for time, how will educators sort through this cornucopia of information and misinformation and find the resources appropriate for the educational needs of their students? Clearly, in order to leverage the great potential of this de-facto worldwide digital library, educators will need help. This paper is concerned with one form of help: databases of *meta-data* or information that describes the relevant characteristics of educational resources sometimes called *learning objects*. Properly constructed meta-data databases that have interfaces designed to match educator's perspectives should enable them to find relevant learning objects more quickly.

There are two other factors that also motivate this work. In the United States, there is currently a strong emphasis on systemic reform in public school education at the primary and secondary school levels. Being *systemic*, this movement is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. For example, the Educational System Reform (http://www.ehr.nsf.gov/EHR/ESR/) division of the US National Science Foundation requires that proposals for funding show evidence of significant collaborations between schools, universities and colleges, business and industry, and other community members in genuine support of sustainable reform (i.e., reform that continues beyond the funded period). As a result, organizations and individuals who have not previously worked together need to become aware of the resources they offer to each other. Hence databases of resources that are tailored for particular locations are needed. The present work is one example of such a database.

A third motivating factor is economic. The cost of building educational materials, particularly technology-supported materials such as software, is high. All too often, persons and groups who are intellectually prepared to develop innovative new approaches to the application of technology to education spend most of their time rebuilding basic functionality. Recent interest in educational object repositories and educational

technology standards is motivated in large part by the desire to be able to find and reuse the work of others. Standards are being developed to describe learning objects [5] and to facilitate the interoperability of these objects once they are found [3]. This work is concerned primarily with standards for describing learning objects so that they may be found. Software interoperability has been addressed elsewhere (e.g., [2, 6]). Standards for describing learning objects also address economic issues surrounding resource databases because databases are expensive to build. Rather than replicate existing meta-data, it is preferable to access existing meta-data repositories. However, this requires standard forms for meta-data.

In summary, these forces require educators and their partners to be aware of the diversity of resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. Resource databases should adequately describe a diverse variety of resources yet relate them all to common educational objectives, describe the resources in terms understandable to educators, and interoperate with other major repositories. In this paper we report on our first efforts to design such a resource database to meet these needs within the State of Hawai'i as part of a systemic initiative known as Hawai'i Networked Learning Communities. Specifically we report on our use of an emerging standard, the Learning Object Meta-data (LOM). The paper provides a brief introduction to the LOM, describes its application to HNLC, and discusses limitations and extensions to the LOM that were required. Finally, readers are provided with information on how to participate in the development of the LOM.

2 Background

2.1 Learning Object Meta-data

Meta-data, simply defined, is data about data [4, 7]. Meta-data defines the characteristics of other data so that it may be interpreted and used intelligently. In this sense meta-data enables us to use data as *information*. The phrase *learning object* is used to inclusively denote a wide variety of entities used to support learning, including but not limited to digital resources such as software, multimedia, or hypertext, and nondigital resources such as courses of study, professional development programs, or persons who have volunteered to serve as mentors. Assembling these concepts, we come to *learning object meta-data*, which is somewhat of a misnomer in that the meta-data is not only describing data, but also other entities that are not data (such as persons). Yet the term "meta-data" is already in wide use for this purpose, so will be used herein.

2.2 Technical Standards

A *technical standard* is a specification of shared terms, interfaces, representations, practices, etc. If an artifact (such as computer or networking hardware, a software program, or data representations) is constructed to be compliant with a technical standard, then that standard ensures that multiple stakeholders will be able to interpret or interface with that artifact without needing to ask for help from the creator of the artifact. That is, a standard helps ensure interoperability and reuse. A standard is expressed in a document that sets forth the scope and purpose of the standard and the mandatory conditions for compliance. The existence of a standard, e.g., for learning technologies, does not mean that everyone is expected to comply with the standard. It only sets forth the conditions for those who elect to claim compliance with the standard.

2.3 The IEEE LTSC Learning Object Meta-data

The IEEE (Institute of Electrical and Electronics Engineers, http://www.ieee.org/) is an international organization for engineers of electrical and information technologies. IEEE has a well-defined standards development process administered by its Standards Activity Board (http://www.computer.org/standards/). The Learning Technology Standards Committee (LTSC), which was founded in 1996 by a group of academic, government, and industry representatives (including the author), chose to use the IEEE standards process for this reason. The LTSC sponsors several learning technology related standards efforts, at various levels of maturity ranging from speculative to approaching balloting. The Learning Object Meta-data draft standard [1] (also known by its IEEE identifier as 1484.12) is arguably the most mature of the LTSC draft standards. According to a recently circulated revision to the Project Authorization Request, "The purpose of this standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors. The purpose is also to facilitate the sharing and exchange of learning objects, by enabling the development of catalogs and inventories, taking into account the diversity of cultural and lingual contexts in which the learning objects and their meta-data will be exploited."

The LOM standard is meant to provide a semantic model for describing properties of the learning objects themselves, rather than detailing ways in which these learning objects may be used to support learning. The LOM indicates the legal values and informal semantics of the meta-data elements, their dependencies on each other, and how they are composed into a larger structure. It is intended to be extended, and in fact a structure has been provided specifically for the purpose. The LOM is agnostic concerning *bindings* or implementations of meta-data in particular representations or notations, such as XML. (At this writing, a study group is exploring a separate XML binding specification.) No particular representation or implementation is specified or implied by the LOM. Systems that are LOM compliant may present users with any interface they wish and store the meta-data however they wish. The LOM specifies only the semantics of the meta-data in order to enable meaningful interchange of meta-data between systems.

An outline of the LOM meta-data elements as of draft 4.1 [1] is provided in Table 1. In this table, nesting indicates a compositional relationship. For example (adopting notation commonly used in the LOM committee), a single 1.3:Catalog.Entry consists of a 1.3.1:Catalogue and an 1.3.2:Entry; while a 9:Classification consists of several types of sub-elements, some of which themselves also have internal structure. Much important information has been left out of this table for space considerations. For example, some data elements may take on multiple values which may be ordered or unordered, and some must be taken from restricted vocabularies or reference other standards for their values.

Table 1 Outline of Learning Object Meta-data Elements

1 **General**	4.5 Installation Remarks
1.1 Identifier	4.6 Other Platform Requirements
1.2 Title	4.7 Duration
1.3 CatalogEntry	5 **Educational**
1.3.1 Catalogue	5.1 Interactivity Type
1.3.2 Entry	5.2 Learning Resource Type
1.4 Language	5.3 Interactivity Level
1.5 Description	5.4 Semantic Density
1.6 Keywords	5.5 Intended end user role
1.7 Coverage	5.6 Context
1.8 Structure	5.7 Typical Age Range
1.9 Aggregation Level	5.8 Difficulty
2 **LifeCycle**	5.9 Typical Learning Time
2.1 Version	5.10Description
2.2 Status	5.11Language
2.3 Contribute	6 **Rights**
2.3.1 Role	6.1 Cost
2.3.2 Entity	6.2 Copyright and Other Restrictions
2.3.3 Date	6.3 Description
3 **MetaMeta-data**	7 **Relation**
3.1 Identifier	7.1 Kind
3.2 Catalog Entry	7.2 Resource
3.2.1 Catalogue	7.2.1 Identifier
3.2.2 Entry	7.2.2 Description
3.3 Contribute	7.2.3 CatalogEntry
3.3.1 Role	8 **Annotation**
3.3.2 Entity	8.1 Person
3.3.3 Date	8.2 Date
3.4 Meta-data Scheme	8.3 Description
3.5 Language	9 **Classification**
4 **Technical**	9.1 Purpose
4.1 Format	9.2 TaxonPath
4.2 Size	9.2.1 Source
4.3 Location	9.2.2 Taxon
4.4 Requirements	9.2.2.1 Id
4.4.1 Type	9.2.2.2 Entry
4.4.2 Name	9.3 Description
4.4.3 Minimum Version	9.4 Keywords
4.4.4 Maximum Version	

Brief descriptions of the major element categories follow. *1:General* provides information such as title, a brief textual description, and keywords. *2:Life.Cycle* describes the development and current state of the resource. *3:Metameta.Data* describes the meta-data itself, e.g., who entered or validated this meta-data instance and what language it is written in. *4:Technical* provides information on media type, size, software requirements, etc. for those learning objects to which these attributes apply. *5:Educational* is intended to provide basic information about the pedagogical characteristics of the resource. This category includes some of the most controversial elements, to be discussed further below. *6:Rights* describes the conditions under which one may acquire and use the learning object. *7:Relation* is intended to describe the learning object in relation to other learning objects. At this writing there is a controversy concerning whether this may be used to control sequencing of a collection of learning objects, or whether that should be deferred to other standards being developed for the purpose. *8:Annotation* allows for the accumulation of comments by persons who have used or are otherwise evaluating the learning object. *9:Classification* provides a means of extending the LOM to meet specialized needs. 9:Classification comes in the form of a generic structure for classifying the learning object in one or more taxonomic systems external to the LOM. Most of our extensions used 9:Classification.

3 HNLC Resource Database

The remainder of this paper describes our first prototype design and implementation of a learning object resource database, specifically focusing on the use of the LOM as a guiding framework for the design, and on ways in which extensions to the LOM were required. I briefly describe the initiative that this database was intended to serve before discussing the application of the LOM itself.

3.1 Hawai'i Networked Learning Communities

The Hawai'i Networked Learning Communities (HNLC, http://lilt.ics.hawaii.edu/hnlc/) initiative is a partnership between the Hawai'i Department of Education (HDOE), the University of Hawai'i, and many other stakeholders in the quality of Hawai'i public education, such as business and nonprofit interests. HNLC's purpose is to prepare all students in Hawai'i's public schools for life and careers in today's world by enabling them to attain high standards in science, math, engineering and technology (SMET) education. The HNLC initiative is supporting HDOE in its systemic standards-based reform efforts by leveraging Hawai'i's rich land, sea, space, and cultural resources. A theme of "global environmental studies, situated locally" pervades the work. From the standpoint of technology-supported learning, HNLC has three major thrusts. First, professional development will help educators make better use of technologies as educational resources in their classrooms. Second, distance collaboration and remote sensing technology will bridge the distances between small rural schools and the islands' rich resources, enabling virtual access to field sites, research laboratories or equipment, and, most importantly, peers and mentors of students, teachers and others involved in the educational process. Third, a web-accessible database will address one of the most frequent requests encountered during our needs assessment: knowing what resources are available to educators in Hawai'i. This paper is about the suitability of the LOM for this database.

3.2 Scope of the Database

The database describes resources for public school education ranging from Kindergarten (K) to 12th grade, also abbreviated as K-12. Standards-based reform is essential to the initiative: hence all resources must be described with respect to the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/), a document specifying what should be taught and how students' learning should be assessed. A wide variety of resources will be described, making this a particularly challenging test implementation of the LOM. For example, the following resources might be included:

- A university program in which Ph.D. students have their expenses paid in exchange for mentoring teachers for a certain number of hours a month. This can take place over the Internet; ideally, the teacher's students become involved in field report in support of the Ph.D. thesis.
- Nationally recognized curricular resources developed at the University's Curriculum Research and Development Group (http://www.hawaii.edu/crdg/).
- A software program with which students can construct explicit visual models of their evidential reasoning while participating in investigations (http://lilt.ics.hawaii.edu/belvedere/index.html).
- A network of autonomous weather stations and remote controlled cameras, to be placed in the Alaka'i swamp (one of the rainiest place on Earth) or Volcano National Park, in some cases with the cameras

trained on individuals of endangered plant species, with radio links to the Internet (http://www.botany.hawaii.edu/pods/).

- A nurse practitioner at a local military hospital who volunteered her time to telementor students on medical topics.
- Malama Hawai'i, a new environmental education project started by the famed Polynesian voyager Nainoa Thompson (http://www.malamahawaii.org/).
- Advanced placement courses in computer science and discrete math, offered by our department to high school students via Hawai'i DOE's Internet-based E-School (http://atr.k12.hi.us/eschool/index.shtml).
- The He'eia Ahupua'a, in which researchers and school children collaborate to study the integration of modern and traditional Hawai'ian land management techniques (Internet collaboration and mentoring is being planned: http://kauila.k12.hi.us/~ahupuaa/).
- A Community College's research grade 24" telescopes, recently displaced from Haleakala by larger telescopes and now being installed for Web-accessible use at the CC. The telescopes are still viable for new asteroid, comet and supernova survey research that can be conducted by high school students over the web, being supervised by college students and their professional mentors.
- Diverse resources for teaching constructed by teachers and made available to others as part of a new product-oriented approach to professional development credits being implemented by HDOE.

All of these fall within LOM's scope of "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (from the original Project Authorization Request, http://ltsc.ieee.org/par-lo.htm) because we will be using distance collaboration and remote sensing technology (as well as the database itself) to support learning using these resources. To control the scope of our work, HNLC will prioritize the description of local resources and interface with other repositories for nationally available resources (e.g., GEM).

4 HNLC LOM Meta-data

In designing the meta-data for resources such as those listed above, we found it necessary to extend the LOM. As previously noted, the LOM was designed to be extended. In some cases the predefined LOM elements were adequate, and in other cases we were able to perform the desired extensions using the LOM 9:Classification facility. However in a few cases it was necessary to extend restricted vocabularies (which is not normally allowed), and in other cases structural issues arose. In this section I describe the most significant extensions, including the issues just mentioned.

4.1 Method

Our team consisted of Susan Johnson and Beth Tillinghast (Library and Information Science students), Laura Girardeau (an Environmental Education graduate), and David Nickles (a Computer Science graduate).

Initially Johnson and Tillinghast wrote informal textual descriptions capturing the important information about a representative sample of the resources that we wanted to describe. After reviewing these descriptions I presented the LOM draft 4.1 [1] to the entire team, which required extensive discussions for clarification. We then went through the textual descriptions and identified LOM elements in which the information expressed could be captured. Where we failed to find LOM elements for an item of information we extended the LOM, either by expanding on the vocabulary of an existing element or by creating an entirely new element under 9:Classification.Where new elements were needed we searched other repositories to find meta-data that we could use. Several iterations were required to understand the LOM structure well enough to define our instances of 9:Classification. (It should be noted that end users are not expected to understand the LOM: the LTSC community expects that suitable interfaces will be developed, and no end user will even need to know that the LOM exists. We were approaching the LOM as information professionals, not end users.) Then Nickles created a Filemaker implementation of the resulting HNLC-LOM and provided the others with an interface for building meta-data (Figure 1). Johnson and Tillinghast then created meta-data for our sample. I then reviewed the result to detect possible misunderstandings and issues. I also compiled a first draft of issues and recommendations. This draft was shared with the LTSC LOM committee, both via email and subsequently face to face in an LTSC meeting (Montreal, June 2000). Thanks to their feedback, many issues were resolved or re-understood as non-issues, and many further clarifications resulted.

4.2 Vocabularies

The data type of LOM elements may be primitive (e.g., a string), reference other standards (e.g., vCard), or consist of a controlled vocabulary. In the latter case, the vocabulary may be restricted, meaning that only the terms listed may be used, or open with recommended practice, meaning that one should attempt to use one of the terms listed as the recommended practice but may extend this vocabulary if needed. One extends the vocabulary by using a tuple of form (See_Classification, *term*). The *term* is the new term being added to the vocabulary. One must define an instance of 9:Classification that has the same 9.1:Purpose as the data element being extended, and define a 9.2:Taxon.Path as needed to indicate where the term falls within the taxonomic system indicated by 9.2.1:Source. (A taxon path can be thought of as a sequence of taxons, which begins at the root of a taxonomic hierarchy and works its way down the tree through intermediate nodes to the leaf node under which the object is being classified.)

For example, suppose one wants to extend 5.2:Learning.Resource.Type with the term "Curriculum" taken from the Gateway to Educational Materials (GEM) Resource Type vocabulary, (http://www.geminfo.org/Workbench/Metadata/Vocab_Type.html).
One would place the tuple (See_Classification, "Curriculum") in the 5.2 location, and then construct an instance of 9:Classification with 9.1:Purpose = Learning.Resource.Type, a single 9.2:Taxon.Path with 9.2.1:Source = "GEM Resource Type," and a single 9.2.2:Taxon with 9.2.2.2: Entry = "Curriculum" (there is no ID available).

Although this seems much more awkward than simply using the term "Curriculum" in the 5.2:Learning.Resource.Type field, two points should be kept in mind. First, it is a powerful general-purpose way of extending vocabularies with information about the taxonomic source of the term, and hence its semantics. If we were to simply add a termto 5.2:Learning.Resource.Type its semantics would be inaccessible, as there would be no place to record where the term came from. Second, the LOM information structures are neither specifications of an implementation nor specifications of a user interface: implementations are free to reorgainze the presentation of information to the user as convenient (e.g., to present extensions to vocabularies *as if* they were simply added to the same field in question).

We found several of the LOM vocabularies for 5:Educational to be insufficient for our purposes. In one case, 5.2:Learning Resource Type, the vocabulary was open and the insufficiencies could be addressed via the extension mechanism just described. However, vocabularies for 5.1:Interactivity.Type (values: Active, Expositive. Mixed, or Undefined) and 5.5:Intended.End.User.Role (Teacher, Author, Learner, Manager) are restricted vocabularies, so cannot be extended in this way. We have made the recommendation that these be changed to open vocabularies until better consensus on an adequate term set can be obtained with the help of the various communities expected to be using the LOM.

4.3 Structural Issues

In some cases we felt that the vocabulary should be replaced with a structured description. This was actually the case for 5.1:Interactivity.Type and 5.5:Intended.End.User.Role (see next section), as well as 5.7:Typical.Age.Range. Concerning the latter, K-12 educational resources in the United States are almost always referenced by grade level rather than age range. Other applications may require other measures. Anticipating the need for flexibility, we recommended that 5.7:Typical.Age.Range be changed to a structured element with 5.7.1 Measure (e.g., "Chronological Age," "GEM Grade," etc.) and 5.7.2:Value (e.g., "12," "7-8," etc.).

More problematic are ways in which the value of one element depends on another. We noted that 5.9:Typical.Learning.Time depends on 5.7:Typical.Age.Range, for example, a textbook might be described as suitable for a fast paced graduate course or a two-semester undergraduate sequence. Erik Duval later pointed out that this applies to 5.4:Semantic.Density and 5.8:Difficulty as well. Hence I recommended reorganizing these elements in a manner such as the following:

5.x Challenge Level, consisting of one or more 4-tuples:
- 5.x.1 Educational Level (formerly 5.7), consisting of one or more pairs:
  - 5.x.1.1 Measure (e.g., Age, US Grade, ...)
  - 5.x.1.2 Value (e.g., 7-8)
- 5.x.2 Semantic Density (formerly 5.4)
- 5.x.3 Difficulty (formerly 5.8)
- 5.x.4 Learning Time (formerly 5.9)

Then one could create multiple instances of 5.x: Challenge.Level, with the values of 5.x.2 through 5.x.4 being dependent on the value of 5.x.1:Educational.Level. It is possible to *implicitly* achieve the same effect by replicating entire LOM metadata instances, one for each developmental level (or age); but we feel that it would be far more perspicuous and efficient to acknowledge the dependency explicitly in a structure such as the above.

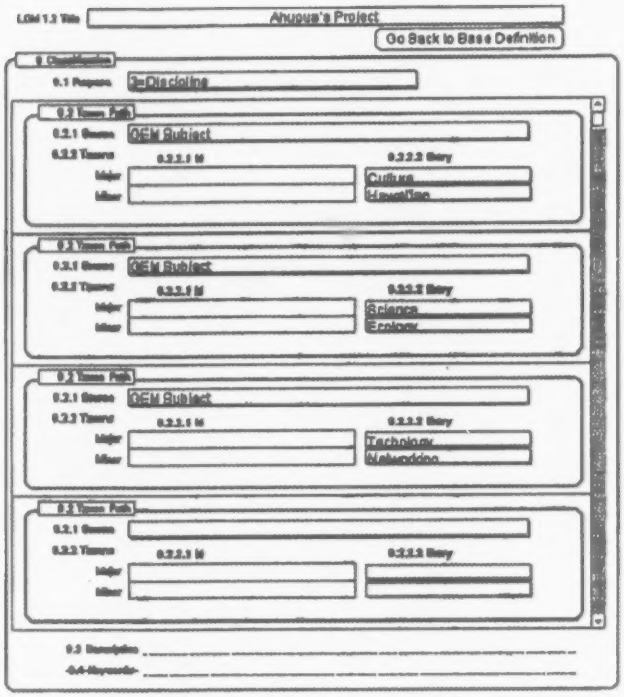


Figure 1. Prototype HNLC Resource Database: a Discipline classification

4.4 Our Extensions to the LOM

The following extensions were made using 9:Classification.

4.4.1 Audience

This extension effectively replaces 5.5:Intended.End.User.Role with the GEM Audience (http://www.geminfo.org/Workbench/Metadata/Vocab_Audience.html), a two-part classification consisting of ToolFor (who uses the tool) and Beneficiary (who benefits). For example, a professional development resource that helps teachers handle learning disabled children in their classes is for the teacher but benefits the particular population of learning disabled students. We would prefer that 5.5: Intended.User.Role be modified to be composed of 5.5.1:Tool.For and 5.5.2:Beneficiary.

4.4.2 Community Involvement

This extension describes how a resource interacts with various stakeholders. We are designing this classification ourselves. We are considering a two-part classification: One for the community entity involved, and the other for the type of involvement.

4.4.3 Discipline

This extension describes the subject matter area covered by the resource. There is presently no LOM field that does this (other than possibly 1.7:Coverage, which has limitations beyond the scope of this paper). We are using the GEM Subject. This is a two-level classification system, requiring a two-step Taxon Path, for example Science/ Astronomy. We found it necessary to add two first-level classifications to the GEM Subject: Technology and Culture. An example using these subjects is shown in Figure 1, a partial screen dump of our Filemaker prototype implementation. We also needed a way to indicate cross-curricular integration. For this we again elected to modify the GEM taxonomy by allowing any major level Subject

BEST COPY AVAILABLE

header to be listed as a minor header under the subject with which it is integrated. For example, Science/Mathematics would indicate that the resource integrates Mathematics into Science (since Mathematics is normally a Major taxon). For the GEM Subject controlled vocabulary see http://www.geminfo.org/Workbench/Metadata/Vocab_Subject.html.

4.4.4 Educational Level

This extension augments LOM 5.7:Typical.Age.Range, and is structured as described in the previous section.

4.4.5 Educational Objectives

This extension addresses content and performance standards. It is distinct from Discipline because it is more specific: it aligns the resource with the particular standards that the resource is intended to help achieve. Examples of national (US) content and performance Standards include America's Choice (http://www.ncee.org/ac/intro.html); NCTM standards for mathematics (National Council of Teachers of Mathematics, http://nctm.org/standards/); the NSES for science (National Science Education Standards, http://www.nap.edu/readingroom/books/nses/html/), and the National Educational Technology Standards (NETS http://cnets.iste.org/). An example of a state standard is the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/).

4.4.6 Pedagogy

This extension addresses the *severe* deficiency of the LOM's 5.1:Interactivity.Type, a closed vocabulary of {active, expositive, mixed, undefined}. We have recommended that the vocabulary for 5.1 be reopened. However our version provides an even richer description of interactivity, using the GEM Pedagogy controlled vocabulary. This vocabulary (http://www.geminfo.org/Workbench/Metadata/Vocab_Pedagogy.html) has three facets: Teaching Methods (GEM provides a large vocabulary), Grouping (individual, small group, large group, etc.), and Assessment (which is sometimes integrated into the pedagogy).

5 Conclusion

Internet technology for learning, including groupware and remote sensing, have the potential to bring teachers and students together with a greater diversity of human, natural and technological resources than was previously possible. Additionally, the current emphasis on systemic reform in public school education in the United States is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. These forces require that educators and their partners be aware of the resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. The HNLC Resource Database is being designed to meet such a need in the context of systemic standards-based reform in the state of Hawai'i. The demands on such a database are high: it should interoperate with other major repositories, adequately describe a diversity of resources, yet relate them all to common content and performance standards and generally describe the resources in terms understandable to educators. The LTSC's Learning Object Meta-data (LOM) is being developed in part to lay the foundations for meeting such needs. In this paper I described our attempt to use the LOM for the HNLC Resource Database. We found that it provides a solid foundation in the form of many well thought out data elements as well as a means for extension. We also found that the LOM does not address all the needs of the HNLC Resource Database. This cannot be expected as the LOM is being designed to serve a variety of applications in government and industry as well as public education. We were able to deal with most of the limitations through the Classification method of extension. However some of these extensions were due to premature closure of the LOM vocabularies. More problematic were structural dependencies between LOM elements that are not well captured at present. These issues were illustrated with examples from K-12 education.

The Learning Object Meta-data standard is under active development at this writing. It is hoped that this paper will help increase awareness within the primary/secondary education sector worldwide of the LOM standards effort, and encourage your contribution to further development of the standard to be more appropriate for primary/secondary education needs. Anyone may participate: see http://ltsc.ieee.org/ for details.

Acknowledgements

Thanks to Susan Marie Johnson, David Nickles and Beth Tillinghast for contributing to the design of the HNLC meta-data, David Nickles for implementing the first prototype of our resource database, and all of the above plus Laura Girardeau for constructing meta-data. Thanks to Erik Duval, Wayne Hodgins, Tom Murray, Brendon Towle, and Tom Wason for their "meta-comments" on my LOM commentary. This work was funded in part by a development grant from the National Science Foundation's Rural Systemic Initiative.

References

1. IEEE Std. 1484.12 (draft). Draft 4.1 of the Learning Objects Metadata (LOM), IEEE, Piscataway, N.J., USA, 2001. Available: http://ltsc.ieee.org/doc/wg12/LOM_WD4.htm
2. Koedinger, K., Suthers, D., and Forbus, K. (1999). Component-based Construction of a Science Learning Space. International Journal of Artificial Intelligence in Education (1999), 10, 292-313. (Also available at http://cbl.leeds.ac.uk/ijaied/home.html)
3. Miller, P. (2000). Interoperability: What is it and why should I want it?. Ariadne 24. Available: http://www.ariadne.ac.uk/issue24/interoperability/
4. Milstead, J. & Feldman, S. (1999a). Metadata: Cataloging by any other name. Online 23(1), 24-31. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html
5. Milstead, J. & Feldman, S. (1999b).Metadata: Projects & standards. Online 23(1), 32-40. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html#projects
6. Roschelle, J., DiGiano, C., Koutlis, M., Repenning, A., Phillips, J., Jackiw, N.,& Suthers, D. (1999). Developing educational software components. Computer, 32(9), pp. 50-58. Piscataway, NJ: IEEE Computer Society.
7. Wason, T. D. (unpublished). Dr. Tom's Meta-Data Primer. Available: http://www.imsproject.org/drtommeta.html

ICCE / ICCAI 2000

Learning Societies in the New Millennium : Creativity, Caring & Commitments

Proceedings

Content

Full & Short Papers (Policies, Ethics, Standards, and Legal Issues)

A Study on the School Information Technology Pilot Scheme: Possibilities of Creative and Lifelong Learning

Health risks with Computer Use in New Zealand Schools

Information technology competency for Hong Kong teachers-A New era and a new paradigam

Present State and Future Direction of Woman Informatization Education in Korea

Space Plan for Effective Educational Software Utilization in Korea

Using Learning Object Meta-data in a Database of Primary and Secondary School Resources

▲ HOME

A Study on the School Information Technology Pilot Scheme: Possibilities of Creative and Lifelong Learning

Siu-Cheung KONG*, Wing-Kee AU and Sai-Wing PUN*****
Department of Information & Applied Technology,
Hong Kong Institute of Education,
10, Lo Ping Road, Tai Po, N.T.,Hong Kong
**Phone: +(852)29487646, Fax:+(852)29487726, Email: sckong@ied.edu.hk*
***Phone: +(852)29487693, Fax:+(852)29487726, Email : wkau@ied.edu.hk*
****Phone: +(852)29487651, Fax:+(852)29487726, Email : swpun@ied.edu.hk*

The Hong Kong Special Administration Region (HKSAR) Government is promoting the use of Information Technology (IT) in education for creative and lifelong learning. A two-year IT-pilot scheme has been launched among 10 primary schools. The first phase of the current study had reported on the planning and implementation of the schools in the first year of the scheme. This paper reports findings from the second year. All 10 primary schools are studied by a case-study approach. This phase aims to investigate the effect of using IT in learning and teaching. Data were collected via browsing web sites, visits and interviews. The research results show that some schools are optimizing students' opportunities for accessing the computing and networking capabilities. Acquiring a LCD projector in each general classroom is an important part of the IT infrastructure for promoting the use of IT in schools. All schools are motivating teachers to use IT to improve the traditional mode of learning and teaching by developing multimedia-teaching unit. Schools need to develop teachers' sense of harnessing technology for rethinking and redesigning educational practice through staff development. It is speculated that school policy plays a crucial role in promoting the paradigm of creative and lifelong learning.

Keywords: **IT in education, lifelong learning, school policy**

1 Introduction

Within the nine-year compulsory education system in Hong Kong, students have to learn in large groups with very few choices of school curriculum. Teachers have to teach more or less the same subject knowledge specified in the formal curriculum and approved textbooks. Chances for learners to keep in contact with the real life experiences were limited. Cheng [1] points out that this kind of learning from traditional school experience is an isolated mode of learning. Perelman [2] further argues that such kind of educational management operated by the government is similar to the socialism planning economy mode of operation. It can be surmised that curricular contents and instructional methods that are structured and rigid do not really cater for the needs of learners in the information era. These arguments indicate that the traditional school education system is seriously "disconnected" from the information society. Contents learnt from school education can rarely be used in real life. In this context, the Hong Kong Special Administration Region (HKSAR) government is promoting the use of Information Technology (IT) in education for creative and lifelong learning to cope with the rapid changes in contemporary society [3, 4, 5, 6]. A document on the reform proposals of the education system review of the HKSAR government stated its vision as follow:

Students are the focus of the whole education reform. **The basic premise is to enable every individual to pursue all-round development through lifelong learning.** ... However, in tandem with changes taking place in the community, our students' learning needs have also changed. It is essential or our education system, including its academic structure, content and modalities, to be duly adjusted in response to these changes [6,

p.4].

A two-year IT-pilot scheme was launched in September 1998 for 10 primary schools and 10 secondary schools. These pilot primary schools, with the support of US$480 000 from the government, were expected to experiment with integrating IT in learning and teaching with a resultant change in the paradigm of learning and teaching which may empower both the learners and the teachers. A study on the planning and implementation of the first year of the scheme in nine primary pilot schools was conducted by using a case-study approach and the results were reported [7, 8]. This paper reports the second phase of this study. During the second-phase study, the research team revisited the schools and aimed at investigating the changes in the mode of learning and teaching of the pilot schools experienced in the second year of the scheme after the implementation of the IT infrastructures in the first year of the scheme.

There are various kinds of models, which attempt to conceptualise the integration of technology into learning and teaching, for example, the Concern-Based Adoption Model (CBAM), the Planning Process Models (PPM) and the Technology Maturity Model (TMM) [9, 10, 11]. CBAM serve as a diagnostic tool for the technology integration planning and implementation by studying the stages of concerns of the planners. CBAM considers developing items in different stages of the integration plan. It better suits longitudinal research. PPM provides general guidelines on the planning process that emphasizes on establishing a comprehensive administrative framework for the technology integration plans and the planning must address the local situation. PPM is especially designed for setting up a well-organized administrative structure and ensuring the implementation of the plan. PPM focuses on the study of a particular school. TMM mainly evaluates the depth of integration of IT with education through observation, such as school planning and implementation of IT in learning and teaching. It also concerns the daily use of IT in school and studies the effectiveness. TMM is appropriate for the study of the implementation of IT in education of several schools for identifying favourable factors or obstacles.

The framework of this study is derived from the guidelines of TMM. Five main items of the model are selected for detailed study. They are student use, teacher use, curriculum integration, staff development, and school policy. This research will report on the daily use of IT in learning and teaching and will discuss the effectiveness of integration. IT in education is developing at its initial stage in Hong Kong. Schools have limited experiences on integrating IT in education. The experiences of pilot schools can be a useful reference for most of the schools intending to integrate IT into learning and teaching. The findings of the study will be important for promoting the use of IT for creative and lifelong learning in Hong Kong.

2 Research Question

The first phase of the study had reported on the planning and implementation issues in the first year of the scheme. Nine pilot primary schools were studied. This study is the second phase of the research and all 10 IT pilot primary schools participates. During this phase, the research team re-visited the nine schools and also visited the one missed in the first phase. The aim of the study is to further investigate the pilot schools' use of IT and to obtain an in-depth knowledge profile of the schools' integration of IT into the curriculum. The core research question of the study is to investigate the changes introduced by the use of IT in learning and teaching with particular reference to the five selected items in the framework of the study [12, 13]. In this regard, two subsidiary research questions are explored.

1. How does IT improve the traditional learning and teaching paradigm?
2. How learning can be enhanced for the emerging paradigm of creative and lifelong learning in the information era when learners are empowered by IT?

3 Research Methodology

A case-study approach was adopted in this research in order to obtain the in-depth profile of the pilot schools relating to the implementation of IT in education [14]. Data were collected via browsing school web sites; school visits and interviews. Table 1 shows the web sites of all pilot primary schools in Hong Kong.

Table 1: Web sites of all pilot primary schools in Hong Kong and number of visitors as at the 16, May 2000

URL	Visitors	URL	Visitors
http://www.buddhist-wingyan-sch.edu	No counter	http://kws.hkcampus.net/	No counter

.hk/			
http://bwcss.school.net.hk/	40200	http://www.lkw.edu.hk/	1951
http://am.npgps.edu.hk/	No counter	http://www.tpomps.edu.hk/	123453
http://plklht.school.net.hk/	72984	http://www.ychchtps.edu.hk/	No counter
http://www.pm.plkhsn.edu.hk/	28126	http://www.skhsjs.edu.hk/	No counter

Samples of lessons plans of teachers and students' work were also collected [15]. These data were organised and interpreted according to the framework of the study. During the school visits, interviews and site visits to all IT facilities of the schools were conducted. The interviewees included school principals and IT coordinators. In all, ten school principals or deputy principals and five IT coordinators were interviewed.

4 Results and Discussions

The initial research result of this phase of study shows that schools are struggling for offering opportunities to students for creative and lifelong learning by different approaches. This section will report on the development or changes of the pilot schools observed in the second phase of the study on the five selected items. They are students' use of IT for learning, teachers' use of IT for teaching, integration of IT in the curriculum, staff development and school policy.

4.1 Students' Use

All ten pilot schools offered Computer Awareness Programme (CAP). This programme provided software operation skills and basic IT knowledge to students. Nine schools scheduled these programmes in regular lessons. One school infused the awareness programme contents in various subjects according to the nature of the content. For example, spreadsheet was taught in mathematics lessons and word processing and email were integrated in English lessons. Results of the first-phase study indicated most students in the pilot schools might access to the computers only once or twice a week in the computer awareness lessons [7, 8]. Students could use computers before or after school hours, recesses or lunch breaks but students' use was infrequent in the first phase. There is a change observed during the site visits of the second-phase study. Students had access freely to the computing and networking facilitates around the environment of some schools. Table 2 shows the location of free access to computing and networking facilities for students in the pilot schools. Schools with more free access locations for students are put towards the right-hand-side of the table.

Table 2: Location of free access to computing and networking facilities for students in pilot schools

Location of Access	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
Classroom Computers			✓				✓	✓	✓	✓
Computer Classrooms		✓		✓	✓	✓			✓	✓
Library Computers	✓			✓	✓		✓	✓	✓	✓
Corridor Computers						✓				✓

There were computers free to use in the general classrooms, computer classrooms, libraries and the corridors. According to the figures estimated from the pilot schools, the home computing access rate ranged from 30 to 60 percent. Therefore free access of computing and networking facilities become an important tool to achieve equity and to promote a school culture of using IT to learn and teach. On average, there were 1.8 computer classrooms in the ten pilot schools. Sixty percent of the schools arrange their computer rooms for students' access besides scheduled classes. Seventy percent of the schools provide 3 to 10 computers in the library for drop-in access. Half of the schools admitted students to use computers in general classrooms. The number of classroom computers ranged from 1 to 4. It was interesting to note that some pilot schools even allowed students to share the only classroom computer with the teachers. All pilot schools allowed students to explore freely on the World Wide Web (WWW) except some of them used filters to bar access to pornographic sites. It could be speculated from the site visits that optimising students' free access opportunities might provide a solid foundation for creative use of the computing and networking capabilities and hence might nourish skills and processes that could support learning as a lifetime habit [16].

4.2 Teachers' Use

A teacher may need to deliver curricular contents in the traditional paradigm of learning and teaching. A teacher may serve as a learner's counsellor, a coach and a facilitator who extends the intelligence of the students by helping them in the emerging paradigm of creative and lifelong learning in the information era [16]. No matter with which paradigm teachers are working, there are chances that learners and teachers need to share and communicate. The existing class structure as learning group requires support to facilitate such sharing and communication in the general classroom. There is preparation work for teachers to carry out their roles using the computing and networking facilities of general classroom.

Three kinds of technical installation modes were reported in the first phase of the study [7, 8]. They are: TV connection, fixed LCD, and mobile LCD. TV connection needs a TV connector to connect the classroom computer and the classroom TV for display. TV sets are standard equipments in general classrooms. Fixed LCD set up requires the setting up of a ceiling-mounted classroom LCD projector for projection but there is no set up work during routine use. Mobile LCD set up requires the transportation of LCD projector for on-site setting. Some schools provide desktop computer in general classroom while the other provide school notebook computers. Teacher needs to obtain both a projector and a computer to conduct class presentation in general classroom. Table 3 summarizes the number of schools by mode of projection preparation and by type of classroom computer.

Table 3: Number of schools by mode of projection preparation and by type of classroom computer

Type of Classroom Computer	TV Connection	Mobile LCD	Fixed LCD
Provide Notebook Computer for Classroom Use	1	3	1
Provide Classroom Desktop Computer	1	1	3

All schools in the pilot scheme provided computing and projection facilities for class use in general classrooms. Teachers could use the facilities to deliver teaching contents through the projection screens or TV sets. Teachers could also conduct interactive teaching by retrieving multimedia teaching units from the Intranet or browsing teaching resources from the Internet. Students could use the facilities to present their project work to their classmates and teachers.

Results of the first phase study indicated that teachers of the pilot schools used the IT facilities more frequently in their workplace for those schools installed ceiling-mounted digital projectors in general classrooms [7, 8]. The second-phase of the study confirmed this case and there was a further development of the trend. Although the cost of setting up a ceiling-mounted LCD projector was expensive, which costed around US$4000 per projector and set up, it was commented as worth for promoting the use of IT in learning and teaching. Teachers showed willingness to use the IT facilities in general classrooms when it was so convenient and easy to carry out their work by using these facilities in classrooms. Table 4 tabulates the findings of the current study on the planning, acquiring and existing distribution of LCD projectors of pilot schools.

Table 4: Planning, acquiring and existing distribution of LCD projectors of pilot schools

Distribution of LCD Projectors	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
a. Existing Projector per School Hall	0	1	1	1	1	1	N.A.	1	1	1
b. Existing Projector per Computer Classroom	1	1	1	1	1	1	1	1	1	1
c. Existing Projector per General Classroom	0.25	0.23	0.25	0.25	0.25	0.25	1	1	1	1
d. Existing TV Connector per General Classroom	1	0	0	0	0	1	0	0	0	0
e. Acquiring Projector per General Classroom					1	1				
f. Planning Projector per General Classroom		1	1							

Results of the study showed that eighty percent of the pilot schools installed LCD projectors in their school halls for large group sharing and presentation. All computer classrooms of the pilot schools possessed ceiling-mounted LCD projectors for instruction and class presentation. Forty percent of the pilot schools set up ceiling-mounted LCD projector in all general classrooms. The ratio of existing projector per general classroom was 1. The other six schools had such ratio ranged from 0.23 to 0.25. Two schools resolved the problem on classroom projection by using TV. However, one of the schools told the research team that ceiling-mounted projector would soon replace TV display because projector could provide better quality

display and the school had acquired sufficient funding for the replacement. For the other four schools, one of them acquired funding for updating the projector per classroom ratio to 1; two of them were planning for the updating but there was no funding at that moment; and another one of them was designing a rotational plan of the school timetable so that all classes could use the ceiling-mounted LCD projection for a certain day of the week. In other words, nearly all schools recognize that ceiling-mounted LCD projection was a necessary tool for presentation in classroom. This finding indicated that integrating IT into learning and teaching needed the support of the IT facilities and those issues such as their readiness, convenient to use and reliability must be addressed.

4.3 Integration of IT in Curriculum

All pilot schools attempted to integrate IT in school curriculum. Data collected from the first phase of the study indicated that there were three ways of curriculum integration. They were (1) interactive delivery of multimedia-teaching unit, (2) presentation of digital knowledge object, and (3) active learning. Interactive delivery of multimedia-teaching unit refers to the use of interactivity and multimedia capability of the computer to deliver units of curriculum contents. Teachers themselves develop most of the teaching units. The main aim of this type of integration is to improve the efficiency of teaching. Presentation of digital knowledge object means teachers present knowledge objects such as pictures, animations, or videos related to the curriculum to students. The main objective of this type of integration is to offer authentic stimuli facilitating class discussion. The third type of integration is to organize learners to learn actively when they are empowered with IT.

All teachers and school principals in the pilot schools showed a strong sense of developing multimedia-teaching unit for improving the traditional classroom learning and teaching activities. The general phenomenon is that there was a great demand on the multimedia-teaching units but the supply was scarce. This was the results of the study of the first phase. Data collected from interviews, site visits of classroom, browsing school websites and Intranets, teaching plans and sample work of students from the second phase of the study indicated that the three ways of curriculum integration were still dominant but the proportion of the three types of integration had changed and the ways to advocate active learning were extended. Active learning included not only project-based work but also learning-on-demand. Table 5 summarizes the three types of integration of IT in curriculum. Pilot schools practising project-based work is denoted by a letter "a" and learning-on-demand by a letter "b" in table 5.

Table 5: Types of Integration of IT in Curriculum

Types of Integration	School 1	School 2	School 3	School 4	School 5	School 6	School 7	School 8	School 9	School 10
Multimedia-Teaching Unit	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Digital Knowledge Object				✓	✓	✓	✓	✓	✓	✓
Active Learning				b	b	B	a, b	a, b	a, b	a, b

Results of the current study clearly indicated that developing multimedia-teaching units for improving traditional classroom teaching was still the dominant type of integration. However, there were some further developments. One of the pilot schools stated that they had developed all multimedia-teaching units for the traditional curriculum. This school planned to deliver one-third of the teaching units on its Intranet for students' self-directed learning. The other nine schools required teachers to participate the development by producing some teaching units. Most schools required teachers to develop two multimedia-teaching units in an academic year. One school started to assist teachers to develop web-based learning contents with feedback instead of developing multimedia-teaching units. Another school revised its plan of developing teaching unit by requesting teacher to design storyboard and provide digital knowledge objects. The implementation work would be handed over for commercial software vendors.

The percentage of pilot schools, using the computing and networking capabilities for presentation of digital knowledge objects, increased from twenty to seventy. There were at least two reasons. Firstly, digital knowledge objects could be collected relatively more easily than developing multimedia-teaching units. Presenting digital knowledge object may enhance the effectiveness of teaching. Interview results reflected that knowledge objects were particularly applicable to subjects like General Studies, Art, Music, Physical Education and Civil Education. Digital knowledge objects such as pictures, music and videos allow students to learn by simulation, and learn how to appreciate. They help students to act with sympathy, and may stimulate discussion and critical thinking.

The third type of integration increases even more. The ratio of pilot schools, adopting this type of integration, increased from less than ten percent to seventy percent. These schools encouraged and organized learners to learn actively with IT. There are two types of activities that advocate learners to learn actively. They were (a) project-based work, and (b) learning-on-demand. One of the prominent learner-centred activities was to organize learners to do project-based work. Learners empowered by IT could use tools such as the search engines and presentation software to collect data and present information. This type of integration may facilitate collaborative learning and can polish lifelong learning skills.

Schools found that a content-rich Intranet can encourage learning-on-demand learning. Teachers discovered that learners liked to revise those multimedia-teaching units used by teachers. Two schools provided digitised Educational TV programme on video server or VCD for students' free access. Students could access these learning resources on demand. During the school visits, it was observed that students began to access schools' Intranet to retrieve learning resources and teacher's multimedia teaching units. A variation of learning-on-demand type of activity is learning-on-demand with feedback. Learning-on-demand with feedback attracted learners to learn actively by providing immediate feedback. Two of the pilot schools installed virtual CD towers in their Intranets. Learners could access educational CD-ROMs by connecting to the school Intranets. These CD-ROM learning materials were attractive to students because feedbacks were usually provided and learning pace could be adjusted. Another pilot school developed web-based learning materials with feedback. It was speculated that feedbacks could motivate students to learn.

4.4 Staff Development

Results from the study of pilot schools in the first phase indicated that most schools were organising school-based training for developing teachers' competencies in using technology for learning and teaching. School-based staff development solved some problems like tailor-made training for teachers of the teaching environment. However, school-based staff development also limited the perspective of teachers on the potential of technology to improve only the traditional paradigm of learning and teaching. This argument is supported by the fact that all pilot schools regarded developing multimedia-teaching unit as a prominent part of integrating IT in school curriculum. It was observed that this was still the dominant approach in the second year of the IT pilot scheme. It could be inferred that most schools were adopting the gift-wrapped approach in promoting IT in education by adding technology to traditional educational practice [16]. However, the gift-wrapped approach will limit the development of skills and processes of learner that support learning as a lifetime habit. Therefore it is critical to conduct staff development by developing teachers' sense of harnessing technology for rethinking and redesigning educational practice.

Staff development is the key for cultivating culture of learning and teaching. Therefore, teacher's development on IT competency should not just focus on developing teachers' IT ability but should also provide space to encourage teachers to redesign educational practices for creative and lifelong learning [17]. It is speculated that organizing staff development by visiting schools with best practices on redesigning educational practice could facilitate cultural shift. This kind of activity may excel the emerging paradigm of learning and teaching in the information era.

4.5 School Policy

All schools attempted to articulate policies to address issues derived from implementing IT in education. The following are the observed common policies of the pilot schools on integrating IT in the school curriculum. Firstly, organizing CAP for students. Secondly, requiring all teachers to contribute in the development of multimedia-teaching units. Thirdly, advocating teachers to share the developed teaching-units within the school. Fourthly, providing computing and networking capabilities in classroom for learning and teaching.

The following are individual policies on integrating IT in the school curriculum advocated by some pilot schools:

- Optimizing students' opportunities for accessing the computing and networking capabilities of the school.
- Organizing the computer awareness curriculum to synchronize with application for learning subject curriculum.
- Reinterpreting and reorganizing the traditional school curriculum to cope with the changes introduced by IT.
- Optimizing students' opportunities to access curriculum learning resources.
- Encouraging teachers to visit schools demonstrating best practices on IT in education.
- Encouraging students empowered by IT to do project-based work.

It can be speculated from the last three common policies that all pilot schools are working for improving the traditional learning and teaching practices using the computing and networking capabilities. However, the individual school policies on integrating IT in curriculum reflect that some pilot schools are attempting to establish a favorable environment to welcome the emerging paradigm of learning and teaching. Principals should work with teachers to think and design school policies for such a pursuit.

5 Discussions and Implications

The core research question of the study is to investigate the changes introduced by the using of IT in learning and teaching. This section will discuss the two subsidiary research questions from the result of the study. Firstly, **what are the observed roles of IT in improving the traditional mode of curriculum instruction?** Secondly, **what are the critical factors identified from the study that will enhance learning for the emerging paradigm of creative and lifelong learning when learners are empowered by IT?**

5.1 Improving Traditional Curriculum Instruction

Exploring ways to improve classroom teaching is the main concern of principals and teachers in the pilot scheme. Joyce and Calhoun [18] studied the effectiveness of teaching mode on students' learning for more than forty years. Results of their studies indicated that learning should include both the memorization of factual knowledge and knowledge construction. There is the basic knowledge of the core school curriculum, such as the fundamental knowledge for learning language and mathematics, which need effective transmission. There are also parts of the curriculum that involve conceptual understanding, communication skill, problem solving ability and creativity. Teachers should assist students to learn them by knowledge construction and assist learners to learn how to learn such ability. Traditional curriculum instruction put efforts to knowledge transmission. The emerging paradigm draws focus to knowledge construction.

Results of the study indicated that the use of IT could improve traditional curriculum instruction in two ways. They are **interactive delivery of multimedia-teaching unit** and **presentation of digital knowledge object**. Teachers of the pilot schools reflect that interactive delivery of teaching contents and presentation of digital knowledge object can shorten teaching time and may enhance teaching quality. There are three main reasons. Firstly, context of teaching and scenes of discussion can be displayed in one shoot. Teachers can ask contextual questions or stimulate students to think immediately with the help of the authentic presentations. Time can be saved from wordy description of scenarios or spending time on sticking diagrams on boards. Secondly, adopting multimedia technology and interactivity of computing capability can assist the teaching of abstract concepts. Interactive teaching contents can be easily replayed for consolidation of concept to be learnt. Therefore the efficiency and effectiveness of learning and teaching may be attained with the help of multimedia-teaching units. Thirdly, there are many drill and practice exercises in the traditional paradigm of learning and teaching. Teachers spend quite a lot of time on validating answers with students. With the help of the TV sets or LCD projectors, teachers can display answers and check them with students efficiently. Time for writing answers on board or reading answers aloud can be saved. Time saved from efficient teaching maybe used for exploring possibilities of learner-centred learning.

5.2 Possibilities of Creative and Lifelong Learning

In responding to the need of every individual to become a lifelong learner, one of the main objectives of the school IT pilot scheme is to develop students with lifelong learning abilities. "Lifelong learning is a continuous engagement in acquiring and applying knowledge and skills in the context of self-directed problems" [16, p.12]. Therefore, learners in the information era are required to work independently, to possess skills and abilities to learn, to communicate and work collaboratively with workmates, and to work with self-initiatives.

Results of the study indicates that those pilot schools which advocate active learning such as group project work and learning-on-demand will favor learners to meet the need of the future society. IT facilities themselves cannot enhance learning and teaching for the emerging paradigmof creative and lifelong learning. It depends on how the learner makes use of the IT facilities to either learn independently or work collaboratively with their workmates. Establishing school policies, such as optimizing students' opportunities for accessing the computing and networking capabilities, organizing a coherence computer awareness curriculum to support subject curricular learning, and reducing curriculum content of the traditional formal

curriculum to cater self-directed work, will increase the possibilities to support learners to learn like a lifelong learner. For example, using those expensive classroom LCD projectors as content delivery tool or group project presentation and communication tool will be one of the reliable indicator to illustrate the possibilities of creative and lifelong learning of our learners.

Therefore, pilot schools desire to contribute in the information era should provide not only **a convenient and reliable IT infrastructure** for learners and teachers, but should also develop **a content-rich Intranet** and devise **appropriate school policy** to support and promote lifelong learning. Whether IT facilities can enhance the paradigm of learning and teaching depends on how learners make use of the facilities to learn independently or work collaboratively in projects with their workmates. Devising school policy to promote the emerging paradigm will be a crucial role of principals and teachers. School policy should be formulated from **strategies developed by principals and teachers**, who rethink and redesign educational practice for lifelong learning support.

6 Conclusion

Five main items of the TMM model were selected for detail study in this research. They were the student use, teacher use, curriculum integration, staff development, and school policy. They formulated the framework of the study. The initial research results of the study show that some pilot schools are **optimizing students' opportunities** for accessing the computing and networking capabilities of the school environment. It is also speculated that acquiring a **LCD projector in each general classroom** is an important part of the IT infrastructure for promoting the use of IT in schools. The convenient use principle for acquiring IT infrastructure was proposed in the first phase of the study and was re-confirmed by the current study. All schools are motivating teachers to use IT in order to improve the effectiveness of the traditional mode of learning and teaching. All schools are **developing multimedia-teaching units** as one way of integrating IT with the existing school curriculum. Seventy percent of the schools integrate IT with the curriculum by selecting digital knowledge objects for presentation. Some schools are struggling for offering opportunities to students for active learning. It is critical to conduct staff development by developing teachers' sense of **harnessing technology for rethinking and redesigning educational practice**. Four **common school policies** of using IT to improve the traditional paradigm of learning and teaching are identified. They are organizing CAP; developing multimedia-teaching unit; sharing the developed teaching-units; and providing computing and networking capabilities in classroom. A number of individual school policies are identified from some of the pilot schools for promoting active learning.

Results of the study show that **IT plays two roles to improve the traditional mode of learning and teaching**. They are the interactive delivery of multimedia-teaching unit and the presentation of digital knowledge object. Time saved from efficient teaching may be used for exploring possibilities of learner-centred learning. **Four factors were identified from the study as critical to enhance learning for the emerging paradigm of creative and lifelong learning**. They are a convenient IT infrastructure, a content-rich Intranet, appropriate school policy and strategies for lifelong learning support. School policy should be formulated from rethinking and redesigning current educational practice for lifelong learning support. This study is still in progress. Further result of the research will be reported after collecting more detail data from the pilot schools.

Acknowledgement

This research [RG999040] was supported by the Hong Kong Institute of Education. The authors would like to acknowledge the support of the Institute and to express gratitude to the 10 IT pilot schools participated in this study.

References

[1] Cheng, Y.C., "A CMI• • Triplisation paradigm for reforming education in the new millennium", International Journal of Educational Management, Vol 14, No. 4, (2000).

[2] Perelman, L.J., "School' s out• • •the hyperlearning revolution will replace public education", Wired Vol 1, No. 2, (1993).

[3] Tung, C.H., http://www.info.gov.hk/pa97/english/patext.htm(accessed on July 20, 2000).

[4] Education and Manpower Bureau, "Information technology for learning in a new era: Five-year strategy 1998/99 to 2002/03", Hong Kong: Author, (1998).

[5] Education Commission, "Review of education system: Framework for education reform", HKSRA: Author, (1999).

[6] Education Commission, "Review of education system: Reform proposals", HKSRA: Author, (2000).

[7] Kong, S.C., & Pun, S.W., "Information technology and school education: A critical reflection", Hong Kong: Joint Publishing (Hong Kong) Company Limited, (2000).

[8] Kong, S.C., Au, W.K., & Pun S.W., "A Case Study on the Implementation of Information Technology Education Pilot Scheme in Hong Kong", Advanced Research in Computers and Communications in Education Volume 2, Amsterdam: IOS Press, pp. 27-34, (1999).

[9] Illinois Staff Development Council, http://isdc.org/CBAM.html (accessed on July 20, 2000).

[10] National School Boards Association (NSBA), "Plans & policies for technology in education: A compendium", VA: National School Boards Association, (1995).

[11] Edmin Open Systems, http://www.edmin.com/tp/tmm.cfm (accessed on July 20, 2000).

[12] Pelgrum, W.J., & Anderson, R.E. (Eds), "ICT and the emerging paradigm for life long learning: A worldwide educational assessment of infrastructure, goals, and practices", Amsterdam: IEA (1999).

[13] Okamoto, T., "The framework and its meanings of new curriculum for Information Technology-Education from primary to senior high school in Japan", Educational Technology Research, Vol 20, No. 1-2, pp. 25-32, (1997).

[14] Kember, D., Lam, B.H, Yan, L., Yum, J.C.K., & Liu, S.B. (Eds.), "Case studies of improving teaching and learning from the action learning project", Action Learning Project: Hong Kong Polytechnic University, (1997).

[15] Crompton, R. & Mann, P. (Eds.), "IT Across the Primary Curriculum", Singapore: Cassell, (1996).

[16] Fischer, G., http://www.cs.colorado.edu/~l3d/ (accessed on July 20, 2000).

[17] Au, W.K., Kong, S.C., Leung, K.P., Ng, M.W., Pun, S.W., "Levels of Information Technology (IT) competency core course elements and assessment tools for teacher training in IT in education", Hong Kong: Education Department, (1999).

[18] Joyce, B., & Calhoun, E., "The conduct of inquiry on teaching: The search for models more effective than the recitation", International Handbook of Educational Change, Great Britain: Kluwer Academic Publishers, pp. 1216-1241, (1998).

Health risks with Computer Use in New Zealand Schools

Kwok-Wing Lai
School of Education, University of Otago, New Zealand
Email: wing.lai@stonebow.otago.ac.nz

With the increased use of computers, and particularly with the increasing use of the Internet in schools, health and education professionals have suggested the need for teachers and students to be ergonomically conscious when using computers. A project was conducted in 1999 to investigate the extent of awareness of health risks associated with computer use in schools of principals, teachers, and administrators of all the primary and secondary schools in Otago and Southland, New Zealand. Results in this study show that although a high proportion of the respondents were aware of these issues, few people took any active preventive measures or participated in any professional development to reduce these health risks. It is also found that nearly two-third of the school administrators, more than half of the teachers, and nearly 30% of the principals in this study had experienced some kind of health problems related to computer use. Strategies to deal with these issues such as the need for professional development are also discussed in this paper.

Keywords: **Health Risks, Social Implications**

1 Introduction

With the increased use of computers, and particularly since the advent of the Internet in schools in recent years [1], health and education professionals have suggested the need for teachers and students to be ergonomically conscious when using computers [2,3,4,5]. They are concerned about a number of health risks involved with computer use which range from discomfort such as eyestrain, wrist and shoulder pain, and overuse syndrome, to musculoskeletal injuries [6,7]. According to some reports (eg refer [7]), the most widespread health risk of computer use is eyestrain. One common problem experienced by frequent computer users is visual fatigue and eyestrain leading to sore and burning eyes, headaches, double vision, and even to nausea [8]. Computer users need to understand that reading text from a computer screen is significantly different from reading print-based materials. Unlike print-based materials which reflect light, the computer monitor (the visual display unit, VDU) is a self-illuminated object. Looking directly at the computer screen is somewhat like looking into a light source. Less surrounding light may be needed or the VDU may create discomfort to the eyes [9]. Poorly designed work environments may thus accentuate the development of Computer Vision Syndrome, defined by the American Optometric Association as "the complex of eye and vision problems related to near work which are experienced during or related to computer use" [10]. This is poised as a big problem for children.

Maintaining a good posture is another example of importance if the computer is to be used for an extended period of time. Poor body posture, as well as poor design of the workstation, may lead to muscle pain, particularly in the shoulders, neck, lower arms and wrists, which, if not attended to, may develop into what are commonly called Repetitive Strain Injuries (RSI). No doubt ergonomically designed furniture and workstation could mitigate some of the 'at risk' postures when teachers and students using computers [6,11]. As teachers and students increasingly have to use the computer for instructional and administrative purposes, they need to understand these issues and to form good work habits as early as possible since bad habits, once formed, are usually difficult to unlearn later.

There is a need for teachers and school administrators to be more ergonomically conscious. The use of laptop computers in schools, for example, where students are expected to use a small keyboard, trackball, or some pointing device for extended periods of time, has already posed a greater risk of developing

occupational overuse syndrome (OOS) [12]. A recent study surveying 314 children in three Australian schools shows that 60% of the participants suffered some kind of back, neck, head and shoulder pain when using and carrying laptop computers [13]. At present very little research has been conducted on health and safety issues associated with computer use in schools, although ergonomic research in the workplace in other settings has been undertaken by organizations such as the International Labour Office [14]. In New Zealand, no systematic research on these issues has been conducted in schools. To fill this gap, a research project was undertaken in 1999 surveying the awareness of principals, teachers, and administrators of all Otago and Southland schools in New Zealand on ergonomic issues and health risks with computer use. Data collected in this study was used for designing training programmes as well as for policy recommendation and formulation.

2 Research questions

The following research questions were investigated in this study:

1. To what extent were Otago and Southland school principals, teachers, and administrators aware of and understood the potential health risks associated with computer use?

2. To what extent have Otago and Southland school principals, teachers, and administrators experienced health problems associated with computer use?

3. To what extent did primary and secondary schools in the Otago and Southland regions have a health and safety policy with regard to computer use by staff, teachers, as well as students?

4. What were the strategies and practices adopted by schools to deal with health issues with computer use?

2.1 Participants

As a regional study, three sets of questionnaires were administered to the (a) principals; (b) school administrators (secretaries); and (c) computing teachers/computer coordinators of all the schools in the Otago and Southland regions of New Zealand. A total of 852 questionnaires were posted to 284 schools (246 primary and 38 secondary schools). 362 questionnaires (43%) from 207 schools (73%) were returned. The overall response rates for principals, teachers, and administrators were 56%, 30%, and 41%, respectively. As can be seen from Table 1, the response rates for primary school principals and secondary school teachers were particularly high.

	Primary Schools		Secondary Schools		Overall Responses	
	Number	%	Number	%	Number	%
Principals	145	59	14	37	159	56
Teachers	59	24	27	71	86	30
Administrators	102	41	15	39	117	41

Table 1: Response rates of principals, teachers, and administrators

3 Awareness of health risks with computer use

3.1 Time spent using computers

Principals, teachers, and administrators in this study were asked the length of time they spent using computers at school. Table 2 shows that school administrators (secretaries, managers), particularly of those in secondary schools, spent much more time (5.1 hours on average per day) on the computer than principals and teachers. Secondary school teachers also spent twice the amount of time on the computer than their primary school counterparts (see Table 2).

	Primary Schools	Secondary Schools
Principals	1.5	1.6
Teachers	1.1	1.9
Administrators	2.9	5.1

Table 2: Average hours spent on the computer per day by principals, teachers, and administrators

3.2 How often did they have breaks?

It is important to have frequent short breaks if users spend an extended period of time on the computer. In this study when asked how often they took breaks when working on their computer, only 5% of the respondents reported having breaks regularly and 1.4% of the respondents reported they rarely had breaks. It is interesting to note that nearly one-quarter (24%) of the respondents could not provide a specific answer to this question and 20% of the respondents did not provide any answer at all. It seems that quite a large proportion of the respondents (44%) have not yet formed a habit of having regular breaks when using computers, as reflected in the following comments:

> "Whenever I feel I need to…"
> "When finished an item & before starting another"
> "usually work until task is completed"

For some teachers, taking breaks was never a big issue because they were "frequently interrupted" anyway. But others seldom took breaks:

> "…When working for extended periods (30 mins +) I very rarely take breaks."
> "…may have break after working more than 2 hrs."

About half of the respondents have provided a more specific answer to this question. Within this group, principals took breaks most often (on average every 37 minutes), followed by teachers (on average every 43 minutes). However, administrators who indicated they spent far more time on the computer, took breaks least often (on average every 46 minutes).

3.3 Were respondents aware of the health issues related to computer use?

In the questionnaires the respondents were asked whether they were aware of the following health risks associated with computer use: (a) back pain; (b) lower arm pain; (c) neck pain; (d) shoulder pain; (e) wrist pain; (f) headaches; and (g) eyestrain. Overall, between 69% and 91% of the respondents were aware of a number of these health risks, as can be seen from Table 3.

	Administrators	Teachers	Principals
Back Pain	92	85	86
Lower Arm Pain	86	79	71
Neck Pain	91	85	79
Shoulder Pain	85	69	71
Wrist Pain	91	92	82
Headaches	91	83	81
Eyestrain	91	90	90

Table 3: Percentages of school principals, teachers, and administrators who were aware of health risks associated with computer use

High level of awareness, however, did not result in high level of active preventive measures undertaken to reduce these health risks. For example, when principals and teachers were asked specifically whether they paid any attention to their own postures, as well as to the lighting in their work environment, only 54% of the teachers reported that they did watch their posture and 60% of them paid attention to the lighting of their rooms. As for principals, they paid even less attention to their postures (49%) and lighting (57%).

The majority of the respondents did not have any purpose-built furniture either. Table 4 shows that although 95% of the administrators surveyed in this study had an adjustable chair to use, less than half of them (42%)

had an accompanying adjustable computer desk. Very few of the teachers and principals had other ergonomically designed furniture to use. The school administrators were also asked whether they have requested any specific items which would make their use of the computer safer. 49% of the administrators in primary schools and only 33% in secondary schools have requested such items.

	Administrators	Teachers	Principals
Adjustable Computer Desk	42	8	22
Adjustable Chair	95	35	75
Foot Support	24	4	3
Screen Filter	41	2	13
Paper Holder	54	27	23

Table 4: Percentages of respondents having purpose-built furniture

The situation was far worse for students. As can be seen from Table 5, very few students used ergonomically designed furniture at school, particularly primary students (although they only spent on average approximately an hour per week on the computer). The situation for secondary students was a little better, but they spent a lot more time on the computer than their primary counterparts (on average 3.7 hours per week).

	Primary	Secondary
Adjustable Computer Desk	5	5
Adjustable Chair	7	70
Foot Support	2	10
Screen Filter	4	15
Paper Holder	13	57

Table 5: Percentages of students using purpose-built furniture

3.4 Health problems with the respondents

When asked whether they had experienced any health problems related to computer use, overall nearly half (47%) of the respondents had experienced some kind of problems themselves. School administrators were affected most (61%) and this was more significant in secondary schools (73%) than in primary schools (57%).

As school administrators worked much longer hours on the computer than the other two groups, it is not surprising that they reported having more health problems. Of the 117 administrators who have returned their questionnaires, seventy-one (61%) reported they had experienced some kind of health problems associated with computer use. Five of these respondents have already had RSI. Thirty-three (28%) administrators had experienced eyestrain, and nine of them reported a deterioration of their eyesight, and as a result had to wear prescription eye glasses. Other health problems included hand and wrist pain (37%), neck pain (30%), shoulder and lower arm pain (41%), and back pain (13%). A third major problem was headaches (27%). The following comments show the importance of having an ergonomically designed work environment:

> "I have OOS in hands, wrists, arms, shoulder tension and neck tension leading to headaches. This was originally due to poor equipment. I now have the proper desk etc and have to monitor how much I use the computer."
> "Chronic neck pain prior to purchase of a copy holder. Eye sight deteriorating - glare is a problem."

As for teachers, forty-five (52%) of the respondents reported having health problems related to the use of computers at work. The two most widespread problems were wrist pain (49%) and eyestrain (44%). The following are some of the teachers' comments:

> "Wrist…when doing a lot of mousing & editing a school magazine – kept me awake at nights. Also lifted some chairs & a computer monitor during room refurbishment. Lifted badly & was off work two and a half weeks with pinched nerve. Could not sit at computer for 4-5 weeks." (A male high school HOD, Computing)

"Back – too tense when working against clock. Arm & wrists – pain after stretches at keyboard. Headaches – at end of every working day. Eye strain – tired, burning eyes." (A female high school HOD, Information Technology)

Forty-five (28%) principals reported having experienced similar health problems related to computer use as teachers, with wrist pain (45%), eyestrain (33%), and neck pain (31%) being the most common ones.

"Eye – using old b/w screen – very sore. Health nurse advised me to minimise my use of that particular computer. Shoulder/neck pain – more evident when programme fails to function properly at a crucial time." (A male primary school principal)

3.5 Dealing with health risks

3.5.1 The lack of information

Having information about ergonomic issues is the first step towards minimizing health risks. In this study the respondents were asked if they had knowledge of ergonomically designed equipment or furniture. They were also asked to give one or two examples as well. Table 6 shows that apparently the respondents' level of knowledge of ergonomic products was very high. Overall, staff in secondary schools knew more about ergonomic furniture and equipment than their counterparts in primary schools.

	Primary Schools	Secondary Schools
Principals	84	93
Teachers	76	96
Administrators	72	93

Table 6: Percentages of respondents who had knowledge of ergonomic products

However, when asked whether they knew any computer software which would help them reduce the health risks of computer use the percentages were much lower, as can be seen from Table 7.

	Primary Schools	Secondary Schools
Principals	11	14
Teachers	9	26
Administrators	6	7

Table 7: Percentages of respondents who had knowledge of software programmes

The principals were asked whether they were aware that the government had developed some guidelines related to health and safety issues in school computer use. Although a package which includes guidelines on safety issues in ICT use was sent out by the Ministry of Education in 1998 to all schools, only 17% of the primary schools and 14% of the secondary school principals were aware of these guidelines.

When asked what specific information they needed, some suggested:

"Information re harmful properties in the air from this electronic gear. How close to sit to monitor screen to avoid exposure."
"Furniture/equipment at the Primary end of education – what's a good height for screen? Are chairs available for 'wee ones'?"

Some requested very detailed information:

"How much time I should sit at the computer before having a break, what exercises I should do and what other equipment would help to counteract some of the problems…"

The respondents were also interested in legal issues related to the health risks of computer use. As suggested by Cameron (cited in Bell, 1999), the public liability health insurance risks have not yet been clearly calculated and could be a major concern for school management in the near future. The following is some of the legal information requested by the respondents:

"Legal advice on possibility of students claiming against schools in later life."
"What are the legal requirement of our employer to provide for this. Strategies for combating to [sic] problem"

3.5.2 The lack of policy guidance

Surprisingly, not a single secondary school in this study had a policy on health and safety issues associated with computer use. While primary schools fared better, only about 6% of them had a standing policy. However, 85% of the primary and 86% of the secondary school principals felt the need for some kind of policy and guidelines. A number of them preferred that policies be developed by the Ministry of Education as 'it would be easier for one organization to carry this out rather than every school or institution reinventing the wheel by producing their own". Some principals felt that since "computer use is being imposed upon schools" and the "new curriculum initiatives require that schools be equipped with computers", the Ministry of Education therefore should be responsible for developing and disseminating guidelines for computer use in schools. These guidelines should be:

"Concise, clear suggestions that are practical for implementation in schools/classrooms..." (A primary school principal)
"...Ministry driven not left up to individuals to decide and Ministry funded workshops easily available especially to rural people." (A rural school principal)

Principals preferred practical and systematic information, provided by experts, and enforced by an outside body such as the Ministry of Education.

From the comments of the principals it is clear that they have a huge concern about how ergonomically designed equipment and furniture should be funded as "the Ministry of Education [is] very good at generating guidelines but very reluctant to resource them". According to one principal, the Ministry of Education should:

"provide the funding and staffing for proper management of computer systems, computer training...education and...development rather than stating 'funding is available in the operations grant." (A secondary school principal)

From another principal,

"so that there is a set of national standards, information and guidelines for schools to make use of. This resource would have to be accompanied by efficient funding to enable aspects to be put into practice." (A primary school principal)

3.5.3 The lack of professional development

Only 10% of the primary and 21% of the secondary schools in this study had organized professional development related to health issues with computer use for their staff. When organized, they were considered as part of the overall professional development, "included in...training for staff on computer skills" and they usually involved some form of inspection from the Occupational Safety and Health Authority (OSH):

"Administrative secretaries have been given reading material regarding the health and safety issues. OSH visits make us aware and keep us up to speed regarding 'good employer' aspects of ensuring staff are aware of H & S [Health and Safety] issues within the responsibilities and rates of their positions".
"Visit to inspect computer facilities by OSH expert...report and recommendations to Board [of Trustees] by OSH expert...address to staff by OSH expert ...replacement/purchase of computer equipment to reflect above recommendations..."

Professional development for the respondents meant gaining knowledge of ergonomic products or measures to prevent OOS. Topics such as psychological stress related to computer use, as well as the feeling of incompetence when using computers with their students due to inadequate training and professional development were seldom included.

Some principals did not know what to include if a professional development programme was to be organized:

> "I would need to seek expert advice on this."
> "I have no idea..."

Some principals even doubted the need for professional development in this area:

> "Our teachers are not using computers during school hours but children are."
> "Very few school personnel use computers for extensive periods so I'm not sure how great the need is."
> "Not interested at this time...It is not a concern to me. I know of problems. But until it affects me I sail on without concern."

It is clear that health and safety issues were not emphasised in professional development in most schools. The following comment summarized well the feelings of many principals,

> "Time has to be spent on training for teaching and computer use. Health and safety is important but not the driving force for in-service training".

The lack of professional development in this area may explain why health issues associated with computer use were seldom discussed with students. In the survey, it is reported that only 34% of the primary teachers and 59% of the secondary teachers have discussed these issues with their students. This is rather unfortunate as, increasingly, students will spend more time using computers in school as well as at home. In this present study 12% of the primary and 11% of the secondary schools have already indicated that their students were using laptop or notebook computer at school. Students need to be aware of these health risks and preventive measures need to be instigated urgently if a safe work environment is to be provided for them.

4 Concluding remarks

Although computer use in the classroom or in the school office is usually very different from an office setting where people can spend all day working on a computer, this study documents a rather widespread health problem in the school setting, particularly with school administrators. This study documents the lack of depth in the understanding of these health risks as well as the inability to come up with some strategies to deal with them, which was at least partly due to the lack of efficient dissemination of information and national guidelines from the Ministry of Education to individual teachers. It was also due to the lack of professional development and discussion of these issues in schools. From the study, we come up with the following recommendations:

1. The need to consider the health risks as a matter of priority. It should be noted that parents and educators are not wilfully ignoring the health risks of having poorly designed computing furniture or the importance of professional development. What they are more preoccupied with is the educational opportunities of the burgeoning technology, and the computer hardware and software needed to meet the educational needs. As commented by a couple of respondents,

> "The issues of health & safety were discussed as our school invested in computer technology. However, the cost of complying with health & safety issues in an old school building was expensive. The priority is to provide hardware at this stage. Our 'typing room' has adjustable chairs, but 'computer room' & IT room have 'ordinary' chairs & desks."
> "How does the school get the money to buy chairs/desks needed when the IT gear is demanding every dollar of hard-won fundraising?"

Ergonomically designed furniture is not a priority compared to hardware and software purchase as 'by the time a school purchases hardware and software [it] seems little [is] left over in [the] budget for ergonomic furniture". Schools simply cannot afford to provide the money. It is a national issue, rather than a local issue. As for professional development, the focus is on how to use the computer to teach and "as part of ICT inservice...these issues are easily overlooked while dealing with the actual understanding of programmes, technical knowledge, etc." It is now high time to treat this as a priority.

2. The need for resourcing. This brings us to our second point: the need for adequate funding to resource ergonomically designed equipment as well as professional development for teachers and school administrators. As commented by one primary school teacher in this study,

> "Computers & chairs at my school are extremely old, damaged beyond repair. Poor choices been made & no funding available to rectify situation. I am unable to work in such conditions & will bring in own personal equipment as not prepared to work with 'dangerous' equipment."

There was a general feeling that funding should come from the national level:

> "This a large issue for education as all available funds targeted into computers & software. Problems of seating at computers & general furniture that has been provided for children an issue that needs lot more attention at national level as unless funds were provided the cost would be out of most schools ability to provide."
> "Teachers within TIM [Text and Information Management] & computer curriculum fully aware of potential health risks associated with computers. Until money is forthcoming for implementation of ergonomically designed computer rooms then professional development is simply **just more talk**. If, in this age of technology where supposedly all schools will march down the urge/rush to have schools & students embrace the wonders computers, where is the finance to ensure health & safety of these same students? You **cannot** have one without the other, but schools do because there is no requirement to do otherwise."

3. The need to consider the school-home link. The school-home link cannot be ignored when discussing issues related to health risks with computer use, as home and after hours use is the most likely time for health issues to arise. A principal from an Intermediate school commented:

> "As a lead school in ICT it is an area we should consider. In most cases staff and pupils sit for only a short period of time at the computers but even so it is important that health and safety issues are addressed. I suspect that this should also be stressed in the home as often children and adults spend long periods of time in front of their computer."

As it is increasingly common for students to have computers at home and typically students spend a lot more time playing computer games and chatting on the Web than using computers at school, it is important to promote healthy computer work habits not only at school but at home as well. Unfortunately, many parents are more concerned about how fast their kids can search the Internet than forming good work habits.

4. The need to take up a broader perspective. In this study we have only looked at the physical health risks associated with computer use. However, the lack of professional development in ICT has created huge psychological stress for many teachers. As commented by one respondent:

> "A great anxiety whenever I have to use it as my inadequacies are likely to be exposed..."

The inadequacies referred to by this respondent had to do both with the lack of training on computer use as well as how it is to be used as a teaching and learning tool. Heath risks teachers should be aware of ought also to include the anxiety and psychological stress they have to deal with in using computers in their classrooms.

In the final analysis, the computer users themselves have to take responsibility of looking after their own well-being. Providing teachers and students with ergonomically designed furniture as well as professional development will certainly help. However, I suspect it is only when they have an in-depth understanding of the issues and an ergonomically conscious work culture, created, and supported by the school as well as the wider community both locally and at the national level, that health risks associated with computer use in schools could be greatly reduced.

Acknowledgements

This research was supported by the Otago Division of Humanities Research Grant (LAMJ21). The author also wishes to thank Alison Grant, Anne Elliot, Philip Munro, and Nicola Elliot for their support in data collection and preparation of this paper.

References

[1] Market Data Retrieval, "Technology in education, 1999", http://www.schooldata.com/pr18.html (accessed on May 1, 2000).

[2] Lai, K.W., "Computer use and potential health risks", Computers in New Zealand Schools, Vol 7, No. 2, pp. 43-47, (1995).

[3] Grant, A., "Information technology in the New Zealand curriculum and occupational overuse syndrome", Computers in New Zealand Schools, Vol 10, No. 2, pp. 37-41, (1998).

[4] Gross, J., "Missing lessons in computing class: Avoiding injury", The New York Times, March 15, (1999).

[5] McMillan, N., "Ergonomics in Schools: Some Issues", paper prepared for New Zealand Accident Rehabilitation, Compensation and Insurance Corporation, Wellington, (1998).

[6] Laeser, K., Maxwell, L., & Hedge, A., "The effect of computer workstation design on student posture", Journal of Research on Computing in Education, Vol 31, pp. 173-188, (1998).

[7] Atencio, R., "Eyestrain: The number one complaint of computer users", Computers in Libraries, Vol 16, No. 8, pp. 40-43, (1996).

[8] Dillon, T. & Emurian, H., "Reports of visual fatigue resulting from use of a video display unit", Computers in Human Behavior, Vol 1, No. 1, pp. 77-84, (1995).

[9] Anshel, J. "Visual ergonomics in the workplace: How to use a computer and save your eyesight" Performance and Instruction, Vol 33, No. 5, pp. 20-22, (1994).

[10] Anshel, J., "Kids and Computers: Eyes and Visual Systems", http://www.ctdrn.org/rsinet (accessed on May 1, 2000).

[11] Oates, S., Evans, G., & Hedge, A., "An anthropometric and postural risk assessment of children's school computer work environments", Computers in the Schools, Vol 14, No. 3/4, pp. 55-63, (1998).

[12] Ministry of Education, "Safety and Technology Education: A Guidance Manual for New Zealand Schools", Wellington: Ministry of Education, (1998).

[13] Bell, J., "Laptops download a hi-tech malady", The Bulletin, March 2, pp. 26-27, (1999).

[14] Rosskam, E. & Baichoo, P., "Preventing workplace injuries and illnesses through ergonomics", World of Work, Vol 21, pp. 5-8, (1997).

Additional Information

A website has been developed as a result of this research project. Its URL is http://education.otago.ac.nz//NZLNet/safety/health_and_safety.html. This website is developed specifically for teachers and it consists of some very useful resources and links on health and safety issues associated with computer use.

Information technology competency for Hong Kong teachers - A new era and a new paradigm

Wing Kee AU*, Siu Cheung KONG, Kin Ping LEUNG***, Eugenia Mee Wah NG**** and Sai Wing PUN*******

Department of Information and Applied Technology, Hong Kong Institute of Education, 10 Lo Ping Road, Tai Po, N.T., Hong Kong SAR, China,

* *wkau@ied.edu.hk*

***sckong@ied.edu.hk*

****kpleung@ied.edu.hk*

*****eugenia@ied.edu.hk*

******swpun@ied.edu.hk*

This paper reports a study on Hong Kong teachers' competency in information technology (IT). The Hong Kong Special Administrative Region (HKSAR) Education Department commissioned and funded this study. The study aimed to refine the four levels of IT competency for teachers as suggested by the HKSAR government in 1998, to recommend the appropriate professional development courses both in terms of contents and related strategies, and the appropriate assessments for all Hong Kong teachers. Multiple research methods were used in this study which included documentary analysis, interviews with experts in Hong Kong and other countries, focus group meetings with local government specialists, principals and teachers, and case studies of some local schools. A framework of IT competency in education for teachers was proposed together with a set of key attributes of a teacher who is IT competent in education. As well, a systematic set of professional development courses were outlined by the research team with a strong focus on how IT could be used in education. This study also suggested a number of professional development strategies to the Hong Kong government including school-based professional development including the concept of hub-schools, and centrally approved professional development providers. Moreover, portfolio assessment was recommended as a suitable way to assess the IT competency for Hong Kong teachers.

Keywords: **Teacher training, information technology, competency, professional development**

1 Introduction

In his inaugural Policy Address, the Chief Executive of the Hong Kong Special Administrative Region (HKSAR) pledged to make Hong Kong "a leader, not a follower, in the information world of tomorrow". To realise this vision, our future generation must be empowered with the knowledge and applications of information technology (IT). To this end then, Hong Kong's teachers must be IT competent in education so that the power of IT can be harnessed for the learning of their students.

In November 1998, the HKSAR Education and Manpower Bureau (EMB) published a policy document entitled "Information Technology for Learning in a New Era: Five-Year Strategy 1998/99 to 2002/03"[5]. This document, among other things, stipulated four levels of IT competency for Hong Kong teachers and outlined a timeline for all Hong Kong teachers to attain the different levels of IT competency over a period up until September 2003. However, the document also indicated that there would be a need to delineate and elaborate on the details of these four levels of IT competency and related training strategies.
Subsequently in 1999, the Education Department of the HKSAR invited interested parties to bid for a research contract, part of which involved the elaboration of these four levels of IT competency, the

recommendation of the appropriate courses and strategies for the professional development of Hong Kong teachers in IT as well as the assessment methods involved. The research team at the Hong Kong Institute of Education won this bid and the project officially began in April 1999. The report was accepted by the government and was released in October 1999 [1].

2 Aims of the Project

This project aimed to refine and elaborate on the four levels of IT competency for teachers as suggested in the "Five-year strategy on IT in education" published by the HKSAR Education and Manpower Bureau in 1998; and to recommend the core and optional course elements and training strategies, appropriate assessment tools and certification mechanism for professional development for four levels of IT competency for teachers.

3 Methodology

Information technology competency is a complicated, topical and important concept. A number of issues were considered before formulating the methodology of the current study. First, IT competency implies some form of literacy with IT. Second, it is an evolving concept and changes with the development of IT that tends to be rather rapid. Third, in the context of this study, we have examined IT competency in relation to teacher enablement and empowerment, which embraces the concept of teachers using IT as learning and teaching tools. Fourth, while most developed economies have made good starts with the professional development which enables teachers to use IT, Hong Kong comes in relatively late which means that special considerations need be made.

The methodology of the present study was based on a comparative perspective, which took into account of the pedagogical practices and competency standards in other socio-economic contexts. In this context, the major approaches used in this study included documentary analysis, substantive reviews of the literature and interviews with a number of experts in five countries (Australia, Britain, France, Singapore and the United States), meetings with local experts (including government specialists, major school operators, school principals and teachers), and case studies of five Hong Kong schools. Based on the data collected and analysed, specific policy and operational recommendations were then made.

The overseas experts interviewed came from five countries: Australia, Britain, France, Singapore, and the United States. The experts were selected based on their professional involvement in setting the IT competency in their countries. There were a total of 12 overseas experts interviewed.

The local experts who attended the focus group meetings came from a variety of sources. Some of them were experienced educators from the tertiary institutions in Hong Kong, some were dedicated frontline teachers and principals. And still some others were representatives from major school operators and from the HKSAR Education Department. There were more than 70 local experts who were consulted. It should be borne in mind though many different, sometimes opposing views were expressed during the focus group meetings. The facilitators of each of the focus groups then tried to facilitate the formulation of some kind of consensus opinions towards the end of the meetings.

The data collected from the visits to the five schools provided valuable insights into the implementation of IT in the Hong Kong school context and allowed the research team to gauge where Hong Kong teachers were at as far as IT competency was concerned and how these schools were handling teachers' professional development in this area.

4 Results and Discussion

From our review of the literature, interviews with experts, discussions at focus group meetings and case studies of schools, it was quite clear that the focus of IT competency under consideration should be on IT competency in education or IT in education competency rather than just IT competency for the sake of using IT. There was a very strong consensus among both the local and overseas experts on this particular issue. This was a critical issue when defining and elaborating the four levels of IT competency in the present

project as one refers to teachers using IT in education rather than using IT for other purposes. Therefore, it is imperative that the focus be on IT competency in education or IT in education competency.

This focus was also reflected in the formulation of IT competency standards in other countries. For instance, in France, three levels of IT competency have been established. The first two of these levels focus on the use of IT only and the third focus on the use of IT in Education. In England and Wales, the IT competency has the educational agenda well woven into the IT competency expected of the teachers over there. In Singapore, the government does not even evaluate the IT technical skills of teachers, rather in their professional development model, teachers are expected to integrate IT into daily learning and teaching as well as curriculum development.

The local experts expressed similar views during the focus group meetings. The following are some of the typical comments:

IT competency must be practical and related to the subjects that the teachers teach.
IT competency should be skill-based initially but should relate to integrating IT into education.
IT competency should be functional based on teaching and learning tasks that teachers have to achieve.

These views are shared by almost all the authors who write about IT competency in education around the globe [e.g., 2, 4, 7, 9, 11, 12, 13]. However, the views expressed by these authors differ somewhat in how these skills relate and be learned by the teachers. For instance, some views tend to suggest that IT as productivity tools and skills can be separated from their integration into learning and teaching contexts [13] whilst others suggested there needs be integration right from day one when a teacher starts to learn to use IT for learning and teaching purposes [11].

The notion of a dichotomous view of IT skills as productivity tools versus their integration in learning and teaching may be difficult to sustain if one considers recent research in situated cognition and learning. In this realm of research, it has been clearly pointed out that learners learn best when what they have learned can be anchored within a context that the learners can put what they have learnt into practice [10]. In defining IT competency in education and in the design of appropriate professional development activities, it would appear advisable and necessary that teachers' learning of IT skills be embedded within the context of education. This point reinforces the views about IT and information literacy which have to be learnt within a professional context.

In the light of the considerations above, the research team proposed a conceptualisation of the four levels into a matrix consisting of the four levels and three domains. The following diagram illustrates such conception.

Levels	Domains		
Basic	IT as Productivity tools	General Integration of IT in Education	Subject-specific Integration of IT
Intermediate			
Upper Intermediate			
Advanced			

One major issue in the professional development of teachers in IT is that often too much emphasis has been placed on the development of technical IT skills without sufficient focus on the application of IT in education. The proposed model will encourage educators to place due emphasis on how IT should be used in education and in particular subject areas in conjunction with the development of the necessary IT skills. Such a conceptualisation will have impact on the actual professional development activities as it will be essential to consider including the elements from the three different domains in all professional development activities. In particular, development of the IT knowledge and skills must, ideally take place in the context of either the general integration of IT in education and/or subject-specific integration of IT.

It should be noted that this conceptual model does not suggest that professional development activities could or should be divided into three separate domains. On the contrary, this conceptual model emphasises that

professional development should be integrated. In other words, the development of using IT as productivity tools should be anchored within a general educational context and/or within subject-specific contexts. This view is very much shared by the overseas experts that we have interviewed. Indeed, in the professional development activities that the research team proposed to the Hong Kong government, all the three domains are closely interwoven together [see 1].

During the consultation with both local and overseas experts, there was very strong support for the three-domain classification. Some experts did suggest that the second and the third domains could be merged to become one. However, this was balanced by another set of views that teachers needed to understand cross-curricular and thematic applications of IT in education. Moreover, it was also surmised that teachers should not just focus narrowly on the application of IT in their own teaching areas. Rather, teachers need be aware of the potentials of integrating IT in other areas as well.

During the consultation process, it was also suggested that perhaps it might not be necessary to have four levels of IT competency, or at least, the four levels should be collapsed into two or three levels. The research team understood that that the four-level IT competency was set as Hong Kong government policy and could not be changed. Therefore, the four-level and three-domain matrix stands as it is.

Moreover, the professional development needs to include general issues such as the changing views of learning and teaching, the changing roles of learners and teachers, how to decide when to integrate IT into learning and teaching, and the strategies that teachers can use to engender such changes within our school system. The EMB document refers to the paradigm shift in learning. In order to effect such a change in Hong Kong classrooms, it is important that there be corresponding changes in Hong Kong teachers' views about learning and teaching.

In our search for similar efforts in defining IT competency by overseas government, overseas universities etc, it was very clear that IT competency was not just about the use of computers and its peripherals. Rather, it refers to a person's ability to handle information via the use of IT when appropriate. For example, in a study by Hoover [6] it was clearly stated that IT competency related to a person's ability to collect data, manage information, make decision, communicate and present. In the School Technology and Readiness Report [3], it was argued that IT Competency would include the necessary skills to acquire, organise, use, maintain, interpret, communicate as well as use technology to process information.

In the light of the above arguments, when formulating the key attributes of a teachers who is IT competent in education and the course contents of related activities, careful considerations were given to the issue of information literacy. For instance, in the courses designed, emphases have been placed on how the participants can process information through various forms of IT such as the accessing and searching of information on the Internet, the organisation and manipulation of information through software such as databases and spreadsheets.

It was acknowledged by all experts involved that IT competency needed to be modified with time. Given the rapid development of IT, it is almost imperative that IT competency will need be monitored and revised on a continual basis. For instance, Web browsers may be important in 1999 but may not be so in 2002. Similarly, the writing and design of Web pages may not be a skill expected at the Basic Level at present, but the situation may, and will probably change in 2001.

In the context of a need to modify IT competency on a continual basis, it is also very clear that the professional development should focus on generic skills with software. For example, for word processing and presentation, rather than focusing on specific software such as Word and PowerPoint, the emphasis should be on the generic skills in operating word processing and presentation software. It is important that a distinction should be made between using particular software as an example in one category of software, and focusing on that software alone. By doing so, teachers can acquire the generic skills so that they will be better able to cope with new software and new versions of the same software. It also means that the shelf life of the IT competency can be prolonged.

In consulting with a large number of local and overseas experts and the literature on the professional development of teachers to use IT, it was clear that the issue of teacher empowerment needs be given very serious consideration when conceptualising IT competency, and, in particular, in designing the professional development programmes.

Given the amount of time allocated for each level of IT competency professional development, especially the Basic Level where only approximately 18 hours of course time is provided, it is important that a number of enablement strategies be used to facilitate the empowerment of teachers. These strategies include the emphasis on initial familiarisation and awareness, ongoing support after the initial courses including learning materials support and human support.

A lot of discussions during our consultation focused on the Basic Level which all Hong Kong teachers must attain in the next two years. There was clear consensus emerging from the focus group meetings and our consultation with the local and overseas experts that the IT competency at the first level should focus on confidence and basic skills building. It was suggested by all experts (local and overseas) consulted that the level of difficulty within the Basic Level should not be set too high so as to frighten the real beginners. The literature on the professional development of teachers also supports the notion that much of the initial stage of professional development requires confidence building and the development of some generic skills upon which the teachers can then develop further advanced skills themselves. The development of confidence and basic skills in using IT will form a good foundation for further self-learning of IT. The principle underpinning this development is the empowerment of teachers with IT.

However, given the little time budgeted for the professional development courses at the Basic Level and the commitment of funding for professional development at the Basic Level only at this stage (for the absolute beginners), it is important that beginners are aware of the potentials of other common applications in education. One needs to bear in mind that some 25% of teachers in Hong Kong will not be expected to go beyond the Basic Level of professional development. Therefore it will be to the advantage of the beginners that certain amount of course time at the Basic Level be devoted to awareness and familiarisation so that beginners can become aware of the potentials of some of the common application and instructional software that could be used in the classrooms. This professional development can include the demonstration and initial familiarisation of how software such as e-mail, presentation software, spreadsheet, databases and some common educational courseware can be used in education in general and in certain subject areas.

While it is recognised that there are many teachers in Hong Kong who might have attained the Basic level IT competency, the project team decided, after consultation with the experts that the IT competency at the Basic level be set at a minimum with no optional element. In other words, the elements proposed in the table below for the Basic level of IT competency would all be considered as core. The decision was based on the reasoning that those teachers who have attained the Basic Level IT Competency can further develop themselves at higher level of competencies.

While there were very interesting discussions for the Basic Level, there were not much controversies for the Intermediate, Upper Intermediate Levels and Advanced Levels. There were discussions on how some IT applications should be placed vis-à-vis a certain level but overall the discussions did not generate as much as debate as to the contents of the Basic Level.

When the research team attempted to define what IT competency is for Hong Kong teachers and delineate the scopes of the four levels of IT competency, we tried to look to our overseas counterparts for their experience. However, we found that we could not quite find a set of similar experience. In fact, very peculiar to the Hong Kong context, we have not found any country that has attempted to define four-level IT competency as we were trying to do. For example, in Britain, there was a holistic set of IT competency without dividing it into levels. In Singapore, the government did not even attempt to define a set of IT competency. In France, there are three levels but it was simply divided into some basic IT skills, general application software usage and linking IT with education. In Australia, the Australian Council of Computers in Education conceptualises IT competency in terms of categories: Understand the use of IT as a personal tool, understand the use of IT within the school as a workplace, institution site or learning place, use IT during the teaching and learning process.

We also consulted with our local experts who did not provide too much comment on the definition or the scope of the four levels of IT competency, suffice to say that the definition needed be flexible and should relate to the work of teachers in schools etc.

As we have indicated earlier, Hong Kong is relatively a late comer in integrating IT into its school system among the developed economies. Consequently, there were a number of issues that need be considered when we tried to define the scope of the four levels of IT competency.

First, from our consultation with the local experts, we were given a clear message that Hong Kong teachers were fairly adept in picking up technical and technological skills. These messages were given to us by frontline teachers and principals during our focus group meetings, and our meetings with the Teacher Preparation Working Party set up by the Government. Although the research team was not necessarily totally convinced of such assertions, it was nonetheless relieved to learn of such possibilities. While there was no attempt to "squeeze" in as much mastery of technical contents as possible at each level, this allowed the research team to be more confident to include more initial familiarisation at the lower levels.

Second, during our consultation with local experts, there were often suggestions that there was a dearth of software in Hong Kong that were suitable to the learning contexts of Hong Kong students, e.g. Cantonese-based, Hong Kong curriculum adapted etc. While there might be many ways to address this issue, training more Hong Kong teachers to produce software would clearly be one of them. There are many tools available to produce software at various levels of complexities. The research team has included some of them throughout all levels, e.g. presentation software, more sophisticated authoring tools and even more sophisticated programming languages at the Advanced Level. From experience elsewhere, it is clearly not reasonable to expect many teachers writing software, the proposed course structure will encourage more interested teachers to take up the challenge. It is also interesting to note that in two of our five case studies, one being a primary school and the other a secondary school, most teachers were involved in producing software for their own use initially.

In the end, we found that there were many common elements that should permeate all the four levels but different elements should be found at each of the four levels. We termed these common elements the Key Attributes of a Teacher who is IT Competent in Education. The Key Attributes can be conceptualised as consisting of three distinct but related areas. These areas are: The practice of teaching, facilitator of learning and general professionalism. The following is a description of the Key Attributes and the elaboration of the four levels.

Key attributes of a teacher who is Information Technology (IT) Competent in Education is a statement of excellence. It succinctly outlines the characteristics expected of an IT competent teacher in Hong Kong. Teacher preparation, continual professional development and self-learning are the major determinants of the extent to which these characteristics are evident in our teachers. It is assumed that not all the characteristics are to be found significantly in teachers who are at the lower levels of IT competency. Nevertheless, all are characteristics to which all teachers should aspire and continue to develop.

The practice of teaching

- Able to use IT as productivity tools to enhance the efficiency and effectiveness of a teacher's work.
- Able to use and integrate IT selectively and critically in learning and teaching contexts including addressing the individual needs of students.
- Be aware of the paradigm shift in learning and teaching including the changing roles of students and teachers, changing conceptions about learning and teaching, a range of instructional strategies that involves using IT which will facilitate and enhance the learning of the students.

Facilitator of learning

- Able to facilitate the learning of the students in areas such as communication, accessing information, development of thinking skills and problem-solving skills, fostering of creativity, self-directed, cooperative and life-long learning, positive attitudes towards IT, and awareness of related equity, legal, ethical and social issues.

General professionalism

- Be aware of the use of IT to support self-learning, co-operative and life-long learning.
- Be aware of equity, legal, ethical and social issues in relation to the use of IT in education.
- Be aware of the current and future trends of IT and its applications in education.

In the context of these key attributes, the IT competency of a teacher can be further described at each of the four levels, Basic, Intermediate, Upper Intermediate and Advanced:

Basic Level:

At the Basic Level, a teacher needs be aware of the instructional, learning and management roles of IT in education, the changing roles of teachers and students including a teacher's new role as a learning facilitator,

and related equity, legal, ethical and social issues. A teacher needs to have basic skills and knowledge in the operations of computers and readily available educational courseware, and using simple features of tools such as word processors, Web browsers, presentation and e-mail software in education.

Intermediate Level:

At the Intermediate Level, a teacher will be able to make use of a wider range and more sophisticated features of IT tools in education, able to integrate these IT tools into learning and teaching contexts effectively, make better use of resources available on the Internet and Intranet, and able to evaluate simple IT-related educational resources such as readily available educational courseware.

Upper Intermediate Level:

At the Upper Intermediate Level, a teacher will be able to handle daily operations of computer networking, resolve simple hardware and software problems, integrate IT into learning and teaching proficiently and critically, and make effective use of authoring tools for lesson and educational resource preparation.

Advanced Level:

At the Advanced Level, a teacher should have an insight of the current and future trends of IT in education and integrating IT across the curriculum, and the core capability to advise the school on the formulation, implementation, management, monitoring and evaluation of its IT plan, including its hardware and software resources, staff development and support in IT, and promotion of IT culture in the school. In addition, a teacher can choose to develop in the areas such as designing of educational courseware and Web-based resources, multimedia production and presentation, database management system, and the conduct of a project in IT in education.

Further information about these levels of IT competency can be obtained at the following URL:
http://itined.ied.edu.hk/Itcompetency.htm

This study also proposed a set of professional development strategies for the Hong Kong teachers in relation to the application of IT in education. Based on a review of the various strategies in a number of countries, it was suggested an eclectic model comprising a number of methods that suits schools individually and the general situation in Hong Kong context would be appropriate. This is largely based on the consideration that the methods used must suit the needs of the schools by providing the necessary flexibility to the schools and the teachers.

There were three main strategies suggested. They were: school-based professional development; the use of hub-schools and centrally-approved providers.

School-based professional development was one strategy favoured by a large number of experts. The reason was partly related to the contextual professional development that could be related to the work situations of the teachers. Also, the cost of such professional development could be reasonably low compared to teachers having to spend time to travel substantial distance to attend courses elsewhere.

The research team understood from our consultation that virtually all secondary schools in Hong Kong have sufficient expertise to conduct school-based professional development at the basic level and beyond. Some primary school will have difficulties but it was suggested that external consultants could be brought in to assist such professional development.

The use of hub-schools could help to overcome some of the problems associated with school-based professional development such as isolation and lack of expertise and resources within individual schools. The hub school concepts requires the identification of a hub school within a cluster of school. Often, this school has some reasonably good IT facilities that could be utilized for the professional development of teachers to use IT. Also, based on overseas experience, the existence of knowledgeable and enthusiastic individual teachers could help to "maintain" the operations of hub schools for professional development purposes.

The research team also recommended that the Government should establish a list of government-approved professional development providers so that when schools do not have the expertise to conduct these activities, these providers can fill in the gaps. This was especially important for professional development

involving more complex IT skills and educational concepts.

In addition, the research team also recommended that a number of issues be considered when devising the appropriate professional development programmes for the teachers. These issues included: Emphasis on self-learning, availability of optional elements for teachers, activities that model more contemporary thinking on the use of IT in education, project-based learning, flexibility and modularization in the organization of development activities, credit-bearing, promotion, time-release and continual support for the teachers.

In this project, the research team was also required to recommend on the assessment methods used in gauging the IT competency of the teachers. Having examined the practices in many other countries, having consulted with the local and overseas experts, the team decided that the best way would be the use of portfolios. Each teacher would be required to produce a portfolio for each level of IT competency as described above. The use of portfolios for assessment in teacher education supports the current emphasis on meaning in learning and the need for the learner to adopt an active role in the learning process [8]. This supports the strong view expressed at the focus group meetings, that is "Assessment should be on whether they [teachers] can apply contents to their teaching subject in the context of the school". It is the informed view of the research team that through the use of portfolio assessment, then teachers' application of IT in education can be properly and authentically gauged. Also, from the perspective of teacher enablement and empowerment, the use of portfolio with the application of IT in real learning and teaching contexts can encourage the teachers to apply what they have learnt during professional development.

5 Conclusions

To conclude, the research team provided more detailed descriptions of the four levels of IT competency, recommended training contents and strategies as well as assessment. It is pleasing to report that the Hong Kong government has now accepted the recommendations by the research team. Large-scale professional development activities are now taking place for the teachers in Hong Kong. Many schools are conducting their school-based professional development activities, some with the help of eight government-approved professional development providers. With funding from the government on hardware and software installation, we are beginning to witness some massive educational reforms in Hong Kong as a result of the IT revolution.

References

[1] Au, W. K., Kong, S. C., Leung, K. P., Ng, M.W. & Pun, S. W., "Level of Information Technology Competency, Core Course Elements and Assessment Tool for Teacher Training in IT in Education: The Final Report". Hong Kong: Education Department, HKSAR, (1999).

[2] Best, T., "Ohio SchoolNet Technology and Learning Matrix. [on-line]", Retrieved on 17 June 1999 from the World Wide Web: http://www.milkenexchange.org/pdc/pdc_resources.html, (1999).

[3] CEO Forum. *The School Technology and Readiness Report.* Washington, CEO Forum, (2000).

[4] Department of Education (Tasmania), "Computers as Tools for Teaching and Learning", [on-line]. Retrieved on 15 June from the World Wide Web: http://www.ecpd.tased.edu.au/toolsTL/tools.html, (1997).

[5] Education and Manpower Bureau (EMB), "Information Technology for Learning in a New Era: Five-Year Strategy 1998/99 to 20002/03". Hong Kong: Education and Manpower Bureau, (1998b).

[6] Hoover, J. L., "Determining Staff Development Needs to Achieve Computer Technology Competence by Instructional Personnel in Gloucester County Public Schools", Blackburg, Virginia: Virginia Polytechnic Institute and State University. (Unpublished paper), (1997).

[7] International Society for Technology in Education, "National Standards for Technology in Teacher Preparation", [on-line]. Retrieved on 16 Apr 1999 from the World Wide Web: http://www.iste.org/Resources/Projects/TechStandards/index.html, (1997).

[8] Klenowski, V., "Guidelines for Portfolio Use in Initial Teacher Education", Hong Kong: Centre for Research and Development, Hong Kong Institute of Education, (1998).

[9] North Carolina State Department of Public Instruction, "NC Technology Competencies for Educators and Self-assessment Tools" [on-line]. Retrieved on 13 January 1999 from the World Wide Web: http://www.ofps.dpi.state.nc.us/OFPS/doclib.htm, (1998).

[10] Pressley M. and McCormick C.B., "Advanced Educational Psychology for Educators, Researchers and Policymakers", New York: HarperCollins College Publishers, (1995).
[11] Williams, M.D. and Wong P., "Proposed IT Competencies for Singapore Teachers", Singapore: Nanyang Technological University/National Institute of Education, (1999).
[12] 李傳彰、高鼎芳，教學科技與教師的資訊能力再造。視聽教學雙月刊，第 39 卷第 3 期，7-14 頁，(1997)。
[13] 洪華欣、施郁芬，未來教師應具備的「電腦與教學」相關知能。視聽教學雙月刊，第 39 卷，第 4 期，20-32 頁，(1998)。

Present State and Future Direction of Woman Informatization Education in Korea

In-Hwan Yoo* Chul-Hyun Lee* Soo-Bum Shin* and Tae-Wuk Lee*
**Dept. of Computer Education, Korea National University of Education*
**San 7, Darak-li, Kangnae-myun, Chongwon-gun, Choongbuk, Korea 363-791*
**E-mail:{bluenull, leesleek, ssb, twlee}@knue.ac.kr*

An informatization society, where high added value can be created through networks is different from an Industrial society where physical labor predisposes discrimination between men and women. As knowledge and information are regarded as the most important resources in an Informatization society, intelligence and emotional ability are given more importance than physical superiority. In light of this, the roles and positions of women are being newly evaluated, and the direction of the women's informatization movement has emerged as a new topic of the era. Korea places a strong emphasis on education and the percentage of women who attend University is also high. Contrary to this, the percentage of highly educated women who become working members of society is very low. These days, this problem has been recognized and education in woman informatization has actively proceeded. Taking various kinds of women's organization as the principal axis, woman informatization projects are actively unfolding. Government has also explored supporting plans in various aspects. This study explores the present state of women's informatization education and it's future direction.

Keywords: **Woman Education, Informatization Education**

1 Introduction

An Informatization Society is expected to be the 3F era: Female, Feeling, and Fiction. Productivity of culture and emotions is more important than labor productivity. Instead of labor productivity, sensitivity and intuition unique to women are expected to contribute a lot to the development of an emotional business that has high added value.

As the roles and position of women are newly evaluated, the direction of the women's informatization movement is emerging as an important topic. As it becomes necessary to have women's informatization education in Korea, a new movement has emerged. In light of this, this study will explore the present state and future direction of informatization education of women in Korea.

2 Present State and Problems of Woman Informatization Education in Korea

The studies on women and the informatization society have been introduced in Korea since the end of 1980. Until now, works on the development of women in an informatization society have been produced intermittently. The Korean Women's Association and National Women's Convention has dealt with "Woman and Informatization Society," and attracted the attention of the society of women overall. However, systematic, continuous and comprehensive studies on women and informatization have been insufficient. Also insufficient are the studies on the concrete policy alternatives for informatizing all women in accordance with national informatization.

2.1 Present State of Women's Informatization Education

Korean Women's Development Institute (http://kwdi.re.kr/)
·Government investing research institute ·Constructs public database first in Korea in 1995. ·Systematizes the professional information related to women and provide it by PC communication network ·Construct total distribution management system on woman information and Internet service in 1997
FemiNet Korea (http://www.feminet.or.kr)
·Established in 1996 with the purpose of ' Woman Informatization , ·Study on woman informatization, education, information culture business, operation of web-site ·Campaign on home informatization
Women Link (http://www.womenlink.or.kr)
·As professional woman movement organization, promote woman informatization ·Explore business to urge woman participation ·Plan the construction of DB on woman information
Asian Pacific Women's Information Network Center, Sookmyung Women's University (http://apwin.sookmyung.ac.kr/)
· Explore woman informatization project most actively among woman organizations attached to universities ·Construct Web-site in 1997 and provides information related to woman ·Hold international seminars · Obtain professionalism by connecting with other inside institutions attached to university including cyber institute ·Obtained the position of Chair of UNESCO · Play a role as main organization in woman informatization in Asia-Pacific regions including Korea and Japan.

<Table 1> Web site of representative women institutes

First, in the case of education, several women's organizations and social education centers for women hold basic computer training and some job training programs and lectures to expand the mind-set for informatization. However, the lectures are sporadic and temporary, and job training programs are limited to extremely small areas, and the content of training focuses on PC utilization, since it doesn't have the fundamental environment necessary.

Among informatization education at government levels, the women's professional training project of the Ministry of Information and Communication has been most systematically promoted. To solve the manpower problems and to nurture women professionals in the multi-media and content fields, the Ministry of Information and Communication has carried out various supporting projects since 1998. The main projects are shown below:

2.1.1 Support Educational Institute Attached to Women's Universities

This project is to support educational institutes attached to Women's Universities with educational expenses. Women university students and unemployed women will be intensively trained in the fields of information communication including S/W programming, system engineering, networking, and game · animation · media in prestigious education institutions exclusively for women, to get a job or open their own business.

2.1.2 Support 'The House of Working Women'

It also supports the education expenses of the House of Working Women. Homemakers and ordinary women can take training courses in the field of information and communication to get a job in the House of Working Women which has its own childcare center.

2.1.3 Support the Foundation of the Business Incubation Center of Women's Universities

To solve unemployment and to activate the foundation of businesses by women professionals, it supports the establishment of the Business Incubation Center in women's universities. With this project, about 16,000 students and homemakers have obtained information training in 1998, and about 250 woman professionals have established their own businesses.

2.1.4 Present State of Information Service and DB Building on Woman Informatization

Centered on a few women organizations and women research centers attached to universities including the Korean Women's Development Institute, FemiNet Korea, Asia-Pacific Women's Information Network Center, Sookmyung Women's University, women-related DB building and information services have been actively promoted. All these institutes have created the environment for women informatization based on the construction of N/W as an information infrastructure, and launched related education, culture and promotional projects.

In detail, 9 women's organizations out of 117, and 5 women's research centers out of 12 attached to universities that can operate social education programs besides the Korean Women's Development Institute, have operating Web Sites. Following are 4 organizations whose activities are the most active.

2.2 Problems in Woman Informatization Education in Korea

In Korea, accessibility to information devices is extremely different between genders. This difference of opportunity results in that of informatization and further causes severe inequality between genders as it becomes an informatization society.

A survey on Internet users by a Korean newspaper showed that the ratio of males to females among Internet users has largely changed. While the ratio of males to females from 1st to 3rd survey was 9:1, the 4th survey showed that female users had largely decreased the ratio discrepancy to 8.15: 1.85. Compared with the gender ratio among world Internet users (6.64 :3.36), that of Korea is found out to have a severe imbalance as ever[4].

Following is the concrete explanation of the problems of woman informatization in Korea[2].

First, the index of woman informatization is relatively low. Especially, that of homemakers was very low. Considering that the household is the basic unit of the nation, and responsible for enforcing social values through the supervision of the homemaker, it is a very severe problem.

Second, the number of women in higher professional training programs is decreasing, even though information training for woman at the regular or temporary training institutes is increasing quantitatively. As well, the professional training courses by temporary training institutes focus on the simple practice-oriented short-term training, reenacting the isolation phenomenon of women labor.

Third, in spite of the quantitative increase in informatization training for women, the number of women working in the information industry is being reduced. Information communication requires professional training in most fields, and it is necessary to make working environments in which women can continue to work and get in-service training even after getting married and having children.

3 Development Direction of Woman Informatization Education

With the advent of the informatization society, job areas divided by gender lost meaning, and accordingly women manpower can contribute to the development of society more and more. Unless fixed ideas on gender roles are discarded and replaced with a flexible way of thinking, the information estrangement of woman will become larger, and result in the loss of one axis of social development[6].
We will explore the development direction of informatization training of woman in the 21st century from this aspect.

3.1 Primary and Middle School Education

We would like to present the desirable direction of informatization education for girl students as follows:
First, school education should implement systematic education of information and provide as many opportunities as possible to allow girl students access to informatization education. Schools should also guide interest and instill a sense of closeness in information technology fields through the information technology related future course guidance after graduation.

In addition, the curriculum should be reorganized to make the most of information devices in each subject. Especially, careful attention should be given to organizing the education courses, so as not to isolate girl students, including elective courses only for girl students. Going one step further, information technology should be actively utilized in girls' elective courses including housekeeping and home economics courses, which will result in natural information education.

Second, the interest of girl students should be attracted to information through various activities including information contests for girl students. Excellent students should be picked out early and guided. Before determining whether the low index of woman informatization is inborn or learned, it is judicious for the government to give the highest consideration to the informatization of girl students in the education system.
Third, information education should be presented to the parents of those girl students who guide them at home. After all, home is the starting point and the last stop of education. An Information-oriented mind-set for students can be decisively affected by their parents. Especially, the informatization education of the parents of primary students has a high possibility to produce positives effect for the students. Accordingly, it will have a profound meaning in terms of education to provide informatization education which parents and students can participate in together.

Fourth, industrial-educational cooperation should be constructed for the education of girl students. Informatization education requires high-priced equipment and high quality personnel due to its character. It is difficult to say that hardware and software infrastructure for informatization education has been established in Korea. However, universities and industries have both foundation facilities and human resources, and as a result, the personnel trained at universities can be regarded as the consumer and beneficiary. Accordingly, the industrial-educational cooperation will result in an effective system for improving the quality of the informatization education and those institutes.

3.2 Policy Direction for Woman Informatization Education

We would like to present the desirable policy direction for the informatization education of women.

First, it is necessary to carry out education of women's problem at an early stage. Informatization education of women is to overcome the imbalance and irrationality that has emerged from gender discrimination. Accordingly, early education of women's problems should be carried out to enable them to overcome the sense of gender discrimination from the juvenile period, and help them with fundamental problem-solving.

Second, it is necessary to select the institutions or women organizations that can act as an axis of informatization education for women, and to allow them to play pivotal roles in that education. At present, many women's organizations have actively carried out and yielded some fruit. However, in reality, there is no center of woman informatization education that can collect the capabilities of many women's organizations. Informatization centers should be selected, networks by region and by institution should be created, and systematic and reasonable informatization education of women should be carried out. This network should also be expanded as an international organization through the Internet.

Third, it is necessary to rearrange and complement the education courses to connect school education to life-time education. For this purpose, education courses for the informatization education of girl students should be rearranged, which should result in systematic and hierarchical life-time education.

4 Conclusions

Due to the special nature of the information industry, women's labor power of processing and creation of knowledge has retained a new evaluation. Women's delicate nature, intellectual power, and creativeness herald the creation of new value. The emergence of new jobs and concepts of working places opens the new horizon for the possibility of the woman labor force. What is important here is, however, not to be satisfied with this possibility, but to turn this possibility into reality.

Educational fever in Korea is relatively high. The rate of women who go to universities is very high. Compared with those of advanced countries, however, less women with high education have made their way into the society, and as a result, the education for women remains as the consumptive type of education.

It is time to discard the view that the informatization education of women is just one area of expansion of

women's right. Korea has to recognize the importance of utilizing the tremendous number of potential women laborers as real available manpower, and to put a large investment and sufficient support into this.

References

[1] Asia-Pacific Women's Information Network Center, Sookmyung Women's University, http://apwin.sookmyung.ac.kr (accessed on July 30, 2000).

[2] Bong Suk, Son, "Information society and solidarity of women in Asia – Present status and assignments of woman informatization", FemiNet Korea(1998).

[3] FemiNet, Korea, http://www.feminet.or.kr/(accessed on July 30, 2000).

[4] Hankyoreh Newspaper, http://www.hani.co.kr/(accessed on July 30, 2000).

[5] Korean Women's Development Institute, http://kwdi.re.kr/(accessed on July 30, 2000).

[6] Tae Hee, Whang. "Women newspaper", Women newspaper office(1998).

[7] Women Link, http://www.womenlink.or.kr(accessed on July 30, 2000).

[8] Woman Newspaper, http://www.womennews.co.kr/(accessed on July 30, 2000).

[9] Young Whan, Yu, "Exploration on means to improve girl students' informatization ability. – Present status and development direction of woman informatization in Korea –", Korean Women's Development Institute(1998).

Space Plan for Effective Educational Software Utilization in Korea

Soo-Bum Shin* Chul-Hyun Lee* In-Hwan Yoo* and Tae-Wuk Lee*
**Dept. of Computer Education, Korea National University of Education*
**San 7, Darak-li, Kangnae-myun, Chongwon-gun, Choongbuk, Korea 363-791*
****E-mail:{ssb, leesleek, bluenull, twlee}@knue.ac.kr***

Need of the ICT(Information & Communication Technology) based education has been emphasized and importance of educational software is being recognized, but it is not being utilized effectively. To solve this problem, we surveyed present conditions, recognition, and obstructive factors of educational software utilization for teachers of elementary schools, junior high schools, and high schools, and school inspectors who use educational software in their schools by questionnaire and interview. On the basis of the surveyed matters, we suggested a plan to utilize educational software effectively in the teacher, educational software, support system, and environment side.

Keywords: **Educational Software, Effective Utilization**

1 Introduction

1.1 Purpose

The key target of the educational informationalization business in Korea is to improve methods and quality of teaching and learning by using various educational software. For this, total 3,400 educational software have been developed and distributed in Korea from 1985 to 1998, and software purchase expenses of 1 million won per school have been supported from 1998 to use software developed by private hands.

Although lots of software are being distributed to each school like this, rate of teachers who have used educational software is lower than expected and schools continuously appeal lack of educational software. But definite and objective factors of why educational software is not used properly have not been found.

Therefore, a realistic and practical plan for effective educational software utilization should be prepared for teachers in their schools by finding problems and actual conditions based on development, distribution, and utilization of present software and gathering opinions of demanders and suppliers of educational software.

1.2 Content and Methodology

This study surveyed the followings by questionnaire and interview[1].

First, Present conditions of educational software utilization. Second, Recognition of educational software utilization. Third, Obstructive factors to educational software utilization.

The subjects of questionnaire were 1568 teachers of 128 schools(8 schools of each two elementary school, junior high school, academic high school, and vocational high school under the Education Administrations of national 16 cities/provinces were selected). Especially, for the above Third matter, interview was added for school inspectors in charge of educational informationalization, chiefs of the information department and teachers in charge of the task in the 9 Education Administrations.

2 Concept and Category of Educational Software

The educational software may be wholly utilized in the education and educational support field.

Jeong Taek-hee et al. define educational software as 'data or program that are directly inputted to a teaching-learning course and mediate interaction between teachers and learners to achieve the educational object'[2].

This study focused on data or educational software made for teaching-learning and set the concept of educational software as "software with teaching-learning purposes of a diskette, CD-ROM, and web type, containing educational matters made with each kind of authoring tools or programming languages". Also, presentation and digital encyclopedia type, which are being used a lot in the field, are included in it.

3 Analysis of Educational Software Utilization

The questionnaires were recalled from 84 schools among 128 schools which received them and the recall rate was about 65.6%. But among them, 6 schools respond unfaithfully, so questionnaires for just 78 schools were handled, the response rate was about 56.7% consequently.

3.1 Present Conditions of Educational Software Utilization

As a result of questionnaire, it was surveyed that 67.8% of respondents have used educational software during the class. But it is just 1 time use and most teachers responded that they did not utilize it now.

Enough	Over 70%	Over 50%	Under 50%	Under 30%	Almost not utilizing	No response	Total
34(4.6)	32(4.3)	66(9.0)	0(0)	65(8.8)	471(63.9)	69(9.4)	737(100)

<Table 3-1> Degree of educational software utilization

The results of surveying reasons for not utilizing(for intending not to utilize) educational software are as <Table 3-2>.

Place	Reason for not utilizing
1	There is no proper educational software.
2	It is not suitable for curricular characteristics.
3	It is thought that there is no special need.

<Table 3-2> Reasons for not utilizing educational software

3.2 Will of Utilization of Educational Software

It was found that respondents who responded that they had a plan to utilize educational software were far more than respondents who had responded that the had not to the question, "Will you use educational software in future?". So it shows that the will of teachers to utilize educational software was significantly high.

Yes	No	No response	Total
453(61.5)	61(8.3)	223(30.2)	737(100)

<Table 3-3> Will you utilize educational software in future?

The reasons for having a plan for software utilization are first, increase of educational efficiency, and second, improvement of teaching quality, and other responses were attraction of students' interests, improvement of a visual effect, and playing a role of a teaching helper.

3.3 Obstructive Factors to Educational Software Utilization

The fact that there is a will to utilize educational software but it is not utilized involves many suggestions. This study considered it as an obstructive factor to educational software utilization and surveyed it by interview. The reason for using interview instead of questionnaire was for consideration of the field conditions which cannot be expected by questioners.

3.3.1 Hardware

(1) Inadequacy of Hardware Environment: To utilize educational software, specifications of hardware should be good. A student has a computer as the level of a computer per 15.8 students including from 286 grade to pentium grade and as the level of a computer per 19.1 students in case of efficient over pentium grade for utilization in Korea. This can be sufficient basis to raise consistent voice for field teachers, 'hardware environment is inferior'.
(2) Inferior Maintenance System: Computer produces various maintenance conditions such as from software error to exchange of computer mainframe. But present condition is that teachers are not sufficient to decide correctly and cope with these conditions.

3.3.2 Educational Software

(1) Lack of Utilization Capability of Educational Software in a Class: There were many opinions that they fall in utilization as an intention of educational software developer is not the same as the intention of teacher in a class. And, it was appeared that it is difficult for the software to connect with curriculum as reconstructing of educational software is difficult.
(2) Lacked Information about Educational Software: When teacher wishes to utilize educational software in a class, information to guide him are so insufficient. This functions as a factor to refuse the utilization of educational software by teacher as well as work excess of teacher.

3.3.3 Teacher

(1) Lack of Utilization Ability and Absence of Practical In-service Training: To utilize educational software effectively, teacher must have the ability to connect the contents of educational software with instruction contents. In-service training can be an appropriate method to improve this ability. But In-service training executed now includes mainly learning of fundamental ICT or development of educational software rather than utilization of educational software.
(2) Lack of a Study Time of Teaching Materials: To apply the educational software on a class in the school field, teacher must confirm the hardware environment, understand the contents and type of educational software by checking, and has an ability to reconstruct the contents of class. He must check various things himself as there are no sufficient existing information for utilization and there is nearly no place to ask. However, it was appeared that teacher did not utilize educational software as his task is so much for these works.

4 Utilization Plan of Educational Software

We examined recognition of teachers, actual condition of utilization, and obstructive factor about educational software as mentioned above. In this study, we will prepare a plan to settle obstructive factors educational software effectively and practically on the basis of this.

4.1 Hardware

We will suggest the plan for hardware as the consideration of 2 conditions such as exchange of the existing old computer and new installation. And other various conditions must be considered for current educational software. In consideration of these condition, gradual plans of the following 3 steps are necessary.
First, basic utilization must be induced by distributing multimedia PCs in classroom primarily. Second, multimedia room must be installed by each school with the first step together. It is because that multimedia room can be utilized for storage of educational software, role of file server, and development of educational software. Third, installed hardware is required to maintain certainly and to reinstall. To ensure the continuous maintenance and reinstallment for hardware can give sense of stability to the school and extend efficient utilization of educational software.

4.2 Educational Software

To utilize educational software efficiently, most of all, educational software with good quality must be developed and distributed in the school field. In addition to the development of educational software with good quality, P.R. about developed educational software is necessary urgently. We suggest plans in

consideration of these conditions as follows.

First, DB on the development educational software must be provided by the level of Ministry of Education. DB must arrange and construct contents to be a standard of selection such as subject, type, and characteristics about each educational software when teachers wish to utilize educational software. Second, educational software must be manufactured with easy type for utilization in a class and its development breaks from the form of collection. And it must be manufactured as a form with easy change of structure according to the class intention of teacher. Third, educational software must receive financial support to evaluate the quality of educational software, which is developed by a private enterprise, and to purchase and use it if it is excellent educational software.

4.3 Teacher

First, in-service training about practice of educational software must be performed. In U.S., State of California performs a in-service training to raise practicable ability educationally in the second step, the level of teaching, of teacher training course[3]. In Korea, the school field also indicates problems of the existing training and requires the training of this level. To supplement problems of the existing training and change it for practical training, first, what part is considered to be the most difficult for teachers must be examined when they intended to use the educational software. And we must analyze hardware problems and software problems met in running educational software and must perform a training about countermeasures against these error conditions to teachers. Especially, we must improve the ability of educational software selection as we let them evaluate educational software and let them apply it on a class during in-service training course.

Second, we must give study time of teaching materials to teacher for utilizing educational software as aiming at efficiency of work by arranging school management and administrative structure. And on the basis of studied contents, we must make a mood to study teaching materials for teacher by giving advantages such as allowance and promotion marks to teacher who carries out developmental class.

4.4 School Support System

In our country now, policies applied on education are made by policy investigators after examination of various facts and then are instructed collectively. To be sure, they provide results of study to the other school by study exemplary school, but practical results of study are not gained due to the lack of source of revenues and manpower. It is also applied in suggesting efficient settlement plan about educational software. To settle these problems, the study composed by following 4 steps must be performed continuously.

First, investigate facts indicated as problems in the school field concentratedly. Second, understand practical problems by analyzing investigated contents. Third, prepare settlement plans for practical problems. Fourth, apply this on the system.

4.5 Reorganization of Curriculum

Great vast digitalized data are being produced due to the development of ICT and the acquisition is possible easily. If students want and try, they can utilize base environment, which has already been prepared, to be able to acquire great information than teachers. Under these environments, it is required to learn method and experience to produce valuable information by utilizing knowledge than committing to memory of knowledge simply. This shows that it is required to reconsider what we teach in the school field. But as current curriculum is knowledge-centered curriculum and ICT is accessed with only simple support level for progress of class, difficulties of teachers have been added a load. Therefore, to aim at efficiency of practical education, curriculum must be reorganized for integrating ICT into education. This means that ICT must not play only a supporting role of education but be a base of education[4].

5 Conclusion

As modern society became informationalization society and knowledge based society, the amount of information increases rapidly and its life is short. Students must live in these society conditions and school must grow society adaptability of students. Currently computer is discussed on the same level of reading,

writing, speaking. In these flow, the importance of educational software has increased. Utilization of educational software enables not only to progress efficient class but also to extend ICT applicable ability of students. But the utilization of educational software is greatly lower than necessity of educational software. To settle this problem, it is required of curriculum and teaching method met with information society and ICT must be not supporting means of education but a base of education. And, first of all, an important thing is field teachers. Systematic support is required to utilize educational software for field teachers and effort of teacher itself is required.

References

[1] Lee Tae-wuk., "Study about Efficiency Plan of Development · Distribution · Utilization of educational software", Education policy study. Ministry of Education(1999).

[2] Jung Taek-hee et al., "Study about quality management plan of educational software", Study report RR 90-18. Seoul: Korean Educational Development Institute(1990).

[3] Technology-Based Performance Standards For Educators, http://ctap.k12.ca.us/grants/teachstds.html (accessed on August 14, 2000).

[4] Davjd F. Salisbury, "Toward a New Generation of Schools:The Florida Schoolyear2000 Initiative", Educational Technology. July. P. 7, (1992).

Using Learning Object Meta-data in a Database of Primary and Secondary School Resources

Daniel D. Suthers
Department of Information and Computer Sciences
University of Hawai'i at Manoa
1680 East West Road, POST 303A, Honolulu, HI 96822 USA
Tel: 1-808-956-3890
Email: suthers@hawaii.edu

The Learning Object Meta-data (LOM) is an emerging standard for annotation of educational entities (digital or nondigital) that are relevant to technology-supported learning. The annotations describe educational, legal, and technical characteristics of these resources. The IEEE Learning Technology Standards Committee sponsors development of this standard. In this paper we describe an application of the LOM to the construction of a database of resources available to schools in Hawai'i, and report on both successes and issues encountered. Recommendations are made concerning modifications to the LOM and adoption of the LOM by others working in primary and secondary school contexts.

Keywords: **Standards, Meta-data, Resource Databases**

1 Introduction

Internet technology for learning, including web-based resources, networked groupware and remote sensing have the potential to bring teachers and students together with a greater diversity and quantity of human, natural and technological resources than was previously possible. Educators and students can now access an enormous variety of web-based expository materials, images, activity plans, simulations, etc., and interact with people from many walks of life over the Internet. Already pressed for time, how will educators sort through this cornucopia of information and misinformation and find the resources appropriate for the educational needs of their students? Clearly, in order to leverage the great potential of this de-facto worldwide digital library, educators will need help. This paper is concerned with one form of help: databases of *meta-data* or information that describes the relevant characteristics of educational resources sometimes called *learning objects*. Properly constructed meta-data databases that have interfaces designed to match educator's perspectives should enable them to find relevant learning objects more quickly.

There are two other factors that also motivate this work. In the United States, there is currently a strong emphasis on systemic reform in public school education at the primary and secondary school levels. Being *systemic*, this movement is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. For example, the Educational System Reform (http://www.ehr.nsf.gov/EHR/ESR/) division of the US National Science Foundation requires that proposals for funding show evidence of significant collaborations between schools, universities and colleges, business and industry, and other community members in genuine support of sustainable reform (i.e., reform that continues beyond the funded period). As a result, organizations and individuals who have not previously worked together need to become aware of the resources they offer to each other. Hence databases of resources that are tailored for particular locations are needed. The present work is one example of such a database.

A third motivating factor is economic The cost of building educational materials, particularly technology-supported materials such as software, is high. All too often, persons and groups who are intellectually prepared to develop innovative new approaches to the application of technology to education spend most of their time rebuilding basic functionality. Recent interest in educational object repositories and educational

technology standards is motivated in large part by the desire to be able to find and reuse the work of others. Standards are being developed to describe learning objects [5] and to facilitate the interoperability of these objects once they are found [3]. This work is concerned primarily with standards for describing learning objects so that they may be found. Software interoperability has been addressed elsewhere (e.g., [2, 6]). Standards for describing learning objects also address economic issues surrounding resource databases because databases are expensive to build. Rather than replicate existing meta-data, it is preferable to access existing meta-data repositories. However, this requires standard forms for meta-data.

In summary, these forces require educators and their partners to be aware of the diversity of resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. Resource databases should adequately describe a diverse variety of resources yet relate them all to common educational objectives, describe the resources in terms understandable to educators, and interoperate with other major repositories. In this paper we report on our first efforts to design such a resource database to meet these needs within the State of Hawai'i as part of a systemic initiative known as Hawai'i Networked Learning Communities. Specifically we report on our use of an emerging standard, the Learning Object Meta-data (LOM). The paper provides a brief introduction to the LOM, describes its application to HNLC, and discusses limitations and extensions to the LOM that were required. Finally, readers are provided with information on how to participate in the development of the LOM.

2 Background

2.1 Learning Object Meta-data

Meta-data, simply defined, is data about data [4, 7]. Meta-data defines the characteristics of other data so that it may be interpreted and used intelligently. In this sense meta-data enables us to use data as *information*. The phrase *learning object* is used to inclusively denote a wide variety of entities used to support learning, including but not limited to digital resources such as software, multimedia, or hypertext, and nondigital resources such as courses of study, professional development programs, or persons who have volunteered to serve as mentors. Assembling these concepts, we come to *learning object meta-data*, which is somewhat of a misnomer in that the meta-data is not only describing data, but also other entities that are not data (such as persons). Yet the term "meta-data" is already in wide use for this purpose, so will be used herein.

2.2 Technical Standards

A *technical standard* is a specification of shared terms, interfaces, representations, practices, etc. If an artifact (such as computer or networking hardware, a software program, or data representations) is constructed to be compliant with a technical standard, then that standard ensures that multiple stakeholders will be able to interpret or interface with that artifact without needing to ask for help from the creator of the artifact. That is, a standard helps ensure interoperability and reuse. A standard is expressed in a document that sets forth the scope and purpose of the standard and the mandatory conditions for compliance. The existence of a standard, e.g., for learning technologies, does not mean that everyone is expected to comply with the standard. It only sets forth the conditions for those who elect to claim compliance with the standard.

2.3 The IEEE LTSC Learning Object Meta-data

The IEEE (Institute of Electrical and Electronics Engineers, http://www.ieee.org/) is an international organization for engineers of electrical and information technologies. IEEE has a well-defined standards development process administered by its Standards Activity Board (http://www.computer.org/standards/). The Learning Technology Standards Committee (LTSC), which was founded in 1996 by a group of academic, government, and industry representatives (including the author), chose to use the IEEE standards process for this reason. The LTSC sponsors several learning technology related standards efforts, at various levels of maturity ranging from speculative to approaching balloting. The Learning Object Meta-data draft standard [1] (also known by its IEEE identifier as 1484.12) is arguably the most mature of the LTSC draft standards. According to a recently circulated revision to the Project Authorization Request, "The purpose of this standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors. The purpose is also to facilitate the sharing and exchange of learning objects, by enabling the development of catalogs and inventories, taking into account the diversity of cultural and lingual contexts in which the learning objects and their meta-data will be exploited."

The LOM standard is meant to provide a semantic model for describing properties of the learning objects themselves, rather than detailing ways in which these learning objects may be used to support learning. The LOM indicates the legal values and informal semantics of the meta-data elements, their dependencies on each other, and how they are composed into a larger structure. It is intended to be extended, and in fact a structure has been provided specifically for the purpose. The LOM is agnostic concerning *bindings* or implementations of meta-data in particular representations or notations, such as XML. (At this writing, a study group is exploring a separate XML binding specification.) No particular representation or implementation is specified or implied by the LOM. Systems that are LOM compliant may present users with any interface they wish and store the meta-data however they wish. The LOM specifies only the semantics of the meta-data in order to enable meaningful interchange of meta-data between systems.

An outline of the LOM meta-data elements as of draft 4.1 [1] is provided in Table 1. In this table, nesting indicates a compositional relationship. For example (adopting notation commonly used in the LOM committee), a single 1.3:Catalog.Entry consists of a 1.3.1:Catalogue and an 1.3.2:Entry; while a 9:Classification consists of several types of sub-elements, some of which themselves also have internal structure. Much important information has been left out of this table for space considerations. For example, some data elements may take on multiple values which may be ordered or unordered, and some must be taken from restricted vocabularies or reference other standards for their values.

Table 1 Outline of Learning Object Meta-data Elements

1 **General**	4.5 Installation Remarks
1.1 Identifier	4.6 Other Platform Requirements
1.2 Title	4.7 Duration
1.3 CatalogEntry	5 **Educational**
1.3.1 Catalogue	5.1 Interactivity Type
1.3.2 Entry	5.2 Learning Resource Type
1.4 Language	5.3 Interactivity Level
1.5 Description	5.4 Semantic Density
1.6 Keywords	5.5 Intended end user role
1.7 Coverage	5.6 Context
1.8 Structure	5.7 Typical Age Range
1.9 Aggregation Level	5.8 Difficulty
2 **LifeCycle**	5.9 Typical Learning Time
2.1 Version	5.10Description
2.2 Status	5.11Language
2.3 Contribute	6 **Rights**
2.3.1 Role	6.1 Cost
2.3.2 Entity	6.2 Copyright and Other Restrictions
2.3.3 Date	6.3 Description
3 **MetaMeta-data**	7 **Relation**
3.1 Identifier	7.1 Kind
3.2 Catalog Entry	7.2 Resource
3.2.1 Catalogue	7.2.1 Identifier
3.2.2 Entry	7.2.2 Description
3.3 Contribute	7.2.3 CatalogEntry
3.3.1 Role	8 **Annotation**
3.3.2 Entity	8.1 Person
3.3.3 Date	8.2 Date
3.4 Meta-data Scheme	8.3 Description
3.5 Language	9 **Classification**
4 **Technical**	9.1 Purpose
4.1 Format	9.2 TaxonPath
4.2 Size	9.2.1 Source
4.3 Location	9.2.2 Taxon
4.4 Requirements	9.2.2.1 Id
4.4.1 Type	9.2.2.2 Entry
4.4.2 Name	9.3 Description
4.4.3 Minimum Version	9.4 Keywords
4.4.4 Maximum Version	

Brief descriptions of the major element categories follow. *1:General* provides information such as title, a brief textual description, and keywords. *2:Life.Cycle* describes the development and current state of the resource. *3:Metameta.Data* describes the meta-data itself, e.g., who entered or validated this meta-data instance and what language it is written in. *4:Technical* provides information on media type, size, software requirements, etc. for those learning objects to which these attributes apply. *5:Educational* is intended to provide basic information about the pedagogical characteristics of the resource. This category includes some of the most controversial elements, to be discussed further below. *6:Rights* describes the conditions under which one may acquire and use the learning object. *7:Relation* is intended to describe the learning object in relation to other learning objects. At this writing there is a controversy concerning whether this may be used to control sequencing of a collection of learning objects, or whether that should be deferred to other standards being developed for the purpose. *8:Annotation* allows for the accumulation of comments by persons who have used or are otherwise evaluating the learning object. *9:Classification* provides a means of extending the LOM to meet specialized needs. 9:Classification comes in the form of a generic structure for classifying the learning object in one or more taxonomic systems external to the LOM. Most of our extensions used 9:Classification.

3 HNLC Resource Database

The remainder of this paper describes our first prototype design and implementation of a learning object resource database, specifically focusing on the use of the LOM as a guiding framework for the design, and on ways in which extensions to the LOM were required. I briefly describe the initiative that this database was intended to serve before discussing the application of the LOM itself.

3.1 Hawai'i Networked Learning Communities

The Hawai'i Networked Learning Communities (HNLC, http://lilt.ics.hawaii.edu/hnlc/) initiative is a partnership between the Hawai'i Department of Education (HDOE), the University of Hawai'i, and many other stakeholders in the quality of Hawai'i public education, such as business and nonprofit interests. HNLC's purpose is to prepare all students in Hawai'i's public schools for life and careers in today's world by enabling them to attain high standards in science, math, engineering and technology (SMET) education. The HNLC initiative is supporting HDOE in its systemic standards-based reform efforts by leveraging Hawai'i's rich land, sea, space, and cultural resources. A theme of "global environmental studies, situated locally" pervades the work. From the standpoint of technology-supported learning, HNLC has three major thrusts. First, professional development will help educators make better use of technologies as educational resources in their classrooms. Second, distance collaboration and remote sensing technology will bridge the distances between small rural schools and the islands' rich resources, enabling virtual access to field sites, research laboratories or equipment, and, most importantly, peers and mentors of students, teachers and others involved in the educational process. Third, a web-accessible database will address one of the most frequent requests encountered during our needs assessment: knowing what resources are available to educators in Hawai'i. This paper is about the suitability of the LOM for this database.

3.2 Scope of the Database

The database describes resources for public school education ranging from Kindergarten (K) to 12th grade, also abbreviated as K-12. Standards-based reform is essential to the initiative: hence all resources must be described with respect to the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/), a document specifying what should be taught and how students' learning should be assessed. A wide variety of resources will be described, making this a particularly challenging test implementation of the LOM. For example, the following resources might be included:

- A university program in which Ph.D. students have their expenses paid in exchange for mentoring teachers for a certain number of hours a month. This can take place over the Internet; ideally, the teacher's students become involved in field report in support of the Ph.D. thesis.
- Nationally recognized curricular resources developed at the University's Curriculum Research and Development Group (http://www.hawaii.edu/crdg/).
- A software program with which students can construct explicit visual models of their evidential reasoning while participating in investigations (http://lilt.ics.hawaii.edu/belvedere/index.html).
- A network of autonomous weather stations and remote controlled cameras, to be placed in the Alaka'i swamp (one of the rainiest place on Earth) or Volcano National Park, in some cases with the cameras

trained on individuals of endangered plant species, with radio links to the Internet (http://www.botany.hawaii.edu/pods/).

- A nurse practitioner at a local military hospital who volunteered her time to telementor students on medical topics.
- Malama Hawai'i, a new environmental education project started by the famed Polynesian voyager Nainoa Thompson (http://www.malamahawaii.org/).
- Advanced placement courses in computer science and discrete math, offered by our department to high school students via Hawai'i DOE's Internet-based E-School (http://atr.k12.hi.us/eschool/index.shtml).
- The He'eia Ahupua'a, in which researchers and school children collaborate to study the integration of modern and traditional Hawai'ian land management techniques (Internet collaboration and mentoring is being planned: http://kauila.k12.hi.us/~ahupuaa/).
- A Community College's research grade 24" telescopes, recently displaced from Haleakala by larger telescopes and now being installed for Web-accessible use at the CC. The telescopes are still viable for new asteroid, comet and supernova survey research that can be conducted by high school students over the web, being supervised by college students and their professional mentors.
- Diverse resources for teaching constructed by teachers and made available to others as part of a new product-oriented approach to professional development credits being implemented by HDOE.

All of these fall within LOM's scope of "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (from the original Project Authorization Request, http://ltsc.ieee.org/par-lo.htm) because we will be using distance collaboration and remote sensing technology (as well as the database itself) to support learning using these resources. To control the scope of our work, HNLC will prioritize the description of local resources and interface with other repositories for nationally available resources (e.g., GEM).

4 HNLC LOM Meta-data

In designing the meta-data for resources such as those listed above, we found it necessary to extend the LOM. As previously noted, the LOM was designed to be extended. In some cases the predefined LOM elements were adequate, and in other cases we were able to perform the desired extensions using the LOM 9:Classification facility. However in a few cases it was necessary to extend restricted vocabularies (which is not normally allowed), and in other cases structural issues arose. In this section I describe the most significant extensions, including the issues just mentioned.

4.1 Method

Our team consisted of Susan Johnson and Beth Tillinghast (Library and Information Science students), Laura Girardeau (an Environmental Education graduate), and David Nickles (a Computer Science graduate).

Initially Johnson and Tillinghast wrote informal textual descriptions capturing the important information about a representative sample of the resources that we wanted to describe. After reviewing these descriptions I presented the LOM draft 4.1 [1] to the entire team, which required extensive discussions for clarification. We then went through the textual descriptions and identified LOM elements in which the information expressed could be captured. Where we failed to find LOM elements for an item of information we extended the LOM, either by expanding on the vocabulary of an existing element or by creating an entirely new element under 9:Classification.Where new elements were needed we searched other repositories to find meta-data that we could use. Several iterations were required to understand the LOM structure well enough to define our instances of 9:Classification. (It should be noted that end users are not expected to understand the LOM: the LTSC community expects that suitable interfaces will be developed, and no end user will even need to know that the LOM exists. We were approaching the LOM as information professionals, not end users.) Then Nickles created a Filemaker implementation of the resulting HNLC-LOM and provided the others with an interface for building meta-data (Figure 1). Johnson and Tillinghast then created meta-data for our sample. I then reviewed the result to detect possible misunderstandings and issues. I also compiled a first draft of issues and recommendations. This draft was shared with the LTSC LOM committee, both via email and subsequently face to face in an LTSC meeting (Montreal, June 2000). Thanks to their feedback, many issues were resolved or re-understood as non-issues, and many further clarifications resulted.

4.2 Vocabularies

The data type of LOM elements may be primitive (e.g., a string), reference other standards (e.g., vCard), or consist of a controlled vocabulary. In the latter case, the vocabulary may be restricted, meaning that only the terms listed may be used, or open with recommended practice, meaning that one should attempt to use one of the terms listed as the recommended practice but may extend this vocabulary if needed. One extends the vocabulary by using a tuple of form (See_Classification, *term*). The *term* is the new term being added to the vocabulary. One must define an instance of 9:Classification that has the same 9.1:Purpose as the data element being extended, and define a 9.2:Taxon.Path as needed to indicate where the term falls within the taxonomic system indicated by 9.2.1:Source. (A taxon path can be thought of as a sequence of taxons, which begins at the root of a taxonomic hierarchy and works its way down the tree through intermediate nodes to the leaf node under which the object is being classified.)

For example, suppose one wants to extend 5.2:Learning.Resource.Type with the term "Curriculum" taken from the Gateway to Educational Materials (GEM) Resource Type vocabulary, (http://www.geminfo.org/Workbench/Metadata/Vocab_Type.html).
One would place the tuple (See_Classification, "Curriculum") in the 5.2 location, and then construct an instance of 9:Classification with 9.1:Purpose = Learning.Resource.Type, a single 9.2:Taxon.Path with 9.2.1:Source = "GEM Resource Type," and a single 9.2.2:Taxon with 9.2.2.2: Entry = "Curriculum" (there is no ID available).

Although this seems much more awkward than simply using the term "Curriculum" in the 5.2:Learning.Resource.Type field, two points should be kept in mind. First, it is a powerful general-purpose way of extending vocabularies with information about the taxonomic source of the term, and hence its semantics. If we were to simply add a termto 5.2:Learning.Resource.Type its semantics would be inaccessible, as there would be no place to record where the term came from. Second, the LOM information structures are neither specifications of an implementation nor specifications of a user interface: implementations are free to reorgainze the presentation of information to the user as convenient (e.g., to present extensions to vocabularies *as if* they were simply added to the same field in question).

We found several of the LOM vocabularies for 5:Educational to be insufficient for our purposes. In one case, 5.2:Learning Resource Type, the vocabulary was open and the insufficiencies could be addressed via the extension mechanism just described. However, vocabularies for 5.1:Interactivity.Type (values: Active, Expositive. Mixed, or Undefined) and 5.5:Intended.End.User.Role (Teacher, Author, Learner, Manager) are restricted vocabularies, so cannot be extended in this way. We have made the recommendation that these be changed to open vocabularies until better consensus on an adequate term set can be obtained with the help of the various communities expected to be using the LOM.

4.3 Structural Issues

In some cases we felt that the vocabulary should be replaced with a structured description. This was actually the case for 5.1:Interactivity.Type and 5.5:Intended.End.User.Role (see next section), as well as 5.7:Typical.Age.Range. Concerning the latter, K-12 educational resources in the United States are almost always referenced by grade level rather than age range. Other applications may require other measures. Anticipating the need for flexibility, we recommended that 5.7:Typical.Age.Range be changed to a structured element with 5.7.1 Measure (e.g., "Chronological Age," "GEM Grade," etc.) and 5.7.2:Value (e.g., "12," "7-8," etc.).

More problematic are ways in which the value of one element depends on another. We noted that 5.9:Typical.Learning.Time depends on 5.7:Typical.Age.Range, for example, a textbook might be described as suitable for a fast paced graduate course or a two-semester undergraduate sequence. Erik Duval later pointed out that this applies to 5.4:Semantic.Density and 5.8:Difficulty as well. Hence I recommended reorganizing these elements in a manner such as the following:

5.x Challenge Level, consisting of one or more 4-tuples:
- 5.x.1 Educational Level (formerly 5.7), consisting of one or more pairs:
  - 5.x.1.1 Measure (e.g., Age, US Grade, ...)
  - 5.x.1.2 Value (e.g., 7-8)
- 5.x.2 Semantic Density (formerly 5.4)
- 5.x.3 Difficulty (formerly 5.8)
- 5.x.4 Learning Time (formerly 5.9)

Then one could create multiple instances of 5.x: Challenge.Level, with the values of 5.x.2 through 5.x.4 being dependent on the value of 5.x.1:Educational.Level. It is possible to *implicitly* achieve the same effect by replicating entire LOM meta-data instances, one for each developmental level (or age); but we feel that it would be far more perspicuous and efficient to acknowledge the dependency explicitly in a structure such as the above.

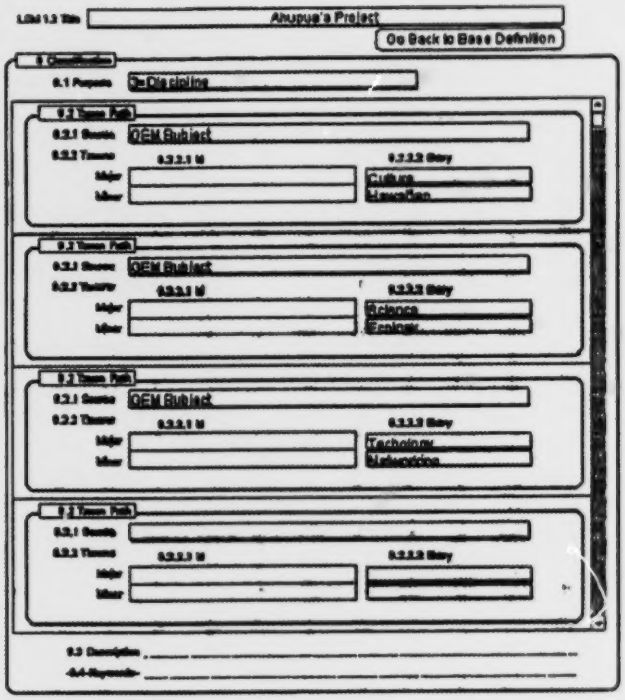


Figure 1. Prototype HNLC Resource Database: a Discipline classification

4.4 Our Extensions to the LOM

The following extensions were made using 9:Classification.

4.4.1 Audience

This extension effectively replaces 5.5:Intended.End.User.Role with the GEM Audience (http://www.geminfo.org/Workbench/Metadata/Vocab_Audience.html), a two-part classification consisting of ToolFor (who uses the tool) and Beneficiary (who benefits). For example, a professional development resource that helps teachers handle learning disabled children in their classes is for the teacher but benefits the particular population of learning disabled students. We would prefer that 5.5: Intended.User.Role be modified to be composed of 5.5.1:Tool.For and 5.5.2:Beneficiary.

4.4.2 Community Involvement

This extension describes how a resource interacts with various stakeholders. We are designing this classification ourselves. We are considering a two-part classification: One for the community entity involved, and the other for the type of involvement.

4.4.3 Discipline

This extension describes the subject matter area covered by the resource. There is presently no LOM field that does this (other than possibly 1.7:Coverage, which has limitations beyond the scope of this paper). We are using the GEM Subject. This is a two-level classification system, requiring a two-step Taxon Path, for example Science/ Astronomy. We found it necessary to add two first-level classifications to the GEM Subject: Technology and Culture. An example using these subjects is shown in Figure 1, a partial screen dump of our Filemaker prototype implementation. We also needed a way to indicate cross-curricular integration. For this we again elected to modify the GEM taxonomy by allowing any major level Subject

header to be listed as a minor header under the subject with which it is integrated. For example, Science/Mathematics would indicate that the resource integrates Mathematics into Science (since Mathematics is normally a Major taxon). For the GEM Subject controlled vocabulary see http://www.geminfo.org/Workbench/Metadata/Vocab_Subject.html.

4.4.4 Educational Level

This extension augments LOM 5.7:Typical.Age.Range, and is structured as described in the previous section.

4.4.5 Educational Objectives

This extension addresses content and performance standards. It is distinct from Discipline because it is more specific: it aligns the resource with the particular standards that the resource is intended to help achieve. Examples of national (US) content and performance Standards include America's Choice (http://www.ncee.org/ac/intro.html); NCTM standards for mathematics (National Council of Teachers of Mathematics, http://nctm.org/standards/); the NSES for science (National Science Education Standards, http://www.nap.edu/readingroom/books/nses/html/), and the National Educational Technology Standards (NETS http://cnets.iste.org/). An example of a state standard is the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/).

4.4.6 Pedagogy

This extension addresses the *severe* deficiency of the LOM's 5.1:Interactivity.Type, a closed vocabulary of {active, expositive, mixed, undefined}. We have recommended that the vocabulary for 5.1 be reopened. However our version provides an even richer description of interactivity, using the GEM Pedagogy controlled vocabulary. This vocabulary (http://www.geminfo.org/Workbench/Metadata/Vocab_Pedagogy.html) has three facets: Teaching Methods (GEM provides a large vocabulary), Grouping (individual, small group, large group, etc.), and Assessment (which is sometimes integrated into the pedagogy).

5 Conclusion

Internet technology for learning, including groupware and remote sensing, have the potential to bring teachers and students together with a greater diversity of human, natural and technological resources than was previously possible. Additionally, the current emphasis on systemic reform in public school education in the United States is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. These forces require that educators and their partners be aware of the resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. The HNLC Resource Database is being designed to meet such a need in the context of systemic standards-based reform in the state of Hawai'i. The demands on such a database are high: it should interoperate with other major repositories, adequately describe a diversity of resources, yet relate them all to common content and performance standards and generally describe the resources in terms understandable to educators. The LTSC's Learning Object Meta-data (LOM) is being developed in part to lay the foundations for meeting such needs. In this paper I described our attempt to use the LOM for the HNLC Resource Database. We found that it provides a solid foundation in the form of many well thought out data elements as well as a means for extension. We also found that the LOM does not address all the needs of the HNLC Resource Database. This cannot be expected as the LOM is being designed to serve a variety of applications in government and industry as well as public education. We were able to deal with most of the limitations through the Classification method of extension. However some of these extensions were due to premature closure of the LOM vocabularies. More problematic were structural dependencies between LOM elements that are not well captured at present. These issues were illustrated with examples from K-12 education.
The Learning Object Meta-data standard is under active development at this writing. It is hoped that this paper will help increase awareness within the primary/secondary education sector worldwide of the LOM standards effort, and encourage your contribution to further development of the standard to be more appropriate for primary/secondary education needs. Anyone may participate: see http://ltsc.ieee.org/ for details.

Acknowledgements

Thanks to Susan Marie Johnson, David Nickles and Beth Tillinghast for contributing to the design of the HNLC meta-data, David Nickles for implementing the first prototype of our resource database, and all of the above plus Laura Girardeau for constructing meta-data. Thanks to Erik Duval, Wayne Hodgins, Tom Murray, Brendon Towle, and Tom Wason for their "meta-comments" on my LOM commentary. This work was funded in part by a development grant from the National Science Foundation's Rural Systemic Initiative.

References

1. IEEE Std. 1484.12 (draft). Draft 4.1 of the Learning Objects Metadata (LOM), IEEE, Piscataway, N.J., USA, 2001. Available: http://ltsc.ieee.org/doc/wg12/LOM_WD4.htm
2. Koedinger, K., Suthers, D., and Forbus, K. (1999). Component-based Construction of a Science Learning Space. International Journal of Artificial Intelligence in Education (1999), 10, 292-313. (Also available at http://cbl.leeds.ac.uk/ijaied/home.html)
3. Miller, P. (2000). Interoperability: What is it and why should I want it?. Ariadne 24. Available: http://www.ariadne.ac.uk/issue24/interoperability/
4. Milstead, J. & Feldman, S. (1999a). Metadata: Cataloging by any other name. Online 23(1), 24-31. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html
5. Milstead, J. & Feldman, S. (1999b).Metadata: Projects & standards. Online 23(1), 32-40. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html#projects
6. Roschelle, J., DiGiano, C., Koutlis, M., Repenning, A., Phillips, J., Jackiw, N.,& Suthers, D. (1999). Developing educational software components. Computer, 32(9), pp. 50-58. Piscataway, NJ: IEEE Computer Society.
7. Wason, T. D. (unpublished). Dr. Tom's Meta-Data Primer. Available: http://www.imsproject.org/drtommeta.html

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsors
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▷Full & Short Papers (Special Education)

Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space

Present State and Future Direction of Woman Informatization Education in Korea

Research on Teaching Da-Yi Chinese Keyboarding by Using Adaptive Input Interface

The effectiveness of integrating adaptive computer device and stimulus fading strategy on word-recognition for students with moderate mental retardation

▲HOME

Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space

Toshinori Yamasaki, Tetsuo Hattori and Yukihiro Matsubara
Faculty of Engineering, Kagawa University
Hayashi-cho, Takamatsu, Kagawa 761-0396 Japan
Yamasaki (hattori, matsubar)@eng.kagawa-u.ac.jp

The students acquire a visual literacy through learning the coloring systematically in the fine arts subject. This paper describes an extraction method for the aesthetic impression of the paintings based on the tone in the Muncell color space for fine arts subject. The impression, which the human being gets from the paintings, depends on the motif, the composition and the coloring. Here, we discuss the evaluation method of the paintings by the computer based on the tone that includes the lightness (intensity) and the saturation (vividness). We perform the evaluation experiment of the paintings that have a unique coloring. The evaluation result approximately resembles the impression of which human being is moved. This method is also useful for retrieving the image database using the ambiguous key words like the impression words.

Keywords: **aesthetic impression of paintings, color tone, color harmony, visual literacy, fine arts subject, image retrieval system**

1 Introduction

Fine arts subject educates the ability of the sense beauty, that is, a visual literacy through recognizing a form and a color. For training such a visual literacy, it is important for the students to understand the nature of color systematically. Visual literacy that is the aesthetic judgment ability becomes the basis of the expression and the appreciation activity in the fine arts learning. The students acquire the visual literacy by experience through repeated practice of painting the picture. On the other hand, there are the empirical rules about the composition and the coloring in the art. As for the color harmony, Ostwald, Muncell and Moon Spencer are well known.

Recently, the multimedia database spreads widely with the development of the network technology. In the multimedia database retrieval, it is useful that we can refer database using the impression words and the ambiguous feeling words in addition to the key words. Recently, an image database retrieving by impression words as beautiful, balmy is reported [1-5].

We report the extraction way of the aesthetic impression degree of the paintings based on the Moon Spencer's color harmony theory [6]. However, in the Moon Spencer's way, we can estimate the degree of the beauty as the numerical value but we cam not know the detail impression like the dark, light, bracing impression which each painting gives. In this study, we describe more concretely the way of extraction the aesthetic impression of the paintings based on the tone in the HLS Muncell color space.

2 The tone and the systematic color names

We call a suitable coloring the color harmony. In the color harmony theory, Ostwald, Muncell and Moon Spencer are well known. Also, a color system is established by JIS (Japanese Industrial Standards) and

PCCS (the Japanese Color & Coloring System).

Here, we use the tone in the Muncell HLS space for estimating the impression of the paintings more precisely. We express a color by the word, which shows the impression of the color like the light green, the dark green. There is a difference between bright and dark, strong and gentle, vivid and muddy in the same color, same hue. We call this difference the tone (Lightness and Saturation). The tone is a concept of the lightness L and the saturation S being compounds and shows an impression of the color, which doesn't depend on the hue well. As the tone has an each image, it is easy to connect the tone the psychological effect of the color. We can evaluate the feeling impression of the paintings by extraction the tone from the image data. In this paper, we adopt the PCCS tone for evaluating the impression of the paintings [7]. The PCCS defines the tone in the lightness L and the saturation S in the Muncell color space and gives color system as the tone and the hue. The PCCS classifies into 12 kinds of tones in each hue and packs the same tone of the every hue. Figure 1 shows the classification of the tone.

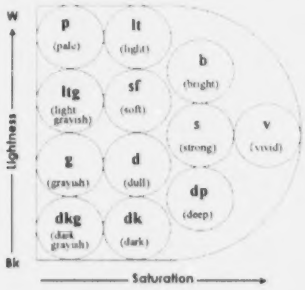


Figure 1 Tone (Lightness – Saturation)

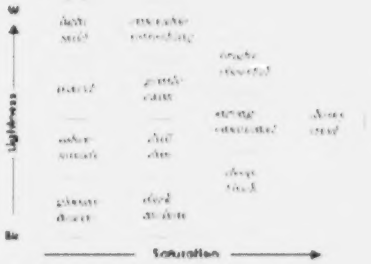


Figure 2 Systematic Color Names

The tone image is defined by the systematic color names in the PCCS color system. The systematic color names is the color expression way that gives a modifier according to each fundamental color like white, red and blue. It sets a way of combining a fundamental color name and modifier. The modifier in PCCS includes an adjective, which shows the hue difference like the tinge of red, green. On the contrary, it has no word, which shows only lightness or a saturation. The bright impression includes not only the high intensity but also the vivid saturation. The mild impression means the high lightness and low saturation. Figure 2 shows the systematic color names of the tone space.

3 Evaluation of the aesthetic impression

After getting the image data through the scanner, we extract the impression feature of the paintings. Figure 3 shows the outline of our method. The resolution and the size of the image data is 120 [pixels/inch] and 640*512 [pixels] respectively. The image data is a full color, bit map.

The image data has RGB color component and doesn't connect with the color sense of the human being straight. Also, it is difficult to adjust the color tone in the color synthesis. Here, we convert the RGB to the HLS value in the Muncell color space, which fits for the color sense of the human being. Mucell color system shows the color as the three components, H (Hue), L (Lightness) and S (Saturation) and is used widely in the coloring. Figure 4 shows the Muncell HLS color space. We get the H[0,360], L[0,1], S[0,1] values through the conversion of the RGB[0-255] value.

BEST COPY AVAILABLE

The number of the colors in the image data is enormous for processing data by a computer. Here, we reduce the number of colors to the degree, which doesn't loose the color tone of the paintings. We divide the H, L and S to 10 and 14 respectively.

Hue (H)	Lightness (L)	Saturation (S)
R	8.5	14
YR	9	13.5
Y	9	13
GY	9	12
G	8.5	11
BG	8.5	10
B	8.5	10
PB	8	11.5
P	8	11.5
RP	8.5	12.5

Table 1 Maximum Values of L, S

Figure 4 HLS Muncell Color Space

Figure 3 Outline of the Extraction Process

The maximum value of the L and the S depends on the coloring material and each hue shown in table 1. Therefore, the value range of the L and S is different according to each hue. For example, the maximum L, S value of the Red and Purple hue is 8.5, 14.0 and 8.0, 11.5 respectively. Here, we normalize the L, S value 0-10 ranges.

From the above way, we estimate the number of the pixel in the S-L tone space through mapping the image data to the tone space. We can find the aesthetic impression of the paintings by estimating the position of the mapped pixel in the tone space because of the correspondence between the tone space and the impression modifier shown in figure 2. In this experiment, we evaluate the number of the colors, which accounts for 70 % of the color area. However, we cannot estimate the impression because the distribution in the tone space becomes apart. Here, we calculate one position of the tone space from several distributed positions using the weight coefficient of each tone position.

$S = W_i S_i \qquad L = W_i L_i \qquad (1)$

Where $Wi = \sum(a_i / \sum a_j)$ a_i is the number of the occupied pixel in each color.

We estimate the impression of the paintings according to the tone index (S, L) defined in equation (1).

4 The evaluation experiment

The simple coloring picture is tested beforehand. As a result, the showy picture of the pure color and the gloomy picture are mapped over the v (vivid) and dkg (dark grayish) tone respectively. Typical paintings and poster works from renaissance to modern are tested in this experiment shown in table 2. Figure 5 and figure 6 shows examples of the paintings and the typical mapping result in the tone space respectively. We can evaluate the aesthetic impression of the paintings using figure 6 and figure 2. The extraction impression is listed as follows.

"Mona Lisa" (2) of Leonardo da Vinci is famous for gently smiling lady. This painting locates near dk (dark) in the tone and gives dark, mellow impression.

Monet's "Water Lily" (5) is said the mystic beauty of the surface of the water and is situated on the tone space near ltg (light grayish). We can say that the water lily has a cooled silent image.

Gogh's "Sun Flower" (8) is painted yellow strongly which he liked most. It is situated on the tone space near s (strong). From this result, we can evaluate that the impression of sunflower is strong, passionate painting.

Figure 7 shows the mapping result of the works in table 2. The above-mentioned results agree with the established reputation and the eye inspection of human being.

Table 2 Lists of Paintings and Design Pictures

	Painter	Style	Work	epoch
1	Leonardo da Vinci	Renaissance	Virgin of the Rock	1503
2	Leonardo da Vinci	Renaissance	Mona Lisa	1503
3	Rembrandt	Baroque	Night Watch	1642
4	Rembrandt	Baroque	Raising of the Cross	1633
5	Monet	Impressionist	Water Lilies	1903
6	Monet	Impressionist	Flower Pot	1903
7	Monet	Impressionist	Popies	1873
8	Gogh	Modern	Sun Flowers	1888
9	Gogh	Modern	Self Portrait	1889
10	Signac	Impressionist	Saint-Tropez	1900
11	Renoir	Impressionist	Theater Box	1874
12	Renoir	Impressionist	Les Grands Boulevard	1880
13	Renoir	Impressionist	La Liseuse	1876
14	Klee	Modern	Baldgreis(Senecio)	1922
15	Matisse	Modern	Green Stripe	1905
16	Matisse	Modern	Red Room	1947
17	Munch	Modern	Screem	1893
18	Munch	Modern	Sick Chiled	1895
19	Poster	Design	Star Wars	
20	Poster	Design	Bug's Life	

Figure 5 Examples of the paintings

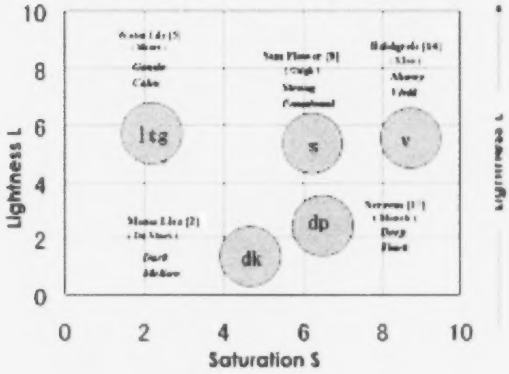


Figure 6 Mapping Result in the Tone (1)

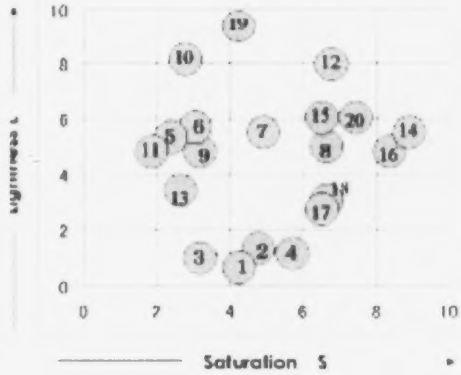


Figure 7 Mapping Result in the Tone (2)

5 Conclusions

We proposed the way of evaluating the beauty and impressive sense of the paintings and design pictures based on the tone in the Muncell color space. We use the tone space, which can concretely express the color impression and a corresponding systematic color names. This method suits the aesthetic impression degree evaluation by the computer because the evaluation processing doesn't depend on the hue.

After getting the image data through the scanner, we convert each RGB pixel the tone space in HLS Muncell color space. We extract the location of the paintings in the tone space by calculating the coefficient of the occupied area. The aesthetic impression is estimated by the location of the used color in the tone space.

The famous paintings from renaissance to modern are tested for extracting the impression feeling. "Mona Lisa" of Leonardo da Vinci and Gogh's "Sun Flower" is estimated as matured darkly and strongly passionate impression respectively. These results tell us that the distinction by the computer coincide with an established reputation of the paintings.

The impression extraction by this way is useful for the students learning how to use color arrangement in their fine arts subject.

Acknowledgments

This research was supported by Grant-in Aid for Scientific Research on priority areas (12040229) from the Japanese Ministry of Education and Culture.

References

[1] K., Hachimura, " Retrieval of Paintings Using Principal Color Information," Proc. 13th ICPR, pp.130-134, 1996.

[2] A., Tojima and K, Hachimura, "Extraction of compositional feature from paintings and application for retrieval," Trans. IPS Japan, vol.40, no.3, pp.912-920, Mar. 1999.

[3] H., Kimoto, "An image retrieval system using impressional words and the evaluation of the system," Trans. IPS Japan, vol.40, no.3, pp.886-898, Mar. 1999.

[4] H. Nozaki and Y. Isomoto, "Information retrieval for fine arts database system," Trans. IEICE Japan, vol.E80-D, no.2, pp.206-211, Feb. 1997.

[5] E., Masuyama, "How to analyze the impression of paintings from the point of KANSEI engineering," Proc. JSISE Conf. '97, K3A32a4, pp355-358, Sep. 1997.

[6] T. Yamasaki, T. Hattori, " An Aesthetic Impression Extraction of Paintings for the Fine Arts Subject," Int. Con. Computers in Education (ICCE99), pp.329-332, 1999.

[7] Nihon Color Research Institute, "PCCS Harmonic Color Charts," 1999.

Present State and Future Direction of Woman Informatization Education in Korea

In-Hwan Yoo* Chul-Hyun Lee* Soo-Bum Shin* and Tae-Wuk Lee*
**Dept. of Computer Education, Korea National University of Education*
**San 7, Darak-li, Kangnae-myun, Chongwon-gun, Choongbuk, Korea 363-791*
**E-mail:{bluenull, leesleek, ssb, twlee}@knue.ac.kr*

An informatization society, where high added value can be created through networks is different from an Industrial society where physical labor predisposes discrimination between men and women. As knowledge and information are regarded as the most important resources in an Informatization society, intelligence and emotional ability are given more importance than physical superiority. In light of this, the roles and positions of women are being newly evaluated, and the direction of the women's informatization movement has emerged as a new topic of the era. Korea places a strong emphasis on education and the percentage of women who attend University is also high. Contrary to this, the percentage of highly educated women who become working members of society is very low. These days, this problem has been recognized and education in woman informatization has actively proceeded. Taking various kinds of women's organization as the principal axis, woman informatization projects are actively unfolding. Government has also explored supporting plans in various aspects. This study explores the present state of women's informatization education and it's future direction.

Keywords: **Woman Education, Informatization Education**

1 Introduction

An Informatization Society is expected to be the 3F era: Female, Feeling, and Fiction. Productivity of culture and emotions is more important than labor productivity. Instead of labor productivity, sensitivity and intuition unique to women are expected to contribute a lot to the development of an emotional business that has high added value.

As the roles and position of women are newly evaluated, the direction of the women's informatization movement is emerging as an important topic. As it becomes necessary to have women's informatization education in Korea, a new movement has emerged. In light of this, this study will explore the present state and future direction of informatization education of women in Korea.

2 Present State and Problems of Woman Informatization Education in Korea

The studies on women and the informatization society have been introduced in Korea since the end of 1980. Until now, works on the development of women in an informatization society have been produced intermittently. The Korean Women's Association and National Women's Convention has dealt with "Woman and Informatization Society," and attracted the attention of the society of women overall. However, systematic, continuous and comprehensive studies on women and informatization have been insufficient. Also insufficient are the studies on the concrete policy alternatives for informatizing all women in accordance with national informatization.

2.1 Present State of Women's Informatization Education

Korean Women's Development Institute (http://kwdi.re.kr/)
·Government investing research institute ·Constructs public database first in Korea in 1995. ·Systematizes the professional information related to women and provide it by PC communication network ·Construct total distribution management system on woman information and Internet service in 1997
FemiNet Korea (http://www.feminet.or.kr)
·Established in 1996 with the purpose of 「Woman Informatization」 ·Study on woman informatization, education, information culture business, operation of web-site ·Campaign on home informatization
Women Link (http://www.womenlink.or.kr)
·As professional woman movement organization, promote woman informatization ·Explore business to urge woman participation ·Plan the construction of DB on woman information
Asian Pacific Women's Information Network Center, Sookmyung Women's University (http://apwin.sookmyung.ac.kr/)
· Explore woman informatization project most actively among woman organizations attached to universities ·Construct Web-site in 1997 and provides information related to woman ·Hold international seminars · Obtain professionalism by connecting with other inside institutions attached to university including cyber institute ·Obtained the position of Chair of UNESCO · Play a role as main organization in woman informatization in Asia-Pacific regions including Korea and Japan.

<Table 1> Web site of representative women institutes

First, in the case of education, several women's organizations and social education centers for women hold basic computer training and some job training programs and lectures to expand the mind-set for informatization. However, the lectures are sporadic and temporary, and job training programs are limited to extremely small areas, and the content of training focuses on PC utilization, since it doesn't have the fundamental environment necessary.

Among informatization education at government levels, the women's professional training project of the Ministry of Information and Communication has been most systematically promoted. To solve the manpower problems and to nurture women professionals in the multi-media and content fields, the Ministry of Information and Communication has carried out various supporting projects since 1998. The main projects are shown below:

2.1.1 Support Educational Institute Attached to Women's Universities

This project is to support educational institutes attached to Women's Universities with educational expenses. Women university students and unemployed women will be intensively trained in the fields of information communication including S/W programming, system engineering, networking, and game · animation · media in prestigious education institutions exclusively for women, to get a job or open their own business.

2.1.2 Support 'The House of Working Women'

It also supports the education expenses of the House of Working Women. Homemakers and ordinary women can take training courses in the field of information and communication to get a job in the House of Working Women which has its own childcare center.

2.1.3 Support the Foundation of the Business Incubation Center of Women's Universities

To solve unemployment and to activate the foundation of businesses by women professionals, it supports the establishment of the Business Incubation Center in women's universities. With this project, about 16,000 students and homemakers have obtained information training in 1998, and about 250 woman professionals have established their own businesses.

2.1.4 Present State of Information Service and DB Building on Woman Informatization

Centered on a few women organizations and women research centers attached to universities including the Korean Women's Development Institute, FemiNet Korea, Asia-Pacific Women's Information Network Center, Sookmyung Women's University, women-related DB building and information services have been actively promoted. All these institutes have created the environment for women informatization based on the construction of N/W as an information infrastructure, and launched related education, culture and promotional projects.

In detail, 9 women's organizations out of 117, and 5 women's research centers out of 12 attached to universities that can operate social education programs besides the Korean Women's Development Institute, have operating Web Sites. Following are 4 organizations whose activities are the most active.

2.2 Problems in Woman Informatization Education in Korea

In Korea, accessibility to information devices is extremely different between genders. This difference of opportunity results in that of informatization and further causes severe inequality between genders as it becomes an informatization society.

A survey on Internet users by a Korean newspaper showed that the ratio of males to females among Internet users has largely changed. While the ratio of males to females from 1st to 3rd survey was 9:1, the 4th survey showed that female users had largely decreased the ratio discrepancy to 8.15: 1.85. Compared with the gender ratio among world Internet users (6.64 :3.36), that of Korea is found out to have a severe imbalance as ever[4].

Following is the concrete explanation of the problems of woman informatization in Korea[2].

First, the index of woman informatization is relatively low. Especially, that of homemakers was very low. Considering that the household is the basic unit of the nation, and responsible for enforcing social values through the supervision of the homemaker, it is a very severe problem.

Second, the number of women in higher professional training programs is decreasing, even though information training for woman at the regular or temporary training institutes is increasing quantitatively. As well, the professional training courses by temporary training institutes focus on the simple practice-oriented short-term training, reenacting the isolation phenomenon of women labor.

Third, in spite of the quantitative increase in informatization training for women, the number of women working in the information industry is being reduced. Information communication requires professional training in most fields, and it is necessary to make working environments in which women can continue to work and get in-service training even after getting married and having children.

3 Development Direction of Woman Informatization Education

With the advent of the informatization society, job areas divided by gender lost meaning, and accordingly women manpower can contribute to the development of society more and more. Unless fixed ideas on gender roles are discarded and replaced with a flexible way of thinking, the information estrangement of woman will become larger, and result in the loss of one axis of social development[6].
We will explore the development direction of informatization training of woman in the 21st century from this aspect.

3.1 Primary and Middle School Education

We would like to present the desirable direction of informatization education for girl students as follows:
First, school education should implement systematic education of information and provide as many opportunities as possible to allow girl students access to informatization education. Schools should also guide interest and instill a sense of closeness in information technology fields through the information technology related future course guidance after graduation.

In addition, the curriculum should be reorganized to make the most of information devices in each subject. Especially, careful attention should be given to organizing the education courses, so as not to isolate girl students, including elective courses only for girl students. Going one step further, information technology should be actively utilized in girls' elective courses including housekeeping and home economics courses, which will result in natural information education.

Second, the interest of girl students should be attracted to information through various activities including information contests for girl students. Excellent students should be picked out early and guided. Before determining whether the low index of woman informatization is inborn or learned, it is judicious for the government to give the highest consideration to the informatization of girl students in the education system.
Third, information education should be presented to the parents of those girl students who guide them at home. After all, home is the starting point and the last stop of education. An Information-oriented mind-set for students can be decisively affected by their parents. Especially, the informatization education of the parents of primary students has a high possibility to produce positives effect for the students. Accordingly, it will have a profound meaning in terms of education to provide informatization education which parents and students can participate in together.

Fourth, industrial-educational cooperation should be constructed for the education of girl students. Informatization education requires high-priced equipment and high quality personnel due to its character. It is difficult to say that hardware and software infrastructure for informatization education has been established in Korea. However, universities and industries have both foundation facilities and human resources, and as a result, the personnel trained at universities can be regarded as the consumer and beneficiary. Accordingly, the industrial-educational cooperation will result in an effective system for improving the quality of the informatization education and those institutes.

3.2 Policy Direction for Woman Informatization Education

We would like to present the desirable policy direction for the informatization education of women.

First, it is necessary to carry out education of women's problem at an early stage. Informatization education of women is to overcome the imbalance and irrationality that has emerged from gender discrimination. Accordingly, early education of women's problems should be carried out to enable them to overcome the sense of gender discrimination from the juvenile period, and help them with fundamental problem-solving.

Second, it is necessary to select the institutions or women organizations that can act as an axis of informatization education for women, and to allow them to play pivotal roles in that education. At present, many women's organizations have actively carried out and yielded some fruit. However, in reality, there is no center of woman informatization education that can collect the capabilities of many women's organizations. Informatization centers should be selected, networks by region and by institution should be created, and systematic and reasonable informatization education of women should be carried out. This network should also be expanded as an international organization through the Internet.

Third, it is necessary to rearrange and complement the education courses to connect school education to life-time education. For this purpose, education courses for the informatization education of girl students should be rearranged, which should result in systematic and hierarchical life-time education.

4 Conclusions

Due to the special nature of the information industry, women's labor power of processing and creation of knowledge has retained a new evaluation. Women's delicate nature, intellectual power, and creativeness herald the creation of new value. The emergence of new jobs and concepts of working places opens the new horizon for the possibility of the woman labor force. What is important here is, however, not to be satisfied with this possibility, but to turn this possibility into reality.

Educational fever in Korea is relatively high. The rate of women who go to universities is very high. Compared with those of advanced countries, however, less women with high education have made their way into the society, and as a result, the education for women remains as the consumptive type of education.

It is time to discard the view that the informatization education of women is just one area of expansion of

women's right. Korea has to recognize the importance of utilizing the tremendous number of potential women laborers as real available manpower, and to put a large investment and sufficient support into this.

References

[1] Asia-Pacific Women's Information Network Center, Sookmyung Women's University, http://apwin.sookmyung.ac.kr (accessed on July 30, 2000).

[2] Bong Suk, Son, "Information society and solidarity of women in Asia – Present status and assignments of woman informatization", FemiNet Korea(1998).

[3] FemiNet, Korea, http://www.feminet.or.kr/(accessed on July 30, 2000).

[4] Hankyoreh Newspaper, http://www.hani.co.kr/(accessed on July 30, 2000).

[5] Korean Women's Development Institute, http://kwdi.re.kr/(accessed on July 30, 2000).

[6] Tae Hee, Whang. "Women newspaper", Women newspaper office(1998).

[7] Women Link, http://www.womenlink.or.kr(accessed on July 30, 2000).

[8] Woman Newspaper, http://www.womennews.co.kr/(accessed on July 30, 2000).

[9] Young Whan, Yu, "Exploration on means to improve girl students' informatization ability. – Present status and development direction of woman informatization in Korea –", Korean Women's Development Institute(1998).

Research on Teaching Da-Yi Chinese Keyboarding by Using Adaptive Input Interface

Ming-Chung Chen*, Hwa-Pey Wang and Lih-Ching Chen Wang*****
**National Chiayi School for the Mentally Retarded*
123, Sec 2, Shi-Shian Rd. Chiayi city,Taiwan.
E-mail:mtchen@blue.com.url.com.tw
***National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan.
E-mail: hpwang@icon.ntnu.edu.tw
****Cleveland State University*
1860 E. 22nd Street, 1438 Rhodes Tower, Cleveland, OH 44114 E-mail: l.c.wang@csuohio.edu

The purpose of this study was to examine the effects of teaching three students with moderate mental disability in a specialized high school in Taiwan to learn Da-Yi Chinese keyboarding by using adaptive input system. A single-subject multiple-probe baselines design across subjects was used. The students used the Unlimiter system as the adaptive input interface to learn to differentiate the locations of the Da-Yi character roots on a keyboard and to learn Chinese keyboarding with Da-Yi character roots. The result shows that all three students can distinguish the locations of the Da-Yi character roots without extra instruction and interact with the computer with Da-Yi input method. The applicability and effectiveness of teaching high school students with moderate mental disability in learning Da-Yi Chinese keyboarding was supported.

Keyword: **adaptive computer system, Da-Yi Chinese Keyboarding, special education, mental disability**

1 Introduction

With the rapid advancement of the Internet, our life has become more tied to the Internet and the utilization of the computer is becoming increasingly important. In daily life, people are becoming more familiar with Internet shopping and using email to communicate. In educational planning, many countries are putting emphasis on classroom computers and the Internet [5][6]. Moreover, various Internet-based learning modes are the focus of research in those countries [12][13] in hope of using the Internet to assist students to learn anytime and anywhere and are consequentially achieving the ideal of equal educational opportunity and quality education.

However, for the disabled, because of their disability in the functions of the body, senses, and cognition, it is hard for them to use the technology of computers and the Internet. Enabling the disabled in utilizing these technologies with an accessible environment is an important issue facing the educators.

The government in Taiwan views the establishment of a computer environment with accessibility for the disabled as a priority. When the Department of Education started putting the infrastructure of computer classrooms and Internet access in place in K-12 schools in 1998, it purchased a batch of computers with specialized Internet accessibility for the local school districts and special education schools in hopes that the disabled students can use the specialized equipment to learn computer skills and the Internet, thus enabling them to further their learning with the help of the computer and Internet.

Specialized computer accessories can reduce the problems that the disabled encounter in input and output so

that they can use the computer more easily. Therefore, as far as input device accessibility is concerned, the emphasis is on the input interface, for example, keyguard, touch-screen, trackball, replacement keyboard -- mini-keyboard and enlarged keyboard, etc. Although these input devices make the computers more accessible and easier to use, no matter which accessible input interface is employed, a user still has to learn a method of Chinese input to be able to use the computer in learning and communications.

Currently, four kind of Chinese input mechanisms are used: keyboarding, voice input, writing input, and optical scan. Keyboarding is the most common input method among them[4][14][15]. In fact, although the other ways are more convenient , keyboarding is more useful for individuals with more severe mental disability, since they experiences difficulty with cognition, speech, and motor skills [8][9].

Whichever input method is employed, keyboarding has to be utilized to complete the process of interfacing with the computer in Chinese. Furthermore, keyboarding, per se, is not restricted to finger typing on a keyboard. It is broadly viewed as using the key codes on the keyboard to spell characters and words. A user can input by clicking the keys with a mouse on a displayed mini-keyboard on the computer monitor, by using a replacement keyboard, by using a single on/off key in conjunction with menu scanning, or even by using Morse code. Thus, it is an important key issue to know how to help the disabled, intellectually and/or physically, to learn effective computer keyboarding that enables them to communicate with people.

There are several methods for typing Chinese characters on the computer. These input methods can be grouped into two categories: One is phonetic-coding input; the other is pattern-coding input. The former is inputting Tzu-Yin phonetic symbols or Han-Yu phonetic spelling to have the computer display the homonyms, while the latter is inputting the codes of disassembled basic character patterns, for example, Chang-Jay pattern coding and Da-Yi pattern coding to have the computer display a corresponding Chinese character. Among the current methods, Tzu-Yin, Chang-Jay and Da-Yi are most commonly used[3].

The authors chose Da-Yi as the input method in this study based on the reasons below:

A. The prerequisite of using Tzu-Yin input method is that one must be able to pronounce and spell out a character[7]. This is difficult for students with mental disabilities.
B. Chang-Jay input method was developed based on the character-construction rules while Da-Yi keyboarding starts with writing-stroke rules. This way, the students could keyboard with the sequence of writing.
C. Some research results show that students with mild mental disability perform worse in using Tzu-Yin keyboarding than in using Chang-Jay [10]. The students spent a lot of time learning. Students with moderate mental disabilities could learn to use the Da-Yi input method quickly.
D. Da-Yi input method may be worthwhile for students with mental disabilities to learn in the information age. But how can we assist the students in learning Da-Yi more effectively and less frustratingly?

Therefore, the purpose of this research was to explore if the students can learn to use the Da-Yi input method on the keyboard.

2 Research Methodology

2.1 Experimental Subjects and Setting

Three high school students with moderate mental disability in the Chia-Yi special school participated in this research. The subjects were selected on the basis of three criteria. First, they were capable of using verbal communication. Secondly, their emotions were stable. Thirdly, their fine motor movement, especially that of the hands, could be controlled by themselves.

Although they are too old to take an IQ test, they were all identified as having moderate mental disability when they entered this school. In order to realize the subjects' characteristics, the researchers reviewed their IEP files and interviewed their teachers. A summary of the subjects' characteristics appears in table 1.

Instruction was conducted by the researchers in the school's counseling room. A personal computer with an Unlimiter computer interface system (called the U1 system by special education educators in Taiwan) were placed on the table. The U1 system was designed by the Assistive Technology Foundation. It is a kind of programmable keyboard that can be designed by the instructor[2]. The subject sat in front of the table and operated the U1 system while the instruction took place.

Table 1 Subject's Characteristics

Subject	Age	Grade	Gender	Experience in Computer Use?	Performance of literature
• •	17y4m	12th	Male	Yes	Can read and write some common words, Articulation disorder Received speech-language therapy.
• •	17y11m	12th	Female	No	Can read and write some common words, oral expression is good
C	18y7m	10th	Male	No	Oral expression is good. Can read printed words excluding his personal information, e.g. name, address.•

2.2 Stimuli

2.2.1 Character roots instruction

There are 253 character roots in the Da-Yi input method. These character roots are divided into 40 groups depending on their attributes. The researchers chose the most frequently used 2 characters for each group, which were a total of 80 characters (see Figure 1).

2.2.2 Keyboarding instruction

328 words that were divided into 4 sequent groups according to the construction of the word were chosen for the keyboarding practice. These four groups are: group A "from left to right" (•), group B "from top to bottom " (•), group C "combination of the previous two types" (•), and group D "from outside to inside" (•). These words were chosen based on their frequency of use and the explicitness of the word formation. The subjects practiced keyboarding from easier character root formations to more complicated ones.

2.2.3 Words for generalized testing

Three groups of tests were designed. The first group contained 28 new words that were never practiced before. The second involved 21 sentences and 172 words that were practiced in the instruction period. The third group were some written articles.

2.4 Apparatus

This study uses a multimedia computer with a 19-inch monitor and Unlimiter, an adaptive input system. Unlimiter is a kind of programmable keyboard for which the user could design the layout to suit their purpose. In this study, the researchers designed a layout as an alternative keyboard for the subjects. The content of the layout is in Figure 2.

2.5 Definitions of Independent and Dependent Variables

The independent variable was the instructional design that contained the arrangement of the keyboarding practice words based on the explicitness of word formation and the use of the Unlimiter computer input system.
The dependent variables were effectiveness of learning (percentage of correctly keyboarded target words) and efficiency of learning (numbers of sessions the subject required in order to reach the master criteria).

Figure 1 the table of Da-Yi character roots

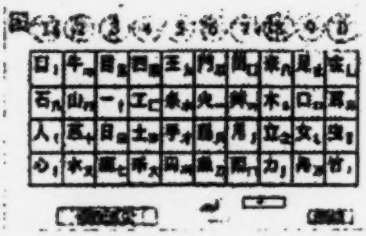


Figure 2 the layout of Da-Yi input method

2.6 Design

A multiple-probe baseline across subjects was used. The particular strengths of the multiple-probe baseline design were: (a) the treatment was not reversed, (b) prolonged baseline measures were unnecessary, and (c) the design permitted the evaluation of academic learning [1][11]. A constant time delay technique was selected for instruction in this study, and verbal praise was used as reinforcement.

2.7 Procedure

The research was divided into two steps: instruction of Da-Yi character roots followed by the instruction of the Da-Yi input method. Researchers randomly decided prior to the instruction which subjects would receive instruction. The next group of subjects received instruction when the previous student group entered the "from upper to lower" keyboarding instruction.

2.7.1 The instruction of Da-Yi character roots

In this step, subjects learned about the 80 Da-Yi characters roots on the layout. The subject would not go to the second step, the instruction of the Da-Yi input method, until he or she reached the master criteria, which was 90% correct responses in three continuous sessions.

2.7.2 The instruction of the Da-Yi input method

There were three periods of instruction. They were baseline, instruction sessions, and maintenance & generalization. During the baseline period, the subjects were measured on their accuracy of keyboarding with the Da-Yi input method. The percentage correct measured after testing each group of target words was used as the subject's baseline performance.

During the instruction sessions period, researchers taught the students the necessary keyboarding rules for the sequence of writing. The instruction started from group A"from left to right". The subject practiced and took a test with the *Microsoft Excel* software. The researchers demonstrated keyboarding the target word if the student could not keyboard it correctly in the 20-second time-delay period. The student could not advance to practicing the next group until he or she reached the master criteria, which was a 90% correct response in three continuous sessions.

In order to examine whether the subjects could maintain and generalize their keyboarding abilities, we continued to assess the subjects' performance of new words, sentences and articles without prompting.

2.8 Reliability

In order to assess the subjects' response accurately, we immediately recorded the results of subjects' keyboarding in *Microsoft Excel*.

3 Result

3.1 Da-Yi Character Roots

The three subjects were measured for their familiarity with Da-Yi character roots by having them indicate the target key on the layout. The results showed that all three students could indicate the 80 character roots under the researchers' order. It meant that the subjects could go to learn Da-Yi input method without supplemental learning of character roots.

3.2 Keyboarding- Four groups of words

The percentage of correctly keyboarded training words in the four groups during the instruction sessions for each subject is presented in Figures 3, 4, and 5. For these three subjects, it is obvious that they could learn to keyboard with the Da-Yi input method. Student A could type these four forms of words almost 100% correctly. The performance of Student B indicated that she fulfilled the criteria in every measurement except the first trial of group A and group D.

Student C only fulfilled the mastery criteria for group A. However, student C could reach the mastery criteria and learn how to keyboard with the Da-Yi input method.

According to the performance of these three subjects, we found that teaching keyboarding to moderately mentally disabled students with the Da-Yi input method using Unlimiter as an adaptive input system is a valid method, especially when student C did not recognize these characters.

The instruction was efficient. Student A reached the mastery criteria in the minimal number of sessions. Student B used three sessions for groups B and C, and four sessions for groups A and D. Student C spent three sessions on group A, four sessions on group C and group D, and five sessions on group B. They all could learn to master the keyboarding rules with the Da-Yi input method with short-term instruction.

3.3 Maintenance & Generalization.

3.3.1 New words

The subject was measured on their generalization of a group of new words after their mastery of the four groups of words with different word formations. The results are presented on table 2. They could generalize the rules of keyboarding for words not practiced before.

3.3.2 Sentence

Students were asked to keyboard 21 sentences and 172 words composed of the words they practiced. The results on table 2 indicate that the three subjects could keyboard almost 100% correctly.

3.3.3 Articles

Due to time limitations, student B only finished article one, and student C did not have the opportunity to type the articles with the Da-Yi input method. As the results in table 2 show, student A and student B could keyboard almost all the content of the articles although some words were never practiced.

Therefore, the three subjects could generalize the rules of keyboarding with the Da-Yi input method they had learned into new words, sentences, and articles.

Table 2 Numbers of correct inputting of the three subjects in generalization test

	New words (n=28)	Sentences (n=172)	Article one (n=130)	Article two (n=227)	Article three (n=142)
Student A	28	172	127	225	136
Student B	25	170	125		
Student C	24	172			

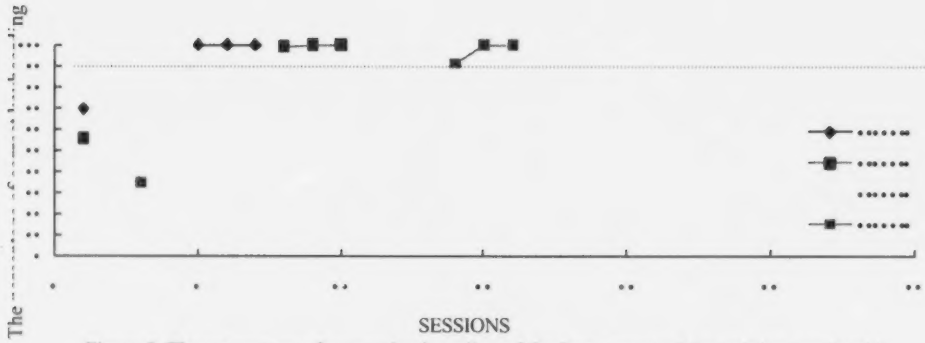


Figure 3. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student A

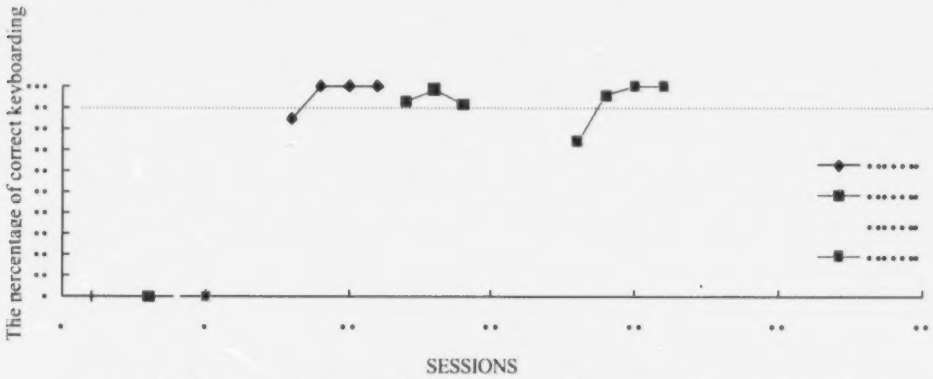


Figure 4. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student B

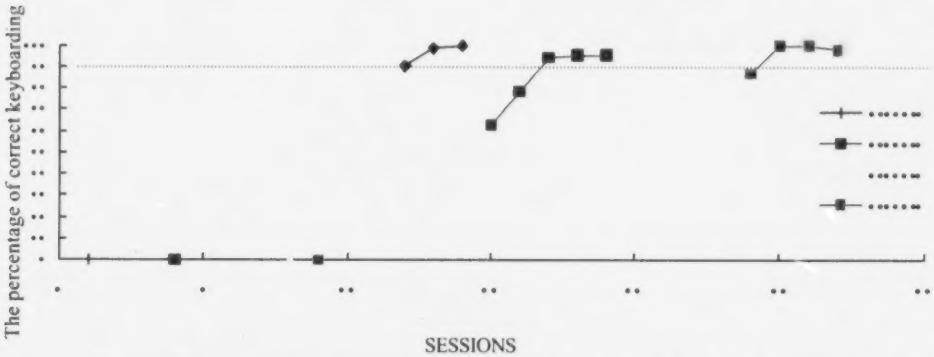


Figure 5. The percentage of correct keyboarding of the four groups of the training words with Da-Yi input method during the instruction sessions for student C

4 Conclusions

The purpose of this study was to examine the effects of teaching students with moderate mental disability in a special high school to learn Da-Yi Chinese keyboarding by using an adaptive input system. The results indicated that all three subjects could learn to keyboard with Da-Yi input method by using adaptive input system. In other words, it was an effective and an efficient way to teach students with moderate mental disability to learn Da-Yi input method by using adaptive input interface. In fact, using the alternative keyboard could provide the students with a simpler keyboard, but more prompts would be needed to discriminate the position of the Da-Yi character roots.

According to the result of this research, special educators may help students with moderate mental disability to learn Da-Yi Chinese keyboarding by using an adaptive input interface system as an input method.

Reference

[1] Alberto, P.A., & Troutman, A. C., Applied behavior analysis for teachers, Englewood Cliffs, New Jersey: Prentice-hall, Inc, 5th Edition, (1999).

[2] Assistive Technology of Foundation., "The handbook of Unlimiter", Taipei: Assistive Technology Foundation, (1999).

[3] Chou, F. S., Lee, T. Z., & Lin, C. C., "Evaluation and redesign of Da-Yi keyboard layout", Journal of National Cheng Gong University• Vol 27, pp. 69-82, (1992).

[4] Dai, J. F., " The study on comparing the Chang-Jay input method and Da-Yi input method", Bulletin of Chinese of the University of Zhong-Shan, Vol 2, pp. 211-234, (1998).

[5] Department of Education of Taiwan, R.O.C., "The infrastructure of information and computer education", http://www.edu.tw:81/information/expand/expand.html(accessed on March 10, 2000).

[6] Department of Education of USA, "FY2000 Major Initiatives and Funding Opportunities", http://www.ed.gov/inits/FY2000/index.html#21cclc(accessed on March 8, 2000)

[7] Huang, Y. H., "Introducing to Chinese character, input and recognition-part B", the Newsletter of Academic Sinia Computer Centre in Taiwan, Vol 14, No. 26, pp. 240-241, (1998).

[8] Lin, B. C., Chang, C. F., & Huang, U. C., "The study on investigating the language disability of the students with mental retarded in Taiwan", Taipei: the Department of Special Education of Taiwan Normal University, (1992).

[9] Lin, B. C., & Qiu, S. Z., "The study of the language ability of students with mental retarded", The Academic journal of Taiwan college of education, Vol 8, pp. 197-228, (1983).

[10] Lui. Z. H., "The study on teaching the students with mental retarded in the middle school to learning Computer Chinese input", unpublished, (1998).

[11] Tawney, J. W., & Gast, D. L., Single subject reseach in special education, Columbus, OH: Charles E. Merrill publishing Co, (1984)

[12] The Center for Highly-Interactive Computing in Education at the University of Michigan, "Foundations of Science: Using Technology to Support Authentic Science Learning", http://hi-ce.eecs.umich.edu/apers/foundations_of_science_using /index.html(accessed on December 15, 1999).

[13] University of Toroto, "Web Knowledge Forum", http://www.learn.motion.com/lim/kf/KF0.html(accessed on December 15, 1999).

[14] Xu, H. J., "An adaptive strategy on keyboarding", Master dissertation, National Taiwan Normal University, (1994).

[15] Zeng , S. X., "Introducing to Chinese input method", The Newsletter of Academic Sinia Computer Centre in Taiwan, Vol 13, No. 8, pp. 85-88, (1997).

The effectiveness of integrating adaptive computer device and stimulus fading strategy on word-recognition for students with moderate mental retardation

Ming-Chung Chen*, Tien-Yu Li, Hwa-Pey Wang*** and Kou-Ping Yang******
**National Chiayi School for the Mentally Retarded*
123, Sec 2, Shi-Shian Rd. Chiayi city,Taiwan.
E-mail:mtchen@blue.com.url.com.tw
*** National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan
E-mail:tienyu@ice.ntnu.edu.tw.
****National Taiwan Normal University*
162, Sec. 1, E. Ho-Ping Rd. Taipei, Taiwan.
E-mail: hpwang@icon.ntnu.edu.tw
*****Assistive Technology Foundation*
5F, 18-1, Sec 3, Ren-Ai Rd. Taipei

The purpose of the study is to examine the effectiveness of the instruction method involving computer device and stimulus fading strategy on word-recognition of two fourth grade students with moderate mental retardation enrolled in a special school. A single subject multiple probe baselines design across subjects is used. The students use the U1 system as the adaptive computer interface to learn word-recognition with the picture cue fading and the word enlarging. The result shows that both two students can identify the four print words correctly, even in different fonts and in different writing ways. The advantages of the adaptive computer interface and stimulus fading strategy are supported.

Keyword: **adaptive computer system, stimulus fading strategy, special education, mental retarded**

1 Introduction

It is getting more important to enhance everyone's reading ability in the information age, including individuals with mental retardation. Reading is a very complex process that involves at least two components, word recognition and comprehension. Word recognition is the base of comprehension [3]. To improve the ability of word recognition has been a hot topic in literature and research [5] [6] [8].

The goal of education for individuals with mental retardation is to help them to adapt to society. So the ability of word recognition is important for them too. In Taiwan, how to teach students with mental retardation to acquire reading skill was not noticed until recently, though the curriculum guide for students with mental retardation in Taiwan has emphasized that the practical language course should help students to learn functional Chinese. However, if we want the individuals with mental retardation to integrate into the mainstream society after they leave school, we should teach them to learn to identify the functional word as early as possible.

In practical, teachers usually use pictorial cues as reading instruction strategy to reduce task complexity, increase motivation, and lead to reading success [8]. The researcher in Taiwan also found that using pictorial cue could enhance the effects of word-recognition of the students with mental retardation [10]. But Pufpaff,

Blischak, & Lioyd indicated that some researchers found these methods were ineffective [8], the main problem is that students could not transfer their attention from pictorial cue to word when picture was absent [9].

Word-recognition is a sort of skills learned by way of stimulus discriminatory learning [1]. Sometimes, it needs to add some kind of stimulus (or control stimulus, prompt) that could assist the individuals to express expected response. Once the individual could respond correctly and stably under the prompt, the prompt should be moved gradually [1]. There are two types of instructional prompts, response prompts and stimulus prompts [1]. Using pictorial cues is one kind of stimulus prompts. That may be an effective strategy that we can use pictures as a prompt to teach individuals with mental retardation to learn to identify the target words, then move the pictorial cue systematically once the individuals could differentiate the target words correctly when the pictorial cue is existing. Sue concluded that stimulus prompts was an effective instruction method on word recognition for students with moderate mental retardation after she had analyzed a great deal of related research [9]. The result of Sue's research, using stimulus fading strategy to teach the three second grade students with moderate mental retarded to learn the specific functional Chinese words, showed that the students could learn effectively and efficiently.

In the past, including Sue's study, most of the special educators who use stimulus fading strategy to teach word-recognition create the cards which were composed of picture and word according to the principle of fading. The instructors should teach and provide the feedback by themselves, and the material couldn't be reorganized. As the computer has been more available in the classroom and the Department of Education in Taiwan has begun to purchase adaptive computer devices for students with disabilities, it facilitates students with mental retardation to study through computer and related adaptive devices. The multimedia could provide the feedback automatically and multi-sensory learning opportunity, and on other hand, the adaptive computer devices could help the students to overcome the interface barrier.

In fact, technology could assist the students with disabilities to learn literature effectively [4]. So could we design a computerized instruction program that embeds stimulus fading strategy and adaptive computer device to teach students with moderate mental retardation effective and efficiently?

2 Method

2.1 Participants and setting

Two students with moderate mental retardation on the fourth grade in the Chia-Yi special school participated in this research. The participants were selected on the basis of three criteria. First, they were capable to use verbal communication. Second, their emotions were stable. Third, they had a history of experiencing difficulties in recognizing words that were taught on their classes.

The IQs were obtained from WISC-Ⅲ, which were administered by the first researchers prior to the beginning of the study. In order to realize the participants' characteristics, the researchers reviewed their IEP files and interviewed with their teachers. A summary of the participant's characteristics appears in table 1.

Table 1
Participants Characteristics

Participant	Age	Gender	IQ(WISC-Ⅲ)	Performance of speech
A	10	Male	Full-Scale IQ:57	Articulation disorder
			Verbal IQ 58	Received speech-language therapy
			Performance IQ 64	About 4 words phrases
B	11	Male	Full-Scale IQ:	Articulation disorder
			Verbal IQ	received speech-language therapy
			Performance IQ	About 2 words phrases

Both of the students had speech disorders and received speech therapy. Student A could answer to the

teacher's question in a short sentence, about four words. Student B was able to use 1-2 words to response teacher's questions. Although the two participants usually paid attention to the teachers on the class, and could do well on the task of picture matching, however, they could not recognize a word after the reading program.

Instruction was conducted by the researchers in the school's counseling room. A personal computer with an U1 computer interface system was placed on the table. The U1 system was designed by Assistive Technology Foundation. It is a kind of programmable keyboard that could be designed by the instructor [2]. The participant was sitting in front of the table and operating the U1 system when the instruction was proceeding.

2.2 Stimuli

Four functional Chinese characters were decided after the researchers discussed with the participant's teachers on the schedule of the reading program. The researchers used the editor of U1 system to create the layout of a printed page after the four target words were chosen. There were two frames on each page. All pictures and words were edited in the center of 11cm x 16cm frame. The word was printed vertically and located above the picture. According to the stimulus fading strategy, each target word was selected in 50-point, 100-point and 130-point Ming type, and the picture was set in 10cm x 10cm, 4.5cm x 4.5cm, 1cm x 1cm. Besides these three kinds of layout, there was another layout that was only 130-point words on it.

In order to avoid the participants to response to the stimuli on fixed location, each word was presented on both sides on different layout. So the researchers designed 10 pages for each fading step, 40 pages for the instruction. Additionally, the researchers designed the other 10 pages that presented the target word alone that were printed in 130-point Kai type to measure the generalization of different font, and 4 pages that was printed horizontally for testing the generalization of different printed direction.

For the purpose of multiple sensory learning, the researchers set up some functions for each frame. The computer would speak out the target word, show the picture of the target word, and then present the target word on the screen when the participant touched the frame on the layout on the U1 system during the instruction.

2.3 Definitions of independent and dependent variables

The independent variables were stimulus fading strategy and the using of U1 computer interface system.

The dependent variables were effectiveness (percentage of correctly identified target words) and efficiency (percentage of wrong response to mastery, and number of session to criterion).

2.4 Design

A multiple probe baseline across subjects was used to assess the effectiveness of integrating U1 system and stimulus fading strategy on word-recognition for the elementary students with moderated mental retardation. The particular strengths of the multiple probe baseline design were: (a) the treatment was not reversed, (b) prolonged baseline measures were unnecessary, and (c) the design permitted the evaluation of academic learning [1]. A constant time delay technique was selected for instruction in this study, and oral praising was used as the reinforcement.

2.5 Procedure

Each participant had two learning sessions (one was in the morning, the other was in the afternoon) each day from Monday to Thursday. In order to balance the effect sequence of instruction, researchers decided which participant would accept instruction randomly prior to the instruction, and decided the sequence of the instruction on each day after both participants attended the instruction.

2.5.1 Baseline

In the baseline period, the participants were tested about their familiarity with the target words. The students were asked to point out the word under researcher's order. During the baseline assessment, the researchers

did not give participants any feedback or promotion, but recorded their response. The percentage of correct response counted after testing each word five times was used as the participant's baseline performance.

2.5.2 Instruction sessions

Prior to instruction, researchers divided the four target words into two groups and decided which group would be taught at the beginning. 'Hospital '(醫院) and 'drugstore'(西藥房) were taught at first, then ' an internal medicine' (內服藥)and ' an external medicine'(外用藥).

Student A attended the step one instruction. Researchers put the 50-point layout on the U1, and read the target word, then ask students A to read the word and touch the target frame. If he could touch the frame correctly in 4 seconds delay period, the researchers said" you did a good job" as the reinforcement and go on the next target word. Others, the researchers would demonstrate the correct response and ask student to do it again. The correct response would be recorded when the student did it by himself. The percentage of correct response was counted after each word was tested five times. The student would not go to the step two instruction until he reached the master criteria, 80% correct response in the continued sessions. Then the instruction procedure would repeated till the participant could discriminate group one words with no pictorial cues. Then went on group two.

The student B would attend the instruction when student A could discriminate the words of group one stably and had the same procedure.

2.5.3 Maintenance and generalization

In order to examine whether the participants could maintain their word-recognition abilities, and generalize it to the different font and written direction. We continued to assess the participants' performance after the instruction sessions and presented the other layout with different font or written direction.

2.6 Reliability

In order to assess the participants' response accurately, we set up a function of the U1 editor to write the participant's answer into the *Microsoft EXCEL* automatically when they touch the frame of the layout on the U1.

3 Result

3.1 Instruction

The percentage of correctly identifying the four target words during the instruction sessions for each participant is presented in Figures 1 and 2. For these two participants, it is obvious that instruction integrating stimulus the fading strategy and the U1 computer interface system was a effective method to teach students with moderate mental retardation to identify these four target words. Both of them could reached criterion during in each session , excepted student B in learning 'drugstore' with no pictorial cues on step four on the first time .

The results for student A (see Figure 1) illustrate that he could identified each target word to 100% correctly in each fading step. It means that he did not have any difficulty in word-identification when the cues were faded. Contrarily, Student B encountered more problems in step 4, excepted ' an internal medicine'.

At the beginning of this study, we set up the criterion for fading the pictorial cue as participant could identify the target word correctly 80 % in 3 consecutive sessions. So there should be 12 sessions (4 steps and 3 sessions for each step) in need for the participant to reach the criterion that identifies the target word with no pictorial cue. The results in Figure 1 and 2 indicate that both of these two participants reached the criterion, excluded 'internal medicine ' for student B. It means that participants could learn efficiently.

3.2 Maintenance and generalization

Performance during the maintenance period shows that these two participants demonstrated great availability.

Both of them could identify the target words almost 100% correctly, excepted 'internal medicine' for student A and 'external medicine' for student B.

The outcome of the generalization is presented in table 2. two participants could identify the target word in Kia type in stead of Ming type in instruction, and recognize the word printed horizontally regardless of verticality at beginning of the instruction.

Table 2

Percentage of correct response of generalization

Participants	Target word	Printed in Kia type	Printed in horizontal direction
A	Hospital	100%	100%
	Drugstore	80%	100%
	Internal medicine	100%	80%
	External medicine	100%	80%
B	Hospital	80%	100%
	Drugstore	100%	80%
	Internal medicine	100%	100%
	External medicine	100%	100%

4 Conclusions

The purpose of this study was to examine the effects of integrating adaptive computer device and stimulus1 fading strategy on word-recognition for students with moderated mental retardation enrolled in 4th grade in a special school. The results indicated that both two participants could identify these four target words without pictorial cue. In other words , integrated adaptive computer input device and stimulus fading strategy could be an effective instruction method for the students with moderated mental retardation to recognize some functional Chinese characters. The results of this study is similar to Sue's study in 1992, she found stimulus fading was an effective strategy to teach students enrolled in the self-contained special class in elementary school to identify the functional Chinese characters.

According to the results of this study, special education educators can teach student to identify new Chinese characters by multi-media computerized instruction that use the adaptive computer input device, U1 system, as the interface and the stimulus fading as the instruction strategy.

Although this study indicates that participants could recognize the target words, it still could not offer enough evidences for us to realize if they could learn to identify each single word through this way. This is an issue worth exploring further.

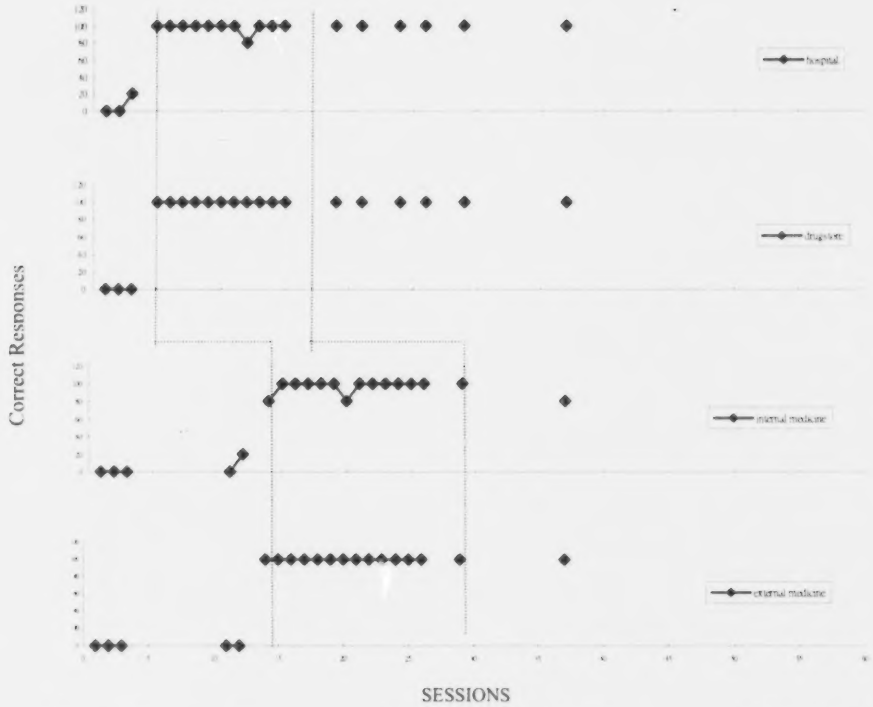


Figure 1. Percentage of correct responses during instruction period and maintenance period for student A

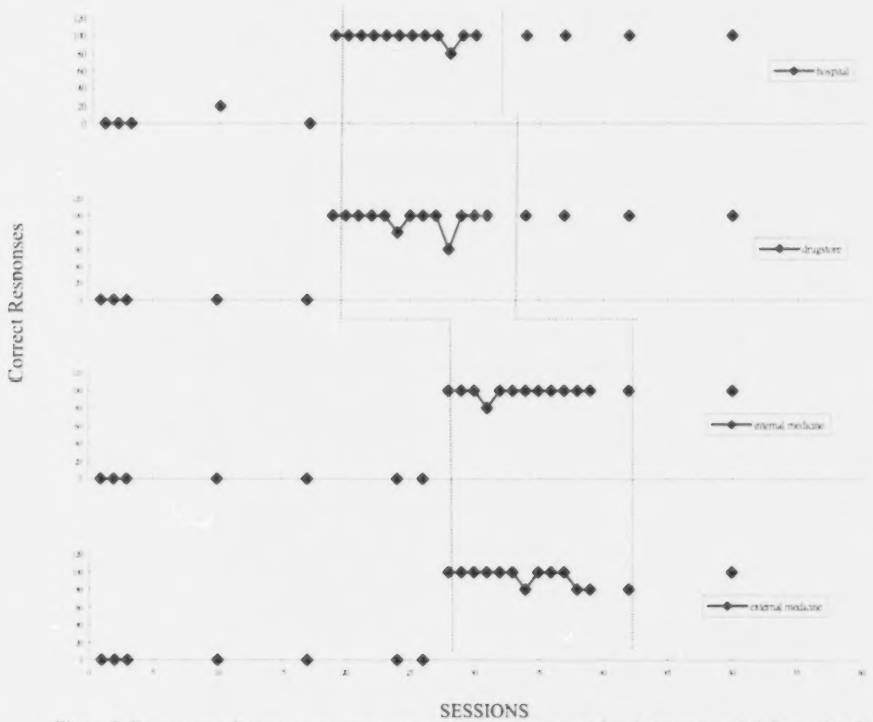


Figure 2. Percentage of correct responses during instruction period and maintenance period for student B

BEST COPY AVAILABLE

Reference

[1] Alberto, P. A. & Troutman, A. C., " Applied behavior analysis for teachers", Englewood Cliffs, New Jersey: Prentice-hall, Inc, 5th Edition, (1999).

[2] Assistive Technology Foundation, "The handbook of Unlimiter", Taipei: Assistive Technology Foundation, (1999).

[3] Bender, W. N., "Learning disabilities: Characteristics, identification, and teaching strategies", Boston, MA: Allyn and Bacon, (1995).

[4] Caver, J. M., & Burton-Radzely, L., "Technology links to literacy. A case book of special educator's use of technology to promote literacy", Calverton, MD: Macro International Inc, (1998).

[5] Chard, D. J., & Osborn, J., "Word recognition instruction: Paving the road to successful reading", Intervention in School and Clinic, Vol 34, No. 5, pp. 271-277, (1999).

[6] Chen, H. F., "The study of instruction of general orthographic knowledge of Chinese characters on elementary students with word-recognition difficulties", Bulletin of Special Education, No.17, pp. 225-252, (1999).

[7] Conners,F. A., "Reading instruction for students with moderate mental retardation: review and analysis of research", American Journal on Mental Retardation, No. 96, pp. 577-597, (1992).

[8] Pufpaff, L. A., Blischak, D. M., & Lloyd, L. L., "Effects of modified orthography on the identification of printed words", American Journal on Mental Retardation, No. 105, pp. 14-24, (2000).

[9] Sue, W. R., "A comparison of two stimulus fading procedures in teaching functional academic skills to students with moderate retardation", Master dissertation, National Changhua University of Education, (1992).

[10] Yang, U. S., "the diagnosis and instruction of Chinese performance for children with mental retarded", Taipei: National Taipei Teacher college, (1982).

Proceedings

Content

▷ Full & Short Papers (Student Modeling)

A Computational Model for Learner's Motivation States in Individualized Tutoring Systems
A Fuzzy-based Assessment for Perl Tutoring System
An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments
Controlling Problem Progression in Adaptive Testing
Development and Evaluation of a Mental Model Forming Support ITS-the Qualitative Diagnosis Simulator for the SCS Operation Activity-
Intelligent Interactive Learning Environment: Design Issues
Microgenetic Analysis of Conceptual Change in Learning Basic Mechanics
Peer Help for Problem-Based Learning
The research on difficulty of asynchronous learning materials based on time distribution
Using Decision Networks for Adaptive Tutoring

▲ HOME

A Computational Model for Learner's Motivation States in Individualized Tutoring System

Behrouz H. Far* and Anete H. Hashimoto**
** Faculty of Engineering, Saitama University*
*** Technical Development Department, IDO Corporation*
Shimo-okubo, Urawa 338-8570, Saitama, JAPAN
Tel: + - - - - Fax: + - - -
E-mail: far@acm.org

A goal of the research is to develop an intelligent tutoring system (ITS) that adapts the delivery of instruction according to the learner's needs by taking into account learner's motivation states. Long-term and short-term parameters involved in the learning process are identified. We have found that learner's motivation has strong influence on the learning achievement. A computational model to represent learner's motivational states, using Bayesian network, is proposed. This model is further used to plan the individualized tutoring actions. This probabilistic model is the key to represent both learner 's knowledge and motivational states.

Keywords: **ITS, Student Modeling, Motivation, Bayesian Network**

1 Introduction

When designing an ITS system, usually, the first consideration is the teaching side, that is, deciding what to teach, what teaching strategies to apply, and what sequence of instruction to follow to facilitate learning. Although all these tasks are of unquestionable importance, to whom to teach, that is, the learning side should not be ignored. Teaching involves knowing what the learner wants or needs to study and planning the teaching material that leads to the desired learning outcome. However, since learners come with different background knowledge and needs, planning the individualized tutoring is not a trivial task.

Both background knowledge and motivational states of the learner have strong influence on the learning outcomes. Educational psychologists have revealed that human's motivational states are the driving forces for learning. In other words, no matter how attractive the lecture is, the learner will not benefit from it if he/she does not have the willing to engage in the learning process. But since bandwidth between the teacher and learner in a conventional classroom environment is relatively unlimited, human teachers may have a chance to bring the unmotivated learner back to the class. In the virtual classroom, the virtual tutor must be equipped with a mechanism to increase learner's knowledge via diagnosis of learner's motivational states and plan the tutoring while keeping learner motivated. We will see that, although motivation cannot be transferred from person to person, there are some principles explaining the increase (or decrease) of motivation.

A goal of this research is to develop a framework of an intelligent tutoring system (ITS) that adjusts instructions to the individual learner's needs by taking into account the motivational states of the learner [1]. A key task is increasing the bandwidth between learner and the ITS system. In order to increase the bandwidth, one must find out the hidden relationship in the learner's behavior and observed learning outcomes. Usually, learning outcome is associated to the learner's knowledge level, only. In this research, we first observe what actions contribute to increase learner's motivation to engage in the tutoring and then to plan a course of actions.

2 The Nature of Human Learning

What makes the learning process easy for one and hard for others? Looking for the answer is the primary concern of educational psychologists. In this section, we look further into the parameters influencing the human learning process.

2.1 Human learning parameters

In educational psychology individual's learning aptitude difference is explained in terms of several external and internal causes [2-5]. The external sources are usually associated to causes beyond the learner's control like the type of media or the learning environment that affect the quality of learning outcome. On the other hand, internal sources are associated with the learner's own parameters like abilities and motivations. In this work, we focus on the internal causes.

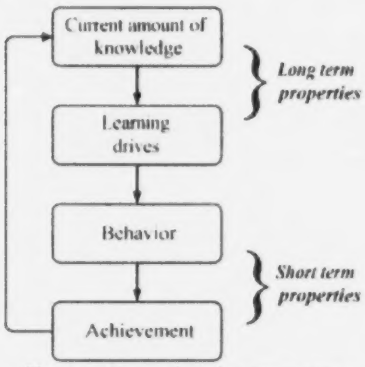


Figure 1 Human learning parameters

Figure 1, shows the set of parameters that influence the learning process. Each block in the model represents the set of parameters that describe the learning process, and the arrows indicate the direction of the influence. The first two parameters depict the learner's intrinsic characteristics. It comprises the learner's current amount of knowledge and aspects describing the learner's unconscious learning drives, like the motivation to learn. The learner's characteristics, in turn, are relevant to his/her behavior. It comprises the conscious learning drives used to measure how much effort his is putting to learn the new material. As the result of the learner's behavior, his/her achievement can be measured by the learning outcomes. The achieved learning outcome, in turn, is fed back to the current amount of knowledge. In Section 3 we specify parameters compris ing each block.

Among the subject's characteristics, one parameter that receives special attention in educational psychology is the motivation that drives learning. Motivation can be classified in two types: extrinsic and intrinsic [4]. Extrinsic motivators comprise external driving forces like studying to pass an exam or to receive a reward. The intrinsic motivators, on the other hand, are internal forces inherent to the individual like the interest in the subject matter or the desire to be successful. The ideal is that both motivators influence learners, but the reality is different. Usually extrinsic motivators, like grades and prizes, become the objective in the classroom. Unfortunately, extrinsic motivators tend to have a short-term effect and affect the learning activity [5,4]. The intrinsic motivators are the parameters that generate learning results in long-term perspectives. The favor to intrinsic motivators can be observed in a study conducted in [6]. The explanation found is consistent with what is known about the relationship between extrinsic motivations (such as grades) and intrinsic motivation (such as challenging tasks): extrinsic motivators tend to inhibit intrinsic motivators. That is, if learners were given the choice, they would rather choose easier exams in order to get high grades than selecting more challenging tasks.

Based on this argument, the proposed tutoring system emphasizes learner's intrinsic characteristics like abilities, progress, and confidence. It does not mean that extrinsic motivators are useless (test grades are not excluded in our system). Rather, the ideal is to balance both kinds of motivating drives. In the next subsection, the theories and principles that support our idea are explained.

2.2 The motivational and learning principles

We think that learning occurs only if the learner is motivated to learn. This desire to learn, whether intrinsic or extrinsic, is the driving force of how much effort the learner is willing to put in order to learn (see Figure 1). These efforts will be measured taking into account the learner's observable behaviors such as the time spent to read a lesson or the frequency of visiting the same lesson to study. Herewith, we define the intrinsic characteristics that later will serve as the backbone of the student model.

1. ***Motivation:*** Motivational state is the force that drives the learner to engage in an activity because of a feeling of need or desire. Though motivation cannot be transferred, it may increase (or decrease)

depending on the situation that the learner is faced. One of the situations in which changes in motivational states may be observed is when the learner is presented tasks that fall in a range of challenge such that success is perceived but not certain [7]. Besides the perceived probability of success, others works [2,3] suggest also that the value of obtaining goal and acknowledge of progress are factors affecting motivation.

2. ***Learning:*** Learning is the ultimately desired change in behavior and knowledge to be achieved by the learner. Because of different background, motivational states and goals, learning results in different acquisition rate and outcomes. With regard to the factors influencing learning, readiness to understand the instruction is an essential requirement. Prerequisite knowledge is suggested as a measure of readiness. Anxiety and uncertainty of achieving goal have negative influences on learning.
3. ***Interest and progress:*** The acquisition of an ability or skill is a potential activator of interest since people tend to repeat things in which they are successful [4]. That is, when learners obtain evidence of their learning progress, not only interest tends to increase but also performance will be superior to what it would have been without such acknowledgment. Progress, may be thought of as the sum of learning achievements.
4. ***Retention:*** Retention is a measure of how well learners remember already acquired facts. The longer the time delay, the lower the retention factor. While time delay decreases retention, rehearsal strengths the ability to recall old information.
5. ***Ability degree:*** The learner's ability degree is a measure of preparedness to learn academic material [3]. We define it as directly dependent on readiness, expertise level, and complexity of the topic. Expertise level, in turn, is measured by the amount of knowledge the learner has accumulated.
6. ***Attention:*** By attention we mean a measure of how the learner is directing his/her mind to the given task. We define it as the result of the positive influence of motivation and ability degree and the negative influence of distraction due to complexity of topic.
7. ***Effort:*** The effort tells us how the learner is behaving in order to achieve learning goals. Since it is not possible to observe it directly, we measure it by the frequency of dedicating to the study (frequency of use), the time delay between studies, the amount of time engaged in reading (time for reading), whether the learner performs the tasks (practice), and whether non-mastered topics are rehearsed (rehearsal).

It is obvious that intrinsic motivators are difficult to measure. Choosing challenging tasks neither brings immediate results nor it is easily measured. Marks and points, on the other hand, are concrete measures, easily interpreted and cause immediate satisfaction. The first task is to use intrinsic motivators in the student model such that they bring immediate and measurable results. The model presented in the next section covers this.

3 Student Modeling Task

In this section, we present the student model, using Bayesian network, based on the parameters mentioned in Section 2. The student model is divided in two parts: the motivational model and the knowledge model. The motivational model is generic, domain independent and applies to all learners. The knowledge model, on the other hand, is domain specific. The subject matter chosen for knowledge model is the concepts of the C programming language.

3.1 Modeling learner's motivational states

Tutoring based on the learner's motivation requires a mechanism to diagnose motivational states. Here, we take an approach that complements the limitation of existing proposals, such as [8]. However, it may introduce a new burden in creating motivational diagnosis. It is due to the modeling process and the task of estimating the probabilities for all variables in the network. On the other hand, the advantage is that it eliminates the learner's burden because the diagnosis is running in background mode while the learner is using the system.

Building a student model based on Bayesian network requires two distinct tasks: the qualitative part that concerns the modeling of relevant variables involved in the domain, and the quantitative part that deals with the probabilities. As we are interested in representing the student motivational model, the qualitative modeling is concerned with the problems of identifying what information about the learner will be modeled and how that information will be modeled. In the quantitative modeling, we are concerned with the problem of specifying how the probabilities will be computed.

3.1.1 Qualitative analysis: encoding of dependence

The difficult part in the qualitative analysis is to find out how the variables influence each other. Our starting point was the learning parameters described in Figure 1: knowledge states, learning drives, learner's behavior, and learning achievements. These rough sets were further expanded based on the learning and motivational principles explained in Section 2. The refinement is done top-down: start from the first parameter down to the last one. The result is depicted in a network of Figure 2. The nodes in the network are divided into two types: directly observable nodes denoted by dashed-lines, and unobservable ones represented by solid-lines. The graph encodes the causal dependency among the motivational aspects relevant in the process. The common positioning of the variables is from cause to effect. An arrow from A to B is read as "A influences (or affects) B". For example, readiness is a factor that influences (or affects) motivation; ability influences attention.

Figure 2 Student's motivational states model

3.1.2 Quantitative analysis: expressing in numbers

The nodes probabilities may come from two different sources: probabilities set by experts and probabilities coming from repetitive calibration. It is worth mentioning that obtaining exact numbers is not really crucial since we are interested in the changes between the parameters rather than the values. In many cases, the advantages of Bayesian networks outweigh the load of eliciting the numbers. For example, locally encoding of information is an important aspect. Deleting or adding new information does not require the whole network be revised.

Initially, the probabilities in the student motivational model are rough estimations. The principles behind learning and motivation were translated to sentences like:

There is a high probability that motivated learners (motivation) works harder (effort)

or

There is a low probability that the learner is persistent (persistence) if the task completion ratio is low (task completion ratio).

We repeated this example for all variables in the network. Next, the qualitative terms like high and low are expressed in numbers. Finally, using a Bayesian network editor that we have built, those values are tested

BEST COPY AVAILABLE

with repetitive calibration.

3.2 Modeling learner's knowledge states

Now, the qualitative and quantitative analyses for the student knowledge model are discussed.

3.2.1 Qualitative modeling: semantic of the network

The network depicted in Figure 3 represents the Bayesian network for the student knowledge models. Again there are two kinds of nodes: knowledge units and test nodes. Knowledge units represent relevant concepts comprising the domain to be taught. Test nodes represent problems that serve to verify the understanding level of each knowledge unit.

In order to build the Bayesian network of Figure 3 we start by eliciting the knowledge units comprising the domain, represented by a solid node, and ranking them according to the difficulty/complexity of the unit. For example, if a unit does not require mastery of other units, then it is a candidate to be in the easiest level. Another unit that requires just mastery of the easiest level unit is the candidate to be the second easiest level, and so on.

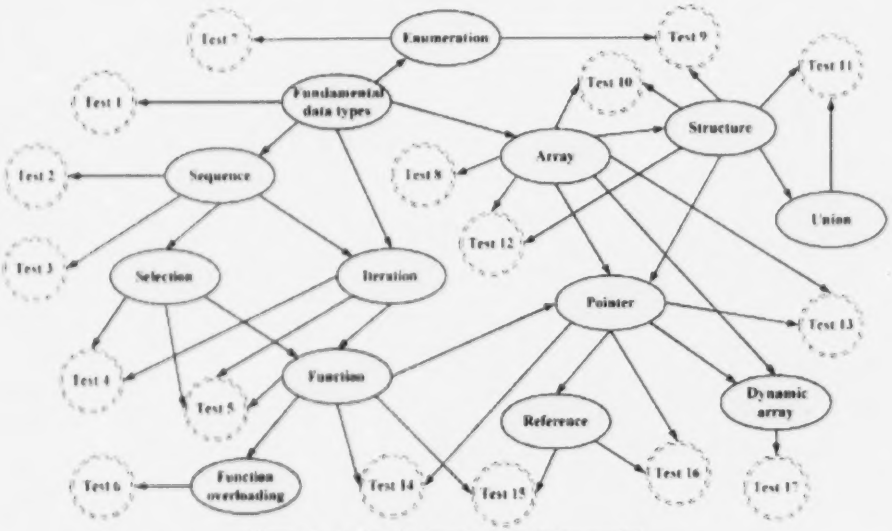


Figure 3 Student's domain knowledge model

Besides this classification, we have to find out how to represent those knowledge units in the network. Usually, Bayesian network is modeled based on cause-effect relationship. Since this is not easily perceived in our case, we extracted the factors that describe the units such as description, usage, and limitation. This analysis helps us to understand the hidden relationship between apparently unrelated units. We observed that some units fulfill the limitation of other units: for example, array and structure. In other cases, units present similarity in usage: for example, pointers and references. A link is added between those units in order to depict the fact that knowing one unit makes the probability of understanding the related unit more likely. Depending on the relevance of the knowledge unit within the domain, we can add more test nodes to the unit. In this example, since "Function", "Array", and "Pointer" play an important role within the domain of programming language, we can elaborate several test nodes covering those concepts.

The line of reasoning is as follows: if the learner solves correctly a problem associated to a knowledge unit, then the probability of knowing that unit increases. A link is added between knowledge unit and test node if it is required to know the unit in order to solve the problem. We add a link between knowledge units if exists a relevance relationship between them. Of course there is a tradeoff between compactness and preciseness. For example, learning about the "Fundamental data types" is essential for all remaining knowledge units, which we would have to add a link between that node and all other units. But, considering the precedence condition of the concepts, we were able to limit the links only to the directly relevant knowledge, such as

BEST COPY AVAILABLE

"Sequence expressions" and "Enumeration".

3.2.2 Quantitative modeling: dealing with probabilities

For each variable in the network, there is a conditional probability table (CPT) with respect to its parent nodes. For example, for the node "Test14", we have a CPT associating the "Test14" node to its parent nodes "Pointer" and "Function" knowledge units. That is, in order to answer the test correctly, the learner must understand both pointer and function. If the learner answers it correctly, it is inferred that he understands both units. If, however, the test was answered incorrectly, then, in the absence of other evidences, the associated units are considered not mastered yet. Suppose that we have already collected evidences that the learner knows about functions. In this case, rather than inferring both units as not mastered, it is more likely that only pointers have not been mastered yet. After including all the evidences and propagating the probabilities through the adjacent nodes, the network reaches an equilibrium state and we obtain the probability of the learner being in mastered level in each knowledge unit.

3.3 How the model works

Since learning occurs only if the learner has the desire or motivation to learn, the task we are concerned with is to keep the learner motivated to complete the tutoring. Consequently, the problems are: how to assess learner's motivational states and how to proceed tutoring in order to keep (or increase) motivation.

Let's consider the following situations: a novice learner who spends a long time without accessing the tutorial comes back to continue the lessons. Because of the long time delay between lessons, it is likely that he/she forgot something about the past lessons and needs a review. But, at the same time, the novice learner would probably become more motivated if he/she made some progress. In another case, an intermediate learner is apparently loosing motivation because of repetitive unsuccessful response to exercises.

In each case, the system can infer different treatments for each learner needs and set appropriate courses of actions. Therefore, the model will be used to perform the following tasks:

1. ***Monitoring:*** observe the learner in a sequence of interactions to adjust prior beliefs about learner's knowledge and learning drives.
2. ***Inference:*** because only a limited number of events are observable, infer what these directly observable actions tell about the other parameters.
3. ***Prediction:*** predict learner's knowledge and motivational states in the next interaction given the information currently available.

To depict the evolution of the tutoring, we represent the learning cycle as a dynamic process, as shown in Figure 4. At each interaction, the learning achievement increases (or decreases) the amount of knowledge the learner possesses in the next interaction, which indirectly increases the motivational states. Including temporal characteristic is important because if episodic interactions were considered, the learner's motivation, for example, would be inferred based on the current situation without taking into account past failure or success in outcome.

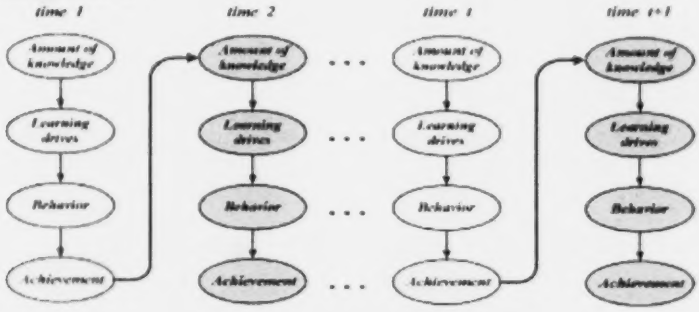


Figure 4 The dynamic process of tutoring

Dynamic Bayesian network [9] provides a mechanism to foresee the probability of interest in the next state

with regard to the current beliefs. That mechanism is called probabilistic projection and can be performed by a three step updating cycle called *roll-up*, *estimation*, and *prediction* phases, as suggested in the dynamic model of Figure 4. Keeping at the most two time slices are sufficient to perform the inferential cycle. Figure 5 depicts the steps for updating a dynamic Bayesian network and below, a brief description of each step.

1. ***Prediction:*** suppose the network in Figure 5(a). Assuming that all the values have been calculated in time slice *t-1*, i.e., $Bel(X_{t-1})$, this probability should be incorporated in the next time slice by estimating $\hat{Bel}(X_t)$. In this step, the predicted probability distribution expected given the evidences known at time slice *t-1* is calculated.

$$\hat{Bel}(X_t) = \sum_{X_{t-1}} P(X_t \mid X_{t-1}, E_{t-1}) Bel(X_{t-1})$$

   Where E_{t-1} is all the evidence at time slice *t-1*; *P* is the probability and "^" denotes an estimation.

2. ***Roll-up:*** the roll-up is the process of removing the network on time slice *t-1* and assigning a prior probability table for the state variables at time *t*, which is the $\hat{Bel}(X_t)$ (Figure5(b)).

3. ***Estimation:*** now, using the standard probabilistic network updating, the probability distribution over the current time slice *t+1* is found and the steps for the next cycle can be repeated (Figure 5(c)).

$$Bel(X_t) = \alpha P(E_t \mid X_t) \hat{Bel}(X_t)$$

   Where α is normalization constant.

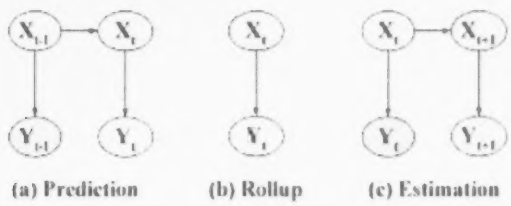


Figure 5 The updating cycle

4 Planning Actions

Through educators frequently rely on experience and common sense to prepare a curriculum plan, there are some theories helping educators to organize the lessons and offer learners an easier way to assimilate new concepts. Following we describe the theories about the sequence of instruction and motivation strategies that we adopt in our project.

1. ***Theories about sequence of instruction:*** helps the instructor to select the next instruction when there are conflicting candidates.
   - *Simple-to-complex theory:* given two concepts A and B, if A is simpler than B, then choose A as the next candidate.
   - *Laws of organization:* if A and B are similar concepts and the learner knows A, then the probability of understanding B becomes higher.

2. ***Motivational Strategies:*** dictates the teaching strategies to apply given the learner's motivational states and experience. Following, some examples of strategies:
   - Whenever a less motivated or confident learner does a task well, present similar tasks that are likely to be successful in order to increase his/her confidence and motivation.
   - If the learner presents high persistence or motivation, let him/her try again the task rather than promptly presenting the correct answer.
   - Show the learner his/her motivational and knowledge states in order to stimulate self-monitoring.

The way of actually planning actions and delivering instructions will be treated in the authors' another paper.

5 Discussions

In order to model motivational states, we need a formalism that simultaneously offers mechanisms to: (a) model the causality explaining the principles involved in the learning process, (b) reason under the uncertainties inherent to the effects of the process, and (c) represent the temporal changes observed due to learning. The framework we proposed in this paper can cover all these factors. It is suitable for handling problems that can be modeled according to certain relevance conditions. In our case, the learning principles are the conditions that enable us to model the learning parameters. Although it is impossible to identify and to model all the parameters involved in learning, but Bayesian network's reasoning mechanism is capable of dealing with incomplete as well as limited amount of data. Moreover, the ability to reason about the problem without necessarily observing all the variables involved constitutes another advantage.

With respect to the computational advantages of Bayesian networks, the structure of the network allows the locally encoding of information rather than globally. That is, once the network is consistently built, each node interacts only with the directly connected nodes [9]. The gain with this property is that addition or deletion of nodes can be done locally without revising the whole network. Additionally, the computation can be performed with regard to the adjacent parameters only.

6 Conclusions

We proposed a framework for an intelligent tutoring system that adapts instruction based on the learners' needs by taking into account learner's motivation states. Our main claim is that learner's needs do not refer only to knowledge needs, but also to motivational needs. The bottleneck, however, is the limited bandwidth between human and machine. The first thought is, then, to direct the research in the latest technology in human-machine interface, like natural language understanding or eyes movement reading methods in order to increase the narrow communication channel. But is it really only the technological bottleneck that hinders the communication between human and machine? If so, then why human teachers have troubles with their pupils? This was the question that arose during the development of this work.

The bandwidth problem limits the communication channel, but providing the system all available information does not guarantee perfect communication. We realized that the cognitive and educational aspects come first. What is behind the human learning process? Why some students learn faster than the others? These questions, then, became the priorities in our work. After eliciting the parameters involved in learning, we faced with the problem of how to make best use of the limited source of information the system was capable of computing. The computational formalism that fulfilled our needs was Bayesian network. This probabilistic method not only reasons under limited source of information but also infers about yet unobserved variables. In this way, we could virtually increase the communication channel.

Planning based on motivational strategies is still in an immature stage and a subject of our forthcoming paper. For clarity, the student motivational model possesses a large number of parameters, which can be omitted according to the intended use. Since the model is modularized and domain-independent, it is also possible to reuse it to teach different domain application. The set of rules to execute motivational strategies we have defined is simply an adaptation of the motivational principles. Improvements are still needed in this direction.

References

[1] Hashimoto, A.H., Hajji, H., and Far, B.H., "A Probabilistic Approach for Student Modeling Task," 13th Annual Conference of Japanese Society for Artificial Intelligence, JSAI' 99, pp. 68-69, (1999).

[2] Eftekhar, N., Strong, D.R., and Hawaleshka, O., "Towards Dynamic Modeling of a Teaching-Learning System: The Unified Theory," International Journal of Engineering Education, vol. 12, no. 6, (1997). Also available at: http://www.ijee.dit.ie/articles/999981/article.htm (accessed on August 7, 2000).

[3] McIlrath, D.A., and Huitt, W.G., "The Teaching-Learning Process: A Discussion of Models," http://www.valdosta.edu/~whuitt/psy702/files/modeltch.html (accessed on August 7, 2000).

[4] Spencer, R., Ludington, J. and Graham, S., "Motivation and Learning: A Teacher's Guide to Building Excitement for Learning and Igniting the Drive for Quality," Peak Learning Systems, (1999). Also partially available at: http://www.peaklearn.com/chap1.html (accessed on August 7, 2000).

[5] Lumsden, L.S., "Student Motivation to Learn," ERIC Digest 92, (1994).
[6] Litchfield, B.C., and Newman, E.J., "Differences In Student And Teacher Perceptions Of Motivating Factors In The Classroom Environment," National FORUM of Applied Educational Research, vol. 12E, no. 3, (1999). Also available at: http://www.nationalforum.com/16LITCHF.htm (accessed on August 7, 2000).
[7] Knight, J., "Educational Foundation," http://ag.arizona.edu/aed/aed695a/educatio.htm (accessed on August 7, 2000).
[8] de Vicent, A., and Pain, H., "Towards Motivating Instructional Systems," In G. Cumming, T. Okamoto, and L. Gomes, editors, Proceeding of the International Conference on Computers in Education (ICCE'99), vol. 1, pp. 744-751, IOS Press, (1999).
[9] Stuart, R., and Norvig, P., "Artificial Intelligence: A Modern Approach," Prentice Hall, (1995).
[10] Hirashima, T., "Student Modeling and Adaptive Interaction," Journal of Japanese Society for Artificial Intelligence, Special Issue on Student Modeling and Adaptive Interaction, vol. 14, no. 1, (1999).

A Fuzzy-Based Assessment for Perl Tutoring System[1]

Tang Ya*, Keith C.C. Chan*, Albert Wu and Pinata Winoto*****
**Department of Computing*
Hong Kong Polytechnic University, Hong Kong
Email:{ csytang, cskcchan } @comp.polyu.edu.hk
***Faculty of Education*
Chinese University of Hong Kong, Hong Kong
Email: albertwu@cuhk.edu.hk
****School of Business and Management*
Hong Kong University of Science and Technology, Hong Kong
Email: pwinoto@ust.hk

In this paper, we present a fuzzy-based assessment for Perl Tutoring system. The Perl Tutor is implemented in a multi-domain framework so that it can teach target domain knowledge by giving supporting knowledge to reinforce the learning. In order to assess supporting knowledge, an assessment is performed *before* the tutoring begins. Its main purpose is to test student's previous declarative knowledge of computer programming. At the end of it, a directed tutoring graph will be generated to optimize the tutoring process.

Keywords: **fuzzy rule, assessment, student modeling, multi-domain tutoring**

1 Introduction

There exist many works on optimized assessment process concerned with the efficiency of testing and its completeness. *Granularity*, *prerequisite relationships*, *Bayesian propagation* and *neighborhood of knowledge states* are some of the successful attempts employed to increase the efficiency of testing [2,5,6,13,17]. Yet, even though they could increase the efficiency significantly, they still have too many burdens given the large knowledge spaces. Fortunately, not all the student models need to be precise to be useful [10]. To ease the burden to student modeling, a fuzzy approach has been used and has so far worked quite well [3,10,11].

The purpose of this paper is to present the fuzzy approach in the assessment of student's knowledge in the Perl Tutoring System [16], which teach programming language (Perl) by reinforcement from other supporting languages (C++ and/or Java). For the effectiveness of reinforcement, the system should quickly evaluate the student's knowledge of supporting languages. But the assessment needs not to be in high precision. Other works related to student modeling almost put their emphasis on the adaptive assessment *during* tutoring [14,15,17]. Yet due to the nature of our Perl tutor, we apply an assessment module *before* tutoring begins and it consists of two parts: questionnaire and testing. During the questionnaire part, students are asked to self-assess their knowledge by filling out a form provided by the system. In order to evaluate their statements, a testing part is given based on those statements. At the end of the assessment, the tutor will have a general picture of students' prior knowledge of supporting languages: with which part they are familiar etc. Since the goal of the assessment is only to get a rough knowledge states for supporting purpose, it should not take too long to complete. Thus, a coarse granularity with imprecise mastery level is appropriate.

In the next part of this paper, we briefly discuss the Perl tutoring system followed by the fuzzy logic. Then we will describe the questionnaire part and the testing part and end with discussion.

[1] The work related to this paper is funded under the Hong Kong Polytechnic University research grant No. PolyU5072/98E.

2 Overview of the Perl Tutoring System

Figure 1 illustrates the directed tutoring graph in the system [16]. The three pieces of knowledge items presented to students are: data type, logical operators and control structures. In the figure,

- Each vertex represents a sub-domain;
- Each pair of the sub-domain may be connected with a unidirectional or bi-directional arc.
- Each arc represents the relationship between two sub-domains.

Moreover, each sub-domain may consist of several vertices, which are the sub-sub-knowledge items of their parent domain. For example, under ' data type' , we also have ' integer' , ' float' , ' boolean' etc.

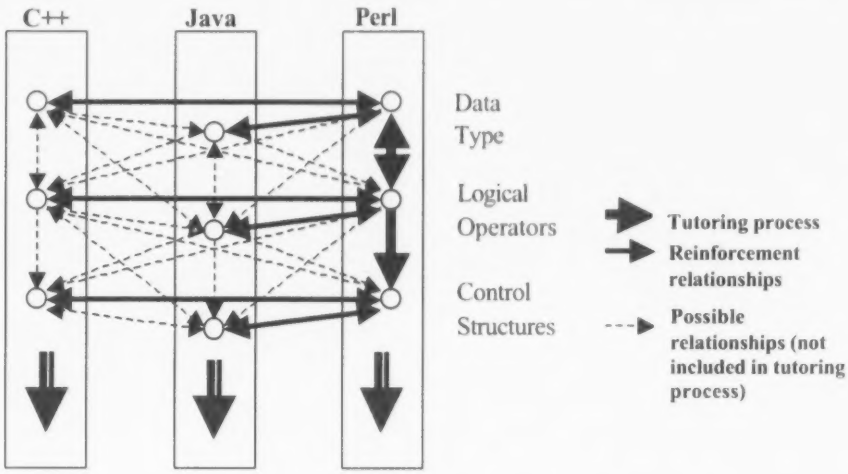


Figure 1 A Digraph of the Perl Tutoring System

C++ [1] and Java share many similarities with Perl, although they, of course, have their own features. See Table 1 for a comparison.

CDR terms (General)			Knowledge piece in PERL	Knowledge piece in C++	Knowledge piece in Java
Operators	Numeric operators		+,-,*,/, %, **	+,-,*,/, %,	+,-,*,/, %,
	Relational operators		<,<=,>,>=,<=>**(for numeric)** lt,le,gt,ge,cmp**(for string)**	<,<=,>,>=	<,<=,>,>=
	Equality operators		=,!=**(for numeric)** eq,ne**(for string)**	==,!=	==,!=
	Logical operators(binary)		&&,||	&&,||	&&,||
	Logical operators(unary)		!,	!,-	!,-
	Bit manipulation operators		&, |, ^, ~	&, |, ^, ~	&, |, ^, ~
	Bit shift operators		<<, >>	<<, >>	<<, >>, >>>
	Auto-increment & auto-decrement operators		++,--	++,--	++,--
	Speical operators	Conditional operators	?:	?:	?:
		Other operators	•,x(string operators) , >,\(**dereference/reference operator**	Sizeof ,	Instanceof
	Multiple operators			+=, -=, *=, /=, %=, &=, |=, <<=, >>=, ++=, --=	+=, -=, *=, /=, %=, &=, |=, <<=, >>=, >>>=, ++=, --=
Control structures			If,if/else, unless/else, While, do/while, for, continue, goto Notes:labled loops can be used within for, while, or do	If, if/else, while, do/while, for, continue, goto, switch, break	if, if/else, while, do/while, for, continue, break, switch Notes:labled loops can be used within for, while, or do
		Special structures	**Foreach** **Redo**	Exit	

Table 1 Similarities and differences in C++, Java and Perl

CDR represents 'cross-domain reference' which serves as a dictionary for the domains. It is composed of basic terms used across the computer language regardless of which language is being referred. If the student has learned computer language before, he will develop a clear picture of the terms or concepts used, which serves as a guide for the learning of Perl. Besides, he will also integrate his former learning into his current. Through this knowledge transfers, the time spent on learning Perl will be greatly reduced [8].

Before tutoring begins, a weight is assigned to every direction of arc that represents the easiness of the acquisition of one sub-domain (target) after acquiring another (source). Since different students have different knowledge levels, the weight assigned to the same arc may not be the same. Thus, the weight across domain is jointly determined by the student model and the characteristics of knowledge (for detailed explanation, refer to [16]), i.e.,

$$w_{ij} = f(\mathbf{d}_{ij}, \mathbf{m}_{ij})$$

Where, w_{ij} is the weight of arc from i to j.

$f: R^n \times R^m \rightarrow R$, is a non-decreasing function.

$\mathbf{d}_{ij}$ is an n-dimensional vector representing the similarity of i and j. $\mathbf{m}_{ij}$ is an m-dimensional vector representing the student model, i.e., the student's knowledge level of i.
The dimension of $\mathbf{d}_{ij}$ and $\mathbf{m}_{ij}$ depends on the number of attributes considered. Moreover, the value of $\mathbf{d}_{ij}$ is predetermined and the value of $\mathbf{m}_{ij}$ is determined based on the student model. Thus, the system would carry an assessment module to test the knowledge of a student towards a specific supporting domain knowledge *before* tutoring begins. In this paper, we focus on the determination of $\mathbf{m}_{ij}$.

3 The Assessment Model—A Fuzzy Approach

Since the main purpose of the model is to test student's overall abilities, it is not necessary for us to gain a very accurate picture of it (although it helps). And somehow we also cannot gain a clear picture of student history. Thus, we choose a fuzzy approach in analyzing the student's performance, and we believe that the imprecise assessment of the student's prior knowledge level is adequate.

3.1 The 'neighborhood of knowledge states'

The *knowledge state* has been defined as the subset of knowledge items from a large item pool that can be mastered by students [4]. Remember that knowledge items in different domains are identified by their names, which in turn are determined by a cross-domain vocabulary. Besides, each item is characterized by its relationship with other items. The neighborhood of a knowledge state was defined by Falmagne and Doignon [7] as all other states within a distance of at most one. It has been utilized for adaptive assessment by Dowling *et. al.* [6]. In our system, we will not measure the exact distance within knowledge items, but we adopt it from another perspective. We define the neighbors of a knowledge item as the possible knowledge items which could be mastered in association with it. Let us have a look at an example.

Example 1.

1. '<','<=' represent 'less than' and 'less than or equal to' respectively, and they are relational operators.
2. '>','>=' represent 'greater than' and 'greater than or equal to' respectively.
3. '==','!=' represent 'equal to' and 'not equal to' respectively, and they are equality operators.
4. '<','<=' can be used for both numeric and strings.
5. '>','>=' can be used for both numeric and strings.
6. '==','!=' can be used for both numeric and strings.
7. Numeric is data type.
8. Strings are data type.
9. The relational and equality operators can be used for all data types, numbers, expressions or their combinations.

Let $M_S(X)$ denotes the student is sure to have mastered X. And $M_l(Y)$ denotes the student is likely to have mastered Y. Where X,Y are sets of knowledge items. Then,

$M_S(X) \square M_l(Y)$ can be interpreted as "if the student is sure to have mastered X, then he/she is likely to have mastered Y."

Then we will have:

1. $M_S(1) \square M_l\{2,4,7,8\}$
2. $M_S\{3\} \square M_l\{6,7,8\}$
3. $M_S\{4,5,6\} \square M_S\{7,8\}$
4. $M_S\{9\} \square M_S\{1,2,3,4,5,6,7,8\}$

For example, if the student knows well how to make comparisons for numeric and strings, then we assume

that he/she is sure to have mastered: what is numeric, what is a string and the usage of the operators. Although we cannot determine that whether he masters other data types or not (that is, he is likely to have mastered other data types such as float etc), we can assess student's knowledge state without having to extensively test his abilities of each knowledge item he/she may have learned. Therefore, test items in our model may test knowledge items in a wider ranger than similar work by Collins *et. al.* [2].

3.2 Fuzzy Logic

To express precisely the notion "sure", "likely" or "unlikely", we adopt fuzzy set methods and therefore using fuzzy rule for the inferences. For example, we define

Answer = {True, False}. And A1, A2 $\subset$ Answer, thus

$$A_i = \mu_{A_i}(T)/\text{True} + \mu_{A_i}(F)/\text{False}$$

Confidence = {unlikely, likely, sure}. And B1, B2 $\subset$ Confidence, thus

$$B_i = \mu_{B_i}(u)/\text{unlikely} + \mu_{B_i}(l)/\text{likely} + \mu_{B_i}(s)/\text{sure}$$

Assume we have two rules: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2

Then, by Mamdani's direct methods:

$$B' = A' \circ R$$

Where, $R = R1 \cup R2$

$$R_i = \begin{pmatrix} \mu_{R_i}(T,u) & \mu_{R_i}(T,l) & \mu_{R_i}(T,s) \\ \mu_{R_i}(F,u) & \mu_{R_i}(F,l) & \mu_{R_i}(F,s) \end{pmatrix} \quad \text{and} \quad \mu_{R_i}(x,y) = \mu_{A_i}(x) \wedge \mu_{B_i}(y)$$

Note here that all operators used, such as: +, /, $\subset$, $\wedge$, $\cup$, and o, are defined in fuzzy domain.[2]

To illustrate it, let us assume that A1 is "doing well in bit shift operator", A2 is "doing bad in bit shift operator", B1 is "understand bit manipulation if doing well in bit shift operator", and B2 is "understand bit manipulation if doing bad in bit shift operator". Then, we can assign values such as:

A1 = 1.0/T A2 = 1.0/F

B1 = 0.5/l + 0.5/s B2 = 1.0/u + 0.1/l

And satisfied: R1: A1 $\rightarrow$ B1 and R2: A2 $\rightarrow$ B2. Thus,

$$R1 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B1}(u) & \mu_{B1}(l) & \mu_{B1}(s) \end{array} \\ \begin{array}{c} \\ \mu_{A1}(T) \quad 1.0 \\ \\ \mu_{A1}(F) \quad 0 \end{array} & \begin{array}{c} \begin{array}{ccc} 0 & 0.5 & 0.5 \end{array} \\ \begin{array}{ccc} 0 & 0.5 & 0.5 \end{array} \\ \begin{array}{ccc} 0 & 0 & 0 \end{array} \end{array} \end{array}$$

$$R2 = \begin{array}{cc} & \begin{array}{ccc} \mu_{B2}(u) & \mu_{B2}(l) & \mu_{B2}(s) \end{array} \\ \begin{array}{c} \\ \mu_{A2}(T) \quad 0 \\ \\ \mu_{A2}(F) \quad 1.0 \end{array} & \begin{array}{c} \begin{array}{ccc} 1.0 & 0.1 & 0 \end{array} \\ \begin{array}{ccc} 0 & 0 & 0 \end{array} \\ \begin{array}{ccc} 1.0 & 0.1 & 0 \end{array} \end{array} \end{array}$$

[2] Many books [18,19,20] in fuzzy set theory provide good explanations on these operators. We are not going to explain it further in this paper due to limited space.

With two rules, the fuzzy relation Ri is made from the implication Ai → Bi (in this case, i=1,2). The compiled fuzzy relation R is given as Mamdani' s method:

$R = R1 \cup R2$, computed as:

$$R = \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix}$$

Now, assume after a series of testing, a student performance show A' = 0.9/T + 0.2/F in doing bit shift operator. Then, we can calculate his performance in bit manipulation as:

$$B' = A' \circ R$$

$$= \begin{array}{ccc} T & F & \\ [0.9 & 0.2] & \circ \end{array} \begin{array}{c} \\ \\ \end{array} \begin{array}{c} \\ u \\ l \end{array} \begin{array}{ccc} u & l & s \\ \begin{bmatrix} 0 & 0.5 & 0.5 \\ 1.0 & 0.1 & 0 \end{bmatrix} \end{array}$$

$$= [(0.9 \wedge 0) \vee (0.2 \wedge 1.0),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0.1),\ (0.9 \wedge 0.5) \vee (0.2 \wedge 0)]$$

$$= [0.2 \quad 0.5 \quad 0.5]$$

$$B' = A' \circ R = 0.2/u + 0.5/l + 0.5/s$$

Which shows 0.5 likely to understand, 0.5 surely to understand and only 0.2 unlikely to understand bit manipulation.

4 Questionnaire and Testing

The questionnaire part consists of a series of knowledge items to be checked by students. The knowledge items are grouped into several groups based on the their similarities and difficulties. Then, students are asked to fill the form about their mastery level in each group. Five grades are provided for each answer, i.e., very familiar, familiar, moderately familiar, not familiar, and never heard. After students provided their answers, the system retrieves a series of testing questions based on the difficulty (upper limit) of students' answers, especially for the items marked 'moderately familiar'. But it does not mean that the presumably mastered items are not tested at all. Even the items marked 'very familiar' will be tested, but with a very low probability. Testing could be in the forms of short program lists or short questions, which are made as short, clear, and simple as possible. The reason is to avoid noise or errors which do not come from student knowledge iteself. In order to avoid ambiguity in judging knowledge level when the question is not answered well, every question only consists few higher level concepts to be handled.

Moreover, an average of membership value is used if the same item occurs in several questions. (We can use Bayesian update but with higher cost, i.e., to set all the conditional probability among every question).
For example, if from question 1, 2 and 3, a student performance on 'bit manipulation' shows

0.8/T + 0.2/F, 0.9/T + 0.3/F, and 1.0/T + 0.1/F respectively,

then the overall performance is, simply, the average, i.e., 0.9/T + 0.2/F.

If the question needed does not exist in the database, then a similar question is retrieved. The measure of similarity is based on the maximum number of high level concept appeared.

Prerequisite relationship

In addition to the neighborhood relationships, prerequisite relationships are also applied. The prerequisite relationship provides not only test item ordering criteria in a "strong" sense, but also in a "weak" sense. In ordinary prerequisite criteria P(A, B) denotes "A is prerequisite of B". In our extended criteria, we introduce A' as:

If A' is closely related to A and $M_S(A') \supset M_S(A)$

then we have $P'(A', B)$, that is, A' is weakly prerequisite of B.

So, if students have mastered item A', we have: they are sure to have mastered B without testing whether they have mastered item A or not. By doing this, we can largely tighten the testing items and thus save more time.

5 Discussion

To know student's learning history and his knowledge level, we cannot ask them too detailed questions in order to gain a more full picture of their knowledge state (although it helps) since it will make student modeling itself a kind of a complex system. But we need them to aid in the assessment, so how much trust should we have in the student's own assessment? This is the question we need answer before we proceed. In our system, we will not generate the tutoring graph solely based on their answers. Our solution is to test by giving them several pre-stored test items: if they can write out the outcome correctly, we assume that he has mastered the knowledge pieces and rules needed for this program.

Thus, the assessment will proceed. Test items need not to be like traditional testing questions in classrooms. They can be mini-programs or short questions provided that they can be used as a guide to assess students' mastery level of declarative knowledge.

Furthermore, we also should consider the nature of the language. For example, If the student has studied both Prolog and Java before, considering the respective relationship of them with Perl, we will still use Java as supporting knowledge because it is closer to Perl. This factor is called Knowledge Relation (K-R), and it will be assigned to $\mathbf{d}_{ij}$.

At the end of the self-assessment section, a directed tutoring graph is generated. And student will be tutored based on it.

Currently, we are constructing the fuzzy rules which are applied for the assessment module, followed by the implementation and evaluation of it.

References

1. Capper, D.M. "Introducing C++ for Scientists, Engineers and Mathematicians", U.K., Springer-Verlag, (1994).
2. Collins, J.A., Greer, J.E. & Huang, S.X. "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the 3rd International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
3. Derry, S.J. & Hawkes, L.W. "Toward fuzzy diagnostic assessment of metacognitive knowledge and growth", Proceedings of the Annual Meeting of the American Educational Research Association, San Francisco, CA, (1992).
4. Doignon, J.-P. & Falmagne, J.-C. "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, Vol 23, pp.175-196, (1985).
5. Dowling, C.E. & Kaluscha, R. "Prerequisite relationships for the adaptive assessment of knowledge", Artificial Intelligence in Education, pp. 43-50, AACE: Charlottesville, VA, (1995)
6. Dowling, C.E., Hockemeyer,C., Ludwig, A.H. "Adpative assessment and training using the neighbourhood of knowledge state", Proceedings of the 3rd International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada, LNCS 1086, (1996).
7. Falmagne,J.-C. & Doignon,J.-P. "A Markovian procedure for assessing the state of a system", Journal of Mathematical Psychology, Vol. 32, pp. 232-258, (1988).
8. Harvey, L. & Anderson, J.R.. "Transfer of declarative knowledge in complex information processing domains", http://act.psy.cmu.edu/ACT/papers/Harvey_Anderson95.html, (accessed on August 1, 2000).
9. Juliano,B.A. & Bandler,W. "Tracing Chains-of-Thought", Heidelbert: Physica-Verlag, (1996).
10. Katz, S., Lesgold, A., Eggan, G., & Gordin, M. "Approaches to student modeling in the Sherlock tutors", Proceedings of the Third International Workshop on User Modeling, Germany, pp. 205-230, (1992).

11. Lesgold, M., Eggan, G., Katz, S. & Rao, G. "Possibilities for assessment using computer-based apprenticeship environments", Cognitive Approaches to Automated, Hillsdale, Lawrence Erlbaum Associates, (1991).
12. Matsubara, Y., Nagamachi, M. "Motivation system and human model for intelligent tutoring", Proceedings of the 3rd International Conference on Intelligent Tutoring Systems (ITS' 96), Montreal, Canada. LNCS 1086, (1996).
13. McCalla, G. I., Greer, J. E. "Granularity-based reasoning and belief revision in student models", Student Modelling: The Key to Individualized Knowledge-Based Instruction, pp. 39-62. Springer-Verlag, Berlin, (1994).
14. Nguyen-Xuan, A., Joly, F., Nicaud, J.F., Gelis, J.M. "Automatic diagnosis of the student' s knowledge state in the learning of algebraic problem solving", Proceedings of the Conference on Artificial Intelligence in Education, Japan, (1993).
15. Sime, J.-A. "Modeling a learner' s multiple models with Bayesian belief networks", Proceedings of the Conference on Artificial Intelligence in Education, Edinburgh, Scotland, pp. 426-432, (1993).
16. Tang, Tiffany Ya. & Wu, Albert. "The implementation of a multi-agent intelligent tutoring system for the learning of computer programming", To appear in the 16th IFIP World Computer Congress — International Conference on Educational Uses of Communication and Information Technologies (ICEUT 2000) Beijing, China, (2000).
17. Villano, M. "Probabilistic student models: Bayesian belief networks and knowledge space theory", Proceedings of the 2nd International Conference on Intelligent Tutoring Systems (ITS' 92), Montreal, Canada, pp. 491-498, (1992).
18. Zadeh, L.A "Fuzzy sets", Information and Control, Vol. 8, pp. 338-353, (1972).
19. Zadeh, L.A. "A fuzzy-set-theoretic interpretation of linguistic hedges", Journal of Cybernetics, Vol. 2, pp. 4-34, (1973).
20. Zhu, Q. & Lee, E.S. "Fuzzy and Evidence Reasoning", Physica-Verlag, Germany, (1995).

An XML-Based Tool for Building and Using Conceptual Maps in Education and Training Environments

Juan-Diego Zapata-Rivera, Jim E. Greer, John Cooke
ARIES Laboratory, Department of Computer Science,
University of Saskatchewan, Saskatoon, Canada
Diego.Zapata@usask.ca

Conceptual maps have been used in many areas as a means of capturing and representing knowledge. Several authors have explored the use of visual tools to enhance the learning process. *Thinking maps* as well as *frame games* use visual patterns of relationships (learners thinking processes) to structure knowledge. Based on their graphical structure it is possible to recognize the thinking process(es) employed in the map. Several software applications have been created to support different kinds of maps, but they use proprietary files to represent their maps. It makes sharing of knowledge difficult and jeopardizes the widespread use of maps. This paper proposes XML (Extensible Markup Language) as the language to describe maps. A knowledge construction and navigation tool (KVT- Knowledge Visualization Tool) has been implemented using XML to represent the kinds of maps supported by *thinking maps* and/or *frame games*. This paper describes the uses of KVT in education and training environments.

Keywords: **Knowledge Construction and Navigation Systems, Conceptual Maps, Thinking maps, Frame Games, XML, and Learner Models.**

1 Introduction

Conceptual maps have been widely used in many disciplines for different purposes. Concept maps have been used in education and training as a means of capturing and representing knowledge. Concept maps are just one of a variety of visual tools employed in schools and corporations. Several authors [2,4,5,6,7,9,10, and 14] have explored the use of conceptual maps to enhance the learning process.

Several authors [1,3,7, and 14] have used map adaptation techniques in hypermedia systems to offer a pertinent group of links to a particular user in a particular situation. Existing map-based navigation systems use different adaptation techniques to change the structure of the map according to the users' goals or preferences.

In this paper, we present KTV (Knowledge Visualization Tool), a knowledge construction and navigation tool that allows students and teachers to create XML-based maps in which they can add different kinds of links to the nodes on the map and navigate throughout the content using their own map. In addition, learners can introduce their own links or use links suggested by the teacher and/or other learners. Students and teachers can remove any unwanted link and define the sequence in which the links will appear. XML-maps are viewed as an important step in the creation of an open representation of maps that facilitates sharing of knowledge and assessment of students' knowledge by comparing their maps.

2 Visual Concept-Mapping Tools

A Visual concept-mapping tools (maps) have been used for constructing knowledge and capturing information about people's thinking processes. Because of the many types of maps available, people may

get confused about what kind of map to choose for a specific problem. Hyerle [4] classifies maps in three categories:

- **Informal representations**, such as *brainstorming webs, web maps*, and *mind maps*, which are used mainly to support association and creative processes.
- **Task specific maps or organizers**, such as *life cycle, text structures*, and *decision trees*, which are used in specific content areas or tasks.
- **Thinking process maps**, such as *concept maps, system thinking maps*, and *thinking maps*, which are used to represent not only content relationships on a specific area, but also the thinking process or kind of reasoning behind the map.

Web maps, mind maps, and *brainstorming maps* have been used to support creative processes. Their informal structure is useful in areas, such as: brainstorming sessions, decision making, problem solving, taking notes, public speaking and planning. Figure 1 shows an example of a mind map created using Mind Manager® MindJET, LLC [8].

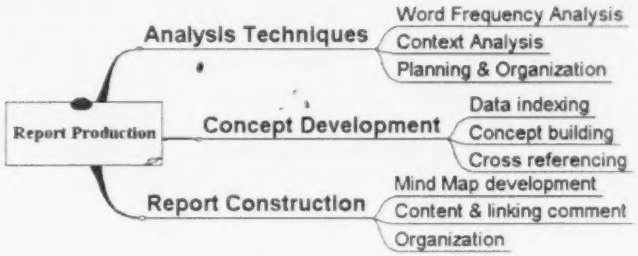


Figure 1. Example of a mind map [8].

Task-specific maps or *organizers* are designed to structure knowledge on a specific area. Figure 2 shows an example of a simple task-specific map (a classification tree) used in a biology class.

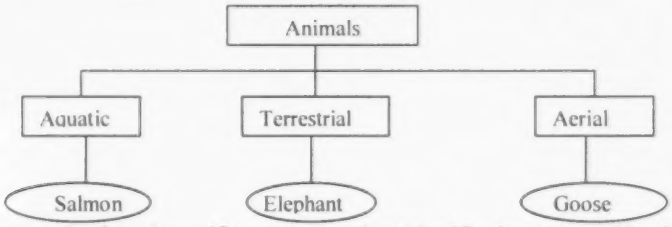


Figure 2. An example of a task-specific map or organizer (classification tree) used in a biology class.

Thinking process maps include concept maps, system maps and thinking maps. Thinking maps [4] are similar to frame games [6]. They use various kinds of visual patterns to represent information relationships and mental processes such as: sequencing, identifying attributes, cause-effect reasoning, analogical reasoning, part/whole reasoning, and classifying information.

Using *concept maps* [5,6,9, and 10] with different types of links, it is possible to represent more or less the same mental processes that thinking maps represent. The main disadvantage of *concept maps* over *thinking maps* is that their graphical structure does not necessarily reflect the thinking process. Figure 3 shows a simple example of a concept map.

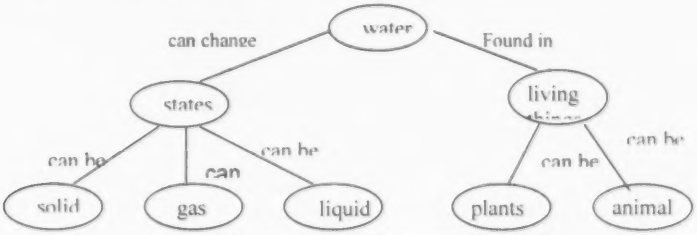


Figure 3. An excerpt of a concept map [10].

Thinking maps and *frame games* integrate knowledge views and make explicit fundamental human cognitive processes. According to Hyerle [1], by using *thinking maps*, it is possible to create any map that can be created using *brainstorming webs* and *task organizers* without being as informal as *brainstorming webs* and less content dependent than *task organizers*. Not only do *thinking maps* support structuring of content but also thinking processes, meta-cognitive abilities and reflection. Figure 4 shows some of the visual patterns supported by *thinking maps* and/or *frame games*.

Thinking map	*Frame game*	*Reasoning*
Bridge map	Analogy pattern	Metaphorical
Multi-Flow map	Cause-Effect pattern	Systems dynamics
Brace map	Part/Whole pattern	Inductive and deductive

Figure 4. Some of the maps (visual patterns) supported by thinking maps and/or frame games.

3 Proprietary Map File Formats vs. XML-Maps

Most of the available commercial products (i.e. [8,11, and 13]) support *mind maps* or variations of them for multiple purposes (i.e. brainstorming sessions, decision making, problem solving, taking notes, public speaking, etc.). These products provide links to external applications, to other maps, and to content on the web. Although, ThinkingMaps® [12] is a software tool for the creation of thinking maps in education and training environments, it does not provide links to external applications, to other maps, or to the web. All these products use proprietary map file formats to represent their maps. It makes difficult sharing of knowledge and jeopardizes the general use of maps.

Using XML as the language to represent maps it is possible to eliminate proprietary files. The creation of a DTD file (Document Type Definition) to validate XML-maps should consider the main characteristics of the maps, such as: linking nodes to external applications, to content on the web, and to other maps. The DTD file proposed in this paper ('XMLmaps.dtd') covers all of the eight kinds of maps supported by *thinking maps* [4] and the ten kinds of maps (visual patterns) supported by *frame games* [6]. We have chosen to work with *thinking maps* and/or *frame games* because of their property of providing different visual patterns to represent different thinking processes. Figure 5 shows a fragment of the DTD file created to validate XML-maps.

Some of the benefits of using XML as the language to represent *thinking maps* and/or *frame* games are:

- XML provides an open format to maintain and share maps as opposed to proprietary file formats.
- By using a common vocabulary in conjunction to XML-maps, it is possible to compare maps. That is, maps can be compared to find similarities and differences in the type of structure employed (thinking process(es) used by the learner to analyze the topic), relation among nodes and types of links and documents attached to each node.
- Any XML query language such as XML-QL or XQL can be used to create queries to compare maps. By comparing maps it is possible to assess learners' knowledge and determine possible misconceptions, or gaps on a specific concept or group of them. By analyzing the type of map used to represent the knowledge it is possible to identify possible problems of the learner with a specific kind of reasoning.
- XML permits collaborative viewing of maps. See section 4.3 (KVT- Navigation System).
- By maintaining the student's knowledge information (XML-maps) in the learner model, new interesting opportunities for assessment, collaboration, adaptation, and inspection can be explored.

- Opening visual knowledge representations is an important step towards the goal of capturing, sharing, and using knowledge across disciplines.

Figure 6 shows a fragment of an XML-map used to study Anatomy. This map has been validated using the grammar rules encoded in 'XMLmaps.dtd'. Figure 7 shows the graphical representation of the same XML-map. This map can be classified as a 'brace map' following the notation of *thinking maps* or as a 'parts-whole' pattern using the *frame games* representation. In both cases, they represent part-whole relationships among concepts and inductive/deductive kinds of reasoning.

```
# Author: Juan Diego Zapata Rivera
# Version: XMLmaps.dtd 1.0
<!--*****************************************************************
ELEMENT: XMLmap
COMMENT: thinking maps structures and frame games-->
<!ELEMENT XMLmap  (CircleMap* | BubbleMap* | DBubbleMap* |
BridgeMap* |FlowMap* | BraceMap* | TreeMap* |MultiFlowMap* )
<!ATTLIST XMLmap
<!--*****************************************************************
ELEMENT: BraceMap
COMMENT: Brace map. whole/ part. Inductive and Deductive Thinking->
<!ELEMENT BraceMap (BraceNode+,Link*)
<!ATTLIST BraceMap
MapId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA   #REQUIRED
Description  CDATA   #REQUIRED
<!--*****************************************************************
ELEMENT: Link
COMMENT: Link description-->
<!ELEMENT Link (FromNode,ToNode,LinkMedia)
<!ATTLIST Link
LinkId CDATA    #REQUIRED
Type   CDATA    #REQUIRED
Name  CDATA   #REQUIRED >
```

Figure 5. Fragment of DTD for XML-maps

```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-stylesheet type="text/xsl" href="XMLmaps.xsl"?>
<!DOCTYPE XMLmap SYSTEM " XMLmaps.dtd">
<XMLmap>
    <BraceMap Type='"BraceMap"' Description='"Example of an XML-map"' Name='"The human body"'
    MapId='"Map001"'>
        <BraceNode NodeId="02" Type='"BraceMap"' Name='"head"' XMLthinkingMapLink='""'>
            <LinkMedia XMLConcept='"head"' Text='""' Application='""' URL='"I"' Sound='""'/>
            <Chlidren>05</Chlidren>
            <Chlidren>06</Chlidren>
            <Parents>01</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink='""' Name='"ears"' Type='"BraceMap"' NodeId="05">
            <LinkMedia XMLConcept='"ears"' Text='""' Application='""' URL='"www.body.xml"'
Sound='""'/>
            <Parents>02</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink='""' Name='"eyes"' Type='"BraceMap"' NodeId="06">
            <LinkMedia XMLConcept='"face"' Text='""' Application='""' URL='"www.body.xml"'
Sound='""'/>
            <Parents>02</Parents>
        </BraceNode>
        <BraceNode XMLthinkingMapLink='""' Name='"torso"' Type='"BraceMap"' NodeId="03">
            <LinkMedia XMLConcept='"trunk"' Text='""' Application='""' URL='"I"' Sound='""'/>
            <Parents>01</Parents>
```

Figure 6. Fragment of an XML-map about 'Anatomy'.

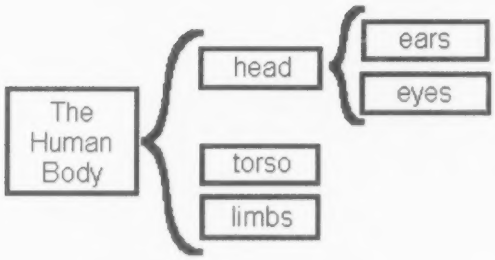


Figure 7. Graphical representation of an XML-map about 'Anatomy'.

4 KVT (Knowledge Visualization Tool)

KVT is a map construction and navigation system that allows the creation of XML-based *thinking maps* or *frame games*. KVT also provides the possibility to link different kinds of resources to specific nodes. In this way, KVT supports personalized navigation throughout the class content. Students can create their own knowledge structure using a set of predefined concepts (*common vocabulary* given by the teacher) and use their own map to access class resources. These resources are suggested by the teacher (*initial links*) or by his/her classmates during the creation of their maps (*collaborative browsing using XML-based maps*).

The class content is not limited to a specific group of pages, videos, sounds, etc. On the contrary, any student or teacher in the class can navigate through the map via the WWW, can add links, and can add new resources. Every participant has access to all of the resources that are associated with the nodes in his/her map. The list of resources attached to a node can be ordered arbitrarily by the learner.

4.1 KVT's Architecture

KVT (see figure 8) is composed of the following modules:

- ***Map Construction Tool***. KVT supports the ten kinds of maps identified in the context of *frame games* [6] and the eight types of *thinking maps* proposed by Hyerle [4,12]. Students select concepts from a predefined list and create their own structure. Having a predefined list of concepts (*common vocabulary*) makes it easier to share, compare, analyze and evaluate maps. Students can link different resources (course materials, web pages, documents stored on different applications, etc) to their map. They can even include other maps in a recursive manner. Students' maps are stored in the learner model for further modification, analysis and evaluation.
- ***The Browser***. This is the main interface to visualize one's map and its associated class content. Students can navigate throughout the content by clicking on any node of the map and selecting one of the links/documents that are available for this node. Furthermore, students can navigate freely and add links and documents to any of the nodes in the map. Students can navigate using links suggested by other students/teachers in a hyperspace created collaboratively for a particular topic and encoded on the map.
- ***The Learner Model***. The Learner module maintains basic learner information as well as their XML-maps (XML files including map structure, links, and order preferences). Students can add, order, modify, or remove links and nodes. Students and teachers contribute to populate each node with different sort of resources, but it is up to each person to remove unwanted resources and define the sequence in which he/she prefers to see the resources.
- ***Course Materials***. Class resources are classified into three main categories: web content, XML content, and general documents (text, sound, images, videos, etc.). They comprise an open range of materials that are organized first by the teacher. Using KVT, students and teachers can create different representations of the knowledge, and as a result of their contributions a highly refined subset of useful documents will be attached to each of the nodes. KVT supports the cooperative creation of information spaces to be used in educational contexts.
- ***Learners and Teachers Share Maps***. Learners and teachers can use KVT in a number of ways. For example, Teachers and learners can visualize maps using different levels of granularity. Learners can use an existing map as a guide to study the content, or use this system as a learning tool to facilitate remembering, create maps collaboratively, share their maps, and engage in interesting discussions

about a particular topic. Teachers can create maps to serve as 'guided tours', which can be used by students to navigate throughout the content. Teachers can use XML-maps to assess the student's knowledge. This can be done by comparing different maps (visually or through queries) to determine problems in the learning process for a particular student or groups of them. Finally, teachers can use this system as an adequate environment to promote reflection among students on a specific topic (map structure and content).

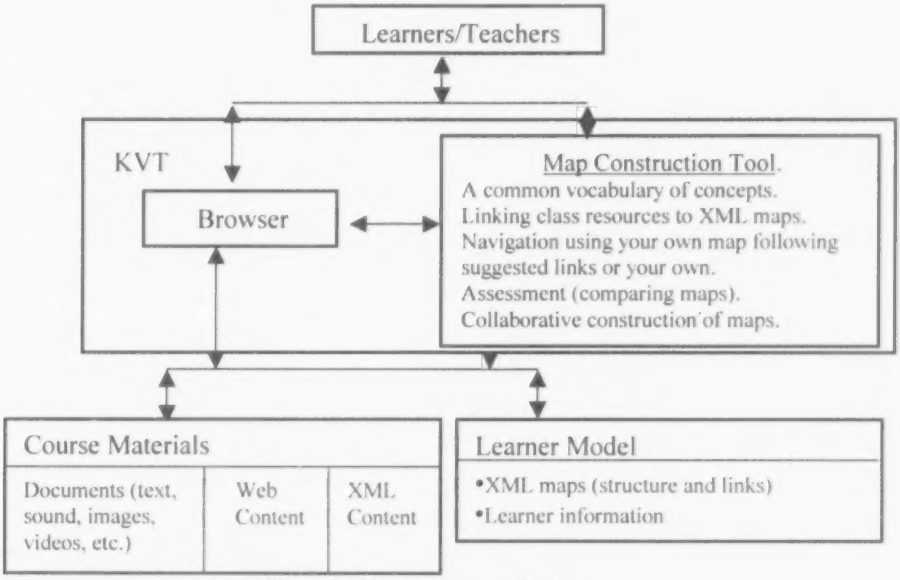


Figure 8. KVT- System Architecture.

4.2 KVT- Linking Documents to Nodes

Using KVT it is possible to add different kinds of documents to the nodes of the map. Figure 9 depicts the user interface provided by KVT to add, modify and remove documents. This interface allows students/teacher to attach a web page, XML document, video, sound, or image to any node on the map. KVT also provides the option to test any of the documents, edit the description and document fields and remove any unwanted link from the map. By clicking the headers on the grid it is possible to change the order in which the links will be presented to the student when navigating using the map. Order preferences are stored in the learner model for further use.

New links/documents for a particular node are automatically shared with all of the maps that contain such a node. This can affect maps of several students/teachers in the system. However, individual sequencing or removal of resources affects only the student's own map. Maps are stored as XML files in the learner model. The example on figure 9 shows a Brace-map that is used to organize information related to Anatomy. The grid of current documents shows the currently available links for the concept 'ears'. It is possible to visualize who included each link (user type/user), the document type location and description.

4.3 KVT- Navigation System

Figure 10 shows how students and teachers can navigate on the web using their own maps and their own links or the ones suggested by others. Just by clicking the concept, a list of current links/documents appears to be selected. If the student has not chosen any particular sequence of resource presentation, this list is initially ordered by type of user (teacher/student). In this environment, it is also possible to navigate freely on the web by entering a URL or just following the links on the current page. When an interesting page is found, it can be attached to any concept on the map by selecting the target concept and pressing the button 'Add Link' located at the bottom of the window.

The example in Figure 10 shows how the student uses the map to navigate by the links related to the concept 'ears'. The current web page corresponds to the first link suggested by the teacher 'Anatomical Tour of the Ear'.

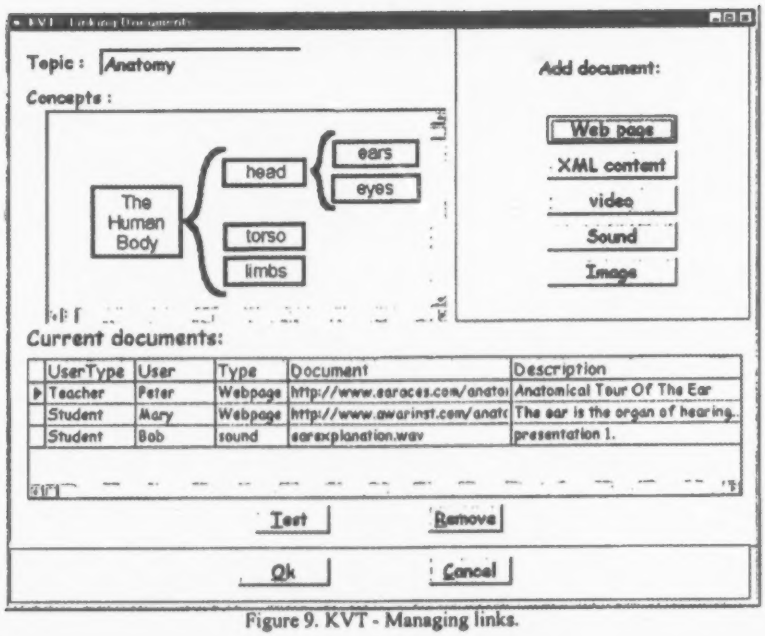


Figure 9. KVT - Managing links.

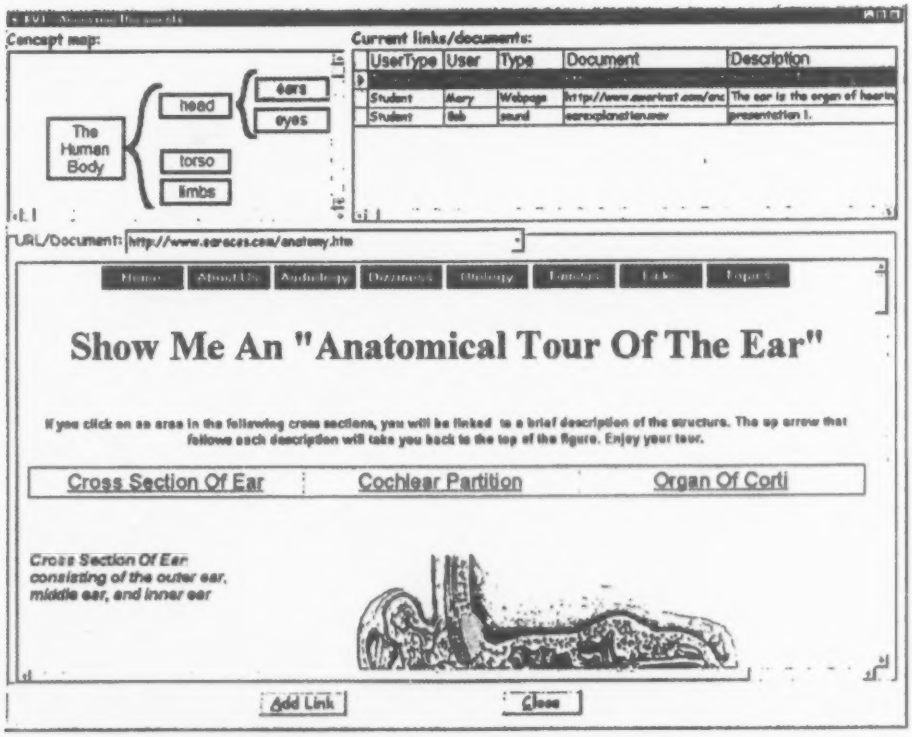


Figure 10. KVT- Navigating on the web using XML-maps and suggested links/documents.

5 Conclusions and Future Work

BEST COPY AVAILABLE

XML offers an excellent language to represent maps. Using XML maps, it is possible to support knowledge sharing without the problems of having proprietary files. By using a common vocabulary for the content and XML maps, it is possible to compare map structures.

XML-maps (*thinking maps, frame games*) are very useful in education and training environments because they support content structure and make explicit fundamental human cognitive processes.

KVT offers an attractive tool for the creation of maps and supports collaborative navigation throughout the content. By using XML-maps, KVT provides a better support to education or training setups that uses maps to create, share and assess knowledge. By including XML-maps into the learner model, new possibilities for visualization and inspection of XML-maps can be exploited in order to improve the learning process.

References

[1] Brusilovsky, P. "Methods and Techniques of Adaptive Hypermedia". In Adaptive Hypertext and Hypermedia. Brusilovsky, P., Kobsa, A., and Vassileva, J. (eds.) Kluwer Academic Publishers, pp. 1-41 (1998).

[2] Buzan, T. "Use both sides of Your Brain". Ed. Dutton. New York (1979).

[3] Gaines, B. R. and Shaw, M.L.G. "Web Map: Concept Mapping on the Web". (1995). Available on-line:http://ksi.cpsc.ucalgary.ca/articles/WWW/WWW4WM/WWW4WM.html

[4] Hyerle, D. "Visual Tools for constructing knowledge", ASCD press. Alexandria, Virginia, (1996).

[5] Jonassen, D., Wilson, B., and Cole. P. "Cognitive Approaches to Instructional Design". G.M. Piskurich (ed). The ASTD handbook of instructional technology. McGraw–Hill. New York, pp. 21.1-21.22. (1993). Also available on-line:http://www.cudenver.edu/~bwilson

[6] Jonassen, D., Beissner, K., and M., Yacci. "STRUCTURAL KNOWLEDGE. Technique for Representing, Conveying, and Acquiring Structural Knowledge". Lawrence Erlbaum Associates, Publishers. Hillsdale, NJ (1993).

[7] Micarelli, A., and Sciarrone, F. "A case-based toolbox for guided hypermedia navigation". In Proceedings of the Fifth International Conference on User Modeling, pp. 129-136 (1996).

[8] MindManager® by MindJET LLC. Test version V3.5.5.SP2. Apr 8, (1999).

[9] Novak., J. D.. Learning, Creating, and using Knowledge. Concept Maps as Facilitative Tools in Schools and Coorporations". Lawrence Erlbaum Associates, Publishers. Mahwah, NJ (1998).

[10] Novak., J. D., and B. D., Gowinn. "Learning how to Learn". Cambridge University Press. Cambridge, England (1984).

[11] THE BRAIN® by Natrificial Software Technologies. Free version 1.73. 9/1/99, (1999).

[12] ThinkingMaps® by Innovative Learning Group. Trial version 1.0.1, (1998).

[13] VisiMap® by CoCo Systems Ltd. Trial version 2.5 c. Nov 1999.

[14] Zyryanov, M. "Adaptive local maps in the hypermedia components of intelligent learning environments'". In: P. Brusilovsky, P. Kommers and N. Streitz (eds.): Multimedia, Hypermedia and Virtual Reality: Models, Systems, and Applications. Lecture Notes in Computer Science, Berlin: Springer-Verlag, pp. 306-310 (1996).

Controlling Problem Progression in Adaptive Testing

Roger E. Cooley & Sophiana Chua Abdullah
University of Kent at Canterbury
Computing Laboratory, University of Kent at Canterbury,
Canterbury, Kent CT2 7NF, The United Kingdom
Tel: +44-1227-823816
Fax: +44-1227-762811
Email: rec@ukc.ac.uk, sc34@ukc.ac.uk

Adaptive testing has, in recent years, been used as a student modelling technique in intelligent tutoring systems. One of the main issues has been to optimise the progression of problems posed as the student performs the adaptive test. Previous research has concentrated on finding a structure in a fixed collection of problems. This paper describes an algorithm for problem progression in adaptive testing. After describing current approaches to the progression problem, the paper discusses the role of expert emulation. It then describes a knowledge elicitation exercise, which resulted in a solution to the progression problem. Part of the knowledge elicitation process was supported by software based on constraint logic programming, clp(FD), and the paper concludes with an assessment of the prospects of developing an extended knowledge elicitation support system.

Keywords: **intelligent tutoring system, knowledge construction and navigation, adaptive testing, constraint logic programming**

1 Introduction

The major advantages of adaptive testing over fixed item testing are that a student's knowledge is explored thoroughly and efficiently, and with a minimum of redundancy. By asking an appropriate number of problems at appropriate levels of difficulty, adaptive testing neither bores by unnecessary repetition nor intimidates by posing a series of inappropriately difficult problems [1]. This makes adaptive testing attractive for student modelling in intelligent tutoring systems [2],[3].

This research was conducted in the context of providing remedial help in mathematics to a transient population of prisoners in a local prison. Here the students are studying courses such as City and Guilds (Key Skills), City and Guilds (Number Power) and for GCSE level examinations. Working with prisoners can face tutors with problems not normally encountered in more conventional settings. Unlike school students, the prisoners not only lack uniform prior knowledge in mathematics, but tend also to join or leave the prison at individual times. This makes the job of the human tutor difficult because of the need to assess the knowledge level of each prisoner before assigning them the appropriate level of one or more of the above courses and examination. Currently, fixed item testing is used as an assessment tool. This approach has a major disadvantage. Many prisoners are 'math anxious' and the use of fixed item testing may undermine their confidence and motivation in the subject. Adaptive testing avoids this danger by presenting problems at an appropriate level of difficulty.

One of the main issues in adaptive testing is the determination of an efficient progression from one problem to another. Previous proposals have included hard-wiring prerequisite relationships between knowledge items [3], and preparing an indexing framework for problems [4]. Section 2 of this paper reviews the major lines of research; and the paper then describes an approach to the progression problem based on the knowledge acquisition techniques used for expert systems. In doing so, it continues in the vein of Khuwaja & Patel's work [5]. The paper presents a rationale for this approach, describes briefly a semi-automated

method of eliciting syllabus content and characteristics, and then presents a progression technique elicited by standard techniques with an expert. It concludes with a discussion of the feasibility of automation in this area.

2 The Progression Problem

In a problem-solving environment, *problem progression* is concerned with the strategy in which the next problem is selected. In adaptive testing, this is usually based on the student's response to the current problem, as the process of selecting the next appropriate problem is crucial to the efficiency and precision of the whole student modelling process. Also, presenting *the right question at the right time* maintains the motivation of the student.

The structure of the domain, that is the way in which problems are related to one another, determines problem progression in adaptive testing; and the two significant and distinctive approaches to determining such structures are discussed in this section.

2.1 Item Response Theory

For adaptive testing systems which adopt the *Item Response Theory* or IRT [6], such as SIETTE [7] and CBAT-2 [8], the domain is made up of test items which are kept in an *item pool*. The construction of an item pool usually involves major empirical studies for content-balancing, to ensure no content area is over-tested or under-tested, and for item calibration. Each test item is associated with one or more of the following parameters – the *difficulty level, the discriminatory power and the guessing factor*. The *difficulty level* measures the difficulty level of a test item, the *discrimination power* describes how well the test item discriminates students of different proficiency, while the *guessing factor* is the probability that a student can answer the test item correctly by guessing.

Problem progression takes place like this. The adaptive test starts with an initial estimation of the student's proficiency, è. A *best* item or problem is selected. This is one which provides the most information about the student, and is calculated from the item's three parameters and current proficiency, è. An ideal item should have a difficulty level close to è, a high discriminatory power and a low guessing factor. A new proficiency, è', and its confidence level are calculated based on whether the student has answered the problem correctly or not, the old è, and the item parameters. The test continues until a stopping criterion is met, for example, when the confidence level of è' has reached a desired level.

2.2 Knowledge Space Theory

There are adaptive testing systems built on the theory of *knowledge spaces[9]*. Examples include a web-based, domain-independent system called RATH [10], a web-based system for the domain of mathematics called ALEKS [11], and a general purpose system for testing and training called ADASTRA [12].

Like the IRT-based systems, the domain is made up of test items of an academic discipline, each of which can be a problem or an equivalence class of problems that the student has to answer. The student's *knowledge state* is defined as the set of items in the domain that the student is capable of solving. For example, if a student has the knowledge state ***{a,b,d}***, this means that he can solve items ***a***, ***b*** and ***d***. Not all possible subsets of the domain are feasible knowledge states. Consider the example shown in [13]. In a domain of mathematics, if a student can solve a percentage problem, (item ***d*** say), then it can be inferred that the student can perform single-digit multiplication, (item ***a*** say), and thus any state that contains item ***d*** would also contain item ***a***. The collection of all feasible knowledge states is called the *knowledge structure*. The knowledge structure must also contain the *null state {}*, which corresponds to the student who cannot solve any item, and the *domain*, which corresponds to the student who can solve or master all items. When two subset of items are knowledge states in a knowledge structure, then their union is also a state. This means that the collection of states is *closed under union*. When a knowledge structure satisfy this condition, it is known as a *knowledge space*.

In practice, items for a domain are derived from instructional materials and systematic knowledge elicitation with teachers. This is also the case with establishing knowledge states where query procedures systematically elicit from human experts the prerequisite relationships between items [3], [14].

Once the domain is represented as a knowledge space, the adaptive testing strategy is then to locate as efficiently and as accurately as possible, a student's knowledge state. Problem progression becomes straightforward. For example, if a student has answered an item correctly (incorrectly), it can be inferred that he can (cannot) answer a prerequisite item and will thus not be asked to solve the latter.

2.3 Other Approaches

The domain can be represented as a *granularity hierarchy* [15] where items which represent a topic, subtopic or skill, are described at various grain sizes and connected together into a granularity hierarchy which allows focus shifts along either *aggregation* or *abstraction* dimensions. In this way, the ability to recognise student behaviour at varying grain sizes is important both for pedagogical and diagnostic reasons.

Other examples include an *indexing framework* for the adaptive arrangement of problems in the domain of mechanics [4], a problem-simplification approach [16], an optimisation expert system where both the knowledge structures of the student and the teacher are represented by structural graph, and problem progression is controlled by the relationship between the student's knowledge structure and that of the teacher's [17]. Evidence of a strong use of a student model in controlling problem progression can also be found in a system called TraumaCASE [18] which automatically generated clinical exercises of varying difficulty, and in the work of Beck, Stern & Woolf [19] who recorded information about a student using two factors – *acquisition* and *retention*. *Acquisition* records how well students learn new topics while *retention* measures how well a student remembers the material over time.

3 Knowledge Elicitation

The concern of the researchers discussed above is to exploit a structure of a syllabus to improve the efficiency of tests. The structure may either be revealed through elicitation, as was done by Dowling and her co-workers, or may be derived from a statistical analysis of student behaviour, (IRT), or it may be seen as being derived from the nature of the problem domain. Though there may be, from some given point of view, an optimal way of structuring a syllabus, the view adopted in this research is that it is a subjective matter to be determined by an expert teacher. Such a teacher might make use of informal statistical information, subject domain information as well as pedagogic information in determining a suitable structure. Studies of intelligent tutoring systems have shown that, as one would expect, it is difficult to transfer systems from one setting to another, because there is considerable cultural variation in both teaching and learning [20]. This provides the prime motive for investigating techniques based on expert emulation for the production of tests for local consumption.

Moreover, this is a natural extension of the *intelligent tutoring systems* endeavour, and it has an additional advantage. A lack of homogeneity amongst a student body can weaken the effectiveness of techniques based on population statistics; and the target body of students with which this paper has been concerned is, educationally, not very homogeneous.

4 Eliciting the Syllabus

There are several problems to be confronted when adopting an expert emulation approach to designing an adaptive test. They include the problems of finding suitable experts [21], selecting appropriate forms of knowledge representation and choosing appropriate methods of knowledge acquisition.

The approach to knowledge acquisition in the research described here is to separate the task of designing an adaptive test into the following sub-tasks:

- describing classes of problems,
- describing the skills used to solve problems,
- describing responses to problems,
- problem generation,
- problem progression based on student responses.

For the particular domain tackled, namely the arithmetic of elementary fraction addition, software has been developed to support the first four of these subtasks using Constraint Logic Programming, clp(FD), embedded in Prolog, [22]. This work has been described in a recent conference paper [23], and is briefly summarised here.

Clp(FD) is actively used by the knowledge engineer conducting knowledge acquisition interviews. The teacher, who is the target of the emulation, is not expected to write constraints, but is more than likely to take an interest in them. During discussions, which involve the production of example problems, the knowledge engineer enters the necessary constraints, or modifies existing constraints, to describe the particular class of problem under discussion. The set of constraints is then solved interactively to produce example problems. These form the basis of a discussion, and may lead to further rounds of discussion and modification.

The description of a class of problems is treated as a set of constraints. This consists of a set of variables, a statement of the domains of the variables, and a statement of the relational constraints that hold between the variables. For example, during an interview, the human tutor wanted to represent a class of problems, which involved the addition of two proper fractions with a common denominator of the form,

$$N1/D1 + N2/D2 = N/D$$

and he wanted to use single-digit integers.

This can be represented in clp(FD) as a code fragment:

```
domain([N1,D1,N2,D2],1,9),        % Single digit integers
N1 #<  D1,                        % First operand - proper fraction
N2 #<  D2,                        % Second operand - proper fraction
D1 #= D2.                         % A common denominator
```

The following is an example of the use of clp(FD) to describe skills. The *cancel fraction* skill can be represented in clp(FD) as:

```
% Simplify the fraction N/D into its lowest form to give X/Y
% Example:  63/81 gives 7/9
cancel(N,D,X,Y) :-
      domain([N,D,X,Y,F], 1,99),
      F*X #= N,
      F*Y #= D,
      maximize(labeling([], [F,X,Y]), F).
```

Here, variable F is the common factor to be cancelled. This is specified by the two relational constraints. The *maximize* predicate in the final line ensures that the largest value of F will be found.

5 Eliciting the Progression

The knowledge elicitation exercise involved approximately 20 hours of interviews spread over a period of three months. Conventional knowledge elicitation techniques, such as structured interviewing, task analysis and construct theory [24], were used.

Early interviews revealed the significance to the expert of the *skills* that students needed to exercise in order to solve particular problems. The following were identified:

a. Add equivalent fractions
b. Cancel fraction
c. Make proper
d. Find the lowest common multiple
e. Find equivalent fractions

The number of discrete skills required to solve a problem was considered as a measure of the difficulty of

the problem; and this measure was used to classify problems, and in so doing reveal a structure of the domain. This coincides with the findings of Beck, Stern & Woolf [19]. However, it is useful to note that this is only one of the many factors in measuring problem difficulty used by Lee [25], who identified, amongst others, the student' s degree of familiarity with a particular type of problem.

In eliciting progression information, it is necessary to avoid the problem of combinatorial explosion. A *head on* approach requires the expert to provide a tree structure of sequences of problems indicating the appropriate *next* problem depending on the outcome of all previously asked problems. Such an approach is unattractive to both expert and knowledge engineer. Instead, an approach adopted was to attempt to uncover the underlying *algorithmic* strategy of the expert.

In general terms, the strategy of the expert is to test the students' abilities to exercise the identified skills at a particular level of difficulty. Failure to return a correct answer causes the questioning process to be resumed at a lower level of difficulty, that is, with problems requiring the demonstration of fewer skills. Whereas successful demonstration of all the identified skills causes the questioning process to be resumed with problems at a greater level of difficulty. The expert started with problems of middling difficulty and adopted a *binary chop* approach to selecting the next level. Within each level of difficulty, the selection of the *next* problem depended on the skills already demonstrated. Each available problem was scored using a set of weights, which favoured previously undemonstrated skills at that level. If the progression problem is viewed as a variant of state-space search, the expert's strategy has more in common with a *constrain-and-generate* paradigm [26], at a given level of difficulty, rather than a naïve *generate and test* approach. A schematic example of the use of this strategy is given below.

In a Prolog implementation of this strategy, a record of students' skills, demonstrated at each tested level of difficulty is recorded, and used to prepare a revision plan.

6 An Example

The human tutor first prepared the adaptive testing strategy for a domain of five skills described above. This is shown in Figure 1 for a domain of five skills.

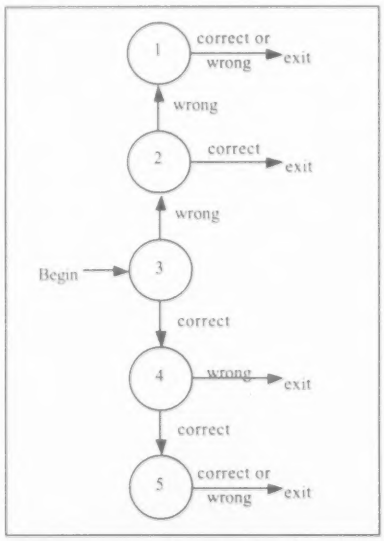


Figure 1: Human tutor' s strategy in adaptive testing for a domain of 5 skills

In Figure 1, the adaptive test begins at node 3 which contains problems each of which can be solved by exactly three skills. If the student gets any problems wrong within that category, he moves onto node 2 which contains problems each of which can be solved by exactly two skills. If he gets all the problems correct within that category, he will exit the adaptive test. The rationalisation for this is described below.

If each of the skills were labelled as a,b,c,d,e, as in Section 5, then at node 3, there are ${}^{5}C_{3}$ that is 10 possible combinations of skills. For example, the combination [a,b,c] would involve a set of problems which each require all the skills **a**, **b** and **c** to be used. Skills **a**, **b** and **c** correspond to *add equivalent fractions, cancel fraction*, and, *make proper* respectively. However in practice, not all these combinations will be found in a valid problem type.

We introduced weights to each combination to enable the choice of the next best combination. We also imposed the following criteria for calculating the weight of each candidate set:

- If a skill has been not been asked yet, it carries a weight of 2
- If a skill has already been asked once, it carries a weight of 1
- If a skill has been asked more than once, it carries no weight
- Select the first set amongst the candidate set with the highest score

The following process shows how problems, each of which, require a combination of three skills are presented to the student.

a. Select [a,b,c] and scores are assigned to the other combinations, based on the above rules:

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5

b. Based on these weights, combination [a,d,e] becomes the next best choice and is thus chosen. The scores for the remaining combinations are recalculated.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3

c. Combination [b,c,d] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1

d. Combination [a,b,e] becomes the next best choice and is thus chosen.

	[a,b,c]	[a,b,d]	[a,b,e]	[a,c,d]	[a,c,e]	[a,d,e]	[b,c,d]	[b,c,e]	[b,d,e]	[c,d,e]
1	*	4	4	4	4	5	4	4	5	5
2	-	2	2	2	2	*	3	3	3	3
3	-	0	1	0	1	-	*	1	1	1
3	-	0	*	0	0	0	0	0	0	0

e. As there are no more candidate sets, no more problems are presented.

The above example shows that out of the ten combinations, only problems of combinations [a,b,c], [a,d,e], [b,c,d] and [a,b,e] were chosen. As described previously, the human tutor would consider the student's previous performance and if any answers to problems were found to be wrong, he would assign problems at node 2 (see Figure 1). Conversely, if all the answers were found to be correct, he would assign problems at node 4 which require problems to be solved with exactly four skills.

The human tutor took the view that if a student has already tackled problems of three skills, whether he got them right or not, information gathered in packets of three skills need not necessarily apply to problems involving two skills. He considered that students may become anxious about problems which require more skills, and although some of the skills may well have been demonstrated in *easier* problems, the student may find it difficult to apply them in *harder* problems.

7 Conclusion

The paper describes the development of an adaptive test in the domain of elementary arithmetic, which required two styles of knowledge acquisition. The first is concerned with describing problems and skills, and it is computer-assisted; whereas the second is entirely manual and is concerned with the ordering, or progression, of problems to be posed to the subject of a test. However, based on this experience, work is currently underway to develop software to aid with eliciting details of progression. A valuable insight gained is that some degree of formalisation of the problem, as well as being convenient for the knowledge engineer, is also acceptable to the expert who helped with this work.

A possible significant difference between the research reported here and the work reviewed in Section 2 is that the approach to progression is not restricted to a fixed collection of problems. In view of Lee' s findings [25], it would be inappropriate to enforce the equating of difficulty with the number of skills. Evidence encountered during the knowledge acquisition experience suggests that the sheer clerical complexity of mapping out sequences of problems, lead to some draconian simplification on the part of the expert. The task ahead, is to find an appropriate balance between convenience and efficiency.

References

[1] Vispoel, W. P., Rocklin, T. R., & Wang, T., "Individual differences and test administration procedures: a comparison of fixed-item, computerized-adaptive, and self-adapted testing", Applied Measurement in Education, 7, pp. 53-79, (1994).

[2] Collins, J. A., Greer, J. E., & Huang, S. X., "Adaptive assessment using granularity hierarchies and Bayesian nets", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 569-577, (1996).

[3] Dowling, C.E. & Kaluscha, R., "Prerequisite relationships for the adaptive assessment of knowledge", Proceedings of the Seventh World Conference on Artificial Intelligence in Education (AI-ED'95), Washington DC, USA, August 16-19, pp. 43-50, (1995).

[4] Hirashima, T., Niitsu, T., Hirose, K., Kashihara, A., & Toyoda, J., "An indexing framework for adaptive arrangement of mechanics problems for ITS", IEICE Transactions on Information and Systems, E77-D, pp. 19-26, (1994).

[5] Khuwaja, R. & Patel, V., "A model of tutoring: based on the behavior of effective human tutors", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 130-138, (1996).

[6] Wainer, H., "Computerized adaptive testing: a primer", NJ: Lawrence Erlbaum Associates, (1990).

[7] Rios, A., Millan, E., Trella, M., Perez-de-la-Cruz, J.L.,& Conejo, R., "Internet based evaluation system", Proceedings of the Ninth International Conference on Artificial Intelligence in Education (AI-ED'99), Le Mans, France, July 19-23, pp. 387-394, (1995).

[8] Huang, S. X., "A content-balanced adaptive testing algorithm for computer-based training systems", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 306-314, (1996).

[9] Doignon, J. P. & Falmagne, J. C., "Spaces for the assessment of knowledge", International Journal of Man-Machine Studies, 23, pp. 175-196, (1985).

[10] Hockemeyer, C. & Dietrich, A., "The adaptive tutoring RATH: a prototype", Proceedings of the International Workshop on Interactive Computer aided Learning (ICL'99), Villach, Austria, (1999).

[11] ALEKS 2000, http://www.aleks.com (accessed on August 15 2000).

[12] Dowling, C. E., Hockemeyer, C., & Ludwig, A. H., "Adaptive assessment and training using the neighbourhood of knowledge states", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 578-587, (1996).

[13] Villano, M., "Probabilistic student models - Bayesian belief networks and knowledge space theory", Proceedings of the Second International Conference on Intelligent Tutoring Systems (ITS'92), Montréal, Canada, June 10-12, pp. 491-498, (1992).

[14] Kambouri, M., Koppen, M., Villano, M., & Falmagne, J. C., "Knowledge assessment - tapping human expertise by the query routine", International Journal of Human-Computer Studies, 40, pp. 119-151, (1994).

[15] McCalla, G., Greer, J., Barrie, B., & Pospisil, P., "Granularity hierarchies", Computers & Mathematics with Applications, 23, pp. 363-375, (1992).

[16] Hirashima, T., Kashihara, A., & Toyoda, J., "Toward a learning environment allowing learner-directed problem practice - helping problem-solving by using problem simplification", Proceedings of the Third International Conference on Intelligent Tutoring Systems (ITS'96), Montréal, Canada, June 12-14, pp. 466-314, (1996).

[17] Matsui, T., "Optimization method for selecting problems using the learner's model in intelligent adaptive instruction system", IEICE Transactions on Information and Systems, E80D, pp.196-205, (1997).

[18] Carberry, S. & Clarke, J. R., "Generating clinical exercises of varying difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 273-275, (1997).

[19] Beck, J., Stern, M., & Woolf, B. P., "Using the student model to control problem difficulty", Proceedings of the Sixth International Conference on User Modeling (UM97), Chia Laguna, Sardinia, Italy, June 2-5, pp. 277-289, (1997).

[20] Payne, S. J. & Squibb, H. R., "Algebra mal-rules and cognitive accounts of error", Cognitive Science, 14, pp. 445-481, (1990).

[21] Lightfoot, J. M., "Expert knowledge acquisition and the unwilling expert: a knowledge engineering perspective", Expert Systems, 16, pp. 141-147, (1999).

[22] Clp(FD) 2000, http://www.sics.se/isl/sicstus/docs/latest/html/sicstus.html#CLPFD (accessed on August 15 2000).

[23] Chua Abdullah, S. & Cooley, R. E., "Using constraints to develop and deliver adaptive tests", Proceedings of the Fourth International Conference on Computer Assisted Assessment (CAA), June 21-22, Loughborough University, UK, (2000).

[24] McGraw, K. L. & Harbison-Briggs, K., "Knowledge acquisition, principles and guidelines", NJ: Prentice-Hall, (1989).

[25] Lee, F. L., "Electronic Homework: an intelligent tutoring system in mathematics", PhD Thesis, The Chinese University of Hong Kong, (1996).

[26] Marriott, K. & Stuckey, P., "Programming with constraints: an introduction", Cambridge, MA: MIT Press, (1998).

Development and Evaluation of a Mental Model Forming Support ITS

- the Qualitative Diagnosis Simulator for the SCS Operation Activity-

Toru Miwata, Tatsunori Matsui, Toshio Okamoto and Alexandra Cristea
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5621
Fax: +81-424-89-6070
E-mail:matsui-t@ai.is.uec.ac.jp

In this study, we built an educational qualitative diagnosis simulator, which models SCS (Space Collaboration System: system the remote conferences and education via satellite communications) conferences. A student engages in the conference, by operating a control panel and proceeds by making the necessary selections according to the agenda of the virtual conference, and its intention and purpose, which can change at any time. The purpose of this study is supporting the student to form a correct mental model in this environment. Therefore, we incorporate an abstract model of possible computations as a logical circuit attached to the SCS system. Using this model, the system has two functions: to diagnose the student' s conceptual understanding mistakes about the SCS system and to explain to him/her the cause of these mistakes. With these functions, we expect to be able to support the student in forming a correct mental model and in understanding the SCS essentials.

Keywords: **Mental Model, Space Collaboration System, Remote Conference**

1 Introduction

Recently, with the increased awareness of the necessity of individual, subjective learning, a change occurred in the building of computer based educational systems. The existing learning supporting systems are based on automatically generating the learning method, according to the relation between the state defining parameters and the subject' s (learner' s) behavior. However, in recent years, the trend to construct systems, that positively encourage the student to work, and allow him/her to change the current state parameters by him-/herself, offer system behavior simulation, moreover, verification and correction of the student inputs, emerged. In this type of subjective/ individual learning environment, it is necessary to add a causality explanation function of the target environment. This is important due to the fact that, by letting the student/ learner adjust and change the system parameters, and then showing him/her the system behavior simulation, as derived from the current configuration and structure, fundamental system comprehension can be supported and achieved [2..11]. We have, therefore, used the above mentioned specifications and background information, to implement an educational qualitative diagnosis simulator, for supporting fundamental system comprehension and understanding. For this purpose, we have based our mental model design on the object oriented approach. The mental model is a representation of the individual comprehension about the structure and functions of the objects involved in the simulated system model. Moreover, depending on the simulation of the object functions within the learner' s mental model, it becomes possible to predict the problem solving act results. Therefore, important learning can occur and, at the same time, causality explanation within the virtual learning environment can be offered. We based the mental model used in our system on the qualitative modeling. The qualitative model is a fundamental model representation based on the causality relations that generate the target system' s behavior. The causality relations are reflected in the relations between the system' s structure, behavior and functions. Here we consider the following definitions. The **structure** reflects how the elements of the target organization are combined. The **behavior** shows how the system characteristics, expressed by the object structure, change in time. The **function** expresses how the goal, related to the object behavior, is achieved. By modeling the

causality relations between the system' s structure, behavior and functions, and designing a qualitative model, the causality relation simulation becomes possible. In our system, we have constructed a qualitative diagnosis simulator for conferences via SCS. SCS, standing for Space Collaboration System, is a remote conferences and distance education system via satellite communications. The learner/ student follows the progress of the conference, by operating a control panel, and making the necessary selections, according to the agenda of the virtual conference, and its intentions and purpose, which can change in time. In this environment, we integrate a computable model abstraction of the remote conference via communication satellites, as a logic circuit. Moreover, based on this abstraction, we add a causality explanation function, and a diagnosis system of the student' s/ learner' s operation mistakes, which generate the appropriate guidance information for the student. In this way, we support the fundamental comprehension of the SCS system.

2 Qualitative reasoning

Qualitative reasoning is one of the most vigorous areas in artificial intelligence. Over the past years, a body of methods have been developed for building and simulating qualitative models of physical systems (bathtubs, tea kettles, automobiles, the physiology of the body, chemical processing plants, control systems, electrical circuits, and the like) where knowledge of that system is incomplete. Qualitative models are more able than traditional models to express states of incomplete knowledge about continuous mechanisms. Qualitative simulation guarantees to find all possible behaviors consistent with the knowledge in the model. This expressive power and coverage are important in problem-solving for diagnosis, design, monitoring, and explanation. Qualititative simulation draws on a wide range of mathematical methods to keep a complete set of predictions tractable, including the use of partial quantitative information. Compositional modeling and component-connection methods for building qualitative models are also discussed in detail [1].

3 SCS

Figure 1 displays the SCS based remote conference concept. SCS was established as a satellite communication network between universities, to enable real-time remote video conferences. Each participant' s station (called VSAT station) is enabled with a satellite communication control panel, an image and sound transceiver control panel, multiple video-cameras, monitors, and so on.

3.1 SCS constrains and limitations

The SCS conference can take place as an inter-station, bi-directional communication between two stations, or as a mult iple VSAT stations communication, where only one station has the role of the moderator, and has authority upon transmission control. In the latter case, all the other station, with the exception of the moderator station, are called client stations, and can participate as such in the conference. The moderator station is decided in advance, before the actual conference, by the conference organizer, according to the requested time-schedules and conference contents. The line control is usually under the sole authority of the moderator station. However, a client station can send a request for line usage for transmission to the moderator. This operation is enabled by the proposal request button existent on each VSAT station panel. By pushing this button, a proposal request notification is sent to the control panel on the moderator station. Moreover, during the conference, it is possible for two different stations to send image and sound, namely, the carrier, at the same time, so there can be up to two distinct proposing stations. The respective client stations are depicted in the lower part of figure 1.

The communication satellite has two reception parts, and a converting switch that allows the selection of the received carrier. Depending on the existing constrains and conditions, a decision mechanism is involved, before actually sending the carrier selection from the satellite. After verifying the current constrains and conditions, the carrier is sent from the satellite. This carrier is sent without exception to all client stations. In figure 1, the sending of the carrier to all the client stations is depicted. The station carriers depicted in figure 1 as a black solid arrows show the connection between the individual stations and the transmission part of the satellite. The figure shows also that the satellite receives only two carriers at a time. However, as all stations are connected with the satellite, as depicted by the solid black arrows, all stations are prepared to send a carrier.

The satellite reception part is built of a receptor, and a converting switch. In this way, by means of the

restrictions set by the converting switch receptor, the satellite can receive, all in all, only two carriers. Moreover, these have to be from two distinct stations only. Also, in the case of multiple carrier reception, the moderator station operator can decide, according to his/ her free will, to commute to the receiving of one carrier only, disregarding the choices and modes of the client stations. These constrains, limitations and specifications, and the fact that the client stations can all in all send only two carriers, are depicted in the figure as dotted thick arrows. The two carriers that can be sent are named [send 1] and [send 2]. Their contents is re-sent from the satellite. The restriction that the two carriers, [send 1] and [send 2], should not come from the same station is enforced before this re-transmission. Only when al the above restrictions are fulfilled, can the received carriers be broadcasted from the satellite to all stations. At the reception of the broadcast signals, each client station can separate the two carriers, [send 1] and [send 2]. The station sending the carrier is also receiving the broadcast, without exception. Therefore, the sound and image received by the transmitting stations are:

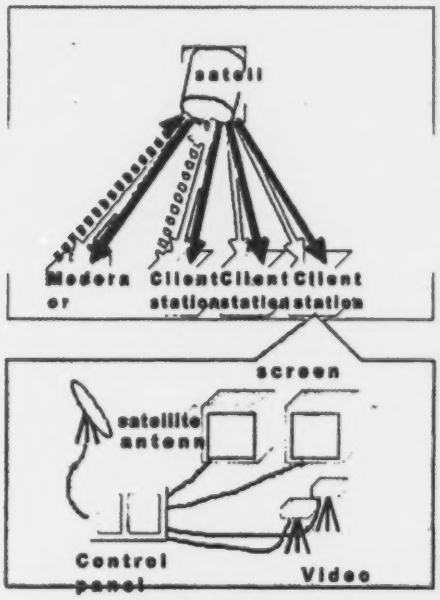


Fig. 1 Conference with SCS

(1) image+sound from the other transmitting station (if existent);
(2)the image and sound sent to the satellite by the station itself.

Moreover, as it is impossible to send the image and sound carrier to a specific station directly, by sending them to the satellite, they are broadcasted automatically to all stations. Bi-directional communication is also possible, but is actually a quasi-bi-directional communication, as the broadcast carrier of the two communicating stations is sent, at the same time, as a broadcast signal to all client stations.

3.2 SCS system frequent user errors

In table 1, the error types for different user skill levels of SCS conference practice, as gathered by surveying 4 domain specialists with over 2 years of SCS system operation experience, is shown. They were asked to give us first a list of frequently appearing user errors during the SCS usage and managing. This list is displayed in table 1 in the column headed by the label "Error/ misconception". Next, they were asked to evaluate the frequency of apparition of these errors for beginner, medium and advanced user. In table 1 their replies were represented as follows: [• •] means high, [• •] means medium, and [• •] means low frequency of errors. The table presents therefore the specialists' primary classification of errors according to the operation skills. To this classification, we have added a new error classification, based on the previously explained SCS system constrains and limitations. We have managed to group all errors enumerated by the specialists into four big classes of errors and misconceptions: A, B, C and D. The definitions of these classes are given below.

Table 1 Error types

Error/ misconception	beginner	medium	advanced	Error classification
Disregarding the function of the satellite• • believing direct/ dedicated tranafer between follow stations is possible.	• •	• •	• •	A,B,C, D
Believing that the sending of two carriers from the same station is possible.	• •	• •	• •	A
Believing that receiving two carriers from the same station is possible.	• •	• •	• •	A
Not understanding that, by switching the carrier to a different station, the current proposing	• •	• •	• •	B

BEST COPY AVAILABLE

station carrier will disappear.				
Believing that all stations can send a carrier at the same time.	• •	• •	• •	C
Not understanding the concept and necessity of the carrier request proposal.	• •	• •	• •	C
Assigning carriers to three or more stations.	• •	• •	• •	C
Not understanding why the image and sound signal sent by ones own station is received again.	• •	• •	• •	D
Believing that bi-directional communication is possible only with a specific station.	• •	• •	• •	D
Assigning the carrier to each station consecutively.	• •	• •	• •	D
Believing that only one broadcast is possible.	• •	• •	• •	D
Not making the distinction between the moderator station and the other client stations.	• •	• •	• •	static state
Believing that the client station is in charge of the transmission control.	• •	• •	• •	static state
Not making the distinction between the two wave forms (signals), [send 1] and [send2].	• •	• •	• •	static state
Believing that the [send 1] wave form is the signal coming from the moderator station.	• •	• •	• •	static state

Class A: Misconception/ incomplete information about the sending of two different waves/ signals with the help of the judgement/ decision mechanism.
Class B: Misconception about the sending of one carrier to one station with the help of the converting switch.
Class C: Misconception/ incomplete information about the receiving of two carriers.
Class D: Misconception/ incomplete information about broadcasting to all stations.

4 The SCS qualitative model

Figure 2 shows the qualitative model of the SCS conference abstraction, in the form of a logic circuit. This qualitative model can express the structure, behavior and functions of the SCS system. In this figure, ve displayed four client stations and one communication satellite. As can be seen, the satellite has two receptors, and one judgment/ decision mechanism, as a converting XOR switch between the two receptors. The two client stations sending carriers at one time can therefore have a pseudo- bi-directional communication. The structure, behavior and functions, so, the objects of the original SCS system are expressed, in this way, as a qualitative model.

The characteristics of this model make it possible to simulate the dynamic changes occurring during a distance conference, allowing to decide and evaluate the proper parameter settings for each station, moreover, to simulate the system behavior in the case of mistaken parameter settings. By using the XOR function, it is ensured that each reception part of the communication satellite can receive only one carrier from only one station. This station has sent a prior transmission proposal to the moderator station, which was accepted.

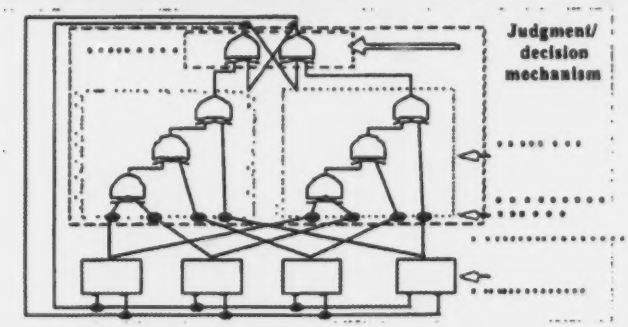


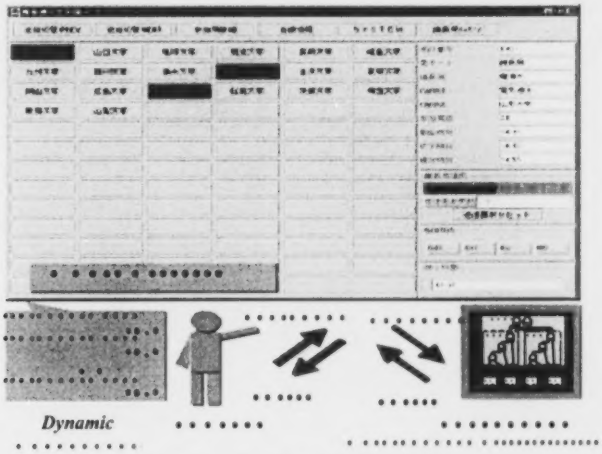
Fig 2 The qualitative model of the • • • system

 BEST COPY AVAILABLE

Next, it is necessary to make sure that the two accepted carriers come from two distinct stations. This restriction is enforced by the judgment/ decision mechanism. The judgment/ decision mechanism eliminates via an extra XOR function the possibility that the two carriers were sent by the same station. If the two carriers, 1 and 2, are validated by the judgment/ decision mechanism, the communication satellite broadcasts one or both to all VSAT stations. Therefore, all VSAT stations will receive the two carriers 1 and 2 and will not be able to receive any other carriers from other stations, or any wrong transmissions. Moreover, by using this model it is possible to infer the error source, as shown previously, based on the SCS system structure. The previous A, B, C, D classification can be thought of as: (A) sending of two distinct waves by using the judgment/ decision mechanism, (B) sending of maximum one carrier per station by means of the converting switch, (C) using of two carriers by means of the satellite reception mechanism, (D) existence of broadcast type of transmission only. In this way, the virtual model enables the learner to derive the cause and source of the operation error, as related to the SCS system structure. Furthermore, we have presented here a model based on only 4 client stations, that is implemented via the XOR module, but as in the case of more than 4 client stations, we can increase the number of the reception part XOR modules, adapting them to the number of stations, we can express, cope with and model therefore the converting switch for any arbitrary, greater than 2 number of client stations.

5 Learning Environment

5.1 System outline and overview



Figure• •Learning environment

Figure 3 shows the overview of the system. The learner/ student is performing the conference steps by taking over the role of the moderator station operator. The goal is to cope with the dynamically changing agenda of the conference, proposed by the system. The agenda presents a description of a dynamic conference state, where bi-directional communication is required. The student can take decisions about the SCS system state and change parameter by operating the control panel. The previously described qualitative model evaluates these settings and parameters.

Next, disregarding if the parameter setup and assignment is appropriate or not, the result of the new user choices is reflected on the control panel of the interface, changing the current representation. The control panel displays also the transmission requests coming from other stations. The student has to choose the appropriate response to these requests. The student has to be able to judge the appropriateness of his/her own operations and actions, by interpreting the information presented on the control panel. By repeating the above steps, the student can learn the constrains and usage of the SCS system. Moreover, to prevent deadlock situations, where the student is unable to judge his/her own errors, due to misunderstandings regarding the SCS system constrains, an explanatory function was added. This is implemented via an explanation button, which can be pressed by the student in need. The student guidance follows as has been previously shown, conform with the SCS qualitative model. In this way, the student can achieve not just a quick, superficial understanding, but also a deep, structure related knowledge about the SCS system. For example, explanation are given such as: "There are only two

BEST COPY AVAILABLE

satellite receptors.", "There is an exclusive OR switch on each receptor, so each receptor can receive from one only station at a time.", "The judgment/ decision mechanism does not allow 2 carriers from the same station.", and so on. By leading the student to understand the connection between the parameter setup and the way the SCS system is actually built, as well as the real system components and the relations between them, via messages and state representations on the control panel, the student can be expected to perform the parameter setting by him/herself successfully in the future.

5.2 System flow

Figure 4 shows the system flow. The rapidly changing conference goal and intention of the agenda is described in chronological order. The contents of this description are on one hand, the conference state change requirements that have to be performed by the student, put into words that can be easily understood by him/her, and on the other hand, the description of the current SCS system state. In figure 4, this is expressed as [word] utterances, at the different moments in time (t0, ..., tn):

$$word : state(t0) \sim word : state(tn)$$

For example, [word] can be a prompting message about the conference state change, with the value of "Please reply to the question from university A!", and so on. As shown in figure 4, the operation panel managing module receives from the agenda, or from the other client stations the current parameter for each given conference state, and then reflects the resulting state on the panel. For example, the button of the station, which is currently in charge of a carrier, turns red. Also, in the case of requests from other stations, the button of the station sending the carrier request signal turns also red.

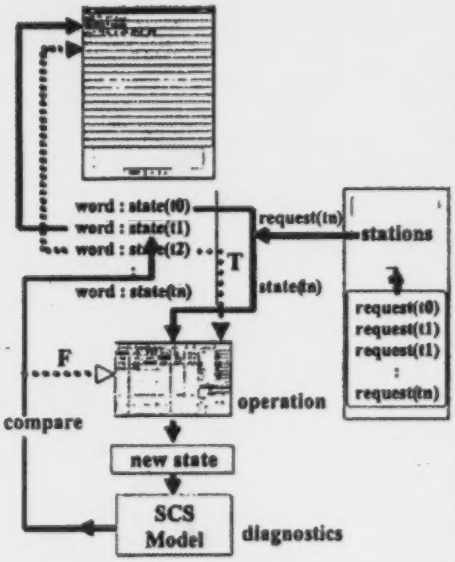


Figure 4 System flow

The student infers the present conference state from the state of the panel. Moreover, from here the student can notice if it is necessary to change the state of the conference, according to the agenda requirements. Next, to change the conference state, the student has to operate the control panel. By doing this, the parameters determining the conference are changed, and a new conference state emerges. This new state is evaluated with the SCS qualitative model. When evaluating with the SCS model, the result is compared with the next agenda. It is, in principle, possible to perform such comparisons on the SCS system without the computable module, and to judge if the operation is appropriate or not, but, in that case, the student cannot achieve a deep understanding of the SCS conference, that is, s/he cannot identify the SCS behavior as derived from structural constrains. In order for the learner to achieve a deep understanding, it is necessary to perform the parameter evaluation with the help of the SCS computable model. After the parameter evaluation, if the settings are judged as appropriate, the system moves to the next agenda. In figure 4, this is the case of "T" (True). In this case, the setup parameters decided by the student are handed over to the administrating module, which, in turn, reflects these changes on the operation panel. On the other hand, if, after the parameter evaluation, the settings are judged as not being appropriate, the system does not move to the next agenda. This case is shown in figure 4 as the "F" (False) case. In such a case, the wrongly set parameters are displayed on the operation panel. In this way, the deficient, real SCS state can be represented.

For example, in the case when three or more stations ask for the carrier at the same time, and the carrier is passed over to them, the moderator station's carrier disappears. The student notices that the espective state is not appropriate, and corrects the setup parameters. Moreover, in the case that s/he doesn't notice the errors, s/he cannot continue with the next agenda. When entering a deadlock situation, the SCS qualitative model can, at the student's request, explain to the student what kind of error s/he has done. In this way, by explaining not the protocol and process steps, but the SCS system behavior, as a result of the structural constrains, our system supports the formation of the SCS learner mental model. For instance, let us consider a case where the present transmission rights belong to universities B and C, and a proposal request is received from university A. This

request is represented on the panel by the button representing university A turning red, together with a simultaneous indication message appearing in the agenda window, stating "Please answer the question from university A". If the student decides to assign a carrier to university A, without previously modifying the state of one or both stations B and C, which have the current transmission rights, the result is that the system will have 3 or more simultaneous carriers at the same time. In this case, the system represents the buttons of universities A, B, C on the panel with red color, and lets the student therefore know that the parameter setup is not appropriate.

At the same time, the agenda window will also display a message for the student. The content of this message is something like: "There are only two receptors on the satellite.", so is an explanation of the behavior, as resulting from the structural constrains.

6 Agenda

Table 2 Agenda example

agenda(t0)	The conference starts.
agenda(t1)	The moderator station is the University of Electro-Communications.
agenda(t2)	Please allocate carrier • to Yamagata University• •
agenda(t3)	Please start sending from the lecturer camera• •
request(t4)	Carrier request • Tsukuba University• •
agenda(t4)	Please reply to the question from Tsukuba University• •
agenda(t5)	The conference has ended• •

The SCS conference is based on a general agenda. Our system offers SCS based remote conference simulation environment and, moreover, stores typical SCS agenda models, in order to dynamically produce conferences that require conference state changes.

In this way, the student becomes the operator of the moderator station, and has to take decisions compatible to the agenda, engaging therefore in the simulated steps of the SCS conference. In table 2 we show an example of a model agenda for our system. In this table, agenda(tn) represents the agenda at moment (tn) in time, and request(tn) represents the carrier request at moment (tn) in time. In the real SCS conference, the time moment concept exists, but, in our system, we have the supplementary restriction that, only after accomplishing the current agenda, it is possible to go on with the new one. As shown above, the agenda is organized as a time series, and the student receives indications and instructions from the agenda window. The changes occurring in the conference state in the respective agenda example above correspond to a respective intention and goal. Disregarding if these intentions and goals come from the original operator's decisions, or if they were prepared by the system from the beginning, the beginner student doesn't have to loose his/her way during the SCS conference proceedings, and can give the panel operation his/her undivided attention. In other words, the indications and instructions coming from the agenda window can be thought of as an experienced operator teaching the beginner student during the SCS conference proceedings. After receiving the indications and instructions from the agenda window, the student can decide on the next conference state that seems appropriate, given the present conference state and the indications received, and operates the control panel to perform the respective change. The new state that results as a consequence of the student's operations is checked by the system, to decode if it is appropriate or not, conform with the indications and instructions of the agenda. One agenda is recorded in the system as one word and 6 state descriptors. The words are the ones that appear in the agenda window. The six possible state descriptors are shown below.

• • *station name (list of all client stations)*
• • *carrier request (list of all client stations)*
• • *carrier 1 (list of all client stations)*
• • *carrier 2 (list of all client stations)*
• • *reception 1 (list of all client stations)*
• • *reception 2 (list of all client stations)*

The state descriptor called "station name" contains a list of all client station names. Next, the carrier request, carrier 1, carrier 2, reception 1 and reception 2 state descriptors contain respective lists of [on] and [off] states corresponding to each station. In figure 3, we show the correspondence between [1] and [0] and [on] and [off].
The reason of describing all client stations carrier and reception states with [off/on] descriptors is to be able to represent also the incomplete understanding of the learner/ student, as well as his/her mistaken parameter setups and assignments.

7 Testing, experiments and evaluation

Table 3 comparison of situation before and after learning takes

Error	Pre Test	Post Test	Error classification
Disregarding the function of the satellite and believing direct/ dedicated transfer between fellow stations is possible.	N/A	N/A	A,B,C,D
Believing that sending of 2 carriers from one station is possible.	3 persons	1 person	A
Believing that receiving two carriers from the same station is possible.	3 persons	1 person	A
Not understanding that, by switching the carrier to a different station, the current proposing station carrier will disappear.	5 persons	1 person	B
Believing that all stations can send a carrier at the same time.	3 persons	3 persons	C
Not understanding the concept and necessity of the carrier request proposal.	5 persons	1 person	C
Assigning carriers to more than three stations.	5 persons	1 person	C
Not understanding why the image and sound signal sent by ones own station is received again.	5 persons	3 persons	D
Believing that bi-directional communication is possible only with a specific station.	5 persons	1 person	D
Assigning the carrier to each station consecutively.	5 persons	1 person	D
Believing that only one broadcast is possible.	5 persons	5 persons	D

We have performed an evaluation experiment of our system over a small sample. 5 beginner students with no SCS system experience were selected as the object of our SCS conference experiment. We have first explained them the control panel representations, meanings and operation mode, as well as the agenda window functionality, and the SCS system setup as a bi-directional communication system. They were able to consult the SCS user manual. Next, we have done a pre-test with the system without the diagnosis mechanism, and followed and checked the operations and mistakes of the beginner operator. Then, we have performed the same experiment, this time, with the help of the diagnosis mechanism. In the last step, we have compared the understanding level before and after learning. The result is displayed in table 3. A system screen display during the experiment is shown in figure 3. This figure displays a student deadlock situation, where the student has asked for an explanation about the deadlock, and the system has next checked the SCS system structure related error cause, and finally displayed it on the screen for the student to see. In the case presented in figure 3, the student hasn't realized the fact that there are only two receptors on the satellite, and has mistakenly allocated carriers to 3 stations. The explanation of his/her error is displayed on the control panel. The state of 3 stations having the carrier is represented on the panel as the respective stations' buttons turning all red (left corner of fig. 3, darkened buttons). However, if the student doesn't grasp the meaning of the representation and the cause and source of his/her errors, and asks therefore the system for help, the system will display the following message: "There are only two receptors on the satellite". With this explanation, the student understands that, as there are only 2 receptors on the satellite, s/he cannot allocate carriers to 3 stations, and will operate the panel correctly in his/her next steps.

According to our system's result shown in table 3, the students can understand the SCS system constrains and limitations, the fact that the signal has to be sent from different stations, the fact that there are only two carriers, and the concept of the XOR receptors of the satellite. However, the broadcasting mechanism was not completely understood. This is probably due to the fact that, in the current simulation system, there is no visual display of the broadcasting mechanism, of the time and direction of the transmission.

7 Conclusion

In this paper, we proposed an educational qualitative diagnosis simulator based on an object-oriented approach to mental model formation. In our model, the structure, behavior and functions of the SCS system are the objects, and from the description of the causality relations between these objects, the student can determine the cause of his/her error, based on system structure judgment.

From educational strategy point of view, QUAD implements and supports a combination of learning methods, like "Reinforcement learning", "Learning by exploring", "Learning by asking", "Learning by applying", "Self-monitoring", and so on. From educational depth point of view, the QUAD system doesn't stop at the procedural surface level, but traces the structural implications, to gain a deep knowledge level.

For further research, we believe that, by expanding the current system, and identifying more precisely the mental model of the student, a more appropriate guidance system can be developed.

References

[1] B. Kuipers; Qualitative Reasoning: Modeling and Simulation with Incomplete Knowledge, Cambridge, MA: MIT Press (1994).

[2] T. Okamoto• O. Matsuda; About the mental model of the ITS based geometrical/ topological proof process, Japanese Journal of Education and Technology,Vol.4, No.15, pp.167-182 (1992)

[3] O. Matsuda, T. Okamoto; based on hypothesis inference/ deduction : about the ITS - student model and its recognition method, IEICE conference, A, Vol. J75-A, No.2, pp.266-274 (1992)

[4] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Japanese Journal of Educational Technology 20(4), pp. 207-226, (1997)

[5] T. Nishida; The basis of qualitative inference/ deduction, Journal of the AI society, Vol.4,No.5,pp.522-527,(1989)

[6] T. Okamoto; Education, Media and Artificial Intelligence, Journal of the AI society, Vol.10,No.3,pp.361 – 367 (1995)

[7] T. Okamoto; Knowledge Processing Technology and Educational Engineering, Journal of the AI society, Vol.20, No.4, pp.207 – 226 (1997)

[8] T. Nishida; The common sense thinking way model of qualitative inference/ deduction• •Journal of the AI society, Vol.2, No.1, pp.30 - 43,(1989)

[9] T. Nishida; Towards applications of the thinking ways and intelligent problem solving techniques of qualitative inference/ deduction• •Journal of the AI society, Vol.32, No.2, pp.105 • •117 (1991)

[10] T. Nishida; Aspects of qualitative inference/ deduction, Asakura publishers (1993)

[11] K. Asai, H. Ohnishi, K. Kondo, K. Tanaka, O. Matsuda; Case base and Collaboration Application based on appropriate• • ¶(control) and the Internet system, technical Report of IEICE, ET97-24 (1997-05)

Intelligent Interactive Learning Environment: Design Issues

Siu-Cheung KONG* and Lam-For KWOK**
**Department of Information & Applied Technology, Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T.,Hong Kong. Email: sckong@ied.edu.hk*
***Department of Computer Science,City University of Hong Kong,Tat Chee Avenue, Kowloon, Hong Kong. Email: cslfkwok@cityu.edu.hk*

Interactive Learning Environment (ILE) provides interaction opportunities between learners and the virtual devices for productive learning. Intelligent ILE (IILE) provides quality feedback or authentic guidance to learners who need help in the ILE. This research aims to explore design implications of IILE by studying model of learner in the mathematics fraction domain. 169 primary four learners were invited to answer 10 open-ended questions on fraction addition and subtraction. A learner model on category of error and error pattern was formulated from the 423 erroneous responses. Results of the study indicated that researchers should study error patterns by understanding work of learners, distinguish careless mistakes from error patterns, and consider scaffolding support.

Keywords: **Intelligent Interactive Learning Environment, Learner Model**

1 INTRODUCTION

There are two categories of Learning Environment (LE): content-free and subject-specific [1]. A content-free LE allows participants and facilitators to formulate their own topics for discussion. Knowledge formulated from such interactions belongs to the learning community [2]. A subject-specific LE involves subject knowledge. Some subject-specific environments stress knowledge transfer like Intelligent Tutoring System (ITS) [3]. Other subject-specific environments such as Interactive Learning Environments (ILE), assisting learners to learn through exploration, put efforts on designing manipulative virtual learning devices [4]. No matter an LE is designed for knowledge transfer or knowledge formulation, subject matter of the learning domain should be carefully studied and incorporated in it [5].

1.1 Design Considerations of an ILE

The study of subject matters plays a crucial role in designing ILE involving knowledge exploration because learners are not obtaining knowledge directly from the ILE. Learners have to learn by analogy, that is, learners have to transfer knowledge from manipulating the manipulative virtual devices of the ILE to grasp the abstract concepts of the subject domain [4]. Expert teachers are skilful in predicting how learners will think and err [6]. This diagnostic ability is tied to an expert's special understanding of the subject and is undoubtedly derived from multiple opportunities to teach the same content [7]. This knowledge includes knowing which aspects of a topic are particularly difficult, what the common misconceptions are, and what representations are important for authentic learning. Shulman [8] termed this kind of knowledge as Pedagogical Content Knowledge (PCK). It is crucial to utilize teachers' expert knowledge, especially knowledge on representation for authentic learning, to design manipulative virtual devices of an ILE.

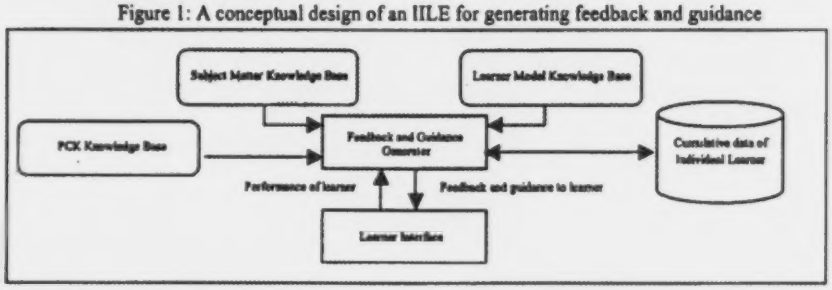
1.2 Design Considerations of an Intelligent ILE

An ILE may provide interaction opportunities between learners and the virtual devices for productive learning. Some learners may learn the subject matter well without the assistance of the virtual learning devices. Some learners may learn well with chances to interact with the interactive learning devices of the environment. However, some learners may need guidance to learn well in the ILE [9]. An Intelligent ILE (IILE) is an ILE that provide feedback or guidance to those learners who need such help in learning the subject domain. Those

learners who do not need help will not notice the existence of the auxiliary service. Learner model of learning in a subject domain may provide information about the behaviour of learners in learning the domain. Studying the learning model of learners may assist IILE designers to formulate design principles and obtain technical details such as formulating mal rules for understanding learning states of learners. A learner model thus may help to tailor-make an IILE for assisting various types of learners in learning the discipline. It is therefore important to study the learning model of learners in a specific subject domain for designing a useful and practical IILE to assist learners of various kinds in the learning process.

Three knowledge bases are therefore important for designing an IILE for learning subject-specific knowledge. They are the subject matter, the learner model of learning in the domain and the PCK of teachers in teaching the discipline. Subject matter knowledge base contains subject matter knowledge. It can provide subject matter advice and knowledge state of learners in the learning process. Learner model contains behaviour representations of learners. Learner model knowledge base may provide information about the learning state of learner. PCK knowledge base contains diverse guidance knowledge for different learning states of learners. It may provide learning advises based on PCK of experienced teachers of the subject domain who know how learners think and err in the discipline. Software agents will monitor the performance of learner in the learner interface. Software agents will determine proactive or reactive responses after a negotiation and communication process in the feedback and guidance generator. The negotiation will be a judgement of the knowledge state of the learner in the domain using both the learner model knowledge base and subject matter knowledge base of the IILE. Final decision will be an outcome after a consultation with the PCK knowledge base of the IILE and the cumulative data of an individual learner. The cumulative data records the historical learning states of each individual learner captured by the IILE. Figure 1 shows a conceptual design of an IILE for generating feedback and guidance.

Figure 1: A conceptual design of an IILE for generating feedback and guidance



1.3 Chosen Subject Domain

A review of literatures indicated that many learners have great difficulties in learning the concepts and procedural knowledge of mathematics fraction [10, 11, 12]. Streefland [11] further pointed out that the main cause of such difficulties is the inadequate and inappropriate teaching in the traditional approaches. As the teaching and learning of mathematics fraction is an internationally renowned difficult topic, it is considered as an appropriate exemplar to be investigated for automation.

2 AIM AND OBJECTIVES

The aim of this research is to study the knowledge of learners in a subject-specific domain and to investigate its implication for designing a subject-specific IILE. There are two specific objectives: (1) to understand the problems of learners in learning the topic; (2) to discuss design issues of an IILE. Such findings may inform the development of IILE for providing quality feedback and guidance to learners.

3 RESEARCH METHODOLOGY

A questionnaire for studying model of primary learners on learning fraction addition and subtraction was designed.

BEST COPY AVAILABLE

169 primary four learners from four different schools were invited to complete the questionnaire through their mathematics teachers. All learners had completed their learning of fraction addition and subtraction before the test. Learners were requested to do the questionnaire on individual basis in a mathematics lesson for about 35 minutes. No discussions were allowed. The answer sheets were not used for any form of assessment but returned to the researcher after the administration. All 169 answer sheets returned were used for data analysis.

4 RESULTS AND DISSCSSIONS

This section will report on the quantitative and qualitative analysis results of all errors responded by participants of the survey and will discuss their implications on designing an IILE. The learner model formulated contains two areas: (1) knowledge of learners on category of error; and (2) knowledge of learners on error patterns of the domain.

4.1 Knowledge of Learner on Category of Error

Nine categories of error were identified and summarized from the 423 incorrect responses. Though incorrect response of each question may contain more than one error, this study selected the primary source of error for classification. Results were summarized in table 1. Categories were organized in descending order of percentage that account for the errors. The summarized result may serve as an important reference in designing a learner model of LE for fraction learning. Among the nine categories, categories 1, 2 and 9 directly related to the subject matter and accounted for nearly forty percent of the erroneous work. Categories 3 and 8 were common types of error in any mathematics exercise. It is interesting to investigate whether learners in this age group would commit these types of error like doing subtraction for addition at a certain level of unconsciousness. The study reflected that these factors might account for another twenty percents of errors.

Table 1: Category of error summarized from the learner model of the study

	Category of Error	Percentage Accounted
1	Improper handling of mixed number in fraction operation	20.4%
2.	Insufficient procedural knowledge for evaluating fraction	14.7%
3.	Calculation or careless mistake	13.5%
4	Unable to set up correct expression for solving word problem	11.6%
5.	Incorrect strategy for evaluating expression	11.4%
6.	Unable to identify error pattern for erroneous work	10.9%
7.	Not responding to question or the piece of work unfinished	8.5%
8.	Conducting subtraction for addition and similarly addition for subtraction	5.5%
9.	Incorrect simplification of answer to the simplest fraction form	3.6%

Though categories 4 and 5 can be purposely avoided, they do play a role in mathematics learning. Setting up expression for solving problems in a scenario may help to test whether a learner has grasped the taught concept. Strategies of evaluating numerical expressions may help to detect whether a learner has knowledge on magnitude of operands and order of evaluation on operators in an expression. The deficiency of this knowledge accounted for twenty percents of errors detected in this study. Categories 6 and 7 accounted for the last twenty percent of learners' work that might not be understandable or remain unfinished. Those 10 percent of learners' work could not be identified for any error pattern reflected that even human teachers might be unable to understand open-ended pieces of work like evaluating mathematics expressions.

4.2 Knowledge of Learner on Error Patterns

This section will report on knowledge of learners with problems in working with fractions on addition and subtraction. After careful analysing error patterns of learners in evaluating and solving simple fraction addition and subtraction problems, two categories were summarized: (1) concrete error pattern; and (2) vague idea on working with fractions. The first category includes some concrete error patterns that can be abstracted into mal rules. The second category contains error patterns that cannot be easily summarized into mal rules but reflect vague ideas and incomplete working procedures of learners. One of the most famous mal rules on fraction addition can be named as "Add numerators and add denominators". Learner with poor knowledge on fraction addition will adopt knowledge of arithmetic addition by adding the numerators of fractions in the fraction expression to give the numerator of the resultant fraction and similarly adding the denominators of

fractions to give the denominator of the resultant fraction. There were four learners committing this type of error in this study. This rule might explain 3% of the errors. The second category of error pattern to be analysed involves high-level abstraction. The group of learners in this category showed no concrete error patterns. However, the pattern illustrated that these learners have some vague ideas of doing fraction addition and subtraction. Examples were illustrated in table 2.

Table 2 Vague ideas for evaluating fraction addition and subtraction expressions

	Error 1	Error 2
Learner 1 (3 score)	$\frac{3}{8}+\frac{1}{6}=\frac{9}{18}+\frac{9}{18}=\frac{18}{18}=1$	
Learner 2 (6 score)	$\frac{1}{2}+\frac{1}{3}=\frac{3}{10}-\frac{2}{10}=\frac{5}{10}=\frac{1}{2}$	
Learner 3 (0 score)	$\frac{1}{2}+\frac{1}{3}=\frac{1\times3}{2\times3}+\frac{1\times3}{3\times1}=\frac{3}{6}+\frac{2}{6}=\frac{6}{5}$	$\frac{3}{8}+\frac{1}{6}=\frac{3\times6}{8\times6}+\frac{1\times6}{3\times6}=\frac{54}{18}+\frac{3}{18}=\frac{12}{18}=\frac{6}{5}$

These erroneous presentations reflected that learners did have vague ideas about the working procedures on fraction addition. They need assistance to organize the disconnected nodes into a semantic net. Result of the studies indicated that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work.

Identify Careless Mistake

The learner model of this study reflected that twenty percent of errors were derived from calculation or careless mistakes. Careless mistakes in this study mean transcription errors or simple computational mistakes form one step to another. The feedback and guidance will be different if an error is identified as a careless one. An IILE should handle not only problems generated from subject matters but also general problems of learner like careless mistake. An authentic guidance should provide not only advices or actions that can assist learners to formulate conceptual understanding of the subject domain but also offer help to learners derived from general problems such as careless mistakes. An IILE should attempt to distinguish careless mistake from other error patterns like human teachers.

Scaffolding Support

The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help learner much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive learning support should be an arrangement of a sequence of situations for facilitating knowledge construction [12]. The role of a mathematics-learning environment will be to help learners to learn, especially those fundamental concepts in mathematics, but not to replace mathematics learning in the conventional manner. Therefore it is fundamental for such kind of learning environment to provide scaffolding support to learner when assistance is needed. Support should gradually withdraw so that learner can stand on its own after leaving the system. Therefore a fraction IILE should be designed like a blank sheet for learner to work with fraction. Feedback and guidance are only provided when it is needed. On the other hand, learner working in the IILE who does not need support will not notice the IILE in behind.

5 CONCLUSION

Studying the learning model of learners may assist IILE designers to formulate design principles and obtain details for understanding learning states of learners. The learner model of this study modelled behaviour of learners in two aspects: error category and error patterns. Nine categories of error were identified. Forty percent of errors were derived from inadequate knowledge of learners on subject matters. Twenty percent could be explained by careless mistakes. Twenty percent involved general mathematics knowledge. The final twenty percent of erroneous work were difficult to be classified or work was not completed. Learner model of the study reflected that some error patterns could be represented by mal rules. However, there were even more that cannot. An alternate method of studying error patterns of learners is to understand their work. Result of

the study indicated that IILE needed to apply a strategy to identify careless mistake so that appropriate guidance to learners can be provided. The forty percent of errors derived from inadequate knowledge of learners reflected that only immediate feedback may not help much and thus authentic guidance should be considered for facilitating conceptual understanding. A productive scaffolding support should be an arrangement of situations for facilitating knowledge construction. The future work of the study is to design ways and means to understand work of students, to devise strategy to distinguish careless mistake from other error patters, and to plan scenarios for assisting learners to learn by exploration in an IILE.

References

[1] Vosniadou, S., Corte, E.D., Glaser, R., & Mandl, H. (Eds.), "International perspectives on the design of technology-supported learning environments", Hillsdale, NJ: Lawrence Erlbaum, (1996).

[2] Duffy, T., & Jonassen, D. (Eds.), "Constructivism and the technology of instruction: A conversation", Hillsdale, NJ: Lawrence Erlbaum, (1992).

[3] Chan, T.W., "An introduction to intelligent computer assisted learning systems research and development", National Science Council Monthly, Vol. 23, No. 5, pp. 456-468, (1995).

[4] Akpinar, A., & Hartley, J.R., "Designing interactive learning environments", Journal of Computer Assisted Learning, Vol. 12, pp. 33-46, (1996).

[5] Wittmann, E.Ch., "Mathematics education as a 'design science' ", Mathematics education as a research domain: A search for identity, Dordrecht: Kluwer Academic Publishers, pp. 87-103, (1998).

[6] Berliner, D.C., "In pursuit of the expert pedagogue. Educational Researcher", Vol. 15, No. 7, pp. 5-13, (1986).

[7] Livingston, C., & Borko, H., "Expert-novice differences in teaching: A cognitive analysis and implications for teacher education", Journal of Teacher Education, Vol. 40, No. 4, pp. 36-42, (1989).

[8] Shulman, L.S., "Those who understand: Knowledge growth in teaching", Educational Researcher, Vol. 15, No. 2, pp. 4-14, (1986).

[9] Cheng, C.C., "Proactive guidance in computer-assisted language learning", Technical Report, LLL-T-24-95. Language Learning Laboratory, College of Liberal Arts and Sciences, University of Illinois, (1995).

[10] Behr, M.J., Harel, G., Post, T. & Lesh, R., "Rational number, ratio and proportion", Handbook of research on mathematics teaching and learning, New York: Macmillan, pp. 296-333, (1993).

[11] Streefland L., "Fractions in realistic mathematics education: A paradigm of developmental research", Dordrecht: Kluwer Academic Publishers, (1991).

[12] Ohlsson, S., "Knowledge requirements for teaching: The case of fractions", Teaching knowledge and intelligent tutoring, Norwood, NJ: Ablex Publishing Corporation, pp. 25-59, (1991).

Microgenetic Analysis of Conceptual Change in Learning Basic Mechanics

Gary Chon-wen Shyi and Shih-tseng Tina Huang
Department of Psychology and Center for Research in Cognitive Science
National Chung-Cheng University
160 San-Hsing, Ming-Hsiung, Taiwan 621, R. O. C.
voice-mail: +886 5 2720411 ext. 6102
e-mail: psycws@ccunix.ccu.edu.tw

Microgenetic approach to understanding the process of cognitive development entails repeatedly assessing participants' performance on a conceptual domain undertaking rapid change. In the present study, we adopted the microgenetic method to examine the conceptual change process in learning elementary Newtonian mechanics. Twelve junior-high school students with comparable competency in mechanics were assigned to two groups, and their understanding of concepts in elementary mechanics were assessed in four occasions by interacting with a computerized test-bank software. Participants in the group-test condition were assessed in a group setting. Participants in the individual-test condition were additionally asked to provide explanations for their answers to each test item. The results showed that while participants benefited from being repeatedly tested and showing a increasingly higher level of sophistication in their understanding for most of the conceptual domains tested, it doesn't matter whether or not they also offered explanations to their own answers. More importantly, the differences in developmental course across conceptual domains and the variability of developmental course within conceptual domains together lend support to the theoretical assumptions of the microgenetic approach.

Keywords: **conceptual change, microgenetic analysis, computer-assisted testing, basic mechanics**

1 Introduction

There is little doubt that one of the major challenges in understanding cognitive development is to have an adequate account for the process of conceptual change. Over the last few decades, research in cognitive development has produced a number of distinctive approaches to understanding the process of conceptual change. Among them, Piaget's stage theory was most prominent and has influenced virtually all trades of research in cognitive development. However, numerous theorists have seriously challenged Piagetian theories over the past decade [1, 2, 3, 4, 6]. One of the main criticisms these theorists raise against the Piaget's theory was its lack of precise specification of the mechanisms underlying conceptual change. Most recently, Siegler and his colleagues have proposed a new approach, the microgenetic analysis, to unravel the process of conceptual change [5, 6, 7]. In essence, the microgenetic method entails a dense sampling of observations so that a concept under rapid change and development can be effectively described and analyzed. In particular, [5] has suggested five dimensions or aspects to reveal the change process, namely path, rate, breadth, variability and sources of change [6]. In the present study, we adopted the microgenetic approach to examine junior-high school students' understanding of basic mechanics. Their understandings were assessed either in a group setting or individually. In the former the participants were merely required to interact with a computerized test-bank software. In the latter, the participants were required to provide explanations to their answers in addition to interacting with the test-bank software. The main reason to have such a manipulation was because there is evidence indicating that self-explanations could promote learning, especially in the conceptual domain [5, 9].

2 Method

Participants. In order to find two groups of junior-high school students with comparable competency in elementary mechanics, we first administered a paper-and-pencil conceptual test of mechanics to 280 junior-high school students from 6 classes of a private high school in the Chiayi County in Taiwan. We then selected 12 among the class of students that had a mean score close to the average performance of the entire sample. Those students had scores that were right at the level of class average. They were randomly assigned to two groups that were tested either individually or in a group setting.

Materials and apparatus. In order to effectively assess participants' conceptual development in their understanding of basic mechanics, we first built a computerized test-bank software. The test bank contained multiple-choice questions with multimedia presentation (see Figure 1 for illustration) and covered nine different units of basic mechanics, namely, (a) displacement and its magnitude, (b) average and instant velocity, (c) 2-D coordinate systems, (d) X-T graphs, (e) V-T graphs, (f) translation between X-T and V-T graphs, (g) motion equations, (h) Hook's law, (i) static equilibrium, and (j) vectors (differentiation and integration). For each unit, we first established the levels of conceptual sophistication that seemed to be appropriate for that unit. The levels represent a progression from rudimentary understanding to elaborate mastery of a given conceptual domain. Due to the variation in conceptual complexity of each unit, the levels of sophistication varied from 3 to 5, reflecting the relative difficulty and complexity among items constructed for each level. There were 10 streams of parallel items constructed for each conceptual unit; as a result the test items for each unit varied from 30 to 50 items. The items were parallel in the sense that only the protagonists and/or numerical quantities were altered between items at the same level of sophistication. Although we constructed a complete set of test bank, only units of *a* (displacement), *c* (2-D coordinate system), *d* (X-T graphs), *h* (Hook's law), and *i* (static equilibrium) were administered to the participants due to the constraints of available time and the background knowledge covered in their regular courses on mechanics.

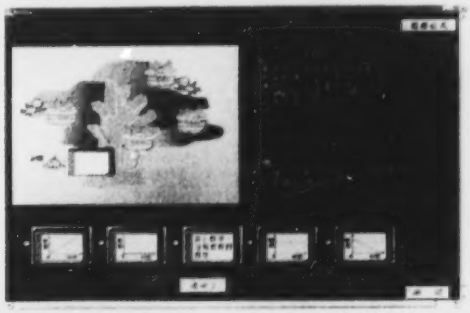


Figure 1. An example of computerized test item for assessing conceptual understanding of basic mechanics.

Procedure. The participants were tested in two groups, six in each group. For the group-test participants, they were assessed in a group setting (in the school's computer room), although their interactions with the test-bank software were essentially independent of one another. For the individual-test participants, they each interacted with the software separately via a notebook. Their interactions with the test-bank software, including the answers they gave for each item and the explanations they offered for their answers, were videotaped. The test-bank software was also equipped with a database for recording various aspects of participants' interactions with it, including the item number, the level of sophistication for a given item, the answer, the accuracy of the answer, the reversal index, and exit type, among others.

Participants' understanding of the five units in elementary mechanics was each assessed four times for both groups, over a period of about 4 months. The first two assessments were conducted toward the end of the spring semester and the second two assessments were conducted at the beginning of the fall semester, interrupted by the summer break. For each assessment, we adopted an adaptive testing principle by using the staircase method typically used in psychophysical research [8] for assessing the threshold. The staircase method we used entailed raising one level of difficulty (sophistication) after correctly answering two

consecutive items at the same level, and lowering the level of difficulty whenever an incorrect answer was encountered. According to Levitt (1971), this procedure would yield a (conceptual) threshold value of about .71, a value that is normally used in psychophysical research. When participants answered incorrectly on an item, they were subsequently given items that were at a lower level. If they answered correctly on items that were presumably easier, they would be given items at a higher level of difficulty. At this juncture, a reversal point would be registered as the level of difficulty for items that were preceded *and* followed by items at a higher level of difficulty. A second type of reversal point has the opposite property, namely items that were preceded and followed by items that were at a lower level of difficulty. For each round of assessment we collected 5 reversal points before allowing the participants to exit from the test. The mean of the five reversal points was then used to define the level of conceptual understanding for the participant.

We also designed alternative routes for exiting the test bank software. Some of the units were relatively easy such that participants were able to correct throughout all levels of difficulty. If that happened, we would allow them to exit when they answered correctly three items in a row at the highest level of difficulty. In contrast, some units were relatively difficult, at least in the first round of assessment, such that participants were unable to advance themselves from the first to second level. We also allowed the participant to exit if they were incorrectly on three items consecutively at the first level.

3 Results

We first computed, for each of the five units examined, the mean value of conceptual threshold for each participant for each of the four rounds of assessment. These mean values of threshold were then submitted to a 2 (group) x 4 (round) mixed analysis of variance (ANOVA) for each unit separately. As can be seen in Figure 3, the differences between the two groups of participants did not reach significance level for four of the five units, namely, displacement, coordinate system, Hook's law, and static equilibrium, F's < 1 or p's > .15. The difference between the two groups approaches significant for the unit of X-T graphs, $F(1, 9) = 4.90$, $p = .054$, indicating that on average the individually tested participants ($M = 2.68$) performed better than their group-tested participants ($M = 2.05$) The main effect of round of assessment was highly reliable for two of the five units, $F(3, 27) = 6.38$, $p = .002$, for displacement, and $F(3, 27) = 5.49$, $p = .004$ for X-T graphs. It was marginally significant for the unit of Hook's law, $F(3, 27) = 2.84$, $p = .057$, but was unreliable for units of 2-D coordinate system and static equilibrium, F's < 1.

Because the participants were tested four rounds in succession, the data allow us to perform trend analyses in addition to the omnibus ANOVA. The results of trend analysis for the three units that participants appeared to undertake rapid change reveal the following findings: For *displacement* unit, both the linear trend and the cubic trend were reliable, $F(1, 9) = 8.51$, $p < .02$, and $F(1, 9) = 12.45$, $p < .01$, respectively. Likewise, for *X-T graphs* unit, both the linear and cubic trends were reliable, $F(1, 9) = 5.79$, $p < .05$, and $F(1, 9) = 7.25$, $p < .03$, respectively. Finally, for *Hook's law* unit, only the cubic trend was reliable, $F(1, 9) = 10.68$, $p = .01$, but the linear trend was not, $F(1, 9) = 2.25$, $p > .16$.

4 Discussion and Conclusion

The findings of the present study indicate that three of the elementary concepts in mechanics we examined—*displacement and its magnitude, X-T graphs,* and *Hook's law*--were under rapid change such that with four rounds of assessment, spanning a period of 4 moths, we had witnessed nontrivial change over time. It is interesting to note that the pattern of conceptual change for both displacement and X-T graphs units not only exhibited a pattern of monotonic increase in level of sophistication, and thus yield reliable linear trends, but also exhibited reliable cubic pattern, indicating that the conceptual understanding was not as stable as a stage theory would have predicted. That is, almost all participants, regardless of the setting in which they were tested, exhibited the pattern that while they had a better performance at the second round of assessment, their performance dropped on the third round of assessment before they advanced themselves again at the four round (see Figure 2). Those who have criticized the stage theories such as Piaget's have noted such a pattern. According to stage theories, participants should at least remain at the same stage of development once they reach at a given stage. It is in this sense that the microgenetic approach can offer a picture that perhaps is closer to the reality of developmental course. There were also units, namely, the *2-D coordinate system* and *static equilibrium*, to which our participants demonstrated their understanding and mastery early on such that no substantial change was observed over the period of assessment. These differences among the

units once again demonstrates the strength of microgenetic method in that not all conceptual domains would undertake a uniform course of development. Finally we were somewhat surprised to find that self-explanations did not exert reliable effects on our participants' performance. One possible reason may have to do with the fact that the test items we constructed were really geared toward participants' basic conceptual understanding, In so doing we may have greatly reduced the complexity of those conceptual domains such that whether or not self-explanations were required was ineffective in promoting conceptual change. [9]

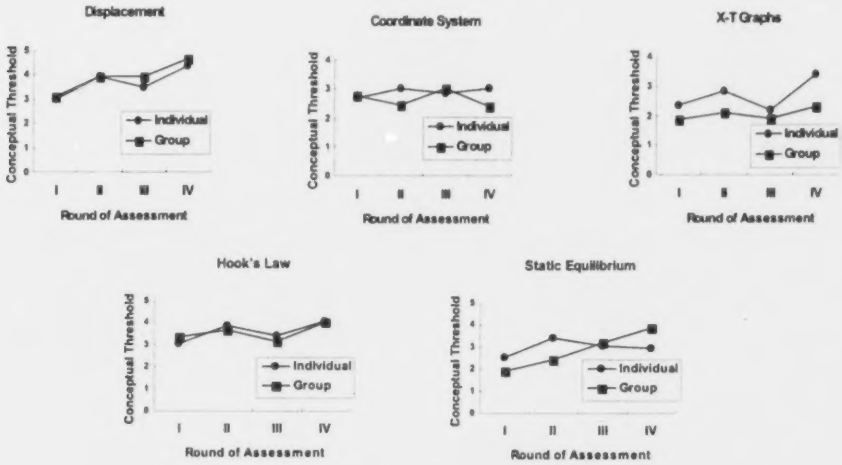


Figure 2. The conceptual threshold value for each unit as a function of round of assessment and test setting (individual vs. group).

References

[1] Case, R. (1992). Neo-Piagetian theories of intellectual development. In H. Beilin & P. B. Pufall (Eds.), *Piaget's theory: Prospects and possibilities* (pp. 61-106). Hillsdale, NJ: Erlbaum.

[2] Halford, G. S. (1993). *Children's understanding: The development of mental models.* Hillsdale, NJ: Erlbaum

[3] Klahr, D. (1995). Computational models of cognitive change: The state of the art. In T. J. Simon and G. S. Halford (Eds.), *Developing cognitive competence* (pp. 355-376). Hillsdale, NJ: Erlbaum..

[4] Klahr, D. (1999). The conceptual habitat: In what kind of system can concepts develop? In E. K. Scholinick, K. Nelson, S. A. Gelman, and P. H. Miller (Eds.), *Conceptual development: Piaget's legacy* (pp. 131-162). Hillsdale, NJ: Erlbaum.

[5] Siegler, R. S. (1995). How does change occur: A microgenetic study of number conservation. *Cognitive Psychology, 25*, 225-273.

[6] Siegler, R. S. (1996). *Emerging minds: The process of change in children's thinking.* New York: Oxford University Press.

[7] Siegler, R. S., & Crowley, K. (1991). The microgenetic method: A direct means for studying cognitive development. *American Psychologist, 46*, 606-620.

[8] Levitt, H. (1971). Transformed up-down methods in psychoacoustics. *Journal of Acoustic Society of America, 49*, 467-477.

[9] Chi, M. T. H., Bassok, M., Lewis, M., Reimann, P., & Glasser, R. (1989). Self-explanations: How students study and use examples in learning to solve problems. *Cognitive Science, 13*, 145-182.

Peer Help for Problem-Based Learning

Susan Bull and Jim Greer
ARIES Laboratory, Department of Computer Science,
University of Saskatchewan, Saskatoon, SK S7N 5A9, Canada.
bull@cs.usask.ca, greer@cs.usask.ca

This paper describes the I-Help peer help network, where helpers and helpees are paired according to the contents of their user models. Although originally designed for large groups, in this paper we suggest ways in which I-Help may be used in a small group, problem-based learning curriculum. The use of I-Help will be very different in this context: it is not expected to be necessary for all students. However, some learners may experience difficulties with some aspects of problem-based learning, such as: scheduling of meetings; involvement in discussions; understanding roles; acquiring skills for problem-based learning; different interaction preferences; differences in cognitive styles. We describe how I-Help may be used to alleviate some of these difficulties, in particular: by putting groups into contact with other groups; or putting individuals into contact with someone outside their group who can advise, or who is facing similar problems, and would like to explore the issues jointly. At the same time, group cohesion is not disrupted.

Keywords: **peer help, problem-based learning, student modelling.**

1 Introduction

Problem-based learning (PBL) is used in many academic subjects (e.g. architecture, business, education, engineering, law, medicine). The first implementations were in medical education, and PBL is still used in many medical sciences courses today. We therefore focus on medical education in this paper, though many of the arguments are applicable to a range of subjects.

Medicine is a difficult subject to teach and learn: the knowledge to be acquired and integrated is broad and very complex. This knowledge is useful only if it can be applied to problems presented by real patients. Such problems are ill-structured, specified with partial information, and often complicated by diverse interacting factors. While acquiring basic domain knowledge is a fundamental activity in medical education, integrative problem-solving is also a fundamental goal.

PBL attempts to focus learning around authentic patient problems or cases, which bring together many interacting issues of a multidisciplinary nature. A core aspect of PBL is that problems should be only partially specified. PBL involves the student in a practical activity, carried out in small groups (usually 4-8, facilitated by a tutor) in which students identify and research their own learning issues [17]. Typically a group will meet to discuss a case, identify learning issues, and then research these individually using a variety of resources (e.g. print-based, web-based and people). They then meet again to report and discuss the case further.

Investigations into the benefits of PBL have produced mixed results, possibly in part because traditional assessment mechanisms are less appropriate measures of the goals of PBL [13,30]. It is stressed that there is, as yet, no evidence that a PBL curriculum is more successful than a traditional approach [27]. Nevertheless, PBL has been embraced by some as the preferred approach to medical education, advantages cited including: the self-directed nature of PBL [27]; a greater tendency towards a deep approach to learning [21]; and positive student attitudes [6]. Others suggest that acquisition of basic domain knowledge may not be well supported in PBL. Learners may later recall less factual knowledge, since they are spending time learning other skills in addition to content [30], and they may lack depth of knowledge [18]. Explanations generated by PBL students can be less coherent, and more frequently incorrect [23]. Learners may also become bored with the PBL process [29]. It has also been recognised that PBL may simply not suit all students' ways of learning [10]. While the peer help system described in this paper can assist in a number of areas, it is this latter aspect that we focus on here.

This paper is neither a critique nor an endorsement of PBL. However, we emphasise that in PBL (as in traditional education), there is a need for tools to support peer interaction for situations where learners need assistance. In this paper we describe how the I-Help (Intelligent Help) system can be used to support students who have difficulties with the PBL approach by putting groups into contact with other groups, or an individual into contact with another learner who may advise or collaborate.

Section 2 of this paper introduces existing examples of computer support for PBL, and describes other systems which mediate peer help. The advantages of I-Help in large groups are described in Section 3. Section 4 discusses how the large group implementation of I-Help may be adapted to support PBL students when they are experiencing problems with the PBL approach. Conclusions are presented in Section 5.

2 Computer support for problem-based learning and peer help

Computer support for group interaction in PBL has been implemented for the asynchronous distance education context; the synchronous distributed learning context; and the co-present small group situation. Kamin et al. [15] describe a combined Web/CD-ROM program containing a video patient case, for use by a group of third year medical students and tutor. It is designed to facilitate asynchronous PBL during a clinical course component, requiring independent and collaborative involvement. Cameron et al. [5] discuss a distributed problem-based learning project using conferencing software together with a web page, to support synchronous sessions aimed at enabling 'authentic PBL' to occur amongst distributed first/second year medical students and a tutor. Koschmann et al. [16] introduce a method of conducting PBL meetings between students and tutor in a face-to-face context, using connected individual laptops and a large shared display. This approach is close to that found in PBL meetings not supported by computers, but offers some advantages: parallel polling (to ascertain each group member's views before they hear the ideas of others); and a record of contributions.

Computer support for PBL may, or may not include actual cases within the program: students may be collaborating about computer-presented cases, or interacting through the computer environment about externally introduced cases. External cases may be provided by the tutor off-line, or may be drawn from a database of patient cases (e.g. PATSy [19]). Systems to support PBL may help to structure and focus PBL discussions. However, even where such systems are available to a student, we believe that additional support is needed by some learners, to help them cope with the PBL situation if they feel uncomfortable with some aspects of it.

While it is acknowledged that many learners benefit from collaborative work, it is also the case that collaboration will not suit all learners; or a particular instantiation of a computational or non-computational collaborative learning environment may not suit a learner who could potentially gain much from collaborative interaction. Thus more flexible means of facilitating peer interaction would be useful. This kind of support will differ from that provided by systems such as the above: students who find the PBL approach difficult may find it useful to be put into contact with a peer who can share experiences about specific aspects of PBL.

An increasing number of peer help systems are attempting to organise learner interactions according to the student models of the individuals concerned – i.e. they have a matchmaking component; or by learner selection of available helpers. The matchmakers in such systems can take account of a variety of factors, but they most often look at students' relative proficiencies in the target domain. A few examples are given below.

An example of a peer help environment is that of Yu et al. [31], where more advanced learners act as mentors. Mentors are selected according to their knowledge, with reference to the following criteria: students who have successfully completed the course; students with high grades in other courses; students who have finished assignments; students who have successfully completed the computer-based tasks about which others need help; teachers and teaching assistants. The assumption is that the group of mentors and the student group do not overlap (though Yu et al. suggest extending the system to allow student-student help). Students select mentors based on availability (mentors may be involved in up to three help sessions); and the current problem (mentors may only help on one problem area at a time).

The above example has the advantage that learners choose to receive help when they need it, and are not forced into a collaborative context if they prefer not to participate. Further, they are guaranteed a knowledgeable helper. Nevertheless, there are drawbacks to this approach outside the setting for which it was designed. The set-up is very rigid: currently only externally acceptable (i.e. tutor-selected) individuals may be mentors. This does ensure that helpers are knowledgeable, but it does not require that they are good helpers. It also does not take account of the fact that students may benefit educationally from giving help, as well as receiving it.

Hoppe [14] proposes integrating knowledge from individual student models to support group learning – i.e. to parameterize group learning. One of the benefits is that peer helpers may be selected for help sessions: a knowledgeable helper can be partnered with a less knowledgeable student. In Hoppe's work this occurs as follows: a learner issues a help request; a menu of potential suitable helpers is offered; the learner selects their choice of helper; the selected helper receives the help request; the helper accepts or rejects the request. This approach is claimed to avoid personal conflicts, as helpers are neither assigned, nor must they interact directly with the helpee if they wish to refuse. It also allows all participants the opportunity to be helpers, as long as they know about the topic. It does not guarantee, however, that selected helpers will be proficient at helping.

Ogata et al. [22] extend this notion of peer help networks, taking into account pre-existing social networks amongst individuals, claiming that these are at least as consequential in a help context, as more official organisational structures. Ogata et al.'s approach allows users to register their proficiencies and social networks, and it also automatically traces user relationships by logging email exchanges. This provides additional information on personal networks, and also on abilities of the user: if an individual answers a question posed by a peer, the helper is assumed to be knowledgeable. These relationships are taken into account when matching potential helpers with those requesting help.

The above approaches allow peer interactions to be initiated by a learner, as required. Helpers are contacted, and may choose to take up or reject interactions. The first example [31] does not require extensive student models, but is quite restricted. The second example [14] expects student models to be in place, though overlay models are sufficient to indicate knowledge levels of individuals. The final example [22] does not require detailed models of knowledge, since it relies on social closeness and self-evaluations together with assumptions about competence based on question keywords in a help request, that has been responded to by the individual being modelled. However, what is not present in these approaches is an ability to match students according to their preferences of interaction method, or individual cognitive style, or to take into account a helper's ability to *help*. Such issues may be just as important for peer interaction to be successful.

The following section describes I-Help: an environment based on multiple user models, to match students who have help requests with potential peer helpers. I-Help aims to accommodate a broader range of characteristics that might be important when pairing learners. Suggestions of how I-Help might be usefully applied in PBL are then given in Section 4. This includes the more common face-to-face PBL context, and use alongside software to support group interaction in PBL, such as described at the beginning of this section.

3 I-Help

I-Help is the integration of several information/help sources brought together through the metaphor of a help-desk [12], designed originally for large student groups. The two principal components are an asynchronous public discussion forum [3], and a one-on-one private discussion facility which may be used synchronously or asynchronously. In the case of the private discussions, multiple distributed user models are used [20] to match students who can help each other in their learning. Each user has a personal agent which uses its owner's student model as a source of information for negotiating help sessions with other users, through their respective personal agents [28]. (Some examples of agent personas are shown in Figure 1.) The following illustrates the sequence of events for a help request. (For an example see [11]).

1. A student contacts their agent to issue a request for peer help;
2. The student's agent negotiates with the agents of other learners, to find appropriate helpers;
3. The top five user-matches are emailed that there is a help request waiting for them in I-Help;
4. To ensure maximum immediacy of response, while not duplicating effort, the first helper to accept the request starts a one-on-one discussion. Requests to other potential helpers are thereby cancelled;
5. Upon completion of discussion, each learner receives an evaluation form through which they evaluate their partner, for student modelling purposes.

The I-Help student model is composed, as stated above, in part from peer evaluations given at the end of a help session by both helper and helpee, about the knowledge of the other participant. The student model also comprises self-evaluations of knowledge level in each of the domain areas. In addition, helpees rate the utility of the help received. Social issues are also considered: learners can add users to their 'friends' list–i.e. people with whom they will preferentially interact, be they 'real friends' or people they do not know, but who have been helpful to them in the past. Students may also add individuals to their 'banned' list–people with whom they wish to have no further dealings. Much information for the student model is easily captured, since it is user-given. It is continually updated as peers evaluate help sessions once they are completed.

Also modelled are individuals' cognitive styles. The identification of cognitive style is based on Riding and Cheema's classification [26], which comprises two dimensions: wholist-analytic and verbal-imagery. The wholist-analytic dimension refers to the extent to which an individual usually *processes* information in *wholes* or separate *parts*; the verbal-imagery style relates to the degree to which an individual tends to *represent* information during thinking in a *verbal* or *image* form. In I-Help this information is provided through a front-end questionnaire. The questionnaire is very short, designed for students who may not themselves be interested in the outcome. The aim is to encourage learners to provide at least some information. While recognising that this is not ideal, partial cognitive style information is considered preferable to no information at all.

Five question types were identified, requiring different cognitive style combinations of helper and helpee:

1. *How does this fit with other things?*
   The first choice of helper for this type of question is a wholist, regardless of the cognitive style of the helpee, because wholists will tend to be better equipped to provide a broader overview.
2. *What are the details of...?*
   For this question type an analytic helper is preferred, regardless of whether this matches with the cognitive style of the helpee, because analytics tend to grasp the details of a topic more readily than wholists.
3. *Can you recommend any good materials for...?*
   The aim is to match individuals on the verbal-imagery dimension, since a verbal learner will more likely recommend materials helpful to another verbaliser, and an imager will do likewise for another imager.
4. *Miscellaneous question*
   This category covers any questions not included in the above. The default is to match all learners on the wholist-analytic dimension. If possible, learners are also matched on the verbal-imagery dimension.
5. *Questions requiring simple answers*
   No cognitive style matching is undertaken for straightforward questions requiring a simple answer, as cognitive styles are likely to have little impact here.

When submitting a help request, the learner indicates the question type from the above selection.

In addition to self and peer user-given information, learner models are updated automatically based on observations of eagerness (browsing and active posting behaviour in the public discussion forums, and amount of help given in private discussions). Furthermore, personal agents note which cognitive style matches seem most successful for different question types, and update the user model accordingly. (This also helps to overcome potential inaccuracies in the initial self-report.) Figure 1 illustrates the sources of information for the student model (open arrowheads), and the differences between private and public discussions. In the private discussions a learner interacts directly with a single peer in each dialogue, to give and receive help. Public discussions take place in forums – there is no direct interaction between two people (solid arrowheads).

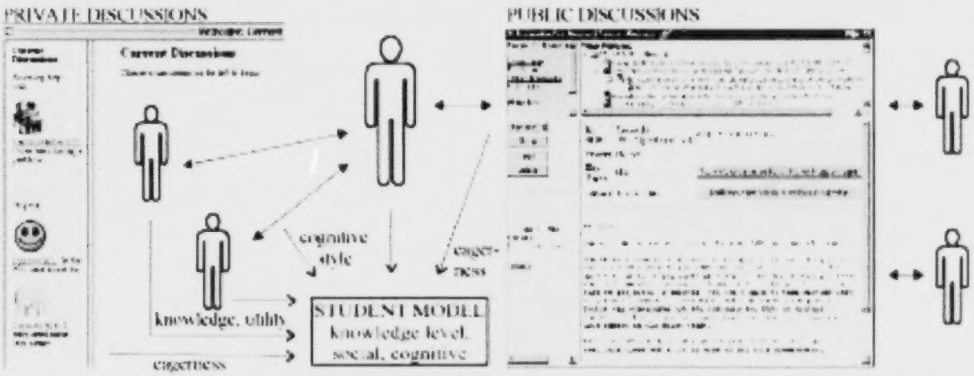


Figure 1: I-Help public and private discussions

In seeking partners, a personal agent tries to balance all relevant information (knowledge level of helpers; helpfulness of helpers; eagerness to help; preferential friends; exclusion of banned people; appropriateness of cognitive style). By default these issues are given equal weighting, but the learner may re-rank each component, as is important for them. For example, some learners may have more flexible cognitive styles. For such students, style may be a relatively unimportant factor. Other students will have more difficulty adapting to someone else's way of learning, and will assign greater importance to cognitive styles – perhaps even preferring this kind of match above the requirement that a helper should be very knowledgeable.

A variation on the peer help scenario involves permitting students to choose the kind of interaction they want, based on the S/UM system [4]. In addition to peer help, students may seek: peer feedback about work drafted or completed; collaborative learning; cooperative learning (i.e. X learns A & Y learns B, followed by tutoring or reporting). In addition to peer help, this allows students who wish to learn collaboratively or cooperatively the opportunity to find the most suitable partner. When a user sends an interaction request, they specify the kind of interaction they are seeking. Their agent negotiates a match with someone who also wishes to interact in that manner, and who has appropriate characteristics (e.g. a helper should have greater proficiency in the topic than the helpee; a collaborative partner should have a similar, non-expert, knowledge level).

In summary, the utility of I-Help increases with the number of users, as good matches become more feasible. Much of the user modelling is performed quickly and naturally by users (self- and peer-evaluations), and these models by themselves are sufficient even early during interactions, before additional system modelling has occurred. Student models contain content, cognitive and social information, which can be ranked in order of importance by learners. Further, I-Help can easily be applied across a broad set of courses: all that is required is a course description (in the form of course component labels) to be provided by the course tutor. Knowledge levels represented in user models, to contribute to matchmaking, are then related to these labels. Apart from reducing the load on tutors, from students requesting information, there are three major educational benefits:

- Students receive help when they have difficulties;
- Students learn through encountering the possibly conflicting viewpoints of others;
- Students will necessarily reflect on an issue when giving help on it.

Thus it is not only those receiving help, who benefit.

4 I-Help in problem-based learning

Due to the nature of PBL, students undertake a lot more research than traditionally educated learners, relying less on teacher-recommended texts. Many students use electronic resources more heavily than other resources [8], and they also use general library resources more extensively than their traditional counterparts [2]. I-Help provides additional human resources, forming a natural extension of this situation, and is likely to be useful to many students in PBL during the research phase. However, in this paper we focus on supporting those students who are uncomfortable with some aspects of the PBL approach itself.

Since PBL is focussed around small pre-established peer groups it is less obvious how I-Help might be applied, as opposed to in larger, traditional classes for which it was originally designed. Nevertheless, as illustrated in the following description, there are a number of situations in which I-Help could be useful in PBL.

There are a variety of potential difficulties to take into account in a PBL course. For example:

- It can be difficult for some students to find time to meet outside scheduled class hours;
- For a group to function effectively, individual team members should all be involved in group discussions;
- Students may not fully understand their role in the group;
- Students may lack the skills to make group interactions work;
- Students have different interaction preferences;
- Students have different cognitive styles.

Considering the first two of these issues, the public discussion forum of I-Help is a useful tool to keep all students in contact with their own group's discussions, but also allowing interaction between particular group members, should help or clarification be needed by some participants, on some group issue. At the same time, all students remain up-to-date with all interactions, at a time that suits them, thus freeing up part of meeting times for questions and group issues less easily handled through computer interaction.

Perhaps more unusual in the PBL context: there may be occasions when students could usefully interact *across* groups. As suggested above, it is not the aim to exclude any group members from any interaction important for group progress, but there may be situations where individuals from different groups could help each other, on issues perceived as not directly relevant to either group as a whole. For example, in some PBL contexts the various roles are divided amongst group members, often rotating. In such situations it might be helpful if individuals from different groups who are performing the same role (e.g. scribe; group leader; information analyst), could interact – especially if it is early in the rotation, and there is less group experience on which to draw. It will also be helpful for students finding their role difficult, who are part of a group whose members do not appreciate the learner's problems. Their personal agent could locate a helper who has successfully fulfilled the responsibilities of the role in the past, or find another student with similar problems, with whom they can

jointly explore aspects of the role. Where the whole group acknowledges a lack of understanding of any role, one of the group members may seek outside assistance on behalf of everyone.

I-Help's user models must therefore be extended to include information about student roles. I-Help must know the current role of individuals, in order to put students in touch with others facing the same tasks; and it should also remember the roles that individuals have previously held, and whether they were competent, and whether they are willing to offer help to novices in these roles. I-Help may then be used to pair individuals in interactions relating to role responsibilities, keeping such interactions amongst those for whom the discussion is currently relevant and/or helpful. As more students come to perform each role, previous help session archives may be accessed as help resources. In this manner, it is hoped that more students may develop an understanding of how to meet their various responsibilities, resulting in improved group functioning.

It has been commonly noted that many students entering the medical sciences do not possess the skills necessary for effective group interaction in PBL – e.g. discussion, decision making, conflict management, leadership, group feedback processes [24]. Although I-Help does not teach these skills, its ability to match students with others who are in a similar position, or who are able to help, provides a form of support not usually available. If a single individual has problems, the other group members may be able to compensate while also supporting the learner's development of the skill concerned. However, where group members recognise a general deficiency, they may use I-Help to put them in contact with a group that functions effectively with regard to the particular skill. They may be invited to observe, as the efficient group models the behaviour during their next meeting, or one of the effective group members may describe how their group tackles these issues. This will be especially useful where there are no resources (e.g. time, staff) for skills training.

Again the I-Help student model must be extended, to accommodate information about group interaction skills. This will involve all groups in a group evaluation process in order that they may provide skills information for the user model, which in itself will be a useful reflective activity. The main difference in the structuring of the model in this case is that skills information will relate to *group* functioning, and not to specific group members. Thus I-Help must also know which students belong to which groups. Skills information need then only be given by one learner.

A potential difficulty encountered by a student who might otherwise do well in PBL is that other group members may have different interaction preferences: some students gain much from brainstorming or spontaneous discussion, while others prefer to reflect and organise their thoughts before communicating. The combination of face-to-face meetings and the public discussion forums helps to cater for all students, while the possibility also exists to arrange collaboration, cooperation and feedback through the private discussions.

Students also have different cognitive styles. Some individuals understand verbal descriptions well, while others need pictures, diagrams, or demonstrations. Some learners deal well with abstract concepts and detail, while others tend towards a more general overview. Although a mixture of cognitive styles might sometimes be complementary in a group setting, and have a positive effect on group performance, some cognitive style combinations may lead to difficulties for some individuals. For example, if most members of a group are analytic, a wholist learner may have difficulty gaining the overview perspective they require to integrate information. Such an individual might find the situation very difficult as a learning experience. It is also possible that the other group members will not understand their difficulty. This is a problematic situation since all group members should be involved in group communications for a group to feel comfortable and function well. Full participation is essential in some groups to avoid resentment by other group members if they feel that one person is not contributing. I-Help private discussions should not, then, be used as an alternative to group interaction, as the group may suffer as a result. However, for students who have problems adapting to the way the other group members work, I-Help may provide a much-needed 'lifeline' by matching them with a student with a similar cognitive style, to support their PBL activities in a 'more comfortable' fashion. Thus they will continue to interact with their group to the best of their ability given the difficulties they experience, but they may also work with another learner outside the group context if they feel this to be useful. This need not detract from the group experience as a whole, since the learner may report back any findings. Taking the above example, such an individual's contribution may now be greater, since they will be able to provide the overview that the analytics lack. Therefore their group contribution may be stronger than any earlier contributions where they had not had this additional learning opportunity, and were interacting only within the confines of the particular group's interaction dynamics.

This section has suggested a number of ways in which I-Help might be useful in PBL. It is not suggested that all PBL students should use it (though the public forum is likely to be generally useful), but that I-Help could arrange peer support in cases where an individual is having difficulties with some aspect of the PBL approach.

Although it does not address the problem of group learning for an individual who prefers to learn alone, or in a different kind of group situation, it does at least provide them with some support that they would otherwise not have.

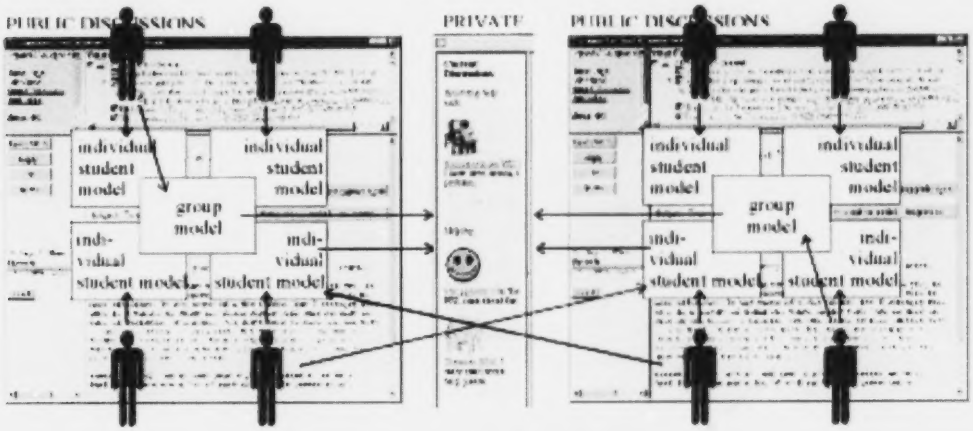


Figure 2: I-Help in problem-based learning

To introduce I-Help to the PBL setting, some additions to the user models are necessary. However, these are very easy to implement, having simplicity in common with the present representations. Currently I-Help user models contain: a quantitative measure of knowledge levels in the various domain areas; a quantitative indication of helpfulness; a quantitative measure of eagerness; a list of friends; a list of banned people; identification of cognitive style; a list of preferred interaction types. The additional information proposed above comprises: a list of roles successfully performed previously (to be added by the individual); the current role of the student (also added by the individual); a list of group membership (provided by one group member); a list of group skills (based on group evaluation, the result of which is entered by one group member). Thus minimal extensions could provide essential support to learners having difficulties in PBL. Provision of this information by students should also encourage them to think about factors that help to make group interaction successful.

Figure 2 illustrates how I-Help can support learners in a PBL setting. Students and peers provide student model information as occurs in large group uses. I-Help also performs some user modelling as described previously. The main difference with I-Help in PBL is that interactions for each group are focussed primarily around public discussions, with each person communicating with other members of their own group. There is less use of the private discussions. Where private discussions do occur, matching takes place according to the student models of individuals in the manner described in section 3. In addition to individual models, in PBL group models are required in order that groups may also be brought together where difficulties are recognised by the group as a whole. Information for the group model is obtained from one of the group members.

5 Conclusions

I-Help was initially designed to promote peer help amongst a group of learners in a large class situation. Some minor extensions to the system were suggested, to enable it to be effective also for students in PBL. Despite many successes claimed for this kind of collaborative interaction, not all students will function at their best with this type of curriculum. In this paper we focussed on PBL in medical education, but the arguments should be equally applicable to other academic disciplines and small group contexts, as long as the overall student numbers are large enough to enable sufficient choices of appropriate partners for cross-group interaction.

In addition to large and small group formal educational settings, I-Help might also be used beyond the classroom to support medical practitioners. For example, while some contexts have adequate funds to implement elaborate means of telemedicine (e.g. the U.S. Army [1]), remote areas which might benefit from access to various forms of telemedicine often find that the low population density does not provide sufficient demand to justify the expenditure required [25]. In rural locations a system like I-Help would provide a low cost means of obtaining expert help at least for some cases. Furthermore, practitioners requesting assistance do not themselves need to know who is the best person to contact. Similarly, I-Help might be useful in putting into contact physicians who

 BEST COPY AVAILABLE

would like to hear experiences of other practitioners. For example, where ethical considerations are important to a case, such as conflicts between medical advice and parental beliefs [7]. I-Help might also be used alongside diagnostic decision support systems in cases where physicians remain unsure about hypotheses, since the advice offered by such systems may sometimes be misleading [9]. Experience with I-Help at university should encourage more individuals to register once they graduate and specialise.

Acknowledgements

This work is funded by the Canadian Telelearning Network of Centers of Excellence, Project 6.28. We thank the ARIES Lab members, in particular: G. McCalla, J. Vassileva, R. Deters, J. Cooke, L. Kettel and J. Bowes.

References

[1] Berry, F.C. "Telemedicine and the army", ARMY Magazine, April 1996.

[2] Block, K.J. "Problem-Based Learning in Medical Education: Issues for Health Sciences Libraries and Librarians", Katharine Sharp Review 5, 1997.

[3] Bowes, J. "Knowledge Management through Data Mining in Discussion Forums", MSc Thesis, Department of Computer Science, University of Saskatchewan, 2000.

[4] Bull, S. "A Multiple Student and User Modelling System for Peer Interaction", in R. Schäfer & M. Bauer (eds) 5 GI-Workshop, Adaptivität und Benutzermodellierung in interaktiven Softwaresystemen, Universität des Saarlandes, 61-7, 1997. On-line proceedings: http://w5.cs.uni-sb.de/~abis97/proceedings/

[5] Cameron, T., Barrows, H.S. & Crooks, S.M. "Distributed Problem-Based Learning at Southern Illinois University School of Medicine", in C. Hoadley & J. Roschelle (eds), Computer Support for Collaborative Learning, Stanford University/unext.com, 86-93, 1999.

[6] Camp, G. "Problem-Based Learning: A Paradigm Shift or a Passing Fad?", Medical Education Online 1(2), http://www.med-ed-online.org/ , 1996.

[7] Coward, H. & Hartrick, G. "Perspectives on Health and Cultural Pluralism: Ethics in Health Care Education", Workshop on Cognitive and Social Science Foundation for Medical Education and Training in the Information Age, Dunsmuir Lodge, Victoria, 2000.

[8] Deretchin, L.F., Yeoman, L.C. & Seidel, C.L. "Student Information Resource Utilization in Problem-Based Learning", Medical Education Online 4(7), http://www.med-ed-online.org/ , 1998.

[9] Friedman, C.P., Elstein, A.S., Wolf, F.M., Murphy, G.C., Franz, T.M., Heckerling, P.S., Fine, P.L., Miller, T.M. & Abraham, V. "Enhancement of Clinicians' Diagnostic Reasoning by Computer-Based Consultation", Journal of American Medical Association 282(19), 1851-1856, 1999.

[10] Gillespie, R.S. "Problem-Based Learning Redefines Medical Education", IMpact (Summer), American College of Physicians, 1995.

[11] Greer, J. & Bull, S. "Computer Support for Collaboration in Medical Education", Clinical and Investigative Medicine, in press.

[12] Greer, J., McCalla, G. Cooke, J., Collins, J., Kumar, V., Bishop, A. & Vassileva, J. "The Intelligent Helpdesk: Supporting Peer Help in a University Course", in B.P. Goettl, H.M. Halff, C.L. Redfield & V.J. Shute (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 494-503, 1998.

[13] Hmelo, C.E., Gotterer, G.S. & Bransford, J.D. "A Theory-Driven Approach to Assessing the Cognitive Effects of PBL", Instructional Science 25, 387-408, 1997.

[14] Hoppe, H.U. "The Use of Multiple Student Modeling to Parameterize Group Learning", in J. Greer (ed), Proceedings of World Conference on Artificial Intelligence in Education, AACE, Charlottesville VA, 1995.

[15] Kamin, C.S., Deterding, R.D., Wilson, B., Armacost, M. & Breedon, T. "The Development of a Collaborative Distance Learning Program to Facilitate Pediatric Problem-Based Learning", Medical Education Online 4(2), http://www.med-ed-online.org/ , 1999.

[16] Koschmann, T.D., Kelson, A.C., Feltovich, P.J. & Barrows, H.S. "Computer-Supported Problem-Based Learning", in T.D. Koschmann (ed) CSCL: Theory and Practice of an Emerging Paradigm, Lawrence Erlbaum Associates, Hillsdale, NJ, 1996.

[17] Koschmann, T. & Stahl, G. "Learning Issues in Problem-Based Learning", Panel at CSCW'98, 1998. http://www.cs.colorado.edu/~public.conferences/1998/cscw98/cscw_workshop.html

[18] Lee, R.M.K.W. & Kwan, C-Y. "The Use of Problem-Based Learning in Medical Education", http://www-fhs.mcmaster.ca/mdprog/pblart.htm , 1999.

[19] Lum, C., Cox, R., Kilgour, J., Morris, J. & Tobin, R. "PATSy: A Multimedia Distributed Web-Based Resource for Aphasiologists in Research and Education", Aphasiology 13(7), 573-579, 1999.

[20] McCalla, G., Vassileva, J., Greer, J. & Bull, S. "Active Learner Modelling", in G. Gauthier, C. Frasson & K. VanLehn (eds), Intelligent Tutoring Systems, Springer-Verlag, Berlin Heidelberg, 53-62, 2000.
[21] Newble, D.I. & Hejka, E.J. "Approaches to Learning of Medical Students and Practising Physicians: some empirical evidence and its implications for medical education", Educational Psychology 11(3-4), 1991.
[22] Ogata, H., Sueda, T., Furugori, N. & Yano, Y. "Augmenting Collaboration Beyond Classrooms through Online Social Networks", in G. Cumming, T. Okamoto & L. Gomez (eds), Advanced Research in Computers and Communications in Education, ICCE '99, IOS Press, Amsterdam, 277-284, 1999.
[23] Patel, V.L. & Groen, G.J. "Reasoning and Instruction in Medical Curricula", Cognition and Instruction 10(4), 335-378, 1993.
[24] Peterson, M. "Skills to Enhance Problem-Based Learning", Medical Education Online 2(3), http://www.med-ed-online.org/ , 1997.
[25] Puskin, D.S., Mintzer, C.L. & Wasem, C. "Telemedicine: Building Rural Systems for Today and Tomorrow", in P.F. Brennan, S.J. Schneider & E. Tornquist (eds), Information Networks for Community Health, Springer, New York, 1997.
[26] Riding, R. & Cheema, I. "Cognitive Styles–an Overview and Integration", Educational Psychology 11(3-4), 193-215, 1991.
[27] Spencer, J.A. & Jordan, R.K. "Learner Centred Approaches in Medical Education", British Medical Journal 318, 1280-1283, 1999.
[28] Vassileva, J., Greer, J., McCalla, G., Deters, R., Zapata, D., Mudgal, C. & Grant, S. "A Multi-Agent Design of a Peer-Help Environment", in S.P. Lajoie & M. Vivet (eds), Artificial Intelligence in Education, IOS Press, Amsterdam, 38-45, 1999.
[29] Wilson, B.G. & Cole, P. "Cognitive Teaching Models", in D.H. Jonassen (ed), Handbook of Research in Instructional Technology, Scholastic Press, New York, 1996.
[30] Woods, D.R. "Problem-Based Learning: Helping your Students Gain the Most from PBL", McMaster University, 1996.
[31] Yu, Y-T., Shan, H-L., Chou, C-Y. & Chan, T-W. "WWW-Based Mentoring System", in Z. Halim, T. Ottman & Z. Razak (eds), Proceedings of ICCE, AACE, 381-389, 1997.

The Research on Difficulty of Asynchronous Learning Materials Based on Studying Time Distribution

Wu-Yuin Hwang and Rueng-Lueng Shiu
Information and Computer Education
National Kouhsiung Normal Univeristy
wyhwang@nknucc.nknu.edu.tw

The purpose of asynchronous distance learning systems is to enhance students' learning performance in the internet. In this paper, we investigate the characteristics of the asynchronous materials and propose the criteria to evaluate them. Employing the criteria, the materials could be adjusted to meet most students' learning pace. First, the TDC (time-distributed curve) which is a learning curve is derived from students' studying time distribution. By the TDC, it is obtained that the more difficult the materials of the chapter are the steeper the TDC becomes. Also the total learning time of each chapter indicates the quantity of the matter. Employing the total time of each chapter, we could evaluate whether the quantity of the matter is sufficient to match students' learning desire.

Keywords: **distance learning learning portfolio learning behavior learing time distribution**

1 Introcduction

1.1 The distribution of learning time with learning attitude

Teachers could interact with their students immediately at the classroom. Thus, they could get the learning behavior of their students by students' response. The learning behavior is regarded as a good measure to evaluate learning performance. But it is really hard to obtain every student's learning process and attitude because there are at least 30 students in each class. However, employing the database technology in asynchronous learning systems, it is possible to obtain all of the student's learning process and studying time.

1.2 Learning time distribution

In traditional education, students learning together in the classroom at the fixed time, and teachers control the course proceeding. But it is difficult to pay attention to all students. However, asynchronous learning systems not only provide a brand-new perspective to long-life learning but also keep track of learning time of all students. In accordance with the learning time of all students, teachers could modify the matter to match learning goals.

2 Experiment and analysis

The experimental course in our asynchronous learning system is "Basic computer concept", the materials of the course are divided into 12 chapters. The progress-control mechanism is that students need to finish the homework of the chapter in order to be promoted to the next chapter. Thirty participants engage in this experiment and they are all teachers.

The student's learning time and login time are recorded by technologies of ASP(Active Server Page) and Database. Therefore, we could get which chapter students read and how long they read the chapter. The important curve, Time-Distributed Curve (TDC), is generated by linear regression analysis. From the slope and the area of TDC, some characteristics and results are obtained.

2.1 TDC and DCA (Degree of Course Acceptance)

Student's reading time each chapter is recorded in our experiment. The recorded time begins from the date when the teaching materials are put in the internet for 15 days. In each chapter, all of the student's learning time everyday is summed up.

Employing the recorded data and derived chart, each chapter has a unique TDC (time-distributed curve) by linear regression analysis. According to the time-distributed curve, teachers may decide whether the materials should be improved.

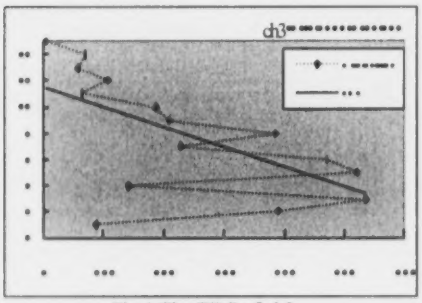


Fig.1 The TDC of ch3

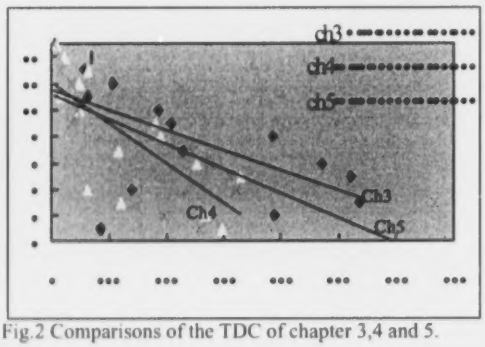


Fig.2 Comparisons of the TDC of chapter 3,4 and 5.

In Fig. 1, the X axle indicates time value and its time unit is one minute not an hour and The Y axle indicates days. For example, the total time on the 4th day is approximate 150 minutes. The slope of the TDC is minus because the total studying time would decrease while students proceed to study the matter.

The value of the slope is required to be concerned. The larger the value of the slope is, the smoother the TDC becomes. For example, figure 2 made comparisons of the TDC of chapter 3,4 and 5. Obviously, the TDC of chapter 4 has the smallest slope because it is the steepest one. And the TDC slope of chapter 3 is slightly larger than that of chapter 5. Thus, it is the most difficult to read chapter 4 and it is the easiest to read chapter 3. The reasons why the materials are hard to study may be either the materials are complicated or the user interface is not friendly to read. According to the above description, the slope of TDC could be termed as Degree of Course Acceptance (DCA, It means the harder the topic to read the smaller is the DCA.)• Besides the TDC's slope is proposed to determine the degree of materials acceptance, there is another important characteristic, the area of the TDC, to influence the amount of learning time.

Based on the area and slope of TDC, the difficulty and quantity of the materials could be evaluated. According to the above description, it is shown that the quantity of materials would affect the amount of learner's studying time, also the difficulty of materials would affect the length of learning period. Due to these reasons, there are two margin lines, quantity and difficulty, in Fig. 3. The two margin lines are termed e are "Margin Line Of Quantity (MLOQ)" and "Margin Line Of Difficulty (MLOD)". There are plentiful materials on the right of MLOQ, but there are poor on the left side. The upper of MLOD the materials are located the harder they are read, but lower are easy.

Since the features of MLOQ,MLOD,DCA and the area of TDC are proposed, there are four kinds of situations that the TDC represents as follow:

1. It is easy to read the material, and the contents are plentiful.
2. It is easy to read the material, but the contents are poor.
3. It is hard to read the material, but the contents are poor.
4. It is hard to read the material, and the contents are plentiful.

BEST COPY AVAILABLE

The MLOQ and MLOD could be employed to enhance discriminating the difficulty of the materials if the DCA and the TDC's area of the chapters are different. Finally, how is the value of the MLOQ and MLOD obtained? The MLOQ is the average of all students' learning time of one chapter. The MLOD is the average of all students' learning days of one chapter.

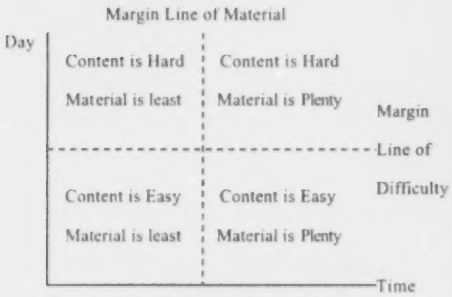


Fig.3 MLOQ and MLOD

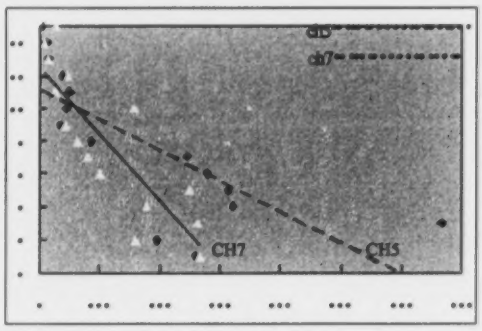


Fig.4 Compares the TDCs of the ch5 & 7

2.2 Time distribution of the interdependent course

What else may affect one's effort in the course? There are relationships between two topics. For example, there are relationships of dependency between chapter 5(Internet I) and 7(Internet II). Generally, the topic "Internet I" is dedicated to construct the fundamental concept and "Internet II" introduces the advanced ideas and practice. According to the normal teaching policy in both topics, the "Internet I" should have fewer and simpler materials than the "Internet II". Thus learners spent much less time to study "Internet I" than "Internet II".

Fig.4 compares the TDCs of the two chapters. As shown in Fig. 4, it is easy to find out chapter 7 has a smaller DCA (the slope of TDC), that is, chapter 7 is harder than chapter 5. Furthermore, the area of chapter 7 is less than that of chapter 5. The TDC of chapter 5 is located at approximately 11 on Y axle and 600 on X axle and the TDC of chapter 7 located at 12 on Y axle and 280 on X axle. According to MLOQ and MLOD as shown in fig.3, we concluded that "The chapter 7 is more difficult than chapter 5, but its quantities are much less". It is different from we described before, "Internet I" should have fewer matters than "Internet II". In our experiment, we provided much more contents in chapter 5 than chapter 7. Therefore the amount of materials in chapter 5 should be reduced.

3 Conclusions

The asynchronous learning service is an on-line collection of hypertext that provides us a new way to learn. Their students with different native intelligence come from any place and go to learn when they would like. It is very important to design and evaluate the asynchronous teaching matters so as to match teaching goals. This paper proposed some basic criteria to investigate the characteristics of teaching matters, then gave an advise to modify them to meet the learning desire. The basic criteria, the area and slope of TDC, are derived from learning time distribution. Through the basic criteria, instructors could modify the materials in accordance with most students' learning pace and talent. Especially, our proposed mechanism is worth much attention to develop the adaptive learning system. Once the asynchronous learner's studying portfolio is available, the materials could be real-time adjusted to match the learner's state.

Reference

[1] • • •

Using Decision Networks for Adaptive Tutoring

Peng-Kiat Pek* and Kim-Leng Poh**
** Singapore Polytechnic*
500 Dover Road, Singapore 139651
E-mail: baiychen@magix.com.sg
*** National University of Singapore*
10 Kent Ridge Crescent, Singapore 119260
E-mail: isepohkl@nus.edu.sg

This paper reports a research project that uses dynamic decision networks in providing teacher with information on students' misconceptions and students with online tutoring. A set of Bayesian networks models the conditional dependencies between learning objectives and goals which are associated with the curriculum. Student's responses to test items are recorded and transformed as evidence into a relevant Bayesian network to compute his likely state of knowledge mastery. The personalized Bayesian network is then converted into a dynamic decision network by adding utility and decision nodes. Tutoring policy is followed through and necessary responses from the student are solicited using additional test items. The student Bayesian network is updated when new evidence arrives, and is again converted to a decision network to determine the next tutoring policy. This process is repeated until the pre-requisites are achieved. The results generated by the system and future directions are discussed.

Keywords: **Adaptive Tutoring, Decision Network, Student Model, Tutoring Strategy**

1 Introduction

Tutoring of students is an ill-structured problem that is characterized by:
(a) Uncertainty of student's knowledge mastery.
(b) Preferences, judgements, intuition, and experience of teacher.
(c) Criteria for decisions are occasionally in conflict, and highly dependent on the teacher's perception.
(d) Decisions must be achieved in limited time.
(e) The student's mental states evolve rapidly.

This study attempts to address these issues by using an intelligent *decision-theoretic* approach. The framework of this research has contributed to the development of an intelligent decision support system called *iTutor*, for tutoring Engineering Mechanics at Singapore Polytechnic.

Probabilistic or Bayesian networks [9] and decision analysis [5] have shown to be capable of solving many real-world problems involving reasoning and decision marketing under uncertainty. Bayes's nets allow for efficient reasoning and inference about combination of uncertain evidence. Student modeling with Bayes's nets for intelligent tutoring had achieved successes, see for example in [16], [11], and [2]. The differences in these works lie mainly in the choice of variables and granularity of the models.

In Villano's Knowledge Space Theory, the basic unit of knowledge is an *item* (in the form of a question). The student's knowledge state is defined as the collection of items that the student is capable of answering. The collection of all feasible states is called the *knowledge structure*, and it is connected by the *learning path*. By incorporating uncertainty at each node, the knowledge space can be transformed into a Bayes's net. The Bayes's net then constitutes a student model where probabilistic reasoning can be performed when evidence is available. Reye on the other hand, uses pre-requisite relationship of domain knowledge and *dynamic belief network* for modeling student's mastery of a topic. Finally, Conati and Vanlehn make use of teacher's

solution(s) as the ideal model to track student's faulty knowledge as the student solves a problem.

Our work here differs from others in that we construct relevant Bayes's nets by modeling learning objectives (**L**), evidence (**V**) from student responses, application of knowledge to different situations (**C**), and learning goal (**G**). A decision network [3] is then formed by adding decision and utility nodes to the Bayes's net. As it is computationally intractable to track student's solution in real time, we use sequential decisions to generate tutoring strategy that anticipates students' responses.

This paper is organized as follows: Section 2 provides an overview of the conceptual framework for the decision theoretic intelligent tutoring system called *iTutor*. The transformation of student's responses to evidence is discussed in Section 3. Section 4 illustrates how the student model is constructed from a set of Bayes's nets, while Section 5 presents the tutoring strategy model using two-step look-ahead decision network. The results of a typical *iTutor* session are illustrated in Section 6. It emphasizes the automation of decision network construction and shows that when student's responses are available, the system is able to diagnose student's misconceptions and to provide adaptive tutoring using the generated strategy. Finally, we conclude by discussing future directions.

2 Framework of Adaptive Tutoring

Figure 1 shows the essential components of adaptive tutoring in *iTutor*.

The ***Evidence Model*** converts the student response (x_{ijk}) to item i into evidence of knowledge mastery for a relevant learning objective (v_{jk}).

The ***Student Model*** consists of a set of Bayes's nets with nodes that are either Evidence, Case, Learning Objective, or Goal. These nodes are initialized with prior information from the teacher's judgement and theoretical probability models. The student model can be subsequently updated to reflect a student's knowledge mastery when evidence is available.

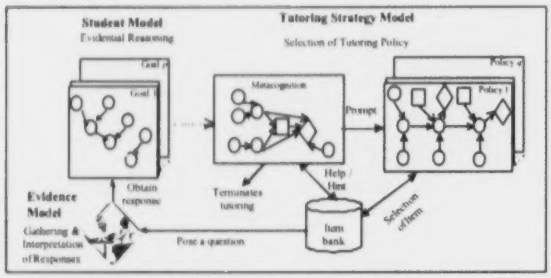


Figure 1: Inferencing Kernel of Adaptive Tutoring

The ***Tutoring Strategy Model*** uses decision-theoretic approach to select *satisfying* [14] learning objectives for tutoring student. The metacognition sub-module determines the appropriate tutor's action: providing more help or hint, prompting another question, or stop the tutoring session. Dynamic Decision Network (DDN) provides approximate solutions for partially observable Markov decision problems, where the degree of approximation depends on the amount of look-ahead. If the decision is to obtain evidence of mastery on a learning objective, an item of difficulty b_i that matches the student's ability θ will be selected. Student's response is collected, evaluated, and transformed into evidence at the relevant nodes in the student model. The *chance* nodes in DDN are updated and a decision policy is generated. In this way, the system is able to adapt tutoring to the needs of the student and achieve the objectives of the curriculum.

3 Evidence Model

The student's responses are processed in the evidence model. Let V_{jk} be the evidence node that indicates the student's (j) mastery state of learning objective k. Let $\boldsymbol{X}$ be the set of responses and $x_{ijk} \in X_{ik} \subseteq X$ be the response to item i which tests the kth learning objective, then

$$\Pr(\boldsymbol{v}_{jk} \mid x_{ijk}) \propto \Pr(v_{jk}) \prod_i \Pr(x_{ijk} \mid \boldsymbol{v}_{jk})$$

where $\Pr(v_{jk})$ is the prior probability which can be obtained statistically from past data. $\Pr(x_{ijk} \mid v_{jk})$ is the likelihood of correct-answer score. An example of the likelihood function is $\delta_k \exp(-b_i v_{jk})$ where δ_k is the importance of knowing learning objective k so as to answer item i correctly and b_i is the difficulty index for item i.

4 The Student Model

The Student Model consists of a set of Bayes's nets, and each Bayes's net models the student's mastery of a key concept (*goal*). In Section 4.1, the structure of the student model is defined. The construction of Bayes's net and the conditional probability assignment are discussed in Section 4.2. Instantiation of an evidence node activates a message passing process in the Bayes's net. This process results in the updating of marginal probabilities at the nodes. Most commercial software for developing probabilistic network possesses efficient algorithm [1] for implementing the message passing process.

4.1 Semantics of the Student Model

The Student Model is a directed acyclic graph (DAG) that represents a joint probability distribution of a key concept and several learning objectives. A node represents the learning objective as a random variable, and an arc represents possible probabilistic relevance or dependency between the variables. When there is no arc linking two nodes, it indicates probabilistic independence between the variables. In this study, the variables are classified into four types Evidence, Case, Learning Objective, and Goal as shown in Figure 2.

Symbol	Name	Function
N_v	Evidence Node	It contains knowledge states based on student's response.
N_C	Case Node	It contains knowledge states that reflect ability to apply knowledge in different situations (cases).
N_L	Learning Objective Node	It contains knowledge states of key learning objectives (defined in the syllabus).
N_G	Goal Node	The concept student is expected to know. Each Bayes's net must have at least one Goal node.

Figure 2: Types of Nodes in Student Model

More formally, a student model in *iTutor* is a DAG $\mathfrak{I} = (N, \psi)$ where $N = N_v \cup N_L \cup N_C \cup N_G$ are the nodes such that N_v is a set of evidence nodes, N_L is a set of learning objective nodes, N_C is a set of case nodes, and N_G is a set of goal nodes.

$\psi = \psi_{pL} \cup \psi_{pC} \cup \psi_{pG}$ are the arcs such that $\psi_{pL} \subseteq N \times N_L$ are arcs into learning objective nodes, $\psi_{pC} \subseteq N_v \times N_C$ are arcs from evidence nodes to case nodes, and $\psi_{pG} \subseteq (N_L \cup N_G) \times N_G$ are arcs from learning objective or goal nodes to the goal nodes.

Notice that evidence nodes have no parent node and only evidence nodes could be the parents of case nodes. Goal nodes are always sink nodes and they have parents that are either learning objective nodes or goal nodes. This signifies that mastery of a concept (goal node) is dependent on the mastery of learning objective(s) and/or pre-requisites (other goal nodes).

4.2 Construction of a Bayes's Net

Figure 3 shows a Bayes's net on mastery of a hypothetical concept (*goal*) "XYZ". Each node has three knowledge states: *non-mastery, partial-mastery,* and *mastery*. The granularity of Bayes's net depends on the number of nodes and its states. However, as the granularity becomes finer, the number of entries in the conditional probability table grows exponentially.

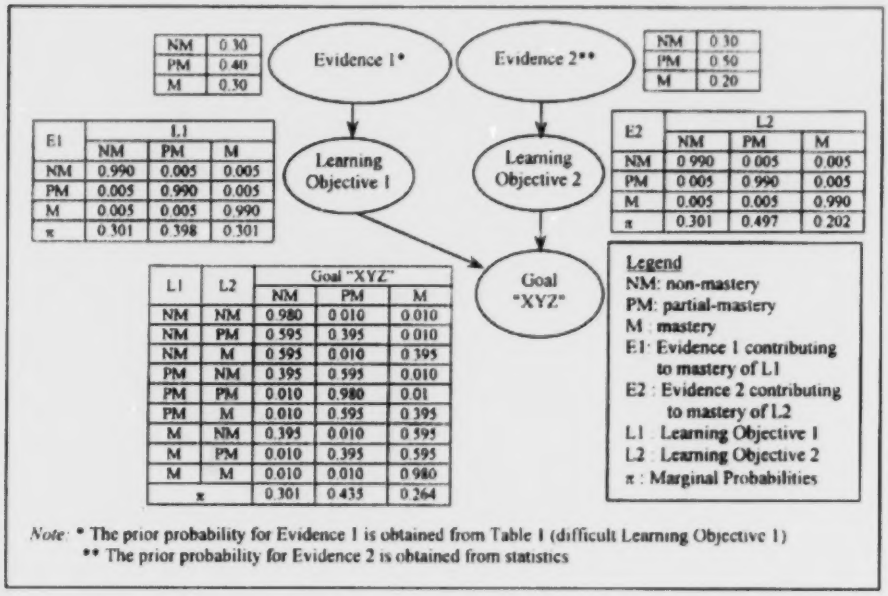
Table 1 Category of Difficulty in Mastering the Learning Objective

	Probability values		
Category	NM	PM	M
very easy	0.001	0.009	0.99
easy	0.01	0.09	0.90
fairly easy	0.05	0.15	0.80
Neutral	0.10	0.20	0.70
fairly difficult	0.20	0.30	0.50
difficult	0.30	0.40	0.30
very difficult	0.40	0.50	0.10

Values at the root nodes are known as *prior* probabilities while that at other nodes are *conditional* probabilities. To use the probabilistic network the random variables must be initialized with prior probability values. These values may be based on teacher's belief or past statistics. An intuitive method is to generate a probability table based on seven-category of the difficulty of learning objectives (see Table 1). These probability values are to be input as the prior probability of the related evidence. The teacher also has the flexibility to amend the values based on their belief and context of usage. On the other hand, the probability values can be obtained from statistics of previous tests/examinations. A simple procedure for the use of past statistics is:

a) Assigned learning objectives to each question;

b) Enter student's responses (in terms of percentage) for the questions that she has answered;
c) Compute the average number of students (in percentage) for each mastery category: 0-40 (non-masterystate), 40-70 (partial-mastery state), and 70-100 (mastery state).



NM	0.30
PM	0.40
M	0.30

NM	0.30
PM	0.50
M	0.20

E1	L1		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.398	0.301

E2	L2		
	NM	PM	M
NM	0.990	0.005	0.005
PM	0.005	0.990	0.005
M	0.005	0.005	0.990
π	0.301	0.497	0.202

L1	L2	Goal "XYZ"		
		NM	PM	M
NM	NM	0.980	0.010	0.010
NM	PM	0.595	0.395	0.010
NM	M	0.595	0.010	0.395
PM	NM	0.395	0.595	0.010
PM	PM	0.010	0.980	0.01
PM	M	0.010	0.595	0.395
M	NM	0.395	0.010	0.595
M	PM	0.010	0.395	0.595
M	M	0.010	0.010	0.980
π		0.301	0.435	0.264

Note: * The prior probability for Evidence 1 is obtained from Table 1 (difficult Learning Objective 1)
** The prior probability for Evidence 2 is obtained from statistics

If a probability distribution function is able to describe the statistics, it can be used. In Figure 3, the values Pr(E2=non-mastery) = 0.30, Pr(E2=partial-mastery) = 0.50, and Pr(E2=mastery) = 0.20 are obtained from statistical data for this particular evidence. It is acceptable for another person to assign different probability values so long as it is consistent with the probability axioms [12]. Since the decision theory approach is normative rather than descriptive, it is able to explain the actions of the decision-maker.

For any node n_q, the conditional probability required to specify the Bayes's net is computed based on the relative importance (*weights*) of the parent nodes $pa(n_q)$ to itself.
If the state of n_q and $\mathrm{pa}(n_q)$ is the same, then $\Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} (w_{pq} - (c-1)\kappa)$

$$\text{else } \Pr(n_q \mid \mathrm{pa}(n_q)) = \sum_{\mathrm{pa}(n_q)} \kappa \qquad (1)$$

where c *is the number of states and* $0 \le w_{pq} \le 1$.

κ is a constant and a measure of uncertainty such as careless errors, lucky guesses, changes in the student knowledge state due to learning and forgetting, and patterns of student responses unanticipated by the designer of the student model. The weights w_{pq} are either assessed based on the teacher's subjective judgment or past students' responses to closely related items.

Referring to Figure 3, since Learning_Objective_1 is dependent only on Evidence_1, $w_1 = 1$. Let Learning_Objective_1 has greater influence on mastery of goal "XYZ" than Learning_Objective_2, $w_{1g} = 0.6$, and $w_{2g} = 0.4$. Assigning $\kappa = 0.005$, the conditional probability tables can be computed using equation (1).

5 Tutoring Strategy

When a student logon to *iTutor*, the system automatically searches his ability index from the database. The

ability index is either computed from the tests taken previously by the students, or from her knowledge states in the student model (see Section 5.1). Human tutors consider the student's emotional state in deciding how to respond. Similarly in *iTutor*, the system considers factors such as response time, response pattern, student knowledge structure to determine tutoring actions: give more hint, help, ask another question, or stop the tutoring session. If the decision is to prompt another item, a learning objective and an appropriate item will be selected to coach her (see Section 5.2). Section 5.3 discussed the generation of tutoring strategy based on student's response.

5.1 Mapping of Knowledge State to Student Ability

Let the student's ability be $\theta_j = (\theta_{j1}, \theta_{j2}, .. \theta_{jm}, .. \theta_{jp})$. A function $f: v_{jm} \rightarrow \theta_m$ where v_{jm} is the evidence at the goal node (g) of mth Bayes's net. An example of such function is:

$$\theta_{jm} = \begin{cases} N(1.5, 0.6) & v_{jm} \geq 0.7 \\ N(0.5, 1) & 0.4 < v_{jm} < 0.7 \\ N(-1, 1.2) & v_{jm} \leq 0.4 \end{cases}$$

where N (μ, σ) denotes a *normal* distribution with mean μ and standard deviation σ

The computed ability index is then used to categorize (Advance, Intermediate, or Beginner) the student. An appropriate learning objective is selected based on the heuristic shown in Table 2. Value assignment is used to compute the path length of Bayes's net and is used as preference for tutoring policy generation. They are as follow:

$$\begin{aligned} &\text{value}(G) = 0 \text{ for } G \in \{\text{Goal nodes}\} \text{ and } \text{ch}(G) = \phi \\ &\text{value}(\text{ch}(N)) = 0 \text{ if } \text{ch}(N) = \phi \\ &\text{value}(N) = \text{value}(\text{ch}(N)) + 1 \text{ for node } N \\ &\text{where } \text{ch}(N) \text{ is the child node of } N \end{aligned} \qquad (2)$$

Table 2 Search Heuristic for Identifying Learning Objective for Coaching

Category	Identification of first Learning Objective for tutoring
Advance	25% of pathLength*
Intermediate	50% of pathLength
Beginner	75% of pathLength
New#	50% of pathLength ($\lceil$pathLength/2$\rceil$)

Note:

* pathLength denotes max(value(N)) $\forall N \in$ Bayes's net.
The value(N) assignment is stated in equation 2

\# The category *New* refers to students who login to the system the first time

5.2 Item Selection

Each item is tagged with an index (b_i) that estimates the minimum ability to answer it correctly with 0.5 probability. The items are assumed to be independent and the index obtained through statistic of past students' attempts or assigned using teacher's belief. Subsequent update of item difficulty index may be performed through item response theory [4] such as Rasch model [10].
From the set of items related to a learning objective, an item i is selected based on: $\theta_j - b_i < \varepsilon$ where ε is a

Table 3 Utility of Various Outcomes

Condition / Expression	Preference
Decision: Stop	
$S(N)$ = "M" & value(N) = 0	1
$S(N)$ = "N" & value(N) = 0	0
k = number of $N_k \in \{(N_k, S_k)\}$ with same S_k	$1 - k/5$
number of tries, n, for the same learning objective	$1 - n/5$
Decision: Ask item on same N	
$S(N)$ = "M"	0
$S(N)$ = "N"	1
$S(N)$ = "P"	$\left(1 - \frac{\text{value(N)}}{\text{pathLength}}\right) \times \eta$ where η is a constant
Decision: Ask item on ch(N)	
$S(N)$ = "M"	1
$S(N)$ = "N"	0
$\gamma = \max(\Pr(S(\text{ch}(N)) = \text{"M"} \mid x = 1) - \Pr(S(\text{ch}(N)) = \text{"N"} \mid x = 0)$	
Decision: Ask item on pa(N)	
$S(N)$ = "M"	0
$S(N)$ = "N"	1
$\gamma = \max(\Pr(S(\text{pa}(N)) = \text{"M"} \mid x = 1) - \Pr(S(\text{pa}(N)) = \text{"N"} \mid x = 0))$	

Remarks: $S(N)$ denotes the knowledge state of node N
ch(N) denotes child node of node N

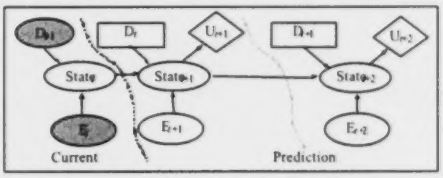


Figure 4: Dynamic Decision Network

Table 4 Utility Values for Item Difficulty Level Selection

Current Knowledge State ($State_i$)	Current Response (E_i)	Next Question Typ (D_{i+1})		
		Easy	Ave.	Diff
Non-Mastery	Correct	-0.2	1	0
	Wrong	0.4	-0.2	-0.4
Partial Mastery	Correct	-0.4	0.2	1
	Wrong	0.4	1	-0.2
Mastery	Correct	-0.4	-0.2	-0.2
	Wrong	-0.2	0.2	-0.2

pre-defined small value. This ensures selected item is challenging and likely to be solved by the student. Teacher's solution will be displayed upon student's request so that she can learn from her mistake. This strategy assumes student's ability is dynamic and can be raised to higher levels through self-paced computer-aided tutoring.

5.3 Tutoring Policy Generation

To bring the probabilistic network one step closer to being a useful *intelligent tutoring system*, automated decision-making capability has been added. When asked to provide a tutoring policy for the student, the system generates a course of action based on her current mastery states. The tutoring policy aims to use a series of items with differing difficulty to determine more precisely her mastery of specific learning objectives. Items are categorized into *easy*, *average* and *difficult*. In this project, a two-step look-ahead dynamic decision network is recommended so as to compromise between the need to invoke policy generation routine for a decision and the long computing time to generate policy with many decisions.

Define a Bayes's net with nodes N,
E_t be the evidence at time t,
$Bel(N)$ be a vector of probabilities (updated over time),
d_t be the decision at time t, and
α be the normalization constant.

Prediction 1: $Bel^*(N_{t+1}) \leftarrow \sum_{N_t} Pr(N_{t+1} \mid N_t, d_t) Bel(N_t)$

Estimation 1: $Bel(N_{t+1}) \leftarrow \alpha Pr(E_{t+1} \mid N_{t+1}) Bel^*(N_{t+1})$

Prediction 2: $Bel^*(N_{t+2}) \leftarrow \sum_{N_{t+1}} Pr(N_{t+2} \mid N_{t+1}, d_{t+1}) Bel(N_{t+1})$

Estimation 2: $Bel(N_{t+2}) \leftarrow \alpha Pr(E_{t+2} \mid N_{t+2}) Bel^*(N_{t+2})$

Expected Utility: $\sum_{N_t} Bel(N_t) \max_{d_t} \sum_{N_{t+1}} Pr(N_{t+1} \mid N_t, d_t) \times \max_{d_{t+1}} \sum_{N_{t+2}} Pr(N_{t+2} \mid N_t, d_t, N_{t+1}, d_{t+1}) \times U(N_t, d_t, N_{t+1}, d_{t+1}, N_{t+2})$

Figure 5: Prediction-estimation Process

Figure 4 shows a dynamic decision network (DDN) used in this study. In addition to the decision nodes for current and future time steps, the DDN also contains the previous decision, D_{t-1}, as an evidence node. When the evidence for state t arrives, the probability distributions of $State_t$ are updated [1] using the prediction-estimation process (see Figure 5). After the initial prediction of probabilities (Bel*), $State_{t+1}$ estimates the new belief based on projected evidence [13]. This process repeats for $State_{t+2}$. Eventually, the expected utility is evaluated by a sequence of summations and maximizations. Tables 3 and 4 show the utility functions for node U_{t+2}. Selecting the outcomes with maximum expected utility value constitute the tutoring policy.

6 An Illustration

6.1 Construction of a Decision Network

In this project, the construction of all probabilistic networks is performed using Netica API [7]. A module leader enters the learning objectives and the weights of the key concept *Forces* using Microsoft Access [6]. The probabilistic values shown in Figure 6 are entered based on past examination results. By clicking the button "Model Construction", a Bayes's net (see Figure 7) and a decision network (see Figure 8) on "Forces"

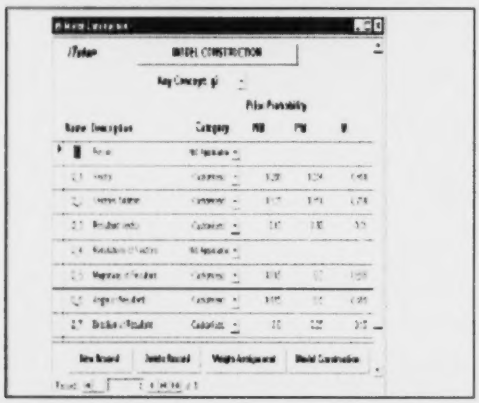


Figure 6: A Snapshot on Data Entry for Model Construction

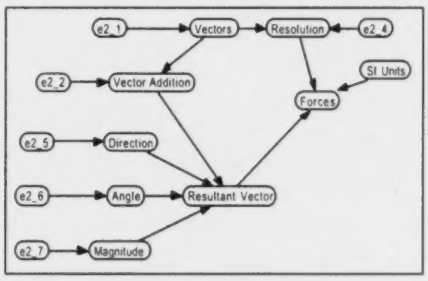


Figure 7: Bayes's Net on *Forces*

will be created. Teachers who are familiar with Netica application [8] can use the generated Bayes's net to perform *what-if* analysis. For example, a teacher may want to determine the likely student's improvement if he provides remedial instructions on "Resolutions of Vectors". He can do so by instantiating the evidence node *e2_4* to "Mastery" state, and observe the probability of mastery in the goal node labeled *Forces*.

6.2 Diagnosis of a Student's Misconceptions

The items to be presented to the students are coded by the teacher using Scientific Notebook [15]. With *iTutor*, the teacher is able to monitor student's progress through the database management tool. Figure 9a shows a snapshot of a student who had answered item "Force_001" correctly and partially correct for item "Force_004". The teacher can track a student's mastery states by clicking the "Advice" button. The system transforms the responses to evidence, and instantiates the evidence nodes in the Bayes's net as shown in Figure 9b. The posterior mastery states are displayed (see Figure 9c). The output also provides the teacher information on specific learning objectives to tutor. In addition, he can also examine the detailed strategy by clicking the "Tutorial Strategy" button. This action causes the generation of a decision network (see Figure 9d). Figure 9e shows items to be posed to the student if she continues with the online tutorial. At any stage, the teacher may intervene by providing personal coaching.

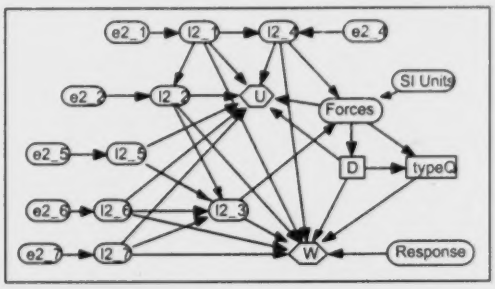


Figure 8: Decision Network on *Forces*

7 Conclusions

Presently, the students' knowledge states remain unchanged until additional evidence is available. The system also uses a constant learning rate for all students. One future direction is to include additional parameters to model student forgetting and learning rates. Another area is to provide a user interface for teachers not familiar with Netica application to perform *what-if* analysis. In this way, the teacher will be able to focus on student's issues rather than to learn another software tool. The next future direction is to include probability functions other than *Normal* distribution. This is essential when the ability distribution of student cohort is not symmetric.

A significant result of this project is the use of Bayesian networks to generate sound probabilistic inferences. Another contribution is the automation of decision networks construction. The recommended strategy is used in adaptive tutoring. With *iTutor*, teacher is able to monitor the student's progress and yet had time for lesson preparation and coaching of weaker students. In addition, the teacher has accessed to the student's knowledge states and actions taken by *iTutor* at every stage of the tutoring process. Moreover, it enables students to have tutorials customized to their needs.

References

[1] Castillo, E., Gutiérrez, J. M., & Hadi, A.S., "Expert Systems and probabilistic network Models", Springer-Verlag, (1997).

[2] Conati C. & Vanlehn K., "Teaching meta-cognitive skills: Implementation and evaluation of a tutoring system to guide self-explanation while learning from examples", Proceedings of AIED '99, 9th World Conference of Artificial Intelligence and Education, Le Man, France, (1999).

[3] Deam, T. L. & Wellman, M. P., "Planning and Control", Morgan Kaufmann, San Mateo, California, (1991).

[4] Hambleton, R.K., Swaminathan, H., & Rogers, H. J., "Fundamentals of Item Response Theory", Sage Publications, Inc, (1991).

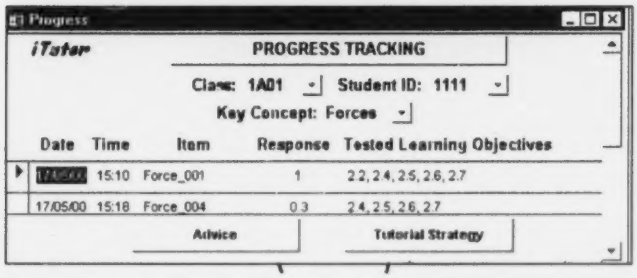
[5] Howard, R.A. & Matheson, J.E. "Readings on the Principles and Applications of Decision Analysis", Menlo Park, California: Strategic Decisions Group, (1983).

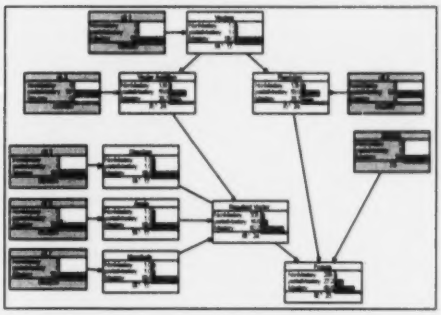
[6] Litwin, P., Getz, K., & Gilbert, M. , "Access 97 Developer's Handbook", 3rd edition, Sybex Inc, (1997).

[7] Norsys, "Netica API Programmer's Library Reference Manual", version 1.06, Norsys Software Corp., (1999)

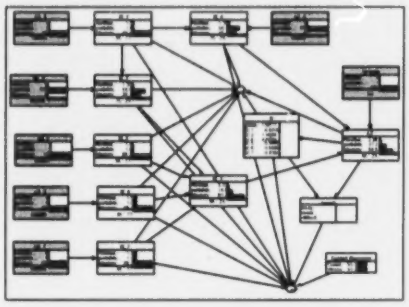
[8] Norsys, "Netica Application Reference Manual", version 1.12, Norsys Software Corp., (1999).
[9] Pearl, J., "Probabilistic Reasoning in Intelligent Systems: Networks of Plausible Inference", Morgan Kaufmann Publishers, Inc, (1988).
[10] Rasch, G., "Probabilistic Models for Some Intelligence and Attainment Tests", Danish Institute for Educational Research, (1960).
[11] Reye, J., "A belief Net Backbone for Student Modeling, Proceedings of Intelligent tutoring Systems", Third International Conference, ITS '96, Springer-Verlag, (1996).
[12] Ross, S., "A First Course in Probability", Prentice-Hall International, Inc., 5th edition, (1998).
[13] Russell, S. & Norvig, P. , "Artificial Intelligence: A Modern Approach", Prentice Hall, (1995).
[14] Simon H.A., "The New Science of Management Decisions", New York: Harper & Row, (1960).
[15] TCI Software Research, "Scientific Notebook version 3.00 Build 939", Brooks / Cole Publishing Company, (1998).
[16] Villano, M., "Probabilistic Student Models: Bayesian Belief Networks and Knowledge Space Theory", Proceedings of Intelligent Tutoring Systems: Second International Conference, ITS '92, Springer-Verlag, (1992)

(a) User interface for teacher to track student's progress





(b) Bayes's net running as background process (transparent to user)



(d) Dynamic decision network running as background process (transparent to user)

Student ID: 1111

The student's mastery states are :

Learning Objective		NonMastery	Partial	Mastery	Value
l2_1	Vectors	0.010	0.010	0.980	93.75
l2_2	Vector Addition	0.014	0.599	0.387	69.87
l2_5	Direction	0.010	0.010	0.980	93.75
l2_6	Angle	0.010	0.010	0.980	93.75
l2_7	Magnitude	0.010	0.010	0.980	93.75
l2_3	Resultant Vector	0.030	0.168	0.802	85.71
l2_4	Resolution	0.014	0.599	0.387	69.87
g1	SI Units	0.000	0.000	1.000	95.00
g2	Forces	0.030	0.272	0.698	81.59

The expected score for this key concept Forces is 81.59.

Based on the knowledge states, you may want to provide coaching in Vector Addition, and Resolution.

(c) Output of student's mastery states

```
Student ID: 1111
With regard to the key concept Forces, the course of action
is :
    select average item from l2_2 (Force_002)
     if response is correct then
        select difficult item from l2_2 (Force_012)
        if response is correct then
              select average item from l2_4 (Force_013)
        else
              select average item from l2_2 (Force_021)
     else
        select easy item from l2_2  (Force_003)
        if response is correct then
              select average item from l2_2 (Force_017)
        else
              select easy item from l2_2 (Force_006)
```

(e) Output of tutoring strategy

Figure 9: Overview of an *iTutor* Session

Proceedings

Content

Full & Short Papers (System Design and Development)

A Code Restructuring Tool to help Scaffold Novice Programmers
A Framework for Internet Based Distributed Learning
A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents
A Novel Distance Learning System for the TIDE Project.
Adaptive Learning Environment Framework
An Educational System that can Visualize Behavior of Programs on the Domain World
An Empirical Study of Design and Use of a Multimedia Composition-Making System for Children
An Implementation of Campus Distance Learning System Using Multicast
Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet
CAI system generator on web -- using automatic trace recording
CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL
Construct in-service Training Web Site for School Teachers
Defining Educational R&D: A Content Analysis of Journal Articles and Implications for Instructional Technology
Design and Implementation of a Chinese web-mail system
Design and Implementation of A N-Tiered Heterogeneous Virtual School Adminstration System
Design and Implementation of a WWW-Based School Official Memorandum System
Design and Implementation of Teaching Models in Web-based Teacher Training
Design of Multiple Metaphors in User-Interface
Designing a Web-Based Action Learning Environment - Integrating Learning and Working in One Environment
Developing an Effective Web-Based Learning Environment for Overseas Chincsc Education
Developing Web-Based Language Learning Environment
Development of 3D simulation programs for classical mechanics - Using Java 3D -
Development of a Web System to Support Computer Exercises and its Operation
Development of CAI System with Character Code Discrimination on WWW Environment

Development of Intelligent Learning Support System with Large Knowledge Base

Development of the Web-based classroom system which a teacher can apply

Implementation of An Object-Oriented Learning Environment Based on XML

Integrating Information Technology with Language Pedagogy for a Second Language Online Writing System

Internet Video on Demand System of Classroom Teaching Cases

Knowledge Analysis of Tasks for Courseware Design

Making the Most of the Internets Potential for Education

Natural language-like knowledge representation for multimedia educational systems

Proposal of an XML-based Knowledge Sharing and Management system supporting Research Activities

Real-Time Handwriting Communication Systems for Distance Education and Collaborative Learning

The Application of Uncertainty Reasoning for an Intelligent Tutoring System

The Automated Teaching Assistant: Automatic construction of teaching materials from course outlines

The Development and Evaluation of a Learning Support System for Converting Web Pages

The Estimation of Music Genres Using Neural Network and its Educational Use

The usability aspects of an universal brockerage and delivery system for the Pan-European higher education

Use of abstraction levels in the design of intelligent tutoring systems

Using Highly Sophisticated Middleware For Building Arbitrarily Distributed Teaching Environment

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

▲ HOME

A Code Restructuring Tool to help Scaffold Novice Programmers

Stuart Garner
Edith Cowan University
Pearson St., Churchlands 6018, Western Australia
E-mail: s.garner@ecu.edu.au

This paper concerns a new software tool called CORT (code restructuring tool) that has been developed by the author to help students learn programming. The paper begins by discussing the difficulties that students face when learning to program and the use of part complete solutions as a teaching and learning method that reduces the cognitive load that students experience.

CORT has been developed to support this use of part complete solutions and its features are outlined. When used by a student, a part complete solution to a given programming problem is displayed in one window and possible lines of code that can be used to complete the solution are displayed within another window. The lines can easily be moved between the windows in order to complete the solution and the solution then transferred to the target programming environment for testing purposes.

Finally, the use of CORT with both undergraduate and postgraduate students at Edith Cowan University is described, preliminary feedback from students indicating that CORT is easy to use and that they perceive that it is helping them in their learning of programming. Four different methods of using CORT have been identified and these will be the subject of future research.

Keywords: **Scaffolding, Programming, Flexible Learning**.

1 Introduction

Learning to write computer programs is not easy [3, 18] and this is reflected in the low levels of achievement experienced by many students in first programming courses. For example, Perkins, Schwartz et al [17] state that:

> *Students with a semester or more of instruction often display remarkable naivete about the language that they have been studying and often prove unable to manage dismayingly simple programming problems.*

and King, Feltham et al [8] state that:

> *even after two years of study, many students had only a rudimentary understanding of programming*

Over the years since the advent of high level programming languages in the 1960s, much has been written about the problems that students have in learning programming and many ideas and initiatives have been put forward for improvements in the teaching and learning process with varying degrees of success. In practice, the ways in which teaching and learning takes place in the domain of programming have changed little and many students still find the learning of programming a very difficult process. The challenge of learning programming in introductory courses lies in simultaneously learning: general problem solving skills; algorithm design; program

design; a programming language in which to implement algorithms as programs; and an environment to support the program design and implementation [6]. In addition, students need to learn testing and debugging techniques to validate programs and to identify and fix problems that they may have within their programs.

Additionally, we are moving ever more rapidly to use more student centred and flexible learning methods within the teaching and learning process. This means that our instructional design for programming courses needs to take notice of these moves and utilise these methods. Fortunately technological improvements have also been significant over the last few years enabling us to more easily produce engaging courseware that can help students studying in a flexible learning mode. As courseware designers, we can produce electronic scaffolds to help students in their learning processes when they are studying on their own with limited access to a human tutor.

2 Use of Worked Examples in the Teaching and Learning of Problem Solving and Programming

There are several methods used in the teaching and learning of programming and one of these is to utilise worked examples. Several researchers have experimented with the use of worked examples in place of conventional instruction and found strong advantages. In the domain of algebra, Sweller and Cooper [19] suggested that students would learn better by studying worked examples until they had "mastered" them rather than attempting to solve problems as soon as they had been presented with, or familiarised themselves, with new material. In their research, students studied worked examples and teachers answered any questions that the students had. Students then had to explain the goal of each problem together with the steps involved in the solution and then complete similar problems until they could be solved without errors. Sweller and Cooper found that this method was less time-consuming than the conventional practice-based model and that students made fewer errors in solving similar problems than students who were exposed to the conventional practice-based model of instruction. There was no significant difference between the "worked example" group and the "conventional" problem solving group when they attempted to solve novel problems and it was therefore concluded that learning was more efficient and yet no less effective when this worked example method was used.

Worked examples are heavily used within the "reading" method of learning programming. According to Van Merrienboer et al [22, 23] the reading approach emphasises the reading, comprehension, modification and amplification of non-trivial, well-designed working programs. However, they also suggest that presenting worked examples to students is not sufficient as the students may not "abstract" the programming plans from them, a plan being a stereotyped sequence of computer instructions as shown in figure 1.

"Mindful" abstraction of plans is required by the voluntary investment of effort and the question then arises as to how we can get students to study the worked examples properly. In practice, students tend to rush through the examples, even if they have been asked to trace them in a debugger, as they often believe that they are only making progress in their learning when they are attempting to solve problems.

Lieberman [10] suggests that students should annotate worked examples with information about what they do or what they illustrate. Another suggestion is to use incomplete, well-structured and understandable program examples that require students to generate the missing code or "complete" the examples. This latter approach forces students to study the incomplete examples as it would not be possible for their completion without a thorough understanding of the examples' workings. An important aspect is that the incomplete examples are carefully designed as they have to contain enough "clues" in the code to guide the students in their completion. It is suggested that this method facilitates both automation, students having blueprints available for mapping to new problem situations, and schemata acquisition as they are forced to mindfully abstract these from the incomplete programs [24].

In one study, two groups of 28 and 29 high-school students from grades 10 to 12 participated in a ten lesson programming course using a subset of COMAL-80 [24]. One group, the "generation" group, followed a conventional approach to the learning of programming that emphasised the design and coding of new programs. The other group, the "completion" group, followed an approach that emphasised the modification and extension of existing programs. It was found that the completion group was better than the generation group in constructing new programs. It was found that the percentage of correctly coded lines was greater and that looping structures were more often combined with correct variable initialisation before a loop together with the correct use of counters and accumulators within the loop. It would appear that the completion strategy had indeed resulted in superior schemata formation for those students within that group. In addition, the completion group used superior comments in connection with the scope and goals of the programs, indicating that they had developed better high-level templates or schemata. It was noted in the study however that both groups were

equal in their ability to interpret programs and that this might indicate that students in the completion group do not understand their acquired templates. It is then suggested that future completion strategies should include the annotation of the examples by students with details of what they are supposed to do and details of the templates (plans) that are being used.

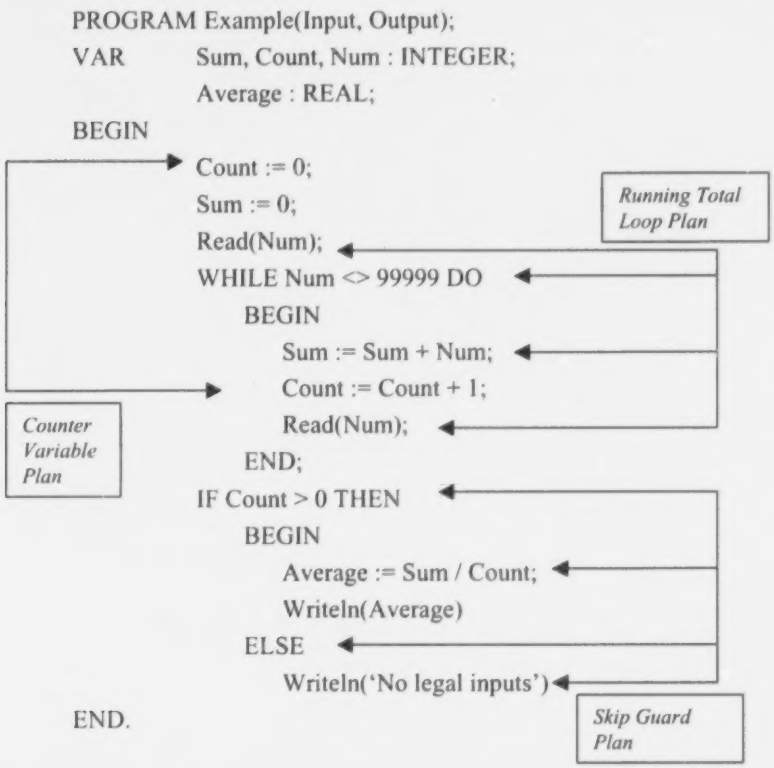


Figure 1

A side effect of the research was also noted. The drop-out rate from the completion group was found to be lower than for the generation group, particularly for female students with low prior knowledge. It was suggested that perhaps the generation of complete programs is perceived as a difficult and menacing task and that the completion strategy overcomes this difficulty.

The stimulation of the "mindful of abstraction" of schemata in students can possibly be improved further requiring them to also annotate the solutions with details of the scope and goals of the solutions and to answer questions on the inner workings of the solutions. The "degree" of completion of the solutions is an important aspect within the completion strategy and in some later work [23] examples are given of completion assignments that might be used early and later in a programming course. In an early part of a course, an example may indeed be complete and include explanations and a question on its inner workings. In the latter part of a course, the example may be largely incomplete and include a question on its workings and an instructional task. Between these two extremes, examples will have varying degree of completeness and in all cases, the incomplete examples are acting as scaffolds for the students.

3 The Cloze Procedure

A scaffolding tool called CORT (Code Restructuring Tool) has been produced that allows students to fill in lines of missing code from programs and this method is based upon the cloze procedure. The term is derived from "closure", a Gestalt psychology term referring to the human tendency to complete a familiar but not quite

finished pattern [2]. The use of cloze was first used to measure comprehension in English readability [9] however it has also been used in the teaching and learning of programming as a way of measuring student understanding of programs [7, 20]. Such program comprehension tests are constructed by replacing some of the "words" or tokens by blanks and requiring students to fill in the blanks during a test. The use of the cloze procedure in testing was found to correlate well with conventional comprehension, question – answer, type quizzes and is also much easier to create and administer, see for example the work of Cook, Bregar et al [2].

Other researchers have experimented with the testing of program comprehension by omitting complete lines of code from programs and requiring students to fill in those lines [5, 13, 14, 15, 16]. Norcio found that students were more likely to supply correct statements if they had been omitted within a logic segment rather than from the beginning of a segment. This is consistent with the chunking hypothesis [12] that specifies that the first element of a chunk provides the key to the contents of the entire unit. Ehrlich looked at the differences between experts and novices in filling in missing lines within various programming plans and, as expected, found that the experts filled in the lines correctly taking into account the surrounding plan whereas novices had more difficulty.

In the various experiments in program comprehension using the cloze procedure, the students had to fill in the lines of code without being given a selection of lines to choose from. In some work done in an area unrelated to programming, students were expected to create an essay using a file of statements, only some of which were relevant to the topic [4]. The students were expected to copy and paste only the statements which they believed to be relevant and then to link them with their own text and it was suggested that learners would consolidate their understanding of the topics by having to actively evaluate all possible statements. The file of statements was acting as a scaffold to student learning.

Although the literature suggests that the cloze procedure has only been used in measuring program comprehension, it appears that it could prove useful as a way of scaffolding student learning of programming. An incomplete solution to a programming problem could be given to a student together with a choice of statements that might be used in the solution. The student would then have to study the incomplete solution and the choice of statements and decide which statements to use and where to put them. CORT uses this idea making the mechanics of placing the statements into the incomplete solution very straightforward for the student and eliminating typing errors and therefore also syntax errors.

4 The Code Restructuring Tool (CORT)

CORT has been designed to support the "completion" method of learning to program and it was decided that the following features would be required in the first prototype:

- Support for part-complete solutions to programming problems. Such solutions help in schemata creation and also reduce cognitive load.
- A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution. This provides scaffolding for students.
- A facility so that students can add and amend lines of code. This would allow scaffolding to be reduced and for students to add more of their own code.
- For visual programming, a facility for students to easily view the target interface. The interface should be annotated with the various object names thereby reducing any split-attention effect and helping reduce cognitive load [1].
- A facility to access tutor created questions concerning the programming problems being attempted and for students to enter answers to those questions. This will promote reflection and higher order thinking.
- A facility to easily transfer a completed solution from CORT to the target programming environment.
- A facility to easily transfer programming code from the target programming environment back into CORT for further amendment.

4.1 The CORT Design

The user interface of CORT has been designed taking into consideration the three issues that have been suggested by Marcus [11] as being fundamental to interface design, namely development, usability, and acceptance. The interface for CORT is shown in figure 2.

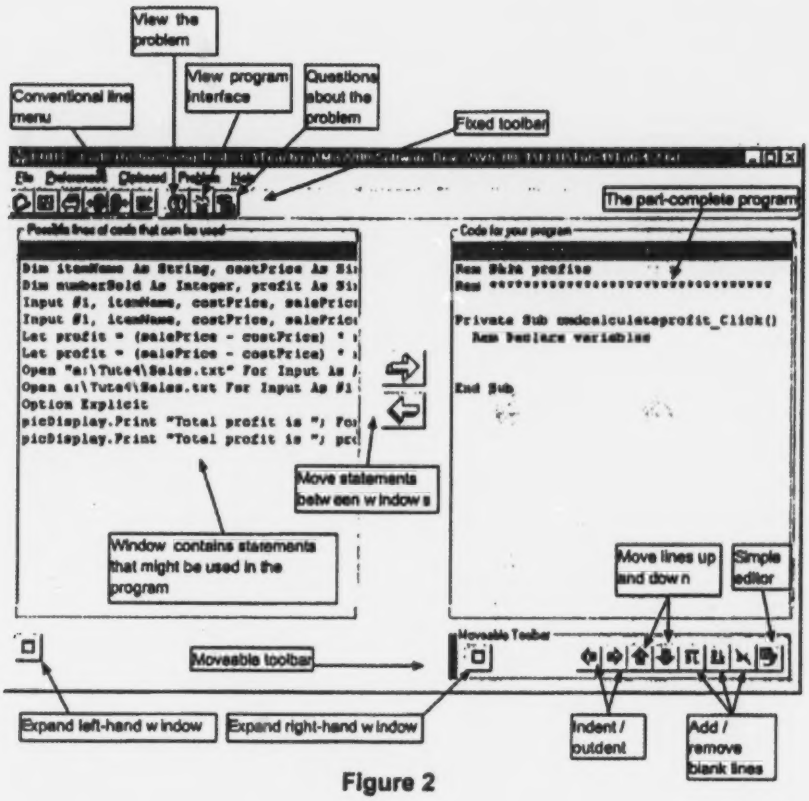


Figure 2

The ways in which the CORT design supports the list of required features are described in the following table.

Feature	Support in CORT Design
Support for part-complete solutions to programming problems	The part-complete solutions are automatically loaded into the right hand window and possible statements into the left hand window. Students load these from a file.
A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution	Two buttons in the middle of the screen will move lines between the windows. One line, or several lines can be selected and moved across.
A facility so that students can add and amend lines of code	A simple editor is provided so that students can add their own lines or amend existing lines.
For visual programming, a facility for students to easily view the target interface	Access to this feature is via a button on the fixed toolbar.
A facility to access tutor created questions on the workings of the programming examples and to enter student answers	Access to this feature is via a button on the fixed toolbar. Student answers are automatically saved.
A facility to easily transfer a completed solution from CORT to the target programming environment	This is provided by a button on the main toolbar. A single click will copy the contents of the right hand window to the Windows clipboard ready for pasting into the Visual BASIC programming environment.

BEST COPY AVAILABLE

A facility to easily transfer programming code from the target programming environment back into CORT for further amendment	This is provided by a button on the main toolbar. A single click will paste the contents of the Windows clipboard into the right hand window, overwriting what is there.

4.2 Use of CORT by Students

A student would typically use CORT as follows:

1. A student loads in a CORT file and the two windows display a part-complete solution to a problem together with possible lines to be used. There is a facility available for the contents of the two windows to be printed out.
2. The student can view the problem statement and the Visual BASIC solution interface by clicking on the appropriate buttons on the fixed toolbar. The problem statement may have already been provided to the student in the form of a handout, however there is also a facility to print it from within CORT.
3. The student moves certain lines from the left hand window to the right hand window in an attempt to complete the solution. Lines can be moved up or down, and indented or outdented in the right hand window. Some problems have too many lines in the left hand window, some of those lines being incorrect.
4. If necessary, the student can invoke a simple editor to amend, add or delete lines of code.
5. The student clicks on the appropriate button to copy the contents of the right hand window to the Windows clipboard.
6. The student invokes Visual BASIC and loads the file that contains the interface for the solution. This is in effect the Visual BASIC solution to the problem without the lines of code and was created by the tutor.
7. The student pastes the contents of the Windows Clipboard into the Visual BASIC editor and tests the program to determine if it works correctly. Use is made of the trace and debugging facilities of Visual BASIC. These facilities provide an insight to the workings of the notional machine.
8. If the student finds a problem with the working of the program, they can return to CORT and make the changes to the code there.
9. The student repeats steps 3 to 8 until they have a working program.
10. The student answers the tutor's questions concerning the programming problem that they have just attempted.

4.3 Initial Student Feedback

CORT has been used for one semester with both undergraduate and postgraduate students in the Faculty of Business and Public Management. The particular units are in the area of software development and the language that the students learn is Visual BASIC.

Each week the students have to undertake completion programming exercises using CORT and after each problem they were asked to comment on the use of CORT for the particular problem that they had just finished. The data was collected on-line through the Web and below are some of the comments that were received:

1. It's very helpful. I can see the interface of the program before actually running it.
2. I think CORT is a very useful tool to play around the codes. It saves me time copying and pasting.
3. Considering the increased workload as the semester progresses it is a bit of a relief that the exercises are much easier with the "fill in the gap" type format in CORT.
4. Without CORT, it's sure that I'll have a lot trouble with this particular problem, which focuses on arrays (a difficult topic). Thanks CORT...
5. CORT was useful in that the part solution helped to understand the logic of VB code
6. CORT is useful . However, I have used the unit text to try to understand the indentation format when writing the code. The directional keys are great for editing the code to meet the required format.

7. This was a challenge! I think that CORT is useful so long as I am not tempted to simply manipulate code until the program runs. If I were having to write programs from scratch I would use CORT so as to format and manipulate code and modules or sub procedures etc.

5 Conclusions

As can be seen from the above, the initial feedback on the use of CORT has been favourable. We have found that students can undertake two or three small programming problems within a one hour tutorial whereas without CORT they could only undertake one such problem. Also, without using CORT students often never manage to successfully complete their assigned problems and this certainly affected their motivation.

By using CORT, students do not have to be concerned with the design of programming interfaces which considerably reduces the cognitive load in the initial stages of learning programming. Also, the reduction of "split attention affect" by labelling all the objects with their names has been very popular with the students.

The above has described a preliminary study of the use of CORT and it has been undertaken to determine its suitability and to fine tune some of its features. CORT can be used in several ways and four distinct methods have now been identified. These will be the subject of further research. The four methods are as follows:

1. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are no extra lines displayed in the left hand window.
2. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are also additional lines displayed in the left hand window that are not required within the program. The extra lines are similar to the required lines, however they are incorrect and act as "red herrings".
3. **Some** of the lines that are required to complete a program are made available in the left hand window of CORT. Other lines that are required for the program completion need to be keyed in by the student.
4. **None** of the lines that are required to complete a program are made available in the left hand window of CORT. All of the lines that are required for the program completion need to be keyed in by the student.

References

[1] Chandler, P. and Sweller, J. (1991). Cognitive load theory and the format of instruction. Cognition and Instruction 8: 293-332.

[2] Cook, C., Bregar, W., et al. (1984). A Preliminary Investigation of the use of the Cloze Procedure as a Measure of program Understanding. Information Processing & Management **20**(1-2): 199-208.

[3] du Boulay, B. (1986). Some Difficulties in Learning to Program. Journal of Educational Computing Research **2**(1): 57-73.

[4] Edward, N. (1997). Development of a cost effective computer assisted learning (CAL) package to facilitate conceptual understanding. CAL97, University of Exeter, UK.

[5] Ehrlich, K. and Soloway, E. (1984). An Empirical Investigation of the Tacit Plan Knowledge in Programming. Human Factors in Compter Systems. J. Thomas and M. L. Schneider. Norwood, New Jersey, Ablex: 113-133.

[6] Fowler, W. A. L. and Fowler, R. H. (1993). A Hypertext Approach to Computer Science Education Unifying programming Principles. Journal of Multimedia and Hypermedia **2**(4): 433-441.

[7] Hall, W. E., III and Zweben, S. H. (1986). The Cloze Procedure and Software Comprehensibility Measurement. IEEE Transactions on Software Engineering **May 1986**: 608-623.

[8] King, J., Feltham, J., et al. (1994). Novice Programming in High Schools: Teacher Perceptions and New Directions. Australian Educational Computing(Sep 1994,): 17-23.

[9] Klare, G. R. (1974-75). Assessing Readability. Reading research quarterly(10): 63-102.

[10] Lieberman, H. (1986). An Example Based Environment for beginning Programmers. Instructional Science **14**(3): 277-292.

[11] Marcus, A. (1992). Graphic Design for Electronic Documents and User Interfaces. New York, ACM Press.

[12] Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity to Process Information. Psychological Review(63): 81-97.

[13] Norcio, A. F. (1980a). Comprehension Aids for Computer Programs. American Psychological Association Annual Meeting, Montreal.

[14] Norcio, A. F. (1980b). Human Memory Processes for Comprehending Computer Programs. Cybernetics and Society, Cambridge, Massachusetts.

[15] Norcio, A. F. (1981). Chunking and Understanding Computer Programs. Human-Machine Systems Symposium, Boston, USA.

[16] Norcio, A. F. (1982). Indentation, Documentation and Programmer Comprehension. Human Factors in Computer Systems, Gaithersburg, Maryland.

[17] Perkins, D. N., Schwartz, S., et al. (1988). Instructional Strategies for the Problems of Novice Programmers. Teaching and Learning Computer Programming: Multiple Research Perspective. R. E. Mayer, Hillsdale, NJ: Erlbaum: 153-178.

[18] Scholtz, J. and Wiedenbeck, S. (1992). The role of planning in learning a new programming language. International journal of man-machine studies **37**: 191-214.

[19] Sweller, J. and Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction **2**(1): 59-89.

[20] Thomas, M. and Zweben, S. (1986). The Effects of Program-Dependent and Program-Independent Deletions on Software Cloze Tests. Empirical Studies of Programmers: 138-152.

[21] van Merrienboer, J. J. G. (1990). Strategies for Programming Instruction in High School: Program Completion vs. Program Generation. Journal of educational computing research. **6**(3): 265-.

[22] van Merrienboer, J. J. G. and Krammer, H. (1987). Instructional Strategies and tactics for the design of Introductory Computer programming Courses in High School. Instructional Science **16**(3): 251-285.

[23] van Merrienboer, J. J. G., Krammer, H. P. M., et al. (1994). Automating the planning and construction of programming assignments for teaching introductory computer programming. Automating Instructional Design, Development, and Delivery (NATO ASI Series F, Vol. 119). R. D. Tennyson, Springer Verlag, Berlin.: 61-77.

[24] van Merrienboer, J. J. G. and Paas, F. (1990). Automation and Schema Acquisition in learning elementary computer programming. Computers in Human Behavior(6): 273-289.

A Framework for Internet-Based Distributed Learning

Andreas Braun* and Andreas G. Harrer**

**Andersen Consulting, Maximilianstr. 35, D-80539 München,* andreas.braun@ac.com

***Technische Universität München, Orleanstr. 34, D-81667 München,* harrer@in.tum.de

Communication technology as well as the communication infrastructure are both changing rapidly. As a consequence, systems that support web-based learning need to be adapted due to changes in technology. This paper describes a model for web-based learning with intelligent tutoring systems (ITS) that allows separation of the concrete communication from the ITSs' implementation. The resulting framework provides a technical solution to distribute any ITS over a network. The ITS SYPROS is used to illustrate how a classical ITS can be extended to a web-based tutoring system with a maximum of code-reuse. The framework may be used freely with any ITS. To accommodate the needs of various ITSs, our model supports several architectures for distributed adaptive tutoring, including the three different models described in [3]: Master-Slave, Communicating Peers and Centralized Architectures. Our main goals are: • •Make the ITS usable for a wide range of users by supporting any web browser on any operating system.• •Offer a simple, extendable and platform independent framework to ease web-based tutoring.• • Provide a solution without royalties.• •Separate the communication technology from the client and server implementation.• •Enable method invocation and parameter passing semantics over the HTTP protocol to virtually support any web browser and users behind firewalls.• •Offer an simple user accounting and user communication functionality.• •Provide a wrapper to connect to an existing ITS. The Java source code is freely available: http://www.in.tum.de/~herzog/sypros.

Keywords: **Web-Based Learning, System Design and Development, Intelligent Tutoring Systems**

1 Introduction

Classical intelligent tutoring systems (ITS) are often platform dependant and not distributed. Modern, distributed intelligent tutoring systems (DITS) provide a more attractive solution with respect to usability and platform independence. Therefore, a modern distributed infrastructure like the internet with communication techniques like CORBA or RMI is suitable. A stable, safe and extendable basis for communication and cooperative work is needed. However, technology in this area is rapidly changing on the one hand. On the other hand communication technologies like CORBA or RMI are (still) not usable with every client, browser or platform and still have several drawbacks which prevent their usability at least for some users: Macintosh users and users with old browsers or behind firewalls/proxies who also want to use secure socket factories, only to name some.

This paper discribes a model and the resulting framework to overcome such problems. We propose to address these problems by providing an API with the semantics of object oriented remote method calls over HTTP and Servlets. Further functionality that is most likely in common for any DITS (such as user accounting and identification, security and administrative functionality) is implemented and encapsulated for ease of use.

In the current version, SYPROS is an ITS in the domain of the synchronization of parallel processes with semaphores [4], a domain of programming problems.

All the typical modules of an ITS [15] like the expert module with different types of cooperating domain experts [13], the instructional module with different tutoring strategies, the student model with cognitive and motivational traits [12], and the interface module with several support facilities, are fully implemented in SYPROS.

The current version system is a classical ITS for single-user mode and is written in C for UNIX systems. The user interface is based on the X Windows system and therefore the ITS is platform dependent. There is no direct support for multiple clients and no accounting, access control or WWW support as it would be needed for a web-based group learning system, which is our ultimate goal [11]. In the current implementation the user interface is divided at function level from the 'intelligence' and database functionality, but is linked to one single executable. The proposed model will provide an application interface (API) for the client and server side. The API will encapsulate various ways of communication over a network using an abstract factory pattern [2,10]. Concrete implementations for Java RMI and servlets are provided. This model is designed to be easily extendable by other means of network transportation (e.g., CORBA or even Sockets). It will include conceptional security at an eligible level. Further, various ways of interfacing to an existing ITS on the server side are given (Java native calls to C/C++ and the connectivity to shell scripts). This factory can also be easily extended. Figure 1 shows the distribution of SYPROS. The servlet proxy Server enables connection for old webbrowsers, running not necessarily on the same machine as the `SyprosServer` implementation. Two clients are connected: "**Old Webbrowser**" connects using the servlet proxy, "**New Webbrowser**" can either use servlet communication or RMI[17]/ CORBA[22] (or anything else).

This work covers two more aspects: a security discussion for the provided model with a special focus on security issues for an ITS and a usability discussion for various platforms and webbrowsers.

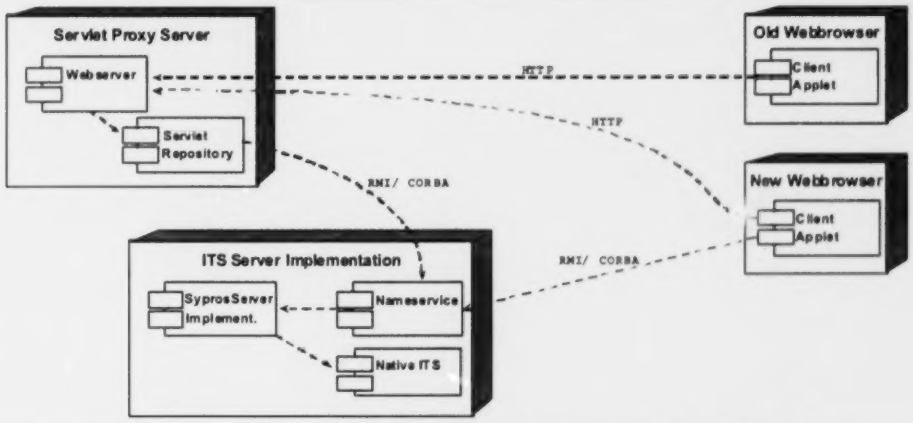


Figure 1. Distribution of client, server and servlet proxy in SYPROS (UML[19]).

Figure 2 shows the different layers for communication and levels of abstraction for a client initiated request. The dotted line between the implementation (application) level and the abstraction denotes that both the client and server implementation are separated from the underlying concrete communication. This model provides transparency in terms of process transparency. (That is, the machine on which the function or method is executed isn't known to the client's application level.) This can be compared to remote procedure calls (RPC) where the client stub and the server skeleton provide a similar transparency. In addition to that, our framework separates the concrete communication (the lowest layer in figure 2) from the application layer using the abstract communication layer. This provides transparency regarding the concrete communication technology used and therefore unburdens the application programmer from changing the application to support new technologies.

For some concrete communication implementations our framework supports language transparency as far as the client's implementation language may differ from the server's (e.g., for CORBA or Servlets).

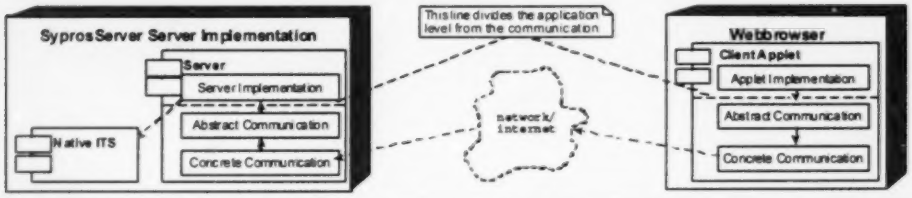


Figure 2. Levels of abstraction and layers for a request initiated by the client (UML deployment diagram).

2 Requirements

All base functionality for a distributed system is implemented. Remote method invocations are implemented independently from the Java RMI package over a `ComObject` which is JDK 1.1[9] compliant. User accounting, login procedures and access control as well as connection state information is supported directly in the framework.

A wrapper is provided to connect to an existing ITS over Java Native Interface (JNI[14]) or shell script invocation.

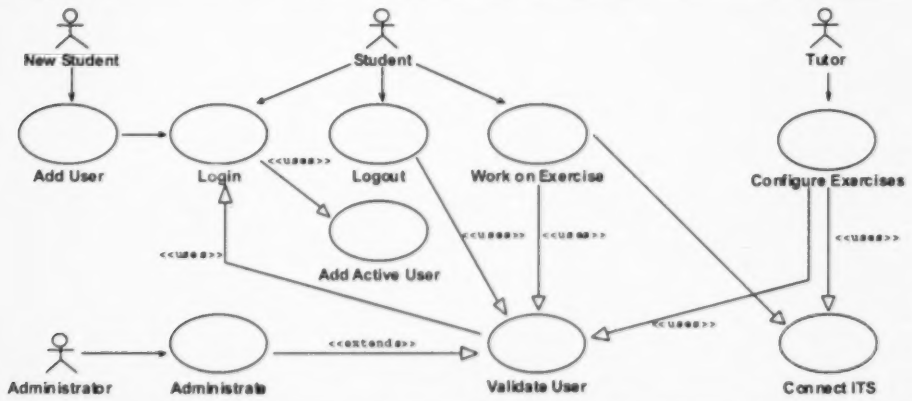


Figure 3. Some interactions among actors and use cases in SYPROS (UML use case diagram).

The use case diagram in figure 3 shows some of the use cases for SYPROS. Four types of human actors are shown in their interaction with the use cases. "**Student**" denotes an actor who is already known to the system. Therefore, "**Student**" logs into the server by passing the "**Login**" use case. "**Login**" performs authentification for which it `<<uses>>` the "**Validate User**" use case, which has knowledge of all valid user entries and so on. After accepting the user's login request some state information for that connection will be stored "**Add Active User**" and a `UserTicket` object is returned to allow stateful and secure client interaction. (`UserTicket` might be encrypted.)

"**New Student**" is an actor who is not known to the system. (Guests are handled identically.) Therefore, she can create a new user database entry herself ("**Add User**"). Later, the gathered information will be used to log into the system as described before.

An active user ("**Student**") might also use other services on the ITS server side. For example, the "**Work on Exercise**" use case first validates the call against the active users database and then uses "**Connect ITS**" (which interfaces the ITS using the wrapper) to work with the tutoring system.

"**Tutor**" is a human actor who might use the "**Configure Exercise**" use case to set up some exercises or check the student's results. The differing permissions (compared to a student) are handled by the "**Validate User**" use case.

An "**Administrator**" user will not use the client interface to connect to the server in this model. The administrator configures the databases and configuration files. Therefore, "**Administrate**" extends "**Validate User**".

Resulting from the requirements given before our model and the framework should further satisfy the following nonfunctional requirements, pseudo requirements and design goals: The server-side installation should be simple and conceptionally platform independent. It should not be addicted to any specific web server and should work with freely available products such as Apache.

The framework is designed to be fully platform independent using the Java programming language. However, some platform dependencies exist from possible webbrowser incompatibilities and the existing ITS. In order to support old webbrowsers or users behind a firewall or proxy, a servlet repository which acts as a proxy and a servlet based client communication is provided. The communication implementation may be switched online in the client implementation[1].

The SYPROS system can be used by four groups of people: students, guests (users who are not known to the system by now), tutors and administrators (tutors who fulfill administrative functions). Therefore, the framework supports users at different level of permissions (similar to e.g., UNIX or WindowsNT).

The client applet should be small so that it is suitable even for slow modem connections. The classes needed for communication on the client side are less than 20 KB in size (without JCE security). Once the Applet is loaded, the response time of the user interface is short, as it is running locally on the client side.

The response time resulting from the security key generation and secret key exchange (Diffie-Hellman for example) of the Java Cryptography Extension (JCE) is rather long especially for strong keys and due to JCE's implementation in Java (see discussion in section 4).

Performance of the network communication depends on the underlying infrastructure. With most browsers, servlets will have a more overhead than CORBA or RMI.

The communication framework aims to support three possible client-server bindings: Static (the server name is stored in the client application), semi-static (the client locates the server once, e.g., at login time) and dynamic (the client looks up the server each time it needs to connect). Client server binding uses name resolution to find a suitable ITS server in the network. The toolkit uses a server string such as "***//{hostname|ip-address}/{service-name}***", just like RMI for either underlying communication infrastructure. At client implementation level, the programmer may decide whether to use static, semi-static or dynamic binding.

Together with the way of client-server binding, stateless and stateful client server connections using tickets are possible. User tickets are invented as "high-level" stateful client-server connection for two reasons: first, the underlying ITS needs to know about the caller; tickets provide an easy way to identify the caller during a learning session. Second, encrypted ticket objects can be used to prevent attacks by intercept and replaying messages (see section 4).

Calling a remote function is somewhat dangerous if the programming language used supports *call-by-reference*[2]. For Java, *call-by-reference* is replaced by a *call-by-copy/restore* semantics. (See Java `RemoteObject` for RMI). A *call-by-copy/restore* semantics can be simulated for servlets using the `EventListener` model. In that case, the servlet proxy uses a `RemoteObject` for the server communication if the communication between the servlet proxy and the server is based on RMI and returns the object to the client using the event model. This may also be encapsulated in the framework.

In case of middleware communication such as CORBA/ RMI the *call-by-copy/restore* semantics can directly rely on the appropriate native semantics. The framework supports synchronous method invocations. Asynchronous calls can be realized using *call-by-copy/ restore*.

---

[1] This feature should be omitted for maximum compatibility with old browsers and Java engines (JDK level 1.1).

[2] Function calls that use *call-by-reference* parameter passing deliver a pointer to the value or data the parameter stores. In a distributed system with different address spaces this triggers side-effects[20].

Java's `try-catch`-statements are used for error handling. Therefore, the framework's error semantics is *at-most-once* by default. At application level, return values might be used to signal unexpected behavior. The SYPROS `login()`-Method for example returns `null` for the `UserTicket` if the server can't accept the login request. Although there are several possible reasons for that (e.g., unknown user, wrong password) their origin is not a communication error.

The resulting framework is described using UML notation for scenarios, use cases and object models[2,19]. The API description is given in standard Java notation[9]. The use of our framework is illustrated by the SYPROS sample.

3 A Model for the Communication Framework

Figure 4 shows the UML diagram for the SYPROS server implementation using the communication framework. The diagram shows two possible extensions for `SyprosServer`: `ComCORBA` and `ComRMI`. In the realworld implementation the programmer has to decide either to use CORBA *or* RMI, as Java does not allow multiple class inheritance.

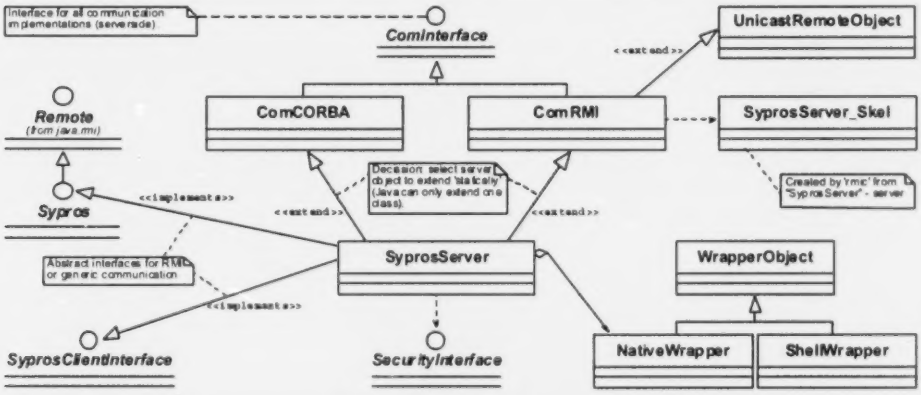


Figure 4. SYPROS server implementation. Class attributes and methods are omitted. (UML class diagram)

Therefore, there are some specialties in the server implementation: depending on the selected communication technology, the programmer has to change the head of the class definition to extend the right `ComInterface`. Further, the server has to implement the `Sypros` interface which defines the exported functions (for the RMI case). `SyprosClientInterface` contains the same definitions like `Sypros` but doesn't depend on the Java RMI classes. This ensures usability for old webbrowsers (with old Java virtual machines, VM) or clients that don't support RMI for other reasons (Macintosh).

```
import sypros.util.*;
import sypros.com.util.*;
import sypros.com.server.ComRMI;

public class SyprosServer extends} ComRMI implements Sypros {
  public  SyprosServer(String hostName, String servName) throws RemoteException
{
    super(serverHost, servName);   // create bindings
  }
  public static void main(String args[]) {
    setSecurity();                 // setup default security
  }
}
```

Figure 5. Client applet implementation for the SYPROS sample.

Figure 5 shows the class definition for the SYPROS server implementation using RMI. The underlined statements would have to be changed for a different type of communication technology.

The client implementation allows dynamic switching of the communication technology. Figure 6 shows the UML class diagram for the SYPROS client Applet. As the client communication model uses an abstract factory pattern [2,19] to create the appropriate concrete communication, the client might be a Java Applet or a Java standalone application. (The server could also be connected using the servlet URLs from HTML or other languages.)

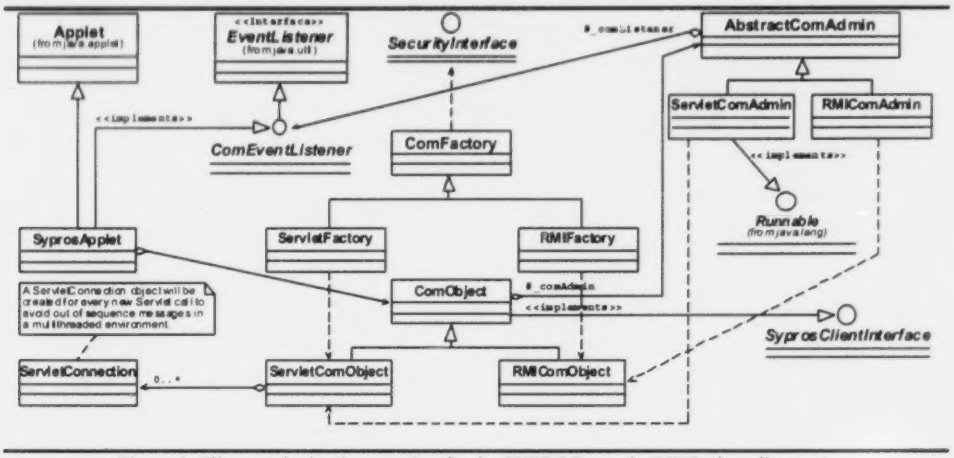


Figure 6. Client applet implementation for the SYPROS sample (UML class diagram).

The classes in the client model can be seen in three categories. First of all, SyprosApplet is the implementation for the SYPROS client interface. (Plus `Applet`, the parent.) As described before, the implementation needs not to be changed for changing communication technologies.

Then the communication classes themselves: `ComFactory`, `ComObject` and their concrete implementations provide the application interface for the implementation. `ServletConnection` is a helper that provides a per-servlet connection for persistent calls in a multithreaded application.

The `AbstractComAdmin` and its concrete implementations for servlets and RMI currently realize notification for server to client messages using the `EventListener` model and can be used for *call-by-copy/restore* type parameter passing.

4 Conceptual Security

Any internet-based application requires a special focus on security issues. The history of designing secure systems, however, teaches the inadequacy of enhancing existing systems with additional security functionality [8]. To integrate the security functionality for secure web-based tutoring, we included security policies in the framework with a top-down approach. We start by specifying the security requirements as part of the security policy:

Authentification:	All subjects and objects of the system have to be authentificated.
Total access control:	Every access to protected units has to be supervised.
Non repudiation:	Every action performed by a subject can be assigned to it's originator.
Communication privacy:	Dataflow over unsafe networks has to be adequately encrypted.
Availability:	Denial-of-Service attacks should be identified.

To meet the authentification, total access control and no-denial requirements, the framework offers integrated functionality that can be adapted or extended to your application needs. Communication privacy

is provided using encrypted transmission (encrypted object serialization) based on the Java Cryptography Extension (JCE). JCE offers secret key agreement protocols (e.g., Diffie-Hellman) and encryption (e.g., Blowfish) with variable key lengths.

Ensuring the availability of a web-based service against denial-of-service attacks is maybe the hardest task. The Servlet-Proxy allows load-balancing, where the typical communication load of an ITS application (little amounts of data, long periods of thinking, infrequent transmissions) can be used to identify attacks.

5 Conclusions and Outlook

Our framework offers an easy and extendable basis for web-based distributed tutoring. The communication technology, security and ITS-integration can be easily adapted to the specific needs of an existing ITS as well as to changing communication or security technologies without rewriting the implementation for the ITS clients or server.

User accounting and access rights deliver the basis to support groups of students. However, support for cooperative work should be included in the ITS itself, like for example in SYPROS.

6 List of tested Browsers

✓: tested ok. no: tested, but failed. –: browser/ OS combination not available for testing.

Webbrowser	Version	Win98/NT		Linux		Solaris/x86		Solaris/Sparc		Macintosh	
		Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI
Netscape	4.04	✓	✓	–	–	✓	–	–	–	✓	no
Netscape	4.05	✓	✓	✓	✓	–	–	✓	✓	-	no
Netscape	4.7	✓	✓	✓	✓	✓	✓	–	–	-	no
Netscape	4.72	✓	✓	–	–	–	–	–	–	✓	no
I-Explorer	4.0	✓	no	–	–	–	–	–	–	–	–
I-Explorer	5.0[3]	✓	✓	–	–	–	–	–	–	–	–
Java Plugin	1.2	✓	✓	✓	✓	✓	✓	✓	✓	–	–

References

[1] Braun, A., "A Client-Server Model for an Intelligent Tutoring System" (transl.), Technische Universität München, Diploma Thesis, May 2000.

[2] Brügge, B., Dutoit, A.H., "Object-Oriented Software Engineering: Conquering Complex and Changing Systems", Prentice Hall, Upper Saddle River, NJ, Oct. 1999.

[3] Brusilovsky, P., Ritter, S., Schwarz, E., "Distributed intelligent tutoring on the Web", in: Proceedings of the 8th. World Conference of the AIED Society, Kobe, Japan, Aug. 1997.

[4] Dijkstra, E.-W., "Cooperating sequential processes", in: F. Genuys (editor), Programming Languages, Academic Press, New York, Oct. 1968.

[6] Duncan Davidson, J., "Java™Servlet Specification v.2.2", Sun Microsystems Inc., Oct. 1999.

[7] Eckert, C., "Matching Security Policies to Application Needs", Proceedings of the IFIP TC11 11th Internation Conference on Information Security, Cape-Town, South Africa, May 1995, p.237-254.

[8] Eckert, C., "On Security Models", Proceedings of the IFIP TC11 12th International Conference on Information Security, Samos, Greece, May 1996.

[9] Flanagan, D., "Java in a Nutshell", O'Reilly & Associates, third edition, 1999.

[3] RMI-Patch applied by Microsoft Service Pack.

[10] Gamma, E., Helm, R., Johnson, R., Vlissides, J., "Design Patterns -- Elements of Reusable Object Oriented Software", Addision Wesley Publishing Company, Reading Mass., tenth edition, 1997.

[11] Harrer, A., Herzog, Ch., "SYPROS Going IDLE -- from a Classical ITS to an Intelligent Distributed Learning Environment", in: Proceedings of ICCE '99, 7th International Conference on Computers in Education, p.836-839, Sep. 1999.

[12] Harrer, A., "Both sides of the coin -- blending cognitive and motivational aspects into a tutoring strategy", in: Proceedings of the International Conference on Computers in Education, ICCE97, p.188-195, 1997.

[13] Herzog, Ch., "Cooperation and competition of syntax-oriented and execution-oriented problem solvers in intelligent programming tutors", in: Artificial Intelligence in Education -- Knowledge and Media in Learning Systems, Proc. AI--ED 97, Kobe, Japan, p.309-316, 1997.

[14] —, "Java Native Interface", JDK Documentation, Sunsoft, 1996.

[15] Martha C. Polson, Richardson, J. J., "Foundations of Intelligent Tutoring Systems", Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1988.

[16] —, "Java Remote Method Invocation -- Distributed Computing for Java", Whitepaper, http://java.sun.com/marketing/collateral/javarmi.html, Sun Microsystems Inc., 1999.

[17] —, "Java Remote Method Invocation Specification", Revision 1.50, JDK 1.2, Sun Microsystems Inc., October 1998.

[18] —, "RMI-IIOP Programmer's Guide", http://java.sun.com/products/jdk/guide/rmi-iiop/rmi_iiop_pg.html, Sun Microsystems Inc. and IBM Corporation, 1999.

[19] Rumbaugh, J., Jacobson, I., Booch, G., "The Unified Modeling Language Reference Manual", Addision Wesley Longman, Inc., Reading Mass., Dec. 1998.

[20] Tanenbaum, A. S., "Modern Operating Systems", Prentice Hall Inc., 1992.

[21] McPherson, Scott, "Java Servlets and Serialization with RMI", in: Java Developer Connection, http://java.sun.com/developer/technical/Articles/RMI/rmi/index.html, Maczieg Software, 1999.

[22] —, "The Common Object Request Broker: Architecture and Specification", Object Management Group, Wiley, New York, 1995.

A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents

Chih-Kai Chang and Kuen-Shan Wang
Department of Information Management
Da-Yeh University
Da-Tsuen, Chang-Hwa 51505 Taiwan, R.O.C.
E-mail: chihkai@mail.dyu.edu.tw

As Web-based course become popular, the Web system accumulates a large amount of log data. Because the log data was generated by learners' behavior on the Web-based course, many researchers agree that analyzing the Web log will bring benefits for learners, instructors, and the Web site manager. In general, one record of Web log can indicate "which Web page was accessed", "who access that Web page", and "when the Web page was accessed". Although many interesting results can be derived merely depending on the general Web log, some important meanings of the Web log were not considered in previous researches. In other words, the content, represented by the Web page, is not included in the general Web log. For instance, a Web page may present homework, a discussion article, a section of curriculum, or a grade reports. However, previous research did not consider the represented content of a Web page in the Web log, in which only the file name of the accessed Web page is generally identified. This paper use data mining technology to analyze learners' online behaviors for mining learner's patterns by transforming general Web log to a content perspective. Hence, the methods of previous research still can be used to find the more meaningful results. Most important of all, our methodology finds patterns based on learning behaviors instead of browsing behaviors.

Keywords: **Web-based course, Web log, Data mining technology.**

1 Introduction

As Web-based course becomes popular, various learning activities can be running on the Web [1]. The asynchronous discussion activity, homework assignment and submission, announcement, and grade reports all can be executed on the Web. Because all the learning activities are represented as Web pages, the Web server will accumulate a large amount of log data for every Web page. Basically one record of the Web log can indicate which page was access by someone in sometime. Hence, many researches analyzed the Web server log to figure out users' motivation, users' response, browsing pattern, and the network traffic [2, 3, 4]. Furthermore, analyzing students' on-line learning behaviors and on-line problem solving activities can also discovery meaningful results [5].

There are at least 116 products of Web log analysis for commercial web sites [6]. The technologies used for analyzing Web server log evolve from traffic-based or time-based assessment to user access pattern analysis. For example, Perkowitz uses access patterns to construct an adaptive Web site [7]. Hence, the interested Web pages will be linked and organized as a proper view for every user according his/her access patterns. The *path* concept, users' sequential Web page access records, is important for constructing user access pattern for Web logs. For instance, Stuart Schechter [8] create users' path profile to predicate users' browsing behavior. Consequently, the field of Web log analysis is growing for the purpose of custom services.

Recently, applications of Web log analysis integrate data mining techniques to focus on the customer behavior patterns. It is because the predictive modeling and link analysis operations in data mining

techniques can be used to answer questions such as "Which of my customs will prove to be good, long-term valuable customers and which will not?", "How can I sell more to my existing customers?", "Is there a recognizable pattern in which my customers acquire products or use services so I can market to them just-in-time?", and so on [9]. Consequently, we intuitively apply data mining techniques to Web log analysis of an instructional Web site.

For Web-based instructors, their requirements for Web log analysis differ from managers of commercial sites. One of the reasons is as Raphen Becker said, "Because many existing systems are targeted toward commercial webs, the answer is yes, course webs require different systems. One reason is simple: most instructors (and even institutions) cannot afford the commercial products, which are priced toward industry and not towards academia."[10]. Although researchers realize the differences between course webs and commercial sites, the proposed methodology for Web log analysis still inheritance from the Web logs analysis products for commercial sites. For instance, Clio project pays efforts to answer the questions such as "What are the more popular parts of the course web?", "How do readers reach particular pages?", and "Can they quickly reach the pages they want?" so on. Unfortunately, most questions of that kind can be answered by existing Web logs analysis products.

When analyzing Web logs of a course Web, we concern that one encounters what specific problems, which can not be answered by existing Web logs analysis products. In other words, only the learning characteristic of the Web-based learning environment can originate the specific problems. Our previous research focus on providing various summary report for Web instructor to solve that problems, which can not be answered by Web log analysis, from any perspectives [11]. Hence, the questions, which a instructor may ask, should be "What are the meanings of the more popular parts of the course web in learning hierarchy?", "What is the concept that leads learners to reach particular pages?", and "Can learners quickly reach the learning goals by reorganizing Web pages?" so on. In other words, the reports of existing Web logs analysis products should be interpreted to mining the pedagogical meanings by instructors, instructional designers, Web designers, and course web architects. Consequently, it is necessary to propose methodology for discovering learner (not user) access pattern in the Web-based course.

To mining the pedagogical meanings from Web logs, the first requirement is to understand the content of every Web page. In other words, the instructor of the Web course not only need to know 'who accessed the Web page', 'when the Web page is accessed', and 'from where the learner come', but also should know 'what the Web page contains'. However, it is difficult to represent the content of a Web page with symbols. The reason is that the content of a Web page may contain many concepts. Consequently, the first step for understanding the pedagogical meaning is reconstructing the Web pages in the site of a Web-based course by endowing only one topic or concept for each Web page. While breaking a Web page into single concept Web pages, one would find that some concepts are not atomic concepts. That is because a major concept will contain many sub concepts. Hence, the second step for understanding the pedagogical meaning of a Web page is to identify its location within a concept hierarchy instead of its location within the hypertext hierarchy.

The second requirement for discovering learners' learning pattern is to mining sequential access paths on previous aforementioned concept hierarchy. Although there are methodologies to reconstruct navigating paths of users' behaviors on a Web site, that information is not enough for a Web instructor to make some pedagogical decisions. The users' access (behavior) pattern can only help Web site manager improving Web site schema because a Web instructor still can not figure out learners' intention merely by analyzing Web logs without supports of the Web page content. The proposed concept hierarchy presents a feasible style for supports of interpreting the Web page content. After learners' navigating paths on a Web site are transforming to navigating paths on the concept hierarchy, a Web instructor can comprehensive how learners learn from the information of what learners read.

This paper proposes a methodology to mining learners' learning pattern by transforming learners' Web page access sequences to sequences of learning a concept in Web logs. The methodology is supported by traditional web logs mining algorithms, which is designed for discovering users' access pattern on a Web site. This methodology is not used to replace traditional web logs mining algorithms nor is arguing that concept hierarchy is a suitable web site schema. Rather, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor get more feedback from learners' navigation on the Web course site. Broadly speaking, this methodology contribute to apply traditional web logs mining algorithms to a specific domain in the technical aspect and progress assessment skills in the Web-based distance learning aspect.

2 Illustrative Example

In overview, there are two steps in this illustrative example of detecting learning status. The first step is data preparation. We design a sophisticate structure of a Web site so that we can recognize the content of the accessed Web page. The second steps will find pedagogical meanings from the contents of the preferred Web pages. In this illustrative example, the result of step two will show that learner is not familiar with the learning topic.

2.1 Data Preparation

The required data was collected from the students in an undergraduate course of Perl programming. Perl is a high-level programming language written by Larry Wall. Perl is a very popular programming language for system administrators and CGI script authors. After a brief introduction of Perl, students were asked to study the Web pages extracted from Perl manual. There are three topics in the prepared Web pages. First topic of Web pages demonstrates how to execute the Perl interpreter, called *Perlrun* in Perl manual. Second topic of Web pages explains the Perl model for declaring importing, and calling a subroutine, called *Perlsub* in Perl manual. Third topic of Web pages describes associativity and precedence of Perl operators, called *Perlop* in Perl manual. Consequently, learners' behaviors recorded by Web logs can be recognized by the topic of accessing Web page.

Synopsis and description compose each topic of Web pages. Synopsis is a summary of a topic and generally contains no more than one page. Figure 1 illustrates the synopsis of the Perlsub topic. Description explains the details of a topic in original Perl manual. For illustration, description for each topic was reorganized into two Web pages. In general, synopsis of a topic is prepared for learners who are familiar with that topic. Learners who are learning a topic will prefer the description of that topic. Hence, we can help a learner just in time if he/she is always looking around the description of a topic.

Aforementioned structure is content structure of learning materials. To present learning materials in a hypertext style, a hyperlink structure is required. We use the full connection style to link all Web pages so that learners can navigate to any destination in any Web page.

Figure 1. Synopsis of Perlsub.

Figure 2 shows the concept structure of the learning materials on the Web site. The notation P_i indicates the Web pages. Although the overview structure is composed of concept hierarchy and contents of learning materials without hyperlink information, the tree structure above the P_i can be used to interpret the content in the page. For instance, the P_j belongs to concept synopsis, which is the partial content of the Perlrun topic.

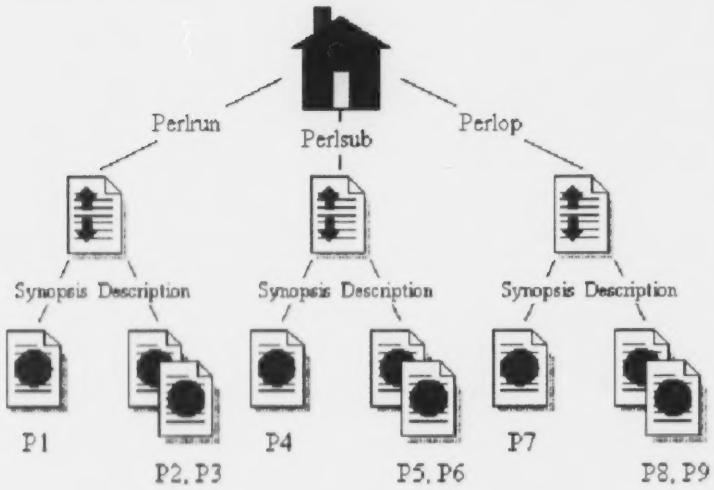


Figure 2. The concept hierarchy of a Web site.

2.2 Mining Processes

There are three learning topics in the Web site, denoted as Perlrun, Perlsub, and Perlop. Each learning topic has two sub concepts, denoted as synopsis and description. The word "synopsis" is used to indicate the Web page for summarizing a topic and the word "description" represents the Web pages that explain a topic in detail. There is an index Web page linking every Web pages to serve as communicating interface with learners. Hence, learners can study any topic in any order through the index Web page. Assume that there is a learner who prefers the "description" Web pages of any topic. In other word, that learner is not familiar with all topics. Hence, the logs of that learner' s browsing behavior on the Web site may be like the sequence:

p2, p3. p2, p8, p9. p5, p8. p5, p1. p2, p5, p6

Because learning can happen in any time, only time nearly browsing behaviors will be related in a learning pattern. Hence, the transaction idea, used in database theory, is involved to cluster learners' browsing behavior. The T*i* means a transaction of the learner' s browsing behavior.

T1: p2, p3
T2: p2, p8, p9
T3: p5, p8
T4: p5, p1
T5: p2, p5, p6

The content of every Web page can be interpreted as a pair of topic and representation style. For instance, p2 belongs to topic Perlrun and is a description of the topic. Hence, p2 is interpreted as (Perlrun, description). After interpreting the transaction data of learner' s behavior, the results are follows.

T1: (Perlrun, description), (Perlrun, description)
T2: (Perlrun, description), (Perlop, description), (Perlop, description)
T3: (Perlsub, description), (Perlop, description)
T4: (Perlsub, synopsis), (Perlrun, synopsis)
T5: (Perlrun, description), (Perlsub, description), (Perlsub, description)

Most of algorithms for mining pattern are derived from aprior [12]. We divide the problem of discovering multi-dimension learner access pattern into four sub procedures, that is litemset phase, transformation phase, sequence phase, maximal phase. Hence, we can use the aprior algorithm for mining pattern. We use the illustrative example to depict the four sub procedures. The litemset phase will generate the large-1 itemset as Table 1.

ID	Large-1 itemset	Support
1	(Perlrun, '*')	3
2	(Perlsub, '*')	3
3	(Perlop, '*')	3
4	('*', description)	4
5	(Perlrun, description)	3
6	(Perlsub, description)	3
7	(Perlop, description)	2

Table 1. Large-1 itemset.

The transformation phase use the feasible IDs of items in the large-1 itemset to substitute items in the transaction of learners' behavior. For instance, the (Perlrun, description) in T1 can be substituted by (Perlrun, '*'), ('*', description), or (Perlrun, description). Hence, the set of feasible IDs is {1, 4, 5}. The result after the transformation phase is following.

T1: {1, 4, 5}, {1, 4, 5}
T2: {1, 4, 5}, {3, 4, 7}, {3, 4, 7}
T3: {2, 4, 6}, {3, 4, 7}
T4: {2, 4, 6}, {1}
T5: {1, 4, 5}, {2, 4, 6}, {2, 4, 6}

The problem is simplified to mining sequential patterns after the transformation phase [13]. Consequently, the sequence phase can generate the large-2 itemset and larget-3 itemset as Table 2 and Table 3.

Large-2 itemset	Support
{1, 4}	3
{2, 4}	2
{4, 3}	2
{4, 4}	3
{4, 7}	2
{5, 4}	3
{6, 4}	2

Table 2. Large-2 itemset.

Large-3 itemset	Support
{1, 4, 4}	2
{4, 4, 4}	2
{5, 4, 4}	2

Table 3. Large-3 itemset.

Finally, the maximal phase will find the most meaningful pattern from large-2 itemsset and large-3 itemset. Initially, the union of large-2 itemset and large-3 itemset is used as the result. Then, some items will be eliminated because they are the subsets of some larger items. For instance, the meaning of {5, 4, 4} is more than its subset {5, 4} and {4, 4}. Hence, the large-2 items, {5, 4} and {4, 4}, will not be deleted from the initial result. Finally, some items will be eliminated because they are less meaningful then items in the result. For instance, the {4, 3} will be deleted because {4, 7} implies {4, 3}. Similarly, the {2, 4} will be deleted because {6, 4} implies {2, 4}. The following table illustrates the result.

Maximal itemset	Real patterns	Support
{6, 4}	{(Perlsub, description), ('*',description)}	2
{4, 7}	{('*', description), (Perlop, description)}	2
{5, 4, 4}	{(Perlrun, description), ('*',description), ('*', description)}	2

Table 4. Maximal itemset.

3 Conclusion

The Web-based learning environment offers opportunities to precisely observe learning processes. However, it is tedious for a Web instructor to discovery useful information from the huge amount of Web logs. Traditionally, a Web instructor uses the Web logs analysis products to realize the unusual parts of a Web site. From the pedagogical standpoint, the results of the Web logs mining algorithms are not very useful for figure out learners' learning process because the contents of Web pages are not considered. This paper proposes a methodology to mining learners' learning pattern, which is related with the Web page contents, from Web logs. The methodology uses Web logs mining algorithms, which is used in Web logs analysis products, and the concept structure embedded in Web pages to mining patterns with pedagogical meanings, so called learning patterns. In our opinions, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor figure out learners' navigation on the Web course site from the concept hierarchy perspective. Consequently, the approach presented here may be not only a feasible application of traditional web logs mining algorithms, but also a possible direction of Web-based learning assessment research.

Acknowledgements

This project is supported by the National Science Council in Taiwan under contract number NSC 89-2511-S-262 -001.

References

[1] C.K. Chang and G.D. Chen. Constructing Collaborative Learning Activities for Distance CAL Systems. Journal of Computer Assisted Learning, Vol. 13, No. 1, pp. 2-15, March 1997.

[2] R. Fuller and J. de Craaff. Measuring user motivation from server log files. In http://www.microsoft.com/usability/webconf/fuller/fuller.htm

[3] T. Sullivan. Reading reader reaction: A proposal for inferential analysis of web server log files. In Proc. Third Conf. Human Factors on the Web, Denver, Colorado, June 1997.

[4] Sun, C. T. & Ching, Y. T. (1995). Hypermedia Browsing Pattern Analysis. International Journal of Education Telecommunications, 1(2-3), 293-308.

[5] Jihn-Chang J. Jehng. Exploring Learning Potentials in Network-enhanced Learning Environment. In Proc. of ED-MEDIA 99, Seattle, Washington, USA, 1999.

[6] Internet Product Watch (1999). Internet Product Watch: Analysis Products. Online document at http://ipw.internet.com/analysis/index.html (accessed March 25, 1999; no creation or modification date available).

[7] M. Perkowitz and O. Etzioni. Adaptive sites: Automatically learning from user access patterns. In Proc. 6th Int. World Wide Web Conf., Santa Clara, California, April 1997.

[8] Stuart Schechter, Murali Krishnan, Michael D. Smith, Using path profiles to predict HTTP requests. Computer Networks, (30)1-7, pp. 457-467, 1998.

[9] Peter Cabena, et al. Discovering data mining: from concept to implementation. Prentice-Hall, Inc.

[10] Raphen Becker, Kevin McLaughlin, and Samuel A. Rebelsky. Project Clio: Tools for tracking student use of course webs. In Proc. of ED-MEDIA 99, pp. 981-986.

[11] C.K. Chang, G.D. Chen, and Kou-Liang Ou. Student Portfolio Analysis by Data Cube Technology for Decision Support of Web-Based Classroom Teacher. Journal of Educational Computing Research, Vol 19(3), 307-328, 1998.

[12] Rakesh Agrawal, Heikki Mannila, Ramakrishnan Srikant, Hannu Toivonen, A. Inkeri Verkamo: Fast Discovery of Association Rules. Advances in Knowledge Discovery and Data Mining, pp. 307-328, 1996.

[13] Rakesh Agrawal and Ramakrishnan Strkant, Mining Sequential Patterns. ICDE, pp. 3-14, 1995.

A Novel Distance Learning System for the TIDE Project.

YAGI Keisuke* KAMEDA Yoshinari* NAKAMURA Motonori* MINOH Michihiko* and Maha Ashour-Abdalla**

**Center for Information and Multimedia Studies, Kyoto University.*
Yoshida Nihonmatu-cho, Sakyo, Kyoto 606-8501, Japan.
Phone:+81-75-753-9048
Fax:+81-75-753-9001
E-mail:yagi@media.kyoto-u.ac.jp

***Center for Digital Innovation, University of California, Los Angeles.*
Box 951567, 3863 Slichter Hall, Los Angeles, CA 90095-1567, USA.
Phone:+1-310-825-8881
E-mail:maha@cdi.ucla.edu

A distance learning system architecture that exchanges information in real time among lecture rooms is discussed. Forty-eight functions are implemented into subsystems and used for the information exchange. Which and how many functions are implemented into each subsystem depends on system design. The distance learning system and a case study of the system design is presented. The system was implemented for the support of two undergraduate courses and was evaluated by a student survey questionnaire. Data from the questionnaire showed that the distance learning system was successfully implemented and transparent for the undergraduate users.

Keywords: **Real-time System, International Project.**

1 Introduction

Research in distance learning has primarily focused on two types of systems: storage based and real time. Real time systems have been seen to be advantageous for interactive discussions between a lecturers and students. For the purposes of this paper, the phrase "distance learning system" refers to a real time type of system. The present paper, addresses the implementation of a real time system to support the TIDE (Trans-Pacific Interactive Distance Education) project. TIDE is a collaborative project among Kyoto University, University of California Los Angeles (UCLA), and Nippon Telephone and Telegraph Corporation (NTT). System architecture, the integration of 48 functions to support the distance learning goals, and other technical issues are discussed. The implementation of the real time system in two undergraduate courses was assessed using questionnaire and survey data.

2 Distance Learning System Architecture

2.1 Information about the lecture

The term lecture is commonly defined as communication between a lecturer and students in a typical lecture hall. However, communication is not limited to that which occurs between the lecturer and the students. Thus, for the purposes of this paper, we use the term "participants" to refer to both lecturers and students. In a typical lecture hall, participants can communicate using all five senses. While audio and visual exchange is easy during a typical lecture, information exchange through smell, taste and touch are more difficult. Thus, in discussing information exchange over a distance, we focused on communication by visual and audio information exchange. Handouts, electronic documents, writing on blackboards, and other nonverbal materials are essential tools for participants involved in a lecture. Additionally, there needs to be a method where participants can point out the visual information of interest to share with other participants. In distance learning situations, pointing needs to be shared among the lecture rooms involved. Thus, in a distance learning environment, the following seven kinds of information need to be exchanged. 1) non-verbal information, 2) content of physical material, 3) content of the electronic material, 4) content of written material, 5) pointing information about the

physical material, 6) pointing information about the electronic material, 7) pointing information about the writings. Verbal communication among participants is one of the most important communication exchanges. Teaching materials like videotapes make sounds. These sounds can be mixed with verbal information easily without degradation. Thus, exchanging verbal information is discussed within the framework of exchanging audio information.

2.2 Function classes for the information exchange

In order to exchange information among lecture rooms, the distance learning system needs to 1) capture, 2) encode and 3) transmit the information to the other lecture rooms. The transmitted information needs to be 4) received, 5) decoded and 6) presented in the other lecture rooms. Thus, six function classes are required for the system.

2.3 System Architecture

From the eight kinds of the information and the six function classes, forty-eight functions are required of the distance learning system. Which and how many functions are implemented into a subsystem depends on system design. The following describes the case study of the system design for the TIDE project. Fundamentally, the visual information can be captured as video streams using cameras. Thus, we initially designed a camera subsystem to implement the seven capturing functions to support visual communication. Because visual information can be presented with projectors, we designed a projection subsystem to implement the seven exposing functions of visual communication. Verbal information can be captured with microphones and exposed with speakers. The exposed sounds are captured with the microphones and causes acoustic echo. In order to cancel the echo, we have implemented the capturing and exposing functions into an audio subsystem. The visual and audio information need to be encoded at the same time for synchronization and the encoded information needs to be decoded at other lecture rooms. To address these issues, we designed a codec subsystem. For transmitting and receiving encoded information from the codec subsystem, we designed a quality of service guaranteed network subsystem. During a lecture, several video streams need to be exchanged because the talking participant and the teaching material are not always occurring in the same location. Unfortunately, our network subsystem has limited bandwidth and it allows the codec subsystem to exchange only one video stream at a time. Thus, we redesigned our system using PC based subsystems as follows: Using an electronic whiteboard, writing content can be captured as vector data. The data can be encoded and decoded on a PC. Thus, we designed an electronic whiteboard subsystem to implement capturing, encoding and decoding of the writing. Because vector data does not require the bandwidth required for audio/video streams, it is transmitted and received over the Internet. When the material on a PC is used, content and pointing information exists locally on the PC and needs to be transmitted and synced with the rest of the components. Thus, we designed a teaching material synchronizing subsystem to implement capturing, encoding and decoding whiteboard functions. The synchronizing subsystem also transmits and receives information over the Internet. Based on the discussion above, Figure 1 shows our distance learning system architecture. Each block in Figure 1 represents a subsystem.

3 Distance learning system for the TIDE project

3.1 Audio subsystem

The audio subsystem needs to address problems with acoustic echo and electronic echo. The electronic echo occurs when a received signal is mixed into the transmitting signal. In our audio subsystem, multiple audio mixers are used to separate the received signal and the transmitting signal.

3.2 Camera subsystem

The camera subsystem consists of four observation cameras and four shooting cameras. Checking the motion region in the successive two frames of video images from the observation camera detects the region of the participant on the image frame. The location of the participant is calculated by giving, in advance, the camera parameters of location, direction, focal length, image aspect, etc. After that, the appropriate camera, camera pan, tilt, and zoom, are chosen to shoot the moving object and/or speaking participant [4].

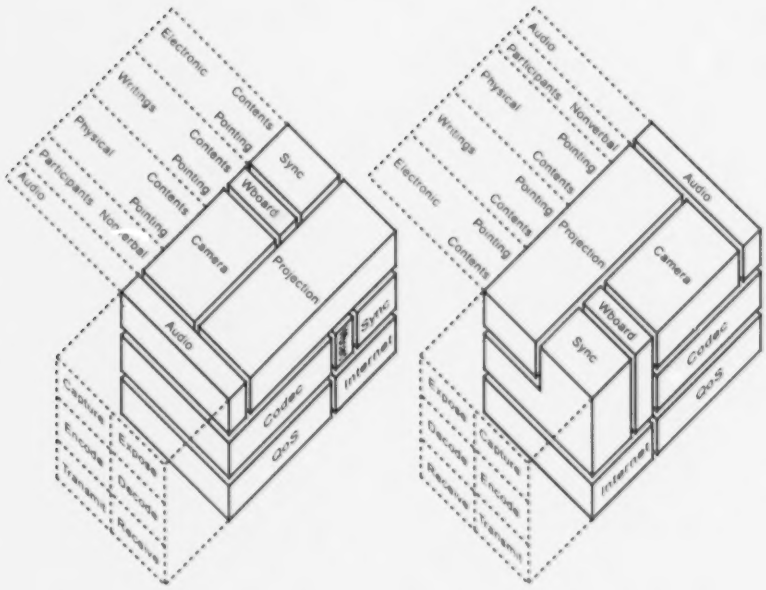


Figure 1: The system architecture of the distance learning system designed for the TIDE project.

3.3 Codec subsystem

For real time communication among participants, the delay caused by encoding and decoding needs to be minimized. It is very time consuming to make highly compressed data streams without degrading quality. For the purposes of this system, the MPEG2 standard was chosen for our codec subsystem. The codec encodes and decodes audio/video signal of 3Mbps in 300 msec.

3.4 Electronic whiteboard subsystem

The electronic whiteboard has two laser scanners on the top and observes position and color of writing marker. The observed position and color information is transferred from the whiteboard to the PC via serial connection. The transferred information can be easily browsed on a PC monitor. Additionally, the whiteboard information can be browsed simultaneously in multiple locations over the Internet.

3.5 Projection subsystem

The projection subsystem presents visual information on video screens. In a lecture hall, it is optimal if students are able to see the screen and the lecturer at the same time. Likewise, it is important that the lecturer also see the screen and students simultaneously. To address these issues, our projection subsystem has large screens behind the lecturer for student viewing, as well as small video monitors in front of the lectern for lecturer viewing.

3.6 Quality of service guaranteed network subsystem

For the stable transmission of the data stream, the system mainly uses ATM (Asynchronous Transfer Mode) network technology. The network subsystem is composed of three parts: GEMnet[1], CalREN2 [2] and Abilene[3]. GEMnet is an intra ATM network of NTT. CalREN2 and Abilene are parts of Internet2 in the United States. GEMnet interconnects Kyoto University and the NTT America Cupertino office over the Pacific Ocean. On the GEMnet, a PVC(Permanent Virtual Channel)connection is reserved with a guaranteed bandwidth of bi-directional CBR(Constant Bit Rate) 5Mbps.

Table 1: Regression coefficients of the principal component of the questionnaire survey.

Principal Coefficient	Middle	End
Interactivity	0.322	0.382
Quality of the teaching materials	(0.107)	0.414
Effectual manipulation of the system	0.304	(0.168)
Presence	0.561	0.637
Unstability of the system	-0.257	(-0.143)

3.7 Teaching material synchronizing subsystem

In order to present the electronic material to all lecture halls simultaneously, the synchronizing subsystem pre-loads the teaching material and transmits the mouse events. This software is appropriate for presenting dynamic teaching materials like movie files.

4 Evaluation

We have conducted two courses between Kyoto University and UCLA from October through December 1999 using our distance learning system. The distance learning system is evaluated by survey questionnaires given to the students at the middle and upon conclusion of each course[5]. The questionnaires asked students to rate various factors of the course on a scale of 1 to 5. We performed a principal component analysis of the survey and found following principal components: 1) interactivity, 2) quality of the teaching materials, 3) manipulation of the system, 4) presence and 5) instability of the system. We also performed a regression analysis to identify predictions of satisfactory grades in the courses. Table 1 shows the regression coefficients derived from the analysis. The coefficients in parentheses exceed the significance level of 5%. As the course proceeded, students' attention shifted from the novelty associated with the new technologies to the teaching materials and course content. This indicated that our system was of high enough quality to be a transparent medium for the students.

5 Conclusions

In this paper, we discussed a distance learning system architecture that exchanged information in real time among lecture halls. After identifying that there exist forty-eight functions required for information exchange, the distance learning system was introduced as a case study. We introduced the seven necessary subsystems and the technical issues surrounding the implementation of these subsystems. Our system was used for two undergraduate courses and evaluated by a survey questionnaire. The data from the questionnaire showed that our system, over time, became transparent for the students.

References

[1] http://www-grd.rdh.ecl.ntt.co.jp/GEMnet/

[2] http://www.cenic.org/salren2.html

[3] http://www.ucaid.edu/Abilene/

[4] KAMEDA Yoshinari *et. al*: "A Live Video Imaging for Multiple Users," Proc. of ICMCS'99, Vol. 2, pp.897 - 902, 1999.

[5] MURAKAMI Masayuki, YAGI Keisuke *et. al*: "Evaluation of distance learning system by the student in Japan and USA," Technical Report of IEICE, ET99-104, pp.67 - 74, Mar. 2000(Japanese).

Adaptive Learning Environment Framework

Christof Dallermassl, Heimo Haub, Harald Krottmaier, Klaus Schmaranz, Philipp Zambelli
{cdaller,hhaub,hkrott,kschmar,pzamb}@iicm.edu

Institute for Information Processing and Computer Supported new Media

In this paper the *Adaptive Learning Environment Framework* is presented. This Framework allows to re-use, combine, and improve existing learning systems or knowledge-databases and equip the resulting meta-learning environment with a new advanced user interface. Especially the last mentioned feature supports a completely new way to learn different materials from different sources without having to switch between systems. The introduction of an abstraction layer between different learning environments and the introduction of different views on the contained learning material allows to combine, extend, and improve available learning systems easily.

Keywords: **Personalized Learning Environment, Middleware, Application Framework, Distributed Object Systems**

1 Motivation

Different learning environments offer different ways to visualize the information and also different functionality (e.g. add annotations, communicate with other students, ...), but *views*, *functionality*, and *data* usually are tightly coupled. This implies that people using more than one learning system have to adopt to different user interfaces, a fact that does slow down learning speed a lot. As can also be seen in the classical learning environment (table, books, paper, pencil) any minor changes in the environment very often have a negative impact on the learning quality and so on the learning speed. Once the learning environment (the table) suits perfectly for a student, only the learning material (the books) and the used tools (preferred pencil, ruler, or calculator) are subject to change.

Neither of today's computer based learning environments is a perfect solution concerning transfer speed, actuality of the material or the way information is presented. Additionally, the majority of learning systems are incapable of using information prepared for other systems, because of incompatible data formats or communication protocols.

A system that allows to combine different electronic learning systems and that also allows to use the superset of their features, thus extending it with additional functionality (e.g. the ability to add annotations to the learning material), could increase the quality of the learning process enormously.

2 System Requirements

Usually learning systems are very hard to extend, as the learning material is tightly coupled to the view on the data. The classical method to overcome this problem is to split up data, view and functionality (Model-View-Controller design pattern [3]). This is also the first and most important requirement of the described framework: provide a *modular, component-based architecture* that makes it easy to create an adaptive learning environment that allows to *re-use data* from available learning systems (e.g. Gentle [4] or Dictionaries).

Separation of material, representation, and functionality offers great possibilities: It allows us to create a *superset of information*: Imagine having different learning systems available, each of them representing a specific subject. For example take a CD-ROM about World War Two, including historic images and reports and a geographical information system that publishes maps and information via Internet (Web-browser). But only a combination of these two information sources allows the users to get a deeper understanding of the facts and figures of each system.

The technique can also be used to improve existing systems and supply them with new functionality that wasn't previously foreseen. Once a module is created that is e.g. able to handle annotations or allow online discussion with other students, all participating learning systems benefit from this functionality.

Another important part is the interface the user is working with. It is at least as important as the contained material, as a good human computer interface optimizes the learning effort [7, 5]. We use the term *view* to describe the (mostly visual) appearance of the learning material. This appearance depends on various factors, e.g. the *output device* the user works with, the *environment* the user works in, the *role*, the user plays (student, administrator, instructor, ...).

According to the Model-View-Controller design, the view on the information must be decoupled from the data-model. This implies that there may exist *different views for the same content.*

As different users play different roles in connection with the learning material, different roles may have different *access rights* to the information. Even if the data source does not provide an access control system, it must be guaranteed that only users with sufficient rights may edit/change/delete the educational or administrative data.

3 Concept

The facts that the *Adaptive Learning Environment Framework* has to be modular, has to decouple data source(s) from view(s), and may add functionality to the underlying learning systems (see section 2) results in a middleware design approach: the framework is put in between the data source containing learning material and views that are used to work with the information.

The Dinopolis [2] framework, which is being developed on the IICM provides such a generic framework [1]. It allows the integration of various types of databases or applications and is able to provide the content in a highly dynamic

way to a broad range of clients/views. The integration of learning material is one special application of the general concept of Dinopolis.

4 Views

A *view* is responsible for giving a visual and logical representation of the learning material. It is completely decoupled from the actual information, so it may be (re)used independent from the information stored in the learning environments. A default view on the course material is usually created by the instructor or the administrator.

Due to the individual style of learning it is absolutely necessary that such a default view is completely personalizeable. Not just the colors [6] and the style of the displayed text should be modifiable, but also layout must be exchangeable. This "personal workspace" must also be applicable to other courses. The view might also depend on the role the user currently has in the system (administrator, student, the person that prepares the course, instructur, ...).

Let us now consider some circumstances where it is necessary to change the view on the learning material. Take a fully featured multi-media course using different sources of information (integrating online and offline systems), different levels of detail (overviews but also information for specialists), etc.

transfer speed: Since we are working in a network environment, transfer speed is a big issue. The higher the available bandwidth, the higher the quality of e.g. the displayed images might be.

output device: Several output devices may be used for consuming a prepared course: Workstations, laptops, terminals, PDAs etc. As a simple terminal is not able to display images, why should the client on a terminal request them? So also the type of the output device must be considered when delivering information.

available sources: We mentioned the online- and offline systems and a combination of those, the hybrid systems using both technologies. For example a student using the course CD-ROM might be able to see a movie, whereas the students participating online (on a network with low bandwith) might only be able to view images instead.

consuming environment: When learning in a public environment (bus, train, ...), the user might want to disable e.g. the sound output, so this data does not need to be sent across the network.

level of knowledge: Depending on their actual knowledge of the learning material the users might not need every basic explanation on the topic of the course.

role: There might not just be an instructor and some students but also separate administrators or other roles. An instructor creates course material, but surly is not involved in administrating user accounts. The student may also be in the role of a candidate for an exam and may fill out an examination in a limited amount of time.

desired level of detail: The system should also consider the level of the desired detail set by the user. It must be possible to switch between different levels in one learning session.

personal preferences: Some users prefer different fonts, colors, screen-layouts, etc.

5 Conclusion

The *Adaptive Learning Environment Framework* presented in this paper is a powerful tool to add a surplus value to existing learning systems and to reduce the burden on students to get used to new interfaces to the material with every virtual class they enroll. Additional features relieve all participating persons, including the tasks of administration and preparation of courses.

It is obvious that the integration of different learning systems may be a very complex task, but the modular structure of Dinopolis including the internal document model is a powerful tool the learning community will not want to miss in the near future.

References

[1] Dallermassl Ch.: "Aspects of Integration of Heterogenous Server Systems in Intranets - The Java Approach", IICM (Institute for Information Processing and Computer Supported new Media) 1999

[2] Dinoopolis: "Homepage of the Dinopolis Open Source Project", available online at `http://www.dinopolis.org`

[3] Gamma E., Helm R., Johnson R., Vlissides J.: "Design Patterns: Elements of Reusable Object Oriented Software", Addison Wesley, 1995.

[4] Gentle-WBT: "Homepage of Gentle-WBT: Web Based Training", available online at `http://wbt.iicm.edu`.

[5] Hedberg, John G., Harper, B., & Brown, C.: "Reducing Cognitive Load in Multimedia Navigation." Australian Journal of Educational Technology 9, no. 2 (1993): 157-81.

[6] Kienegger-Domik G.: "Intelligent Visualization Systems in Educational Environments", Proceedings of ED- MEDIA'95, Graz, Austria, pp.17-22, June 1995

[7] McFarland, Ronald D.: "Ten Design Points for the Human Interface to Instructional Multimedia.", T.H.E. Journal 22, no. 7 (February 1995): 67-69.

An Educational System that can Visualize Behavior of Programs on the Domain World

Taketoshi Ando*, Yoshinobu Kawada*(†), Ryoji Itoh*, Tatsuhiro Konishi*, Yukihiro Itoh*

* *Department of Computer Science, Shizuoka University.*
Johoku3-5-1, Hamamatsu, Shizuoka, 432-8011, Japan.
Tel: +81 - 53 - 478 – 1474•• Fax: +81 - 53 - 478 – 1499
E-mail: s5005@cs.inf.shizuoka.ac.jp

In this paper, we discuss extension of our educational system that gives domain-oriented-explanations of programs. A programmer solves problems on a world where elements necessary to describe the problems and the solving processes of them (objects in the problems, relation among the objects, and so on) are represented. We call such a world 'the domain world' of the problem. Our system has a domain world model and simulates a target program on the model, to understand behavior of the program. By analyzing the result of understanding, it generates an explanation. Outputs of our original system are only verbal explanations. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the program. Therefore, we are trying to add a facility of generating explanations by using animations (visual explanations) to the system. Our extended system can generate both visual and verbal explanations (bimodal-explanations) in various abstraction levels. We discuss the method of generating bimodal-explanations from the result of simulation.

Keywords: **Intelligent Tutoring System, Programming Education, Algorithm Animation System, Bimodal-explanation**

1 Introduction

The purpose of our research is to construct an educational system that helps novice programming learners by explaining domain-oriented-functions of programs. We take Pascal as our target programming language.

Programming is generally carried out in the following process.

Step1. A programmer understands a problem that must be solved.
Step2. He considers the solving process of the problem on a world where the problem is present. We call such a world 'the domain world' of the problem. For example, when he considers a solving process of sorting, he imagines a world in which he pays attention to numerical order such as greater and lesser (we call this world the world of greater and lesser).
Step3. He implements the algorithm: selects data structures suitable to represent the domain world and translates the algorithm into a programming language.

Usually, relatively simple problems are set in novice class of programming. So it is rare that learners fail in the step 1. But they tend to confuse because they cannot distinguish between step 2 and 3. So many novice programmers cannot find whether the causes of bugs are hidden in the algorithm or in their implementation. On the basis of this idea, we proposed an educational system explaining programs using vocabularies on a domain world[2][5][6][7]. Difference of our system from existing educational systems of programming [1][8] is that the purpose of our system isn't pointing out bugs in learner's programs, but rather helping learners find bugs by themselves. Our system helps learners in the following way:

- To help learners to understand sample programs given by a teacher by explaining them.
- To help learners to find and fix bugs in their own programs by explaining the faulty behavior of them.

Our previous system outputs sentences using vocabularies on a domain world as the explanation. However, when the system explains by using only sentences, some learners cannot get a concrete image of behavior of the

(†) *Presently with System Integration Group, VICTOKAI, LTD.*

program. If animations of the behavior of programs are shown with the sentences, learners can easily understand their algorithms. Therefore, we realize the ability to generate animations (visual explanations) that show behaviors of the target programs. In this paper, we discuss the way to generate visual explanations for programs in the domain world of greater and lesser.

Existing algorithm animation systems can be classified into two types: The first one is a system such as courseware editors embody particular commands to target programs in order to generate visual explanations, like Zeus[3] and TANGO[9] system. So, this type of systems can generate visual explanations of high quality by using concrete objects on the domain world. For example, a length of bar is used to concrete values of variables on the visual explanation of XTANGO system. The second type of system doesn't need embodying particular command to target programs, like UWPI[4] and tracers. However, this type of systems cannot generate any visual explanation using concrete objects on the domain world. They can only generate visual explanations showing structure of data and changes of contents of variables. Our system can generate a visual explanation using concrete objects on the domain world without embodying any special commands to programs. It generates visual explanations on the basis of the result of "simulation based program understanding[5]". So it can accept buggy programs and generate visual explanations of buggy behaviors of the programs. Moreover, it can also generate verbal explanations on the basis of the result of program understanding.

In the next section, we illustrate an overview of our previous system. In section 3, we point out some functions necessary to generate an effective explanation by using both verbal explanation and visual explanation (a bimodal-explanation). In section 4, we describe the method of constructing the bimodal-explanation system. Then, we show examples of bimodal-explanations by our system.

2 Our Previous Work

2.1 Overview of our previous system

Our previous system is composed of the static analyzer, the simulation based analytical unit and the explanation unit (Figure 1). In this paper, we omit detail of the system (For further details, please see our previous papers[2][5][6][7]). The static analyzer parses target programs and analyzes information necessary for the simulation such as data flow. The simulator simulates target programs, and the observer observes the world model while simulation, and recognizes some important characteristics of data or patterns of structured data. The explanation generator generates verbal explanations of target programs.

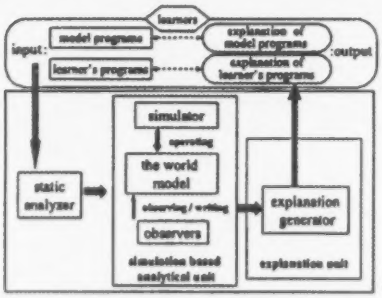


Figure 1: Configuration of our system

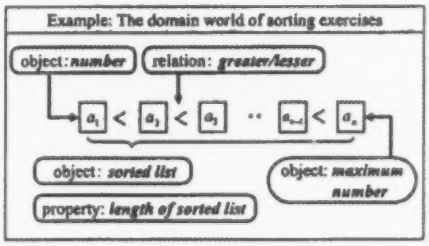


Figure 2: An example of domain world

2.2 Domain world models

We examine programming exercises and classify them into 15 types. We prepare domain world models designed for each type of exercises [2].

A domain world model consists of four types of elements called 'object', 'property', 'relation among objects' and 'change'. For example, Figure 2 shows the domain world model of greater and lesser as an example. In order to recognize specified characteristic or patterns in the domain world, our system has daemon units called "observer" which are burnt when they are observed. In the Figure 2, the object *'maximum number'*, *'sorted list'* and property *'length of sorted list'* are recognized by observers. There are some cases that some observers take outputs of the other observers as their inputs. Then the outputs of observers make hierarchy. When a result of observation is output on the basis of a result of another observer, the former has larger grain-size than the latter and implies the fact corresponding to the latter.

2.3 Generation of a verbal explanation

The explanation unit generates verbal explanations of the target program by using results of simulation and outputs of observers. The results of observations have a hierarchical structure, as mentioned above. The system generates a hierarchical verbal explanation by using the hierarchical structure (it also uses syntactical structures of programs). In other words, the system notices the largest grain-sized result of the observation firstly, in order to generate the verbal explanation. Secondly, if learners request the detailed verbal explanations, the system generates the explanation using results of observation having smaller grain size. Figure 3 shows the example of verbal explanations generated by our system. It illustrates the verbal explanation of behavior of a sorting program on the domain world of greater and lesser. The indentation in the figure means that *behavior 1* and *behavior 2* are executed sequentially and that *behavior 2* is equivalent to the sequence of *behavior 2-1, behavior 2-2,* and *behavior 2-3*. Each Behavior is implemented by a single statement or a sequence of statements. When a verbal explanation for a behavior implemented by a sequence of statements is clicked, more detailed verbal explanations showing the way to implement the behavior are displayed.

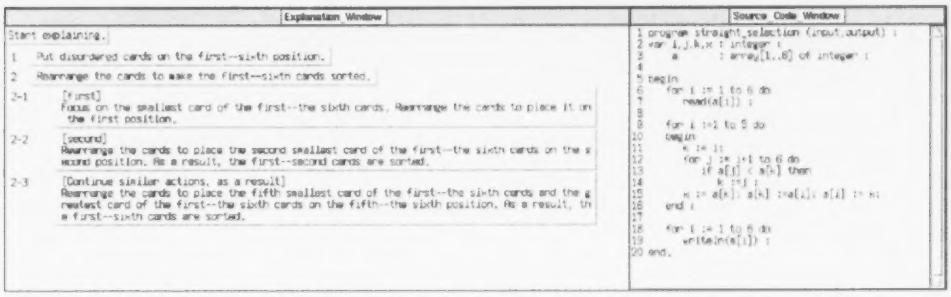


Figure 3: An example of the verbal explanation of a target program

Next, we show procedures for generating the hierarchical verbal explanation like Figure 3. An input is a result of simulation of some statements (For further details, please see our previous paper[7]).

(1). The case that a certain behavior is implemented by a sequence of statements.
The system observes differences of the states of the domain world model before and after execution of the sequence of statements. According to these differences, the explanation unit selects a template and generates verbal explanations for the statement. Now we show an example of a template.

- The case that extension of the sorted list is observed.

The differences are composed of the following three elements.

Object(s) recognized at the state before execution of some statements: a sorted list
Object(s) recognized after execution of the statements : an extended sorted list
Recognized changes of states of objects : an extension of the sorted list

A template for the extension of the length of a sorted list is applied (Please see Figure 3).

Template: "Rearrange the [Type of added object] to place [An added object] on [The position of the insertion] position. As a result, [A sorted list at the after state] [Type of inserted objects] are sorted."

"[]" means a procedure which generates a certain pattern of string.••

[An added object]
: A procedure that generates a noun phrase expressing the new object added to the sorted list.

[A sorted list at the after state]
: A procedure that generates a noun phrase expressing the range of the sorted list at the after states.

(2). The case that a certain behavior is implemented by a single statement.
The explanation unit calls each procedure corresponding to types of the statement. The procedures are defined for each structure of the program like sequential structures, selective structures, iterative structures, an assignment statement, a statement for input, and a statement for output. Same as the case (1), templates are prepared for each structure of the program. For example, we show a template of 'if' statement.

Template: "if [explanations of the conditional clause], [explanations of the 'then' clause]
(otherwise [explanations of the 'else' clause]) "

[explanations of the conditional clause]
: The procedure that explains the conditional statement of 'if' statement.

[explanations of the 'then' clause]
: Apply the procedure for generating the verbal explanation to the clause recursively.

[explanations of the 'else' clause]

: Apply the procedure for generating the verbal explanation to the clause recursively.

Thus, the system can generate hierarchical verbal explanations. When a verbal explanation generated by the procedure (1) is shown and a learner requests more detailed explanation, the system tries to apply the procedure (1) recursively to make such an explanation. If it cannot generate any explanation, it applies the procedure (2).

3 Functions necessary to generate an effective bimodal-explanation

In order to construct a system generating effective visual explanations, we have to consider what visual explanation is effective for learners to understand an algorithm or behavior of a target program. By designing mock up visual explanations repeatedly, we find that the effective visual explanation has following three facilities.

(1) The facility to generate visual explanations with various grain-sizes.
When learners learn programming by using a system explaining behaviors of programs, they need various grain-sized explanations. For example, when a learner wants to grasp algorithm roughly, a large grain-sized explanation would be effective. On the other hand, when he wants to understand a precise method of implementation, smaller grain-sized explanations are effective. Moreover, when he wants to diagnose his own program at a glance, he needs the largest grain-sized explanation. When he wants to find buggy codes, he needs smaller ones. In order to generate such various grain-sized visual explanations, the system should be able to :

- regard a sequence of statements as a blackbox and generate a visual explanation showing its function.
- generate a visual explanation showing a function of each statement sequentially.

(2) The facility to explain a function of a program by using both animations and verbal texts.
If a system shows only visual explanations, learners sometimes cannot understand behavior of target programs clearly, because such learners cannot understand what phenomena are essential. Thus, it is necessary for our system to have the facility to generate verbal explanations showing a major phenomenon of each step of visual explanations. Thus our system should have a facility of generating combination of verbal explanations and visual ones (bimodal-explanations).

(3) The facility to generate explanations on the total effect of a sequence of statements.
Generally, a task is achieved by a sequence of statements, and each sub-task is achieved by each sub-sequence of the statements. When the system shows a sequence of explanations each of which has a certain grain-size corresponding to a sub-task, a learner sometimes cannot find the fact that the task has been achieved. In order to prevent learners from such misunderstanding, the system should show them a verbal explanation remarking the fact.

4 Methods to realize the functions to generate bimodal-explanations

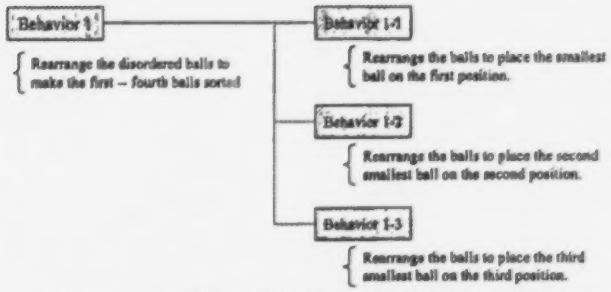
4.1 Basic ideas

(1) The method of generating visual explanations on various grain-size.
As we describe in section 2, our system can generate hierarchical verbal explanations. In other words, it can understand behavior of a target program on various grain-size. And the system holds the result of understanding as hierarchical data. Therefore we can realize a system generating visual explanations on various grain-size, by developing a method to generate a visual explanation from a result of understanding.

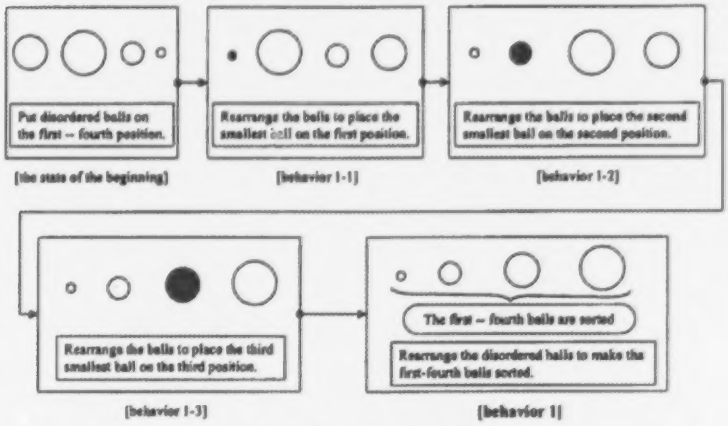
(2) The method of generating combination of verbal explanations and visual explanations.
Our program understanding mechanism can recognize the major phenomena in the domain world. And we have already developed a method to generate verbal explanations from the result of program understanding. Thus, if the system can generate a visual explanation from the result of it by the method (1), it becomes to be able to generate both visual explanations and verbal explanations remarking major phenomena from common data.

(3) The method of generating explanations on the total effect of a sequence of statements.
By generating an explanation remarking that a task is achieved just after explanations of sub-tasks are finished, the system can generate explanations on the total effect of the task. The explanations of the task and the sub-task can also be generated by the method (1) and (2). For example in Figure 4, just after the explanation corresponding to the behavior 1-3 is finished, the system generates the explanation corresponding to the behavior 1 as the explanation of the total effect. As a result, the explanation shown in Figure 4 is generated.

In consequence, if we can realize the method (1), the method (2) and (3) can also be realized. Therefore we discuss the detail of the method (1) in the next section.



(a): An example of a hierarchical structure of behaviors of a program



(b): Generated explanations

Figure 4: An example of a bimodal-explanation of a total effect

4.2 Generating visual explanations

The system visualizes behavior of the target program in various grain-size. The generated animations are shown with verbal explanations. The detail of our method to generate verbal explanation is seen in [6], so we omit it in this paper.

At first, the system starts explaining with the largest grain-size, then shows more detailed explanation on an action of which detail a learner wants to see.

The methods to draw a step of animation are classified into the following two types:

1) The method of visualization for a function implemented by a single statement.

2) The method of visualization for a function implemented by a sequence of statements.

The detailed process of 1) and 2) is discussed in 4.2.1 and 4.2.2 respectively.

4.2.1 How to generate a visual explanation of a function implemented by a single statement

In order to generate a visual explanation on a statement, we prepare specific procedures for each type of a statement. The statements of inputting, assignment, selection, and iteration have their individual procedures.

Procedures for inputting statement should be classified into several types in order to generate effective explanations. For example, the basic function of inputting statement "read (A);" must be "a datum is input to the variable A". However, showing only the basic function is not always a good explanation. If a meaningful datum has been stored in the variable "A" before inputting, the system should also explain that the datum is deleted by the inputting. Therefore, the procedures for inputting statement are classified according to some conditions on the role of the statement in the target program and the domain world: for example, the condition whether the datum stored in the destination variable of inputting has been referred before the input sentence or not (if it has been referred, it must be meaningful).

BEST COPY AVAILABLE

An Empirical Study of the Design and Use of a Multimedia Composition-Making System for Children

Kaori Iwashita*, Shinya Kawakami and Bipin Indurkhya**
Department of Computer Science, Tokyo University of Agriculture and Technology, Koganei City, Tokyo, Japan, tel: 81-42-364-3311
**e-mail: kaorii@ma.neweb.ne.jp, **e-mail: kawakami@fairy.ei.tuat.ac.jp*

In this paper, we describe our experiences in designing and using a multimedia composition-making system for children. The system allows children to make compositions using pictures, sounds and text. Moreover, it also allows pictures in the composition to be animated. We experimented with children using this system in three different settings. In the first setting, no topic was assigned to the children. In the second and third experiments, children were given a topic (different for each experiment) for composition related to their activity. We present here the results of our experiments and comment on how the constraints imposed by the topic affect children's expressive abilities.

Keywords: **animation, children's expressive abilities, constraints and creativity, multimedia composition.**

1 Introduction

In recent years, many researchers have studied multimedia techniques and have incorporated them into various educational systems. For example, Silva [5] described a multimedia soundscape system, "They Are Catching Sounds in the Park!", for environmental education. In this system, children search for sounds by clicking anywhere in the picture. When they click an appropriate object, its associated sound and information are presented to the children. Brna [1] proposed a system for composing and writing stories via cartoons. Harviainen [2] presented a co-authoring system in which many users work together to compose a story. Ishii [3] and Kawakami [4] have developed other systems for making stories with multimedia. All this research demonstrates that multimedia has much potential for stimulating the ability of children to express themselves. In particular, we find that children can express their creative and imagined ideas much better with pictures and words than with words alone. Moreover, if we add an ability to attach sounds to pictures, and allow pictures to be animated, then this expressive power increases considerably.

Motivated by these factors, we have developed a system to help children write multimedia compositions, and have tested it with children in three different settings. In this paper, we describe our system and report on our experiences with children using the system.

2 Prototype of the System

We developed a prototype of a multimedia composition-making system. Using our prototype,

- Children can express their thoughts and ideas via pictures, sounds, text, and animation sequences. In our system, children must first choose a background scene, in which they can then insert picture objects, sounds, and text.
- Except for the background, children can attach sounds and text to picture objects, and can animate them to make a multimedia composition.

This system has two modes: a 'Set up' mode for the teacher or supervisor to allow them to determine which background scenes, picture objects, sounds, etc. are made available to the children for writing a composition,

and a ' User' mode for children to write compositions.

The ' Set up' mode has the following two functions:

1) Select situation: Set the context or theme for the composition.
2) Edit situation: Set the categories of background scenes, picture objects and sounds corresponding to a theme.

The ' User' mode has the following seven functions:

1) Select background scenes.
2) Select picture objects.
3) Select sounds.
4) Write text.
5) Animate composition.
6) Save composition.
7) Load composition.

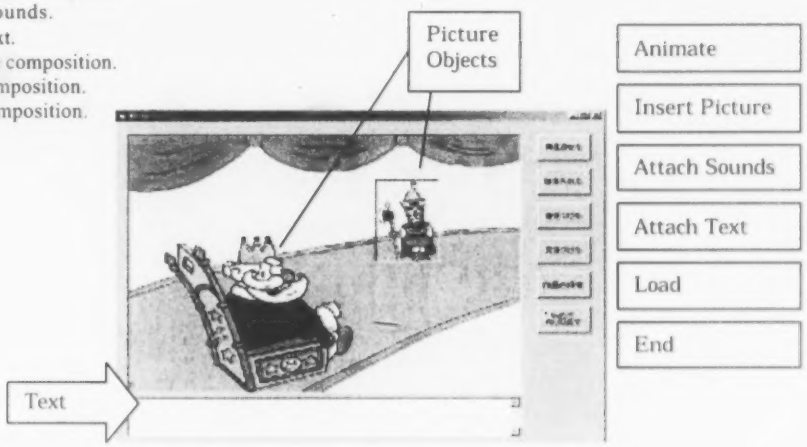


Figure 1. An example of the main window

By double clicking on a picture in the main window, the sound attached to that object (if any) can be heard. Also, when the picture of an object is selected in the main window, the text attached to it is displayed in the text box.

The animation module has five functions: show picture, hide picture, output sound, show text, and move picture.

To replay animation, children click the 'start' button in the animation window. When the button is clicked, the system starts the animation sequence as previously specified. It replays each action one by one, but it pauses when the action is ' show text ' . To continue from there, the user needs to click the ' start ' button again.

3 Experiments with the system

We did three different experiments in which children used our system. In each experiment, the setting and the tasks given to children were different, as described below.

3.1 Experiment I

In this experiment, we studied a constraint-free use of the composition system. The children were not given any specific topic of composition, and they could use the system any way they like to create any composition freely. We prepared 54 background scenes, 185 pictures and 68 sounds. Because no topic was given, children chose a variety of themes.

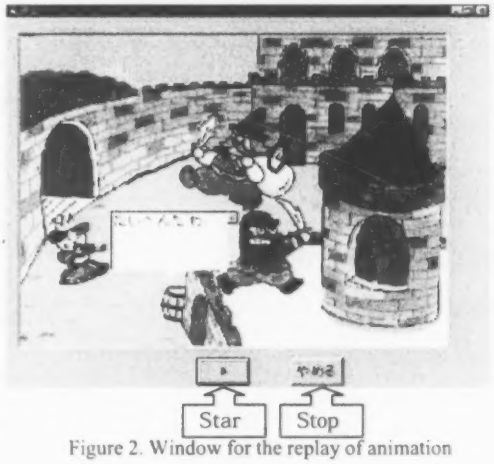


Figure 2. Window for the replay of animation

BEST COPY AVAILABLE

3.2 Experiment II

In this experiment, we introduced a constraint by giving a topic of composition to the children, and analyzed the generated compositions. The experiment was done at an activity center for children. At this center, children of each grade come periodically, and play or make some handicraft. One of the handicraft projects for third-grade children was making kites. So, the following week, we asked the children to make a composition about kite making. For the experiment, we prepared a version of the system with six backgrounds scenes of craft rooms. Three of these were scenes with kites in them, and the others were scenes with only a room and tables without kites. We also prepared 68 pictures and 35 sounds appropriate for kite-making activity.

3.3 Experiment III

In this experiment, we introduced a tighter constraint by giving a more specific topic of composition to children, and studied its effect. We asked the children to make a composition for the story "The coward king and robber" (original title in Japanese). The original story is written in Japanese. At the same activity center for children used in Experiment II, the children made an extended version of this story, made a picture book to illustrate various scenes in the story, and then told the story using these pictures at their Christmas party. The week following the party, we asked the children to make a composition for this story using our system.

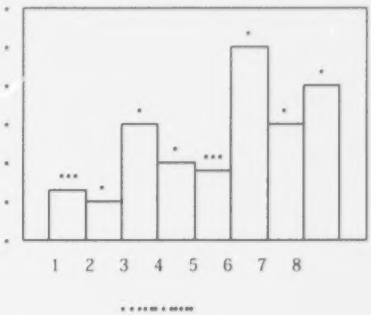


Figure 3. Differences between the composition picture and the original picture from the picture book (for each background scene)

For this experiment, we prepared a version of the system with eight background picture scenes related to the story. We also prepared 66 picture objects and 33 sounds appropriate to the story.

In this experiment, we were interested in analyzing the differences between compositions made using our system and the corresponding pictures in the picture book for this story that the children had made earlier. We used the following method for computing the difference. The picture objects were grouped into ten categories, and the difference between two pictures (with the same background scene) was calculated as follows:

> For each picture object category: if there is an object of that category in both the pictures, we say that the difference between the two pictures with respect to that category is zero. If one picture has an object from that category, and the other has none, we say that the difference with respect to that category is one. The difference between two pictures is the sum of the differences over all ten categories.

Figure 3 shows the result of applying this procedure.

We see that the differences for the climactic scenes (scenes 6• 7) are higher than the other scenes.

3.4 Discussion

An analysis of the compositions produced in the three experiments is shown in Tables 1, 2 and 3. Table 1 shows the average number of compositions produced by a participant in each experiment. We see from it that the children were most expressive when the topic was most constrained (Experiment III).

Table 1. Number of compositions per participant

	Experiment I	Experiment II	Experiment III
Number of participants	11	7	5
Number of compositions per participant	1.3	1.4	4.6

Table 2 shows a more detailed analysis of compositions with respect to how multimedia features of the system were used.

Table 2. Number of multimedia features per composition

Multimedia feature	Experiment I	Experiment II	Experiment III
Picture objects	3.6	11.2	6.9
Sound attachments	1.1	2.4	1.6
Text attachments	-	1.1	1.6
Animation	1.0	2.8	9.9

Here we see that picture and sound attachments are used most in Experiment II. This may be because in this setting children were describing a situation using generally one page (screen). For this, they used many objects and sound attachments to provide information about the depicted situation. We also see that text attachments and replay actions were used most in Experiment III. It might be because in this setting they were describing a story, for which text attachment is a useful way to express characters' utterances, and animation is useful to express characters' movement. We also would like to point out that in Experiment III there were fewer picture objects and sound attachments per composition. This is because to show the flow of events in the story, children made many compositions (Table 1).

Table 3. Analysis of animation operations per composition (in percent)

Animation operation	Experiment I	Experiment II	Experiment III
Show picture	0	0	53
Hide picture	0	0	4
Output Sound	13	0	10
Show text	-	0	15
Move picture	87	100	18

In this table we see that in Experiments I and II, mostly the 'move picture' operation was used. In composing a story, however (Experiment III), the 'show picture' was used most. We also found that the 'hide picture' operation was rarely used.

4 Conclusions

From our experiments, we see that the multimedia features of the composition-making system are most useful in illustrating a story or a narrative. Sound and text attachments and animation operations can be very helpful in expressing movement of characters and the progression of events in a narrative. We also found that many children are most expressive when they are given a focus of composition.

From these results, we propose that a system such as ours can be used in the classroom for children to make compositions about field trips and class excursions. For each trip or excursion, the teacher can set up the system appropriately by choosing relevant picture and sound libraries before children use the system. In this way, we feel that our system can provide a step forward from Silva [5]. Children are more actively involved in making compositions with our system than in exploring with 'They are catching sounds in the park!"

Acknowledgements

We would like to thank all the children who participated in the experiments, and the staff at the children's center for their cooperation. We thank Professor Yoshiyuki Kotani, and members of the Kotani-lab for their help and cooperation during this research. Some pictures used in the background of Experiment III were taken from [6].

References

[1] Brna, P., Martins A., & Cooper B., "My First Story: Support for Learning to Write Stories", Advanced Research in Computers and Communications in Education, pp. 335-341, 1999.

[2] Harviainen, T., Hassinen, M., Kommers P., & Sutinen, E., "Woven Stories: Co-authoring over the Internet", Advanced Research in Computers and Communications in Education, pp. 285-292, 1999.

[3] Ishii, Y., Indurkhya, B., Inui, N., Nose, T., Kotani, Y., & Nishimura., H., "A System Based on Rodari's 'Estrangement' Principle to Promote Creative Writing in Children", ED-MEDIA & ED-TELECOM 98,

Vol. 2, 1685-1686, 1998.
[4] Kawakami, S., Indurkhya B., Inui, N., & Kotani, Y., "A Story Making System for children", Advanced Research in Computers and Communications in Education, 359-360 1999.
[5] Silva, M.J., Silva, J.P., & Hipolito, J., ""They Are Catching Sounds in the Park!" Exploring Multimedia Soundscapes in Environmental Education", ED-MEDIA & ED-TELECOM 98, Vol. 2, 1274-1279, 1998.
[6] Yamawaki, K., & Miyamoto, E., "Yowamushi o-sama to to-zoku", Kyoiku Gageki, 1989.

An Implementation of Campus Distance Learning System Using Multicast

Jiang Dongxing, Tao Chaoquan, Fang Guowei, Shen Peihua
Computer and Information Management Center of Tsinghua University
Qinghuayuan No.1, Beijing 100084, P.R.China
Tel: +86-10-62772150, Fax: +86-10-62782728, E-mail: jdx@cic.tsinghua.edu.cn

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The Campus Distance Learning System is an important way to solve the problem. This paper starts with an examination of some existing solutions, and then introduces the primary-secondary model multimedia network teaching system designed by researchers in the Computer & Information Management Center of Tsinghua University. The system is composed of three parts: the primary classroom system, the secondary classroom system, and the courseware management system. It fulfills real-time interactive teaching and learning, and multipoint communication, and at the same time records the teaching materials as courseware. The paper focuses on the constituents, structure and characteristics of the system, and expounds in detail the implement technology based on multicast. In the end, the paper points out some problems calling for further consideration.

Keywords: **Network distance learning; primary-secondary model; multicast**

1 Introduction

A problem common to many universities is that thousands of students want to take some certain courses but only a few can actually take them owing to the shortage of teachers. The traditional resolution was videoing and then broadcasting through CATV. This used to play an important part in television education, but it can not support the interaction between the teacher and the students, and the information that is limited by TV is not sufficient for lectures. With the network becoming more and more popular, network education instead of CATV is being received by more and more people. Many companies and universities have developed different network distance learning systems, the following are several famous systems.

Remote Education System of VTEL: This system is an application of the VTEL videoconference system in education. It adopts a complete set of software and hardware developed by VTEL and can implement mulitpoint bi-directional interactive network education.

IP/TV of CISCO: IP/TV is software developed by Cisco company, supporting video on demand and video broadcast. It adopts the client/server model and is mainly used for transferring high quality video, audio and data via computer networks. The system supports three ways of video transferring: live, on-demand and scheduled.

Multimedia Distance Education System of SATCOM: This system includes a program courseware generation system and a courseware on demand system.

2 Primary-Secondary Model Multimedia Network Teaching System

2.1 System Constituents

The primary-secondary model multimedia network teaching system is composed of three parts: the primary classroom system, the secondary classroom system and the courseware management system (See figure 1).

The primary classroom is where the teacher stays. In this classroom, the video and slide of the lecture are recorded synchronously. The video and slide information is broadcast live through multicast, and at the same time the information is stored in the courseware library for asynchronous use.

The secondary classroom is the classroom without the teacher, maybe a remote classroom. Students in this classroom can join the lecture by registering and playing the composite stream courseware synchronously with the primary classroom.

The courseware management system provides the directory service, user register management, asynchronous courseware on demand, and other management functions of the coureware library.

The free terminal can join the lecture from anywhere of the campus network through registering. It can also play courseware on demand from the courseware management system.

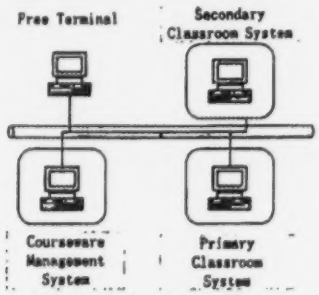


Figure 1 System constituents

2.2 System Structure

Figure 2 shows the structure of the primary-secondary model multimedia network teaching system. Its subsystems are as follows:

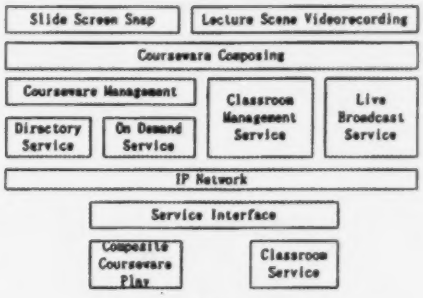


Figure 2 System structure

- Courseware synthesizing: The courseware synthesizing is the kernel subsystem of the primary classroom system. In this procedure, both the basic materials of the courseware – lecture scene videorecording and slide screen snaps are compressed into the composite courseware with synchronous timestamp. Afterwards, the courseware is stored into disks and multicast at the same time by the system.
- Lecture management service: The lecture management service is anther important subsystem of the primary classroom system, its main functions being registering new courseware in the courseware management system, requesting for the multicast address, configuring the multicast scope and lecture management.
- Directory Service: This is the kernel function of the lecture management system. It provides lectures and courseware lists and user management.
- On-demand Service and Live Broadcast Service: On-demand service is an asynchronous courseware service provided by the courseware management system while live broadcast service is a synchronous

service provided by the lecture management system. Both of them provide composite stream courseware to the user, the former using unicast and the latter using multicast.

- Lecture Service: This is an interactive supporting system provided by the secondary classroom system. With it students in the secondary classroom can participate in the discussion. The means of interaction may be keyboard typing, and speaking with a microphone.

2.3 System Characteristics

The main characteristics of the primary-secondary model multimedia network teaching system are the following:

1) It uses two streams to play the teacher's videorecording and slide screen snaps, and the quality of the slide screen snaps is the same as that of the slides in the primary classroom.
2) The lecture scene is kept in the archives in real time, and can be replayed at any time.
3) The teacher can discuss with students in remote classrooms through videoconference, and they can write on the same electronic white board.
4) The audience can have interlocution with the lecturer by text typing.

3 Implementing the System with Multicast

3.1 The Multicast Technology

By keeping routers informed about multicast hosts, multicast datagrams can traverse an internetwork and reach many hosts simultaneously. The ability to traverse an internetwork and reach an unlimited number of "member" hosts simultaneously without affecting others adversely is the linchpin of multicast. A Class D IP address in the range from 224.0.0.0 to 239.255.255.255 is a "multicast address." Each is also known as a "host group address," since datagrams with a multicast destination address can be received by all hosts that have joined the group that an address represents. Figure 3 shows the datagrams spreading abroad.

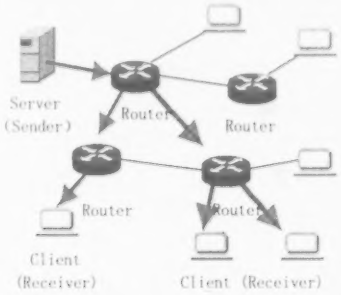


Figure 3 Datagrams sent only to hosts in a group

The mechanisms incorporated into WinSock 2 for utilizing multicast capabilities can be summarized as follows:

- Three attribute bits in the WSAPROTOCOL_INFO struct, which are used by **WSAEnumProtocols()** to discover whether multicast communications are supported for a given protocol;
- Four flags defined for the *dwFlags* parameter of **WSASocket();**
- One function, **WSAJoinLeaf()**, for adding leaf nodes into a multicast session;
- Two **WSAIoctl()** command codes for controlling multicast loopback and the scope of multicast transmissions (SIO_MULTICAST_SCOPE and SIO_MULTIPOINT _LOOPBACK).

We can benefit from using multicast to implement network teaching system, which can be described as the following:

1) Because the member of a multicast group is dynamic, and no authority is requested, the terminal can join or quit a group at any time;
2) All hosts belonging to a multicast group have a clear physics network topology;
3) All users in one subnetwork that join the same multicast group share the same stream over network, and this can greatly lighten the network load.

3.2 System Implementation

In the practical system, we adopt the combinative way of multicast and unicast: using multicast to broadcast information from the primary classroom, and using unicast to implement the interaction between the primary classroom and the secondary classroom. Figure 4 shows the structure of the practical system in detail.

The primary classroom system is composed of a server, a teacher's PC, a video recorder, two overhead projectors and an electronic white board. The teacher's PC is used to play slide of the lecture, and it projects the slide to the electronic white board. If the teacher writes something on the electronic white board, the teacher's PC will capture the written information and combine it with the slide. At the same time, the teacher's PC compresses the slide/written information and sends it to the server. The server takes charge recording the video/audio information, receiving the slide/written information from the teacher's PC, and broadcasting the information with multicast. At the same time, the server stores all information into special type file, which is the composite courseware.

The full function secondary classroom is made up of a server, a video recorder, two overhead projectors and an electronic white board. The server receives the video/audio and slide/written information from the primary classroom, and projects the video information on the white wall, the slide/written information on the electronic white board.

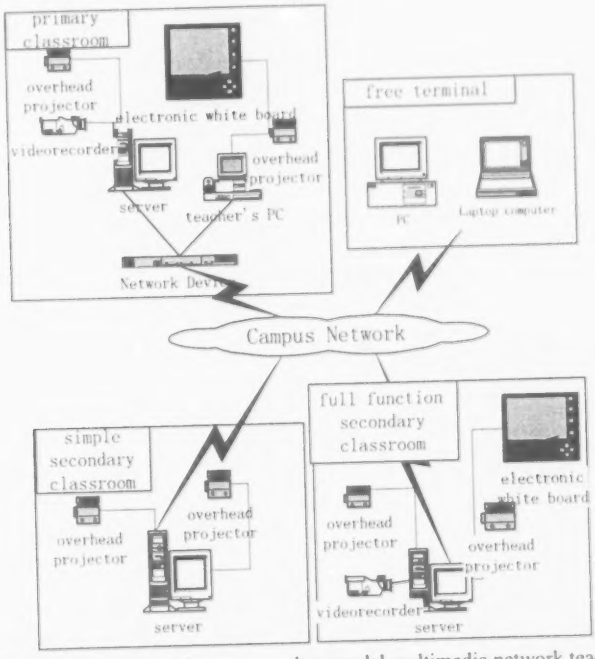


Figure 4 The topology of the primary-secondary model multimedia network teaching system

The simple secondary classroom is made up of a server and two overhead projectors. The server receives the video/audio and slide/written information from the primary classroom, and projects the information on the white wall separately.

The free terminal may be any PC connected to the network. It receives the video/audio and slide/written information from the primary classroom and displays it in different windows.

The teacher in the primary classroom and the students in the secondary classroom can discuss with each other. This is implemented with unicast. During the discussion, the server in the secondary classroom records the information of the students and sends it to the server of the primary classroom. The server of the primary classroom receives this information and projects it on the white wall. If students in the secondary classroom write something on the electronic white board, the servers will transmit the written information,

which will be shown on the electronic white board of the primary classroom at the same time.

4 Conclusions

In our experiments, we use lossless a compression algorithm and the slide screen snaps can be compressed to 1%~2%, it means that the slide screen snaps will take up 100~200Kbps bandwidth. In another side, the video information can be compressed into 128Kbps by MPEG-4 and all the information of this system can be fit in a 384Kbps channel. This system is available for long distance learning and of course for campus distance learning.

The primary-secondary model multimedia network teaching system has built a virtual network classroom system. It will play an important role in making better use of teaching resources and improving teaching efficiency.

References

[1] Jiang Dongxing, Lin Ehua, "Windows Sockets Network Programming", Tsinghua Univ. Press, (1999).

[2] Colin Perkins and Jon Crowcroft, "Real-Time Audio and Video Transmission of IEEE GLOBECOM'96 over the Internet", IEEE Communications Magazine, pp.30-33, (1997).

[3] Victor O. K. Li , Wanjun Liao, "Distributed Multimedia Systems", Proceedings of the IEEE, (1997).

[4] Song Yunxian, "The present and future of network education", Multimedia World, (1997).

Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet

Min-Huei Lin , Ching-Fan Chen, Chen-Nan Chiang
Department of Information Management
Aletheia University
Tamsui, Taiwan, R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

The popularity of WWW (World Wide Web) produces lots of new instructions or substitutive cases to build a new future, therefore educational units need to develop various computer-assisted instructions. To ensure good learning effect, the instructive strategy adopted by most CAI systems is to provide tremendous amount of multimedia data in order to attract the learner and a complete process of instruction is like the scenario of a presentation. The purpose of this thesis is to discuss how the multi-tier developing architecture can let the multimedia learning resources be used and shared in WWW from a view of organization's requirements, such that teachers, measuring researchers, and learning researchers can perform different tasks according to their own specialties independently. We also propose and implement a multimedia presentation system to let various authors with various identities author and present their presentation, i.e. CAI systems, conveniently and correctly. We compare the general hierarchy of a multimedia presentation system with the multi-tier architecture proposed by us, and we can know how the tasks are divided and assigned to corresponding professionals to accomplish the whole teaching materials through working cooperatively. It is possible to have a suggestion to develop CAI software for educational department.

Keywords: **Multimedia Presentation System, CAI System, Multi-tier**

1 Introduction

Although there exists many arguments, object-oriented is still spread out in 1990's and it seems to be a possible survival direction in software crisis. Besides this, we can use component oriented to build a set of CAI systems via existing papers that can be divided into several areas, e.g. research of interface, learning methods of computer assisted instructions, application of virtual reality, networking exam, virtual classrooms (including distance instruction), individual researcher objects, and etc. For example, the processes of mental model research emphasize the use of information of objects, so researchers just make the analysis components of mental model, the key point of this study is the component of mental model, not the scenario of teaching and the interface of designation. Another example, fuzzy theory should be used in the research of learning analysis, the key point is to provide learning analysis for content of exam, and it can make the analysis component purely. From the two examples, we can find the generation in proper components analysis, so all we have to do is making the component of its own domain. Each researcher only concerns its own theme without being concerned with the entire system, then can reuse the resources and get the complete experimental environment. This thesis constructs the developing architecture of CAI through component oriented and logical dividing of multi-tier structure, and emphasizes that the discussion of developing architecture is the beginning of the series of research.

2 Multimedia presentation system

2.1 General Hierarchy of Multimedia Presentation System

On Internet, the way to play multimedia objects is hypermedia shown in the Fig.1. To display such a scene on homepages, we can divide the designation into two layers, frame layer and resource object layer. The resource object layer stores all the multimedia objects participated in playing, the frame layer records the objects that compose each frame, the schedule of playback, the arrangement of objects on screen, and the events that may change the playing flow of inter-frames.

A multimedia resource may be a picture, a text description, a video, or other materials that can be used in a multimedia computer. A topic is a resource carrier that presents the resource to the addressee. A frame is a composite object that represents related issues that a presenter wants to illustrate. A frame may contain push buttons, one or more topics to be presented, and a number of knowledge. A message with optional parameters can be passed between two frames (or back to the same frame) to trigger a multimedia presentation action.

In the two layers, we make some definitions by referring the various links defined in [7].
An inheritance* (successor or precedence) *link: is a property inheritance between two frames and is used in the process of knowledge collection of an activated frame before the logical inference of the frame proceeds.
A usage link: is a link that represents a message passed between two frames.
An aggregation link: indicates that a frame is using a resource.
A resource association link between two resources: indicates that the two resources are correlated.
A frame association link between two frames: indicates that the two frames are correlated.

2.2 Models of Presentation systems

In 1983, James F. Allen advocated in ACM• There exist thirteen temporal relationships between two intervals, namely, before, meets, overlaps, during, starts, finishes and the other six inverse relations as well as equal. The thirteen corresponding temporal operators constructed from the Allen's interval-based temporal logic are depicted in Fig. 2.

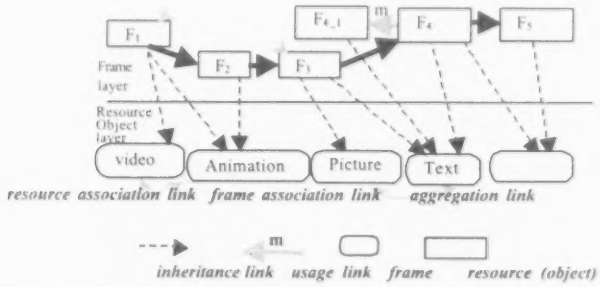


Fig.1 the way to play multimedia objects on Internet is hypermedia

Relation	Diagram	expressions	relation	Diagram	expressions
P before Q	P Q	P; ε(n);Q	P before Q	Q P	P‖ Q
P meets Q	P Q	P;Q	P meets Q	P Q	P‖ Q
P during Q	P Q	P‖ Q	P during Q	P Q	P‖ Q

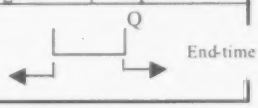
Relation	Diagram	expressions	relation	Diagram	expressions
P finishes Q		P Q	Start-time		Q End-time

Fig. 2 Temporal Relationships (Allen 1983) and their corresponding temporal operators

2.3 Define the Playback of Multimedia Presentation

We define some notations used in our presentation system. The F_i denotes the frame in the frame layer. The O_i denotes the resource in resource layer. The $F_i.O_i$ denotes that the resource O_i is one component of the frame Fi. The m_i denotes a triggered message when users push a button, a hypertext or a hypermedia. The m_iF denotes that the frame F will be displayed after the message mi is triggered, and the $m_\varepsilon F$ denotes that the frame can be directly displayed not depend whether the message is triggered or not.

For example, a presentation displayed one frame by one frame can be described by the following expression $S = m_\varepsilon F_1\ (m_1F_{21}+m_\varepsilon F_{22})\ m_\varepsilon F_3\ m_\varepsilon F_4\ (m_1F_{51}+m_\varepsilon F_{52})$. According to Fig.1, we know that the $F_i.O_i$ is an aggregation link, $m_\varepsilon F_1$ is an inheritance link, and m_1F_1 is a usage link.

2.3.1 Define the Properties of scenario

A complete process of instruction is just like the scenario of a presentation, and can also be described by the expression $S = m_\varepsilon F_1\ (m_1F_{21}+m_\varepsilon F_{22})\ m_\varepsilon F_3\ m_\varepsilon F_4\ (m_1F_{51}+m_\varepsilon F_{52})$.

2.3.2 Define the Properties of Objects

We denote a media object as O = (N, T, D, UM, OAL, PT), and describe the attributes of an object below:
O_i.N *(Name)*: is the identifier of the object.
O_i.T *(type)*: What multimedia device is used to carry out this resource (e.g. sound, video, text or picture).
O_i.D *(Duration)*: records the display time of the object.
O_i.UM *(Usage model)*: the situation about the usage of objects, such as the object is a background or a referent.
O_i.OAL *(object association link)*: describes the relationships between objects, and is specified like **O_i.FAL**={O_1(*association Keyword description*), O_2 (*association Keyword description*) ,...}, we use association keywords to describe the related relationships between O_i and O_1, the same as O_i and O_2.
O_i.PT *(Player Type)*: describes the way to play the object.

2.3.3 Define the Properties of Frames

A frame F_i is denoted as F_i =(N, O, FAL, L, P, UM), and the meanings of its attributes are listed below:
F_i.N*(Name)*: assign a unique name to a frame F_i.
F_i.O*(resource objects)*: the set of all the resource objects participated in the frame F_i, $O = \{O_i \mid O_i \in O\}$.O is the set of all objects stored in database.
F_i.FAL*(frame association link)*: $F_i.FAL = \{(C_i, F_k) \mid C_i \in \{\Diamond, \odot\}, F_k \in F\}$.The relationships between F_i and F_j are divided into inclusive and exclusive relationships; we denote them by $\odot$ and $\Diamond$ respectively. The $F_i \odot F_j$ represents the two frames are inclusive, that is, whenever the F_i is displayed, the F_j must be displayed also. The $F_i \Diamond F_j$ represents the two frames are exclusive, that is, whenever the F_i has been displayed, the F_j can't be displayed. F is the set of all frames.
F_i.L *(Layout)*: the spatial arrangement of the objects of F_i for the presentation. For example, the (X_{j1}, Y_{j1}) and (X_{j2}, Y_{j2}) are the position on the screen arranged for O_j, $F_i.L = \{O_1\ (X_{11},Y_{11})(X_{12},Y_{12}),\ O_2\ (X_{21},Y_{21})(X_{22},Y_{22}), \ldots\}$.
F_i.P *(Presentation)*: the duration of playback of all objects in the F_i. We use the 13 temporal relations proposed by Allen and use $\varepsilon(n)$ to represent units of time. OP is the set of all operators used to describe the temporal relations between objects. P is a set composed of O_i OP O_j, $P=\{(O_i, op, O_j) \mid O_i, O_j \in O, op \in OP\}$, $OP = \{:, \|, \|, \|, \|, \|, \varepsilon(n)\}$, $F_i.P=\{\cup P_i \mid P_i \in P\}$. For example, $F_i.P=\{(O_1 \| O_2),(O_1 \| O_3),(O_3 ; O_4),\ldots\}$.
F_i.UM*(Usage model)*: describes usage of frames, e.g. the frame is designed for teaching or for taking exams. For example, expression F_i.UM = exam means that the frame is an exam frame.

3Three-layer CAI architecture

3.1 Partition the CAI system into Components

The flow of instruction is from teaching course, taking examinations, speculating the advanced contents of instruction according to the result of examination, to achieve the goal of instruction. Generally, the teachers, educators or scholars take part in editing the CAI systems and the computer engineers are responsive for implementing the CAI systems, so they often spent lots of time on mutual communication. We analyze the CAI systems and partition the CAI systems into various components that are designed by various persons respectively, and these persons work together to achieve the whole function of the CAI systems. To partition the components clearly, we use the UML to describe the flow of CAI systems shown in the Fig.3, and we can know the following things:

- Step1 to step4 is for identifying the users.
- Step5 to step8 is for displaying the teaching of courses or questions of exams.
- Step9 to step11 is for analyzing after the exams are finished.
- Step12 to step14 is for designing the advanced courses after the fitting analysis is finished.
- Step15 is for exiting the CAI system.

In Fig.3, we can classify the partitioned components of CAI systems into four kinds listed below.

- The verification component for logging the usage of systems and maintaining the security of system. —is managed by system administrators or computer engineers.
- The course and exam component for instructing students in learning and taking exams. —is managed by teachers, educators or scholars.
- The fitting analysis component for the learning process of students. —is made by educators and scholars.
- The database component for storing the media objects and instruction materials. —is implemented by art designers or computer workers, and is managed by computer engineers.

3.2 Three-layer CAI architecture

From the CAI system described with UML shown in Fig.3, we can know that the course and exam component is the most important one and the other components are discussed in other area. In our system, we propose the Multi-layer CAI architecture to construct the CAI systems, and use the management of components to distribute the resources over the servers on Internet to achieve the goal of resource sharing.

We present a 3-layer CAI architecture model that expresses different points of view and is fully flexible and component oriented [2,3]. Based on the efficiency of systems, the model is partitioned into 3 layers--resource layer, presentation layer and evaluation layer. It raises the productivity of system development and improvement process, also promotes the individual skills and development of distributed computing environment.

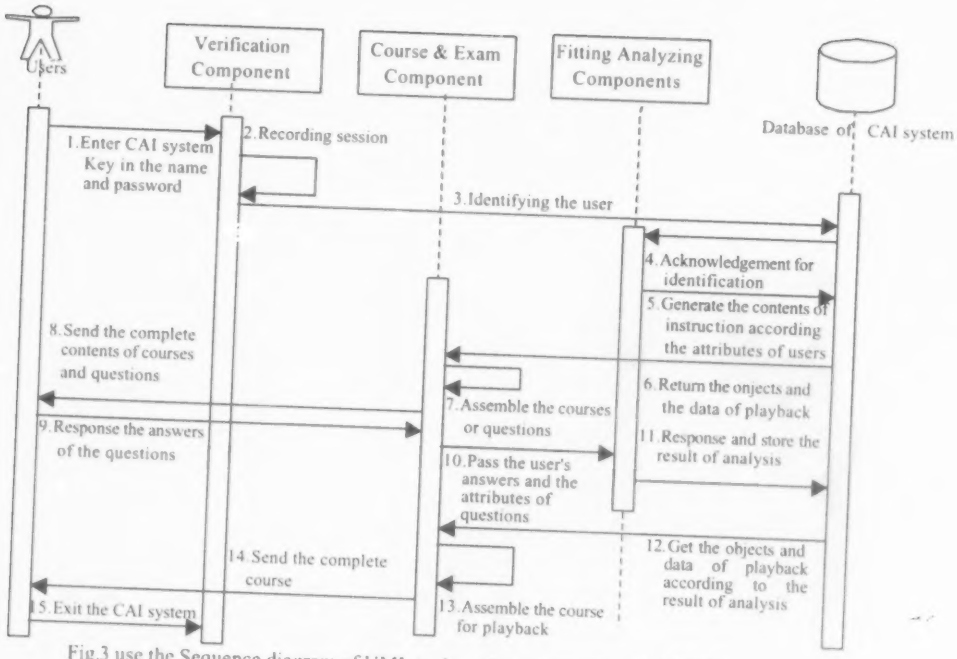


Fig.3 use the Sequence diagram of UML to describe the process of CAI [8][9]

3.3 Relationship between Three-layer CAI architecture and hypermedia

From the Table 1 and the frame and resource objects defined in our multimedia presentation system, we can analyze that to what layer the settings of various objects belong listed in Table 2[2][4]. In the components of scenario, we define the miFi that describes which frame should be displayed after the message is triggered, i.e. we can use the expressions to define the schedule of playback of the frames about designing exams and teaching. The components of plot or story just describe the flow of teaching courses defined by users.

From Table 3, we can design and implement the system on Internet more easily to let teachers or other education experts design their teaching materials or questions of exams conveniently and systematically.

4 Conclusion

Different researchers can benefit from this architecture by studying their own knowledge domain independently. Shortening the time spent on completely developing the whole system is to promote the successful rate of resolving the kernel problems. Researchers can't benefit from studying their own domain only; it's necessary for them to know our open architecture that can easily expand one system into various domains.

Users can acquire an easy-used and reusable system from defining components of multimedia and instructive units of CAI. Our architecture lets teachers have the suitable flexibility and lets various experts and scholars participate in the installation of CAI system. The educational authorities can take our architecture as a referenced architecture for developing the multimedia education. Our system is shown in Fig. 4. The prototype of our system has been completely implemented and published in some various conferences or journals. [1] [5] [9] [10]

Table 1. Three-layer CAI architecture [2][4]

Layer	Researcher	Participants
Resource	Researcher of Interface	Designer of animation , graphic, sound
Presentation	Researcher of learning theory	Teacher, Instructor
Evaluation	Researcher of evaluation	Manager, researcher of educational policy

Table 2. Explanation of part of components [2][4]

First layer (Evaluation layer)	
Components of fitting analysis	This component is made according to some theorem. After analyzing the data acquired from the process that the students take exams and learn, there are some various frames generated.
Components of evaluation and analysis	This component is made according to learning evaluation and learning retrieval of theorist or researchers.
Second layer (Presentation layer)	
Components of scenario	This component is made according to the researchers of learning theory or teaching materials.
Components of structure	This component is made according to learning environment.
Third layer (Resource layer)	
Components of exam	This part must include the parameter or properties which is used broadly
Components of background	Background is concerned to the interest and attention of learner.
Components of referents	To help users of different levels from different method and presentation
Components of multimedia	The components make the CAI lively which may be somebody of cartoon

Table 3. Explanations of part of components

Explanation of part of components		Set the values of necessary item needed
First layer (Evaluation layer)	Components of fitting analysis	
	Components of evaluation and analysis	• F_i.O • F_i.Layout and F_i.UM= exam • F.Presentation and F_i.UM= exam
Second layer (Presentation layer)	Components of scenario	• S
	Components of structure	• F_i.Layout and F_i.UM=learn • F.Presentation and F_i.UM=learn
Third layer (Resource layer)	Components of exam	• O_i.UM = exam
	Components of background	• O_i.UM =Background.
	Components of referents	• O_i.UM = Referents

References

[1] Bal Wang , Ching-Fan Chen, Min-Huei Lin. " A Multimedia Presentation Syste~ on Web -- Dynamic Homepage Approach"., The Institute of Electronics, Information and Communication Engineers(IEICE) Transactions on Information and System, Vol.E82-D,NO.4,April 1999. pp. 729-736

[2] Min-Huei Lin, Ching-Fan Chen, Ian-Ru Li, " Building Component Oriented Multi-tier CAI Architecture in the Internet ", ICCE'98 (The Sixth International Conference on Computers in Education) , Beijing,china,1998,pp.180~pp.186.

[3] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Wei-Yu Li , Ya-Ting Chuang. "A Three-Tier Multimedia Presentation System in Internet", ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 162-166.

[4] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Ian-Ru Li. "Building multimedia component oriented Multi-tier CAI architecture in the Internet".ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 158-161.

[5] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE'99(International Conference on Computers in Education).

[6] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bai Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design—A Scheme to Promote the Effect of Web CAI" . ICCE' 99(International Conference on Computers in Education).

[7] Chung, C.-M.; Shih, T.K.; Kuo, C.-H.; Lin, W.-C. . "Supporting the reuse of multimedia presentations" , Information Sciences, Vol: 101, pp. 131-151.

[8] Min-Huei Lin, Zheng-Kui Huang, Bai Wang, , Ching-Fan Chen• "Using Object Oriented Method in Network CAI Model" • The 8th International Conference on Computer-Assisted Instruction.

[9] Min-Huei Lin, Zheng-Kui Huang, Bai Wang , Ching-Fan Chen.• "Management of the Object–Oriented Resources Application System – an Instance of Distance Education" • Distance Education. Vol. 12 , June 1999. pp.53-61.

[10] Bai Wang, , Ching-Fan Chen , Min-Huei Lin , Chien-Ming Pan , Jen-Shan Huang , Hsing-Ten Chein• "An Authoring Tool on Web" • •The 8th International Conference on Computer-Assisted Instruction.

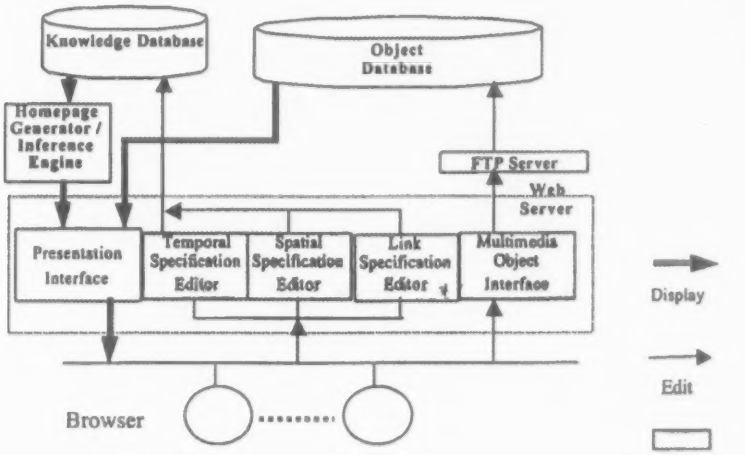


Fig.4. System architecture

CAI System Generator on Web -- using Automatic Trace Recording

Min-Huei Lin, Ching-Fan Chen, Si-Hao Hu, Ming-Hong Taai and Yung-Hsiang Chiu

Department of Information Management
Aletheia University
Tamsui, Taiwan
R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

By the prosperity of computer media, many companies treat electric media as their developmental base and use these electric media in more effective way. It goes without saying that the domain of teaching has developed on the Internet and many CAI systems have been already used in the teaching. The goal of our research is to create CAI systems by automatically recording the trace of editing. So in the thesis, we define the actions of users through image, audio, schedule, point and the module of event, and present the generated CAI systems dynamically on web.

Keywords: **CAI System Generator, Multimedia, Web**

1 The goal

Currently, many teachers and students use CAI systems as their teaching tools, and most teaching materials are designed by both teachers and system engineers. But teachers are generally in the passive position, and if they want to make teaching materials according to their own ideals, they have to learn how to use HTML to design homepages. Usually, students may not understand the meanings of teaching materials very well through the static homepages written in HTML. So we propose and implement an auto-recorded multimedia presentation system to let authors construct dynamic homepages of CAI systems directly through browser on web from automatically recording the trace of their editing.

2 Structure of system

We show the structure of our system in Fig. 1. In the auto-recorded system, we can catch the screen of process of users' operations, or insert sound or image information to the process. Then, these multimedia resources and related information are stored in Information Database and Media Database. The information of presentation schedule is recorded in information database. In the media database, contents of multimedia objects are recorded. In Fig.2, we can see the interactions among Image, Sound, Timer, pointer and Event. Image Module is to make necessary pick-ups for required images, decide what images are picked up in the Event Module Database and store their transition and filename in the forms. Sound Module is used to record sound, thereafter the sounds can be played at proper time by temporal scheduling. Pointer Module is to record the location of mouse pointer. When the transition has something wrong, we can make an adjustment in the coordination. In Timer Module, the time sequences are recorded in the form of Timer Pointer. The schedule designed through directly recording or specified by users is stored in the event database, and the generated multimedia objects will be presented according to the schedule built on the Timer Pointer. Event Module will react to all the other modules. It can decide what modules are going to work, and react to them. When users need to present teaching materials, the Java & HTML Generator will generate and send java code and HTML code to users' browser, then users can see the dynamic homepages. In Fig. 3, we can see a dynamically presented Web CAI system that is produced by recording and modified through the authors' edition and arrangement.

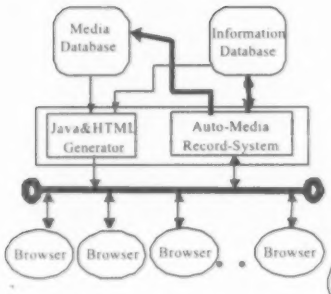


Fig.1 Structure of System

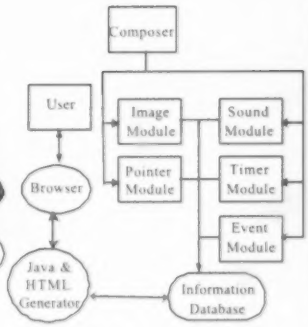


Fig.2 Modules of System

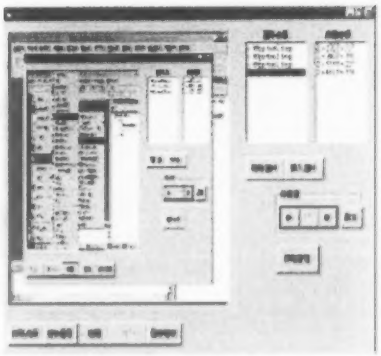


Fig.3 The interface of Auto-Recorded System

3 Conclusion

We still continuously work on the pack technique of the multimedia file because the transmittance of image and audio are limited by the bandwidth of the Internet. However, teaching through Internet is an inevitable trend in the future, so how to make the best efforts between editing the teaching materials and let the learners learn as efficiently as possible are our goals.

References

[1] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE' 99.

[2] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bal Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design–A Scheme to Promote the Effect of Web CAI" . ICCE' 99.

[3] James F. Allen "Maintaining Knowledge about Temporal Intervals", Communications of the ACM, Vol. 26, No. 11, 1983.

[4] http://windowsmedia.com

BEST COPY AVAILABLE

CoCoAJ: Supporting Online Correction of Hypermedia Documents for CALL

Hiroaki Ogata, Yoshiaki Hada, Cheng Feng and Yoneo Yano
Dept. of Information Science and Intelligent Systems,
Faculty of Engineering, Tokushima University
2-1, Minamijosanjima, Tokushima 770-8506, Japan
Tel: +81-886-56-7498 Fax: +81-886-23-2761
E-mail: {ogata, hada, feng, yano}@is.tokushima-u.ac.jp
URL: http://www-yano.is.tokushima-u.ac.jp/ogata/

This paper describes an online markup-based composition learning environment system called **CoCoAJ** (Communicative Collection Assisting System for Java). It allows students and teachers to exchange marked-up documents via Internet, and its environment is very similar to a real world one in which people use pen and paper. In order to record and exchange corrected compositions with marks and comments, this paper proposes XCCML (eXtensible Communicative Correction Mark-up Language), that is based on XML (eXtensible Mark-up Language). XCCML facilitates teachers to analyze and reuse the marked-up documents for the instruction.

Keywords: **Computer assisted language learning, Collaborative writing, XML, Online document correction, Hypermedia.**

1 Introduction

Recently, teacher-centered instructional approaches in traditional writing classrooms are replaced with more active and learner-centered learning approaches with collaborative writing tools[2]. These tools can (1) change the way students and teachers interact; (2) enhance collaborative learning opportunities; (3) facilitate class discussion; and (4) move writing from solitary to more active and social learning. Writing compositions includes various sub-processes such as planning, transcribing, and revising, which do not need to occur in any fixed order [19]. In particular, the review process assisted with computer-based writing tools, has recently received much interest (see as examples [4, 9]).

Many researchers developed online markup systems employing some markup models. However, it is very difficult to analyze and reuse the marked documents that are collected through the writing classroom because the documents do not have a common structure. Therefore, it is necessary to define the generalized format for encoding and exchanging the marked-up documents in order that online markup systems are used easily and widely.

CoCoA (Communicative Correction Assistant system) has been developed for supporting foreigners and teachers to exchange marked-up documents by e-mail [14]. Its environment is very similar to a real one in which people use paper and pen. CoCoA allows teachers not only to correct the compositions sent from foreigners by E-mail, but also foreigners to see where and why the teacher had corrected them. CoCoA improves the opportunities that foreigners have for writing Japanese compositions and for receiving instructions from teachers. **CCML** (Communicative Correction Mark-up Language) [15] has also been proposed for the representation of marked-up documents, which is based on **SGML** (Standard Generalized Mark-up Language) [8]. With CCML, teachers and students can exchange marked-up documents via e-mail [16, 17]. In the experimental use of CoCoA, most of users commented that CoCoA was easy for them to understand the mistakes in documents because of the use of marks, and that the optional view of the original, marked or revised text was very useful. However, CoCoA cannot show users a hypermedia document including figures, tables, movies and links because it deals with only text.

This paper tackles how to correct hypermedia documents by the extension of CoCoA. This paper proposes **CoCoAJ** (CoCoA for Java) to do so. Also this paper describes **XCCML** (eXtensible CCML) for correcting

BEST COPY AVAILABLE

hypermedia documents, that are based on XML (eXtensible Markup Language). XCCML is combined CCML with HTML (Hyper Text Markup Language) that can represent hypermedia documents including pictures, movies, audios and so on.

We have been investigating technological support for Japanese language learning among overseas students. For example, CAI systems called Kanji Laboratory [7], JUGAME [23], GRACILE[23] and JULLIET[1] were developed to support Japanese language learning. However, an on-line mark-up supporting system for Japanese language learning has not yet been proposed. Usually, in a Japanese writing classroom, teachers have to individually review learners' documents using pen and paper[18]. It takes a lot of time for teachers to do this. Therefore, we have implemented CoCoA for writing Japanese composition.

2 Online markup models

There are some editing systems that support teachers to review and correct the students' drafts with online mark-up. Farkas & Poltrock [5] classified the mark-up models as followings:

(1) *Silent editing model*: This is the simplest model and it requires no special techniques. However, it is very difficult for the author to check the editor's work. This model is destructive because the editor cannot readily recover the original words once he/she has changed it.

(2) *Comment model*: This model employs pop-up notes, temporary footnotes, hidden text, and special symbols placed within the text. This model can work for special groups and ad-hoc situations. A system called XyWrite[10] was proposed with this model.

(3) *Edit trace model*: In this model, the editor works in the manner of an author, deleting, adding, and moving text as usual. The computer can compare the editor's new version with the original text, and allows the author to view the draft that contains the editor's changes. This model is apt to encourage heavier editing and less regard for the author's original text. Microsoft Word accepts this model.

(4) *Traditional mark-up model*: This adapts the traditional paper mark-up model to the computer screen. The symbols are both familiar and intuitive for editors and authors; for example, deletion, insertion, and move. For instance, Red Pencil allows the editor to apply a complete set of traditional editing symbols directly to a document. The editor uses "digital ink" to mark a traditional editing symbol along with the words. Moreover, MATE[6] allows the editors to use both digital ink and voice command toward pen and voice computing. In this model, authors and editors can interpret the editor's markings much more readily than in the edit trace model.

There are many systems that employ traditional mark-up which allows multiple users to mark-up an electronic document as if they were marking up a printed copy of the document. However, such systems do not globally come into practical and wide use in composition writing classes because of their special format. Moreover, it is very difficult to analyze and reuse the marked documents because the marked documents are unstructured. Therefore, the system should provide a generalized and structured format for encoding and interchanging marked-up documents via the Internet.

3 XCCML

Based on the experimental results, we propose XCCML for exchanging marked-up documents. XCCML is an application of XML, and it supplies a formal notation for the definition of generalized mark-up languages. XML is a device- and system-independent method of representing texts in electronic form. That is to say, XML is a set of mark-up conventions used together for encoding texts. A mark-up language must specify what mark-up is allowed, what mark-up is required, how mark-up is to be distinguished from text and what the mark-up means.

3.1 Features of XCCML

The main characteristics of XCCML are:

(1) Based on the experiment, XCCML presents six marks and annotation XCCML tags.

(2) The marks have three degrees of importance levels against respective corrections.

(3) The original text is generated through removing all the XCCML tags.

(4) The revised text is derived from the XCCML document.

BEST COPY AVAILABLE

(5) Because XCCML documents are text-formatted, it is easy to send them by e-mail.
(6) CCML documents easily make up full-text databases.
Needless to say, XCCML inherits its features from XML.

3.2 XCCML structure

As shown in table 1, XCCML documents consist of three parts: header, body and close. "Header" represents additional information about the document. For instance, "next" tag denotes the next version of the document. The marks for review are shown in the "Body" as XCCML tags. "Close" shows the editor's comments. In one sentence, "insert," "replace" and "delete" marks were used, while "join," "separate" and "move" marks were used over two sentences. The part between the start tag and the end tag denotes the learner's mistakes. The "string" attribute represents the revised part of the document.

Table 1: Marks and XCCML tags.

Correction	Mark	Tag
1. Insert	text	<Insert string="text"/>
2. Replace	text2	<Replace string="text2"> text </Replace>
3. Delete		<Delete> text </Delete>
4. Separate		<Separate/>
5. Join		<Join/>
6. Move	id id	<Movefrom refid="id"/> <Moveto id="id"> text </Moveto>

(1) Root tags

Tag name	Explanation	Attribute	Attribute's contents	End tag
XCCML	Beginning of XCCML tag	Version	Version number	</XCCML>
Head	Header information	None		</Head>
Body	Corrected document	None		</Body>
Close	Overall comments	None		</Close>

(2) Tags in header section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Title	Title of the document	String	Title name	None
Editor	People who corrected the document	Name	Name of the editor	None
		Email	Email address	
Author	People who write the original document	Name	Name of the author	None
		Email	Email address	

(3) Tags in body section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Insert	Insert words	String	Inserted words	</Insert>
		Level	Level of importance	
		Comment	Comment for the correction	
Replace	Change words	String	Corrected words	</Replace>
		Level	Level of importance	
		Comment	Comment for the correction	
Delete	Delete words	Level	Level of importance	None
		Comment	Comment for the correction	
Separate	Separate a paragraph	Level	Level of importance	None

		Comment	Comment for the correction	
Join	Join paragraphs	Level	Level of importance	None
		Comment	Comment for the correction	
Moveto	Moved position from the original spot	Fromid	ID	None
		Comment	Comment for the correction	
Movefrom	Original position of the words	Toid	ID	</Movefrom>
		Level	Level of importance	
Annotate	Comment for the correction	String	Annotation contents	None
		Level	Level of importance	

(4) Tags in close section

Tag name	Explanation	Attribute	Attribute's contents	End tag
Comment	Overall comment	None	None	Necessary

3.3 Level of marks

We found that the marks do not have the same level of importance. We identify corrections on the following levels:

(1) Weak correction: The learner does not need to revise the document.
(2) Normal correction: The learner should correct the document.
(3) Strong correction: The learner must correct the document.

The strong corrections denote the important part of marks to be revised in the document. Using the importance level that the teacher had entered, the system provides the learner with the marks he/she wants to see. Therefore, the learner can avoid information overload from the reviewed documents. Every tag in table 1 has an attribute "level" that a teacher gives a number from one to three. Its default is two as normal correction.

3.4 Level of annotations

It is very important for a teacher to annotate the marked text for instruction in composition. For example, PREP Editor [12] is a word processor that allows writers and reviewers to create electronic margins, or columns, in which they can write and communicate through their annotations. We identify the following different kinds of annotations:

(1) Explanation: This is used for explaining the reason of a correction.
(2) Question: This is used for asking the learner a question; e.g., what do you want to write?
(3) Comment: This shows the educational view of the teacher with respect to the document.

4 CoCoAJ

CoCoAJ consists of CoCoAJ-Editor and CoCoAJ-Viewer. A teacher corrects the document of overseas students with CoCoAJ-Editor and the system saves the marked document in XCCML format. CoCoAJ-Viewer interprets the XCCML document, and shows the learner the marked document.

4.1 Learning processes using CoCoAJ

By using CoCoAJ, a learner receives instruction about a Japanese composition from a teacher with the following processes:

(1) The learner writes an original text with his/her familiar editor.
(2) The learner sends the document to his/her teacher with his/her own e-mail tool.
(3) CoCoAJ-Editor makes the document double-spaced. The teacher corrects the document with online marks and annotations. Then, the system allows the teacher to set the importance level to the marks in the document.
(4) After CoCoAJ-Editor saves the marked text as a XCCML document, the teacher sends it to the learner by e-mail.

(5) CoCoAJ-Viewer provides the learner with the marked text after interpreting the XCCML document. Then, the system allows the learner to select the importance level to see the important part of the marked text.
(6) CoCoAJ-Viewer automatically generates both the original text and the revised one from the XCCML document. After editing the revised text, the learner can send it again to the teacher and continue refining the text.
(7) CoCoAJ maintains the version of the document, if the learner wants to revise the same document.

4.2 System configuration

Figure 1 depicts the learning environment of CoCoAJ.

(1) XCCML parser: This module analyzes XCCML documents using the XCCML parser after reading them through the file management module. Then, it provides the results of correction according to the level of importance of marks.
(2) Correction module: This module inserts XCCML tags into the learner's document, according to the revision of the teacher. After saving the marked text, the teacher sends it by e-mail to the learner.
(3) Original text display module: This module generates the original text from the XCCML document by removing all the XCCML tags.
(4) Revised text display module: This module generates the revised text by applying XCCML tags.
(5) File management module: This module manages the versions of the documents. When the learner sends the teacher the revised document, the system creates a new XCCML document, inserts the "next" tag into the old XCCML document, and also enters the "previous" tag into the new XCCML document.

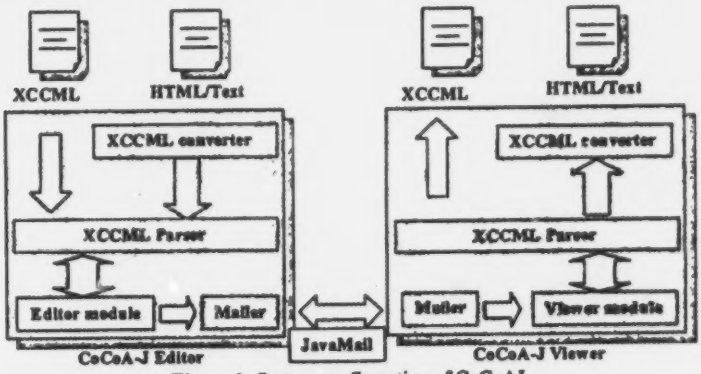


Figure 1: System configuration of CoCoAJ.

4.3 User interface

Figure 2 shows the screen snapshot of CoCoAJ-Editor. First, the learner writes a Japanese composition with a word processor and saves the document as HTML format. After that, the learner sends the document to the teacher by e-mail. By selecting a mark from the mark palette shown in the upper window, the teacher can revise the document. Moreover, the teacher can annotate the document using the annotation palette, and he/she can classify the marks according to the level of importance. The user can see the correcting document at the left side in the window and "*" means the user inserted the comment. The user can see the comments for the correction at the right side in the window. In this figure, the teacher substitutes "allow" with "allows" and gives a comment "*2". Also the teacher can see the original document and revised one by selecting window tag. After saving the marked document as a XCCML (see appendix A), the teacher can send it to the student by e-mail. Using CoCoAJ-Viewer, the learner obtains the same marked text that the teacher revised. By selecting the level of importance, CoCoAJ-Viewer provides only the marks over the level. The learner can reply to the teacher's comments and collaboratively write a composition with the teacher.

BEST COPY AVAILABLE

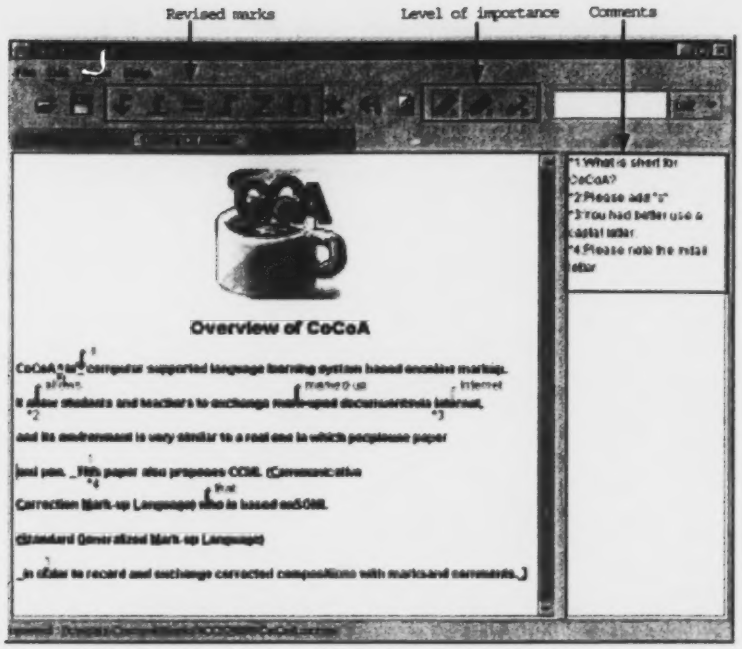


Figure 2: Screen snapshots of CoCoAJ-Editor.

5 Conclusions

This paper proposed a computer mediated language-learning system called CoCoAJ and XCCML for exchanging electronic marked-up documents. Now we are trying to propose XCCML to W3C (World Wide Web Consortium), and to show an XCCML document into Web browsers. After that, CoCoAJ will be able to be used for learning any language in an open-ended writing classroom. In our future research, we will investigate how to classify students' writing errors in their drafts, and how to assist a review process with AI technologies.

Acknowledgment

This research was supported in part by the Grant-in-Aid for Scientific Research (B) (2) No.09558017, No.09480036, and No.09230214 from the Ministry of Education, Science, Sports and Culture in Japan.

References

[1] Ayala, G. & Yano, Y. (1995). "GRACILE: A framework for collaborative intelligent learning environments", *Journal of the Japanese Society of Artificial Intelligence*, vol.10. no. 6. pp.156-170.

[2] Bonk, J. C. & King, S. K. (1995). "Computer conferencing and collaborative writing tools: Starting a dialogue about student dialogue," 1995 Proc. of Computer Supported Collaborative Learning.

[3] Brock, N. M. (1995). "Computerised text analysis: Roots and research," *Computer Assisted Language Learning*, vol.8, no.2-3, pp.227-258.

[4] Coniam, D. (1997) "A computerised English language proofing cloze program," *Computer Assisted Language Learning*, vol. 10, no. 1, pp.83-97.

[5] Farkas K. D., & Poltrock, E. S. (1995). "Online editing mark-up models, and the workspace lives of editors and writers," *IEEE Trans. in Professional Communication*, 38(2), pp.110-117.

[6] Hardock, G., Kurtecbach, G., & Buxton, W. (1993). "A marking based interface for collaborative writing," *Proc. of the ACM Symposium on User Interface Software Techonogy*, pp.259-266.

[7] Hayashi, T., & Yano, Y. (1994). "Kanji Laboratory: An environmental ICAI system for Kanji learning," *IEICE Trans. on Information and Systems*, E77-D(1), pp.80-88.

[8] Herwijnen, E. (1990). *Practical SGML*, Kluwer Academic Publishers.

[9] Kehagia, O. & Cox, M. (1997). "Revision changes when using word processors in an English as foreign languages context," *Computer Assisted Language Learning*, vol. 10, no. 3, pp.239-253.

[10] Kincade, D. & Oppenheim, L (1994) "Marking it up as we go along: Into editorial production's electronic future," *Journal of Scholarly Publishing*, Vol. 25, No. 3, pp.233-242.

[11] Matsumoto, Y, Kitauchi, A., Yamashita, T., Hirano, Y., Imaichi, O. & Imamura, T. (1997) "Japanese Morphological Analysis System ChaSen Manual," Nara Institute of Science and Technology Technical Report NAIST-IS-TR 97007. (in Japanese)

[12] Neuwirth, M. C., & Wojahn, G. P. (1996). "Learning to write: Computer support for a cooperative process," *CSCL: Theory and practice of an emerging paradigm*, Koshmann, T. (Ed.), Lawrence Erlbaum Associates, Publishers, pp.147-170.

[13] Ochi, Y., Yano, Y., & Hayashi, T. (1996). "JULLIET: Interactive learning environment for Kanji compounds learning," *Proc. of Educational Multimedia and Hypermedia 1996*, pp.539-544.

[14] Ogata, H. and Yano, Y. (1997). CoCoA: Communicative Correction Assisting System for Composition Studies, *Proc. of ICCE 97*, pp.461-468.

[15] Ogata, H., Yano, Y., and Wakita, R. (1998). CCML: Exchanging Marked-up Documents in a Networked Writing Classroom, *International Journal of Computer Assisted Language Learning*, Vol.11, No.2, pp.201-214.

[16] Ogata, H., Feng, C., Hada, Y., and Yano, Y. (1999). Computer Supported Proofreading Exercise in a Networked Writing Classroom, *Proc. of ICCE 99*, Vol.1, pp.414-417.

[17] Ogata, H., Feng, C., Hada, Y. and Yano, Y. (2000). Online Markup Based Language Learning Environment, *International Journal of Computers & Education*, Vol.34, No.1, pp.51-66.

[18] Sato, M., Kano, C., Tanabe, K., & Nishimura, Y. (1994). *Practical Japanese Compositions*, Bonjin-sya. (in Japanese)

[19] Scardamalia, M., & Bereiter, C. (1986). "Research on written composition," M. Wittrock (Ed.), *Handbook of research on teaching* (third ed.), Macmilian, pp.778-801.

[20] Schwind, B. C. (1995) "Error analysis and explanation in knowledge based language tutoring," *Computer Assisted Language Learning*, vol.8, no.4, pp.295-324.

[21] Shimano, H. (1986). *Handbook of proofreading*, Miki Publishers, Japan, in Japanese.

[22] Yano, Y., Miyoshi, K., & Hayashi, T. (1993). "Development of a game style environmental ICAI system for Kanji idiom learning," *Proc. of International Conference on Computers in Education '93*, pp.411-413.

[23] Yano, Y., Ogata, H., Sakakibara, R., & Wakita R. (1997). "CoCoA: Communicative correction assisting system for learning Japanese compositions", *Transactions of Japanese Society for Information and Systems in Education*, vol. 14, no.3, pp.21-28. (in Japanese)

Appendix A: **XCCML document in figure 4.**

```
<?xml version="1.0" encoding="Shift_JIS"?>
<!DOCTYPE XCCML SYSTEM "XCCML.dtd">
<XCCML>
<HEAD>
<Title string="Overview of CoCoA"/>
<Editor name="Hiroaki Ogata" email="ogata@is.tokushima-u.ac.jp"/>
<Author name="Yoshiaki Hada" email="hada@is.tokushima-u.ac.jp"/>
</HEAD>
<BODY>
<CENTER><IMG width="128" height="128"
src="image001.gif"/></CENTER><CENTER><H2>Overview of CoCoA</H2></CENTER> <H4>
CoCoA <Annotate level="3" comment="What is short for CoCoA?"/> is<Insert string="a" level="3"/>
computer supported language learning system based ononline markup.<BR/>
 It<Replace string="allows" level="3" comment="Please add &#34;s&#34;."> allow </Replace> students
and teachers to exchange<Replace string="marked-up" level="3"> mark-uped</Replace> document via
<Replace string="Internet" level="1" comment="You had better use a captal letter.">
internet</Replace>,<BR/> and its environment is very similar to a real one in which people use paper<BR/>
and pen. <MoveTo fromid="1" level="2" comment="Please note the initail letter."/>This paper also
proposes CCML (<U>C</U>ommunicative<BR/> <U>C</U>orrection <U>M</U>ark-up
<U>L</U>angua<Replace string="that" level="3">ge)</Replace> who is based on SGML<BR/>
 (<U>S</U>tandard <U>G</U>eneralized <U>M</U>ark-up <U>L</U>anguage)<BR/>
<MoveFrom toid="1" level="2">in order to record and exchange corrected compositions with marks and
comments.</MoveFrom></H4></BODY>
<CLOSE>
<Comment/></CLOSE>
</XCCML>
```

Construct in-service Training Web Site for School Teachers

Jia-Rong Jerome Wen* and Wen-Chin Chen**
**jerome@nknucc.nknu.edu.tw*
***timmy@icemail.nknu.edu.tw*

1 Introduction

Information technology grows rapidly recently. People use Internet to obtain many kinds of information. The Internet has become the most important path in cyber world. In the last five years, using the Internet to carry out distance learning, especially for teachers' in-service training, changes the style of education.

To actualize the policy which was to build an lifelong-learning education environment, Ministry of Education delegated National Kaohsiung Normal University (NKNU) to manage Asynchronous Distance Learning class for high school teachers in Oct, 1999.

2 Construct Asynchronous Distance Learning Web page

Generally speaking, teachers have to control the instructive materials, activities, learning process and evaluation. Every instruction system must include all of the three factors as following:

2.1 Instructive materials and activity designing

If we just put the materials onto web site, they look like electronic books on Internet. It is helpless for students. Therefore, when designing the contents of curriculum, we make it in "practicing" orientation. Activities make teacher and students interact with each other and avoid students to feel humdrum or like reading an electronic book.

2.2 Evaluation

When students finish learning a chapter, we give them an formative evaluation to verify whether students master the thesis or not. If students pass the formative evaluation, they can continue the curriculum. If not, they have to go back and learn it again until they pass the formative evaluation. The system would give some feedback to students, they would know which part of contents they don't understand yet. Then, we always hold an examination when finishing the curriculum, the summative evaluation. (Figure-1)

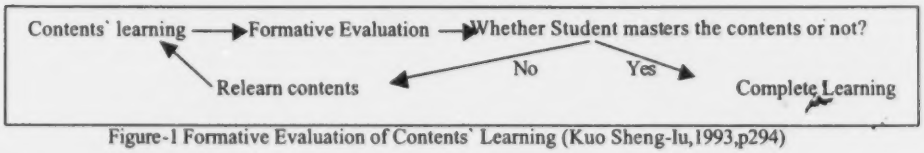


Figure-1 Formative Evaluation of Contents' Learning (Kuo Sheng-lu,1993,p294)

2.3 Learning process

Instead of quantification of examination, we should care about the reflection from students after instruction and learning. Grades cannot decide students' learning efficiency. During designing the materials, we considered every details of students' learning process. These include

- counts in connection
- counts in joining the forum
- contents what student discuss
- chatting situation between teacher and students

- Homework – students work hard or not
- Chapter evaluation (formative evaluation)
- teachers and students communicate by email

All items can be saved into database so that we can estimate student' s behavior in learning.

3 Concepts on designing curriculum

We design several activities and strategies. The activities will make students concentrate on the contents. we consider about the strategies as following:

3.1 Homework:

We assign homework after students finish learning every chapter. They can evaluate themselves through homework to know how much they learn and review contents again.

3.2 Operative Orientation:

In the homework, they have to work some operation by computer, such as computer game.

3.3 Self-determination:

Self-determination means that students have to study by themselves and plan study schedule by themselves.

3.4 Interactive :

We define interaction into two ways : one direction and two direction (Table-1).

	One direction	Two direction
Asynchronous	Announcement FAQ	On-Line Forum
Synchronous		Chat Room

One direction: teacher to student
Two direction: teacher and student

Table-1 Interactive model

3.5 User Interface• •

What users feel about it is very important in internet environment. Hyperlink always be mazes for a novice in the internet. Trying to solve user interface problem , we use several ways as following :

3.5.1 Frame• eut web pages into several frame to reduce confusing

3.5.2 Tree menu• from the reaction of students , the tree menu is easy to access the pages

3.5.3 Learning Path• guideline for students on the web

References

[1] Fred Jevons."Distance Education and Campus-Based Education : Parity of Esteem", New South Wales, Australia : Peter Smith and Mavis Kelly. (1987)

[2] Kuo Sheng-lu(1993). "The Evaluation of Psychology and Education", Chin-Hua , 7th Edition., (1993).

[3] Lisa Neal(1998). "Distance Learning". ACM(http://www.acm.org)(accessed on May 15,2000).

[4] Mei-Sheng Chao, "The Impact of a Systems Approach on Interactive Distance Teaching: The Development of the ATM Video Network System at National Chung-cheng University", ETR&D, Vol 47. No 2. pp. 112-117(1998).

[5] Sun Chuen-tzai, Chu Ching-hao, & Shiu Idi, "The research of constructing hypermedia teaching material", Information and Education• vol. 67• pp 13-25(1998).

[6] Wang Chien-Shin, "Web-based network system for instructive management", Information and Education, Vol. 67• pp 3-12(1998)

[7] Wen Jia-rong, "The research on present Statement and Requirements of junior-high-school Information Education", Information and Education, Vol. 51, pp17-26(1996)

[8] Wen Jia-rong, Wu Ming-lung , "Information Education Theories and Applications in New Age ", Song Kang ,1st Edition.(1999).

[9] Han Shan-ming, "Information Education Fundamental Construction – Speed", Information and Education, Vol. 68, pp14-16 (1998)

Design and Implementation of a Chinese Web-mail System

Chang-Sheng Chen*, Jian-Liang Liu and Shian-Shyong Tseng****
Department of Computer & Information Science, National Chiao-Tung University
1001, Ta Hsueh Rd., HsinChu, Taiwan 300, R.O.C.
Tel: +886-3-5731721 Ext.56605
Fax: +886-3-5721490
**E-mail: cschen@cc.nctu.edu.tw*
***E-mail: jlliu@cis.nctu.edu.tw, sstseng@cis.nctu.edu.tw*

E-mail is one of the most popular services on Internet. Fast message transportation, good GUI designs and enhanced localization capabilities in end-user environments are the key factors. However, there still exist some addressing problems for many users since it is based primarily on the ASCII character set. For those who do not know English well, ASCII set is hard to memorize and is prone to making errors. As more users joining the Internet, this kind of problems should not be ignored. Especially, these become major problems for students and teachers in primary/secondary schools. Currently, many approaches are proposed to support the Chinese and/or multilingual DNS name resolution. However, according to our study, most are designed to support URL addressing with Chinese characters in between. Few if any works on the e-mail addressing issue. This paper presents a description of our experimental system, which supports localized Chinese e-mail address mapping by using the LDAP directory service. In the future, if there is any standardized multilingual addressing scheme available, it could be incorporated into our system. The same user interface could still be used. With minor modifications, the same approach should be easily adapted for utilization in other language system.

Keywords: **Chinese, LDAP, URL, web-mail**

1 Introduction

E-mail is one of the most popular services on Internet. Fast message transportation, good GUI designs and enhanced localization capabilities in end-user environments are the primary keys. Most people would like to communicate with each other via their native language(s) if possible. By the efforts of computer scientists, most of us could write and read e-mail contents in local language today. However, as to the addressing part, that is another story. There still exist some addressing problems in internetworking for many users because they are based on the 7-bit ASCII character set. For those who do not know English well, ASCII character set is hard to memorize and is prone to making errors. With more users joining the Internet, this kind of addressing problems should not be ignored.

Up till now, there is no multilingual addressing standard, no multilingual registry in gTLD[11], ccTLD on the DNS[7] naming infrastructure. Currently, RFC 1035[7] is the main implementation obstacle. It limits the valid domain name character set to be a subset of the ASCII character set. Furthermore, while using in DNS, all the capital letters and their corresponding little characters are treated as the same by historical reason. These make the non-ASCII addressing still not possible in general.

There are many proposed approaches [10][13][17] to support the Chinese and/or multilingual DNS name resolution. To name a few, internetworking scientists in Asia Pacific region (including China, Hongkong, Japan, Korea, Singapore, Taiwan, etc.), RIPE, etc., are undertaking some IDN projects for developing multilingual addressing environments. However, according to our study, most of the proposed solutions are mainly designed to support the URL addressing with multilingual characters in between. Few if any

addresses the e-mail addressing issue.

We had designed and implemented a web-mail system with Chinese addressing capabilities by incorporating the LDAP directory services [3][4]. Conceptually, we could view an ASCII e-mail address as one of the attributes of some user's profile. By storing users' profiles on directory servers, software with directory-enabled capabilities could be easily used to extract the ASCII e-mail information for further utilization. In this way, our system provides a workaround solution for the Chinese e-mail addressing problem indirectly by translating a Chinese name to its corresponding ASCII e-mail address. The same approach could be easily adapted for utilization in other language system.

1.1 Chinese E-mail addressing

Every e-mail message could be divided into two parts: the header and the body. Now the problem to send messages with multilingual characters in the body can be dealt with by using MIME[1]. Before sending, the sender programs encode messages with the MIME standards. The messages are then transported over the Internet to the destinations. At last, they are decoded with MIME enabled clients. However, as for header sections, we still do not have a standard solution for non-ASCII addressing. Up to now, almost all mail client and server software on Internet commu nicate with the ASCII addressing expression only. Could there be any systematic approach (or workaround solutions) for supporting non-ASCII e-mail addresses?

To further describe the main ideas, let us check the three (pseudo) e-mail expressions shown below:

- jsc.cis84@nctu.edu.tw
- Jian-Shyong Chen< jsc.cis84@nctu.edu.tw >
- • • • •< jsc.cis84@nctu.edu.tw >

On the first look, they seem different; however, basically they mean the same thing. That is, jsc.cis84@nctu.eu.tw is the true component for e-mail address routing. However, using LDAP addressing book, the last form with Chinese name could be a good candidate for providing a workaround solution to support multilingual addressing.

1.2 Web-based Environment

WWW browsers have become standard applications for Internet access today. For those who do not have their own computers on working places (e.g. students in school environments), there are some obvious advantages through using browsers to send or receive mails:

- No additional software is necessary. All one need is a browser program.
- The browser programs (e.g. IE, Netscape, etc.), being the most popular software, can often reduce the learning time of users.
- Web-mail systems could be easily adapted for supporting roaming access.

1.3 Mail Routing with Directory Service Support

By putting e-mail addresses with forms like the last one shown above onto LDAP directory servers and through the translation of directory-enabled web-mail systems, we could achieve the goal of communicate with multilingual addressing indirectly. This is promising for many people.

Let us describe the working paradigm shown in Figure1. The mail routing is performed as below.

- The user types the Chinese name of the recipient (for example, "• • • •"), together with additional information (e.g. school name, city name, etc.), through the client mail interface.
- The client then consults the LDAP server to see if there is any one matching the search condition. If yes, all the matched people's information will be returned to the client, and the user can choose the one wanted. After that, the LDAP Server will return the related ASCII e-mail address of the recipient
- Using the returned ASCII e-mail address, the client sends the message to the destination SMTP server.

In principal, there is no need to alter the original mail server routing. It works as before on one condition. That is, if there are distributed LDAP servers on the related sites, with chaining and referral capabilities enabled.

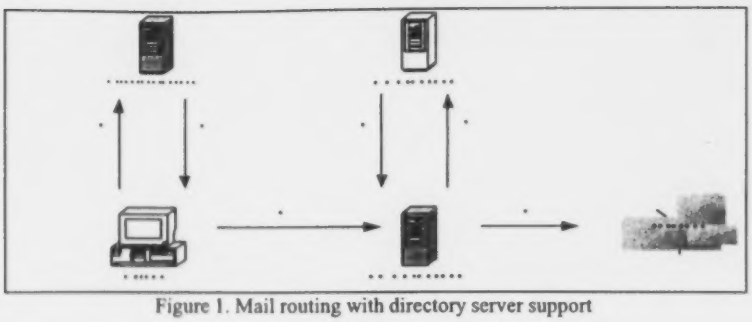


Figure 1. Mail routing with directory server support

2 Related Work

There are several proposed approaches to solve the Chinese URL addressing problem. Three of them will be described briefly in Sec.2.1, Sec.2.2, and Sec.2.3. Interested users are encouraged to visit the related web sites for more details. In Sec.2.4, we will describe the main practical problems of these systems.

2.1 mDNS [13]

The mDNS project is under joint development by researchers in TWNIC, Academia Sinica, and National Central University, Taiwan. The goal is to develop an internationalized DNS system to help the "non-English" DNS architecture to become standardized. mDNS would not effect the existing gTLD or ccTLD. Although the proposed experimental architecture can accept Chinese (BIG5) URL, it is not full Chinese URL. It is necessary to modify the source code of the ".tw" root server; however, it is not necessary to modify the existing client software.

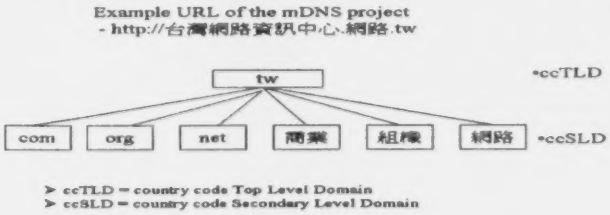


Figure 2. The experimental architecture of the ccTLD ".tw"

2.2 iDNS [17]

The iDNS project is mainly under development by Singapore researchers. As shown in Figure 3, the key component of iDNS is the domain name proxy server, which translates the i18n (internationalization) domain name to the format of UTF-5 and transmits the translated format to the real DNS server. When the iDNS system receives the ASCII domain name, it will consult the old existing DNS system. However, if it receives the non-ASCII domain name, it will be routed to the i18n branch system.

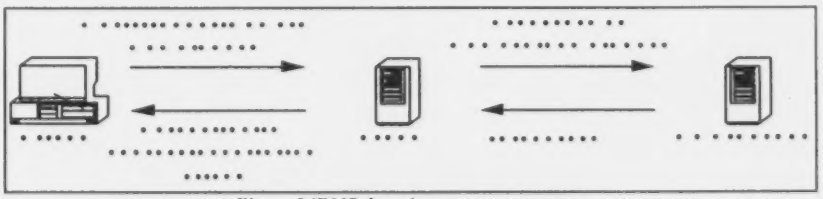


Figure 3 iDNS domain name proxy server

2.3 cDNS[10]

The cDNS project, run by researchers in CNNIC, is developing similar scheme. The main idea of cDNS is the proposed ***DNS forest*** architecture instead of the traditional rooted DNS tree structure. Interested users are supposed to refer to the web site of CNNIC for further details.

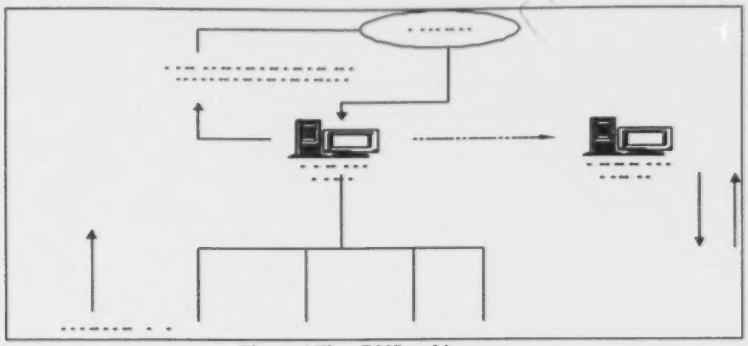


Figure 4 The cDNS architecture.

2.4 Practical Application Problems

Although it looks promising in the first place; however, up to now most of the proxy/caching and mail servers (ex. Squid and sendmail) cannot accept non-ASCII addressing. As mentioned in the introduction section, RFC 1035 is the current implementation obstacle, which breaks all the paradigms. It's nearly impossible to keep compatibility with the current system without modifying the source code of these servers, recompiling and reinstall the systems.

3 Overview of the LDAP Directory Service

It seems that we could not get an immediate multilingual addressing solution without modifying the existing servers all over the Internet. That is why we think that the LDAP enabled web-mail system might be a good workaround solution to try. Before further on, let us make some introduction on LDAP.

3.1 Why LDAP?

Historically, X.500 [3][4] is based on the ISO stack. It is just too complex and hard to implement in the real environments. LDAP [3][4][8][9] is the protocol initially designed as one front end of X.500. Since LDAP can be easily implemented and can be used to exchange information between LDAP servers, standalone LDAP directory server becomes popular gradually. As shown in Figure 5, Desktop PC can access the data of LDAP/X.500 directory server by LDAP protocol.

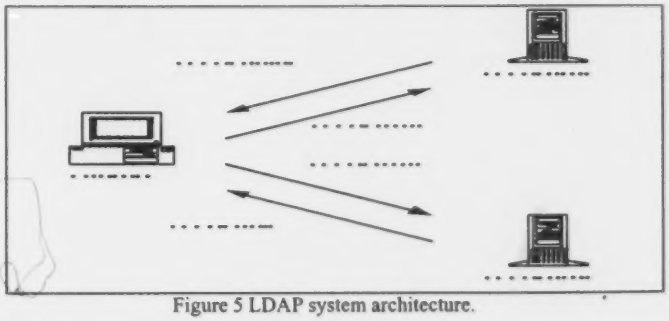


Figure 5 LDAP system architecture.

3.2 How Does LDAP Work?

LDAP stores the information hierarchically, where data is stored as key-value pair. [4][6] Each key will be mapped to one or many values. For example, *cn* (common name) will be used to store user name, mail will be used to store user's email address, etc [2][4]. Every node in the tree architecture of the LDAP directory will be viewed as an object, which has one or many *objectclass* attributes to identify the node. The *objectclass* definition of the system is that it should have what kind of attributes and it is allowed to have what kind of attributes. We also can extend the original *objectclass* by adding the attributes we want. Every node in the tree will be identified by *DN* (Distinguished Name) attribute [4][6]. The hierarchical relationship of the tree can be divided by locality or corresponding categorization. For example, the directory tree could be constructed according to the domain name. From the top level, c=tw (country code), o=edu (organization), ou=NCTU (organization unit) to ou =CIS (organization unit), the information in an example leaf node is a student named jacky, studying in the Dept. of Computer and Information Science. Through the tree architecture, LDAP clients can perform search, delete, modify operations and any site manager can add ACL (Access Control List) mechanism to control the access. [3][4] For more details, interested users are encouraged to read the related LDAP documents listed in the reference sections. [3][4][6][15]

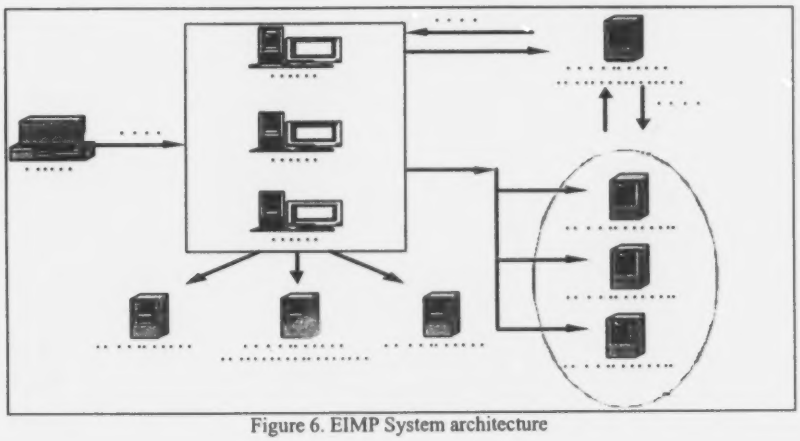


Figure 6. EIMP System architecture

4 Our System Design

We built up an EIMP (Enhance IMP; based on the IMP[12] project) system on a Linux platform [14][15]. The main system components are Apache+PHP(WWW), IMAP+Sendmail(Mail), OpenLDAP(LDAP), etc. We enhance the web-mail system by integrating the LDAP directory service and adding the Chinese naming capabilities. As shown in Figure 6, users can connect the logon server through www browsers and types his/her user name (Chinese or ASCII) and password. After passing the authentication, the LDAP server will return the user's IMAP[14] server location to the logon server. Then it will connect the related IMAP server to retrieve the user's mail(s). On the other hands, users can send mails through the SMTP server and store their address book information in the database server. Thus, for users wishing to send mail to his friends, even if they do not remember the exact email address, they can still find the email addresses by the help of LDAP servers, as shown in Figure 7.

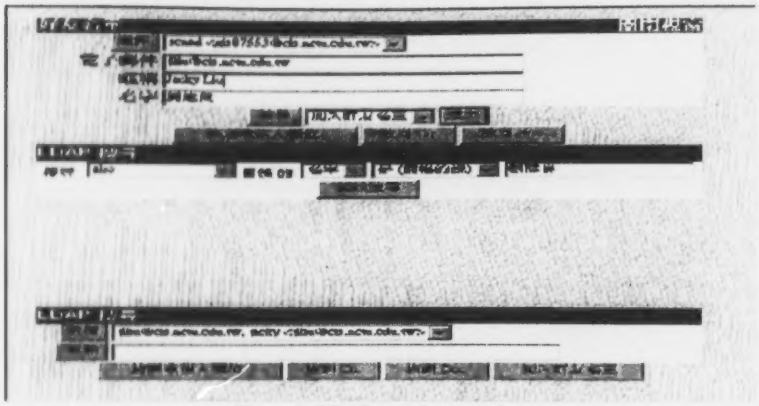


Figure 7. LDAP search screenshot

5 Problems and Discussions

As we know that, although it looks promising; however, up to now most of the proxy and mail servers (e.g. Squid and Sendmail, etc.) cannot accept non-ASCII addressing. Hence, it's nearly impossible to keep compatibility with the current system without modifying the source code of these servers, recompiling and reinstall the systems.

Non-ASCII communication issues are new hot topics in many research applications. While this is true in the DNS system, similar situation appears on the LDAP protocol suites. As more directory servers have been set up, there are more chances for directory servers to share and exchange their information through chaining or referral [3][4][5]. LDAPv3 addresses the issue by using the UTF-8 [16] encoding, while LDAPv2 use T.61, which lacks the capabilities to handle 8-bit data. Hence, in building distributed Directory server groups, software packages with LDAPv3 ready should be the proper choices.

We choose the IMAP (and not POP3) protocol for serving our mail access since IMAP servers support both the offline and the online modes. Currently, most sites use POP3 as the access protocol since it is simple and usually gives low impact to the system performance. However, as the POP3 protocol operates only in off-line mode, it could not meet the new trend for supporting the e-mail roaming access.

6 Conclusions

E-mail is one of the most used Internet applications today. However, non-ASCII addressing system is still a research issue. Most of the proxy and mail servers (e.g. Squid and Sendmail, etc.) still cannot accept non-ASCII addressing. Internetworking scientists from members at APNIC, RIPE, etc. are undertaking some piloting projects for producing multilingual internetworking standards. However, no one knows when the solutions will be ready. This is not good for primary/secondary school education on most parts of the world.

In this paper, we describe our approach for the Chinese e-mail addressing and authentication problems. We have designed and implemented a web-mail system with Chinese addressing capabilities by incorporating the LDAP directory services. Conceptually, we could view an e-mail address as one of the attributes of some user's profile. By storing users' profiles on directory servers, software with directory-enabled capabilities could be easily used to extract the ASCII E-mail information for further utilization. In this way, our system provides a workaround solution for the Chinese e-mail address problem by translating a Chinese name to its corresponding ASCII e-mail address. This should be promising for many people. For example, using such LDAP-enabled web-mail system, primary/secondary school education could benefit a lot since most of the communication activities could be done in their local native language.

In the future, if there is any standardized multilingual addressing scheme available, it could be incorporated into our system. The same user interface could still be used as well. Furthermore, with minor modifications,

the same approach should be easily adapted for utilization in other language system.

Acknowledgment

This work was supported by the National Science Council of the Republic of China under Grant No. NSC89-2511-S-009-014. We would like to thank the anonymous reviewers for suggesting improvements and offering encouragement.

References

[1] Freed, N., Borenstein, N. "Multipurpose Internet Mail Extensions (MIME) Part One: Format of Internet Message Bodies", RFC 2045, (1996)

[2] Howes, T., etc., "The String Representation of Standard Attribute Syntaxes", RFC 1778, (1995)

[3] Howes, T., etc., "A Scalable, Deployable, Directory Service Framework for the Internet", INET 95

[4] Howes, T., etc., "Understanding and Deploying LDAP Directory Services", Macmillan Technical Publishing, (1999)

[5] José, Rui J.P.; Costa, António; Macedo, Joaquim; Freitas, Vasco, "Providing multiple external views on directory user interfaces" in Computer Networks and ISDN Systems, Vol 28, No. 4, pp. 543-550, (1996)

[6] Kille, S., "A String Representation of Distinguished Names", RFC 1779, (1995)

[7] Mockapetris , P., "Domain Names--Implementation and Specification" ,RFC 1035, (1987)

[8] Wahl, M., etc., "Lightweight Directory Access Protocol (v3)", RFC 2251, (1997)

[9] Yeong,W., Howes, T., Kille, S., "Lightweight Directory Access Protocol", RFC 1777, (1995)

[10] Chinese Domain Name Consortium, http://www.cdns.org/e-index.shtml (accessed on August 1,2000)

[11] ICANN, http://www.icann.org (accessed on July 1,2000)

[12] IMP@horde.org, http://www.horde.org/imp (accessed on April 23,2000)

[13] mDNS TANet Testing Project, http://mdns.twnic.net.tw, (accessed on June 1,2000)

[14] Message Access Paradigms and Protocols, http://www.imap.org/papers/imap.vs.pop.html (accessed on May 9,2000)

[15] LDAP Linux HOWTO, http://www.linux.org/help/ldp/howto/LDAP-HOWTO.html (accessed on May 10,2000)

[16] Unicode - Basic Questions, http://www.unicode.org/unicode/faq/ (accessed on June 1,2000)

[17] Welcome to iDNS , http://www.idns.org (accessed on June 1,2000)

Design and Implementation of A N-Tiered Heterogeneous Virtual School Administration System

Huang Gooshyon
Tamkang University Information Center
151 Ying-chuan Road, Tamshui, Taiwan 251
Tel: +886-2-2621-5656-2681
E-mail:georgehw@mail.tku.edu.tw

There are two types virtual school administration systems, web-based or voice-based, which are currently used by students. They are systems with different access mechanisms but same business logic, and require two times of resources for development and maintenance. Whenever the business logic of the systems changes, both of the systems need to be implemented. As the wireless communication grows more popular, the school has been considering adding a wireless interface to the system. However, with current architecture, the only way to add a wireless application protocol (WAP)-based system is to implement an additional system from scratch. Since the voice-based system and the web-based system have the same business logic, they can be integrated into one. We can dedicate an application server for the business logic, which interacts with the web-based interface and the voice-activated interface with a set of application programming interface (API). With the extraction of the business logic and the business logic API, developers for the voice-activated interface and the web-based interface can implement the interfaces without specific knowledge of the business logic of the system. With this design and architecture, the system can be further expanded to support a WAP-based interface and other interfaces easily.

Keywords: **Internet, wireless, virtual school, heterogeneous**

1 Introduction

The Internet is widely used for school education, especially virtual school education [2][3][4]. The advantage of the Internet is its capability of supporting multimedia and its attractiveness to the user. For the virtual school education, the students study via the Internet. They do not have to be in the classrooms of a school and can learn at anywhere at anytime. However computers and communication networks are needed to support virtual education through the Internet. The cost of the computers and setting up the communication networks is very expensive. Thus, the systems are not available everywhere. Furthermore, system interfaces must be developed in order to allow the users to access the computers and the networks. The purpose of these system interfaces is to provide an easier way for the students to access the systems and to allow the students to interact with the instructors real-time. Those systems interface do not need to be attractive and colorful since its main goal is to provide a mechanism for the students to access information real-time. For a web-based system, the homepage can be design in a way to reduce the network traffic and system load. However, not every student can access the computers and the networks due to his financial situation or the load of the system. For the students who cannot access the computers and the networks, the telephone (the voice activated based interface) provides another popular access media. Therefore there are needs for systems to support both telephone (voice- based) and web browser (web-based) interfaces [1]. The web-based system is more visual and more user friendly, however, the voice-based system is more convenient, more affordable, and requires no hardware investment from the students. As the technology evolves, the wireless communication is gradually taking over the traditional wire line communication. To support the wireless communication the system will need to be expanded to support the wireless application protocol (WAP)-based interface [10].

Originally, a couple of the school administration systems we had can be accessed via a regular telephone or via a web browser but not both. They were basically two different systems, though they support the same business logic. Both of them have their own user interface and system logic and were designed, implemented, and maintained separately. To support them two sets of resources are needed. The original system architecture is shown in Figure 1. Developers for both of the systems handle both the business logic's and the user interface's design and implementation. Whenever the business rule changes, both of the systems need to be modified and updated. It is very costly and difficult to keep both of the system consistent.

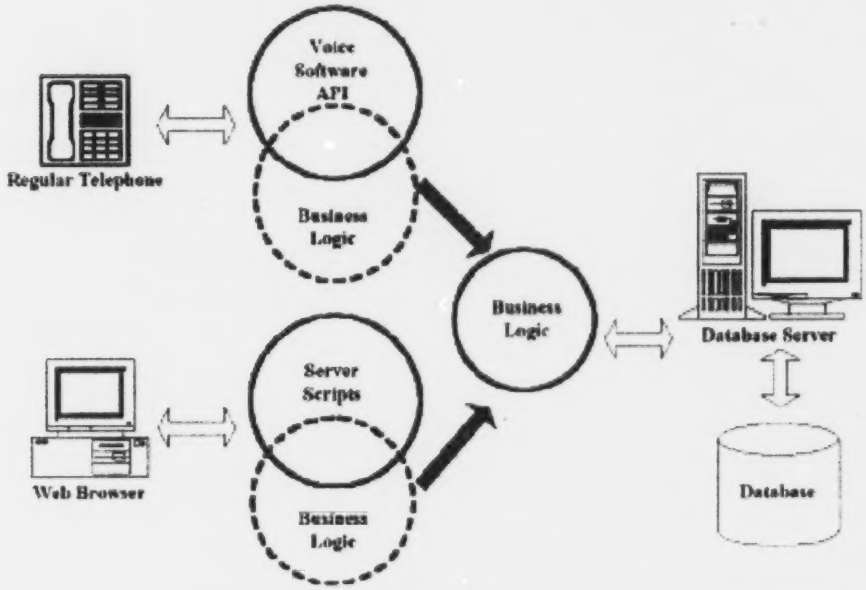


Figure 1. Logic view of voice system and web system

To reduce the maintenance cost of the two systems and to make them easier to be upgraded and expanded, we have proposed to integrate the two systems by extracting the business logic module out of them and migrate it into an application server. The remaining of the systems is migrated into a web server and a voice server respectively. By doing this, we dramatically reduced the cost of maintaining the system. After the architecture change, whenever there is a business change, only the application server is affected. We reduced the maintenance cost by 50%. No more concerns about the consistency of the systems. With the modification of the system architecture, we make it more scalable and expandable. The system can be easily expanded to support other access media without making changes to the application server. For example, to support a WAP-based interface, a WAP server can be easily introduced and integrated into the modified system architecture.

2 System Architecture and Implementation

2.1 Architecture

The administration system is an N-tiered system.

- Data Services Tier: The database services and implementations.
- Business Logic Tier: The business rule of the system.
- Translation Tier: Translate the I/O between application server and gateway server. For the voice-based system, the gateway server is the voice server. The purpose of the voice server is to translate PSTN and HTTP between application server and usual telephone. For the web-based system, the translation tier is transparent; it does not do anything. For the WAP-based system, the WAP Gateway is the gateway server. The purpose of WAP Gateway is to translate the WSP/WTP and HTTP between WAP telephone and web server.

- Presentation (UI) Tier: The input and output of the web-based system is HTML. The input and output of the voice system is the key press and voice of usual telephone. The input and output of the WAP-based system is WML [10].

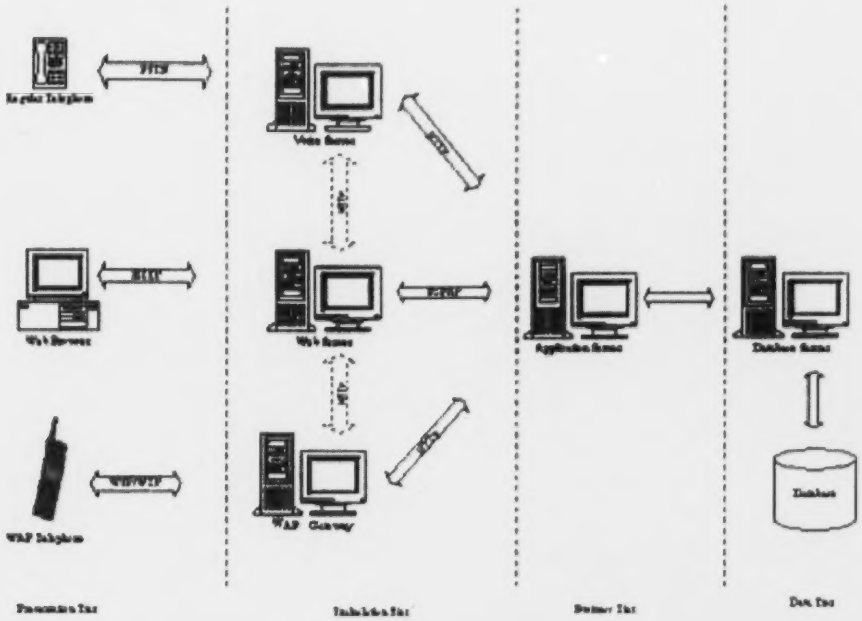


Figure 2. System Architecture

In the Architecture, the application server is the most important part. The application server needs to process business logic and interact with voice server, web server, and WAP Gateway. Because the protocol between the application server and the voice server and the WAP Gateway is HTTP protocol, we can set the application server and the web server in the same machine. The developers of the application server are more responsible, because they must handle business rule, HTML and WML. The developers of the other systems implement User Interface and do not have the knowledge of business rule of the system, because the developers of the application server handle the business rule. The application server sends different output format to different systems by parameters. Under the Architecture, after building the web system, the other systems are easily to build.

2.2 Architecture of the Voice System

Because taking business logic out of the voice system, the function of voice system is coherent. It translates the output of web server to telephone. The output format of web server is HTML. So the voice server has to simulate to web browser, shown as in Figure 3.

Figure 3. The communication methods are between voice server and web server.

BEST COPY AVAILABLE

3 Case Study

The Enrollment System of the Tamkang University [7] is designed and implemented following the architecture of this paper, shown as in figure 4. The system has been deployed and used by thousands of concurrent users [8].

3.1 Hardware Structure

We used thirteen Pentium based servers to implement the system. Six of them are used as the web servers. One machine is used as the UNIX Gateway. One server is used as the alert and automating email server. Four voice servers are used to support the voice activation. Finally, all student enrolment information is stored in one database server. The network hardware are two 100 MB/sec switch hub.

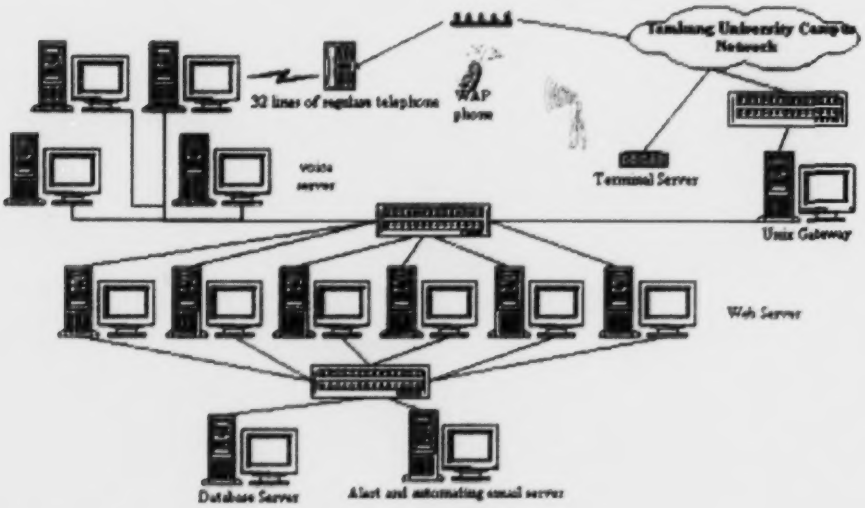


Figure 4. System Hardware Structure

3.2 System Software

OS: Microsoft NT4.0 is used for the web servers, voice servers, and the alert and automating email server. Free BSD 3.0 is used for the UNIX Gateway [8].
Web server: Microsoft IIS 4.0.
Database: Microsoft SQL Server 6.5.

3.3 Load Balancing and Scalability

To make the system suitable for all schools, we also took into considerations of the cost of hardware and the scalability of the system. A set of low-end servers can be grouped together to replace a high-end server[6]. To achieve this, a DNS server is needed for the load balancing work. The simple round robin methodology is used for the load balancing. With the current flexible four-tiered architecture, servers can be added into the system to share the performance load whenever the system load is heavy[9].

3.4. Security

Two security strategies are used to increase security:

1. Packet filter: It only allows IP packets through port 80 to access the web server, the packets of the other ports can not pass through. The web system can avoid being attacked by the other machines.
2. Supports multi-protocol: TCP/IP protocol is used between the web server and outside systems. IPX protocol is used between the web server and the database server. The web server should be hacked, the database server is kept away Internet and the database is still safe.

BEST COPY AVAILABLE

3.5. Network Management and Monitoring

The alert system has the following features:

1. Monitoring the system: It sends to keep-alive message to web servers, voice servers, and database servers in every period.
2. Network management system: Checks network traffic between web servers, voice servers and database server.
3. Auto Backup the data of database server.

3.6. User Interface Design

One of the most important criteria of the virtual school administration system is to let students access and retrieve correct information real-time. The user interface must be simple to reduce network traffic and system download time. The homepages for the web system and WAP are simple and straightforward to improve system performance. The look and feel of the WAP homepage depends on the WAP telephone the user users. An Ericsson r320 model WAP homepage is shown here as a sample WAP homepage. We can compare the home pages for the web system and WAP system.

Figure 5. The display of the homepage of WAP-based system

3.7 Log statistics and analysis

Duration of enrollment period, the system generates the log automatically everyday for statistics and analysis, as shown in Table 1.

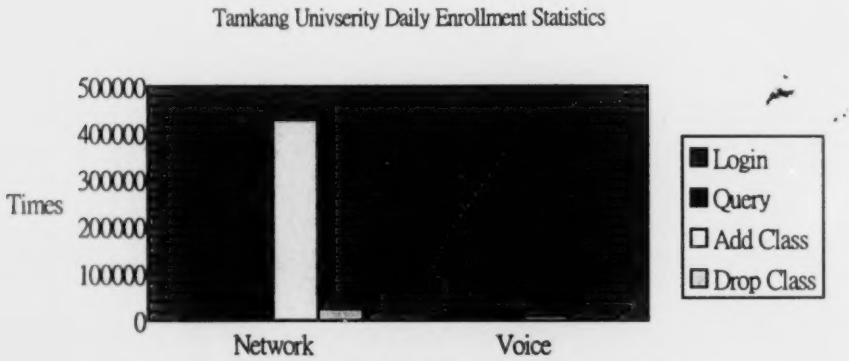


Table 1. Tamkang University Daily Enrollment Statistics

BEST COPY AVAILABLE

By comparison, the load of the web system is much heavier than the load of voice system. Since the voice system has 32 telephone lines, it can only support 32 concurrent users. In the peak hour of the enrollment (the first hour of each grade enrollment), the load of the web server is high.

We expect the voice system and the WAP system to be fully loaded during the peak hour. A dedicated business logic-processing server is used for the voice system and the WAP system. Since the telephone lines of the voice system and the WAP system are limited (up to 32 lines), a dedicated web server for the business logic processing of the voice system and the WAP system is sufficient.

4 Conclusions and future development

The development and maintenance resource of the heterogeneous systems depends on how many access media. The more access media, the more resource it needs. My proposal has the following advantages:

- Resource Reducing: Because the business logic is centered, heterogeneous systems need one business-logic process only, the resource of development and maintenance is less than usual systems.
- Expandability: With the N-tiered system architecture design, the business logic system was designed and implemented to support different UI systems. Different UI access method can be easily added into the system.

In the system, the application server interacts with voice server and WAP Gateway on HTTP protocol., so the application server must have functions of the web server. We can develop a new structure of the application server for voice-based system and WAP-based system, and the application server interacts with the voice server and WAP Gateway on TCP/IP.

References

[1] C. Chou and C. T. Sun, "A Computer Network-Supported Cooperative Distance Learning System for Professional Communication Education", IEEE Transactions on Professional Communication, Vol. 39, No. 4, pp. 205-214, (1996).

[2] Colin McCormack & David Jones, "Building a Web-Based Education system", John Wiley & Sons, (1998).

[3] Dwyer, D., Barbieri, K.& Doerr, H. M., "Creating virtual classroom for interactive education on the Web", Computer Networks and ISDN Systems 27, pp. 897-904, (1995).

[4] Nian-Shing Chen, "Web-based Learning Environment", Information and Education, Vol. 64, April, pp. 2-13, (1998).

[5] C. T. Sun, C. Chou & B.K. Lin, "Structural and Navigational Analysis of Hypermedia Courseware", IEEE Transactions on Education, Vol. 41, No. 4, CD-ROM, November, (1998).

[6] Chen-Chung Liu, Gwo-Dong Chen, Kuo-Liang Ou, Baw-Jhiune Liu & Jorng-Tzong Horng, "Managing Activity Dynamics of Web Based Collaborative Applications", International Journal of Artificial Intelligence Tools, Vol. 8, No. 2, (1999).

[7] Gooshyon Hwang & Chao-Tsong Fangtsou, "Introduction of Tamkang University Enrollment System", Ministry of Education Computer Center Newsletter, Vol.8802, (1999)

[8] Jack Chou, "NT Dynamic Web Server Design", Unalis Company, (1997)

[9] J.J.P. Tsai, S.J. Yang & A. Liu, "An Integrated Architecture for Distributed Real-Time Systems Analysis", in IEEE Second World Conference on Integrated Design and Process Technology, Austin TX., pp. 152-159, (1996) Dec. 1996

[10] WAP Forum, http://www.wapforum.org/what/whitepapers.htm (accessed on July 1, 2000)

BEST COPY AVAILABLE

Design and Implementation of a WWW - Based School Official Memorandum System

Gi-Ping Lee, Yue-Shan Chang and Ching-Chuan Chou
Department of Electronic Engineering, Ming-Hsin Institute of Technology
1 Hsin Hsing Road, Hsin-Fong, Hsin-Chu, Taiwan 304 R.O.C.
louis@mheman.et.mhit.edu.tw, ysc@mhit.edu.tw, ruth@mhit.edu.tw

1 Introduction

The official memorandum is a very important document that offers a decision path of something in the most organizations. In general, the executed policy usually needs agreement of decision-maker through official memorandum. All the official memorandums are traditionally passed by one-by-one human delivery from faculties to managers in an organization. It may results in the lower performance of administrative. Even though some administrative operations are via e-mail or other approach. It have some limitations, such as the official documents usually need the signature of decision-maker, it is not ease to overcome via the e-mail.

In order to have a speedy the administrative operation environment, especially the official memorandum delivery, we design and implement a WWW-based Official Memorandum System in a school. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application.

Obviously, the system is based on the client-server model. Implementing the system has some existing techniques can be used, such as CGI, Java/Servlet [3], Java/CORBA [3]. Lotus' InterNotes [1] product uses CGI mechanisms to allow Web browser access to documents and forms managed by the Notes Server. Documents to be placed on the Web are translated by a program to HTML. These documents and forms are accessed through a standard HTTP server as though they were normal HTML documents. Java is a portable object-oriented language, and also a good platform for writing client/server web-based applications. Servlets are secure protocol and platform-independent server side web-enabled software components, written in Java. Java/CORBA has a clear advantage over CGI solution, such as flexibility, maintainability, and responsiveness etc.

Security issue in the system will be taken care by using traditional approaches. There are two secure mechanisms will be used: one is account/password, the other is the firewall. First one can prevent non-authority user log-in into system and disrupt the system. All the general users must apply for an account excepting the chief of department. And the system will force all users to change the password periodically. This mechanism can avoid internal hackers. Second one is to avoid external hackers who intrude into system for non-authority accessing. Few hackers, of course, can intrude into and disrupt the system. Some approaches can be used for enhancing the security of information, such as data compression/decompression before accessing to/from database and checking the data consistency of duplicated database periodically. All of them are the future works

Fault tolerance is in order to enhance the reliability of system. In fault-tolerance community, many approaches have been proposed to enhance the data reliability [4,5]. The approach in the system is database replication. We use warm stand-by primary/backup scheme to improve the system availability. Many issues in the data replication that have to be guaranteed are employed like the [5]. These issues are such as idempotent operation, data consistency, and recovery. Because the system is a three-tier scheme, all operations supporting fault-tolerance are implemented in the core of the system. This feature can also prevent the database crash during the formal execution phase.

A complex system has to be manageable in an easy way. In order to enhance the system flexibility, a web-based management tools should be implemented. System manager can add and remove user easily. In

BEST COPY AVAILABLE

addition, system manager can also maintain the database, such as record manipulation, in an easy way.

Many features are described previously. In addition, we will support some important functions shown as following: Official documents writing, Official documents progression tracking, Auto-delivery, Automatic signing, Urgent document notification.

2 Design and Implementation

According to the described above, we design the system architecture like as Figure 1. The architecture is simple and complete. The system includes an Official Memorandum System and a replicated database. The system will receive requests from clients. For security issue, we add a firewall in the front of web server. All the requests must be checked by the firewall for ensuring the request is an authority request. In addition, the Official Memorandum System is responsible for all the features described above, which include fault-tolerance. A replicated database is also included in the system. The database used in the system is the SQL database.

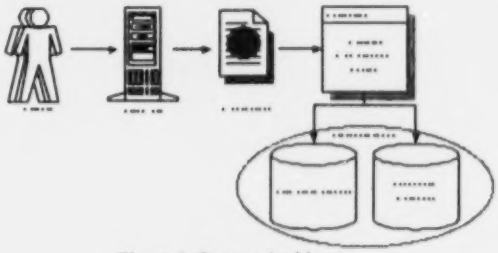


Figure 1. System Architecture

The whole system is implemented and run on the Windows NT 4.0 and SQL server 7.0. The programming paradigm is ASP that using VBscript. With the fault-tolerant, the system needs to access primary and standby database separately. To guarantee the consistency of two databases, we apply the traditional two-phase commit protocol on the replicated database transaction processing.

Figure 2 shows the GUI of document reviewing for those chiefs of department. When they login into the system, the system will show the urgent document on top of the reviewing page, which indicate these documents have to review first. The document reviewing process will sign the signature automatically when the process achieved.

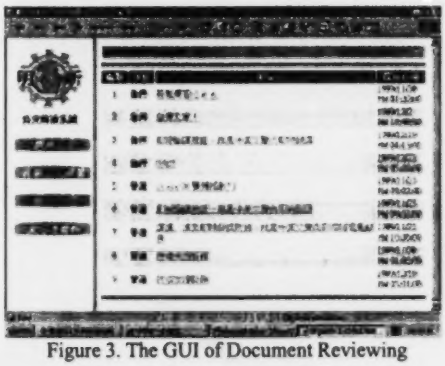


Figure 3. The GUI of Document Reviewing

3 Conclusions

In this paper, we have been stated the design and implementation of a web-based official memorandum system. This system can migrate the conventional official memorandum system to network. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application. In order to avoid the informal accessing to this system, the firewall is utilized at the front-end of the system. Besides, the duplicated databases are used in this system to prevent the database crash during the formal execution phase.

BEST COPY AVAILABLE

References

[1] Lotus Development Corp., "Lotus InterNotes Web Publisher", Setember 1995, http://www.lotus.com/corpcomm/334a.htm.

[2] Evans and D. Rogers, "Using Java Applets and CORBA for Multi-Users Distributed Applications", IEEE Internet Computing, Vol. 1, May-June 1997, pp.43-55.

[3] Guang-Way Sheu, Yue-Shan Chang, Deron Liang, Shyan-Ming Yuan, Wintson Lo, "A Fault-Tolerant object service on CORBA" in Proc. of the 17th International Conference on Distributed Computer Systems (ICDCS'97) Baltimore, USA, pp.393-400.

[4] Yue-Shan Chang, Jyh-Tzong Chiou, Shang-Rong Tsai, "Highly Reliable File Services on the DMINIX System, " The 11th Technological and Vocational Education Conference of R.O.C., Vol.3, Mar. 1996, pp. 30-39.

Design and Implementation of Teaching Models in Web-Based Teacher Training

See-Min Kim*, Shin-Chon Kang, Young-Kyun Back****
** CRADLE, Tokyo Institute of Technology*
2-12-1, Ookayama, Meguro-ku, Tokyo, Japan 152-8552
Tel: +81-3-5734-3233, Fax: +81-3-5734-2995,
E-mail: kim@ak.cradle.titech.ac.jp
*** Korea National Universty of Education*
Darak-ri, Kangne-myon, Chongwon-kun, Chugbuk, Korea 363-791
Tel: +82-431-230-3431, Fax: +82-431-233-0664,
E-mail: skytop@chollian.net

The reform of teacher training started in May 1995 in the Republic of Korea with reform of the educational system. The core of the reform was reinforcement of teacher training activity and introduction of a DTTS(Distance Teacher Training System). Then, in order to introduce a DTTS, the project for distance teacher training model development started in September 1997. This paper is related to a design and implementation of a teacher model in a DTTS. The teaching models of the following 4 types were carried out. 1) Problem-Solving type, 2) Seminar type, 3) Lecture-Practice type, 4) Courseware type. This system was in operation from October 1998. Current problems of this teacher models include: 1) Poorness of course contents, 2) The difficulty of checking a learning process, 3) Insufficiency of feedback to a trainee etc.

Keywords: **Distance Teacher Training, Teacher Model, Web-Based Learning**

1 Introduction

In Korea, reform of teacher training started on May 31, 1995 with the announcement of a reform of the educational system proposal. Philosophical bases for reform of teacher training are the spirit of the opened education, enshrining the principles of, opened an educational opportunity, the learning speed, the contents of learning, and the learning method, etc. The contents of reform are as follows[5]:

1) Obligation of periodical training;
2) Execution of distance education that introduced high technology of information communication engineering;
3) Reflection to the personnel affairs and the salary of a training result;
4) Authorization of a special course completion result in a graduate school and a social-education organization;
5) Attempt to the improvement of the training organization that enabled selection of the training organization by the teacher and let competition pass in qualitative.

These are summarized the following: 1) reinforcement of teacher training activity 2) introduction of a DTTS(distance teacher training system). It aimed at an expansion of the training opportunity, and overcoming restriction of time and space, with a reduction of training expenses. The project of DTTS development started in September 1997. It was sponsored by the Korea Multimedia Education Center. This project was divided into 4 sub-projects: Develop a training support model, design for teaching model, courseware development, and development for system management model. This paper is related to a design and implementation of a teacher model in a DTTS.

A teacher model is dependent on the contents of course, the learner characteristic, learning environment, etc. [6]. According to the questionnaire for the teachers and educational professionals of Choi [2], the suitable course for distance teacher training is as follows.

1) Various culture subjects (humanities a subject and a theoretical field).
2) Teaching methods expected such as discussion and workshop, then a lecture.

In Korea, as a training course into the distance teacher training, the culture subject of 11 was chosen. These were, "Foreknowledge of the future society and a counter plan", "Understanding of traditional culture", "The world in the 21st century and the Korea", "An information society and a computer", "Environment and education", " Raising of national morality nature", "An information society and multimedia education", "Theory and practice of open education", "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education for a unification counter plan".

In consideration of the characteristic of subjects and learner, strategies of WBI(Web-Based Instruction)[1], the teaching model of the following four types was proposed. 1) Problem-solving type, 2) Seminar type, 3) Lecture-practice type, 4) Courseware type. These are described at length in sections 2-4.

2 Design of the Teaching Model

In this project, the model of distance teacher training was divided into the macro model and the micro model, and was developed accordingly. A macro model is the framework of the whole DTTS, and a micro model is the course of training, that is, a teaching model. A macro model and a micro model are unified and distance teacher training is managed.

2.1 Web-Based Instructional Strategies

The acquisition process of the knowledge in WBI and the approach of the learning of constructivism are very similar. The most basic principles of constructivism concern fundamental philosophical assumptions about knowledge and learning[4]. The first, more generally accepted principle is that what a person "know"is not passively received, but actively assembled by the learner. The second principle is that learning serves an adaptive function. That is, learning is not the storage of "truths,"but of useful personal knowledge. This means the importance of the context of learning. Context has a lot to do with what is perceived as useful knowledge and how what is learned is integrated with existing knowledge. And the assumption that education is about acquiring universal truths. Since each person has different experiences and constructs an individual account of these experiences, each persons' s reality is slightly differenbt. New expereriences are interpreted within the context of these individual realities, implying that each person "know"a particular thing in a slightly different way.

We introduced the application of a repertoire of cognitively oriented instructional strategies implemented within a constructivist and collaborative learning environment, utilizing the attributes and resources of the internet[1]. The instructional strategies may be designed the following ways:

1) Support to the interaction between a lecturer- learner, and a learner-learner.
2) Introduce a hyper-textual function and support individualization learning.
3) Various learning materials provide in real time or non-real time (multimedia support)
4) The contents of learned and an evaluation results are analyzed rapidly and correctly, and it offers feedback to learner and system side.
5) Provide of DB Retrieval Function for learning information
6) It cooperates with other educational networks, and mutual reference can be carried out.

2.2 The contents-characteristic of subjects

The courses designed by the DTTS were culture subjects of 11. Generally, the contents of culture subject in a training course are unlike 'learning subject' that gains new knowledge. The culture subjects are mainly implicated that the contents of knowledge or skill newly asked for with a social change. And it takes into consideration that learning environment is being home, designed so that it might participate in learning not passive position but positively.

1) Show many concrete examples so that positive and concrete study can be performed.
2) Show or introduce the newest data and the newest present condition. And a learner performs creation of a report, discussion, and practice based on this.
3) In order to check rationally learning process which is the blind spot of home study, a small-scale subjectivity formula or report is required of an evaluation item.

4) The teaching contents are selected based on an opinion of the highest specialist of the field.

2.3 The learner-characteristic of in-service teacher and consult the needs analysis

In designing we considered the needs analysis of teacher needs[2]. And also considered the spirit of teacher training reform, that is the open educational opportunity, the learning speed, the learning contents, and the learning method, etc.

3 Proposed Teaching Models

3.1 Problem-Solving type Model

This model is used the following three subjects with "understanding of tradition culture", "information society and a computer "and "environment and education". The characteristics of contents of these subjects have much problem socially now. For example, the latest children cannot have understand about traditional culture, and do not understand value either. Moreover, although environmental problems are scattered in the familiar place, the problem consciousness does not exist. It is the learning which considers how it is efficiently introduced, how solving these problems at an educational field.
Problem-Solving type model is shown in **Figure 3.1**.

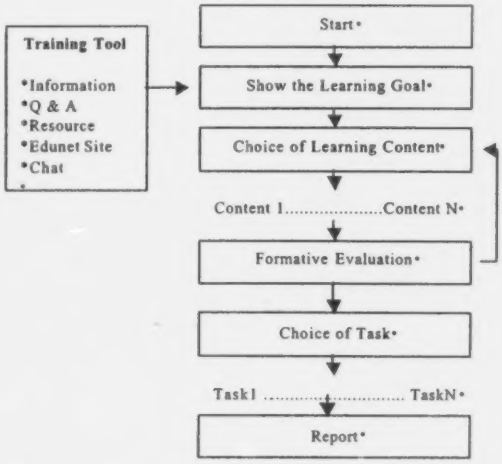


Figure 3.1 Problem-Solving type Model

3.2 Lecture-Practice type Model

Two subjects, "An information society and multimedia education" and "Theory and practice of open education" used this model. It is designed so that it might practice how theoretical knowledge may be reflected in the actual educational field. Through these courses, teacher can to help a child learn the capability that it can count measure to an information society, and how a teacher should just utilize the concept and the technology of multimedia for lesson activity. And more recently, it often pleads the open education. While introducing the concept of the open education and the example of the practice, teacher also gives an opportunity to consider an educational-practical use proposal directly.

3.3 Courseware type Model

Since three subjects, "Foreknowledge of the future society and a counter plan", "The world in the 21st century and the Korea", " Raising of national morality nature" were the contents of the type learned as new knowledge.
After having chosen the learning unit from the table of the learning contents, and learning using various data, composition which finishes a course through formation evaluation and generalization evaluation was designed.

3.4 Seminar type Model

This model uses the following three subjects. That is "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education of a unification counter plan". At first a group is constructed by the theme and to be performed learning in Seminar form so that learner might have an opportunity to expand the view and develop the main point by the mode of opinion exchange.

Seminar type model is shown in **Figure 3.2** below.

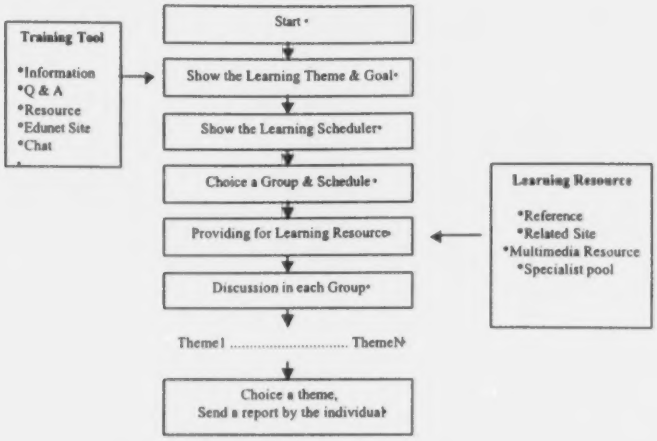


Figure 3.2 Seminar type Model

4 Implementation

The proposed model went into test implementation from October 1998. And now the model is used for qualification study of elementary and the 1st class positive teacher of middle, and general training of an elementary deputy schoolmaster.

As problems of this teaching model the following may be mentioned: 1) Poorness of course contents, 2) The impossibility of checking a learning process, 3) The insufficiency of feedback to a learner etc.

5 Conclusions

The distance education which used the high technology of information communication engineering in Korea started in 1997[3]. Insufficiency of a lecturer and restriction of a training opportunity are well said as a problem in teacher trainings. As one proposal for solving this problem, the project of "Development of a distance teacher training system" started and virtual teacher training actually started from October 1998. Thereby, little by little, teacher training environment becomes better and we think that the opportunity of training and the improvement in qualitative teacher training may also be anticipated.

There are problems that should still be correct and complement continuously in this training system. But the problems that should solved urgently are preparing the method of evaluation, the monitor staff who helps training, and a specialist pool.

References

[1] Bijan B. Gillani & Anju Relan., "Incorporationg Interactivity and Multimedia into Web Based Instruction", Web-based instruction, Badrul H. Khan, (Eds.), Educational Technology Publications, Inc,. pp. 231-237, (1997).

[2] Choi, Sang-gun., "Development of Distance Teacher Training System", Seoul: Korea Education Research Institute, (1995).

[3] C. H. Lee., "Pre-service & In-service Teacher Training for Computer Education in Korea," Advanced Research in Computer and Communications in Education. G. Cumming et al.(Eds.), IOS Press, pp. 433-440, (1999).

[4] Mark Grabe & Cindy Grabe., "Integrating Technology for Meaningful Learning", Houghton Mifflin Company, pp.32-76, (1998)

[5] Pang, Myung-suk., "Teacher's Information Literacy Training in the republic of Korea", Seoul; Korea Multimedia Education Center, (1998).

[6] Willis, B., "Instructional development for distance education," (ERIC Document Reproduction Service NO. ED 351 007), (1992).

Design of Multiple Metaphors in User-Interface

Yu-chen Hsu
National Tsing Hua University, Taiwan
arbia@ms55.hinet.net

As computer systems have become more sophisticated, several researchers have proposed the use of multiple models or metaphors to design computer systems and have argued that the provision of multiple metaphors would better match the characteristics of complex target systems. Multiple metaphors refer to the use of two or more distinct metaphors, each explaining various aspects of the target system. A multiple-metaphor interface means the combination of two or more metaphors to design the interface for a computer system. Although we see the strength of using multiple metaphors in interface design, not many guidelines for selecting and combining metaphors in creating a system are available. Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. In this paper, the theoretical basis for the use of multiple metaphors is discussed. The method in designing metaphorical interfaces is proposed as the author created the interfaces for a metaphor study. Issues of metaphorical interface design are discussed and detailed procedures in generating and combining metaphors in creating interfaces for a hypermedia system are presented.

Keywords: **Multiple metaphors, analogy, structural cues, interface design guidelines**

1 Introduction

Metaphor is traditionally a concept belonging to the fields of linguistics and philosophy. In 1980, Lakoff and Johnson [1] presented new ways of thinking about metaphor regarding everyday experience. They consider the essence of metaphor to be "understanding and experiencing one kind of thing in terms of another" (p. 5). They demonstrate that people's conceptual systems are metaphorical and people's actions every day are a matter of metaphor. In human-computer interaction, a metaphor is "present when terminology or concepts from a familiar non-computer domain are used to depict computer functions and objects in a user interface" [2]. Two components of a metaphor are the base domain and the target domain. The base domain is "the area of knowledge or expertise which a person already possesses," while the target domain is "the area of knowledge or expertise in which a person is trying to become familiar" [2]. When a computer user learns a new computer program, he calls upon his prior knowledge (analogies or metaphors) as the basis on which to form a new mental model. Designers can take advantage of users' existing mental models to present ways of conceptualizing computer functions and to design interfaces for computing systems [3]. Carroll, Mack, and Kellogg [4] describe the use of metaphor as a way to control the complexity of user interfaces by designing the actions, procedures, and concepts of new interfaces based on users' familiar actions, procedures, and concepts from previously learned interfaces. Metaphors used in this way are called interface metaphors.

Because humans learn new concepts or knowledge in terms of what they already know, almost all the computer interfaces in the world contain various types of metaphors taken from other domains. The current concern in computer interface design for ease of use, encourages the use of familiar objects and icon-based operations. Using these, computer users do not have to interact with command line syntax like they did before. This trend also facilitates the growth of the Internet [5]. Ratzan [5] argues that "metaphors may themselves suggest further implications, inferences or interactions of computer components. Metaphors help make sense of the online environment" (p. 47). Nevertheless, design guidelines derived from research findings on Internet metaphors are far behind their present demand in the practitioner field.

2 The use of multiple metaphors in interface design

While metaphor is useful for helping people to reason about new knowledge, mismatches between the base and target domains may occur, which lead to incorrect inferences. Carroll, Mack, Kellogg [4] claim that metaphor must provide incomplete mappings to their target domains. "If a text editor truly appeared and functioned as a typewriter in every detail, it would be a typewriter" (p. 69). Mismatches happen in situations in which the attributes and relations of a single metaphor can not be perfectly correlated with the attributes and relations of the target domain. This is especially true when the target domain is so complex that no individual model can fully explain anticipated behavior. In this case, the use of multiple metaphors to design interfaces may be a solution [6]. Benking and Judge [7] explain that three or more complementary metaphors may be used together in order to adequately represent some complex systems. Booth's [8] argument provides a basis for the use of multiple metaphors. He notes that people "appear to have blocks of knowledge relating to different domains and use parts of these knowledge blocks when they believe that it is appropriate" (p. 73). One kind of composite metaphor (multiple metaphor) is the use of complementary metaphors to represent functions of an interface, with each metaphor representing a function at a single level. Carroll et al. give an example of this kind of composite metaphor -- the integrated office system, which includes electronic mail, spreadsheets, text editing, and decision support, each with a different metaphor to represent it in the system.

In terms of the theoretical basis for multiple metaphors, Rumelhart and Norman [9] conducted a study on teaching new users to learn a text editor. They observed that students made errors because of their inadequate conceptualization of the various parts of the computer system. This resulted from the insufficient mental models students brought to the situation; they limited the kinds of analogies they might have employed. The authors note that no single metaphor can fully explain a complex piece of subject matter. Thus, they postulate an effective solution to eliminate student errors -- the provision of a more appropriate analogical framework, with different conceptual models to help students in their reasoning. They developed the "secretary," the "card file," and the "tape recorder" models, each explaining various aspects of the text editor, and claim that, although none of the models are perfect, as people grow more experienced in a domain, they become better at choosing appropriate models for a specific situation. In teaching this subject matter, it is effective to present a set of models, each with their own built-in context dependencies, as alternative conceptualizations of the target domain.

Collins and Gentner [10, 11] found that analogies allow people to create multiple mental models for use in reasoning about a complex system. They discuss Gentner's [12] analogy hypothesis and note that "a major way in which people reason about unfamiliar domains is through analogical mappings" (p. 247). They used analogies to map the set of transition rules from a known domain (the base) into the new domain (the target), thereby constructing a mental model that can generate inferences in the target domain. To test this hypothesis, they observed how subjects reason about evaporation and did an analysis of their protocols. The qualitative data suggests that subjects formed three different levels of interrelated mental models in reasoning about the target domain. These findings support the view that people learn the target domain by partitioning it into different component models, each mapped to a different base domain.

Multiple metaphors have also been employed in the field of artificial intelligence. Burstein [13] presented a model for students to learn a programming language. This involved the use of a box analogy, an algebra analogy, and a human processor analogy. In the example, the author used analogies in such a way that each analogy covered several levels of description, but served different functions. The use of multiple analogy models has been found to be more helpful in facilitating students who are learning the new domain in this case.

Spiro et al. [14] describe the danger of using single analogies in learning and instruction. They suggest that misconceptions are often caused by the reductive effect of analogies. "When analogies are used to 'start simple,' the knowledge ultimately acquired often stays simple. Well-intended analogies often result in oversimplified knowledge" (p. 502). They present eight situations in which the use of an analogy induces misconceptions or mismatches. One common characteristic of these eight situations is that users tend to depend too much on the properties of an analogous source domain in understanding the topic (target) domain. To solve this problem, they propose an antidote -- the use of integrated multiple analogies to represent complex concepts. They claim that by introducing new analogies which emend the missing or misleading aspects of the earlier analogy, the strength of the original analogy is retained, but its weakness is discarded. To give an example, muscle fiber function is proposed as the target concept, which is then explained by three analogies -- the rowing crew, the turnbuckle, and the Chinese finger-cuffs analogies. To integrate multiple analogies, they propose the technique of "composite imaging with selective contingent instantiation" (p. 522), in which three analogy models are created separately for the comprehension of the muscle fiber function with

the applicability of the elements in each analogy being context-dependent. Although the authors claim that this technique could be applied mentally or to computer graphic displays, its implications for the design of a composite metaphor are limited.

The advantage of using multiple metaphors in designing computer interfaces can be seen. However, there is no accepted standard for designing an interface with multiple metaphors. In the following section, the issues or problems of designing a multiple-metaphor interface will be discussed.

3 Issues to consider in the design of multiple (composite) metaphor interfaces

Judging from previous studies [15, 2] and my experience, I conclude a number of difficulties that designers or researchers would face in creating a multiple metaphor interface. Since the generation of a multiple metaphor interface involves the selection and combination of multiple metaphors, design considerations and problems will be discussed below within these two phases.

3.1 Selection of metaphor

When selecting metaphors to design interfaces for computer systems, the designer needs to consider several issues, which include the type of information, description level of metaphors, users' expert levels and prior knowledge, users' tasks, methods of task completion, and appearance of the interface.

* The *type and structure of information* of the target system influences how designers select metaphors. These attributes include the information content and structure of the target system. Designers need to consider the type of content information when choosing appropriate metaphors.

* In terms of *description level* of the target system, Booth [8] claims that "the level of description of a metaphor is concerned with the type of information that a metaphor might be expected to communicate" (p. 77). He takes an example from Moran's [16] Command Language Grammar and says that a metaphor can be aimed at the task level, the semantic level, the syntactic level, or the physical level. This characteristic increases possibilities, but also the difficulty in designing a metaphorical interface.

* When choosing metaphors, the designer should consider *users' prior knowledge* in their familiar domains as a basis for designing tools for learning new things. Stagger and Norcio [17] claims that, when designing multiple models for users to learn new knowledge, designers need to consider the expert level of the users and the tasks to be completed. As users gain expertise in the target area, their ability to manipulate multiple models increases. Since metaphors work by mapping previously acquired knowledge of users to the target domain that they are going to learn, some attributes (objects, relations, actions, effects) of the base domain must match with the attributes of the target domain. The selection of metaphors should be based on a user's familiar knowledge.

* Carroll et al. [4] explain three aspects to consider in designing a metaphor: the *tasks, methods, and appearance levels.* The task level describes users' goals and what they can do; an example is the information search in the present study. The method level describes how tasks are accomplished. The appearance level is the "look and feel of the task situation vis-à-vis the physical implementation of the domain" (p. 78). It includes aspects of the hardware and the presentation of screen objects.

In addition to consideration of the above criteria in selecting interface metaphors, designers also face some design problems described by Cooper [18]: 1) there are not enough metaphors; 2) the metaphors do not scale well; and 3) the ability of users to recognize them is questionable. As the number of metaphors increases in designing an interface, there are more constraints regarding the criteria of metaphor selection. Carroll and Thomas [3] suggest that when using two or more metaphors to design a system, one should not choose objects or procedures that are exclusively alternative to each other, so as to avoid interference and confusion. In another article [19], Carroll and Mack argue that good metaphors should also not provide completely transparent and comprehensive mapping, so that they may better enable users to learn.

3.2 Combination of metaphors

Once multiple metaphors are selected, designers need to identify an optimal way of combining the metaphors. This issue has not been well discussed by scholars, so there are not many guidelines regarding how to combine multiple metaphors to create a computer interface.

Beyond the issues discussed above, designers face some additional problems in combining multiple metaphors. First, it is hard to draw the boundaries between different metaphors. Booth [8] raises this question for designers: "how [can we] signpost the boundaries of metaphors within a system so that users know when a metaphor is no longer relevant and when another metaphor is appropriate [?]"(p. 78) Second, although the idea of using multiple metaphors has been suggested for interface design by practitioners, the way to operationalize multiple metaphors to create interfaces is very difficult to carry out. Most previous studies used separate analogies to teach new knowledge, or they used separate metaphorical interfaces to help users to learn new computer systems. Methods for combining different metaphors in a system have not been explored. Smilowitz [2] was a pioneering researcher who tried to mix two metaphors in an interface in her experimental studies. Due to the challenging nature of this case, there were design deficiencies in her approach to combining multiple metaphors. Smilowitz tried to mix two metaphors within the navigation area in a hypertext system. But navigation tools are only a part of an interface. The design in her study limits users' perceptions of the metaphorical interface.

In light of the above difficulties, the application of structural cues taken from multiple metaphors may be a solution to integrate two or more metaphors in designing an interface. The next section is a brief review on structural cues in computer interfaces.

4 Hypertext structure cues

Dillon [20] presents a discussion on the structure in documents. He argues that the meaning of structure differs depending on different standpoints: from the perspectives of writers, readers, or from the consideration of reading/writing tasks. There is a difference in the structures of a paper and an electronic document. Compared to a paper document, a hypertext document does not have the same amount of information available to the readers, and its structures do not have equal transparency. In a hypertext system, the author can create numerous structures from the same information. Due to the lesser experience novice users may have with hypertext systems, "users' schemata of hypertext environments are likely to be 'informationally leaner' than those for paper documents" (p. 114). These reasons may explain why users easily become lost in hyperspace.

One way to solve navigation problems in hypermedia is to provide structure aids that inform users of what information is available, as well as where it may be located and how it may be organized. Hulley [21] discuss hypermedia and notes that "its structure needs to be made obvious to the users [,] and a means of browsing and navigating around it needs to be provided." In addition, he thinks that "the methods chosen for structuring information need to be the most suitable for the user's needs; they must support the tasks that the user wants to carry out and provide an interface which can be easily understood or learned" (p. 173). Thuring, Hannemann, and Haake [22] argue that the coherence of a hyperdocument has an impact on the reader's information processing. Well designed hypertext structures plus the presence of rhetorical cues may facilitate coherence; so designers should provide cues at both the node (within nodes) and net (between nodes) levels. Rouet and Levonen [23] describe the prototypical representation of hypertext as "a set of text units connected through multiple links, that is, a text network" (p. 15). Due to the navigation problems which a novice user may experience, they argue that novice users need analogies with conventional structures.

5 Procedures used to create multiple-metaphorical interfaces

From the literature review we know that a single metaphor does not cover everything in the interface. The use of two or more metaphors in designing an interface may be a solution for the problem of mismatch and may better represent the elements as well as the relations to the target system. In addition, structural cues or metaphors should be provided to hypermedia users for them to understand the way to navigate the system.

Because of the present vogue for interface metaphors and the limited research available in this area, there is no accepted standard for designing metaphorical interfaces. Interface design in this area is more laborious because of this problem concerning the operational definition of metaphorical interfaces. Due to the problems designers or researchers may experience when combining multiple metaphors to create an interface, the

creation of a metaphorical interface by combining structural cues that are derived from two or more metaphors may be a useful way to help users to search within a hypermedia system.

In my metaphor study, I compared single versus multiple-metaphor interfaces on their effects in facilitating users' information search behaviors in a hypermedia system. There were three interfaces as the independent variable in the study, with the first interface containing less metaphorical elements, the second containing some metaphorical elements from a single metaphor, and the third (multiple-metaphor interface) containing more metaphorical elements from two metaphors.

A method was proposed to create the metaphorical interfaces based on existing design guidelines and the revision of design methods used by other researchers. In this strategy, the metaphors work as the source for the structural cues to be combined in creating a metaphorical interface. Metaphors were used as the basis for deriving navigational cues, but those cues were not treated illustratively. In other words, the cues are related structurally to the metaphors but do not necessarily represent elements of the metaphors in a pictorial way. The metaphors used provided a logic for the designs, which guided the choice of structural cues that distinguish the three interfaces by the varying degrees to which they appear. This approach leads to a more precise operational definition and manipulation of the variables.

A detailed review of the method for creating the three interfaces for the experimental study is presented in the following paragraphs.

5.1 Selection of context and task for the study

In the study information searches were chosen to be the user task in order to investigate the effectiveness of using metaphors as a navigational aid in designing a hypermedia system.

5.2 Selection of information content (information system)

After the task had been chosen, the information content was identified based on the scope and structure of the system, the depth and width of the information structure, characteristics of the information related to the target system, the familiarity of the content to the potential subjects, the availability of the system, its ease of implementation, appropriate metaphors for this information content, and software used to create the hypertext system. These issues were identified partially through a review of articles describing the processes that other designers went through to create metaphorical interfaces and the criteria they took into account [24, 25, 26, 27, 28, 29]. The web sites of some universities, the web pages of the Library of Congress and the National Science Foundation, a CD-ROM in science, a health database, geography information, the lives of musicians, world art and wars, and American history were reviewed. Some systems were good because they have structures embedded within them for information searching and navigation; but there were no appropriate metaphors for those types of content. For the other systems, there were appropriate metaphors that matched the content or elements, but the information structures were not useful for information searching.

The CD-ROM "The Enduring Vision" [30] was finally chosen as the content on which to base the hypertext system. It contains 33 chapters of American history. The same content as that in the CD-ROM can be found in the book The Enduring Vision, and the CD-ROM structure is similar to the structure of the book. This similarity between the book and CD-ROM was a positive factor which influenced my choice of the CD-ROM. It made the job of creating the three variances of hypertext easier, because the content did not have to be restructured to fit the book metaphor. Four chapters with a total of ninety-eight articles in nineteenth-century American history were selected from the program to create the hypertext system.

5.3 Selection of metaphors

The chosen hypertext system placed constraints on the variety of possible metaphors that could be used to design the interfaces. The issues taken into account at this stage included the subjects' prior knowledge concerning the metaphors, the characteristics of hypermedia systems versus the attributes of metaphors, the overall structures of metaphors in covering hypermedia systems, the appropriateness of metaphors for information searching, potential mismatches between the metaphors and the hypermedia system, existing metaphors used in other software, ease of representation, manifestations /appearances of metaphors, guidelines for metaphor design, and methods of combining multiple metaphors. In addition, the characteristics proposed by Lin [15] were also taken into consideration. These are: (1) the style of presentation of information, (2) the size of information units, (3) the degree of user control over the ordering of information, (4) routes of

traversing, (5) the visibility of linkages among units, (6) the implied internal structure of information units, and (7) the style of access to specific information. Some other design guidelines were also taken into consideration when I created the metaphorical interfaces. After several unsuccessful attempts (using different combinations of multiple metaphors such as timeline, map, journey, path, container, building…), the book and folder metaphors were ultimately selected, based on the above guidelines and the consideration of possible ways of metaphor combination.

One criterion in selecting multiple metaphors is that the chosen metaphors must be independent of each other. In other words, one metaphor can not be a secondary (subordinate) metaphor to the other one (the primary metaphor). According to Cates [24], a primary metaphor refers to the principle or first metaphor employed, and a secondary metaphor means a subsequent metaphor employed. The secondary metaphor "stimulates images and semantic expressions related to those stimulated by the primary metaphors which they are intended to accompany."(p. 98) If one metaphor is subordinate to the other, then they can be seen as the same metaphor.

The reason I selected book and folder metaphors is that each could map to different aspects of the hypermedia system, so they are complementary (see Table 1 for analysis of metaphor functions). Spiro et al. [14] propose the employment of multiple analogies in learning and instruction. They identify eight ways that analogies may induce misconceptions. Based on their framework, I analyzed the strengths and weaknesses of book and folder metaphors and used them in the design of three interfaces. Due to the scope of this paper, this analysis will not be discussed in the current paper.

Table 1: Analysis of metaphor functions and structural cues

	Elements related to content or to the hypermedia structure	**Metaphor functions related to hypermedia characteristics**
Book metaphor	• Books have structure. Each book page can be used to place an information unit (e.g. a web page) • A book has a cover, a table of contents, chapters, sections, and pages • Turn page/ page number • Open/close a book	• There is visibility of linkages among units • A book structure implies the internal structure of information unit in a hypertext system • A book has a particular style of information presentation and access to specific information • Book pages need to be accessed sequentially by page turning or by reading the table of contents (Lin, 1989, p. 48)
Folder metaphor	• Each folder can be used to place an information unit • Folder tabs with labels enable users to easily identify the content of a folder • Flexible ordering of information (Lin, 1989, p.46)	• Folder tabs allow random access to specific information units (Lin, 1989, p. 46) • Information units in different levels can be directly accessed

5.4 Combination of two metaphors and the creation of three interfaces (use of structural cues)

After each metaphor was selected, all of their objects and functions were analyzed using the POPIT model as shown in Table 2 [24]. The design problems which previous researchers faced in combining multiple metaphors in one interface (the creation of a composite metaphor interface) have been discussed in previous sections. In addition, Lakoff and Johnson [1] claim that "metaphors do not imply a complete mapping of every concrete detail of one object or situation onto another; rather they emphasize certain features and suppress others" (p. 96). It is also impossible to manipulate metaphorical elements in an interface from complete absence to presence.

In view of these difficulties, the three metaphorical interfaces were created in such a way that each interface contains various degrees of structural cues taken from one or two metaphors, with the cues ranging from minimum to maximum. Rather than call them the no-metaphor, single-metaphor, and multiple-metaphor

interfaces as in previous studies, they were called "the interfaces with different degrees of structural cues derived from single or multiple metaphors."

Table 2: POPIT Model (Cates, 1994)

	Book (Cates, 1994)	**Folder**
Properties	Book cover, pages, table of contents, chapters, sections, title	Tabs on the top of each folder, several folders can be put together, labels or keywords on the tabs
Operations	Open or close a book, turn page forward and backward	Folder tabs can be thumbed through, it allows random access, flexible ordering of folders
Phases	Turn pages, open, close, begin reading, find information/words, highlight	Select the folder, open the folder, select section by way of thumb tabs
Images	Book cover, layout of books	Same size and shape for each folder, tab in different location on the top, tabs have different colors
Types	Reference works, recreational books	Information storage

First interface (interface A with minimal cues)

There were a total of one hundred screens in this interface. Interface A contains a minimal degree of metaphorical concepts. In addition, the three interfaces in this experimental study needed to have similar structures and styles of information presentation for the sake of comparison and data collection. Since all computer interfaces contain some degree of metaphors taken from other domains, it is impossible to rule out metaphor elements totally. In the hypertext system, each article was organized hierarchically with its title listed in previous levels as hyperlinks. This made the title lists look more like the content lists of a book. For this reason, interface A still contains a small number of metaphorical elements, partially due to the nature of the information content.

Second interface (interface B with medium cues)

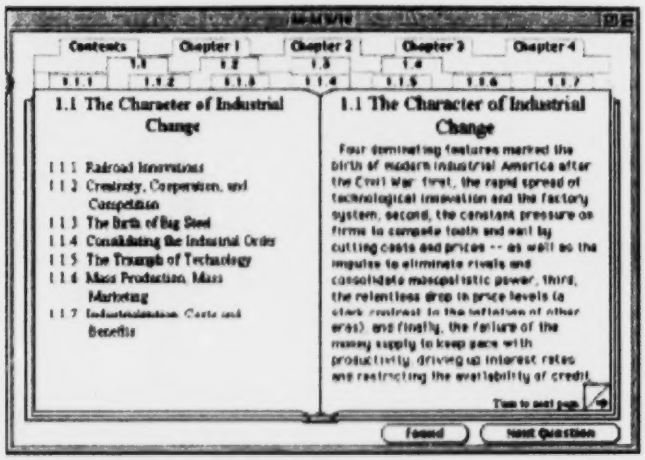
There were a total of four hundred and twenty seven screens in each of the interfaces, B and C. The same structural components and elements can be found in all three interfaces: 1) four levels in the system, 2) a main page as the first level with hyperlinks linking to the second and the third level, 3) articles in the second, the third, and the fourth levels with or without hyperlinks linking to the next level, and 4) titles and body text for each article. Based on the analysis, terms, images, structures, and operations were taken from a book metaphor to add to the design of the second interface. This causes the second interface to contain more structural cues from a book metaphor. All the information was presented in book format; for example, the text of each article was presented on double-sided pages, as in a real book. Users can click on the dog-ear to turn to the previous or next page. In addition, the title of each article was labeled with chapter, section, and subsection number to resemble the title of a book.

Third interface (interface C with maximum cues)

In order to compare the effects of the interface in which the structural cues were taken from only one metaphor with the interface in which structural cues were taken from multiple metaphors, a third interface was created (see Figure 1). Extra structural cues, including images, structures, and operations of a folder metaphor, were added to the second interface to create the third one. Whereas information presentation in a book metaphor is linear, the folder metaphor conveys the hypermedia attribute of flexible information access. The book metaphor worked as the main metaphor and was broader in its scope, while the folder metaphor was added to the design to supplement the book metaphor. Booth [8] describes the dimensions of a metaphor in terms of its scope and level of description. The scope describes the number of concepts that a metaphor addresses, and the level of description deals with the information types that a metaphor communicates. Similarly, Hammond and Allinson [30] describe four levels of information that a metaphor may convey: task information, semantic information, lexical information, and physical information. Using those concepts to examine the design in the present study, the book metaphor has a larger scope and it conveys four information levels: the hypertext structure, the layout, the terms, and the operations; but the scope and information levels of the folder metaphor are more restricted. The main function of the folder metaphor is to provide a flexible means of information access so that users can randomly access articles in different levels.

The structural cues taken from the book and folder metaphors include content lists, section titles and number, double-paged layout, book turning corners, folder labels with section numbers, physical layouts of book and folder metaphors, and so on. Those elements consist of textual and graphical structural cues, which were combined to create the metaphorical interfaces.

Figure 1. Screen-shot of the third level for interface C (multiple-metaphor interface)



6 Conclusion

Metaphors do not apply equally in the interface designs, and usually only the most salient points are drawn from a metaphor. The book and folder metaphors are not alternative choices; instead, they complement each other (in a non-exhaustive way). This is consistent with Benking and Judge's [7] view of using three or more complementary metaphors to explain complex systems. Due to the consideration of ease of manipulation in the experimental study, only two metaphors were chosen for the design of the interfaces. At each step in creating the interfaces, not only more possibilities, but also a few constraints were added to the design. The selection and combination of the structural cues did not result in perfect designs, but they were completed with much deliberation concerning the many design possibilities and tradeoffs.

Designing metaphorical interfaces involves many other issues that are beyond the scope of the present discussion. The compatibility between the metaphors to be combined may play an important role in appropriately conveying the functions of each of the interface elements. Interfaces that are created with incompatible metaphors could cause misunderstanding and hinder users' performances. The problems of selecting and combining multiple metaphors have been discussed in this paper, and the procedures for creating the metaphorical interfaces have been explicitly presented. There are many complex design issues involved in the creation of metaphorical interfaces. The design of a metaphorical interface relies on appropriate metaphor selection and combination in order to achieve optimal effects. Further research is needed to explore other possible ways to combine multiple metaphors to create user-friendly interfaces.

Due to the scope of this paper, the whole process of creating metaphorical interfaces can not be discussed in detail. However, it is the hope of the author that the method presented can provide interface designers and researchers with insight in creating metaphorical interfaces.

References

[1] Lakoff, G., & Johnson, M., Metaphors We Live By. Chicago, IL: University of Chicago Press, (1980).
[2] Smilowitz, E. D., Metaphors in user interface design: An empirical investigation. Unpublished doctoral dissertation, New Mexico State University, (1995)

BEST COPY AVAILABLE

[3] Carroll, J. M., Thomas, J. C., Metaphor and the cognitive representation of computing systems. IEEE Transactions on Systems, Man, and Cybernetics, SMC Vol. 12, No. 2, pp. 107-116, (1982).

[4] Carroll, J. M., Mack, R. L., & Kellogg, W. A., Interface metaphors and user interface design, In Helander, M. (Ed.), Handbook of Human-Computer Interaction (pp. 67-85). North-Holland: Elsevier Science Publishers, (1988).

[5] Ratzan, L. D., Maing sense of the Internet: A metaphorical approach. Unpublished doctoral dissertation, The State University of New Jersey, New Brunswick, (1998).

[6] Williams, M. D., Hollan, J. D. & Stevens, A. L., Human reasoning about a simple physical system, In D. Gentner & A. L. Stevens, Eds, Mental Models, pp. 134-154, Hillsdale, NJ: Lawrence Erlbaum Associates, (1983).

[7] Benking, H., & Judge, A. (1994). Design Considerations for Spatial Metaphors [On line]. Available HTTP:

[8] Booth, P. A., An Introduction to Human Computer Interaction. Alwrence Erlbaum Associates, Publishers, Hillsdale: C4, p65-101, (1989).

[9] Rumelhart, D. E., & Norman, D. A., Analogical processes in learning. In J. R. Anderson (Ed.), Cognitive Skills and Their Acquisition (pp. 335-361). Hillsdale, NJ: Lawrence Erlbaum Associates, (1981).

[10] Collins, A., & Gentner, D., Multiple models of evaporation processes. Proceedings of the Fifth Annual Conference of the Cognitive Science Society (pp. 16-20). San Diego: CA, (1983).

[11] Collins, A., & Gentner, D., How people construct mental models. In D. Holland, & N. Quinn (Eds.), Cultural models in language and thought (pp. 243-268). New York: Cambridge University Press, (1987).

[12] Gentner, D., Are scientific analogies metaphors? In D. S. Miall (Ed.), Metaphor: Problems and Perspectives (pp. 106-132). Atlantic Highlands, NJ: Humanities Press, (1982).

[13] Burstein, M. H., Concept formation by incremental analogical reasoning and debugging. Proceedings of the International Machine Learning Workshop (pp. 19-25). Monticello, IL: University of Illinois, (1983).

Designing A Web-Based Action Learning Environment - Integrating Learning and Working in One Environment

Feng-Kwei Wang* and John Wedman**
**University of Missouri - Columbia*
221-I Townsend Hall, Columbia, MO 65211, USA
Tel: +2-573-8843918
Fax: +2-573-8844944
wangfeng@missouri.edu
***University of Missouri - Columbia*
303-H Townsend Hall, Columbia, MO 65211, USA
Tel: +2-573-8824546
Fax: +2-573-8844944
wedmanj@missouri.edu

Action learning has become a popular approach to management education. Many advocates of "work while you learn and learn while you work" define action learning as an experience-based approach to developing workers by integrating real workplace problems and dilemmas in development programs as a way to work and learn concurrently. In tandem with the increasing acceptance of action learning, Web-based learning has become a common practice in both school and work settings. The authors contemplate that Web technology be utilized to build a Web-based action learning environment. In this environment, the tools and resources selected and devised are intended to facilitate the pedagogical processes of action learning. The biggest advantage of this environment is that learners are able to conduct action learning without constraining to time and space boundaries. The authors also argue that any technology-based learning environment would be flawed without a sound design framework and strong cultural and leadership supports for implementation.

Keywords: **Action Learning, Web-based Learning Environment, Knowledge Repository**

1 Introduction

Recently, learning based on socio-cultural theories such as situated learning [1] and cognitive apprenticeship [2] have gained attention in academic education and corporate training. There are three core doctrines of socio-cultural learning theories [2,3,4,5]. First, knowledge is situated in meaningful tasks that the learner carries out. Second, learning is a social process in which the learner interacts with peers or experts. Third, mediated tools and signs in the socio-cultural milieu of the learner affect learning processes and results. In other words, these theories hold that learning occurs in a socio-cultural context where the learner carries out authentic tasks. Thus, it becomes essential to combine working and learning contexts in the workplace if learning is to be effective. In parallel with the development of socio-cultural learning theories, action learning has become an emerging paradigm for workplace learning [6,7]. The tenet of action learning is learning through action [8,9]. In action learning, learners learn with and from each other, with the help of facilitators, by working on real problems and reflecting on their own experiences.

In addition to the emerging learning theory that has changed today's landscape of learning design and implementation, learning technology is another area that has a deep impact on the construction of learning environments. The technological advancements that the Internet and the Web have brought about have outpaced pedagogical and human learning theories [10]. The interactive, distributed, and collaborative features the Web offers present unprecedented opportunities for experimentation in creating an online learning environment that allows learning to occur without temporal and spatial constraints. Learning anytime, anywhere through the Web has become a common practice in the educational circle [11].

This paper intends to provide the design framework of a Web-based action learning environment (WALE) that combines contemporary learning theory and learning technology to facilitate and support the process of action learning. We begin with an overview of action learning and groupware technology, which a WALE is built upon. Then, we introduce the design framework of a WALE. We also present an actual WALE we built to give readers a better understanding of this WALE framework.

2 Action Learning

The concept of action learning made its appearance in 1954 as a method of problem solving. In 1967, Revans first implemented action learning in Belgium as a method of management development. Revans [12] defines:

> "Action learning is a means of development, intellectual, emotional or physical, that requires its subject, through responsible involvement in some real, complex and stressful problem, to achieve intended change sufficient to improve his observable behaviour henceforth in the problem field" (p. 4).

According to Revans [9], learning (L) is the sum of acquired programmed knowledge (P) and questioning insight (Q) and is denoted as:

$$L = P + Q$$

P represents the traditional instruction received in formal academic institutions such as business schools, and is deployed by experts. Q represents one's own findings from managerial experiences and is exercised by leaders. It should be noted that P and Q are complementary parts of a total development process [13, 14].

In a typical action learning program, programmed instruction might be given on a designated theory or theoretical topic. In conjunction with the programmed instruction, learners are asked to apply their prior and new knowledge to a real project that organizational sponsors have sanctioned. Throughout the program, learners continue to work on the project with assistance from qualified facilitators or advisors as well as other learners who help them make sense of their project experiences.

Action learning situates learners in a real-life problem in which they learn from and with others as they solve organizational problems. While there are many variations of action learning, Beaty, Bourner & Frost [15] argue that four essential elements of action learning are

* real problems,
* group reflection,
* personal responsibility, and
* action based

First, learners learn from tackling organizational problems they face within their work contexts. Second, learning is a social interaction in which learners learn with and from a group of others who are also engaged in managing real problems. Third, members of the group are accountable for solving their own organizational problems. Fourth, action learning does not stop with theoretical solutions. It is concerned with implementing the actions that the group has explored.

Action learning holds that learning for learners means learning to take effective actions [14], which only occurs

when learners actually engage in taking actions. The best actions for learning are those that solve an organization's real problems, those actions that are significant to the learners themselves. The learning process is a social interaction in which a group of learners work together as a team on the problems. The learners learn best with and from one another through peer interactions and discussions.

"Action learning is holistic in its view of the person [learner], the management process, and learning. It is highly situational, flexibly treating elusive problems and combines a social process with individual needs" [14, p37]. Its value lies in the situated characteristics of knowledge and skills acquisition. Through hands-on experiences with peers in solving real-life problems, learners can develop their own theories of learning and management in action, which are tested against real-world experiences as well as established tenets [16]. Learners are able to sharpen their problem-solving, communication and critical-thinking skills and to build skills that are germane to their own particular organizational needs. Furthermore, action learning, in a broader sense, has much in common with the concept of the learning organization [14]. The critical features of action learning are in accordance with the five disciplines of the learning organization: system thinking, personal mastery, mental models, building a shared vision, and team learning [17]. From this perspective, action learning is not only a matter of individual learning and action but is also an organizational transformation process that deals greatly with organizational dynamics and culture.

3 Augmenting Action Learning with Technology

While action learning is taking off and is proven to be effective in management education [18, 19], we believe that Web technology can augment its effectiveness. First, the use of Web technology to communicate organizational information, to coordinate workflows, and to collaborate on work tasks becomes indispensable in solving today's organizational problems. Since action learning emphasizes that learning comes out of business actions, we believe Web technology is instrumental for learning, in that the common Web functions can concurrently support working and learning. Second, the most vital resource in action learning is the participants' own experiences and resources. The sharing of these experiences and resources often occurs only when participants convene in action learning meetings where the majority of problem diagnosis, group discussion, solution planning, and collective reflection take place. Consequently, these valuable experiences and resources are not captured, widely disseminated, or even lost outside action learning meetings or programs. Third, time and geographical boundaries often put constraints on where and when action learning meetings can occur. The communication functions of Web technology such as e-mail and online bulletin boards provide the means to break the limitations of space and time. These functions enable the continuity of learning process beyond face-to-face meetings. Furthermore, the collaborative features of Web technology can be used to engage people in the action learning process. Although well-designed action learning programs do a good job of involving participants in learning and action, the ability to let people collaborate anytime, anywhere creates an expectation that action learning is a collective effort and every participant is contributing.

4 Web-based Action Learning Environment

With the characteristics of action learning and Web technology in mind, we develop a framework for designing a Web-based action learning environment (WALE) as shown in Figure 1. In this framework, learning occurs when learners engage in action learning to solve organizational problems with the support of Web tools and resources. The tools and resources selected and devised for the learning environment are intended to facilitate the pedagogical processes of action learning. The design of action learning and technological support has to take into account the organizational context and should be constantly evaluated and improved accordingly. The Web tools and resources are devised into three categories: knowledge repository, collaborative tools, and cognitive tools.

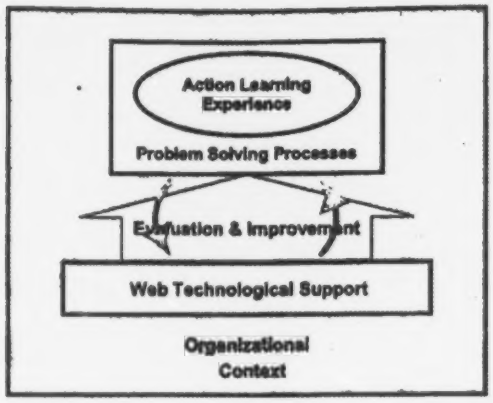


Figure 1. The design framework of a Web-based action learning environment

4.1 Knowledge Repository

At the conceptual level, a knowledge repository is about capturing and preserving the theory and practice of practitioners in an organization. The theory component represents what Ravens called programmed knowledge (P). In action learning, there is much in theory that can inform action. For one thing, it allows practitioners to see problems in a new light. Further, it might even reveal problems undiscovered for lack of recognizable solutions. The practice component is Revans' Q that represents practitioners' own findings from their experiences. These experiences are transformational and knowledge-based in a way that is useful to an organization. They provide the means of organizational learning, from which organizational members can gain insight and understanding. In action learning, experiences edify the program participants' past success and failure of actions. They also provide the questioning insights upon which the participants can reflect and guide their future actions.

At the detailed level, a knowledge repository is a collection of electronic documents that contains basic concepts in a subject domain and extracted experiences from practitioners including cases, lessons learned, best practices, techniques, tips, references, and other knowledge granules with powerful searching functions and easy navigational tools.

4.2 Collaborative tools

Collaborative tools, which include computer conferencing, electronic mail, and shared workspace, are used to promote collaboration among participants in an action learning program. Participants take on problem solving collaboratively through this online environment built on computer networks. Through the networks, multiple perspectives and diverse learning approaches can be stimulated, with each reinforcing the others [20]. Computer conferencing permits the development of online, asynchronous, many-to-many person discussions. Electronic mail allows each participant to send messages relating to personal issues to a specific person or group [21]. Computer conferencing and electronic mail extend the time and space boundaries of action learning beyond action learning meetings and moves learning directly into the workplace. They enable action learning anytime, anywhere and make action learning an ongoing process. The shared workspace serves as the group memory, recording group activities and information in action learning. It is capable of tracking a participant's or a group's action patterns and learning paths, which indicates what actions have been performed and what information has been accessed. Each participant can either reflect on his or her own action learning history or can learn from others by reviewing the group processes.

4.3 Cognitive Tools

BEST COPY AVAILABLE

Kozma [22] explains that the computer can alleviate the learner's information processing burden, thereby extending human cognition. In case problem solving activities, computer tools are used to ease and enhance the performance of cognitive tasks. Such tools in a WALE include performance support, hypermedia, and navigation functions. First, performance support functions are a set of Web tools or electronic job aids that participants use to facilitate problem solving. These functions ease the cognitive load of many arduous but necessary work and/or learning tasks and make learning and problem solving more efficient. The use of problem diagnosis forms and online action learning guidelines are two examples. Second, in a hypermedia environment, knowledge is purportedly organized by mirroring the structure of human thinking. The process of imitating human thinking proceeds through associating one piece of information to a related piece of information. It functions as "knowledge on demand" and exhibits the capacity to branch from one thought to related knowledge or experiences [23]. That being so, an appropriately structured hypermedia system should be able to mirror the semantic network of an experienced or knowledgeable performer or expert [24]. Third, navigation functions such as searching, navigation maps, indices, history, and bookmarks prevent learners from getting lost in the spacious knowledge ocean and point participants in the right direction. Navigating with such tools quickly brings participants the part of knowledge that they are looking for. Navigation maps show where participants are and where they have been in knowledge repository. Similarly, indexes offer participants different ways of identifying and viewing knowledge. In contrast, the history function keeps track of navigational paths and allows participants to trace their learning processes. Finally, bookmarks register particular knowledge locations for later quick access.

5 Learning and Working in a WALE

From the process standpoint, building a WALE encompasses a set of interrelated processes that engage participants in the problem-solving activities. These processes become a way of identifying and understanding interrelated factors while helping fill gaps, minimize redundancies, and eliminate conflicts toward common goals. They enable participants to develop themselves by building, reflecting on, renewing, and sharing what they know and how they do things in solving organizational problems. In this way, a WALE integrates learning and working in one environment through: 1) online action learning activities with peers and facilitators, 2) the utilization of Web-based learning and performance support tools, and 3) full-time access to problem solving resources and results (see Figure 2).

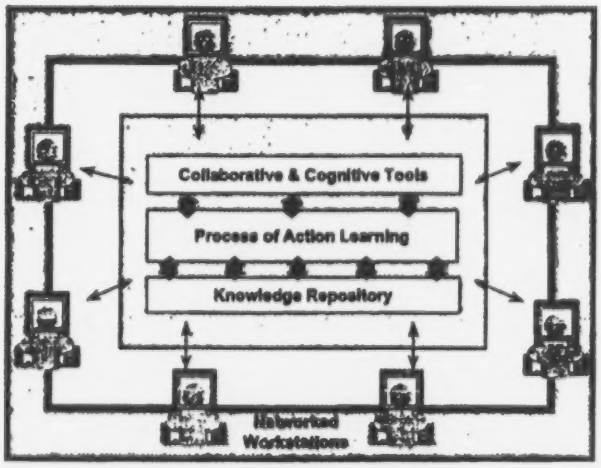


Figure 2. Working and Learning simultaneously in a WALE

BEST COPY AVAILABLE

6 A Case in Point

Teacher education programs have been challenged to respond to advances in technology. Unfortunately, these programs are criticized for not adequately preparing teachers to use technology in their teaching. The Office of Technology Assessment (1995) reported on technology in teacher education and noted significant limitations, including 1) faculty not modeling technology use; 2) students learning about technology – not with it; 3) field experiences not designed to model the use of technology; and 4) technology isolated from the main curriculum and pedagogy of teacher education. These limitations point to the need to revamp teacher education programs at many universities.

While teacher education faculty are central to the problem and its eventual solution, individual faculty are typically powerless to address these limitations. Deans, Directors of Teacher Education, Department Chairs, and other college and school-level leaders are best positioned to make a response, but seldom are these individuals prepared to deal with the many complexities, technical and otherwise, creating barriers to integrate technology in teacher education. Moreover, the rate of technological changes makes technology integration in teacher education a perpetual endeavor. Learning to solve problems means taking action in solving problems.

Funded by a grant from the U.S. Department of Education, a consortium of teacher education programs at the Universities of Missouri, Nebraska, Oklahoma, and Kansas, and Texas A&M was established to tackle many similar problems found in integrating technology in teacher education. This consortium is grounded with a common vision: teachers and students enabled by new and emerging technology and building a better future for all. The common mission is to better educate future generations of teachers to use technology. Recognizing that accomplishing the mission is an ongoing endeavor and the means to the end is constantly in flux due to fast emerging technology innovations and student needs, the leaders of consortium programs take the action learning approach to prepare themselves and their programs.

Adopting the WALE framework, the consortium, led by the University of Missouri, initiated a WALE development project to deploy a knowledge repository to support action learning programs engaged by respective consortium members. The Technology Integration Process (TIP) knowledge repository captures, organizes, and disseminates the collective knowledge about technology integration in teacher education, thereby leveraging the professional knowledge across many programs. Figure 3 shows the entry screen of the TIP system.

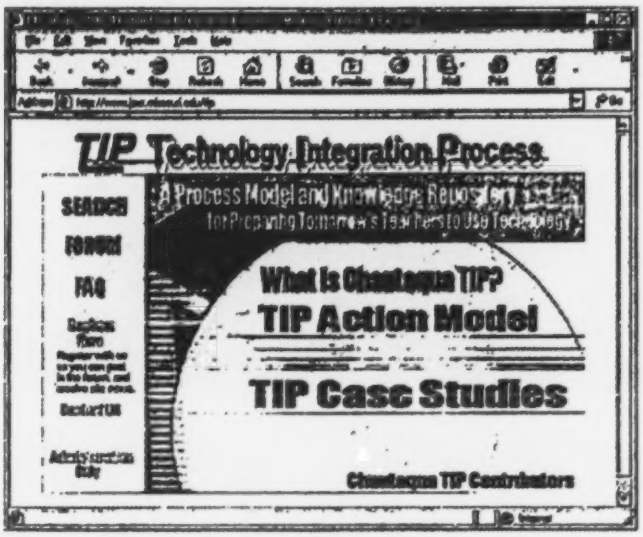


Figure 3. The entry screen of the TIP system

BEST COPY AVAILABLE

To start with, the TIP design includes a process model for technology integration in teacher education. The model consists of five inter-related processes: research, design, development, delivery, and evaluation. Two or more subprocesses were identified for each process. This TIP action model represents the P component of Ravens' learning model: the theory of technology integration in teacher education. To capture the TIP experiences (the Q component) of participating programs, dedicated project staff was sent to collect knowledge about TIP actions in each participating program. These experiences categorized according to five TIP processes were written as descriptive documents enhanced by multimedia elements. Each experience is titled as a TIP case and can be searched by name, by category, and by program as well as through a full-text search engine spanning the entire database.

Following the action learning approach, knowledge collection at each participating program began with a two-day self-study facilitated by the project facilitator. The self-study process opened with an orientation to the goals of the project and a demonstration of the knowledge repository from the functional and conceptual perspectives. Attention then turned to identification of the strengths and limitations of the program in relationship to the elements of the TIP action model. More site visits followed for problem diagnosis and solution implementation. In these follow-up meetings, in light of presented problems with the program and illuminating TIP cases in the system, the participants reflected upon the problems and solutions to develop action plan. It was then up to the participants of each program to carry out the plan. In the meantime, project staff continued the tasks of TIP knowledge discovery and collection and preserved the knowledge in the system that also facilitates the information exchange and knowledge dissemination throughout project lifespan. Individuals from participating programs are periodically notified when new knowledge (i.e., documents) was added to the system. Also, notifications are sent out when a new threaded discussion is initiated or when existing discussions are active. In this way, TIP action learning becomes an ongoing and collective effort from all contributing partners of this consortium.

7. Conclusion

The utilization of the Web for action learning is one possible efficient and effective way to leverage the intellectual capital of an organization in solving organizational problems. In this paper, we have laid out the design framework of a Web-based action learning environment. We illuminate our design with an actual WALE that we built to integrate technology in teacher education. We also understand a successful WALE is more than a design framework and a new technology implementation. While Web technology may have the advantage of removing boundaries of space and time to facilitate and enhance action learning, it may cause other difficulties by eliminating ordinarily desirable interpersonal communication channels necessary for effective action learning. Our experience has shown that the successful application of a WALE relies upon a judicious marriage of a sound design of Web technological tools and resources and inner strengths of participants, with reflections upon learnings from experiences of action in the real world of work and life. It must focus on critical successful factors that include fostering a conducive learning culture, marshaling true leadership support, deploying a nurturing process model, and sustaining the change throughout the organization. Also, it must move us to a view that sees learning in the context of the workplace so that higher individual and organizational performance can be achieved.

References

[1] Lave, J. & Wenger, E. "Situated learning: Legitimate peripheral participation", New York: Cambridge University Press, (1991).

[2] Brown, J. S., Collins, A., & Duguid, P., "Situated cognition and the culture of learning. Educational Researcher", Vol. 17, pp. 32-42, (1989).

[3] Bonk, C. J. & Kim, K. A., "Extending sociocultural theory to adult learning", In Smith, M. C. and Pourchot, T. (Eds.), Adult learning and development: Perspectives from educational psychology, Mahwah, NJ : Lawrence Erlbaum Associates. (1998).

[4] Tharp, R., & Gallimore, R., "Rousing minds to life: Teaching, learning, and schooling in a social context", Cambridge, MA: Cambridge University Press, (1988).
[5] Wertsch, J. V. "Voices of the mind: A sociocultural approach to mediated action", cambridge, MA: Harvard University Press, (1991).
[6] McLaughlin & Thorpe. R., "Action Learning: A Paradigm in Emergence", British Journal of Management, Vol. 4., No. 1., (1993).
[7] Yorks, L., "The emergence of action learning", Training & Development, Vol. 54, No. 1, pp. 56-56. (2000).
[8] McGill, I. & Beaty, L. "Action learning: A guide for professional, management and educational development", London, UK: Kogan Page, 2nd Edition (1995).
[9] Revans, R., "Action learning: New techniques for action learning", London, UK: Blond and Briggs, (1983).
[10] Salomon, G., "Novel constructivist learning Environments and novel technologies: Some issues to be Concerned with. Research Dialogue in Learning and Instruction", Vol. 3, No. 1, pp. 3-12, (1998).
[11] Morris, K., "Wiring the ivory tower", Business Week, pp. 90-92. (1999, August 9).
[12] Revans, R., "The nature of action learning", Management Education and Development, Vol. 10, No. 1, pp. 3-23. (1979).
[13] Korey, G. and Bogorya. Y., "The managerial action learning concept-theory and application", Management Decision, Vol. 23, No. 2, pp. 3-11, (1985).
[14] Mumford, A., "Learning in action", Personnel Management, Vol. 23, No. 7, pp. 34-37, (1991).
[15] Beaty, L., Bourner, T., & Frost, P., "Action learning: reflections on becoming a set member", Management Education and Development, Vol. 24, No. 4, pp. 350-367, (1993).
[16] Marsick, V. J., "New paradigms for learning in the workplace", In V. J. Marsick (Ed.), Learning in the workplace (pp. 11-30). New York: Croom Helm, (1987).
[17] Senge, P. M., "The fifth discipline: The art and practice of the learning organization", New York: Doubleday/Currency, (1990).
[18] Froiland, P., "Action learning: Taming real problems in real time", Training, Vol. 31, No. 1, pp. 27-34, (1994).
[19] Keys, L., "Action learning: Executive development of choice for the 1990s", Journal of Management Development, Vol. 13, No. 8, pp. 50-56, (1994).
[20] McCarthy, R., "Multimedia: What the Excitement's All about", Electronic Learning, Vol. 8, No. 8, pp. 26-31, (1989).
[21] Harasim, L. M., "Global Networks: An Introduction", In Linda, L. M. (Ed.) Global Networks: Computers and International Communication. Cambridge, MA: The MIT Press, pp. 3-13, (1993).
[22] Kozma, R., "The Implications of Cognitive Psychology for Computer-based Learning Tools", Educational Technology, Vol. 27, pp. 20-25, (1987).
[23] Amthor, G., "Interactive Multimedia in Education: Concepts and Technology, Trends, and Model Applications, Megamedia and Knowledge Systems", T.H.E. Journal, Special Issue: IBM Multimedia, pp. 2-11, September, (1991).
[24] Jonassen, D. H., "Acquiring Structural Knowledge from Semantically Structured Hypermedia", A paper presented in the AECT annual convention, Washington, D.C, (1992).

Developing an Effective Web-Based Learning Environment for Overseas Chinese Education

Grace Chen and Kent Wang
Potomac Institute
47618 Loweland Terrace
Potomac Falls, VA 20165, USA
Grace@pidcusa.com

The world of education is in a period of rapid change. Technology in the education has recently become a primary goal of Overseas Chinese Education. Yet with all these new resources available to teachers, the opportunity for improved teaching is eclipsed by the intimidating task of finding ways to utilize computers and the Internet in a classroom environment. Overseas Chinese demographics are placing pressure on educational institutions to develop more cost-effective instructional delivery systems. In response to this pressure, education is exploring new ways of defining classrooms and utilizing distributed resources. The direction of this exploration is being guided by newly evolving technologies and information delivery systems, advances in neuropsychology and the cognitive sciences, and new philosophies and educational paradigms. The introduction of the Internet in Overseas Chinese Education has been the seminal event precipitating the emergence of one such paradigm characterized by fluidity of roles, individual learner-directed content, distributed resources, virtual facilities, and asynchronous class times. It uses technology to create learning environments with neither walls nor clocks. This paper will explore these technologies and how to develop an Effective Web-based instruction Learning Environment for Overseas Chinese Education.

Keywords: **WBI, Web-based Learning, Instruction Design, Overseas Chinese Education**

1 Introduction: The Need for WBI

As education explore new delivery systems and environments, it is necessary to observe and evaluate their effects on instructional quality and student learning. Some seek to shift the bulk of instruction to distance and distributed environments as a solution to the problems facing Overseas Chinese education today. Traditional, synchronous delivery methods utilizing physical facilities, teachers, and students have been through countless iterations and refinements. Their interactions and effects have been measured. The role of reading materials, visuals, lectures, feedback, demonstrations, and student dynamics has all been observed over many years. Before abandoning or reducing the traditional, it is necessary to ensure any modifications of existing paradigms will result in instruction that is at least as beneficial to both learners and educators as the existing one. Numerous reform movements and technical innovations have been introduced into classrooms in recent years. We have learned that these changes will not be accepted unless they are perceived to be beneficial for both teachers and students.

2 The Web Impact Instruction Design

Several things generally happen as teachers begin to use the Internet. The first occurs as teachers realize their pedagogical style needs to change if they intend to use the Internet significantly for teaching. This is typically a gradual shift but pedagogical styles do seem to change because of the robust nature of resources

available and the difficulty of control over Internet usage. Some research on non-Internet network teaching activities also supports this idea. Generally, studies have found that when technology is introduced into the classroom, students experience an increase in motivation and self-esteem, accomplishment of more complex tasks, development greater technical skills and utilization of outside resources. Few studies, however, exist on the effects on student learning in distributed environments.

By combining the attributes of both Delivery of Content and System Management, and by answering in the positive the questions/issues unique to each, the instructional web-page developer will be more likely to create a strong and viable system/program that will teach, train, instruct, etc, all those whom they hope to educate via their instructional web sites. By adhering to these attributes, such a system can truly be called an Instructional System.

3 Creating good Web-based instruction

Not only does Web-based instruction need to follow good instructional design principles, but it needs to conform to good teaching practices and sound Web design principles as well. The first question educators should ask themselves before deciding to convert a course to the Web is, under the existing circumstances, is the Web itself an appropriate delivery medium.

Simply putting a course online because it is a new technology is not sufficient cause to justify the development time and cost. Another major concern is whether the online course will provide for the same level of quality teaching that a traditional class offers. Students will not accept the course if they perceive that it will be inferior.

Creating good Web-based instruction is not simply putting lecture notes online nor is it merely creating a virtual library of links to content related sites. It includes ensuring that good instructional, teaching, content, cognitive, visual, and usability design principles are followed as well as ensuring that it fulfills both teacher and student needs. Users need to perceive WBI as following objectives:

- **The Online Syllabus**
  An online syllabus provides the instructor with a way to change course material easily, and the student with a complete and up-to-date picture of the course requirements. The format need not duplicate the print version. Hypertext links to sample relevant disciplinary web sites may be helpful in giving students a sense of the disciplinary context for the course.

- **Personal Home Pages**
  Personal home pages can be used to foster the sense that the class is not just a collection of isolated individuals but a community of learners who can profit from interacting with one another. Home pages encourage students to learn about each other so as to encourage contact and mutual interests.

- **Interactivity**
  Adding discussion forums and chat sessions to your online course is a common way to add an interactive component to a web-based course. There are many implementations of bulletin board and chat session software to choose from. A second method of interactivity is, of course, e-mail. It's a good practice to have an online list of the e-mail addresses of all students.

- **Assignments**
  The web page listings of homework assignments, upcoming events and exams can be more interactive than the familiar print counterparts. If some homework assignments, for example, are based on online materials, they can be directly linked to the class schedule.

- **Announcements**
  To be effective, announcements need to be read; for that to happen, students need to know when a new announcement has been posted. Alert sounds or perhaps a blinking link added to a page can let students know of new announcements, or perhaps, even a mass e-mail to all students in the course.

- **Testing**
  Online drill or practice testing can be used to reinforce material, even if the results are not used as part of a grade. Reading comprehension questions, for example, in short answer or multiple choice

formats can provide students with an assessment of their level of understanding of text.

- **Content**
  Perhaps the most difficult part of developing a web-based course is creating the online content. You can begin by transferring your basic lecture materials to the web and integrating media such as sound, images, and video. Remember, to experiment with incorporating some of the new web-based learning paradigms described above.

4 Summary

In conclusion, developing an effective Web-based learning environment for Overseas Chinese education is not simply putting lecture notes online nor is it merely creating a virtual library of links to content related sites. It includes ensuring that good instructional, teaching, content, cognitive, visual, and usability design principles are followed as well as ensuring that it fulfills both teacher and student needs.

Developing Web-Based Language Learning Environment

Yun Du
Second Language Teaching and Curriculum Center
Moore Hall 255, East-West Road
Honolulu, Hawaii 96822
Tel: (808) 956-5130
E-mail: ydu@hawaii.edu

The World Wide Web is becoming a popular media to conduct distance learning. However, using the Web for distance language learning is still a challenge. This paper introduces a Web-based language learning environment which is used to deliver upper-level second language courses. The three major design considerations (instructional design, interaction design and knowledge-building capability design) are discussed. The functions and major features of the learning environment are also described.

Keywords: **Web-based learning environment, computer-assisted language learning**

1 Introduction

Today's distance learning no longer assumes that knowledge is static and education is a certain years' procedure. Instead, knowledge is changing and evolving, so that education is a life long process. Education should be able to meet people's needs, no matter how old they are, where they are, or what jobs or positions they hold. The World Wide Web, with its worldwide access and friendly interface, becomes the desired media for conducting distance learning today. Compared with traditional classroom teaching, Web-based learning offers new opportunities:

- It extends the boundaries of learning so that learning can occur at any time, in any place. As a result, learners have more flexibility of choosing the way to learn.
- It emphasizes on collaboration and interaction that can be effectively employed toward learning. Using the Web, learners can not only communicate with the instructors or classmates, but also can go beyond the classroom to collaborate with people from other schools, institutions, organizations, and to ask questions to professionals and experts.
- Various resources of information on the Web extend the content of the instruction. Students are able to access multimedia information on almost every subject and in multiple languages.
- Web-based instruction offers opportunities for more creative activities. Students can search information on the Web, create their own resource repository, meet virtually with classmates and instructors, and do a lot more.

In this paper, a Web-based learning environment for language learning will be introduced. This learning environment is used for delivering instructional resources in Chinese at the 3rd/4th-year level and in Korean at the 2nd/3rd-year level to learners nationwide via the Web. The first Web-based class using the learning environment, CHN399 *Chinese Reading and Writing Course,* was officially offered to the students at University of Hawaii in the spring semester, year 2000. The last two units of the course also involved students from Taiwan to collaborate with students at UH. The course is a success. Twelve students have completed the course. In the

fall semester, in addition to this course, a *Chinese Listening and Writing Course* and a *Korean Reading and Writing Course* will also be offered, using the same learning environment.

2 Major Design Considerations

The design of the Web-based language learning environment has been focused on three parts: instructional design, interaction design and knowledge-building capability design.

2.1 Instructional Design

Instructional design addresses the pedagogical issue of language learning. It determines the goal and format of the course, the instruction approach, the activities involved and the evaluation criteria. For this learning environment, we adopt an instructional model that contains the following five stages:

- Stage 1 Pre-activities: aim at activating students' prior knowledge, and helping them predict the content of the text
- Stage 2 Global activities: emphasize on helping students master the content and the main points of the text
- Stage 3 Specific information activities: use various language-centered tasks to train students to memorize the main points of the text while reading
- Stage 4 Linguistic activities: allow student to use the new knowledge after the they have mastered the content and main points of the text
- Stage 5 Post activities: integrate what have been learned from the previous four stages and help students accomplish a language task that involves using the new words, concepts and knowledge

Based on these stages, a series of activities have been designed. Students are evaluated mainly by the quality of their writings, and also by the quiz conducted at the end of each unit.

2.2 Interaction Design

Communication is very important for language learning. Communicative language learning theory emphasizes on interaction between learner and instructor as well as between learner and learner. Underwood [3] proposed a series of "premises for communicative CALL" (CALL refers to Computer-Assisted Language Learning), including "focuses more on using forms than on the forms themselves", "Teaches grammar implicitly rather than explicitly", "allows and encourages students to generate original utterances rather than just manipulate prefabricated language", etc. Interaction has been carefully designed to embed these principles into the learning environment. Different Web-based forums were developed for different learning purposes: asking questions about the text, practicing language through task-based group discussion, diagnosing grammar mistakes and writing essays on a specific subject. The asynchronous communication mode provides the following advantages:

- Students can have more flexible schedule; they can access the class at any time.
- Students have more time composing messages, and can modify messages even after they have been submitted. This is good for language learners who not only concern the content of the message but also the form of the language.
- Students can save specific messages for future reference.
- Students can search and retrieve specific messages afterwards.

2.3 Knowledge-building capability design

There are three major aspects of current learning theories. First, learning is a process of knowledge construction, not of knowledge recording or absorption. Effective learning depends on the intentions, self-monitoring, elaboration and representational constructions of the individual learner [2]. Second, learning is knowledge-

dependent, and knowledge-driven [1]. People use current knowledge to construct new knowledge. Third, learning is highly tuned to the situation in which it takes place. Knowledge is not independent of the contexts (mental, physical, and social) in which it is used [2]. These theories indicate the importance of supporting knowledge building in a learning environment so that students can acquire, record, share, and integrate knowledge.

In our Web-based language learning environment, in addition to allowing students to discuss and share ideas in the forums, based on the characteristics of language learning, the knowledge building also includes following processes:

- Store resources related to the subject
- Build word vocabulary
- Compile grammar rules
- Collect and comment on writing examples, commonly used phrases and idioms, etc.

3 Major features of the Web-based language learning environment

The components of the final system are shown in Figure 1.

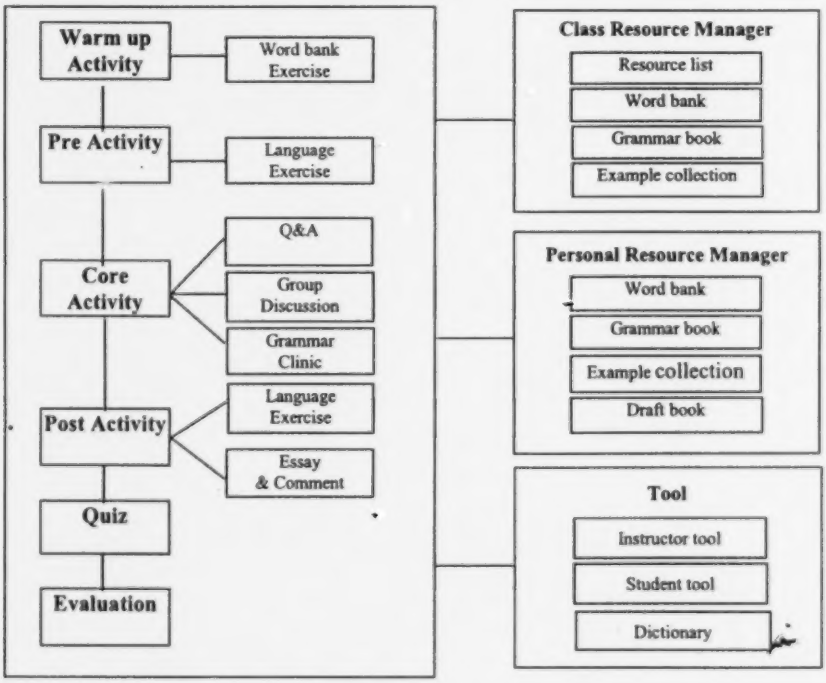


Figure 1. Components of the Web-based language learning environment

3.1 Language teaching/learning support

The system supports language teaching based on a specific instructional model that sequences the learning process into several stages. The goals, processes, activities and tasks are well integrated into the functions of the system. Different rights and privileges are assigned to instructors and students to ensure that the teaching and learning procedure is followed. Using the system, the students are able to do language exercises, share

information, ask questions, participate in task-based group activities, write essays, comment on fellow students' writing, build vocabulary, summarize grammar points, and so on, while the instructors are able to teach reading and writing skills, answer students' questions, correct grammar mistakes and evaluate students' progress.

Based on the instructional model, the learning process is sequenced into the following activities:

- Warm up activity: involves students' building word vocabulary (called *word bank*). This activity corresponds to the first stage of the instructional model: pre-activity that aims at activating students' prior knowledge about the topic.

- Pre-activity: involves doing language exercise such as matching words. This activity is also part of the first stage of the instructional model.

- Core activity: contains three parts. The first part involves students reading text (that is stored on CD-ROM), doing reading comprehension exercises and asking questions. This part corresponds to the second stage: global activities, and the third stage: specific information activities. The second part of the core activity is for students to participate in small group discussion to accomplish a given task, e.g. decide where to eat dinner. In the third part, instructors select mistakes from students' messages and post them in a forum called grammar clinic, and the students are asked to correct these mistakes. These two parts are designed to fulfill the goals of stage four: linguistic activities.

- Post activity: requires students to write an essay on the given topic. This activity is designed to integrate the knowledge they have learned, which corresponds to the fifth stage of the instructional model.

In addition to these activities, each unit of the class also has quiz, aiming at evaluating students' mastery of the material through quantitative criteria.

3.2 Database support

The system is developed using database technology. The database system is implemented on Microsoft SQL server. Basically the database system collects the data generated by the activities involved in the class.

- Stores the information of students and instructors
- Supports word bank
- Supports forums for class interaction
- Supports class and personal resource manager
- Supports quiz and grading
- Supports collecting survey data
- Collects data for administration such as login records

3.3 Asynchronous interaction

Web-based forums support the interaction among users. The asynchronous forums allow students to do the following things:

- To participate in the activity at any time
- To edit a message even after it has been submitted
- To save a specific message for future reference or as a knowledge item
- To search and to retrieve messages

The class interaction is supported by five forums:

- ***Class news forum***
  This forum is for instructor and students to exchange information including class announcement, cultural trivia, etc. Both instructors and students can post threads as well as replies.

- ***Essay forum***
  This forum is for students to post their essays and comment on essays written by fellow students. Both instructors and students can post threads as well as replies. (See Figure 2.)

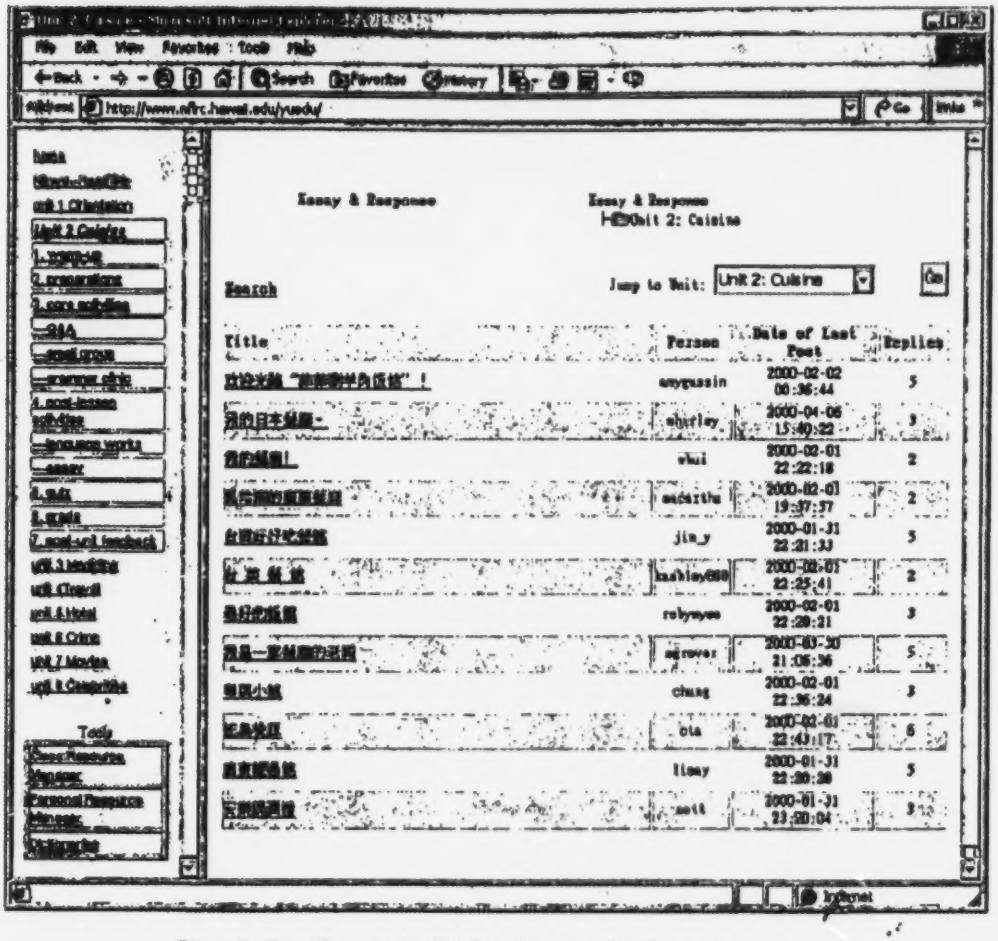


Figure 2. Essay forum in the Web-based language learning environment

- ***Q&A forum***
  This forum is for students to post questions regarding the content of the text as well as the usage of the CD-ROM. Both instructors and students can post threads as well as replies.

- ***Small group discussion forum***
  This forum is for students to participate in task-based group discussion. Students will be directed into their group when they enter the forum and they can post messages there. They can go to see other groups' interaction, but they cannot post any messages in other groups' discussion area.

BEST COPY AVAILABLE

- ***Grammar clinic forum***
  Instructors select grammar mistakes from the students' posts, put them in this forum, and ask students to correct them. Only instructors can post threads, students can only post replies.

Designing individual forum for each activity or task makes it possible for forums to serve different purposes and to have different controls over students' privilege of posting messages. For example, in grammar clinic forum, only instructors can post threads (students can only post replies), but in class news forum, everybody can post threads. In all the forums, the instructors reserve the rights to delete messages.

3.4 Knowledge building

The system provides knowledge-building capability that allows users to gather information, discuss ideas with others as well as generating, storing and retrieving knowledge. The knowledge building process is facilitated using two tools: class resource manager and personal resource manager. Both the resource managers include resource list, word bank, grammar book, and example collection. In order to support knowledge building at both collective level and individual level, the knowledge- building tool has two types: one for the whole class (class resource manager), and one for the individual student (personal resource manager). Class resource manager can be accessed by the whole class, while personal resource manager is individualized and can only be accessed by student himself or herself. The personal resource manager also includes a draft book for the student to store his or her writing drafts. The instructors have most of the control over class level knowledge-building tool, but the students have full control over their own knowledge-building tools. The knowledge-building functions provided include:

- Allows knowledge-building at both class level and individual level
- Allows users to collect information resources (Web sites, article, etc.) into *resource list*
- Allows users to collect words into *word bank*
- Allows users to collect or compile grammar rules into *grammar book*
- Allows users to collect writing examples or idioms into *example collection*
- Allows users to save messages from discussion forums to the resource managers
- Allows users to write note or comment on resource or knowledge items

Currently, the grammar book and the example collection in class resource manager are controlled by the instructors, meaning that instructors summarize grammar points and select examples and put them in the class resource manager. Students can read them but they cannot put their own notes there.

3.5 Online quiz

Students can take quizzes online. The quiz contains multiple choices and is graded automatically so students can get their grade immediately after they submit the answer. Instructors can check students' quiz grades along with the information such as how long the students complete the quiz and their answers to each question.

3.6 Tracking capability

The tracking system built for this learning system record student's clicks into the database while they are navigating the class. The information recorded include the location of the student, the action the student makes, the time of the action and other relevant data such as the message the student is reading. The tracking system offers the following benefits:

- The tracking system can provide valuable information for system developer. Users use a system in different ways. Therefore, how users navigate our the learning system, how they use the interface and how they use the various functions become interesting questions whose answers will help the system developer understand the operation of the system so that the system can be improved to better meet users' needs.

- The tracking system also provides valuable information for the instructors. It tells the instructor how students do self-learning in the distant environment, how they follow the process designed for the course, how they participate in the activities, how they approach a task, how they respond to a teaching strategy, and so on. The information will help the instructors understand students' behavior (e.g. learning strategy) and adjust their teaching methods to make the course more effective.

3.7 Monitoring and evaluating performance

The system provides ways for the instructors to conduct teaching as well as monitoring and evaluating students' performance:

- Monitor students' participations according to their login records, frequency and length of their posts, and so forth
- Evaluate students' performance according to their participations, contents and form of their writings, and so forth
- Give grades and feedbacks to students
- Understand students' learning behavior by analyzing tracking records

4 Conclusions

Observations from the Web-based Chinese reading course show that this Web-based language learning environment successfully support the class operation. Students and instructors are able to choose their own time, place and pace to work on the course. And, they have been engaged in active interactions during the course. The functions provided by the learning environment meet the instructional goals and requirements.

References:

[1] Glaser, R., "Education and thinking: The role of knowledge", American Psychologist, Vol 39, pp. 93-104, (1984).

[2] Resnick, L. B., "*Knowing, learning and instruction*", Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).

[3] Underwood, J., "Linguistic, computers, and the language teacher", Rowley, MA: Newbury House, (1984).

Development of 3D simulation programs for classical mechanics - Using Java 3D -

Yasuyuki NAKAMURA* and Hiroshi NAKANO**
School of Informatics and Sciences, Nagoya University
Nagoya, 464-8601, Japan
*Tel: *+81-52-789-4753 **+81-52-789-4801*
*E-mail: *yasuyuki@info.human.nagoya-u.ac.jp*
***nakano@info.human.nagoya-u.ac.jp*

1 Introduction

As LAN and Internet have diffused in recent years, environments of computers have been well filled and computers have become more popular among students. These developments make it possible for the style of education of physics to become various.

Recently many groups develop simulation programs for education of physics. We develop simulation programs for physics education using C language, XForms and Mesa library on Linux computer [1]. There are not only 2D but also 3D simulation programs. These programs are used in physics experiments for students [2,3]. One of the weak points of our system is a difficulty for opening our programs to the public. Only students attending the class can execute the programs.

On the other hand many programs coded by Java are also proposed and an education environment are prepared on the Internet. On World Wide Web (WWW), there are many programs coded by Java that are opened to the public [4,5]. Condensed Matter Theory Group of Kyushu University in Japan opens a virtual laboratory for the introduction of physics on WWW [6]. In the laboratory one can study physics with a simulation and an explanation for it. It is very good idea to open the programs to the public through Internet, but most of those programs are for 2D simulation. We think that 3D simulation is more exciting and is more helpful for understanding the motion of objects, because 3D simulation is more realistic.

Our aim of this study is to develop 3D simulation programs and open them to the public through Internet. We develop programs using Java in order for as many as people to utilize them and make use of Java 3D API for realizing 3D visualization. To our knowledge, there are still only a few programs proposed for education with use of Java.

2 Environment of development and execution

Our simulation programs are developed on an IBM PC/AT compatible computer. We adopt Linux as an operating system (OS) and XFree86 3.3.6 for X Window system. Java 2 SDK v 1.2.2 for Linux Production Release, Java 3D 1.1.3 API and Mesa 3.1 are used for developing applications. One of the reasons for adopting Linux is that Linux system has a reputation for its stability. Although applications are developed on a computer with Linux operating system, one can use any kind of computers and operating systems for execution of applications. This is merit and what we aim for in developing applications.

3 Example

We developed some programs with use of Java and Java3D by way of trial. One of them is a simulation of motions of ball in a box under gravitation, whose snapshot is shown in figure 1. We list below special features of these applications.

- We make use of Swing API for graphical user interface (GUI). Swing is provided as one of the standard APIs in Java2 and we can develop applications with common GUI operations in total independence of a kind of a computer and OS using Swing API.
- One can execute programs not only as an application on a local computer but also as an applet on a

browser through Internet. Java Plug-in is necessary for executing programs on a browser in the present. However this restriction will be solved in the future.

- Real-time simulations can be realized with use of thread class of Java. Furthermore, one can execute applications in slow-motion mode and in fast-forwarding mode.
- Java3D uses a tree structure for realizing 3D visualization. By changing branches and leaves, objects can be moved, transformed, replaced and so on.
- Java is a class-based object-oriented programming language. Therefore we can easily add or remove objects. Furthermore rules of motion can be specified to objects. Then we can realize various motions of objects.
- Since Java2 is prepared for Unicode and Locale, internationalized programs can be developed.

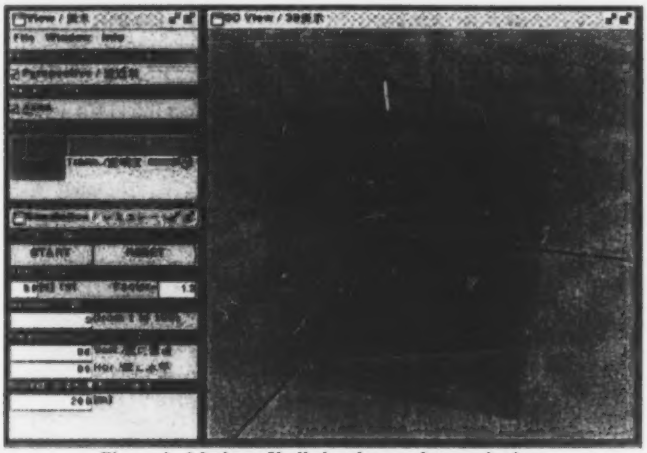


Figure 1. Motion of balls in a box under gravitation.

4 Conclusions

We propose an educational system for elementary physics with use of Java and Java 3D API. Our system offers 3D simulation programs with use of Java 3D. 3D visualization of the system of classical mechanics helps students to understand the behavior of the system and to have interests in physics. Since our programs are developed by Java, anyone who has an environment of Java can execute them on WWW. Therefore we can open our programs to the public and we can receive responses and evaluations for our programs. Note that one needs Java Plug-in for execution of our programs in the present. In the future, we want to increase the number of simulation programs and open those programs to the public.

This work is supported by the Japanese Grant-in-Aid for Science Research Fund from the Ministry of Education, Science and Culture.

References

[1] Yasuyuki Nakamura and Hiroshi Nakano, "Development of simulation programs for classical mechanics –Using UNIX system –", Computer & Education, Vol. 6, pp. 107-111, (1999).

[2] Butsurigaku Kiso III Home Page, http://kiso3x0.phys.human.nagoya-u.ac.jp/ (accessed on August 9, 2000)

[3] Yasuyuki Nakamura and Hiroshi Nakano, "A Computer Network System for Physics Education –Using Linux –", Proceedings of the Seventh International Conference on Computers in Education (ICCE' 99), Chiba, Japan, November 4-7, pp. 821-822, (1999)

[4] JAVA Physics Resource Mailing List, http://www.nep.chubu.ac.jp/~nepjava/applet.htm (accessed on August 9, 2000)

[5] Simulations on Physics, http://www2.tky.3web.ne.jp/~inaga/index.html (accessed on August 9, 2000)

[6] Virtual Laboratory, http://www.cmt.phys.kyushu-u.ac.jp/virtuallab.html (accessed on August 9, 2000)

Development of a Web System to Support Computer Exercises and its Operation

Hajime Kitakami, Sueda Takashi, Yasuma Mori and Susumu Kuroki
Faculty of Information Sciences Research, Hiroshima City University
3-4-1 Ozuka-Higashi, Asa-Minami-Ku, Hiroshima 731-3194, JAPAN
Tel: +81-(0)82-830-1587
Fax: +81-(0)82-830-1587
E-mail: kitakami@its.hiroshima-cu.ac.jp

This paper describes the development and operation of a Web-based system to support computer exercises used in a course on data structures and algorithms. To develop such a system, this paper proposes using the functions of a Web-based system to deal with a learner's state transition model based on computer exercises. The Web system developed by us has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participant and teacher, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of this system resulted in students' heightened motivation to work, good communication between participants and teachers, and a reduced workload for teachers.

Keywords: **Web, Database, Exercise, Autonomous Learning, Domain Model, Communication, Questionnaire, Data Mining, Operation, Evaluation**

1 Introduction

The new curriculum of the Department of Intelligent Systems at Hiroshima City University has added computer exercises to subjects related to algorithms and programming, thus encouraging students, from freshmen to sophomores, to make the most of their ability for practical programming with representative algorithms. The curriculum offers two ongoing three-hour courses that include theory and practice.

This paper focuses on computer exercises for the course "Data Structures and Algorithms," which is a part of the core curriculum for sophomore students. The general objective of the course [1, 2] is to facilitate the transition from computer literacy to a professional level of information processing. Even though students have considerable knowledge of computer operations, they do not have perfect command of them. Moreover, they do not have enough experience in basic programming techniques. In order for them to have command of the theory and the practice, we have developed many exercises to improve the management of participant registration and learner's goals, information about the exercises, mutual interaction between participants and teachers, management of report submissions, and collection of questionnaires, among others. However, a problem arises because the workload for both teacher and students increases in the process. To solve this problem, we have developed the necessary support Web system dealing with a learner's state transition model based on computer exercises. Moreover, we report the operational results obtained from real exercises.

2 Assessment of learners' situation before the training

The contents of the courses "Data Structures and Algorithms I" and "Data Structures and Algorithms II" were divided into two courses, each including both theory and practice, using C in the new curriculum. The former includes major elements such as stack, queue, list, naive sort, recursive function, quick sort, tree structure, and binary sort in the second semester of the first year. The latter includes major elements [3, 4] such as complexity, file processing, linear search, binary search, hash, B-tree, pattern matching, graphical

searches, Kruskal, and Dijkstra in the first semester of the second year. Since students can easily understand the content of many classes if they have attended C in an earlier semester, "Structured Programming" was also organized into two courses including both theory and practice using C in the first semester of the first year. This course includes major expressions such as if-, while-, and for-statements, array, data types, pointer, function, and structure in C. Moreover, the teaching of computer literacy includes major elements such as word processors (e.g., LaTex), programming tools (e.g., mule, e-macs), drawing tools (e.g., TGIF), the input tool for Japanese characters, electronic mail, X-window, and the shell command on UNIX, among others, in the same semester.

An evaluation of the learners' situation before starting the course "Data Structures and Algorithms II" that is the focus of this paper provided the following results:

(1) Students did not have much knowledge about algorithms and data structures with practical usage. They had learned simple and short programs but did not have much experience with longer programs. For example, they did not have experience in how to update longer programs by themselves.

(2) They did not have enough motivation for autonomous learning. They were less eager to learn than freshmen. For example, they did not consult textbooks or dictionaries on their own when they had trouble understanding an exercise.

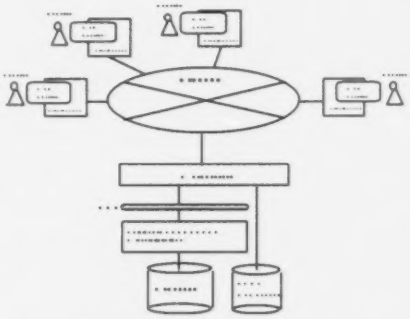


Figure 1. System Configuration

(3) Twenty-five percent of the students did not understand the C language. Seventy-five percent of the students tended to forget the C language, since they had not had a chance to practice it for more than 2 months after the second semester of the first year.

(4) Many students did not have sufficient skills to attain perfect command of software tools such as TGIF or LaTex.

3 Conceptual view of the computer exercise

Figure 1 shows the system configuration to support the exercise. Since each learner does his exercises at a workstation connected to the Internet, he can access information managed by the Web server. The Web server stores the exercises as HTML documents. The application program located in the CGI (Common Gateway Interface) manages information related to his registration, personal goals, and questionnaires. The application program is implemented in Parl, Shell, and SQL. The information inputted by the Web browsers is stored in the database and used by the learners.

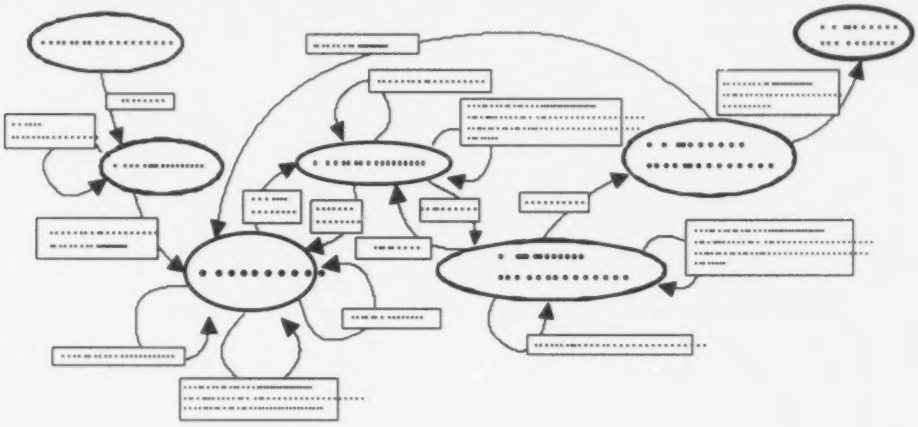


Figure 2. Computer Exercise Model

We tried to computerize human work as much as possible in the existing computer exercise. Notice of all 15 exercises included in the course was given on the Web page. We connected both basic programs and measurement data to the Web page for each exercise. Using a Web browser, both could be downloaded from the Web server to a student's site. Before starting on the first exercise, students had to fill out an electronic registration form for the class using the Web browser. When a student inputted his school number, name, password, and e-mail (electronic mail) address in the registration form, the system issued him a registration number using e-mail and the Web page. If the student needed any information about the exercises after that, he could get it by inputting his registration number and password using the Web browser.

Figure 2 represents the state transition for the computer exercise model. "Starting the Course," located at the left side of Figure 2, represents the state before starting the class. The student moves to the state of "Completing the Course" if he finishes all exercises successfully. If the student inputs personal data in the class registration form, the student moves to the state of "Class Participant." If the participant replies to the first questionnaire and inputs his personal goals for the exercise using the Web browser, he moves on to the state of "Exercising." At this stage, the learner is allowed to solve the exercise. If the learner inputs a question to the teacher on the Web page, he receives a reply from the teacher on the Web page. After finishing the exercise, the learner moves on to the state of "Making the Report" and can answer our questionnaire for the exercise as he finishes the exercise. If the learner submits his report to the teacher, he moves on to the state of "Waiting for the Evaluation." If the evaluation is poor, the teacher contacts the student, helps him, and asks him to re-submit the exercise. The Web system does not support their interaction in the situation, since we believe that face-to-face communication is preferable. This situation is different form Fujimoto's Classroom Management System [5]. After the learner reaches the state of "Completing the Submission," he will input his personal goals for the next exercise. After that, he will move to the state of " Exercising."

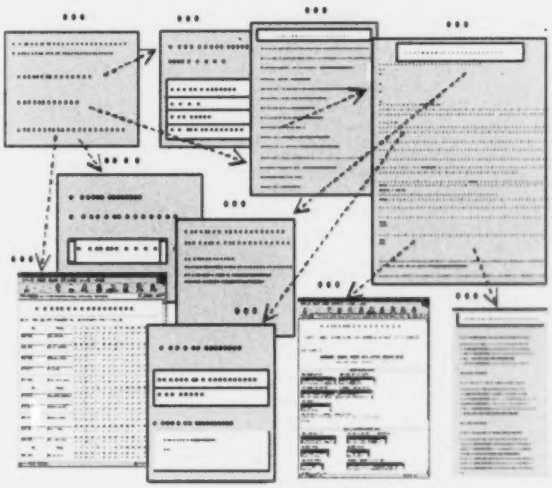


Figure 3. An Example of System Operation

We place great importance on the use of educational methods [6, 7] including "Reading, Writing, and Using an Abacus" to achieve the goal of "autonomous learning and thinking." For students belonging to the categories (1)-(4) mentioned above, the computer exercise model includes the following educational methods. Students in (1) and (3) are asked to read longer programs downloaded from the Web server, write the respective flowchart, update the subparts, and measure their performance in the state of "Exercising" shown in Figure 2.

Students in (2) are asked to define their personal goals before reaching the state of "Exercising" and write a self-evaluation in the state of "Making the Report." In the state of "Exercising," students are given an ambiguous exercise to learn the value of searching for information. In this way, students are encouraged to develop their creativity skills. Moreover, students are strongly advised to use textbooks and dictionaries if they have unresolved questions. Students in (4) are strongly encouraged to use such tools as TGIF and LaTex when preparing a report that includes figures and text. We believe that longer programs particularly enhance their proficiency in using tools. In order to determine an accurate grade for each exercise, we evaluate the reports submitted by the students and their answers to the questionnaires. Since we receive the results of the questionnaires immediately through the Web, we use such results to improve the exercises and coach the students. Moreover, the students can also receive their scores in a very short time. Students can compare each other's scores if they are given access to the statistics. Giving students access to the statistics is regarded as the key to ensuring an environment of awareness [8].

4 The results of system operation

Figure 3 represents an example of the operation of the system. Web page number (1) in the figure relates to the state of "Starting the Course." Page (2) is the class registration form. Page (3) gives anchors for information about all 15 exercises included in the course. If a learner selects one of the exercises on the page, he can use the exercise page (4). He can access his record of submissions and re-submissions using Web page (5). After inputting his personal goals using Web page (6), he moves on to the state of "Exercising." When he finishes the exercise, he moves on to the state of "Making the Report" and inputs the questionnaire on Web page (7). The results of the questionnaires are immediately stored in the database. Not only the teacher but also the learners are able to compute the statistics of the results from the database in real time. Page (8) relates to the statistics. Pages (9) and (10) are for teachers' use only. In page (9), each student has 15 check boxes, each divided into an upper and a lower section. If the report evaluation is good in the state of "Waiting for the Evaluation," the teacher puts a checkmark in the upper check box. If not, he puts the checkmark in the lower check box and helps the student so that he re-submits his work. Page (10) is useful for analyzing questionnaires stored in the database. The analysis includes the method of data mining [9] implemented in SQL.

Application of the system operation started at the Department of Hiroshima City University in April 1999. This system motivates students to do their exercises, provides good communication between participants and teachers, and reduces teachers' workload. The evaluation results of questionnaires and examinations related to the exercises are as follows:

(1) Ninety percent of students studied for 0.5-2.0 hours at their homes and were interested in the lecture.
(2) Twenty-six percent of students spent less than 2.0 hours preparing the report and exercising, 53% spent 2.0-5.0 hours, and 21% spent more than 5.0 hours, not including class work.
(3) Seventy percent of the 12 students (25%) previously mentioned understood the C language. Moreover, all students made progress in their studies.
(4) Ninety-five percent of the students reported good understanding of the algorithms used in the exercises. Eighty-seven percent of the students passed the examinations.
(5) The students acquired good skills at using TGIF, LaTex and other programs to write reports.
(6) Seventy percent of the students felt that the teacher did his best in the classroom, and 17% of them barely approved of his performance.

5 Conclusions

We proposed a computer exercise model for the course of "Data Structures and Algorithms II" and developed a Web support system for computer exercises using the model. We place great importance on educational methods including "Reading, Writing, and Using an Abacus" so that our students acquire the skills of "autonomous learning and thinking." Computer exercises using the Web system give students a chance to enhance their capabilities of "autonomous learning and thinking" and "creativity." The system run on the Web server has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participants and teachers, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of the system resulted in students' motivation to do the exercises, good communication between participants and teachers, and a reduction of teachers' workload. In order to achieve more concrete results, the students studied more at home and were enthusiastic about doing their exercises. Moreover, the students learned how to make a report using TGIF, LaTex and other programs.

Acknowledgements

We thank Assistant Professor Dr. Akira Sato of Hiroshima City University for his help with the exercises. We also thank Mr. Jun Ogawa, Mr. Takashi Maesako, and Mr. Kohei Matsumoto, TAs (Teaching Assistants) of Hiroshima City University, for their help with the exercises. This work was supported in part by a Grant-in-Aid of Scientific Research (C) from the Japan Society for the Promotion of Science and a Hiroshima City University Grant for Special Academic Research.

References

[1] Denning P. J., Comer D. E., Gries D., Mulder M. C., Turker A., Turner A. J., and Young P. R.: Report of the ACM Task Force on the Core of Computer Science, Association for Computing Machinery Press (1988).
[2] Computer Science Educational Curriculum for B. A. Degree Program in Computer and Engineering J97, Information Processing Society of Japan, 158p. (1997).
[3] Aho A. V., Hopcroft J. E., and Ullman J. D.: Data Structures and Algorithms, Addison-Wesley (1983).
[4] Leendert A.: Programs and Data Structure in C, Second Edition, John Wiley & Sons (1992).
[5] Fujimoto R., Suganuma A., and Mine T.: Development of a Classroom Management System on the Web, Advanced Research in Computers and Communications in Education (ICCE'99), Ed. by Cumming G. et al., Vol. 55, IOS Press, pp. 756-759 (1999).
[6] Angelo T. A.: Beginning the Dialogue: Thoughts on Promoting Critical Thinking, Teaching of Psychology, Vol. 22, No.1, pp. 6-7 (1995).
[7] Kuhar M. B: Critical Thinking: A Framework for Problem Solving in the Occupational Setting, AAOHN JOURNAL, Vol. 46, No.2, pp.80-81 (1998).
[8] Dourish P. and Bly S.: Portholes: Supporting Awareness in a Distributed Work Group, Proc. of CHI'92, pp.541-547 (1992).
[9] Fayyad Usama M., Piatestky-Shapiro G., Smyth P., and Uthurusamy R.: Advances in Knowledge Discovery and Data Mining, AAAI Press/ MIT Press (1996).

Development of CAI System with Character Code Discrimination on WWW Environment

Hiroyuki Watanabe and Katsuhiro Kato
Department of Electrical and Electronic Engineering, College of Engineering, Nihon University
1 Nakagawara, Tokusada, Tamuramachi, Koriyama, Fukushima 963-8642, Japan
E-mail: {hiroyuki, kkatoh}@ee.ce.nihon-u.ac.jp

1 Introduction

The CAI systems on the Worldwide Web are accessed by learners all over the world. However, the server-client type CAI system has a problem in that the character code does not translate into other character codes. Therefore, in the previous CAI system[1], the S-P chart used for data analysis was readable only in the Japanese version[2]. The new client program runs Java applet corresponding to the character code of the learner's language and the character code in the tag is transferred to the server together with the learner's data. The character code in the tag is decoded on the server side, and the HTML file provides the S-P chart. As a result, even if the CAI system is accessed from various countries, the character code of the learner's language, such as Japanese or English, can be decoded by one server program and the SP chart corresponding to the character code can be provided.

2 Flowchart for the Character

Code Decoding

This CAI system is constructed through the WWW client program with Java applet corresponding to the character code of the learner's language, and the WWW server program with the Java application[1]. Below is a description of the process. (see Fig. 1).

(1) The Japanese or English learner selects Java applet in Japanese or in English, respectively. The questions or hints are displayed. The learner's answer is judged via the WWW client program which is online.

(2) When the WWW client is only one Java applet, the WWW server has a character code error for the difference between the languages of the client and the server. For character code decoding the following code is added in the tag by Java applet.
<GET> M dir_name learner_name JPN
..for Japanese
<GET> M dir_name learner_name ENG
..for English

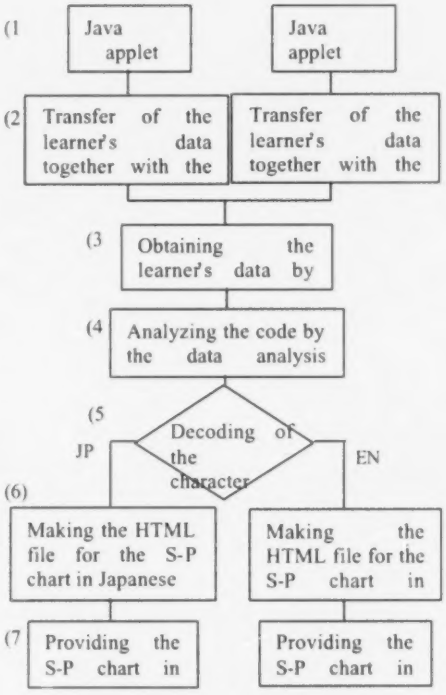


Fig. 1: Flowchart for the character code

The "<GET>" is one of the tags transferred from the client to the server. The code "M" is the data management related to the language. The "dir_name" is the directory name of the courseware for the saving of the learner's answers. The "learner_name" is the learner's name. The last code "JPN" or "ENG" is the character code of each learner's language.

(3) The character code together with the learner's data, which includes the learning score and its time, are obtained by the WWW server program through the Internet or the Intranet.

(4) Even if the language code is different, the learner's data is saved with the same file name in the same directory for the courseware. The learner's data is managed collectively, and the data analysis program analyzes the character code in the tag.

(5) The character code difference between Japanese and English is decoded.

(6) The learner's ranking is placed with the data of all learners, which has been stored in the server for each courseware. The S-P chart and the result of the statistical analysis which is formatted by the HTML are made corresponding to the character code of each learner's language.

(7) The S-P chart with the character code of each learner's language is provided to the WWW client.

3 Results

Fig. 2 shows the S-P chart in English for the score. The score for each learner is sorted vertically to the smallest value, which is the S-curve, and the score for each question is sorted horizontally to the smallest value, which is the P-curve. The S-P chart displays the learner's ranking. The attention coefficients for each learner and each question are shown. Furthermore, the evaluation of the learner, the average and its standard deviation are also shown. The S-P chart can also be accessed and displayed in Japanese.

Fig. 2: S-P chart in English.

4 Conclusions

For a good study, it is important that the S-P chart be provided for the learner. In this paper, the character code corresponding to Japanese or English, together with the learner's data, is transferred to the server from the client by Java applet. The S-P chart, which is written in Japanese or in English, could be provided by one server program making the HTML file corresponding to the character code of the learner's language. As a result, many server programs will not need to prepare character codes for the learner's language. This should increase the number of learners and give learners more definitive rankings. Each learner can access the courseware by typing the following URL through the Internet.
http://133.43.15.87/~webcai/index_e.html

References

[1] H. Watanabe & K. Kato, "Development of the ICAI system in WWW for individualized education", Proceedings of the 5th International Conference for Young Computer Scientists (ICYCS'99), Nanjing, China, Aug.17-20, pp.966-970, (1999).

[2] H. Watanabe & K. Kato, "An analysis of response time distribution for CAI courseware", Proceedings of the 7th International Conference on Computer in Education (ICCE' 99), Chiba, Japan, Nov.4-7, pp.125-132, (1999).

BEST COPY AVAILABLE

Development of Intelligent Learning Support System with Large Knowledge Base

Katsuyuki SUGAYA and Setsuo OHSUGA
Department of Information and Computer Science, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, Tokyo 169-8555, JAPAN
E-mail: {sugaya, ohsuga}@ohsuga.info.waseda.ac.jp

The objective of this paper is to present framework for developing intelligent learning support system with large knowledge base. Recently, the need for effective learning support and training is mounting, especially in industry or engineering fields, which demand the learning of complex tasks and expertise knowledge. Intelligent learning support system is being employed for this purpose, thus creating a need for cost-effective means of developing learning support systems. In this study, intelligent learning support system is assumed as a part of the intelligent knowledge management support system. The factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, a new design of the system and learner modeling technique are discussed as well as a way of generating specific intelligent learning support system.

Keywords: **Intelligent System Design, Large Knowledge Base, Learner Model, Model-based Diagnosis, Knowledge Management**

1 Introduction

The purpose of this paper is to introduce a new framework for developing intelligent learning support system using large knowledge base. This system is a part of the intelligent systems that is developing to enable the expertise knowledge management.

In daily life, human has to interact with and reason about a large number of systems. This includes physical devices as well as non-physical systems. Also in professional work a growing number of people has to be trained in operating and designing large complex systems such as airplanes, nuclear power plants, and enterprises. Consequently, the goal of education or teaching may vary from inducing insight in the physical principles underlying the behavior of the device to teaching behavior analysis in the context of system design, operation, and maintenance. In addition, recently systems in the real world are becoming larger and more complicated. Rapid progress in science and technology has created a need for people who can solve complex problems and operate and maintain sophisticated equipment. In these situations, we, human beings, have to solve various types of problems using expertise in the large and complicated systems. Therefore the need for effective learning support or training is rising, given the increasing complexity of the workspace, especially in engineering or industrial fields.

Many computer assisted instruction techniques exist that can present instruction, and interact with students in a tutor-like fashion, individually, or in small groups [3]. The introduction of artificial intelligence technology and expert systems technology to computer assisted instruction systems gave rise to intelligent tutoring systems. In the intelligent tutoring system, for example, intelligent tutors that can model the learner's understanding of a topic and adapt the instruction accordingly [2]. Although intelligent tutoring systems research has been carried out for over 15 years, few tutoring systems have made the transition to the commercial market. Authors consider that some serious problems exist in the current methodology of developing intelligent tutoring systems. As an example, each system is developed independently, and tutoring expertise is hard-coded into individual systems. In particular, the problem of learner modeling technique exists as a basic issue. The system must have learner model that represents an estimate of the

learner current understanding of the domain knowledge to be used by tutor in order to give adaptive guidance and explanations to the learner. A number of learner modeling techniques have been developed [8]. However, not every model can be called complete expressing the learning condition of the learner. Hence, the motivation for this study comes from the need for effective intelligent tutoring systems, particularly development of more complete learner modeling technique.

For these problems like above we consider that the factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, authors present a new framework of the intelligent learning support system those enough practical conditions. Several concepts are included in this study; expert knowledge management with large knowledge base, knowledge sharing, knowledge processing, model-based learner diagnosis, etc.

2 Expert Knowledge Management using Knowledge Base System

In this section, we introduce briefly the key concept of our knowledge base system. Our research groups have tried to solve various problems by knowledge-centered intelligent system. The main concept is Multi-strata modelling scheme [5]. This modelling scheme is applied many intelligent systems, and these systems rewarded with good results, e.g. automatic programming system [1]. And we considered that Multi-strata model is strongly support the development of intelligent tutoring systems [6][7].

2.1 Intelligent System with Large Knowledge Base

At first, we discuss to apply large knowledge base for the architecture of intelligent learning support systems, which can generate learning support systems for a wide range of domain.

In these days, with the developing of science and technology, the systems which human manages with are enlarged and more complicated. In particular, it is too difficult to transmit expert knowledge from expert engineer to novice engineers. In the engineering field, even a large system developed by many expert engineers. When the system grows lager and more complex, the knowledge that is needed to build the system is more specialized and subdivided. In these situations, some serious problems are occurred. For instance, it is difficult to communicate between expert engineer and another fields' engineers or novice one. In other words, it is too more expertise to transmission of expert knowledge from human to humans. For this reason, the expert knowledge hiding is occurred in some engineering companies.

When the knowledge is specified and subdivided, in the situation like classroom, it is not appropriate to transmit the knowledge from expert engineer to novice one e.g. next generation engineers. Therefore, we propose the transmission of expert knowledge through the large knowledge base system (Fig.1).

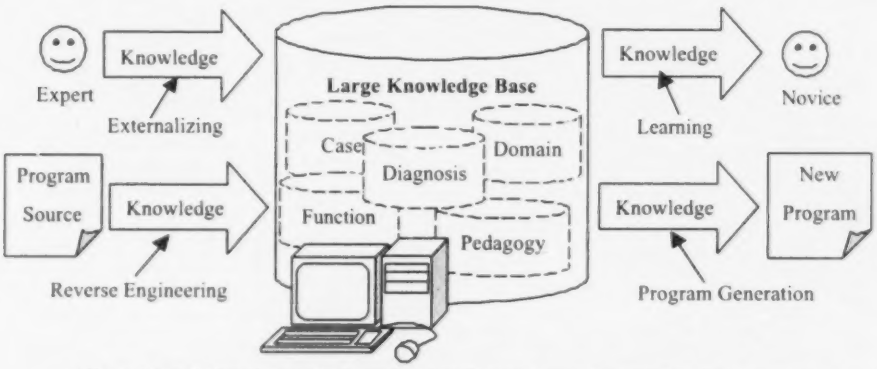


Fig.1: Knowledge Transmission using Intelligent Large Knowledge Base System

In this study, we consider that intelligent learning support system is a part of intelligent knowledge management support system. Moreover, we believe that knowledge management or learning support system is one of large and complex problem solving systems. The term problem is used here in a wide sense to mean what a person wishes to know or wants to do. There are various types of problems such as analysis,

design control, decision-making, planning, and teaching. Most of them are not well dealt with by conventional software method but require the system a capability to find a solution itself in a large space. Since the space is open, self-controlled exploration in the space is necessary. The system must be provided with the various methods to solve the different type of problems, each of which is represented by a specific knowledge chunk. Furthermore, a complex problem concerns different problem domains and since a problem requires domain specific knowledge, the system must be provided with a global knowledge base including the various type of domain knowledge.

In order to use knowledge effectively, the system must be able to extract only the necessary knowledge from the knowledge base referring to the type and the domain of the problem to be solved. For this purpose knowledge must be well structured. All used knowledge is accumulated in the large knowledge base (Fig. 1).

2.2 Necessity of Knowledge Processing Language

The whole of the problem solving process is from accepting external representation of problems to generating solutions. In order to represent problems in the system a processing language is necessary. The language has to meet two conditions: it has to be usable for representing problems; and it has to be processable by computer processor. In ordinary computers only the procedural language is used both for processing by the processor and for representing problems. The knowledge base system, on the other hand, introduces the second language to separate the above two aspects, as well as a conversion mechanism between them. The second language is a declarative knowledge representation language. The conversion either in the declarative forms or from the declarative to the procedural form is necessary. This is the inference. It can be implemented as a procedural program on conventional computers.

The specification for the second language must be decided so that it can represent these conditions. It had to be suited for representing predicate including data structure as argument and also for describing higher-level operation such as knowledge for selecting object knowledge. KAUS (Knowledge Acquisition and Utilization System) has been developed for the purpose by our research & development team.

3 Adaptability of Learning Support System

To meet the condition of adaptability, it is necessity to represent the learner's understanding of learning domain. In this section, we discuss a learner modeling method that is applied to diagnostic techniques in artificial intelligence.

3.1 Issues of Learner Model

The performance of intelligent learning support system depends largely on how well it knows why the learner fails to solve problems. Because of the sophisticated interaction requires information about the learner, the system has to maintain some kind of model of the learner. This model may include cases about what has been done before or information about what the learner is believed to know. The process of gathering information about the learner is mostly referred to as cognitive diagnosis. Ohlsson has given a widely accepted definition of cognitive diagnosis: "cognitive diagnosis is the process of inferring a person's cognitive state from his or her performance" [4]. We consider that the point of learner model is to represent knowledge state of learner, especially his/her fails to solve problem. To satisfy this requirement, we focus diagnosis techniques.

A diagnosis is defined in terms of one or more reasoning steps that the learner cannot have solved problem. A major advantage of this approach is that it can be based solely on a model of these correct reasoning steps; no knowledge is required about the specific misconceptions that learners may have about the domain of learning. Instead we model all primitive inferences that are required to arrive at the correct solution. In addition, our approach to diagnosis of learner behavior exploits results from model-based diagnosis as it is defined in the field of artificial intelligence.

3.2 Model-based Learner Diagnosis with Case Base

Model-based diagnosis is a prominent area within artificial intelligence and emerged in the last about 15 years. The technique of model-based reasoning has been widely researched and accepted as the principal

diagnosis in electronic circuit analysis, power station maintenance, medical diagnosis domains, etc. However, little emphasis has been put on its application to education or training system domain. The basic principle in model-based diagnosis is the description of system as a causal model. With the model at hand, the behavior predicated by the model is compared to the actually observed behavior. Since the predictions of the model are based on the assumption that the components work correctly, these assumptions may be partially dropped to accommodate for a detected behavior difference and thus diagnose faulty behavior.

However, there are some weaknesses in model-based diagnostic technique. The most serious weak point is the diagnosis time. It sometimes takes so much time to diagnosis. Therefore, we must be considering that it is necessary to model concerning the trade-off between the cost of a diagnosis time and its precision. Case-based reasoning, by contrast, excels in covering weak-theory domains, domains whose phenomena we do not yet understand well enough to record causality unambiguously. This feature allows case-based reasoning to be used in domains where model-based reasoning cannot be applied.

In the case-based reasoning, a reasoning engine remembers previous situations similar to the current one and uses them to help solve the new problem. However, case-based diagnostic technique has been criticized on many grounds. For example, that being specific to the system being diagnosed, they are non-constructive and that, having no analytic basis, the methods are restricted to specified faults and have a known level of competence. We think that the model-based diagnosis, being independent of the particular device descriptions, is intended to overcome these difficulties.

Therefore, we consider developing the approach of the model-based diagnosis system with case base. Model-based reasoning and case-based reasoning have the potential to complement each other quite well. However, no work has been done on specific issues of learner modeling using combine model-based reasoning with case-base. The outline of model-based learner diagnosis with case base is following. When the set of learner's behavior data input the diagnosis system, the diagnosis engine reasons the state of his/her knowledge consulting the diagnosis knowledge base include case base and object model base. The design of the model-based diagnosis system begins from describing the system as diagnosis object model. The system, which is a diagnosis object, is considered to be a set of domain models. The diagnosis object model that has knowledge of proper action, and the set of the behavior of learner as input value are given to a system. The first behavior of the system that received input is to seek whether there is a history about the same case in the case base. If the record to apply in the case is found, case base returns list of learner's knowledge, which should examine to diagnosis engine. Diagnosis engine does investigation about domain model of each record given to it, by comparing a simulation result in object model with the actual behavior of learner. Diagnosis process is finished if a trouble is recognized. When there was no record that complied with the input value in the case base, the process starts to use diagnosis domain object model. This domain object model has the hierarchical structure. A process begins from making the error model that one component in the extreme high class in the diagnosis object model is supposed to be out of order. The purpose of this process is to simulate using a made error model to examine whether the result of the simulation is the same as the behavior of learner. If there is no contradiction in the simulation result, the model-based reasoning is done again toward each domain knowledge model of the lower layer. In the same way, a diagnosis process is repeated until a trouble is recognized in knowledge component of the extreme lower layer. All process of diagnosis is knowledge processing by KAUS.

4 Discussion

The objective of this study was to develop a new intelligent learning support system, especially to focus two conditions; generality and adaptability. Authors in first propose the architecture of intelligent learning support system with large knowledge base to enough generality, which modeled by using multi-strata model. In second presented the model-based learner diagnosis to meet adaptability. All of the knowledge was represented by KAUS in intelligent learning support system that was assumed a part of the intelligent problem solving system. The issue of learner diagnosis is very important point to achieve adaptive instruction in intelligent learning support system. We proposed that fault diagnosis techniques be applied to infer the state of learner's knowledge. So we discussed the feature of diagnostic techniques, especially model-based reasoning with case base. Model-based reasoning appears to be a more promising technique than other knowledge-based methods because it can diagnose the faults that have not been pre-determined. Fails in learner's knowledge can be diagnosed automatically based on the models, which describe the correct behavior. However, because model-based approach reasons from the actual structure and function of knowledge, it is inefficient for some problems. Furthermore, obtaining domain models is sometimes either

difficult or too complicated, whereas most of the fails can be diagnosed based on past experience, which is very effective if the rule base or the case base is either comparatively small or well-indexed. A better solution is a hybrid approach integrating some of the diagnostic approaches. A case base will be provided to access the solutions to some fails diagnoses occurred previously, of which the domain models are unavailable. For some diagnoses, their solutions and contexts can also be stored in the case base for reuse later. Frequently occurring fails can be diagnosed efficiently even by a few of heuristic diagnostic rules. We believe that such a hybrid diagnostic approach will perform better than any of them does. In order to achieve this goal; we have considered the division of object model and problem type. On this part, it is necessary to carry out examination that will be more profound in future work.

References

[1] Aida, T. & Ohsuga, S., "Intelligent Systems Must Be Able to Make Programs Automatically for Assuring the Practicality", Lecture Note in Artificial Intelligence 1415, pp.47-56, (1998).

[2] Costa, E, New Directions for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1991).

[3] Mandl, H. & Lesgold, A., (eds.), Learning Issues for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1988).

[4] Ohlsson, S., "Some principles of intelligent tutoring", Instructional Science, Vol. 14, pp.293-326, (1986).

[5] Ohsuga,S., "Multi-Strata Modeling to Automate Problem Solving Including Human Activity", Proc.Sixth European-Japanese Seminar on Information Modeling and Knowledge Bases, (1996).

[6] Sugaya,K. & Ohsuga,S., "Design of Intelligent Education System using Multi-Strata Modeling Concept", Proc. The Sixth International Conference on Computers in Education, Vol.1, pp.305-311, (1998).

[7] Sugaya,K. & Ohsuga,S., "Framework for Developing Intelligent Tutoring System Using Multi-Strata Model", Advanced Research in Computers and Communications in Education, Vo.1, IOS Press, pp.832-835, (1999).

[8] Wenger,E., Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge, Morgan Kaufmann Publishers, Los Altos, California, (1987).

Development of Intelligent Learning Support System with Large Knowledge Base

Katsuyuki SUGAYA and Setsuo OHSUGA
Department of Information and Computer Science, Waseda University
3-4-1 Ohkubo, Shinjuku-ku, Tokyo 169-8555, JAPAN
E-mail: {sugaya, ohsuga}@ohsuga.info.waseda.ac.jp

The objective of this paper is to present framework for developing intelligent learning support system with large knowledge base. Recently, the need for effective learning support and training is mounting, especially in industry or engineering fields, which demand the learning of complex tasks and expertise knowledge. Intelligent learning support system is being employed for this purpose, thus creating a need for cost-effective means of developing learning support systems. In this study, intelligent learning support system is assumed as a part of the intelligent knowledge management support system. The factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, a new design of the system and learner modeling technique are discussed as well as a way of generating specific intelligent learning support system.

Keywords: **Intelligent System Design, Large Knowledge Base, Learner Model, Model-based Diagnosis, Knowledge Management**

1 Introduction

The purpose of this paper is to introduce a new framework for developing intelligent learning support system using large knowledge base. This system is a part of the intelligent systems that is developing to enable the expertise knowledge management.

In daily life, human has to interact with and reason about a large number of systems. This includes physical devices as well as non-physical systems. Also in professional work a growing number of people has to be trained in operating and designing large complex systems such as airplanes, nuclear power plants, and enterprises. Consequently, the goal of education or teaching may vary from inducing insight in the physical principles underlying the behavior of the device to teaching behavior analysis in the context of system design, operation, and maintenance. In addition, recently systems in the real world are becoming larger and more complicated. Rapid progress in science and technology has created a need for people who can solve complex problems and operate and maintain sophisticated equipment. In these situations, we, human beings, have to solve various types of problems using expertise in the large and complicated systems. Therefore the need for effective learning support or training is rising, given the increasing complexity of the workspace, especially in engineering or industrial fields.

Many computer assisted instruction techniques exist that can present instruction, and interact with students in a tutor-like fashion, individually, or in small groups [3]. The introduction of artificial intelligence technology and expert systems technology to computer assisted instruction systems gave rise to intelligent tutoring systems. In the intelligent tutoring system, for example, intelligent tutors that can model the learner's understanding of a topic and adapt the instruction accordingly [2]. Although intelligent tutoring systems research has been carried out for over 15 years, few tutoring systems have made the transition to the commercial market. Authors consider that some serious problems exist in the current methodology of developing intelligent tutoring systems. As an example, each system is developed independently, and tutoring expertise is hard-coded into individual systems. In particular, the problem of learner modeling technique exists as a basic issue. The system must have learner model that represents an estimate of the

learner current understanding of the domain knowledge to be used by tutor in order to give adaptive guidance and explanations to the learner. A number of learner modeling techniques have been developed [8]. However, not every model can be called complete expressing the learning condition of the learner. Hence, the motivation for this study comes from the need for effective intelligent tutoring systems, particularly development of more complete learner modeling technique.

For these problems like above we consider that the factors necessary for the intelligent learning support system discussed here are generality and adaptability. In order to achieve the goal, authors present a new framework of the intelligent learning support system those enough practical conditions. Several concepts are included in this study; expert knowledge management with large knowledge base, knowledge sharing, knowledge processing, model-based learner diagnosis, etc.

2 Expert Knowledge Management using Knowledge Base System

In this section, we introduce briefly the key concept of our knowledge base system. Our research groups have tried to solve various problems by knowledge-centered intelligent system. The main concept is Multi-strata modelling scheme [5]. This modelling scheme is applied many intelligent systems, and these systems rewarded with good results, e.g. automatic programming system [1]. And we considered that Multi-strata model is strongly support the development of intelligent tutoring systems [6][7].

2.1 Intelligent System with Large Knowledge Base

At first, we discuss to apply large knowledge base for the architecture of intelligent learning support systems, which can generate learning support systems for a wide range of domain.

In these days, with the developing of science and technology, the systems which human manages with are enlarged and more complicated. In particular, it is too difficult to transmit expert knowledge from expert engineer to novice engineers. In the engineering field, even a large system developed by many expert engineers. When the system grows lager and more complex, the knowledge that is needed to build the system is more specialized and subdivided. In these situations, some serious problems are occurred. For instance, it is difficult to communicate between expert engineer and another fields' engineers or novice one. In other words, it is too more expertise to transmission of expert knowledge from human to humans. For this reason, the expert knowledge hiding is occurred in some engineering companies.

When the knowledge is specified and subdivided, in the situation like classroom, it is not appropriate to transmit the knowledge from expert engineer to novice one e.g. next generation engineers. Therefore, we propose the transmission of expert knowledge through the large knowledge base system (Fig.1).

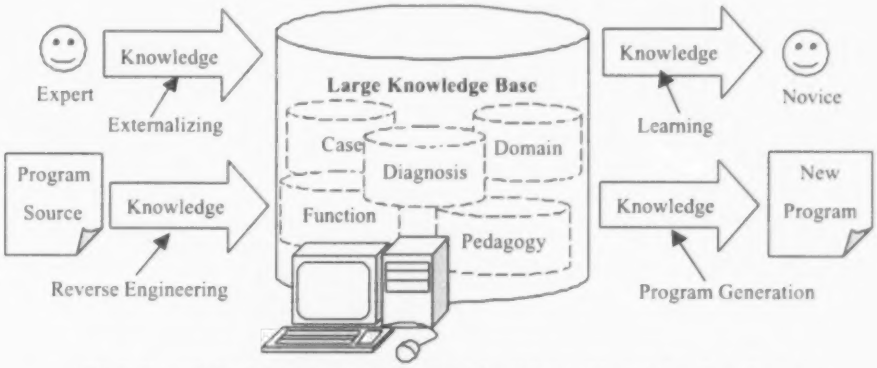


Fig.1: Knowledge Transmission using Intelligent Large Knowledge Base System

In this study, we consider that intelligent learning support system is a part of intelligent knowledge management support system. Moreover, we believe that knowledge management or learning support system is one of large and complex problem solving systems. The term problem is used here in a wide sense to mean what a person wishes to know or wants to do. There are various types of problems such as analysis,

design control, decision-making, planning, and teaching. Most of them are not well dealt with by conventional software method but require the system a capability to find a solution itself in a large space. Since the space is open, self-controlled exploration in the space is necessary. The system must be provided with the various methods to solve the different type of problems, each of which is represented by a specific knowledge chunk. Furthermore, a complex problem concerns different problem domains and since a problem requires domain specific knowledge, the system must be provided with a global knowledge base including the various type of domain knowledge.

In order to use knowledge effectively, the system must be able to extract only the necessary knowledge from the knowledge base referring to the type and the domain of the problem to be solved. For this purpose knowledge must be well structured. All used knowledge is accumulated in the large knowledge base (Fig. 1).

2.2 Necessity of Knowledge Processing Language

The whole of the problem solving process is from accepting external representation of problems to generating solutions. In order to represent problems in the system a processing language is necessary. The language has to meet two conditions: it has to be usable for representing problems; and it has to be processable by computer processor. In ordinary computers only the procedural language is used both for processing by the processor and for representing problems. The knowledge base system, on the other hand, introduces the second language to separate the above two aspects, as well as a conversion mechanism between them. The second language is a declarative knowledge representation language. The conversion either in the declarative forms or from the declarative to the procedural form is necessary. This is the inference. It can be implemented as a procedural program on conventional computers.

The specification for the second language must be decided so that it can represent these conditions. It had to be suited for representing predicate including data structure as argument and also for describing higher-level operation such as knowledge for selecting object knowledge. KAUS (Knowledge Acquisition and Utilization System) has been developed for the purpose by our research & development team.

3 Adaptability of Learning Support System

To meet the condition of adaptability, it is necessity to represent the learner's understanding of learning domain. In this section, we discuss a learner modeling method that is applied to diagnostic techniques in artificial intelligence.

3.1 Issues of Learner Model

The performance of intelligent learning support system depends largely on how well it knows why the learner fails to solve problems. Because of the sophisticated interaction requires information about the learner, the system has to maintain some kind of model of the learner. This model may include cases about what has been done before or information about what the learner is believed to know. The process of gathering information about the learner is mostly referred to as cognitive diagnosis. Ohlsson has given a widely accepted definition of cognitive diagnosis: "cognitive diagnosis is the process of inferring a person's cognitive state from his or her performance" [4]. We consider that the point of learner model is to represent knowledge state of learner, especially his/her fails to solve problem. To satisfy this requirement, we focus diagnosis techniques.

A diagnosis is defined in terms of one or more reasoning steps that the learner cannot have solved problem. A major advantage of this approach is that it can be based solely on a model of these correct reasoning steps; no knowledge is required about the specific misconceptions that learners may have about the domain of learning. Instead we model all primitive inferences that are required to arrive at the correct solution. In addition, our approach to diagnosis of learner behavior exploits results from model-based diagnosis as it is defined in the field of artificial intelligence.

3.2 Model-based Learner Diagnosis with Case Base

Model-based diagnosis is a prominent area within artificial intelligence and emerged in the last about 15 years. The technique of model-based reasoning has been widely researched and accepted as the principal

diagnosis in electronic circuit analysis, power station maintenance, medical diagnosis domains, etc. However, little emphasis has been put on its application to education or training system domain. The basic principle in model-based diagnosis is the description of system as a causal model. With the model at hand, the behavior predicated by the model is compared to the actually observed behavior. Since the predictions of the model are based on the assumption that the components work correctly, these assumptions may be partially dropped to accommodate for a detected behavior difference and thus diagnose faulty behavior.

However, there are some weaknesses in model-based diagnostic technique. The most serious weak point is the diagnosis time. It sometimes takes so much time to diagnosis. Therefore, we must be considering that it is necessary to model concerning the trade-off between the cost of a diagnosis time and its precision. Case-based reasoning, by contrast, excels in covering weak-theory domains, domains whose phenomena we do not yet understand well enough to record causality unambiguously. This feature allows case-based reasoning to be used in domains where model-based reasoning cannot be applied.

In the case-based reasoning, a reasoning engine remembers previous situations similar to the current one and uses them to help solve the new problem. However, case-based diagnostic technique has been criticized on many grounds. For example, that being specific to the system being diagnosed, they are non-constructive and that, having no analytic basis, the methods are restricted to specified faults and have a known level of competence. We think that the model-based diagnosis, being independent of the particular device descriptions, is intended to overcome these difficulties.

Therefore, we consider developing the approach of the model-based diagnosis system with case base. Model-based reasoning and case-based reasoning have the potential to complement each other quite well. However, no work has been done on specific issues of learner modeling using combine model-based reasoning with case-base. The outline of model-based learner diagnosis with case base is following. When the set of learner's behavior data input the diagnosis system, the diagnosis engine reasons the state of his/her knowledge consulting the diagnosis knowledge base include case base and object model base. The design of the model-based diagnosis system begins from describing the system as diagnosis object model. The system, which is a diagnosis object, is considered to be a set of domain models. The diagnosis object model that has knowledge of proper action, and the set of the behavior of learner as input value are given to a system. The first behavior of the system that received input is to seek whether there is a history about the same case in the case base. If the record to apply in the case is found, case base returns list of learner's knowledge, which should examine to diagnosis engine. Diagnosis engine does investigation about domain model of each record given to it, by comparing a simulation result in object model with the actual behavior of learner. Diagnosis process is finished if a trouble is recognized. When there was no record that complied with the input value in the case base, the process starts to use diagnosis domain object model. This domain object model has the hierarchical structure. A process begins from making the error model that one component in the extreme high class in the diagnosis object model is supposed to be out of order. The purpose of this process is to simulate using a made error model to examine whether the result of the simulation is the same as the behavior of learner. If there is no contradiction in the simulation result, the model-based reasoning is done again toward each domain knowledge model of the lower layer. In the same way, a diagnosis process is repeated until a trouble is recognized in knowledge component of the extreme lower layer. All process of diagnosis is knowledge processing by KAUS.

4 Discussion

The objective of this study was to develop a new intelligent learning support system, especially to focus two conditions; generality and adaptability. Authors in first propose the architecture of intelligent learning support system with large knowledge base to enough generality, which modeled by using multi-strata model. In second presented the model-based learner diagnosis to meet adaptability. All of the knowledge was represented by KAUS in intelligent learning support system that was assumed a part of the intelligent problem solving system. The issue of learner diagnosis is very important point to achieve adaptive instruction in intelligent learning support system. We proposed that fault diagnosis techniques be applied to infer the state of learner's knowledge. So we discussed the feature of diagnostic techniques, especially model-based reasoning with case base. Model-based reasoning appears to be a more promising technique than other knowledge-based methods because it can diagnose the faults that have not been pre-determined. Fails in learner's knowledge can be diagnosed automatically based on the models, which describe the correct behavior. However, because model-based approach reasons from the actual structure and function of knowledge, it is inefficient for some problems. Furthermore, obtaining domain models is sometimes either

difficult or too complicated, whereas most of the fails can be diagnosed based on past experience, which is very effective if the rule base or the case base is either comparatively small or well-indexed. A better solution is a hybrid approach integrating some of the diagnostic approaches. A case base will be provided to access the solutions to some fails diagnoses occurred previously, of which the domain models are unavailable. For some diagnoses, their solutions and contexts can also be stored in the case base for reuse later. Frequently occurring fails can be diagnosed efficiently even by a few of heuristic diagnostic rules. We believe that such a hybrid diagnostic approach will perform better than any of them does. In order to achieve this goal; we have considered the division of object model and problem type. On this part, it is necessary to carry out examination that will be more profound in future work.

References

[1] Aida, T. & Ohsuga, S., "Intelligent Systems Must Be Able to Make Programs Automatically for Assuring the Practicality", Lecture Note in Artificial Intelligence 1415, pp.47-56, (1998).

[2] Costa, E, New Directions for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1991).

[3] Mandl, H. & Lesgold, A, (eds.), Learning Issues for Intelligent Tutoring Systems, Springer-Verlag Publishers, New York, (1988).

[4] Ohlsson, S., "Some principles of intelligent tutoring", Instructional Science, Vol. 14, pp.293-326, (1986).

[5] Ohsuga,S., "Multi-Strata Modeling to Automate Problem Solving Including Human Activity", Proc.Sixth European-Japanese Seminar on Information Modeling and Knowledge Bases, (1996).

[6] Sugaya,K. & Ohsuga,S., "Design of Intelligent Education System using Multi-Strata Modeling Concept", Proc. The Sixth International Conference on Computers in Education, Vol.1, pp.305-311, (1998).

[7] Sugaya,K. & Ohsuga,S., "Framework for Developing Intelligent Tutoring System Using Multi-Strata Model", Advanced Research in Computers and Communications in Education, Vo.1, IOS Press, pp.832-835, (1999).

[8] Wenger,E., Artificial Intelligence and Tutoring Systems: Computational and Cognitive Approaches to the Communication of Knowledge, Morgan Kaufmann Publishers, Los Altos, California, (1987).

Development of the Web-based classroom system to be implemented by the teachers

Go Ota* and Kanji Akahori*
**Cooperative Research Center Saitama University*
***Tokyo Institute of Technology*
*E-mail: *gohome@jona.or.jp **akahori@cradle.titech.ac.jp*

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan from the year 2002. Accordingly, all the schools have been rushing to deploy the personal computers and prepared to connect to the Internet through 2001. While the scope of this project aims at covering 40000 or more schools, there exists the two major problems: 1) The number of teachers who have expertise in handle the PC and the Internet, are too far short in proportion to the number required. 2) Dial-up networking prevents the students from having access to the Internet any time when they want. With a view to overcoming these problems, we have designed and developed the Intranet system or "micro Internet for classroom: mIc". The "mIc" is developed and designed to incorporate the various functions such as web-mail, electronic bulletin board "BBS", mailing list, search engine, web video conference and etc. Since "mls" consist of Microsoft Active Server Pages (ASP), it can be used from Web browsers and custom-tailored at ease.

Keywords: **Intranet, Collaboration, Video-conference, BBS**

1 Introduction

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan at both the elementary school and the junior high school in 2003 and at the high school in 2002 respectively. Accordingly, all the schools have been rushing to deploy the personal computers and are prepared to connect to the Internet through 2001. While the PC have been gradually and extensively, it seems quite obvious that far small number of the teachers can handle the PC and the Internet to the contrary.

The Minister of Education has been sending the computer engineers or other computer technical personnel to school since 1994 with a view to training the teachers about the computer and the Internet. They are also required to see to it that both the teachers and the students can implement the PC and the Internet smoothly without any problems. Additionally, The Ministry has been initiating their own training programs for the teachers as well. While the project is supposed to cover 40000 schools or more, it has been experiencing the extreme difficulties of the shortage in the engineers and the technical staffs to reach out all the teachers in 4000 schools or more. It has been experiencing the difficulties as well as that Dial-up networking prevents the students from having access to the Internet any time when they want.

Despite these difficulties, it seems quite viable that all the students will get accustomed to the computer and the Internet at the earliest convenience. We, therefore, have designed and developed the Intranet System(micro Internet for classroom: mIc)

2 Design of mIc

This system "mIc" is developed and designed for both the teachers with least knowledge about the PC and the Internet, and the students as well to learn the various functions.

(a) Simulation of the Internet.
We are of an opinion that the E-mail and Electronic Bulleting Board shall be viable tools for "collaboration" among the students. Should the students require any information from the Internet, the search engine shall be inevitable to learn as well. We, therefore, have designed to incorporate these functions in the system. The teachers simply use the system without any other programs and the students can experience those functions as if they were connected to the Internet.

(b) Web-based easy operation.
The teachers can use "mIc" from Web browser. Therefore, should the teachers use the system, they can create new BBS, mailing list and registration of the students on Web based. As far as the teachers will use solely "mIc", the profound knowledge about the Internet server and the program of CGI is not necessary.

(c) Customization.
The curriculum of "Information and Computers" varies depending on the computers deployed ,the network system applied, and the objective of the education for PC & the internet in each school respectively. The system "mIc" can be customized by merely changing the text-files.

3 Structure of mIc

Considering the Standardizing the server of the average school environment, "mIc" will be installed in WindowsNT server or Window98. Please take note that less than 10 people can work with Window98 simultaneously.

3.1 ASP and COM

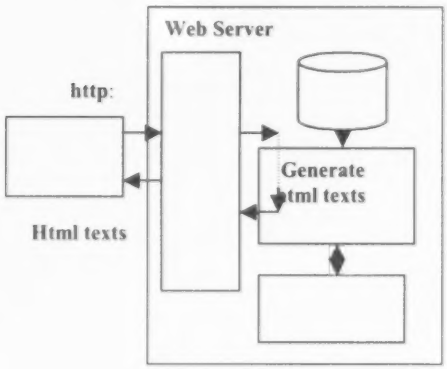


Figure 1: The Action of ASP

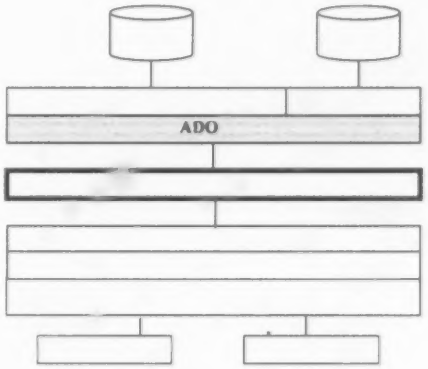


Figure 2: The structure of mIc

The system "mIc" consists of Microsoft Active Server Pages(ASP) which is the server-side execution environment. The ASP can run scripts and Component Object Model(COM) on the server . It can also easily create the dynamic contents and the powerful Web-based applications. The COM is the Microsoft software architecture that allows application to be built from binary software components. Windows itself and many other applications such as WORD, EXCEL and etc. are consisted of the COM.

Figure 1 shows the process of "mIc". ASP files appears to be the same as the HTML files but it includes additionally VBscripts or Javascripts, which call COM. At first, a browser makes a request to the server to send an ASP file in such a manner as to the HTML file. Secondly, the server executes ASP file and Bvscripts or Javascripts At last, the server send these to a browser. By using ASP, a browser only interprets common HTML without executing scripts in the client environment. Figure 2 shows the structure of "mIc". We have applied to some COM, which have access to a database, a browser, files, and a mail server. ADO is the database access COM and the system uses Microsoft Access or SQL Server.

3.2 Setup of mlc

The system "mlc" can be easily installed by simply copying the ASP files in such a manner as for HTLM files .The teacher will be required to edit the "mlc"' configuration file which contains such information as URL, the install path and etc. Should a teacher wish to display some comments enabling the students to take note for their reference, he simply input the comments in the text-file corresponding to the exact page. The "mlc" can build more than one system in one server by creating more than one data base file.

4 System function

The functions of "mlc" will be detailed as follows;

4.1 Registration

The teachers can register the students with the use of browser. They can register even many number of students at once with the use of EXCEL or ACCESS. If the teachers will use BBS and E-mail via other programs than "mlc", they will be required to register newly each time they change the application.

4.2 System Menu

Three different user modes are available in the menu , one for a teacher , one for students and one for a guest respectively. The teacher can customize the menu for each mode. Should the teacher not use the mailing list, he can simply edit the configuration file to turn off the flag of the mailing list and the menu eventually will not display the button of the mailing list.

4.3 Web mail

The system "mlc" has two different Web mail modes whose user interface are the same , the one simulation mode and the other SMTP/POP3 mode. While the simulation mode will not actually allow to send or receive mails via the Internet, it will allow to simulate the mail functions without the mail server. Should you have the mail server and use the SMTP/POP3 mode, it will allow to send or receive mails via the Internet as the regular web mail.

4.4 Electronic bulletin board (BBS)

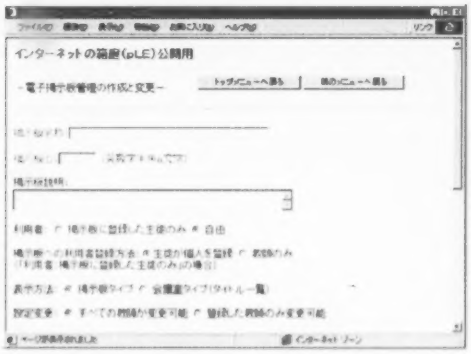


Figure 3: Screen image of Defining BBS

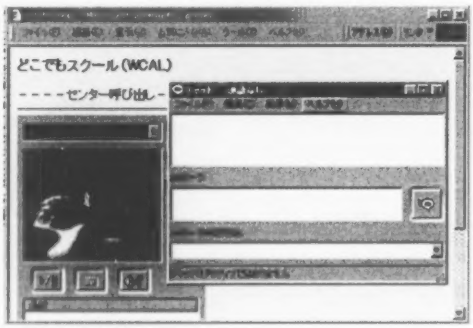


Figure 4: Screen image of Video conference

The system "mlc" allows to set up more than one bulletin board. Should the teacher wish to create a new BBS, he will be required to simply define the BBS on the browser and no new program will be necessary(Figure 3). "mlc" allows to set up the users' list covering the users who can have the access only in the BBS. The users' list can be selected in accordance with the student attribution such as Class , Group and etc.

4.5 Mailing list

The operation of the mailing list will follow the same manners as mentioned above for BBS.

4.6 Search engine

Since "mIc" has a directory service like "YAHOO" , the teachers and the students can add any new URL to the directory for their reference. If "mIc" is installed in WindowsNT server with Microsoft Index Server, the text-matching search engine can be used. The attention is drawn that "build-up of HP" has become one of the most important curriculum in Japan . The student can register their own HP's in the directory of "mIs" and can subsequently search them in the classroom.

4.7 Web Video conference

Since the Video conference is very efficient and effective tool in term of the international communication, we have designed to incorporate the function "Web Video conference" in the system so as to suffice in this respect(Figure 4). A student can communicate with other students and visualize them via web video conference and refer to the data interactively via web data conference. Data conference allow the students to collaborate on "chat", "whiteboard" and "program sharing" without Video and Audio. Since the web videoconference is based on Microsoft Netmeeting 3.0 Active X, the multipoint data conference is possible and thus more than one student can participate the meeting simultaneously.

4.8 Generator of the questionnaire

Understanding strongly the importance of the questionnaire so as collect of the opinion from the students for various topics, "mIc" is designed to generate automatically the questionnaire in the form of HTML and ASP files. The teacher can easily make these files by filling in to the points raised as question on the web pages . The form filled in by the students can be saved to the text file in the form of the spreadsheet such as Excel.

5 Further development(future work)

We have already started to introduce the system"mIc" at schools ranging from the junior high school through the university . Having learnt from the experience, it seems very obvious that the teachers can make BBS and use search engines at ease. Through the continued experiments, we are prepared to improve the system further.

mIc Web Site (In Japanese)
URL www.jona.or.jp/~gohome

References

[1] Michael,G., Greg Merley, Distance Education A System View, Wadsworth Publishing Company, (1996)
[3] Go,O.,Kanji ,"Development of integrated Collaboration System with BBS and mailing list"(1999)
[2] Go,O.,Kanji, A.,"Development of School intranet system baeed on COM and ASP", (1999)

Implementation of An Object-Oriented Learning Environment Based on XML

Geng-Hong Su, S. S. Tseng*, Chang-Jiun Tsai, and Jing-Ru Cheng
Department of Computer and Information Science
National Chiao Tung University
Hsinchu 300, Taiwan, R.O.C.
Tel: +886-3-5712121 ext. 56658
Fax: +886-3-5721490
E-mail: sstseng@cis.nctu.edu.tw

In [12], we proposed the architecture of Object-Oriented Course Construction System (OOCCS). Based upon OOCCS, dynamic and individualized course frameworks can be constructed from the teaching objects in accordance with the aptitudes of students. Besides, the teachers can change the content of teaching materials easily by just inserting, deleting or modifying the related teaching objects. In this paper, we design an authoring system to assist teachers in construct teaching objects by using XML technology, and construct some mathematical teaching objects for showing the dynamic and individualized course frameworks.

Keywords: **Object-Orientation, Web-based Learning Environment, XML**

1. Introduction

The web-based educational systems are becoming more and more popular over the world. Several approaches, which are used to organize the teaching materials appropriately, have been developed in the past ten years [1][2][4][6][8][11]. One of them is just putting all of teaching materials on the web looked just like an electronic book although some friendly user interface or interesting multimedia has been added [1][2][8][11]. [4] and [6] provided the evaluation mechanismwhich works at the end of each section of course materials to find out what instructional objectives the students do not learned well. According to these evaluation results, the system can offer the remedial teaching materials properly for students to learn again. However, in above two approaches, the students always need to learn all teaching materials at least once no matter how the teaching materials are suitable for them or not when they enter a new section. Therefore, we are interested in developing a tutoring system, which can offer different teaching materials for different students in accordance with their aptitudes. As shown in Figure 1, the traditional course model usually arranges the teaching materials in sequential and monotonous way. It means that the individualized course framework may not be offered in accordance with their aptitudes.

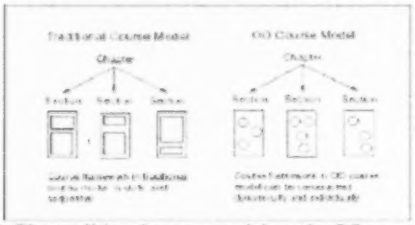


Figure 1. The traditional course model vs. the OO course model

* Corresponding author.

In last year, we proposed the architecture of Object-Oriented Course Construction System (OOCCS) [12]. Based upon OOCCS, dynamic and individualized course frameworks can be constructed from the teaching objects in accordance with the aptitude of students. Besides, the teachers can change the content of teaching materials easily by just inserting, deleting or modifying the related teaching objects.

In this paper, we design an authoring system to assist teachers in construct teaching objects by using XML technology, and construct some mathematical teaching objects for showing the dynamic and individualized course frameworks.

2. Related Work

In the traditional course model, the arrangement of the teaching materials in a section is sequential and monotonous. In this way, without appropriate segmentation and labeling on teaching materials, it is difficult for an individualized tutoring system to offer appropriate teaching materials for students in accordance with their aptitude. The "segmented materials & materials attributes" relationship actually is very similar to the "class & class members" relationship in object-oriented mechanism. Therefore, object-oriented course model [12] have been proposed to model the segmented teaching materials. In this model, the teaching materials of a section are divided into several segments according to the instructional objectives defined by educational experts. Besides, each of them is attached with four labels, the background knowledge, instructional objective, the learning level and the difficulty level, which are described detailedly in Table 1.

Table 1. Instructional Objective Class Definitions

CLASS MEMBER	DEFINITION	INITIALIZE
Background Knowledge	■ The prerequisite instructional objectives before learning the background knowledge.	Base class
Instructional Objective	■ The gained knowledge after learning.	Base class
Learning Level	■ The appropriate level of instructional objective for students. ■ Smaller learning level is more basic for students.	Base class
Difficulty Level	■ The difficulty of a specific object.	Sub-class

As shown in Fig. 2, the object-oriented course model basically is a two-tier architecture: the fist tier is the instructional objective base-class and the second tier is the teaching material sub-class. Based upon the inheritance property of object-oriented concept, the attribute of teaching material sub-class can be easily inherited from the corresponding base class. When teachers want to transform a teaching material into a teaching object, they must select an appropriate instructional objective base-class and determine the instructional objective and the difficulty level. Then the system would automatically derive a teaching material sub-class and generate a concrete teaching object from the sub-class. This transformation process is repeated until all the original teaching materials are transformed into teaching objects.

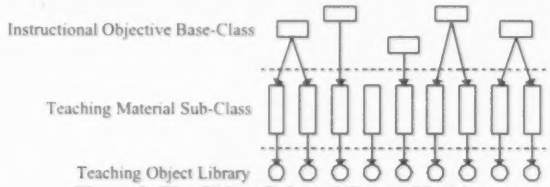


Figure 2. The Object-Oriented Course Model

In the first tier, for a given section of a teaching material, an instructional objective base-class with the value of class members can be constructed according to the instructional objective defined by educational experts. In the second tier, for a teaching material sub-class, the class members are initialized from the base class, such as instructional objective, background knowledge and learning level, are completely inherited from the base classes through the inheritance paradigm. The class member, difficulty level, is initialized in the teaching material sub-class according to the content of a particular teaching material. The instructional objective base-class in the first tier and the teaching material sub-class in the second tier compose the course template library in the object-oriented course construction system.

Based upon object-oriented course model, the architecture of object-oriented course construction system

(OOCCS) has been proposed in last year. As shown in Fig. 3, there are five components, the Course Template Library, the Teaching Object Library, the Learning Record Database, the Individualized Course Construction Engine, and the Evaluation Center, in OOCCS. Furthermore, the individualized course construction algorithm and the course framework revision algorithm has been proposed too.

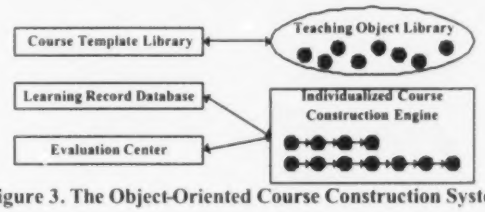


Figure 3. The Object-Oriented Course Construction Systems

3. Data Representation

In this paper, the Extensible Markup Language (XML) [3] is used as the tool of data representations for the content of teaching materials. Based on XML document model, the Document Type Definition (DTD) and schema can be used to evaluate whether the teaching materials are well formed and valid. Besides, the Extensible StyleSheet Language (XSL) [5] can be used to translate one XML document into several different representations. To compose the XML-format teaching materials with different kinds of XSL-format layout templates, different course frameworks can be generated according to students' aptitudes from only one set of teaching materials. Most important of all, under the XML mechanism, the teaching materials own the following benefits including Extensibility, Machine-Readable, Validation, and Convenience.

3.1 The DTD and Schema

Schema in the database is used to determine the order and data type of each field. Similarly, a Document Type Definition (DTD) or an extensible set of rules, also called a schema, is used to validate an XML document by the XML parser. An XML document that follows a DTD or a schema is said to be valid. The Document Type Definition (DTD) describes the structure of an XML document. The DTD includes the information about what elements must be present, which ones are optional, what their attributes are, and how they can be structured with relations to each other. In object oriented course model, four attributes Major Concept, Background Knowledge, Difficulty Level, and Learning Level are included in a teaching object. The corresponding DTD of the teaching object is as follows.

```
<?XML version="1.0">
<!DOCTYPE TeachingMaterial [
    <!ELEMENT TeachingMaterial      (To+)>
    <!ELEMENT To                    (Attributes)>
    <!ELEMENT Attributes            (MajorConcept,BackGroundKnowledge,DifficultyLevel,LearningLevel)>
    <!ELEMENT ContentType           (#PCDATA) >
    <!ELEMENT LinkPath              (#PCDATA) >
    <!ELEMENT MajorConcept          (#PCDATA) >
    <!ELEMENT BackGroundKnowledge   (#PCDATA) >
    <!ELEMENT DifficultyLevel       (#PCDATA) >
    <!ELEMENT LearningLevel         (#PCDATA) >
/>
```

The schema for the XML document is used to define the syntactic structure and partial semantics of XML document types. As such, the schema is an alternative to XML DTDs and can be used to define the same class of document types (with the exception of external parsed entities). Besides, the schema extends the language of DTDs by the following supporting.

- **An extensive (and extensible) set of data types.**
- **Inheritance among element types.**
- **Namespaces.**
- **Features to enable robust distributed schema management.**

The XML Schema of a teaching object is designed in Fig. 4. In the schema for teaching object, we define an element "Attributes" with content type "Attribute" in the "Teaching Material" element. For an element "Attributes", four sub-elements Major Concept, Background Knowledge, Difficulty Level, and Learning Level are included.

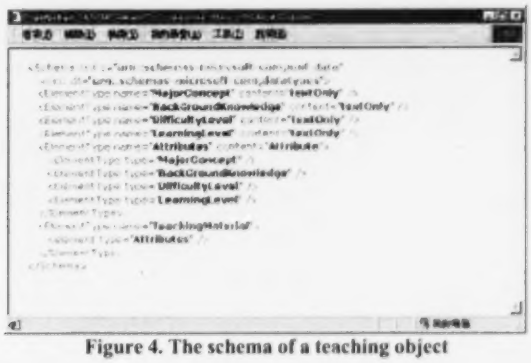


Figure 4. The schema of a teaching object

3.2 The Extensible StyleSheet Language (XSL)

The XML document is a tree-like structure containing the elements, attributes, entities, and so on. The XSL documents takes the tree generated by XML, called the "source tree", and create a new "result tree" that includes all of the objects to be output along with proper formatting information. Through the Document Object Model (DOM) API, an XSL processor can be invoked to apply formatting information to these objects and output them in the browser.

Style-sheet developer usually considers two parts, pattern and template. The pattern is used to match with elements and attributes and the template is used to generate the result tree. For example, the template rule as shown in following looks for "TeachingMaterial" elements in the source tree and are placed inside an <xsl:stylesheet> element. When the processor finds such element, the formatting portion of the template rule is applied to the paragraph content.

```
<xsl:stylesheet xmlns:xsl = "http://www.w3.org/TR/WD-xsl" xmlns:fo=http://www.w3.org/TR/WD-xsl result-ns="fo">
    <xsl:template match="TeachingMaterial">
        <fo: black font-size = "10pt" space-before="12pt">
            <xsl:apply-templates/>
        </fo:block>
    </xsl:template>
</xsl:stylesheet>
```

4. Experiments

As shown in Fig. 5, the architecture including the Teacher Module, Logic Module, and Student Module is designed for the object-oriented learning environment. Besides, in these three modules, there are four components including the Authoring Interface, the Teaching Material Importing Interface, the Course Construction Engine, and the Course Formatting Interface.

- **The Teaching Module**

  An Authoring Interface is designed for teachers to mark-up their teaching contents with corresponding tags.
- **The Logic Module**

  The teaching material importing interface is designed to accept, parse, and finally insert XML-format teaching contents into teaching material database. Besides, a course construction engine is also designed to organize the different course frameworks according to students' aptitudes.
- **The Student Module**

  The course-formatting interface is designed for students to generate course framework easily according to their learning situations.

BEST COPY AVAILABLE

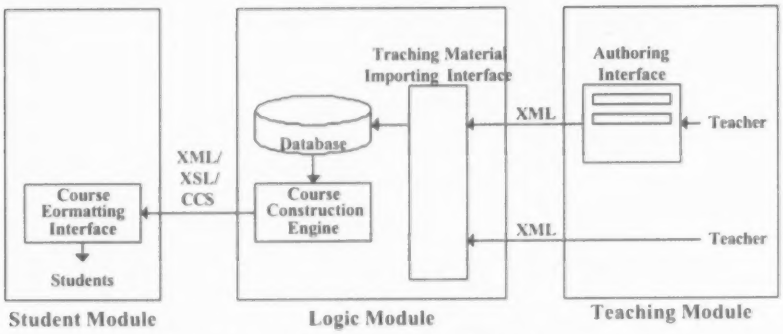


Figure 5. The object oriented learning environment

4.1 The Authoring System

For the teaching objects in the object-oriented course model, they contain not only the teaching contents but also the attributes including the background knowledge, the instructional objective, learning level, and the difficulty level. According to these attributes, it implies these attributes are very important because the course construction engine can organize different course framework for different students. A friendly authoring interface is designed as shown in Fig. 6 to help teachers to author and combine these attributes with teaching contents smoothly. Besides, for the consideration of extensibility, machine-readability, and validation, we choose the Extensible Markup Language (XML) to markup the teaching contents with important meta-information (attributes).

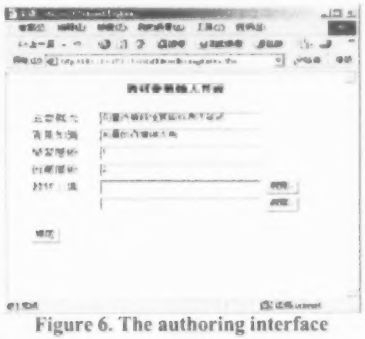


Figure 6. The authoring interface

The teachers need to fill-in the attributes of the uploaded teaching contents and the XML-formatted teaching materials would be automatically created. According to these attributes shown above, the following XML document in Fig. 7 would be generated. Besides, XML schema would be used to check whether the generated XML document is well formed and valid. This checking process is very important for making sure the structure of inputting data is right. Fig. 8 shows the XML schema for the teaching materials.

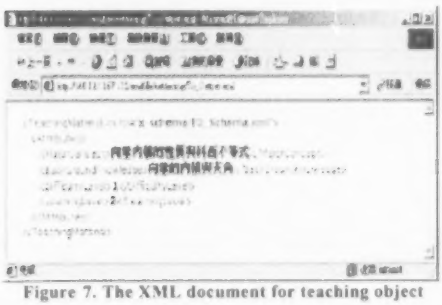


Figure 7. The XML document for teaching object

Figure 8. The XML schema for teaching object

BEST COPY AVAILABLE

4.2 The Teaching Material Importing Interface

The teaching material importing interface is designed for importing and parsing the XML-format teaching materials first and then inserting them into teaching material database.

■ Parse the teaching materials

For parsing the teaching materials, the Microsoft's XML parser, which resides in a file called Msxml.dll and is a Component Object Model (COM) object, could be used in this processing with any ActiveX-compliant environment, including VB and Active Server Page. The following shows the codes of our experiment using the Active Server Page with the Microsoft' s parser.

```
Set objXML = Server.CreateObject("Microsoft.XMLDOM")
  If Not objXML.Load(Server.MapPath("TO.xml")) Then
  With objXML.parseError
      If .errorCode <> 0 Then
            Response.write "Parse Error"
      Else
            Response.write "Error Occured.."
      End If
      End With
  End If
  Set m_Root=objXML.documentElement
  Set KNode=m_Root.selectNodes("Attributes")
  Response.write "• • • • • • • • • • • • • • • • • • • • • • <br><br>"
  For Each node in KNode
      Response.write   node.selectSingleNode("MajorConcept").Text      Response.write
      node.selectSingleNode("BackGroundKnowledge").Text
      Response.write node.selectSingleNode("LearningLevel").Text      Response.write
      node.selectSingleNode("DifficultyLevel").Text
  Next
```

In the parsing process, an objXML object is first created as Microsoft DOM document and then uploaded teaching materials would be loaded. By checking the "parseError" property to objXML, the uploaded teaching material would be checked whether is well formed and valid. If the checking result is right, several methods including the "DocumentElements", "SelectNode" and the "SelectSingleNode" in the DOM objects can be called to parse the XML-format teaching materials and retrieve the attributes.

■ Insert the parsed result into database

After parsing the uploaded teaching materials, system would insert the teaching materials and the meta-information (attributes) into database. Because database allows difficult data formations to be created dynamically from the same data, the XML-format teaching materials are imported into the database for manipulating teaching materials efficiently.

After parsing XML-format teaching materials and inserting the parsed result into database, the feedback is shown in Fig. 9. The importing interface can parse the uploaded teaching materials and check whether the teaching materials are well formed and valid. Therefore, teachers can edit the teaching materials in the client side and then upload the final teaching materials through the importing interface into server. By this way, the distributed authoring environment is obtained.

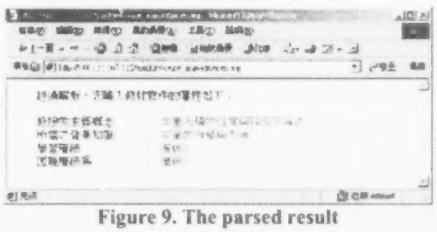


Figure 9. The parsed result

4.3 The Course Construction Engine

The Course Construction Engine is designed to organize the teaching objects according to the Individualized Course Construction Algorithm and the Course Framework Revision Algorithm [12]. By applying these algorithms, the individualized course framework can be constructed from the teaching objects stored in the database and can be organized in accordance with the aptitudes of the students.

In the construction process, the generated course frameworks are saved in the XML format. This means that the course framework contains not only the teaching contents but also the attributes (meta-information) including the Background Knowledge, the Instructional Objective, Learning Level, and the Difficulty Level. These attributes are encoded in the defined XML tags and can assist the course-formatting interface in changing the representation for the course frameworks dynamically and easily.

4.4 The Course-Formatting Interface

The course-formatting interface is designed for presenting the course frameworks, which are organized by the course construction engine. In the interface, several different XSL-format layout templates would be designed. Students can choose the desired layout template, and this template can be used to translate the XML-format course framework into readable teaching materials for reading and learning. The following results show the same course framework with Learning Level 1 and Learning Level 2 in Fig. 10 and Fig. 11, respectively.

Figure 10. Learning Level 1

Figure 11. Learning Level 2

As shown in the above results, through the layout templates in the course-formatting interface, an XML-format course framework can be constructed into different layouts automatically. It is important for object oriented course model when students want to choose other layout of the course framework, because the different course frameworks can be provided by changing the layout templates easily.

5. Concluding Remarks

In this paper, based upon object oriented course model, we design an authoring system to assist teachers in construct teaching objects by using XML technology. All of teaching objects would be stored in database for further usage of OOCCS. OOCCS can offer different course frameworks to the students according to their aptitudes. When the students do not learn some major concepts well, OOCCS can precisely offer the related teaching objects for them to learn again.

In the experiment, the authoring system, the teaching material importing interface, the course construction engine, and the course-formatting interface are imple mented under object-oriented and XML concepts. Teachers can edit the teaching materials in the client and then upload into server easily. After the course construction engine and course formatting interface transform the teaching materials into teaching objects, OOCCS can organize course framework in accordance with students' aptitudes automatically.

However, there are still some disadvantages including the "additional teaching material preparation time" and the "not suitable for all curriculums". In the future, we will try to develop a friendly front-end on the WWW to

BEST COPY AVAILABLE

minimize the effort needed to prepare teaching materials, and then apply object-oriented course model to the mathematics curriculum to examine how they work.

Acknowledgment
This work was supported by the National Science Council of the Republic of China under Grant No. NSC88-2213-E-009-078.

References

[1] Alessi, S. M. and Trollip, S. R., "Computer-based instruction: Methods and development (2nd ed.)," Englewood Cliffs, NJ: Prentice-Hall, (1991).
[2] Antal, P, "Animated explanations using adaptive student models," Proc. of INES '97, Page(s): 573 –576, (1997).
[3] Bray, T., Paoli, J., and Sperberg-McQueen, C. M., "Extensible Markup Language (XML) 1.0," World Wide Web Consortium (W3C), http://www.w3.org/TR/1998/REC-xml-19980210 (Feb 1998).
[4] Chou, C., "A computer logging method for collecting use-reported inputs during formative evaluation of computer network-assisted distance learning," Proc. of ED-Media' 96 Conference, (1996).
[5] Clark, J., and Deach, S., "Extensible StyleSheet Language (XSL) Version 1.0," World Wide Web Consortium (W3C), http://www.w3.org/TR/1998/WD-xsl-19981216 (Dec 1998).
[6] Campbell, J.O., "Evaluating costs and benefits of distributed learning," Proc. of 27th Annual Conference, (1997).
[7] Essenius, R. P. and Wissenburgh, C., "Adaptive computer-based training in electronic engineering," Proc. of MCMC '97, Page(s): 73 –82, (1997).
[8] Hwang, G.J., "A Tutoring Strategy Supporting System for Distance Learning on Computer Networks," IEEE Transactions on Education, Volume: 41, No. 4, Page(s): 343 –343, (1998).
[9] Principe, J.C., Euliano, N., Lefebvre, C., "An interactive learning environment for adaptive systems instruction", Proc. of the 1998 IEEE International Conference on Acoustics, Speech and Signal Processing, Volume: 3, Page(s): 1901 -1904, (1998).
[10] Srisethanil, C. and Baker, N., "ITS-Engineering: providing adaptive teaching in the engineering tutor." Proc. of Frontiers in Education Conference, Volume: 1, Page(s): 2a3.22 -2a3.26.
[11] Sun, C. T. and Chou, C., "Experiencing CORAL: design and implementation of distance cooperative learning," IEEE Transactions on Education, Volume: 39, No. 3, Page(s): 357 –366, (1996).
[12] Su, G. H., Tseng, S. S., Tsai, C. J., and Zheng, J. R., "Building an object-oriented and individualized learning Environment on the WWW," Proc. of ICCE' 99, Page(s) 728-735, Chiba, Japan, (1999).
[13] Vassileva, J., "Dynamic Course Generation on the WWW," Proc. of AI-ED' 97, IOS: 498-505, (1997).
[14] Weiss, D.J. and Kingsburg, G.G., "Application of Computerized Adaptive Testing to Educational Problems," Journal of Educational Measurement, Volume: 21, Page(s) 361-375, (1984).
[15] Yu, P.T. and Shyi C.W, "Intelligent Computer-Assisted Learning System: A Mental-Model Approach", project report of National Science of ROC, NSC 85-2511-S-194-005, (1999).

Internet Video on Demand System of Classroom Teaching Cases

- Building "RAPSODY": An Intelligent Media-Oriented Remote Educational System for Self-Learning Support -

Hisayoshi INOUE and Toshio OKAMOTO
Graduate School of Information Systems
The University of Electro-Communications
1-5-1 Chofugaoka, Chofu-City, Tokyo, 182-8585 JAPAN
TEL: +81-424-43-5623
E-mail: {ino,okamoto}@ai.is.uec.ac.jp

Our study aims to accumulate information for teachers, about established teaching methodologies and techniques. For the purpose of our study, we construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education". In this paper, we describe the details of our video searching system, the design of the database tables, and we show an example of system operation.

Keywords: **Information Education, Teacher Education, Distance Learning, VOD, Rapsody**

1 Introduction

In now-a-days advanced information society, the demands about teachers' competence are high and diverse. Concretely, teachers are required to posses on one hand curriculum development ability, learning environment design ability, group learning, individual learning, simultaneous learning, and on the other hand the previous abilities should be supported by class practice ability, observation and evaluation ability, and last but not least, the ability to connect the textbook's world and the real world.

It is difficult to raise and form this complex set of abilities, with the help of only the presently available education and training methodology for teachers. Therefore, the necessity emerged [1] to examine the feasibility of a new systematic approach, for supporting the teachers' literacy progress, by building on their natural talents/ and abilities, and expanding these to reach the required width and breadth.

The information technology science is offering the tools for the development of an environment supporting the teachers' endowment progress. The knowledge concerning the teachers' education contents and methods is stored as multimedia information, in the form of pictures, videos and sound tracks. Moreover, by using the network environment, it is possible to make use of all resources over the net, without any constraints or restrictions of time and/or geographical location.

With this goal in mind, we are researching the development of an integrative distance education training system for supporting teachers' self-training, called RAPSODY (Remote and Adaptive System of Oriented Dynamic Teaching/Learning) . Up to now, the availability of video records and guidance plans about lessons was limited to education training centers or universities, etc. The present research intends to make the information on educational activities and practices public, and aims at joint usage and re-usage of teachers' self-learning and self-training methodologies and tools. Concretely, we develop a retrieval system based on dialogue patterns, by using a database of lesson videos.In order to jointly use the information in the distributed environment, or to be able to re-use it, we implemented a Video On Demand (VOD) system. The (teacher) user can control/manage the specification and stop/suspension of

the regeneration point for the distributed VOD.

The main purpose of our research is therefore to propose a distance-learning environment on the Internet, for improving the teachers' practical abilities. In this paper, we describe the video on demand system developed until now, the indexing method of the classroom teaching movie example database, the system's functions and the system's evaluation.

2 The outline of the system

2.1 The structure of the system

Fig. 1 shows the structure of the search system. The system is built of the following three parts:

- Web browser;
- Lesson video example database;
- Video distribution server.

The web browser has the role of the user interface. The search/retrieval mechanism searches the lesson example video database via three types of relational database files.

The video distribution server stores the lesson scenes' videos. The video distribution server performs the VOD function at the users' requests. The search functions performed for the user are of the following two types.

- Keyword Search
- Feature Oriented Search

The Keyword Search (fig. 1,) takes place as explained below.

a-1) The user designates the search conditions.
b-1) The search mechanism compares the search conditions input by the user, with the available class example video database.
c-1) The search mechanism extracts the record(s) matching the searching conditions.
d-1) The result is displayed as the search result.

The Feature Oriented Search process (fig. 1,) is done as shown in the following.

a-2) The system dialogue mechanism enquires about the video characteristics/features desired by the user.
b-2) The user can answer to the system's enquiry vaguely [2].
c-2) The decision making table (showed later on in table 6), obtained from the user, is the basis for the evaluation of the specific search conditions. The gathered search conditions are passed over to the search mechanism of the database.
d-2) The database search mechanism compares the search conditions resulting from the evaluation with the lesson example videos contained in the database.
e-2) This result is displayed as the search result.

The search result is formatted as an URL list that is shown to the user. These URLs perform the function of linking the search result and the actual videos on the VOD server. The (teacher) user chooses the URL that s/he wants to refer (Fig. 1,).When the URL is chosen, the VOD client software, embedded via the Web browser plug-in, starts, and the video playback begins.

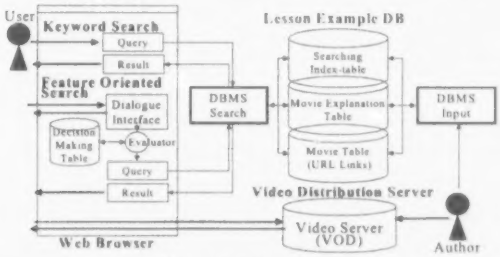


Figure 2 Sstem Organization

3. Database structure

3.1 Lesson (unit) database

The following three relational database files define the video lesson database.

- Searching Index File
- Movie Explanation File
- Movie File

In the following, we will explain in detail each database file type.

3.2 Searching Index File

The Searching Index File results from the comparison of the video database with the search items. The search items are organized in items for the Keyword Search and items for the Feature Oriented Search. In table 1, we show the Searching Index File for the Keyword Search, and in table 2, the Searching Index File for the Feature Oriented Search.

For the Keyword Search, the search conditions are given directly by the user. The Searching Index File slots are "lesson name (unit)", "learning contents (subunit)", "used information equipment/machinery/device(s)", "used tool(s) application(s)" and "class viewpoint".

In the Feature Oriented Search, the system generates the search conditions, based on the information obtained from the user. The Searching Index File (Feature Oriented Search) employs comparison of the extracted search conditions and the database, depending on the dialogue with the user. The slots of the Searching Index File for the Feature Oriented Search mechanism are "teacher activity " and "student activity ".

Table 1 Searching Index File (Keyword Search)

index frame database basic search key

record fields	value type
ID (primary key)	*numerical value type*
lesson name (unit)	*text type (menu selection)*
learning contents (subunit)	*text type (menu selection)*
used information equipment/ machinery/ device(s)	*text type (menu selection)*
used tool(s) application(s)	*text type (menu selection)*
class viewpoint	*text type (menu selection)*

Table 2 Searching Index File (Feature Oriented Search)

index frame database feature search key

record fields	value type
ID (primary key)	*numerical value type*
teacher activity	*text type (menu selection)*
student activity	*text type (menu selection)*

3.3 Movie Explanation File

Table 3 shows the contents of the Movie Explanation File, regarding the movie features. When the user is about to commence the lesson, the points, which need his/her attention, are explained via the contents of the Movie Explanation File. These explanations are used when displaying the search results.

Table 3 movie explanation file

movie feature description video feature information)

record fields	value type
camera angle	*text type (menu selection)*
equipment existence	*text type (menu selection)*
equipment usage	*text type (menu selection)*
number of teachers	*text type (menu selection)*
teachers' movements	*text type (menu selection)*
existence learning supporter(s)	*text type (menu selection)*

number of students	*text type (menu selection)*
students' movements	*text type (menu selection)*
existence of a central student	*text type (menu selection)*

The explanation information in the Movie Explanation File (table 4) resumes the lesson scenes compiled by the video registrants, and the information on how the checkpoints, necessary for the lesson, were estimated. The slot of table 4 called "teacher's aim", corresponds, for instance, to the classification 8 presented later on in table 7.The "checkpoints 1 to 3" express the free description of the image, from the points of view shown below.

Checkpoint 1 the movie preconditions to be considered;
Checkpoint 2 what should be extracted/ understood from the current movie;
Checkpoint 3 the necessary forecast of the movie's following development.

Table explanation file

4 movie

movie explanation database

record fields	value type
ID (primary key)	*numerical value type*
teacher's aim	*text type (menu selection)*
checkpoint 1	*text type (item description · within 100 characters)*
checkpoint 2	*text type (item description · within 100 characters)*
checkpoint 3	*text type (item description · within 100 characters)*

3.4 Movie File

Table 5 shows the Movie File. The Movie File contains pointers to the real videos. The VOD server houses the real videos. Table 5 contains the Movie File slots called "thumbnail picture (still picture)", "previous movie", "movie URL (movie file name)", and "next movie".

Table 5 movie file

movie database

record fields	value type
ID (primary key)	*numerical value type*
thumbnail picture (still picture)	*text type (still movie file name)*
previous movie	*text type (URL type input)*
movie URL (movie file name)	*text type (URL type input)*
next movie	*text type (URL type input*

For the discrete movie time-series {P(t)}, the following relationship exists:
$[P(t-1),P(t),P(t+1)]$ = [previous movie, movie URL, next movie];$P(t=0)$ ={still picture};where t is the time.

4 The system's behavior

Figure 2 shows the search conditions input interface (for Keyword Search). Figure 3 shows the search result display interface. After the (teacher) user specifies the conditions for the desired video search via the search conditions input interface, the search starts. The result of this is displayed in the search result display interface [3] [4]. This interface shows the value of the slots called " still picture", "lesson contents (subunit)", "teacher's aim", "checkpoints", "teachers' activity" and "students' activity". The "still picture" can be seen in figure 3 (). Next to being a significant snapshot of the lesson video, the still picture has also the role of a pointer to the real video (a link to the VOD video file), so describes the URL (figure 3,). By clicking on the still picture, the video starts (figure 3,). The "teacher's aim" (fig. 3,) and "checkpoints" (fig. 3,) are, as mentioned before, the most important information for image explanation. The figure also presents the (teacher) user with help/support information about other items and record fields.

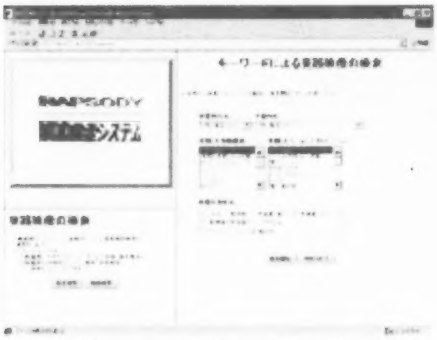


Figure 2 search conditions input picture

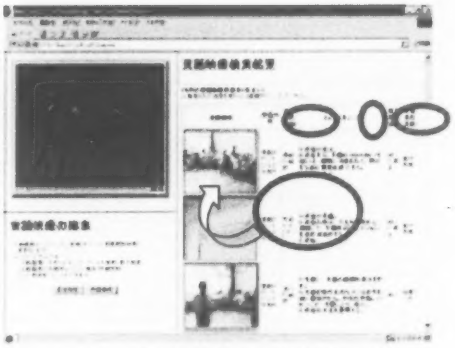


Figure 3 search result display picture

5 Conclusions

We construct a searching system for lesson example videos, and we develop an environment for facilitating the usage of our example videos, and for encouraging teachers' collaboration. Concretely, we focus on the domain of the new subject introduced in the Japanese curriculum, called "Information Education".We have presented in this paper the summary of the video search VOD system we have developed, moreover, we have shown the database organization and the system's behavior.As for the future tasks and research, we are planning to investigate about building a flexible key for the video search mechanism. We are studying at present the dialogue mechanism, with the immediate goal of using the search result's negative feedback information to the user's request, to serve as a new search key.

References

[1] Okamoto, T. (research representative/delegate) : "1998. Advanced Information Society; synthetic research on the contents, system and form of teachers' education – midway report", 1997, 9 year research funds foundation of the Ministry of Education, A)(1)09308004 stage report.

[2] Stain, A, Gulla, J.A, Muller, A. and Thiel, U.: "Conversational Interaction for Semantic Access to Multimedia Information", Intelligent Multimedia Information Retrieval, pp. 399-421, MIT Press, 1997.

[3] Noguchi, H.: "Data representation and management in image databases", IPSJ, Vol.33, No.5, pp. 457-465, 1992

KNOWLEDGE ANALYSIS OF TASKS FOR COURSEWARE DESIGN

Lorna Uden & Neil Willis
School of Computing, Staffordshire University,
The Octagon, Beaconside, Stafford, ST18 0AD, UK.
Phone: +44 (0)1785 353276
Fax: +44 (0)1785 353497
E-mail: L.Uden@staffs.ac.uk
E-mail: N.Willis@staffs.ac.uk

Substantial changes have taken place in the nature of jobs over the last twenty years, primarily due to the proliferation of computer-based technology. These changes have shifted the demands on human performance from primarily physical to cognitive. Cognitive tasks components usually have significant 'transfer task' components in addition to procedural components. Task analysis is a critical step in the development of computer-assisted instruction. Traditionally there are two well-known methods for analysing tasks in courseware applications. These are Hierarchical Task Analysis and Information Processing Task Analysis [3]. Although both of these methods have been effectively used in designing training for procedural skills, they offer little insight for analysing training involving complex cognitive tasks. Both of these analyses identify the external structure of the information, but do so independently of how they are actually structured in human memory. We believe that Knowledge Analysis of Tasks (KAT) offers an alternative method for task analysis in courseware applications. KAT differs from other task analysis methods in that it is based on the theory that people not only perform tasks, but also develop structures to represent the knowledge that they require to perform a particular task. The results of KAT are used to produce a model of tasks in terms of Task Knowledge Structures (TKSs). TKSs represent the knowledge people possess about tasks they previously learned and performed in a given dimension. The application of the theory of TKS and the analysis method of KAT can be used effectively in the design of interactive courseware applications. This paper describes a case study showing how KAT can be applied in the task analysis of interactive courseware applications.

KEYWORDS: **Task Analysis, Task Knowledge Structures, Knowledge Analysis of Tasks, Task Procedures.**

1 INTRODUCTION

According to Jonassen, Hannum and Tessmer [6], task analysis is the most crucial part of the instructional design process. Task analysis solves three main problems for designers. These are:

- It defines the content required to solve the performance problems or alleviate a performance need.
- The process forces the subject matter expert to work through each instructional step.
- It helps the designer to view the content from the learner's perspective.

There are several typical methods of conducting task analysis in courseware design. The most prominent methods are the Hierarchical Task Analysis and Information Processing Task Analysis [3]. However, the main weakness of these methods is that they are only loosely connected to any theory of psychology that would allow the task analysis to result in principles and theoretically based recommendations. Task analysis is also a critical part of human-computer interaction design. A variety of techniques are available for performing task analysis in user interface design [10]. However, the theoretical or empirical evidence

offered by these methods for their existence is weak [7].

We believe that Knowledge Analysis of Tasks (KAT) offers an answer to these limitations. KAT differs from other task analysis methods in that it is based on Task Knowledge Structures (TKS), which are an attempt to provide a theoretical underpinning to the method. KAT is concerned with assessing and modelling the knowledge people possess and utilise in carrying out tasks. It identifies the knowledge requirements of tasks and is aimed at assisting in the generation of design solutions. KAT has been used successfully in designing effective software systems [8]. It is our belief that KAT can offer an effective task analysis method for courseware design. This paper describes a case study showing how KAT can be used to analyse tasks for searching for information on the Internet in a courseware application. Section two of the paper presents a brief review of KAT and TKS. This is followed by the case study of the courseware application. Section four concludes the paper with recommendations for further research in KAT and TKS in courseware applications.

2 Overview of KAT & TKS

Johnson and Johnson [7] developed the Knowledge Analysis of Tasks (KAT) method. It incorporates Task Knowledge Structures into the process of task analysis. Johnson and Johnson [7] describe KAT as the collection of data from a variety of sources, such as task performers, instructors, supervisors and others, directly or indirectly affected by the task. The results from this analysis are used to produce a model of tasks in terms of task knowledge structures.

2.1 Task Knowledge Structures

According to Johnson and Johnson [7], task knowledge is represented in a person's memory and can be described by a Task Knowledge Structure (TKS). TKSs are assumed to be acquired through learning and previous task performances, and are dynamically represented in memory. This is akin to the theoretical position taken by Schank [11] in assuming that the knowledge of frequently occurring events is structured into meaningful units in memory. Empirical support for this assumption can be found in the work of Galambos [4], who showed that people recognise and use structures of events, such as the order, the sequence and importance of activities within the event sequence, to understand, explain, and make predictions about these events. Another support for this is the work of Graesser & Clark [5] on text comprehension. The assumption is that all the knowledge a person possesses about a task is contained within the TKS and that the TKS is activated in association with task performance. The suitability of utilising this form of conceptual knowledge for teaching a computerised domain is supported by Scumalhofer and Khun [12], who state that mental models present a more complete picture of the cognitive components in learning to use a computer system.

2.1.1 Implications of TKS

If we assume the existence of task knowledge structures, by which people structure their knowledge in a particular way, it follows that this task knowledge can be analysed, modelled and predicted [7]. This has important implications for learning. It suggests that by understanding the knowledge structure, recall and processing could be optimised to give quick and efficient task performance by appropriate training techniques and interface design. According to Johnson and Johnson [7], people acquire knowledge about tasks and subsequently transfer this knowledge to new or different tasks. Therefore usability and learnability are directly related to the amount of knowledge that the person is able to transfer from one task to another. The benefits to be gained from enhancing this transfer come in the form of reduced time and the achievement of a higher level of task performance in a shorter length of time.

A TKS is related to other TKSs by a number of different relations, which include temporal or experimental relations. TKS theory provides a method for the analysis and modelling of the tasks in terms of goals, procedures, actions and objects. In addition, TKS theory identifies the representitiveness (typicality) and centrality (importance) of a particular aspect of task knowledge. Within each TKS, different types of knowledge are represented. There are four components to a complete TKS model. These are as follows:

1. A goal-oriented substructure.
2. Task procedures.
3. A taxonomic substructure comprising the generic task actions and objects.
4. A summary task knowledge structure.

Task models in terms of TKS involve goal-oriented and taxonomic substructures and procedures. A goal-oriented substructure can be represented by a network of structured goal nodes that direct sequences of events that unfold over time and eventually satisfy subgoal nodes. Goal nodes can vary in hierarchical level. Goals and subgoals can be represented by nodes with links between them. Nodes can be treated as conditions, as states or as desired states (subgoals). Subgoals can also be hierarchically and concurrently related to each other. The goal-oriented substructure 'calls up' appropriate knowledge from the taxonomic substructure by use of procedures. Associated with subgoals are sets of procedures that have to be executed in order to achieve subgoals directly or indirectly. Any subgoals may give rise to further planning activity and subsequent subgoals and this may be indirectly related to a procedure set.

Task procedures define the of action object combinations in the execution of a given subgoal. They are the processes by which the taxonomic substructure is activated. The taxonomic substructure represents knowledge about generic actions and objects and the relationships between them.

We have chosen TKS as our approach because we believe that the theoretical or empirical evidence for their existence, offered by other cognitive task analysis methods is weak. Although production rules of Anderson [1] can be used to model goals, operations, methods and selection rules, we believe that these production rules also bear a closer relationship to the way a person does (or would) structure their knowledge of task [7]. We also believe that the knowledge a person possesses about a task is contained with the TKS and that the TKS is activated in association with the performance. The suitability of utilising this form of conceptual knowledge for teaching a computerised domain, is supported by Scumalhofer & Kuhn [12], who stated that mental models present a more complete picture of the cognitive complexities in learning to use a computer system. If we assume the existence of task knowledge structures, by which people structure their knowledge in a particular way, it follows that this task knowledge can be analysed, modelled and predicted [7]. This line of thought has great implications for the study of learnability. It suggests that by understanding the knowledge structure, recall and understanding can be optimised to give quick and efficient task performances, via appropriate training techniques and interface design. Johnson and Johnson [7] suggest that usability and learnability are directly related to the amount of knowledge a person is able to transfer from one task to another. The benefits to be gained from enhancing this transfer come in the form of reduced training and the achievement of a higher level of task performance in a shorter length of time.

2.2 KAT Method

KAT can be divided into three parts: knowledge gathering, knowledge analysis and TKS construction. Before the analysis is undertaken, it is imperative that the objective of the KAT exercise be identified. This is to establish domain boundaries and help to ensure that attention is concentrated on the most critical and relevant activities. Once this has been accomplished, domain gathering can begin. The principle inputs to this stage are the objective itself and the information gathered through interviews, questionnaires and observations. The major output is a preliminary picture of the domain knowledge expressed in terms of procedures, actions, objects and goals. The next stage, knowledge classification, takes the outputs of the first stage and categorises each in terms of its representative, central and generic properties. During the final stage, the actual TKS model is constructed.

3 Case Study

The case study we have chosen to demonstrate KAT is "How to use the Internet". The purpose of the task analysis is to identify the tasks or domain the students have to learn in order to use the Internet effectively. Stage 1 of KAT is Knowledge Gathering.

3.1 Knowledge gathering

A wide range of powerful methods of cognitive task analysis have been developed and applied over the last ten years [9]. Although these methods have been used successful in many applications, few have become accessible to training practitioners and instructional designers. All of these methods required considerate time and resources. All have been part of research effort conducted by scientists as opposed by practitioners. We have chosen to use Applied Cognitive Task Analysis (ACTA), which is a streamlined cognitive task analysis method, developed by Klein Associates [9]. We have chosen it as our method to elicit task knowledge from our subject matter experts. The main reason for our choice is that ACTA allows us to elicit

and represent cognitive components of skilled task performance and the means to transform those data into design recommendations without having to be knowledge engineers, cognitive psychologists and human factor/ergonomics professionals.

We used a structured interview for eliciting task knowledge from our subject-matter experts. The method we used is known as). ACTA consists of four sequential steps, of which the first three steps comprise three different stages of interviews. The final step is used to sort and organise the gathered information into what could be the most important tasks. The four steps are Task Analysis Interview, Knowledge Audit, Simulation Interview and Cognitive Demands. It is beyond the scope of this paper to describe these steps. Interested readers are invited to contact the first author.

3.2 Analysing the Task Knowledge

The data collected through the ACTA interviews formed the basis of the data for the knowledge analysis of tasks. It provides information about the actions and objects and the goals and subgoals that are involved in a task. The simulation interviews also provided opportunities to find out information about the procedures and strategies used in performing a task.

The knowledge gathered during the ACTA process needs to be identified in terms of the components of a TKS, namely actions and objects, and the structure of those objects, procedures and goal structure. In addition, the knowledge gathered and identified has to be analysed in order to identify representative, central and generic properties of tasks within a given domain or across domains. Some task components are more representative/typical of a task than are others. Central task components are those necessary to successful task execution. Without these central components, the task goal will fail to be achieved. Generic task components, on the other hand, are those common across a number of task performers.

3.3 Task Model Construction

Having gathered and identified the knowledge required for the tasks to be learned, the next stage is the construction of the task model using TKS. The aim of this approach is to identify the structure, content and attributes of learners' task knowledge in line with TKS theory. There are three components to complete a TKS model:

- Goal-oriented substructure
- Task procedures
- A taxonomic substructure from the generic task actions and objects.

3.3.1Goal-oriented sub-structures

The goal structure component of the model identifies the relations between different goal states. There are two general forms of relations: hierarchical and control relations. Hierarchical relations show how a goal can be decomposed into further collections of sub-goals. Control relations show how goals and sub-goals are related to each other for execution. They include sequential, parallel, unordered and optimal relations. Both hierarchical and control relations can appear in all parts of the goal structure components of the TKS model. Goal structures can be represented diagrammatically using tree structures to represent hierarchical components, and transition networks to represent control relations. Figure 1 shows a tree diagram of the evaluation of a search result.

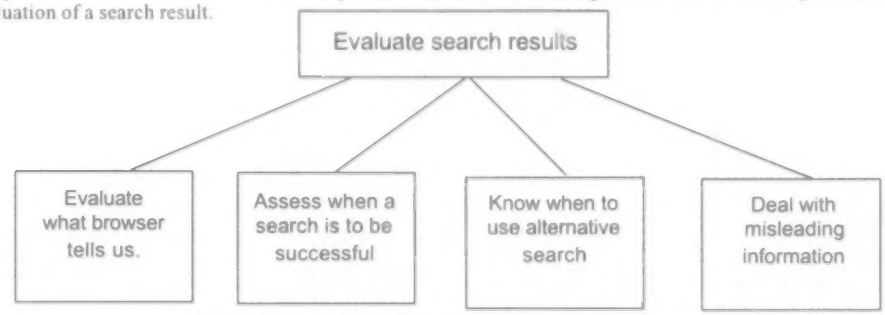


Figure 1 A Tree diagram for Evaluation of Search Result.

3.3.2 Task Procedures

These are directly related to the lowest level goals in the tree structure and they represent the detailed executable form of the task. Task procedures contain actions and objects and the relations between them. The relations include sequential, parallel, iterative and conditional control relations. These control relations exist within a procedure body and determine how the actions will be executed with respect to the objects. Procedures can 'call' other procedures and form parts of the bodies of other procedures like programming languages. Each procedure is defined by a precondition, which determines the context that must exist before it can be executed. Upon execution of a procedure, a defined post-condition will result. The pre and post conditions of procedures are defined in the procedural sub-structure and provide a way of representing the relationship between the goal structure and the procedural sub-structure.

Task procedures are the process by which the taxonomic sub-structure is activated. Not only that, the tasks may be decomposed in different ways; there may also be a choice between a number of different strategies which are context-dependent competing sets of procedures. One set of procedures may be more appropriate than other sets. Contextual information and the circumstances under which the task is to be executed will affect strategy appropriateness. Single procedures in a given strategy may differ in how central they are to the task as a whole. The task procedures for "Deal with misleading information and instruction" are shown in Figure 2. Included in the task procedures are actions and objects of tasks.

```
START
1.0     Knowing How to Deal with Misleading Info & Instructions
1.1     IF results returned matches, THEN
1.1.1                   IF the most relevant link can be found, THEN
1.1.1.1                         Click on the link to go to the page
1.1.1.2                         IF NOT FOUND message is displayed (i.e. Link is broken), THEN
1.1.1.2.1                               Apply Edit-URL strategy process to find page
                                ENDIF
                        ENDIF
        ELSE
1.2                     IF results did not return no match, THEN
1.2.1                           Modify search strategy
1.2.2                           Perform search process
1.2.3                           Go to step 1.1
                        ENDIF
        ENDIF
END
-----------------------------------------------------

START
2.0     Edit-URL strategy process
        DO
2.1                     Position cursor at the end of the URL in the Address bar
2.2                     Start deleting the last part of the URL and stop before the first '/'
2.3                     Perform search
2.4                     IF directory page appears, THEN
2.4.1   Browse directory to find any possible relevant link
2.4.2   IF a possible relevant link is found, THEN
2.4.2.1                 Click on the link to go to the page
2.4.2.2                 IF the desired information is not found on the page, THEN
2.4.2.2.1                               Go to step 2.1
                                ENDIF
                        ENDIF
                        ENDIF
        ENDDO
END

-----------------------------------------------------
```

START
3.0 *Search process*
3.1 Type keyword(s) into search text box
3.2 Hit the search button
END

The actions included:

- Evaluating search results
- Choosing and clicking on a relevant link
- Evaluating the relevance of a page
- Deciding on alternative course of action when a broken link is encountered
- Deciding on another search strategy
- Editing the URL (deleting the end part of the URL)

The objects included:

- Web browser
- Browser address bar
- Browser content window
- Search keyword / phrase
- Search result
- Search engine
- Cursor
- Search button
- Search text box
- Directory page
- Hyperlink
- Not Found error message

Figure 2. The procedures for ' dealing with misleading information'

3.3.3 Taxonomic sub-structure

The taxonomic substructure represents knowledge about objects and the relationships between them. There are three levels to the taxonomic substructure. The top level is the superordinate level. The basic level of the taxonomic substructure contains the objects that constitute the superordinate task category. The basic level task category represents knowledge about: (i) in which task procedure a category member is used, (ii) which other task object a category member is related to, and what that relationship is, i.e., whether the category member causes, enables, follows or is carried out in conjunction with other task objects, (iii) which actions are associated with a category member, (iv) what features or properties a category member possesses, (v) the usual circumstances under which a particular category member occurs, for example, whereabouts in the task the category member is manipulated, (vi) whether or not the object is central and (vii) a pointer or reference to the most representative instance of that object. The bottom level of the taxonomic substructure is the subordinate task category, which contains a particular instance of the type of the object represented at the basic level. The taxonomic substructure of searching the Internet is shown in Figure 3.

Generification / Typicality (T) / Centrality (C)

Generic Objects	Specific Objects
Web browser	Microsoft Internet Explorer (T) Netscape Navigator (T) Mosaic Content window Title bar Tool bar Address bar Status bar Animated logo Bookmarks (favourites)

Search keyword (C)	Single keyword Phrase
Search result	Page title Percentage of relevance Brief description of page URL of page
Search engine (C)	Search text box Search button Alta Vista Excite Lycos Infoseek Yahoo, etc.
Hyperlink	Text (T) Image (T)
Search technique (C)	Boolean Double quotes Wildcard Search-engine specific techniques Other unique strategies
Cursor Directory page Not Found error message	

Figure 3. Taxonomic Sub-structure for Task Analysis on Searching the Internet

4 Conclusion

There are many methods available for courseware designers to use for task analysis. However, the main weakness of these methods is that they lack theoretical or empirical evidence for their existence. Knowledge Analysis of Tasks can be used effectively in the analysis of tasks for courseware design, as shown in the case study. Evidence to support that task knowledge is represented in conceptual or general knowledge structures in long-term memory is found in the work of Galambos [4]. Buckley and Johnson [2] have demonstrated the usefulness of TKS in the analysis of a prototype messaging system. The main achievement of KAT has been the modelling of tasks in terms of TKS. Each component of TKS represents different types of knowledge required by the tasks, whilst the goal structure identifies relations between different goal states – both hierarchical and control-relations. These models are represented diagrammatically using tree structures for hierarchical and transition networks for control. KAT offers the courseware designer a powerful method with which to model knowledge. By modelling knowledge, the designer is forced to understand the knowledge structures with which he/she is dealing. Reflection upon these 'building blocks' of problems solving is something that other methods fail to encourage. The design is focused on the expert's cognitive skills, rather than on the technical details of design. The models in KAT also provide an excellent reference point for the designer to return to during implementation in order to refocus the design if needs be. The biggest drawback of this method is the time it takes for design. However, we believe that the benefits of KAT outweigh its drawbacks and strongly recommend its use.

REFERENCES

[1] Anderson, J. R., "Cognitive psychology and its implications", Freeman, (1985).

[2] Buckley, P. & Johnson, P. (1987). Analysis of communication tools for the design of a structured messaging system. http://www.dcs.qmw.ac.uk/publications/report_abstracts/1987/403

[3] Gagné, R.M., Briggs, L.J. & Wager, W.W., "Principles of Instructional Design Holt", Rinehart & Winston. 4th Edition, (1988).

[4] Galambos, J.A. "Knowledge Structures for Common Activities", In J.A. Galambos, R.P. Ableson & J.B. Black (eds.), Knowledge Structures, Lawrence Erlbaum Associates, (1986).

[5] Graesser, A.G. & Clarke, L.F., "Structures and Procedures of Implicit Knowledge", Ablex, (1985)

[6] Jonassen, D., Hannum, W. & Tessmer, M., "Handbook of Task Analysis Procedures", Paeger, (1989).

[7] Johnson, P. & Johnson, H. "Human Computer Interaction: Psychology, Task Analysis and Software Engineering", McGraw-Hill Book Publishing Company, (1992).

[8] Johnson, P. & Johnson, H. & Wilson, S., "Rapid Prototyping of User Interfaces Driven by Task Models," In J.M. Carroll (ed.), Scenario-Based Design: Envisioning work and technology in system development, John Wiley & Son, (1995).

[9] Militello, L.G. & Hutton, J.B., "Applied Cognitive Task Analysis (ACTA): A practitioner's Toolkit for understanding cognitive task demands", Ergonomics, Vol. 41, No. 11, 1618-1641, (1998).

[10] Roberts, D., Berry, D., Isensee, S. & Mullaly, J., "Software Engineering Series, Designing for the User with OVID: Bridging User-Interface design and software engineering", Macmillan Technical Publishing, (1998).

[11] Schank, R.C., "Dynamic Memory: A theory of reminding and learning in computers and people",. Cambridge University Press, (1982).

[12] Scumalhofer, D. & Khun, O., "The Psychological Processes of Constructing a Mental Model when learning from being told, from examples, and by explanation", In T.A. Galambos (ed.), Knowledge Structures, Lawrence Erlbaum Associates, (1986).

Making the Most of the Internet for Potential for Education

John Wang* and Dilek Sanver**
**RS Information Systems, Inc./university of California, Berkeley*
3402 Sepulveda Blvd, #421, Los Angeles, CA 90034, USA
Telephone: (805) 982-3312
Fax: (805) 982-2659
Email: jgwang@csua-berkeley.edu
***University of California, Irvine*
Irvine, CA 92697,USA
Telephone: (310)390-7429
Email: dsanver@uci.edu

Who is building Web sites today? Entrepreneurs, writers, hobbyists, educators and students from the elementary grades and up are building them, not Java programmers, In fact, very few Web sites are actually built by professional programmers That is why strategies for making the most of Internet' s potential for education is important: It brings the power of Internet to non-programming Web-builders like teachers and their students. Internet is an exciting, dynamic technology that is challenging for education. With new specifications, new classes, and general updates, one must accept the fact, when integrating Internet Technology into instruction, that the course will never be the same because the subject matter is in a never-ending state of change. In today' s technological environment, curriculum development must be iterative; in other words, it is an ongoing repetitive process that is required due to the constant change of the subject matter and the technology. In order to be making the most of Internet's potential for education, we proposed these six basic phases— understanding, planning, research, development, refinement and implementation. This article describes how to effectively use this six-phased approach Follow these phases, the educators and learners can collaborate to enhance existing material and produce new innovations for education.

*The paper was not available by the date of printing.

Natural Language-like Knowledge Representation for Multimedia Educational Systems

Eva Heinrich and Ray Kemp
Institute of Information Sciences and Technology
Massey University, Palmerston North, New Zealand
E-mail: E.Heinrich@massey.ac.nz R.Kemp@massey.ac.nz

The appropriate use of multimedia is becoming increasingly important in computer teaching systems. Not only are students stimulated by being presented with information in a variety of forms, but such an approach also more closely resembles the real world where they have to assimilate what they see and hear, abstracting out what is relevant. With the diversity and amount of multimedia material that may be present in these systems, a powerful form of knowledge representation is required to support navigation and knowledge retrieval. The (human or computer) tutor may wish to refer to document segments, to recap important points, provide feedback, give hints and so on. The student also may wish to refer to items previously seen or heard. The Flexible Structured Coding Language, FSCL, is a natural language-like, formalised description language which allows the formulation of rich yet structured sentences. These sentences are attached to segments of multimedia documents. FSCL provides an easily accessible approach for knowledge representation, precise and rich description of complex contents, correct and complete retrieval within the descriptions, and retrieval across data of different media types. FSCL can be extended to integrate ontologies, inference of knowledge and freeform querying performed by the learner.

Keywords: **Multimedia, knowledge representation**

1 Introduction

Computer-based educational systems have developed from standalone applications, using mainly text and graphics, which focused on teaching a restricted set of subjects or skills. Today's multimedia systems are often distributed across the web using a client-server approach and aim to integrate teaching material from multiple subjects areas. These systems collect feedback on the progress of the learner and attempt to provide material at the appropriate levels. An example of such a system is GENTLE [5].

Beside the technical challenges of managing such a system, a number of conceptual ones arise. One of these is knowledge representation and the related issue of knowledge retrieval. One problem with supplying a learner with a flexible learning environment is the need to provide a mechanism for locating appropriate information. This is a non-trivial task considering the vast amount of diverse material stored and the complexity of the concepts incorporated into the learning material. Another requirement is to give the learner a mechanism for questioning the system. This can be for retrieving specific material or for asking conceptual questions concerning the subject area.

To illustrate some of the requirements for a computer-based educational system, consider a small scenario. Imagine a web-based teaching module on the use of machinery. This module could consist of a number of multimedia documents: for example, a video showing an instructor demonstrating the use of the machinery, a set of images displaying various technical features of the machinery or a set of text documents explaining various procedures. These multimedia documents, annotated with appropriate knowledge representation mechanisms and generic domain knowledge, have to be stored. Based on this information a range of material could be retrieved: a segment of the video document showing the instructor demonstrating a specific task; additional information from images or text documents relating exactly to this task; the status of

the machinery at a specific position in the video inferred from the domain rules.

After a brief overview on current approaches to knowledge representation in computer-based educational systems, we consider how the Flexible Structured Coding Language, FSCL [9,11], may be applied to this problem. We will first describe FSCL in the form it is used in its original context of studies of human behaviour and then discuss the advantages of using FSCL in computer-based educational systems. We then suggest some modifications to FSCL to provide extended support for computer-based educational systems and conclude the paper by summarising the contributions this natural language-like approach to knowledge representation can give us.

2 Current approaches to knowledge representation

To access the appropriate information in a computer-based educational system, a knowledge representation scheme is necessary. This provides a meta-level description of the contents of the educational system. In this paper, we consider the format of this meta-level description, not its technical realization in a database or file system. Before we describe some common approaches to meta-level description, we want to briefly discuss why a meta-level description is necessary and why it is not possible to extract the information directly from the learning material.

The retrieval of information from documents directly has limited scope both on a technical and on a conceptual level. Technically, searching through text based documents is easy and allows for identification of keywords, phrases or sentences. Achieving the same level of retrieval for video documents is much harder. Techniques exist to automatically parse video documents to detect scene changes [8, 23] and objects [6, 17]. However, a number of problems still have to be overcome to provide sufficient access to video content [13].

Setting the technical difficulties in accessing video or audio documents aside, there are still conceptual considerations which will demand some meta-level description of content. Retrieving appropriate information from a collection of documents will, in many cases, require access to the semantics of these documents. Searching through these documents on a keyword (or object) basis is unlikely to produce satisfactory results [2]. The transition of factual ('she was smiling', a smiling face, a sunny picture) to conceptual (happiness, pleasant atmosphere) information has to be made to access the semantics of a document. This is not possible without some meta information or description of these documents.

A number of approaches are used to facilitate the access to the semantics of documents in preparation for information retrieval. Ontologies provide a modelling scheme for a specific domain creating a shared vocabulary for the description of contents [4]. Topic maps [22] create organising principles for information by defining topics, the associations of topics and the occurrence of topics in documents. Conceptual graphs [20,21] capture knowledge about a specific domain and make this knowledge accessible to deduction using first order logic.

In the analysis of data in the social sciences, a *description* approach is common. Codes or annotations, called descriptions, are attached to specific locations of multimedia documents to assist retrieval. These can contain any kind of factual or semantic descriptions of the documents' contents. Domain specific codes or freeform textual annotations are common in analysis programs like The Observer [16], Nudist [18] or its successor, NVivo [19]. All the approaches mentioned above have been proposed to overcome the technical and conceptual difficulties of accessing the information contained in multimedia documents and to facilitate the retrieval of appropriate information. In this paper, we propose the use of FSCL as a meta-level description mechanism. In the next section we introduce the main features of FSCL. We follow this by a discussion of its advantages for knowledge representation and retrieval, and indicate how FSCL can be combined with ontologies and conceptual graphs.

3 Knowledge representation using FSCL

FSCL is a natural language-like description language. It aims to combine the expressiveness and flexibility of natural language with the rigour of formalised approaches. The main components of FSCL are its *vocabulary*, *grammar* and *categories*. The vocabulary can be freely defined by the author of the teaching material. Any word can be used and the vocabulary can be extended at any point of time. Whereas the vocabulary is likely to be defined for a specific domain, the grammar is generic. It is designed to formulate 'subject - verb - object' and 'concept - object' sentences and combinations of these elements, including

conjunctions, prepositions, adjectives and adverbs. The role of the categories is to bridge the vocabulary and the generic grammar. The grammar is defined on the categories. Each word of the vocabulary has to belong to exactly one category. This construct allows for the structure of the description language to stay the same across applications in different domains. The categories of FSCL have been defined in accordance with the word classes of the English language. The categories are: Person/Thing, Activity, Concept, Conjunction, Preposition and Descriptor (which combines the word classes adjective and adverb).

FSCL has been incorporated into an information system to support the analysis of multimedia documents, called PAC [12]. Sentences formulated with FSCL can be, in a system like PAC, attached to a segment of a multimedia document. The sentences, together with document identifiers and segment specifications are stored in a database and later used for retrieval. Because the structure of the FSCL sentences is well known, it is possible to access the semantics of the information stored. The retrieval of information from FSCL descriptions is achieved using the Flexible Structured Query Language, FSQL [9].

FSQL provides three layers for querying: the first layer is based on the properties of FSCL and allows the correct and complete retrieval of information from the description sentences; the second layer provides for Boolean combinations within sets of description sentences; the third layer accesses the properties of the multimedia document segments attached to the FSCL sentences and facilitates time and position comparisons. More detailed information on FSCL and FSQL can be found in [9]. Specific information about information retrieval across multiple media formats is given in [10].

4 Advantages of using FSCL

The most convenient and expressive language available to us is natural language. Yet looking at knowledge retrieval with computer systems, natural language poses a range of well known and not yet fully solved problems. The main problem lies in the vast amount of implicit knowledge necessary to see words in the right context and to fully understand a sentence [21]. Various large scale projects are underway to attack these problems, like WordNet [15], an ontology for natural language processing, and the Cyc system [14], attempting to construct a 'complete' ontology of the world. Our approach is far less ambitious. We acknowledge that using full natural language for knowledge representation and retrieval would be highly desirable. Yet with the enormous difficulties associated with this approach we were looking for a much simpler solution. FSCL provides us with a number of advantages:

- We have a natural language-like notation. Any FSCL sentence can immediately be understood by a human reader. The importance of this is confirmed in the discussion of the five principles of knowledge representation by Davis *et al* [3].

- We have a language and can deduce the structure of our sentences. We have therefore more power than with the keyword approach commonly used in information retrieval, which suffers from low precision and low recall [21].

- We can build a powerful vocabulary by integrating the FSCL categories with ontologies.

- Of special interest to computer-based educational systems is that we can link our form of knowledge representation with multimedia documents.

FSCL has been successfully used to support the study of behaviour recorded in multimedia documents. It has given analysts the possibility to create rich descriptions of behaviour and to analyse the descriptions in a precise way [9]. We want to keep the main features of FSCL in formulating natural language-like, structured and flexible sentences attached to multimedia documents. Further, we want to adapt FSCL for a more general use in knowledge representation and retrieval. Our ideas in this direction are presented in the next sections of this paper.

5 Proposed extensions

We want to indicate several areas of possible changes and extensions to FSCL: changes to its categories and grammar forms; extensions to include ontologies; conversion of FSCL sentences to conceptual graphs to facilitate inferencing; and the introduction of freeform querying.

5.1 Changes to categories and grammar of FSCL

As described in section 3, the FSCL categories and grammar have been designed to formulate sentences of the forms 'subject - verb - object' and 'concept - object' in the context of studies of behaviour. To simplify the construction of the vocabulary, adjectives and adverbs have been combined in the FSCL category 'Descriptor' [9]. Adhering to the general FSCL principle of having a formal grammar on fixed, defined categories we are currently investigating a number of changes to FSCL to adapt it to a more general use in knowledge representation. The exact format of the changes has to be determined through applying FSCL in a range of web-based educational systems. Our current thinking centres around the following topics:

- We are investigating changes to the FSCL categories. Merging the categories Person/Thing and Concepts to a more general category, Noun, would address the potential conflict between abstract and concrete terms (see the discussion about the abstract term 'students' and the specific individuals in section 5.3). The category 'Descriptor' could be split up into separate categories of 'Adjectives' and 'Adverbs'. The grammar of FSCL had to change accordingly to accommodate the different roles of adjectives and adverbs within a sentence. The advantage over the current approach in FSCL would be that with this change adverbs could be positioned correctly as in natural language English sentences.

- In natural language, words occur in different grammatical forms in different roles in a sentence ('the instructor *starts* the motor'; 'the motor is *started*'). The current FSCL has a strict separation between its categories. While a word can be defined in its derivations in multiple categories (Activity: starts; Descriptor: started), it is not possible to create a semantic link between the different word forms. We are looking at introducing such a link together with a meta-level grammar to be able to detect semantic equivalence between sentences with word derivatives in different parts of speech.

- The grammar of FSCL could be extended to recognise a wider range of sentence structures. Clausal variations like imperatives ('Start the motor!') or questions ('Is the motor running?') can be introduced. Conditional sentences of the form 'if C then S' would support inference as outlined in more detail in the following section. A wider range of sentence structures recognised correctly by FSCL would increase the potential for knowledge retrieval and inference.

5.2 Extension to use ontologies

FSCL uses hierarchies to define the words of the vocabulary. These hierarchies are defined within the FSCL categories. They are used to group related words and to allow for a retrieval of information on different levels of granularity. These hierarchies, as they are currently used in FSCL, can be seen as simple forms of ontologies. While a number of issues have to be addressed to base FSCL on more substantial ontologies, none of these seems to pose a real problem.

- Users of FSCL define the vocabulary they need for their particular domain. The experience, so far, as reported in [9], show that users define their vocabulary as multiple hierarchies within each FSCL category. These hierarchies could be joined under the FSCL category name to build one ontology within each FSCL category.

- An ontology typically moves from the abstract to the concrete, from concepts to instances. The vocabulary in FSCL is organised in the same way. In a study on 'learning to read', e.g., individual students' names were grouped under the term 'students', individual teachers' names under the term 'teachers' [9]. A term like 'students' contains two components: it has an abstract component in describing a group of the population in general with the property of 'attending school to learn'; it has a concrete component in grouping together specific, named individuals. In the current uses of FSCL this distinction has not caused any problems.

- Not all FSCL categories contain vocabulary which necessarily should be structured as ontologies. While it can be of advantage to organise the vocabulary in the FSCL categories 'Conjunction' and 'Preposition' in hierarchies these words will not build ontologies as they not define 'categories of the world'. Yet the coexistence of ontologies and hierarchies in the vocabulary of FSCL should not create a difficulty.

5.3 Conceptual graphs and inference

FSCL is an easy to understand and effective scheme for an author to create their own vocabulary and use it

together with the grammar for describing the contents of a multimedia document such as a video. Currently, knowledge retrieval is performed using the complementary query language FSQL. FSQL addresses the grammatical structure of FSCL sentences, takes advantage of the hierarchy information built into the vocabulary, and offers Boolean, time and sequence query options. However, there is no deductive feature in this scheme which would allow us to be able to infer facts or relations that are not explicitly stated. For example, given the statements:

If anyone starts the motor then the motor is running

The instructor starts the motor

which describes the situation in a training video then we may wish to be able to answer the question:

Is the motor running?

To be able to function at this level, we need the power of a first order logic system. Conceptual Graphs, CG, [20] give us this power.

Our proposal is that the user should describe their domain in terms of FSCL. The statements in this language can then be automatically translated into a CG format. This process is quite straight forward since FSCL is unambiguous, allowing many of the problems of natural language translation to be circumvented.

When a query is made, or some information needs to be located within the document segment then an initial attempt can be made to do this by using FSQL. If this fails then the deductive power of the CG representation is invoked. Standard theorem proving techniques within CG would enable us to check the veracity of a statement. As a bonus, we would get a step-by-step justification of the result proved, similar to the explanation given in expert systems.

5.4 Freeform Querying

Based on a limited yet flexible vocabulary and on a limited grammar, as offered by FSCL and FSQL, a query system can be developed which allows the user to pose questions to the educational system. As the structure and the vocabulary of these questions is known, the educational system can 'understand' these questions. Questions can be mapped against a repository of previously asked questions. If a semantically equivalent question is stored, the corresponding answer is retrieved and presented to the user. If a semantically close question is stored, this previously asked question can be used to facilitate the answering of the new question. As questions and knowledge representation are constructed by the same underlying mechanisms a mapping from question to knowledge representation is possible. This can be used to assist the answering of questions based on the knowledge descriptions and to find the appropriate segments of the multimedia teaching material.

The approach presented here does not attempt to answer any natural language question but a restricted set. The vocabulary is restricted to allow the construction of meaningful questions in a particular domain. The grammar is restricted to allow the construction and comparison of meaningful questions based on the vocabulary. The grammar is generic as it is based on categories which are used to organise the vocabulary across domains. The restriction of vocabulary and grammar distinguishes this approach from the AskJeeves [1] search mechanism. The existence of a grammar distinguishes this approach from keyword based search mechanisms as used in library systems or by internet search machines.

The general idea is to provide the user with specific answers to questions. These answers are retrieved from a body of stored answers only if semantic equivalence can be guaranteed. If semantic closeness is detected the relevant questions with their answers are given to a human operator who then decides on the suitability of the match.

6 Conclusions

In this paper we have considered the need for a knowledge representation mechanism for computer-based educational systems. We have first indicated a number of commonly used mechanisms and have then discussed the Flexible Structured Coding Language, FSCL. We have suggested that FSCL provides an effective mechanism for knowledge representation and subsequent knowledge retrieval, based on the nature of FSCL as a natural language-like description language which allows for flexible, rich yet structured description of learning concepts. As extensions to FSCL we have suggested the integration of more substantial ontologies, the conversion of FSCL sentences into conceptual graph structures and the introduction of freeform querying.

References

[1] AskJeeves, http://www.aj.com/index.asp (accessed on February 2, 2000).

[2] Davenport, G., "Indexes Are 'Out', Models Are 'In'", IEEE Multimedia, Fall 1996, Vol. 3, No.3, pp.10-15, (1996).

[3] Davis, R., Schrobe, H. and Szolovits, P., "What is knowledge representation?" AI Magazine, 14:1, pp. 17-33, (1993).

[4] Decker, S., Erdmann, M., Fensel, D. and Studer, R., "ONTOBROKER: Ontology Based Acess to Distributed and Semi-structured Information", Proceedings of Eighth Working Conference on Database Semantics, Semantic Issues in Multimedia Systems, R. Meersman, Z. Tari and S. Stevens (Eds.), Kluwer Academic Publishers, Boston, (1999).

[5] GENTLE, www.gentle-wbt.com (accessed on April 10 2000).

[6] Gong, Y., Zhang, H. Chuan, H. C., Sakauchi, M., "An Image Database System with Content Capturing and Fast Image Indexing Abilities", Proceedings of the International Conference on Multimedia Computing and Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

[7] Grossmann, R., "The Existence of the World, An Introduction to Ontology", London: Routledge, (1992).

[8] Hampapur, A., Jain, R., Weymouth, T. E., "Production Model Based Digital Video Segmentation", Journal of Multimedia Tools and Applications, 1, 9-46, Kluwer Academic Publishers, Boston, (1995).

[9] Heinrich, E. A., "Multimedia Information System for the Support of Studies of Behaviour", Doctoral Dissertation, Massey University, Palmerston North, New Zealand, (1999).

[10] Heinrich, E. and Kemp, E., "Description and Retrieval across Multiple Media Formats", 4th International Workshop on Query Processing and Multimedia Issues in Distributed Systems, DEXA'00, IEEE Computer Society Press (2000).

[11] Heinrich, E., Kemp, E. and Patrick, J.D., "A Natural Language Like Description Language", 10th Australasian Conference on Information Systems (ACIS), B. Hope and P. Yoong (Eds.), School of Communications and Information Management, Victoria University of Wellington, Wellington, New Zealand, pp. 375 – 386, (1999).

[12] Heinrich, E., Patrick, J.D., and Kemp, E., "A Multimedia Information System to Support the Analysis of Human Behaviour Recorded on Video", Computers in Psychology, Conference Proceedings, CTI Centre for Psychology, University of York, York, (1998).

[13] Jiang, H., Montesi, D., Elmagarmid, A. K., "Integrated Video and Text for Content-based Access to Video Databases", Journal of Multimedia Tools and Applications, 9, pp. 227-249, Kluwer Academic Publishers, (1999).

[14] Lenat, D.B. and Guha, R.V., "Building Large Knowledge-Based Systems; Representation and Inference in the Cyc Project", Addison-Wesley Publishing Company, Reading, Massachusetts, (1990).

[15] Miller, G.A., "WordNet: a lexical database for English", Communications of the ACM, 38:11, pp. 39-41, (1995).

[16] Noldus Information Technology, "The Observer Video-Pro, Version 4.0 for Windows". Wageningen, The Netherlands, (1998).

[17] Palhang, M., Sowmya, A., "Learning Object Models from Real Images", Proceedings of the First International Conference on Visual Information Systems, Victoria University of Technology, Melbourne, Australia, (1996).

[18] QSR Software, QSR NUDIST 4 Overview, http://www.qsr.com.au/Software/N4/qsrn4.htm (accessed on June 22 1998).

[19] Richards, L., "Using NVivo in Qualitative Research", Melbourne: Qualitative Solutions and Research Pty, (1999).

[20] Sowa, J.F., "Conceptual Structures: Information Processing in Mind and Machine", Addison-Wesley, Reading, Massachusetts, (1984).

[21] Sowa, J.F., Knowledge Representation; "Logical, philosophical, and Computational Foundations", Brooks/Cole, Pacific Grove, CA, (2000).

[22] Topic maps. ISO/IEC JTC1/SC34 - Document Description and Processing Languages. http://www.ornl.gov/sgml/sc34/document/0058.htm, (accessed on February 8 2000).

[23] Zhang, H., Gong, Y., Smoliar, S. W. and Tan, S.Y., "Automatic Parsing of News Video", Proceedings of the International Conference on Multimedia Computing Systems, May 1994, IEEE Computer Society Press, Los Alamitos, California, (1994).

Proposal of an XML-based Knowledge Sharing and Management System Supporting Research Activities

Kyoko Umeda*, Takami Yasuda and Shigeki Yokoi***
**Graduate School of Human Informatics Nagoya University,*
***School of Informatics and Sciences Nagoya University*
Furo-cho Chikusa-ku Nagoya-City 4648601 Japan
umeda@info.human.nagoya-u.ac.jp

The proposed system is primarily focused on research activities which create various kinds of knowledge through trial and error. The knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is easily utilized for research activities, because they are accumulated as visible data. However, the latter is not utilized in many cases even if they are informative and useful. Therefore, a web-based management system giving attention to un-formalized knowledge as well as formalized information would be a possible solution. This paper describes the features of the system based on the XML, and shows an example of usage through a trial system. Functions of the system include: (1) collecting un-formalized information related to formalized knowledge, (2) connecting un-formalized knowledge with formalized knowledge, and (3) creating feedback information while using the system. The system creates a repository in a lab, a collaborative space for research activities, and a set of new document and knowledge.

Keywords: **Research Activities, Knowledge Sharing and Management System, Formalized/Un-formalized Knowledge, XML**

1 Introduction

Researches on system environments that share knowledge on the Web have increased because of the needs for accumulating and utilizing knowledge [3][8]. Specially aiming learning activities, the Covis [1], for example, visualizes processes of collaboration between users, and memorizes the processes through the Covis Collaboratory Notebook. Another example is the CSILE [4][9] with networked computer environment particularly designed to support progressive discourse. In CSILE, students write text or graphic notes to convey their explanations. Similarly, the KIE [6] have collaborative environments that make network discussion possible by using the interface called Netbook. Users of the Shrlok [2] also have shared knowledge environments. They can discuss their opinions in an opened condition and make hypertext links between relevant knowledge. Thus, users of these four systems can exchange their own opinions and argue their individual ways of thinking, based on ideas and questions stored in the Database (DB) system [7]. Therefore, in these four systems, students can be subjective while having clear objectives. Teachers can also help students solve problems, and students can collectively work on problems.

The process of advanced researches, on the other hand, is not the same as that of education because researches might not always have definite objectives. In many cases, new things can be discovered from one trivial thought, and researchers enlighten and encourage each other. Individual studies can be more important in a condition where there is no instructive person who clearly knows and ultimate goals. Although research activities have a different characteristic from education activities that have clear goals, few studies aiming research activities have been discussed.

This paper proposes an XML-based knowledge sharing and management system. It focuses on an accumulative style of knowledge management for supporting research activities, rather than for learning.

The activities in a laboratory produce various kinds of knowledge by repeating trial and error. That knowledge is classified into formalized knowledge, such as papers or reports, and un-formalized knowledge, such as suggestions or advices. The former is accumu lated as visible data in the form of paper material or digital data. On the other hand, the latter is only spoken and is not represented in the real material. Therefore most of that information is not recorded. However, it is important to accumulate and share the un-formalized knowledge because live suggestions or advices are often very useful to promoting research activity. Their accumulation is useful for participants to remember knowledge and also for peer that cannot attend the discussion process.

Thus, we focus on this un-formalized knowledge. By making the un-formalized knowledge active as memorandums and by connecting them with meta-data of formalized knowledge, the proposing system creates a new set of knowledge documents, Knowledge DB. Proposing system allows users to produce feedback information while using it. The system by using the XML could effectively help research activities. Finally we provide some considerations on the prototype system.

2 The outline and features of knowledge sharing and management system

Chapter 2 summarizes the features of the proposal.
The system consists of the following three steps.
(1). It attaches un-formalized knowledge with formalized knowledge, for example paper and reports, as memorandums.
(2). It connects the above information with meta-data of formalized knowledge.
(3). It utilizes connected knowledge and feedback the information.

If more than two documents share the same information, they are connected through a memorandums. That is to say, the memorandum connects clearly the original documents existing independently in DB. Such connections are useful for the documents retrieval and research analysis. Further, continuous cycles of connection, searches and analyses can be occurred, which assemble a lot of knowledge and information.

At this time, the trial of this system is focuses on Research DB. However, it is reasonable that fundamental policy is not changed even if the DB is changed, because XML is used for exchanging between applications and our system process only the meta-data.

Three advantages of the system are:
- It provides auxiliary information for user's document retrieval by attaching a memorandum to original documents.
- The original documents are related with each other by the connection with the memorandums, and it creates a new document set.
- It supports continuous research activities for users to analyze sets of information and knowledge.

3 Adoption of XML technology

Chapter 3 discusses advantages of the XML, which is one important characteristic in the system.

We adopted the XML, a standard language for information exchange, for two reasons. The first was the need to do knowledge management on the Web because the sharing space accumulated knowledge can be accessed anytime and anywhere. The second was the need to consider the connection with another advanced DB, such as CG and 3D data. Thus, the system would be more flexible because of the XML.

Effectively, the XML is used in two aspects. One is as a way for exchange between DB and systems. The other is for the preservation of information, including the XLink function [10]. Considering that memo randum and data items can change in near future, XML has several advantages: It can set flexible data lists, and express arbitrary number of elements in a tree structure [5].

4 The system configuration

Chapter 4 shows the configuration of the system.

The system consists of three main parts: (1) Sets of Knowledge-Memos, (2) Knowledge processing system, and (3) Interface for knowledge sharing on the Web. (Fig.1). The role of the part (1) is collection and accumulation of knowledge. Part (2) connects two kinds of knowledge. Part (3) relates to the interface for users. The followings sections present their details, respectively.

4.1 Set of Knowledge-Memos: Collection, accumulation of the memorandums

The system needs to collect un-formalized knowledge, such as advices or suggestions from teachers and researchers, even though they are not in any form. Thus, the style of memo randums to formalized knowledge, like papers, are adapted. This chapter presents the concept of "Knowledge-Memo".

4.1.1 The proposition of the Knowledge-Memo concept

The system adopts concept of memorandum called "Knowledge-Memo", in order to collect un-formalized information. We classify Knowledge-Memos into two types to be attached to the original documents in accordance with their natures. In this way, layers of un-formalized knowledge can be created.

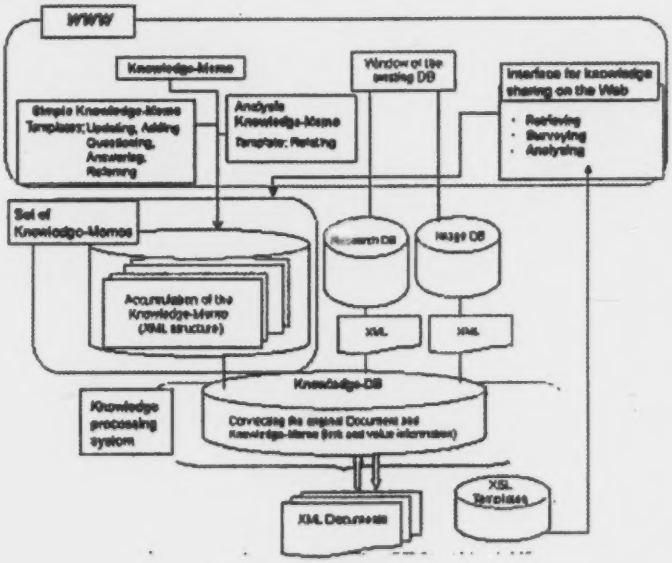


Fig.1. System overview

Simple Knowledge-Memo: specific information which users want to attach. For example, "This paper is an updated version of named B paper." This type of memo randum can be registered at the same time original paper is entered in the DB.

Analysis Knowledge-Memo: constructed and connected information that is based on researchers' analyses. This type of memo randum can be a Simple Knowledge-Memo because it can be re-analyzed. Users would register Analysis Knowledge-Memo as research results of documents and memorandums.

According to making of the Knowledge-Memo, new sets of documents are created. One objective of proposed system is to change from fragmentary and separated information to collected new knowledge, due to the analyses of researchers in a common created space.

4.1.2 Collection and accumulation of Knowledge-Memo

BEST COPY AVAILABLE

The following templates make inputting memo randums simple.
Information inputted in prepared templates is stored on the Web as Knowledge-Memos through XML structure. Types of the Simple Knowledge-Memo are updating, adding, questioning, answering and referring. Analysis Knowledge-Memo includes relating memo randums.

Usage of these templates is as follows.
Updating templates: describing information and explaining reasons for renewal, which create relationships between before and after renewal.
Adding templates: adding information, such as advices and references to original documents.
Questioning templates: asking questions to documents. When inputting Questioning templates, e-mails would be simultaneously sent to a person who created the original documents.
Answering templates: answering to questions. Automatically sent to the person who wrote questions.
Referring templates: referring to external documents and create new relationships with sites on the Web.
Relating template: describing relationships between documents which are based on analysis of documents and Knowledge-Memos. More than two documents and memos can have relationships.

Several tags of the XML are also used:• •<key> for keywords, • <hi> for highlights, •
 for starting new lines. In an experimental usage of the system, users were free to use these tags without any restriction and enforcement. If tags were used, words would be shown in only emphasized style on the screen. (Fig.2). However, the system would better more reflect users' intentions if the use of new tags were available and inventive Extensible Stylesheet Language (XSL) was developed.
As previous discussion shows, the system has an advantage of creating sets of documents, which reflects users' intentions.

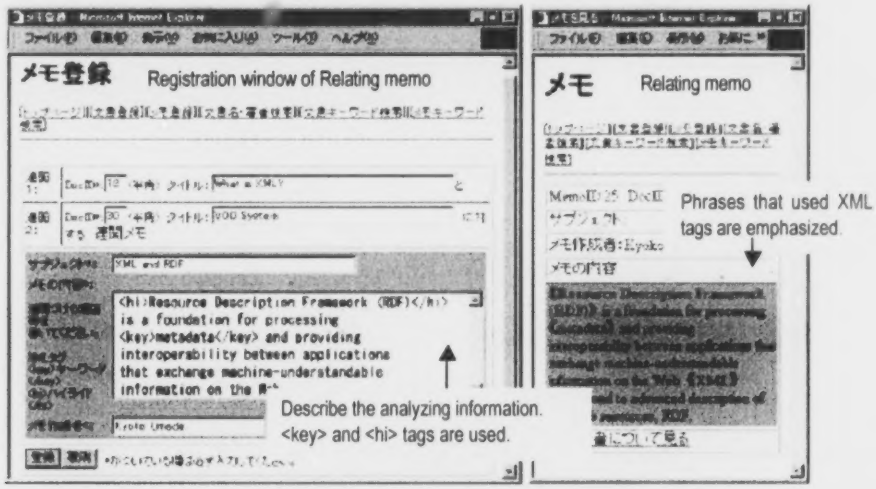


Fig.2 Input screen of "Relating memo" used to input XML tags. (Left)
The "Relating memo" including enhanced expressions created through XSL (Right)

4.2 Knowledge processing system: Connecting the original document and Knowledge-Memo

After collecting un-formalized information, the system connects it with formalized information. Such connection creates a Knowledge repository.

The process of connection is as follows. First of all, this system picks up necessary meta-data from Research DB and stores it in a XML structure. Such information is connected to the Knowledge-Memo which is also in a XML structure. Thus, a Knowledge repository is created. The system employs XLink function to connect un-formalized information with documents. Because of XLink potential, it is possible to make multidirectional links among original documents from a remote resource, that is, from a Knowledge-Memo related to original documents. Moreover, the system also creates lists of linkage

BEST COPY AVAILABLE

information about existing Knowledge-Memos related to one original document. That is, from one individual document all its existing connections are easily obtained (Fig.3). Unfortunately, the experimental utilization of the system in this paper uses Internet Explorer5 which still does not support all these XLink functions. That is why the system utilizes link functions of HTML, reflecting the structure of the XLink. If the XLink was supported, it would be easily possible to make relationships between documents through the above simple structure. The fact that these connections are automatically created by users' simple operation constitutes an advantage of the system.

The Knowledge DB pulls out necessary information, and displays on a Web interface. The system uses XSL templates to arrange and display requested information.

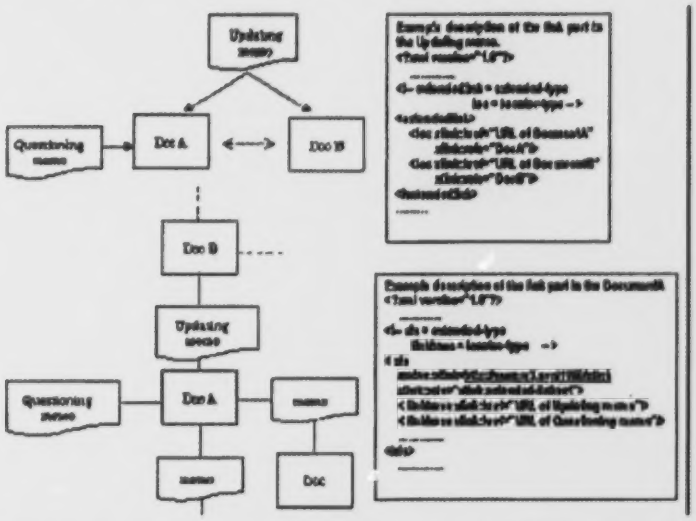


Fig.3 Description examples of relation between documents and Knowledge-Memo based on XLink. The memorandum associates remote documents through extended link (above). The external linkset centralizes the link information (below).

4.3 Interface for knowledge sharing on the Web

Peers use a trial system on the Web as a part of research activities. In order to make a user-friendly interface, we studied the flow of research activities. As the result, three processes, such as retrieving, surveying and analyzing information, are prepared for their research activities.

First, two retrievals are available, which include searching documents and Knowledge-Memos. Document search is a method which is often used, and it searches a document from a title or keyword. If an Updating memo is shown as a result, and there are some corrections on the documents including updated document. In another word, Updating memo provides help of the retrieval. Moreover, a renewal reason has the possibility to become a reference when a peer writes a paper. Retrieving from Knowledge-Memos may be useful for getting information toward vague ideas. It can be more efficient than previous ways, because researched results are sets of documents and memorandums. Further, due to the XSL, it is possible to sort by dates and to filter by types of memorandums.

In a Surveying process, connection between documents and memorandums is visualized, when traversing search results. For example, even if users think that there is no relationship between documents, there might have some kind of relationship after following links. Such new researches can help proceeding researches.

BEST COPY AVAILABLE

With respect to analyzing information, a new finding, resulted from surveying information, can be used for making analyzing memo in a combination with related and added memorandums. These processes can be continued by adding new information and findings that stimulate utilization. On the Web, a common space, such utilization can increases effective research activities. .

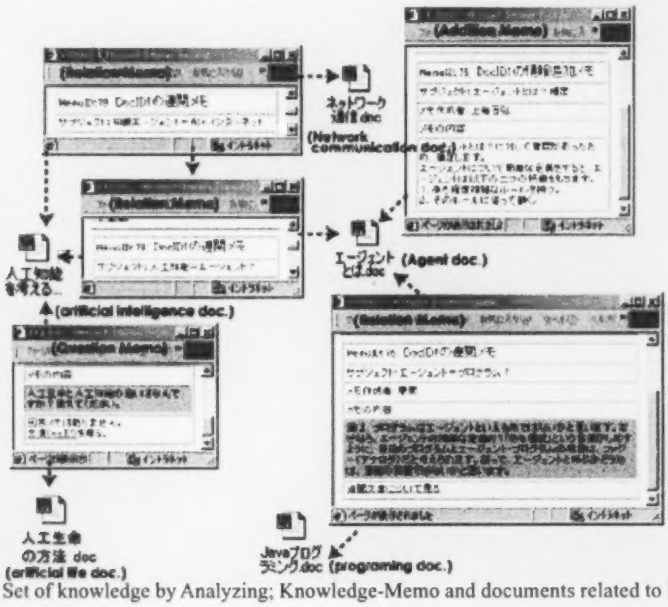


Fig.4 Set of knowledge by Analyzing; Knowledge-Memo and documents related to it.
Documents and Memos are gathered around the "Agent document".

5 Prototype evaluation

Usage of the system and evaluation of the prototype are discussed and reviewed in this section.

5.1 Usage of the system

In order to study further, followings show a way of system utilization, based on discussions and reports in a research group which studies agent technologies in a laboratory. Suppose that there are three members, named A, B and C, in the group.

(1) "A" makes and reads a report, "About Agent" in a seminar. After the seminar he registers the report in Research DB. At the same time, conclusion of discussion, advice, etc. are also registered as Knowledge-Memos.

(2) "B" who was absent for discussion reads the report. Then "B" asks, "What does autonomy mean?" in a Questioning memo. Such question is registered in memorandums of questions related to reports, and at the same time, "A" will get the e-mail.

(3) "A" answers the question from "B" in Answering memos, which is registered in Answering memos, and e-mail is sent to "B".

(4) "C" tries to do a programming of an agent by using Java. He finds a report of "About Agent" written by "A" through a keyword search, "agent". "C" completes his report, referring A's report. . He makes a Relating memo, for example, describing which part of the agent report is quoted and how it is useful for him.

After repeating these memorandums registrations, it is possible to analyze information as shown Fig.4. Members of agent seminar could gain the following effects at this time.

5.2 Test results

Seven students in a lab used a practical sample test of the system, and answered questionnaires. Table.1 shows the results.

	Yes	No
(1). Helpfulness of the Knowledge-Memo.	93%	7%
(2). Easiness of inputting the Knowledge-Memo.	58%	42%
(3). Acceptance of sharing ideas written in the memo with other users.	93%	7%
(4). Satisfaction of inserting XML tags for emphasizing and changing colors.	67%	33%
(5). Usefulness of the system. (i.e. connecting the Knowledge-Memo with documents, resulting in a set of new documents.)	71%	29%

Table1. Results of questionnaires.

The overall evaluation of the system was positive. In terms of the question (1), students used the Knowledge-Memo for connecting to related documents and getting information of their documents. There were several responses in question (2), which demanded for the improvement of the interface when inputting the memorandums. Some students suggested a possibility of creating more successful system if incorporating with other laboratory members. In the question (3), most students were positive for informing and sharing ideas through memorandum with other users, since they can identify their ideas and get some comments. As for question (4), some students complained the new tag system that requires additional input. However, other students recognize the advantages of the system that can emphasize the keyword and change colors as far as the tags were not so complicated. Finally, most students recognize the structure of relationships centered on the document is useful for research activities.

5.3 Discussion

Test results lead to three fundamental findings.

(1). The system is useful for using and searching documents because it is possible to use information of Knowledge-Memo as well as abstracts.

(2). The system is convenient, since it enables users to make relationships with other preserved documents, to create new sets of documents, and to traverse from memorandums.

(3). The system is effective for informing and sharing opinions with peers because it enables to identify their ideas, to get some comments, and to record the process of studies.

From these results, it is possible to conclude that this management system effectively supports research activities, which collects and accumulates peer's knowledge and promotes collaborative and shared utilization.

Furthermore, we need to evaluate more effects for future research, such as;

- Is there any possibility in this system to give linkage of documents that seem to have no relation with each other?
- Is there any possibility that the results of using this system, such as creation of new document sets and analysis of memorandums, can give deeper understanding and new definition to users?

Additionally, this system should be improved in terms of the following three points.

(1). Revision of interfaces, including the interface for inputting the memo and the interface for classifying documents by theme.

(2). Addition of the level of importance to Knowledge-Memos for arrangement and classification, in order to promote re-use of knowledge.

(3). Exploration and employment of XLink potential. (Current browsers, such as IE or Netscape communicator, do not support XLink functions.)

6 Conclusions

The proposed web-based management system is primarily designed for research activities. Previously, databased and written information, such as papers and reports, were only available for research activities, even though other information, such as ideas and opinions, are also important knowledge. The new management system enables to utilize un-formalized knowledge as well as formalized information.

Positive responses from lab members who used a trial system show that because separated and fragmentary information are collected through Knowledge-Memos, effective and efficient research activities would be feasible. A lot of information and ideas toward papers are collected by members as databases, which creates sets of documents. Researchers can collaborate with other researchers through the system.

From the technical standpoint, the system utilizes the XML in two parts of exchange and preservation. Users' intentions on the WWW can be more reflected by the XML.

For the future usage, since only meta-data is managed in a XML, the utilization of documents as well as digital data is feasible. Further, the system can connect knowledge more easily, since XLink functions will be realized soon. Important advantages of the system include creation of relationships, and searches of information and knowledge. Improvement of the interface and the classification memorandums will be necessary for the long term.

References

[1] D.K. O' Neill, L.M. Gomez, "The Collaboratory Notebook: a Networked Knowledge-Building Environment for Project Learning", Proc. of Ed-Media 94, pp.416-423 (1994)

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano, "Knowledge Awareness Map fro Open-ended and Collaborative Learning on World Wide Web", Proc. of ICCE99, pp319-326 (1999)

[3] I. Nonaka, "The Knowledge-Creating Company", Harvard Business Review, November-December1991, pp96-104 (1991)

[4] J. Oshima, "Students' Construction of Scientific Explanations in a Collaborative Hyper-Media Learning Environment", Proc. of CSCL97, pp187-197 (1997)

[5] N. Pitts-Moults, C. Kirk, "XML Black Book", The Coriolis Group. Inc. (1999)

[6] P. Bell, E.A. Davis, M.C. Linn, "The Knowledge Integration Environment: Theory and Design", Proc. of CSCL95 (1995)

[7] S. Puntambekar, "An integrated approach to individual and collaborative learning in a web-based learning environment", Proc. of CSCL 99, pp458-465 (1999)

[8] T.H. Davenport, "Integrating Knowledge Management into the Organization", Diamond Harvard Business, August-September 1999 pp26-36 (1999)

[9] Knowledge Forum 2.0, http://www.motion.com/lim/kf/KF1.html (accessed on August 1, 2000)

[10] XML Linking Language (XLink) Version 1.0, http://www.w3.org/TR/2000/CR-xlink-20000703/ (accessed on August 1, 2000)

A Real-time Handwriting Communication System for Distance Education+

Hsin-Chu Chen* Jho-Ju Tu and Jianping Zhang*****

Department of Computer and Information Sciences, Clark Atlanta University , 223 J.P.Brawley Dr., SW, Atlanta, GA 30314. hchen@star.cau.edu.

*** Instructional Technology Center and School of Education, Georgia Southwestern State University, 800 Wheatley St., Americus, GA 31709. tu@canes.gsw.edu*

**** Department of Computer Science, Utah State University, Logan, Utah 84322. jianping@zhang.cs.usu.edu*

1 Introduction

In this paper we present the design and implementation of a handwriting communication system for real-time graphical information exchange. This system provides an environment for a user to write and erase messages on a computer screen using a light pen or a mouse and to transmit the handwriting message to another user on the Internet in real time. The communication techniques employed for the system include the basic client-server model and peer-to-peer model. The client-server model is mainly for sending handwriting information using the world wide web. The peer-to-peer model, however, is aimed at real-time communications between two end users on the network to conduct instant dialogues. The system is implemented using Java . It can be integrated into many different applications such as collaborative learning, on-line discussions, and distance education.

2 Communication Models

A handwriting communication system may be implemented using a client-server or a peer-to-peer model. Each model has its cons and pros. The client-server model, in which the client sends requests to the server and the server responds to the request [3], works well in situations when immediate responses are not necessary. For a real-time instant dialogue or information exchange, however, the client-server model alone is somewhat restrictive due to its limited degree of interactivity. To achieve a full degree of interactivity for this type of applications, a peer-to-peer model that allows for full duplex real-time communications is more appropriate, since the two end users of the system may send and receive information at the same time, roughly speaking.

In addition to communication models, we must also take into account the nature of the communication protocols and decide which to use. Information exchange carried over the Internet normally requires support from either TCP or UDP, which are the two protocols operated at the transport layer in the TCP/IP protocol suite [1]. When TCP is employed, the information is sent as a data stream, similar to a telephone conversation. Since TCP requires a connection setup prior to transferring data, it incurs an initial time delay. UDP, on the other hand, does not require such a connection setup. However, the delivery of datagram packets, which are independent data units sent individually from the source to the destination, is not guaranteed. Datagram packets may arrive out of order too. For textual information, UDP may not be a bad choice because the user normally can tolerate, to certain degree, occasional loss of packets or misplaced textual data. In our handwriting system, the handwritten information is represented as numerical data which are sensitive to the loss of any single bit of information, therefore, TCP is our natural choice.

+ This work was supported in part by the Army Research Laboratory under grant DAAL01-98-2-D065.

3 System Design

Our design philosophy for the development of the handwriting portion centers around the following principles: interactivity, functionality, reliability, user-friendliness, and portability. A handwriting communication system must possess two important capabilities. The first is the ability to support the writing by a light pen, or a mouse if such a pen is unavailable, and the display of the handwritten data. The second capability should allow users to transmit and receive handwritten data from the network. To achieve these goals, a friendly graphical user interface, which requires the use of abstract windowing toolkit and event handling, is a necessity. In order to make the system a useful communication tool on the Internet, it must support both textual and graphical information exchanges. The system must also provide functions for users to overwrite or modify handwritten message received over the network. In addition, the programming language used for implementation must be platform independent so that the system can be easily ported to other machines with different operating systems.

4 Description of the System and its Applications to Distance Education

As mentioned earlier, we use Java [2, 4] as the programming language and TCP as the transport protocol for transferring handwritten data in our current client-server communication system. A graphical user interface consisting of buttons, radio check boxes, and a handwriting area, as well as the operations associated with the interface have been developed using the abstract windowing toolkit. All main tasks of the system are invoked from within the event handling functions. Our system currently allows users on the Internet to exercise handwriting from within a web page that contains the client code and send the information to the server that accepts the handwritten data. It can also be used to enhance online presentations over the Internet. This is due to the fact that the system allows users to perform handwriting directly on the specified writing area in a web page. By putting the presentation material inside the handwriting area, it is possible to add notes, make corrections, highlight important subjects on the spot during the course of the presentation.

The handwriting communication system has many applications in distance education and on-line collaborative learning. It can be used by an instructor to deliver on-line lectures via the web; the instructor may use one part of the screen to present prepared presentations and another part to highlight the important points of his/her presentation using a light pen. It can be used by fellow students in different locations to solve problems collaboratively and work on team projects. In addition, the instructor and students can use it to conduct on-line class discussions and answer student's questions by employing the communication capability.

5 Conclusions

In this article, we have presented the basic approaches, design considerations, and implementation of a real-time handwriting communication system on the Internet as well as its applications to on-line education. Our design philosophy centers around functionality, interactivity, portability, and user friendliness.

References

1. Andrew S. Tanenbaum, "Computer Networks", NJ: Prentice Hall, 3rd Edition , (1996).
2. David Flaganan, "Java in a Nutshell, Sebastopol", CA: O' Reilly & Associates, (1996).
3. David Gunter, et al., "Client/Server Programming with RPC and DCE", IN: Que, (1995).
4. Patrick Naughton and Herbert Schildt, "JAVA: The Complete Reference", CA: McGraw-Hill, (1997).

The Application of Uncertainty Reasoning for an Intelligent Tutoring System

Hown-Wen Chen*, Teran Wu and Dong-Yih Bau
Institute of Information Management, Da-Yeh University
112, Shan-Jeau Rd., Da-Tsuen, Chang-Hwa, Taiwan
Email :hwchen@aries.dyu.edu.tw

The activity of test and evaluation is an important part of Computer-Assisted Instruction systems. In most systems, 「absolutely learned」 and 「absolutely unfamiliar」 are often used to represent the status of a student in learning a novice concept. However, for each target concept, there are usually more than one related sub-concepts with different degrees of importance. Thus, it is quite difficult to instruct each individual student effectively according to his learning status in those conventional systems. A hybrid technology of fuzzy theory and uncertainty reasoning are thus used in the research. The proposed intelligent tutoring system was designed to illustrate:「 1.automatically tracking and analyzing the current learning status of a pupil, especially detecting the formation of learning barriers or misconceptions; 2. autonomously leading pupils to visit assisted learning path and thus proposing tutorials to make the learning of students more effectively. 3.linguistically explaining the implicit behavior of a pupil during the whole learning process. In addition, the mathematical course of teaching Pythagoream Theorem was used as the content of our test-bed. A simulation by hand and positive feedbacks from teachers of junior high schools illustrate the reasonableness and applicability of the proposed tutoring system.

Keywords: **Pythagoream Theorem, Fuzzy Logic, Uncertainty Reasoning, Intelligent Tutoring System**

1 Introduction

Researches about Intelligent Computer Aided Instruction (ICAI) have incrementally grown since 1970, for example, standard intelligent tutoring systems [1], or participants in virtual environments [2], or a virtual instructor in a training environment [3]. However, as known, the effectiveness of education would depend on the local culture. But, there are few intelligent tutoring systems focusing on Taiwanese students have been reported. CORAL [4] was designed as an interface system, without any artificial intelligence module of teachers' expertise, to provide a long-distance collative learning environment of virtual learning. As discussed in lots of tutoring systems, the most challenging issue is how to evaluate and diagnose the learning of students. Tests are a typical and popular method of evaluation. Taking the GRE as an example, people have taken the test through computers since 1992. The IBM co. and Arthur Anderson Co. have begun to work on the development of a computerized testing system. Such systems, which change the form of tests from conventional paper-to-pencil to on-line, are proliferating rapidly. For ICAI, it becomes more popular that the evaluation of pupils' learning should not be simply classified as「absolutely learned」and「absolutely unfamiliar」. In addition, ways of leading each individual pupil to enjoy an efficient learning experience is also pursued. In the research, we proposed an intelligent tutoring system which can afford the most appropriate tutorials to each pupil according to his learning status and thus can prevent pupils to trap into a misconception too long.

2 The Organization of Tutorials and Maintaining Principles

Before implementing our tutoring system, some special issues and adopted techniques must be introduced.

Those topics include the organization of tutorials, a way of representing pupil's learning status, and the detection of any formed misconception.

2.1 The Construction of a Hierarchical Concept Tree

In general, tutorials would be organized as a tree hierarchy of curriculum in the order of chapter, section, sub-section, paragraph, etc. Since learning a complicate concept must depend on the success of learning all its related sub-concepts, the kind of structure cannot be claimed to be suitable for both learners and instructors. That is, too few containment or precedence information about curriculum is available. Thus, learning concepts and related tutorials are re-arranged as a hierarchical conceptual tree of containment here. According to literatures [5] and interviews with teachers of junior high schools, the concepts related to learning Pythagoream Theorem for native pupils can be analyzed and constructed as Figure 1. In the tree, the learning of any parent conceptual node must follow after at least one of its children nodes.

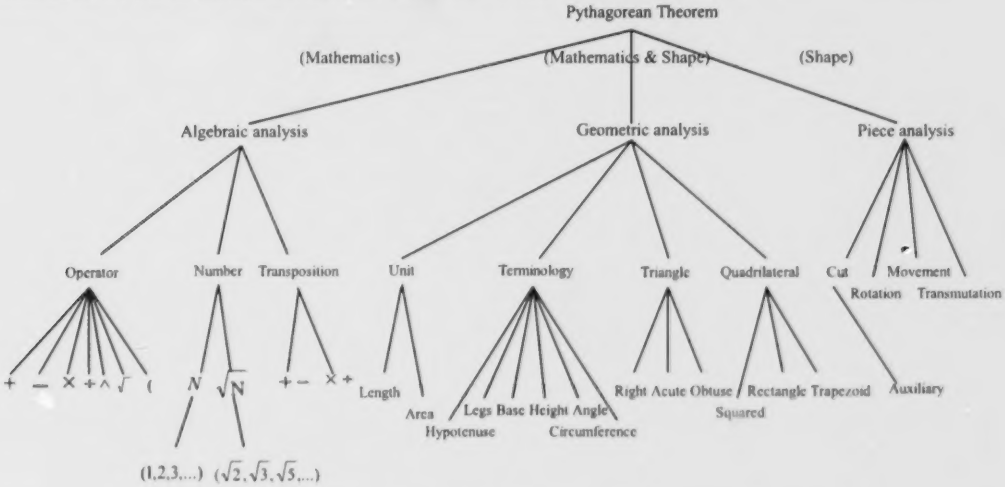


Figure 1. A hierarchical concept tree of Pythagorean Theorem

2.2 The Setting of Node Weights within the Hierarchical Concept Tree

To express the corresponding degree of importance, an integer is assigned to each testing question related to individual concept [5]. However, it is still a heavy burden even for an expert to quantitatively assess the extent. Besides, the estimated grade of importance is too subjective in general. In our system, the influence of each node on learning its parent node is defined through fuzzy theory as follows:

Step 1: Some teachers in junior high schools are asked to evaluate the relevance of nodes related to their parent node in the hierarchical concept tree.

Step 2: Fuzzy theory is included to quantify teachers' opinions in the designed questionnaire obtained in step 1. Five possible values for linguistic variables are used. Note magnitudes 0.0 and 1.0 are not adopted in the memberships because of product operations and symmetry.

Step 3: Murray's or Ishihawa's Max-Min method is used to fuzzily integrate those multiple expertise. After that, a defuzzification process to evaluate the mass centroid of fuzzy numbers is applied. The weights of nodes within the hierarchical concept tree are thus settled as shown in Figure 1.

2.3 The Maintenance of Belief Parameters

To increasing the expression power of the proposed system above "absolutely known" and "absolutely unfamiliar", a belief parameter m and another updating parameter λ described in Dempster-Shafer Theorem [6] are applied here to assess the familiarity degree of a pupil to a particular learning concept within the hierarchical concept tree. To describe the meaning of the updating parameters λ and θ (θ=1-λ), two cases must be taken in account:

Case 1: <u>Making a correct answer</u>

λ and θ can be used to denote the belief degree of promoting to a higher level and of staying on the same level within the conceptual hierarchy, respectively.

Case 2: Making a wrong answer

λ and θ can be used to denote the belief degree of degrading to a lower level and of staying on the same level within the conceptual hierarchy, respectively.

As to defining the updating rules of the belief parameter m, a general sub-tree structure is considered. In the tree, a node f has three children nodes labeled as a, b, c, and the interconnection links are labeled as W_{af}, W_{bf}, W_{cf}.

Case 1: *Making a correct answer in the test for the conceptual node a*

A promotion within the conceptual hierarchy must be activated. The belief parameters of the two relevant nodes a and f are thus modified as

$$m_f^t = (W_{af} \bullet \lambda) + m_f^{t-1}$$
$$m_a^t = (W_{af} \bullet \theta) + m_a^{t-1} \qquad \textbf{(eqn. 1)}$$

m_f^t, m_a^t : the magnitudes of belief after promotion

m_f^{t-1}, m_a^{t-1} : the magnitudes of belief before promotion

W_{af} : the weight of link between nodes **a** and **f**

Case 2: Making a wrong answer in the test for the conceptual node **f**

A degradation within the conceptual hierarchy must be activated. The belief parameters of the four relevant nodes, **f** and its children nodes **a, b, c,** are thus modified as

$$m_f^t = (\theta) + m_f^{t-1}$$
$$m_a^t = [\, W_{af} \bullet \lambda \bullet (1 - m_a^{t-1}) \,] + m_a^{t-1}$$
$$m_b^t = [\, W_{bf} \bullet \lambda \bullet (1 - m_b^{t-1}) \,] + m_b^{t-1} \qquad \textbf{(eqn. 2)}$$
$$m_c^t = [\, W_{cf} \bullet \lambda \bullet (1 - m_c^{t-1}) \,] + m_c^{t-1}$$

Case 3: If a correct answer is made in the topmost conceptual node, it is impossible to promote anymore. However, the belief of the topmost conceptual node is still updated with eqn. 1.

Case 4: If a wrong answer is made in the lowest conceptual node, it is impossible to degrade and the belief of the node is updated with eqn. 2.

2.4 The Strategy of Instruction

Several principles have been applied in the proposed system:

The instruction and assessment examination would only take place in the conceptual node with the largest belief. However, all assessment tests for its children nodes with weights larger than a pre-chosen threshold must be answered correctly. If the mentioned condition is not satisfied, the focus of instruction and assessment would be transferred to one of its children nodes instead.

According to Dempster-Shapfer Theorem, the procedure of normalization must be applied after each updating of belief.

There is an implicit relationship between the magnitudes of weights and belief parameter λ. To avoid the learning process to be not in progress, according to eqn. 2, the magnitude of belief updating in any child node (a) must be larger than that of parent node (f). Thus,

$$W \bullet \lambda \bullet (1) > 1 - \lambda$$
$$\Rightarrow \lambda > \frac{1}{(1 + w)} \text{ for all possible w}$$

2.5 The Analysis of Learning Traces and Detection of Misconceptions

Two kinds of traversal information would be recorded during the learning process: the weighted correct rate of answering testing questions for each conceptual node, and the traversal path of all visiting nodes.

First, the weighted correct rate can be used to indicate the current comprehension degree of a concept during the learning progresses. As known, the status near to the ending of learning should be emphasized. In other words, a pupil would be regarded as having been familiar with the concept if he can finally pass the

corresponding test independent of times of previous failures. To simulate the phenomenon, three kinds of information must be kept: the number of making wrong answers W, the number of making contiguous correct answers after the last wrong answer C, and the total number of answering T. The weighted correct rate is defined as 1-W / [(T-W-C)+W+2*C], i.e., 1-W/(T+C). The interpretation of the weighted correct rate would be based on fuzzy expression in our system.

Another important issue is the way of detecting the formation of a misconception. A misconception may be caused by some blind spots of learning and thus always makes the learning process trap into a loop. A good diagnosis module of a tutoring system must have such kind of detection capability and could inform the other tutorial guidance module to show some appropriate auxiliary tutorials. If the test of each child node has passed, i.e., the learner has traversed and correctly answer all questions related to the concepts of all children nodes, the conceptual node is marked as P (Passed). If a learner cannot pass the test of a conceptual node and all its children nodes satisfy one of the following two conditions, then the learner is identified as trapping in a misconception corresponding to the conceptual node. The two conditions are <i>the child node has been marked as P; or <ii>the weighted correct rate is absolutely 1 (100%).

3 The Development and Design of Our System

Based on those described ideas, a prototype tutoring system comprising a testing and evaluation module has been developed and demonstrated. Microsoft Visual FoxPro 6.0 is used under the platform of Microsoft Windows 98. There are four modules included in our system shown in Figure 2.

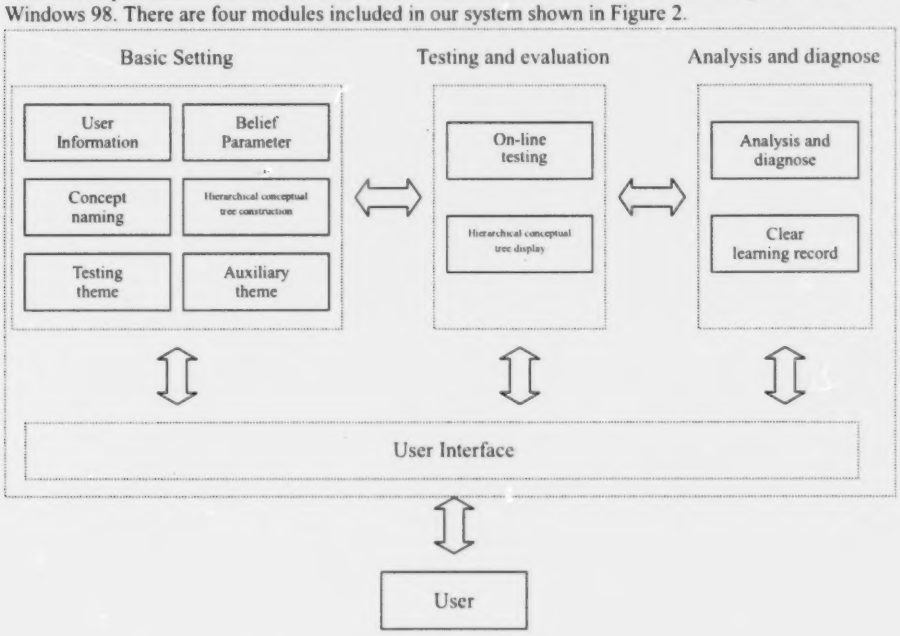


Figure 2. The architecture of the tutoring system

4 Conclusion and Future Work

In the research, techniques of fuzzy theory and uncertainty reasoning are applied to create a novel tutoring system. As demonstrated, the proposed tutoring system shows an excellent capability to present proper tutorials to guide pupils, precisely evaluates their learning status, and then shows auxiliary teaching materials to prevent pupils from trapping in any formed misconception. Finally, the traversal of learning would be analyzed and interpreted by fuzzy expressions.

Besides, some issues are worthy of deeper investigations through the study:

1. Some adaptive techniques of machine learning, e.g., genetic algorithm and artificial neural networks, should be applied to help instructors to automatically choose or tune parameters used in the tutoring system.
2. More applications about the proposed system should be examined to show its portability.

Acknowledgement

This study is supported by National Science Council of R.O.C. under contract number NSC88-2520-S-212-003

References

[1] Anderson, J.R,"Cognitive modeling and intelligent tutoring", *Artificial Intelligence*. 42, pp.7-49, (1990).
[2] Pimentel, K. and Teixeira, K, "Virtual Reality: Through thenewlooking glass", Blue Ridge Summit, PA: Windcrest/McGraw-Hill, (1994).
[3] Rickel, J. and Johnson W. L, "Pedagogical agents for immersive training environments", Proc. of the 1st International Conf. on Autonomous agents, New York, (1997)..
[4] Chien Chou and Chuen-Tsai Sun, "The design and implementation of a cooperative distance learning environment: The CORAL experience", Education Technology and Media, 26, pp. 13-21, April, (1997).
[5] C. S. Hsu, H. F. Dou and G. J. Huang, "The application of concept inheritance in learning diagnosis system", Proc. of ICCAI'98, pp. 602-609, (1998).
[6] Shafer, G., "Mathematical Theory of Evidence ", Princeton University Press , Princeton , New Jersey ,(1976).

The Automated Teaching Assistant: Automatic construction of teaching materials from course outlines

Chris Houser*, Shigeki Yokoi and Takami Yasuda****
**Kinjo Gakuin University, Omori 2-1723 Moriyama-ku Nagoya 463-8521 Japan, houser@kinjo-u.ac.jp*
***Nagoya University, Furo-cho Chikusa-ku Nagoya 464-8601 Japan*

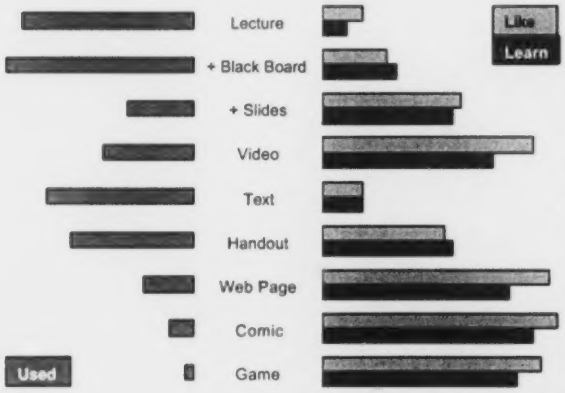
Keywords: **Lecture Preparation, Automation, Design of Teaching Materials.**

1 Educational Media: Yet Another Digital Divide

Instructors can use many media. Traditional teachers lecture while outlining on a black board; they assign readings from texts and printed handouts. Technological teachers lecture (or direct activities) while showing PowerPoint slides; they assign readings of web pages.

Instructors can use many media. Which do they in fact use? Which do students prefer?

We polled 200 students at three Japanese colleges. We asked students how often they saw, how well they liked, and how well they learnt from nine educational media. Responses were similar for all students across different colleges, different grades, and different majors. This graph summarizes their unified opinion.



The left side shows how frequently students saw each media. Common were traditional media (lecture, black board, text, and handout). Modern media were rare.

The upper bars on the right show how well students liked each media. The modern, rarely used were well liked. The lower bars show how well students thought they learnt from each media. Students claimed that well-liked media also taught the best.

In interviews, teachers claim they have no time to prepare multimedia slides and web pages, no time to learn PowerPoint. Students want multimedia; teachers don't prepare it. A digital divide separates a generation of computers from a generation of chalk.

How can we span this divide? These teachers brightened at the idea of a teaching assistant who would prepare these multimedia teaching materials, but only if the assistant could work from existing materials – typically typed course outlines – without supervision. They wanted a completely automatic teaching assistant.

So we created one.

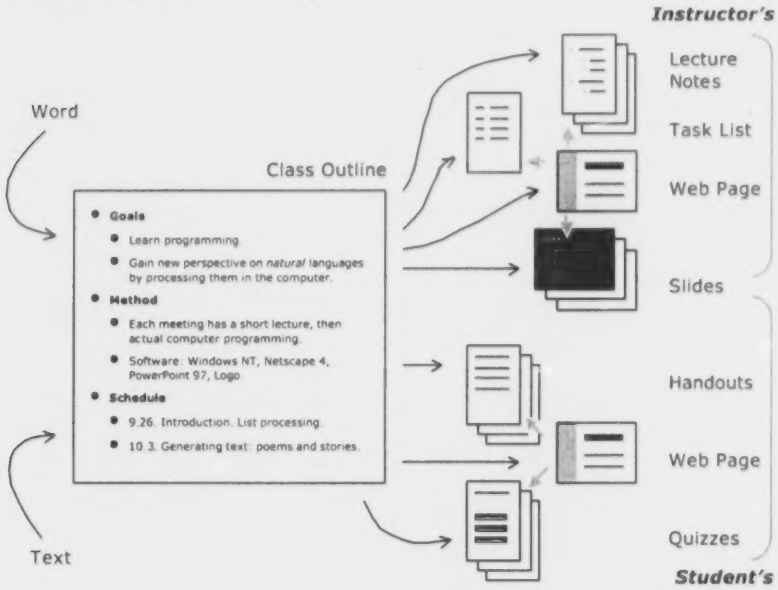
2 The Automated Teaching Assistant

The Automated Teaching Assistant (ATA) converts course outlines to multimedia teaching materials.

To use the ATA, instructors first prepare course outlines. They can use their favorite text editor or word processor, on any type of computer. Instructors then drag their saved file over the ATA program icon. The ATA reads the course outline and constructs a folder filled with teaching materials:

- syllabus (in the form of a class web page) [5]
- instructor' s notes (teaching plans)
- student' s handouts (outlines of each meeting)
- instructor' s task list (things to do, to prepare this class, sorted by date due)
- graphical slides visualizing each point in the outline [3, 4]
- web-based quizzes, tests, assignments, polls, class evaluations, and peer evaluations [1, 2]

The sketch below shows how a class outline is translated to teaching materials. Black arrows show the flow of information; **gray** arrows show hypertext links:



All these materials are automatically uploaded to the class' s web server. Then students can view the materials from anywhere in the world. Instructors can travel to any classroom in the world with a working web browser, and give their lectures. There are no papers or floppy discs to carry, no worries about hardware and software compatibility, no need to install software, no fear that needed software will be missing.

The ATA is completely automatic: it has no commands or options. Teachers submit their outlines; seconds later the materials are all available on the internet. This automation contrasts sharply with the common manual production of multimedia materials.

If instructors were to create these teaching materials without the ATA, they would need to purchase and then study expensive and complex multimedia software, such as PowerPoint and DreamWeaver. In addition, they would have to learn at least some design theory, for they would need to learn how to make attractive and comprehensible slides, handouts, and web pages. (Although some instructors might find this an interesting diversion, others may resent it as time stolen from their research and content preparation.) Then, before every class, instructors must manually convert their lecture plans into slides and web pages. In our experience, this takes an average of four tedious hours to prepare each meeting. Most instructors, in fact, are unwilling or unable to spend this much time preparing lectures. So students are disappointed.

But if these instructors would use the ATA, it will cost them only seconds, but will greatly increase their student's satisfaction. The ATA is more efficient because it factors the *style* (layout and design) out of the

substance (logic and content) of teaching materials. Instructors need concern themselves only with the creation of the abstract content of their classes; They can delegate the tedious physical layout and distribution to the ATA.

Using the ATA, we prepare lectures in an average of 40 minutes. The ATA allows us to prepare in only 17% of the time – it speeds preparation five times.

References

[1] Houser, C., "Introduction to Interactive web pages Using CGI", *Proceedings of C@LLing Asia 99* (1999).

[2] Martin, L., *WWWAssign*, http://www.northpark.edu/~martin/WWWAssign (1999).

[3] Meyer, E., *Designing Infographics*, Hayden, Indianapolis, Indiana (1997).

[4] Rabb, M., *The presentation design book*, Ventana Press, Chapel Hill, NC (1993).

[5] Weinman, L., *Designing web graphics*, New Riders, Indianapolis, Indiana (1996).

The Development and Evaluation of a Learning Support System for Converting Web Pages

KOYAMA Yasuhiro*, YOKOYAMA Setsuo, AKAHORI Kanji***
**Graduate School of Decision Sciences and Technology, Dept. of Human System Science, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo,*
TEL: 03-5734-3233
yasu@ak.cradle.titech.ac.jp akahori@ak.cradle.titech.ac.jp
***Information Processing Center, Tokyo Gakugei University*
yokoyama@cs.u-gakugei.ac.jp

In recent years, the use of the Internet for school projects has become popular, even in the primary level. One of the difficulties in the use of the Internet is the arrangement and integration of Web materials to meet the learner's goals. This paper presents a tool that will help meet this challenge. It will also describe how the tool was developed and what are the results of its evaluation. The features of this tool are the following: 1) learner can easily gather Web pages as thumbnail of a screen image; 2) learner can make a list of thumbnails; 3) thumbnails can be sorted, with comments added; 4) arranged thumbnails can be displayed by HTML. Further, the learner can make a presentation using thumbnails. The authors later conducted an experiment to verify the effectiveness of this tool in arranging Web pages. The developed thumbnail tool and the browser's bookmark tool were compared. The results showed that our developed tool was more effective than the bookmark tool, especially in following areas: (1) more recognizable contents of Web pages (2) easier operation, and (3) more user-friendly for students.

Keyword: **WWW, Exploring Projects, Screen Image, Thumbnail, Bookmark**

1 Introduction

In recent years, the use of the Internet for school projects has become popular, even in the primary level. In Japan, Ministry of Education will implement the integration of technology in K-12 starting 2002. Thus, students will need to have the skills needed when using the Internet for various school subjects. For project-based learning using the Internet, the popular tool for surfing and gathering online data will be the search engine. It enables the easy gathering of various online data. But not all online data is reliable and accurate. Also, if not updated, the data or information in web pages can become obsolete. So learners need a tool that will help collect, select, organize and integrate the web pages that meet their learning needs.

Currently, the tool that is available to learners is the bookmark tool. It enables users to save Web pages with its title. It also makes it easy to access the web site's URL. But the bookmark tool leaves much to be desired in terms of the organization and integration of online data. Because data gathering using search engines is a vast task, there is an immediate need for easy browsing. The bookmark tool is a tree-structured file system, which is not quite adequate for quick and easy browsing. Moreover, it is hard for learners to appreciate the significance of Web pages when they appear only as text names when bookmarked.

In addition to doing research projects, learners also engage in making presentations of their projects using the Internet. To help learners in this activity, the authors proposed a tool that will provide students an easy way of making a file for their presentation. So, the authors developed and evaluated a learning support system which will enable learners to arrange and integrate Web more effectively.

2 Conceptual Framework for Tool Development

To reduce the load on making our choice information , the following 2-part approach was taken:

(1) The centralized of system approach. In advance searches, the tool will automatically narrow down the search to the closest level possible (filtering approach). This means the goal is an intelligent tool that can select information and improve the precision of narrowing down the search.

(2) The centralized of human approach. By adding available information as hint, in order to reduce extraneous information. This a support to the select available information.

The overall goal of this 2-part approach is to enable an easy narrowing down of a search.

When gathering web pages for a school project using the Internet, the tool that was developed by the authors enables the capturing of web pages and viewing them as thumbnail images. The authors believe that thumbnail images are more effective in providing visual cues of the content of Web pages. And, by displaying thumbnails, learners can arrange Web pages holistically, that is, they can visualize the whole composition. The authors made the hypothesis that more visual information as that provided by thumbnail images will be more effective when arranging Web pages for a project or presentation.

For presentations, the popular tool is Microsoft PowerPoint. Compared to OHP presentations, the use of motion pictures and animation makes a presentation more dynamic. But for children who are beginning computer users, the use of such tools may not be easy or may require more technology resources than what is available. But, by converting web pages directly to a HTML coding for presentation, the learning curve will be lower. So the authors proposed to add the function of being able to integrate selected web pages into a HTML coding for presentation in the development of their new tool.

3 The development of the new tool

3.1 Overview of the new tool

The developed new tool enables users to arrange Web pages using thumbnail images (**Figure1**). The functions of the developed tool are: listing thumbnails, sorting, and scrolling. The added function of a memo or comment line is to enable the users to add new information or data. The developed tool will then automatically generate the HTML coding for presentations. Through the use of HTML, learner can easily make a presentation (**Figure4**). **Figure2** shows the system configuration. The procedure for the use of the developed tool is as follows:

1) Learner displays Web pages or self-produced HTML pages using Web browser.
2) Screen image of Web pages and page title are saved to a database.
3) Lists of thumbnail from the database are displayed. Learner arranges web pages on the display, and add own comments to thumbnail.
4) Finally, using the arranged materials, learner makes a simple presentation

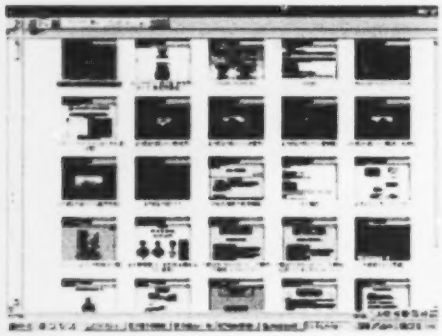


Figure1: A page showing the list of thumbnail images 1

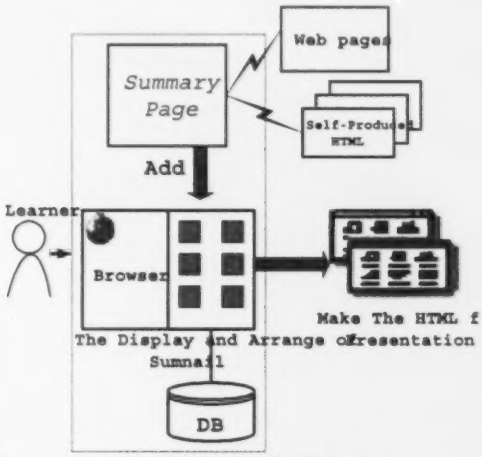


Figure2: System Configuration

3.2 The type of display Web page

In displaying the collected Web pages, the following 3 modes were used,
[1] Converting to thumbnail screen images
[2] Manipulating the original Web pages
[3] Making a presentation
The following sections explain further these 3 types.

3.2.1 Converting to thumbnail screen images

When selecting Web pages to put together, the user clicks a button to add a Web page. The web page is then converted to a thumbnail screen image (**Figure3**). Thumbnail screen images are Bitmap file made of large volume of data, so this Bitmap file is converted to a JPEG file. After that, the thumbnail is saved to the database.

3.2.2 Manipulating the original Web pages

By double clicking the thumbnail screen image, the learner can access the original Web page. It is just conceivable that learner will want to arrange the thumbnail web pages, and at the same time, have access to the original web pages. **Figure3** shows how the original web page and the lists of thumbnails are displayed at once. To change the display size, the learners can move from side to side, the display size control button located at the center of the display.

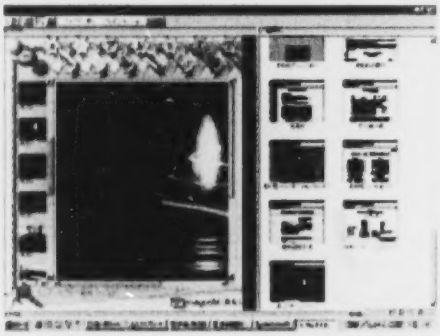


Figure3: A page showing the list of thumbnail 2

3.2.3 Making a presentation

Figure4 is the display of HTML for presentation. Arranged thumbnails are displayed in a sorted order. Learners can make a presentation using the display. Each Web page is composed of a link to the thumbnail, a link to the URL, and an area for comments or memo. The purpose here is to provide a function that will enable the easy arranging and integrating of Web pages for a presentation.

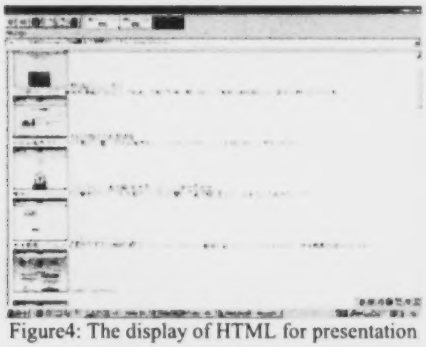


Figure4: The display of HTML for presentation

4 Evaluation of the tool

4.1 Purpose

The object of this evaluation is to verify the usability of the tool developed by the authors. Particularly, it will study the thumbnail screen images' usability for arranging Web pages. The subjects are the tool group using the developed tool and the bookmark group using only the regular bookmark tool. The groups were given the task to arrange Web pages about a specific theme. To collect data, the following were done:

(1) conduct a questionnaire survey. Subjects evaluated the operationality of the tool and were asked to give written comments of their experience of using the tool.

(2) In terms of arranging web pages, users compared the tool with the bookmark tool, and the analyses of the following data items were done.

1. work time
2. total number of times a URL is accessed
3. number of times a URL is re-accessed (the same Web page is accessed more than 2 times)
4. number of times thumbnails are sorted
5. number of times thumbnails are deleted

4.2 Method

The subjects arranged Web pages based on a theme using the developed tool and the bookmark tool. Thirty (30) Web pages were prepared in advance by the experimenter. To get a history of how they operated the tools (history of operation), a video record of how the subjects used the tool was made from a TV converter to a VHS video tape. After the experiment, the subjects answered the questionnaire. The experiment had the following stages

1. The use of the developed tool and the bookmark tool was explained to the subjects;.
2. The content of the task (theme of project) was explained to the subjects
   Theme A: the sights of Tokyo that you want to introduce to friends
   Theme B: the sights of Osaka that you want to introduce to friends
3. To eliminate order of effect, the subjects were divided into 4 groups (Table 1).

	Former	Latter
1Group	Theme A Using the tool	Theme B Using bookmark
2Group	Theme B Using the tool	Theme A Using bookmark
3Group	Theme A Using bookmark	Theme B Using the tool
4Group	Theme B Using bookmark	Theme A Using the tool

Table1: Subject groupings in the experiment

4.3 Results

To compared the developed tool and bookmark tool, questionnaire data was analyzed for significance using the t-test The results are given in **Table2**.

	Average	Result
Thumbnail screen image is more recognizable	**4.17**	**
The lists of thumbnail are more recognizable	**4.17**	**
Useful for arranging web pages	**3.83**	*
Recognizes the contents of a web page	**4.33**	**
Useful for school projects that use the Internet	**4.67**	**
Useful for making a presentation	**4.42**	**

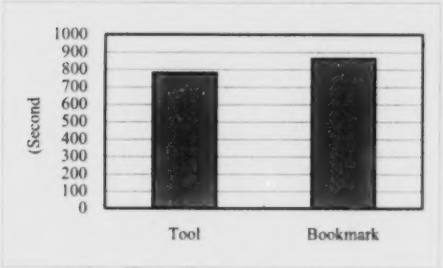
*p<.05,**p<.01 t-test (two-tail test) the average(max5)

Table2: The results of the questionnaire

T-test results show that web page titles with thumbnails are more recognizable than text-only web page title. And as to browsability, the lists of thumbnail are more recognizable than the tree structure of the bookmark tool. Inquiry as to "useful for arrangement" was significant at the 0.05 level. But as to the ability of operation in the questionnaire, couldn't get level of significance. Because the interface of sorting the thumbnails will not be enough to good for learner.

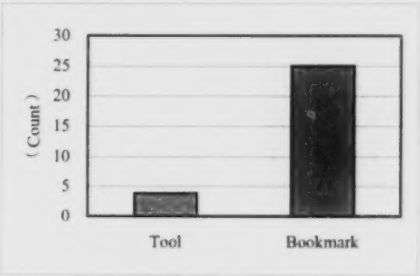
In the analyses of the history of operation (reference 4.4 (2)), the record shows that the thumbnail screen image is useful to learner when arranging web pages. The results are indicated in **Figure6-10**. From the results, the following items were verified:

* For shorter work time, the developed tool is comparatively more efficient than the bookmark tool (Figure6).
* By using the thumbnail screen image, the learner is able to better recognize the contents of the web page (Figure7,8).
* Lerner is comparatively able to estimate whether to use web pages or not (Figure10).



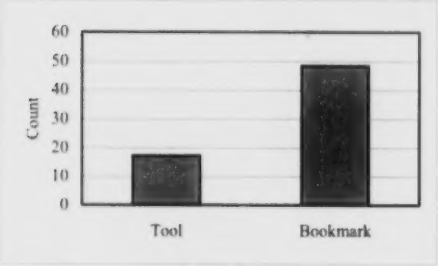
+p<.1

Figure6: Comparing the average of work time



**p<.01

Figure8: Comparing the average number of times of re-accessing URL



**p<.01

Figure7: Comparing the average of the total number of times of accessing URL

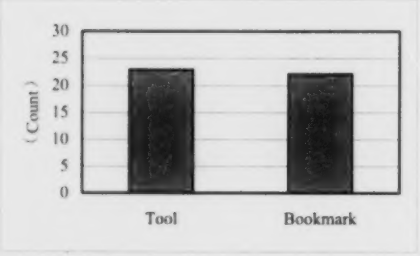
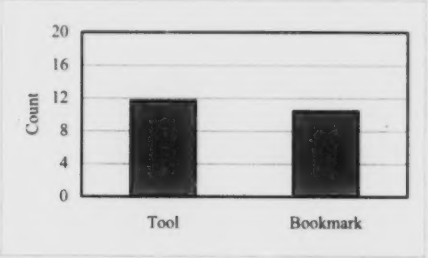


Figure9: Comparing the average number of times of sorting thumbnails



+p<.1

Figure10: Comparing the average number of times of deleting thumbnails

4.4 Analysis

The results of the evaluation procedures show that

1) based on the questionnaire, there were good results as to the functionality of the thumbnail screen images. And from the subjects' comments, "the lists of thumbnail is useful", "helps better recognize contents of the web page", and "the arrangement of web pages using the tool is convenient and useful".
2) based on the results of history of operation, work time, in terms of the number of times of accessing and re-accessing the URL and the number of times of deleting thumbnails, got good results in the given level of significance.

'n terms of browsability, providing the user with a list of thumbnail is more useful than the bookmark tool. Accordingly, for arranging web pages, the list of thumbnail was better for integrating the collected data and for reviewing them. For arranging web pages, the results of the history of operation show that the developed tool is more useful than the bookmark tool.

5 Conclusions

In this research, a tool for learning to support the arrangement and integration of web pages was developed and evaluated. The results of the study can be summarized as follows:

1. Development of the learning supporting tool
   This research addressed the problem of selecting information for research projects using the Internet [1.Introduction], and examined how to resolve the problem by developing a tool that is both effective and user-friendly. The research also considered the interface of the tool and provided a conceptual framework [2.Conceptual Framework for Tool Development] in its development.
2. The evaluation of subjects about ease of operation and usefulness of the tool
   In the experiment phase of the paper [4.The evaluation of tool], a questionnaire was used to measure the as to ease of operation and usefulness of the tool., and got good results.
3. Verifying the efficiency of the tool for manipulating web pages
   When it comes to accessing and re-accessing URLs, the tool was more useful than the bookmark tool. For arranging web pages, the availability of a list of thumbnail images made it easier to integrate the selected web pages and to review them.

5.1 Future Studies

For future studies, the following are recommended:

1) Modification of the tool and adding more functions
2) A detailed analysis of the operation history

Acknowledgement

The authors would like to thank Dr. R. Santiago for her great assistance.

References

[1] Akai, K. and Koike, H., "Experimental Studies on Visual Search of Image Files" (in Japanese), The Special Interest Group Notes,: Information Processing Society of Japan(IPSJ), Vol.98, No.35, 98-H1-78, pp.27-32(1998)

[2] Ueda, M., "Development of a system of learning support using the Internet" (in Japanese),: Japan Society for Educational Technology(JET), 99-4, pp.9-16(1999)

[3] Mizobuchi, S. and Furuyama, T., "An analysis on the effect of indexes on WWW information selection process" (in Japanese), The Special Interest Group Notes of IPSJ,: Information Processing Society of Japan(IPSJ), Vol.98, No.116, 98-H1-81, pp.31-36(1998)

The Estimation of Music Genres Using Neural Network and Its Educational Use

Yasuhiko TSUJI*, Kanji AKAHORI*, Atsuhiro NISHIKATA*
Graduate School of Decision Science and Technology, Tokyo Institute of Technology
2-12-1, O-okayama, Meguro-ku, Tokyo, 152-8552, Japan
Tel: +81-3-5734-2991
Fax: +81-3-5734-2991
E-mail:tsuji@ns.cradle.titech.ac.jp,
akahori@cradle.titech.ac.jp,
nisikata@cradle.titech.ac.jp

To develop a learning support system of music genre, a neural-network-based system was developed that can estimate the genre of music from partial information of a standard MIDI file of music. Standard MIDI files of 120 music titles has been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal after the Neural network of the system had been trained. Comparison shows that, the system developed, has a higher judgment rate than that of subjects. Next, the weight of the links were examined by an expert, 5 of the nodes in the Hidden Layer could be extracted.

Keywords: **Music Education, Neural Network, Intellectual Learning Support, MIDI**

1 Backgrounds and Objectives

Recently, popular music, for example *Beatles* etc, is included in recent music textbooks of Elementary, Junior High and High Schools in Japan. So, it is thought that music education using popular music will increase more and more in course of time. When students learn popular music, music genre of the music is an important factor[1]. In order to learn the musical feature of each genre, it is thought to be very effective. Systematic genres studying of popular music, in which students seems to be interested, is thought to be a way of the students' music experience enrichment.

An "Automatic Composition MAGIC (Music system for Arrangement and Intelligent Composition) Considering Music Style" was developed [2] by Minamikata in 1989 is one of the researches in the research field that treats plural genres of popular music. This System supports composition and adaptation using heuristic rules divided by music taste of genre. It is said that rule-based system like this is effective when the system reproduces a already-known music taste or rule for the system, but there is an anxiety that generated music is conventional, and it is a problem for an unknown taste.

It can be said that the genre of popular music is the combination of different music. Now, many researches have done the grouping of music. Concerning Neural Network-based research, the research of Sakamoto (1999) grouped the music according to the sensibility information by using SD method [3]. If consider the flexibility and generality grouping by neural network differs from that of grouping by rules or multiple different analysis. So, it is said that moderate result can be expected for any unknown input by the process of grouping by Neural Network.

Based on the above research, we aim to develop the learning support system which can provide feedback on "Feature as the genre" of an unknown music with the Neural Network training of the music of various genres. Based on the above-mentioned background, we conducted this research in the following way. At the beginning, reserve experiment was done by an expert of popular music to confirm the factor for the estimation of the genre. Based on the obtained finding, we trained the Neural Network. Here the Neural Network was composed using the partial information as input signal and genre of the music as output or

teaching signal. In order to use this system for education purpose in the future, the meaning interpretation for each factor of the Hidden Layer of the trained Neural Network was identified by an expert of popular music. Then, the genre estimation experiment was done using the subjects who seemed to have general experience of popular music. Lastly, the estimated average result of the subjects and the estimated result of this system was compared to show the effectiveness of this system.

2 Estimation of Music Genres by Expert

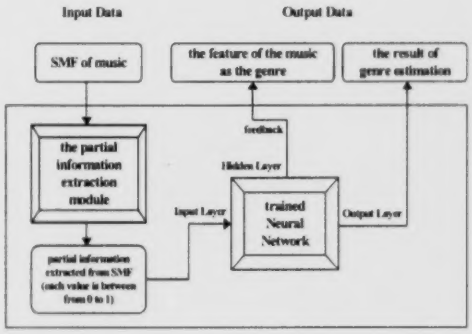
When music and genre are trained to the Neural Network, the problem is that we should take data to make an input signal from a long standard MIDI file. Therefore, we examine the mounting method of this system by knowing how the person judges the genre. For that, in the preliminary experiment we ask the expert about the factor of the genre estimation. The subjects had different musical instrument performance experience for ten years or more. The procedure was that they were made to listen ten in total of five genres. Also the factor to estimate the genre was interviewed. As a result, the following factors were found.

(1) The factor to estimate the genre is various according to the genre, and it's vague information.
(2) The factor to estimate the genre is local & partial information.

From (1), at first we got to the hypothesis that the estimation of music genre based on rules is very difficult and not proper. Under the above hypothesis, we propose to use Neural Network to deal with vague information in this research. As the input from (2), we judged that it was appropriate to extract partial information that seemed to be necessary for estimating the genre of music, and to assume it to be an input value of the Neural Network. The standard MIDI file (Hereafter, it is abbreviated as SMF) that is already a descriptive language was used as music.

3 Genre Estimation System

Figure.1 shows the composition of the genre estimation system. The flow of this system is as follows. When the user inputs SMF of music, the partial information extraction module extracts some partial information from the music. Then, it is put to the Input Layer of the Neural Network that has already been trained for music and the genre. The Neural Network feeds back the result of estimating the genre obtained from the Output Layer. Moreover, the feature of the music as the genre obtained from the Hidden Layer is planned to use as feedback in the future. If the module is developed, the user will be able to learn the genre.

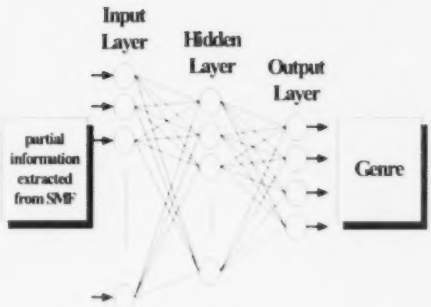


3.1 Extraction of Partial Information from SMF

SMF of the General Midi correspondence was used in this research. SMF includes various musical information such as Note-On (time of starting to ring each music sheet), Note-Off (time of finishing to ring each music sheet), Velocity (the strength of each attack), Note Number (pitch), and Program Number (kinds of musical instruments and tones) etc. The following three information of these score information were decided to use in the partial information extraction module.

BEST COPY AVAILABLE

1. Kind and tone of musical instruments extracted from Program Number (henceforth, we call it "Musical Instruments and Tones", which is expressed by an array of 128 Boolean type variable. Each valuable shows whether musical instruments (tones) of Program Number 1-128, were used in that music or not.).



Distribution of Rhythm extracted from the statistics of position of Note-On per a bar (henceforth, we call it "Distribution of Rhythm", which is expressed by an array of 16 integer type variable. Each variable shows the frequency for which Note-On event is held at the rhythm in one bar in the SMF.).

Distribution of Pitch extracted from the note number (henceforth, we call it "Distribution of Pitch", which is expressed by an array of 12 integer type variable. Each variable shows the frequency for which each pitch of 12 music scales is used in the entire music of SMF.).

3.2 Composition of Neural Network

Figure 2 shows the composition of the Neural Network. We adopted the Back-Propagation algorithm as the learning algorithm of the Neural Network. For the input signal, we used a combination of the values.

4 Outline of Genre Estimation Experiment using this system

4.1 Method

By the above-mentioned methods, the genre estimation experiment by this system was performed. 120 music titles of SMF which are composed of 30 titles each in Japanese popular ballad, Jazz, Hard Rock, and Heavy Metal, tried to be learned by the Neural Network. In this research, the combination of the following partial information was learned as an input data.

Musical instrument and tone 128bit
Distribution of rhythm 16bit
Distribution of pitch 12bit
Musical instrument and tone, Distribution of rhythm (+) 128+16=144bit
Distribution of rhythm, Distribution of pitch (+) 16+12=28bit
Musical instrument and tone, Distribution of pitch (+) 128+12=140bit
Musical instrument and tone, Distribution of rhythm, Distribution of pitch (+ +) 128+16+12=156bit

The number of units of Hidden Layer in each Neural Network is assumed to 10-30. The number of units of Output Layer is as many as the number of genres that the Neural Network learns. In this case, it requires four units in Output Layer, because there are four genres.

4.2 Result

The result of training is shown in Table 1. In the Table 1, "NN" means Neural Network, and - in NN means the Neural Network whose input information is described above. The result of training, NN was converged about 650 learning times, and

NN	Input Layer	Hidden Layer	Output Layer	Judgment Rate	Judgment Percentage	Learning Time
	128	20	4	119/120	99.2	X
	16	10	4	97/120	80.1	X
	12	10	4	103/120	85.8	X
	144	30	4	120/120	100	About 650
	28	30	4	111/120	92.5	X
	140	30	4	119/120	99.2	X
	156	30	4	120/120	100	About 1100

NN was about 1100 learning times, but other NN were not converged within ten thousand learning times. So, the trained Neural Network was able to judge the genre of learned music at 100%.

From this, it is suggested that the Neural Network like - that has single partial information in Input Layer can't finish learning, But the combination of those partial information make it enable to learn. This result supports the findings of experts at the preliminary experiment in Chapter 2 whose also says that the factor to estimate the genre is various according to the genre.

4.3 An Analysis of Hidden Layer

The Hidden Layer in the Neural Network is analyzed here. There is a heuristic method that each cell's tendency in which it is likely to make active or inactive is found by an expert, and then the meaning of factor is obtained[4],[5]. We used that method here.We focused on the weight of the link between Hidden Layer and Output that is above 10. Each unit from No.1 to 5 are activated by following genres.

Unit No.1: Hard Rock
Unit No.2: Hard Rock, Jazz
Unit No.3: Hard Rock, Jazz, Japanese Popular Ballad
Unit No.4: Heavy Metal
Unit No.5: Japanese Popular Ballad

Table 2. Analysis of Each Factor in Hidden Layer

Unit	Name of Factor
1	Hard Tone Factor
2	Synthesizer Tone Factor
3	Jazz-Acoustic Factor
4	Rhythm Tendency Factor
5	Combination Factor of Electric Instruments and Rhythm Tendency

Finally, each unit was named by a music expert. The summarized result is shown in Table 2.

5 Experiment by Subject

To investigate at how much rate can the subjects, twenty-five female university students were asked to listen to eight music titles of 4 genres of SMF with MIDI sound randomly, and to judge the genre and the factor for each music.The judgment rate of all the subjects was 66.5%.

To compare the judgment of subjects with this system, Neural Network was trained with 119 titles, and was made to estimate the genre of subtracted one as unknown music.

As a result, both Neural Network and have a judgment rate of 100% for eight unknown music titles. From this, the judgment of this system is higher than that of subjects with general experience of popular music.

6 Summary of Results

In this research, development and evaluation of genre estimation system ware performed aiming for the development of learning support system of music genre. The results are summarized as follows:

(1) The preliminary experiment for experts with an experienced popular music was performed, and a result that says that the factor to estimate the genre tends to be local & partial information was obtained.

(2) From this finding, genre estimation system using Neural Network was developed.

(3) 120 music titles have been identified into 4 genres, Japanese Popular Ballad, Jazz, Hard Rock and Heavy Metal at the rate of 100% by training the Neural Network to identify these 4 genres.

(4) The judgment rate was 66.5% as the result of the estimation experiment for subjects with general experience of popular music.

(5) This system was made to estimate 8 music titles, as an unknown music, out of 120 which were used in the genre estimation experiment by subjects. As a result, the estimation rate of 100% which is higher than that of the subjects (66.5%) was obtained.

(6) Each unit of Hidden Layer in trained Neural Network was enable to be named, and the factors of each unit were able to be extracted by the expert of popular music.

From this finding of 6, providing feedback on the features of the music from Hidden Layer becomes possible by the way of observing the result of meaning explanation of Hidden Layer in which the Neural Network has the feature of the music as a genre, observing the state of fire, and observing the input units which have tendency to make active to the fired units in the Hidden Layer.

From the result described above, the possibility of the development of a learning support system using this system for music genre is shown. And, it was thought that the trained Neural Network of this system has the application possibility not only to the learning support system but also to the supporting composition and adaptation.

Acknowledgement

The authors would like to thank Mr. UZZAMAN MD. ANIS and Assistant. Taizan SUZUKI for their cooperation.

References

[1]Hiroshi UEDA, Kazumi AKAIWA etc.: Hajimeteno ongakutsuu:50 genres 500 CDs, Ongakunotomosha,1993

[2]Junichi MINAMITAKA, Mayumi INO, Kunio SATO, Shigenori MORIKAWA: Automatic Composition MAGIC Considering Music Style, Collected lecture papers of the 39-th National Convention of Information Processing Society of Japan, No.3, pp.2242-2243,1989

[3]Takashi SAKAMOTO, Yoshinobu KAJIKAWA, Yasuo NOMURA: Classification of Group According to Tune's Impression Using Nonlinear Distinction Analysis in the Music Sensibility Space, Transactions of Information Processing Society of Japan, Vol.40, No.4, 1999

[4]Hisayoshi ITO, Hiroki ITO, Kanji AKAHORI: An Analysis for the Neural Network Supporting Users' selection of Menu Items,IEICE technical report, (Educational Technology) ,Vol.96, No.500, pp.53-60, 1997

[5]Michio MATSUBARA: Evaluation of Global Processing of Students in Electric Circuit, Transactions of Society Japan Science Teaching, Vol.39, No.1, 1998

The Usability Aspects of an Universal Brokerage and Delivery System for the Pan-European Higher Education

Borka Jerman-Blažic
University of Ljubljana, Faculty of Economics and Jož ef Stefan Institute
Jamova 39, Ljubljana, Slovenia
Borka@e5.ijs.si

This paper gives short overview of a recently launched EU project for universal exchange of university course units for the higher education based on a brokerage and delivery system model. The basic components and characteristics of the approache are described. More attention is given to the approach that will be used for assesment of the innovation and for evaluation of the learning and educational achievements.

Keywords: **distance learning, brokerage and delivery system**

1 Introduction

The new technologies are transforming the ways business operate and the ways people work. They are also reshaping the expectations, needs, and opportuniies in education and learning. The customers of the education market are forcing the education to become demand-led, rather than production driven. The current technologies are providing basis for a new just in time, on demand approach the electronic educational products to be offered by virtual or classical universities through special platforms acting as intermediaries between the consumers and the suppliers of educational material. It is clear that the new tecnology alone will not make this new model of more efficient education to happen by itself. Rather, new innovative models of production, brokerage, delivery and presentation are needed that will put together the participants of the education process to collaborate globally and to use the advantages of the powerful technology.

The European project »UNIVERSAL-brokerage and delivery system for exchange of university course units for the Pan European Higher education« [1] is one of the attempts this model to start to work. The project is part of the Vth Framework program of User friendly information society [2] funded by the Commission of European union. The project started in March this year and will last 3 years. The conzortium of the project is large as it encompassess 17 partners from EU[3], among them twelve higher education instituitions from all over Europe, two research organisations, one SME[4] and two telecom service providers. The consortium has also partners from outside Europe as the model developed is expected to have global applications. These are: the Moscow research institut, HEC from Montreal and Nanyang Technological University from Singapore.

The model and the implementation in UNIVERSAL is based on an education brokerage and delivery system being developed to incorporate training by provision of valued-added services to both the customers of the system and the suppliers of the educational material. The major characteristic of the system is offer of different types of learning and delivery of the educational material and its distributive nature. There is no central site for delivery of educational material. Additional characteristic of the model is the system that will be developed for pan-european acreditation of the purchased and performed university course units by the participants belonging to institutions of the European higher education system. At this early stage of the

[1] UNIVERSAL –IST-1999-11747
[2] URL:http://www.ispo.cec.int
[3] EU stands for European Union
[4] SME- Small or Medium Size Enterprise

project is not possible to predict all expected circumstances and consequences that such system may have in the furure development of the educationa nad training. Brokergae approach in provision of distance education must first address a number of technological and educational issues which are part of the UNIVERSAL work program. In depth discussion of the pedagogical paradigms that may take place as well as te number of technological issues of the work program are not possible to be discussed in this article because of space restriction. Here, we concentrate on the basic characteristic of the model; highlithing the implementation scenario and giving more information about the usability aspects of the technology that will be evaluated through monitoring of the educational.

2 The model and the architecture of the system

The model being developed is based on creation of an open, cross-border, educational market environment coupling brokerage and delivery of "live" and "packaged" [5] courses. The proposed framework accommodates and adds value to the various business models and course structures employed in European HEI[6] institutions. It will enable:

- a single faculty wishing to experiment with the simple import of external material to enrich a specific course,
- an existing alliance between institutions to make their exchange more efficient and to enrich it with types of course units not previously exchanged,
- an Open University to extend the range and depth of its courses.

The UNIVERSAL brokerage platform is an interactive hypermedia environment offered to the academics and administrators of European educational institutions to plan and select courses. It de-couple offers and course units provision on the supply side from enquiry, booking and delivery on the demand side. The most important element that enable this de-coupling is the catalogue of offered educational material and the supporting processes, that adequately describes all the properties, educational and technological of the course units. This approach is implemented as brokerage platform and a number of delivery platforms, see Fig.1.

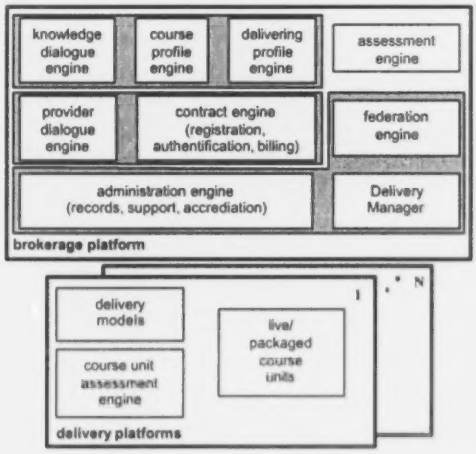


Fig.1 The general architecture

The brokerage platform is further divided in a customer part, a provider part and an administration part. In the customer part, a knowledge dialogue engine is responsible for the dialogue to the demanding institution or to the enquiring student. When interacting with customers, the dialogue engine establishes their background knowledge and guides them in the selection of a course unit. Prospective customers are

[5] Packaged courses are multi-media textbooks and WWW based courses, live courses are CWCS broadcasted courses

[6] HEI stands for Higher Education Institution

presented with choices according to a) pre-requisites and conditions attached to different types of courses (course profile engine), b) the suitability of different Institutions offering courses and c) the different delivery modes available for a particular course (delivery profile engine). Students will be able to make inquiries and express interest in course units that their home institutions have pre-selected and are willing to recognise and give credit. [7]In the provider part a provider dialogue engine is mainly used for feedback from the system back to the content provider. It is also used to handle the offer of content provision to the brokerage system to help academic and administrator users to plan new courses, submit course units, obtain customer records as well as learning progress profiles and assessment results. Demands for course units are sent to the administration engine, which looks for, offered course units fitting into the demand profile. The contract engine sets up the contract between offering and demanding side, thus it is dealing with registration, authentication and billing. In the administration part the system is driven by the administration engine, which is mainly a service database combined with a search engine. The tasks of observing and managing course scheduling and delivery issues, as well as timed interactions between the system and customers to enable the provision of joint courses are the responsibility of the delivery manager. The federation engine is dealing with distribution issues of the engineering implementation, like consistency, caching, forwarding of requests.

For each class of course unit there is an appropriate delivery platform. Variations in delivery platforms are due to the nature of the interactions and differences in media content and formats. The project will implement a limited range of delivery platforms, linked to the brokerage platform, sufficient to show the potential of the model. Each delivery platform contains an inherent delivery model and specific elements dealing with the media content itself.

3 The technology applied

The technology used is ubiquitous, Internet based, offering common, portable solutions and large-scale, shared, cross-border systems. These systems include, but are not restricted to:
Brokerage system is WEB based with Internet links. It is a central point of information, control and administration and logically will be centralized which means that only certain parts will be distributed or redundant for reasons of performance and high availability. The brokerage system will essentially be an E-business system that uses technologies like XML, Java / RMI, CORBA / ODP traders or agent based systems. standard security technology and intrinsic service negotiation for content delivery. Advanced transaction and billing functionality based on AAA[8] security technology, implement sophisticated administration and monitoring interfaces to the delivery systems and the integration of assessment capabilities

Delivery system similarly to the brokerage platform consists of an existing product/technology plus some enhancements ("glue" or "shell" around it), that acts as mediator between the delivery system and the brokerage platform. Defining a unique architecture for this interfacing allows adding additional systems / products by just implementing the appropriate interfaces that plug into the general architecture. A delivery system within the general architecture (see Fig.1) consists of content source, network and content sink. The content source can be a standalone system or part of a broader platform. The same applies to the content sink. The following delivery systems previously tested and used will cover the required functionality: Non-real-time delivery systems: retrieval of non-real-time mono-media and multimedia contents (e.g. browsing through text and hypertext information, download of content files). Real-time A/V systems: Real-time retrieval of multimedia contents (stored and live contents including A/V material like MPEG-2 streams) in synchronous and asynchronous manner (on-demand, live and scheduled broadcast scenarios) using IP technology (unicast, multicast), and broadband technology (ATM, ADSL,). CSCW systems: Videoconferencing and Computer supported co-operative work (CSCW) to enable interactive forms of tele-lectures combining parallel transmission of A/V streams and course material (e.g. slides) with the possibility to interact with the lecturer as well as with other parts of the audience. This family of delivery systems shall also support real-time experiments, simulations and case studies.

---

[7] Scheduling of actual course units remains the prerogative of the institutions and booking of places on courses is considered to be an internal function of the institutions

[8] AAA stands for Authentication, Authorization and Access Control

All delivery systems are inter-working with the brokerage platform and content provider systems to synchronise announcement and content delivery, to guarantee controlled user access, and to manage selection, compatibility and resource usage in delivery. All supported delivery modes will be available as profiles of the A/V delivery family. This means that each content provider can easily select the appropriate profile according to the nature of his contents and his network resources. It is important to note that used the A/V delivery technology is not based on the current average bandwidth and quality availability of the ubiquitous Internet. It will offer real high quality of A/V contents as broadband communication over the Internet (with technologies like ADSL) for a relevant number of users is available in Europe as well as the broadband services emerging in the convergence technology market (broadband over Satellite or cable-TV, interactive digital TV services) are expected to boost the widespread usage of broadband A/V information in the global IT environment. CSCW technology applied follows the principle of standards compliance and openness as for example the powerful CSCW tool ISABEL, developed in the RACE and ACTS projects ISABEL and NICE, then the standards-based (e.g. ITU H.323) COTS products (e.g. MS NetMeeting), MBONE multimedia conferencing tools (VIC, VAT, WB) developed within project MECCANO etc.

4 Content provision and description

The general architecture and model envisaged as a point of interaction of "sellers and buyers" on one hand, and of "place of commerce for actual content" requires an intelligent abstract description of the contents. Therefore, meta-data standards for multimedia contents and for educational environments are applied in the catalogue building of course units. The meta data system used is based on the specification of the IEEE LOM 3.8 meta-data scheme[9] with some extensions relevant to the platform developed as for example: attributes that specify the copyright and IPR[10] protection, attributes that describe information about digital signatures, watermarking, attributes that describe the network requirements for provision of appropriate quality of service, attributes relevant to live content and attributes defining the type of the course unit which may be: packaged, live, CSWC or mixed. The content provision and course description is based on a meta-dada system selected from available standard documents or previous projects results (1).

Several projects, that have investigated the management of information retrieval and the utilization of metadata for education and training have already proposed sets of meta-data requirements, like the Instructional Management System (IMS) project in the US (2) or the GESTALT (3) project in Europe. Some of the proposed sets have been evaluated and selected for the use in the UNIVERSAL project.

They are:

- **Learning resource content meta-data:**

Learning resource content meta data that enables cataloguing of contents of arbitrary aggregation level. UNIVERSAL supports the following granularity levels: *Fragment (Course Unit)*, *Lesson*, *Module* and *Course*. Each learning resource submitted by the "seller" is classified according to the aggregation levels and is added to the UNIVERSAL catalogue. UNIVERSAL supports "packaged" learning content, which is asynchronous in nature and synchronous learning content. Synchronous learning content is delivered as live transmissions of lectures, optionally supplemented by synchronous group ware communication technology. The special or unique features of the live content is described by specially developed attributes that are not part of the current existing meta-data standards.

- **Course structure meta-data:**

The UNIVERSAL brokerage platform not enables "buyers" to locate, use and re-use single course units. A functionality of the brokerage platform enables combination of single course units into higher levels of aggregation e.g. for full subject. This allows production of "custom" tailored complete courses. This is reflected in the course structure meta enabled by Course Structure Format (CSF) defined by the AICC and the ADL (1).

---

[9] IEEE Learning Objects Metadata document by WG 12 of IEEE Learning Technology Standardization Committee, URL:http://ltsc.ieee.org/wg12/scheme.html

[10] IPR stands for Intellectual Property Rights

- **Contents packaging meta-data:**

Like many other LMS, the UNIVERSAL platform offers the possibility to access packaged course units, which are mainly pre-recorded. Packaged courses enable an interaction with the contents itself, the interaction with the lecturer is usually not offered. UNIVERSAL packaged courses are described according to well-defined rules, specified e.g. in available standards like the IMS CPS (Content Packaging Specification).

- **Descriptive information about assessment procedures:**

Assessment is an important concept in on-line education and learning. Although the UNIVERSAL platform is not designed to assess the student's advancement and the learning achievement, it will enable consumers or "buyers" to assess the functionality and usability of the platform and the delivery process. The assessment is performed with on line involvement of the students. Student's responses will be captured using some form of structured mechanism with designed template(s) for such purpose. This is especially required in the cases when questions in the templates involve multiple choice, matched items, text selection, etc. Several structures exits for this purpose already: QML, SATML, and the IMS "Question and Test Interoperability Information Model" (QTI), UNIVERSAL team will decide which of the proposed template will be used for particular part of the platform and the delivery system used.

- **Meta-data for synchronisation:**

The asset management is important if the system is built up from re-usable learning resources e.g. units of lower aggregation level as is the case with UNIVERSAL catalogue. . In such cases the lifecycle management of the unit must be supported e.g. a component is not deleted from the asset management system in cases when the course unit is added to a module or larger course. This property of the system is described within the meta-data for synchronisation.

The UNIVERSAL consortium brings together a selected group of engineering and business schools across Europe who are interested in pooling their academic resources for the purpose of broadening the choice of courses and pedagogical materials offered to students and teachers and to provide opportunities for international collaborative learning. Although a few of its members have already established bi-lateral academic exchange programmes, in the initial phase of the project, partners are collecting course units developed within particular partner or outside in order to build a catalogue for the greatest market potential for the brokerage platform. The catalogue contains in addition to the meta-data information also: brief description of the educational objectives of the academic content for the students to whom courses are offered. In addition to that, brief description of teaching methodology used at each institution, description of the academic calendar for each institution, and description of the academic accreditation process for each institution are also information provided in the catalogue. Currently course units are collected from the following fields: Introduction to Information Systems, Regional Economic Development and Telecommunication, Global Marketing Management, Business Case studies, Metallurgy simulations and experiments, Foreign Languages and Cross-cultural Behaviour, Statistics for Economist, Tele-management.

The UNIVERSAL brokerage platform enables to locate, use and re-use single course units and combine single course units into higher levels of aggregation. This approach makes possible a definition of custom tailored structure for a complete course, which will lead, to a definition of a standard system of granularity for learning resources with the other projects from the IST cluster "Flexible University".

Several institutions already made suggestions for a hierarchy of aggregation levels. The IEEE LTSC and the IMS so far define four levels of granularity: *Fragment*, *Lesson*, *Module* and *Course*. Some other US based systems of aggregation can be found in the bibliography enclosed (8).

A course structure representation defines all of the course elements, the course structure, and all external references necessary to represent a course and its intended behaviour. The ADL together with the AICC, IEEE and IMS have developed the so-called Course Structure Format (CSF) which was the recommended approach for the UNIVERSAL project. The CSF promotes reuse of entire courses and encourages the reuse of course components by exposing all the details of each course element. The CSF is intended to reduce or eliminate dependency of a course on a particular LMS implementation.

The CSF is also intended to represent a wide variety of course structures and content "aggregations".

Content structures can be represented by the CSF that range from very small "chunks" of content – as simple as a few lines of Hypertext Markup Language (HTML) or short media clip – to highly interactive learning content that is tracked by an LMS. The CSF is neutral about the complexity of content, the number of hierarchical levels of a particular course (i.e., "granularity"), and the instructional methodology employed to design a course.

The UNIVERSAL platform incorporates continuous assessment of content and the system itself based on the interactions between the customers using the delivery of course units and the system itself. This information will be used to improve the overall scheme and the content to teachers, administrators and other possible customers.

5 The usability and evaluation

"Evaluation is the activity that throughout the planning and delivery of innovative programs enables those involved to learn and make judgement about the outcomes of the innovation concerned "[11]. The UNIVERSAL project aims also to develop tools to monitor the innovation process of education and learning and to develop best practice guidance.

The assessment of the content and the overall system, components for functional assessment are incorporated in both the brokerage system and in each of the delivery systems. Results from previous projects including the deployment of trans-national multimedia learning schemes[12] have shown that it is vital that all participants involved in the creation of the exchange platform and its educational content have a mutual understanding of the platform' s operations, functions and of the components' interaction. To fulfill this goal it is necessary to give the users the tools enabling an easy the use of the exchange platform such as: an administrator guide, oriented towards the management of the platform, from a technical ("how to use") point of view as well as from a content ("what to do") point of view; a user guide, describing the day-to-day use of the system e.g. to a teacher wishing to use content available through the platform (how to access the catalogue, how to book a live course, etc). In addition, in the case of "live" delivery systems (on-line live courses with CSWC), experience have shown that it is necessary to organise "hands-on" training sessions to free the teacher from the fear of new tools and to strengthen their "moderation" skills when working with a geographically distributed class through a TV-like systems. Classes in the live courses will be mainly cross-border meaning that most participants will not be working in their mother tongue and there will be a mix of cultures present in any one of the classes. As part of the preparation for participation in the main trials a short "Language & Behaviour" courses that will (I) help participants with their colloquial English (since the majority of the courses will be held in English) and (II) help them be aware of differences in cultural behaviour, e.g. questioning style will be provided.

The student/teacher ratio varies greatly among the UNIVERSAL consortium partners. A set of software monitoring tools are being studied to be implemented into the brokerage platform to make it possible for students to continuously assess their personal progress and to choose the academic path best adapted to his or her acquired knowledge and skills; for course unit providers tools will be used to improve the effectiveness of programmes offered to learners and modify content accordingly; tools will be used also to analyze the way learners use the courseware provided; to enable a global assessment of the usability of the platform etc. The monitoring tools as well as the usability evaluation techniques used for assessment of the innovation technology approach are being developed/selected in accordance with the ACTS Usability Evaluation Guidelines[13]. These guidelines define the testing and evaluation methods, experiments design, definitions of interviews, observations, heuristic evaluation and surveys.

The evaluation instruments for courseware evaluation and corresponding measures will include:

- Pre-task/post-task questionnaires
- Task experience questionnaires
- Computer experience questionnaires
- Exams or assessment of performance
- Post course questionnaires

---

[11] Stern(1988) in Evaluation of Learning Technology Implementation, by Barry Jackson, URL:http://ltdi.icbl.hw.ac.uk

[12] Project LEVERAGE AC 109 from the IV Framework Program-ACTS

[13] USINACTS – AC224, IV Framework Program -ACTS

- Knowledge quizzes
- Logs - logging times

The approach for educational assessment will follow the practical guidelines developed within the LTDI technology developed within the Learning Technology Dissemination Initiative funded by the Scottish Higher Education Funding Council[14]. As a result of this a set of guidelines identifying best practices for future users of an academic brokerage platform will be produced. Academic partners will have the possibility to review the existing experiences and pool their lessons learned from prior involvement in flexible, distance, and collaborative teaching and learning programmes. This information cover issues such as the choice and format for resources provided to students and teachers, access to tutors or teachers, methodology, independent study and collaborate work, learner motivation, learner monitoring, course accreditation etc.

6 Conclusion

The UNIVERSAL is a project that implements the EU policies regarding the development of the European higher education and the user-friendly information society in particular:

- By improving the quality and diversity of the pan-European HE system
- By promoting the globalisation of the exchange of HE course units
- By enabling partners from economically disadvantaged regions, particularly in Central and Eastern Europe to participate in these developments and helping them to strengthen and enrich their course offerings and the foster the education in general.

Most of the activity within the project will be tightly connected with the usability aspects of the applied methods and technology. Usability evaluation and proposed improvement will be based on the past experiences, guidelines and standards developed within projects that have addressed this issue of modern technology in depth. The consortium expects wide acceptance among the higher-level education institutions in Europe.

References

[1] Advanced Distributed Learning Network (ADLNet), *http://www.adlnet.org*

[2] Instructional Management Systems project, *http://www.imsproject.org*

[3] GESTALT:Getting Educational Systems Talking Across Leading-Edge Technologies, *http:www.fdgroup.co.uk/gestalt/*

[3] SCORM, Sharable Courseware Object Reference Model: *http://www.adlnet.org/Scorm/docs/scorm_2.pdf*

[4] IMS Question & Test Information Model, *http://www.imsproject.org/question/index.html*

[5] SATML Standardised Assessment & Testing Markup Language *http://www.engr.ucf.edu/aim/research/1998/tess/satml/default.htm*

[6] QML Question Markup Language, *http://www.questionmark.com/qml/index.htm*

[7] IEEE LTSC WG17: Content Packaging Working Group, *http://ltsc.ieee.org/wg17/index.html*

[8] IMS Content Packaging Specification, *http://www.imsproject.org/content/index.html*

[14] LTDI, Philip Crompton: Evaluation: A practical guide to methods and Stephen Draper: Observing, measuring or evaluating courseware URL:http://www.icbl.hw.ac.uk/ltdi

Use of abstraction levels in the design of intelligent tutoring systems

Ruddy Lelouche
Département d'informatique
UNIVERSITÉ LAVAL Québec G1K 7P4 CANADA
Tel.: (+1-418) 656 2131, ext. 2597 Fax: (+1-418) 656 2324
e-mail: lelouche@ift.ulaval.ca

In problem-solving domains (mathematics, physics, engineering, and most "exact science" disciplines), the knowledge to be acquired by the student is twofold: the knowledge describing the domain itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an educational system in such a domain encompasses three knowledge types: the domain knowledge and the problem-solving knowledge, i.e. the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process. In this paper, we show how these three knowledge types can be modelled, how they should interact with one another in order to fulfil the system educational purpose, and above all how abstraction levels can shed a uniformizing light on the system operation and make it more user-friendly. We thus hope to bring some contribution to the general and important problem of finding a generic architecture to intelligent educational systems.

Keywords: **Intelligent tutoring systems, Abstraction, Complexity, System Design**.

1 Introduction

Teaching is a very complex process in itself. Teaching strategies and activities vary considerably: by the role and autonomy they give to the learner, by the type of interactions they trigger with him/her, by the evaluations they enable, by the relationships they make between theory and practice, etc. From that last perspective, teachable domains can be classified according to the type of knowledge to be acquired by the student: "know", "know-how", and "know-how-to-be". Examples of such domain types are respectively: anatomy or a language grammar, the skill to solve a mathematical or medical problem, and the capability to adapt to one's environment or to deal with personal relationships. We are more particularly interested in the second type.

Moreover, almost all teachable domains vary in complexity, from simple basics to relatively complex problems to solve or situations to deal with. Thus, a student should learn and master the basics of such a domain before being taught wider notions. And when a human tutor detects errors or misunderstandings, s/he usually draws the student's attention on a small subset of the involved knowledge, so that s/he may correct his/her errors and/or misunderstandings, focusing either on a given set of the domain knowledge or on the scope of knowledge involved by a given problem.

Problem-solving (PS) domains are the ones in which we are interested here. In such a domain, the knowledge to be acquired by the student is twofold: the domain knowledge itself, but also and mainly the knowledge necessary to solve problems in that domain. As a result, an education-oriented system in such a domain, which we here call a PS-ITS, must encompass three knowledge types: the domain knowledge and the problem-solving knowledge, constituting the knowledge to be acquired and mastered by the student, and the tutoring knowledge, used by the system to facilitate the student's learning process.

This paper has two goals: to present each of the three types of knowledge involved in a PS-ITS, and for each type of knowledge, to show how abstraction and complexity levels appear and how we think it is possible to deal with them.

To do so, we present in section 2 our domain knowledge modelling and how we exemplify it in a few PS domains . Next, in section 3, we focus on the advantage of separating the problem-solving knowledge from the domain knowledge in a PS-ITS, and we present some problem-solving activities in various domains. In section 4, we briefly describe some principles of tutoring knowledge modelling in a PS-ITS. In each of these three sections, we show how to use abstraction and complexity levels, exemplifying them in a few typical domains.

Finally, section 5 presents the educational interests of using abstraction and complexity levels when modelling the three types of knowledge involved in a PS-ITS.

2 Domain knowledge

In order to describe the domain knowledge, we first present its characteristics in a general PS-ITS (section 2.1). We then show how we model it in a few PS domains (section 2.2), and how such an approach lets us introduce the notions of abstraction and complexity levels (section 2.3).

2.1 General

The first type of knowledge involved in every ITS, the *domain knowledge* (DK), contains all theoretical and factual aspects of the knowledge to be taught to the student. Although its specific structure can be varied, it typically may include concepts, entities, and relations about the domain [Brodie & al., 1984], object classes and instances [Kim & Lochovsky, 1989], possible use restrictions, facts, rules, [Kowalski, 1979; Clocksin & Mellish, 1981], semantic or associative networks [Findler, 1979; Sowa, 1984], etc.

The main system activities centred on this knowledge type are:

- providing the student with theoretical presentations and explanations about the various knowledge elements and their relationships in the teaching domain;
- providing the other modules of the ITS, i.e. problem-solving and tutoring, with the necessary background of domain knowledge that they need.

2.2 Application to a few domains

In the particular domain of **cost engineering**, Lelouche and Morin [1997; Morin, 1998] represent this type of knowledge with concepts, relations, and a special case of relations modelled as concepts, the factors.

Concepts can be basic entities like investment, interest, investment duration, present and future values, compounding, compounding period, interest rate, annuity, etc.

Concepts are linked to one another by various types of *relations*: either usual knowledge-representation relations, like *subclass of*, *element of*, *sort of*, etc., or numerical relations represented by formulæ. Such a formula is:

$$F = P \times (1 + i)^n \tag{1}$$

which, given the present value P of an investment over n periods at interest rate i, computes the corresponding future value F of that investment.

A formula such as (1) can be rewritten as:

$$F = P \times \Phi_{PF,i,n} \text{ where } \Phi_{PF,i,n} = (1 + i)^n \tag{2}$$

$$P = F \times \Phi_{FP,i,n} \text{ where } \Phi_{FP,i,n} = (1 + i)^{-n} \tag{3}$$

thus introducing the *factors* $\Phi_{PF,i,n}$ and $\Phi_{FP,i,n}$. Factors allow us to separate their definition (rightmost equalities above, a quantitative aspect) from their possible uses in the application domain (leftmost equalities, a qualitative aspect).

Similarly, the factor $\Phi_{AP,i,n}$ converts a series of identical annual amounts A into a unique present value P:

$$P = A \times \Phi_{AP,i,n} \text{ where } \Phi_{AP,i,n} = \frac{(1+i)^n - 1}{i\,(1+i)^n} \tag{4}$$

Actually, $\Phi_{AP,i,n}$ is a sum of Φ_{FP} factors (see details below). The factor $\Phi_{PA,i,n}$ does the reverse process:

$$A = P \times \Phi_{PA,i,n} \text{ where } \Phi_{PA,i,n} = \frac{i\,(1+i)^n}{(1+i)^n - 1} \tag{5}$$

There exist other factors converting gradient and geometrical series of amounts into a present or future value; such factors are also computed as a sum of $\Phi_{FP,i,n}$ factors.

In **geometry**, *concepts* are basic elements like point, line, segment, and later more elaborate elements like angle, then square, rectangle, circle, ellipse, polygon, solid, polyhedra, etc. Examples of *relations* between concepts are adjacency (of segments or angles), parallelism (of lines or line segments), complementarity (of angles), etc. Upper-level, more abstract concepts are then defined using lower-level ones, as well as relations between these lower-level concepts (e.g. a triangle is a set of three segments adjacent pairwise).

In **mechanical physics**, we similarly introduce *concepts* like time, distance, velocity, acceleration, mass, force, and later angle, angular velocity, angular acceleration, moment of inertia, torque, etc. We also introduce *relations* like the one defining velocity as the variation in distance per unit of time, or the one stating that the acceleration a is proportional to the force F that is applied. Introducing a generalization from linear to rotational movement, another relation defines angular velocity as the angle variation per time unit, and another one states

that the angular acceleration α of a solid body is proportional to the torque τ that is applied to it. More precisely, we have:

for a linear movement $F = M \times a$ where M = total mass of the body (6)

and for a rotational movement $\tau = I \times \alpha$ where $I = \sum (m \times r^2)$ (7)

Equation (6) expresses Newton's second law. In equation (7), I is the moment of inertia and is expressed in terms of the mass m of each of its particles and of its distance r to the rotation axis. Obviously M in equation (6) and I in equation (7) play the role of factors as in cost engineering.

Although formulæ like (2-7) related to factors essentially involve quantitative aspects, the similarities and differences between them, and the circumstances regulating the use of either one, are of a deeply qualitative ground. In **cost engineering**, if the *value* of factors is indeed calculated from two or three numerical parameters, the *context* in which they are defined depends on whether we have to timewise move a unique amount or a series of amounts, identical or not, or conversely to compute an equivalent annual amount, etc. In fact, this context corresponds to the type of conditions that govern the investment, or *investment conditions type*, without respect to the amounts and durations involved, and is thus essentially qualitative. Similarly, in **physics**, the proportionality between force and linear acceleration, or between torque and angular acceleration, expresses a qualitative relationship. Only if the need arises, the exact relationship can be expressed by using the actual mass M in formula (6) or the result of the computation of the moment of inertia I in formula (7), which in the general case involves a simple or double integral. Indeed, did not the use of qualitative reasoning originate with qualitative physics?

2.3 Towards the notions of abstraction and complexity levels

In most PS-domains, abstraction most obviously appears in the *definition of the domain concepts* themselves, like we showed in all three domains above.

If *factors* are used in the domain, it also appears that every factor introduces an additional intermediate abstraction level between the concepts implied in the equation defining it. For example, in the case of formula (1), or equivalently formulæ (2) and (3) in **cost engineering**, or in the case of formula (6) and (7) in **physics**, we have (see figure 1):

- at the bottom of the hierarchy, basic concepts "making technicalities explicit" if necessary: the interest rate and the number of periods in cost engineering, the distribution of mass within the body volume in physics ;
- above them, concepts more fundamentally related to the problem being solved, namely in cost engineering the present and future values of the investment, and in physics the force and acceleration, or the torque and angular acceleration;
- between these two levels, an intermediate level created by the introduction of the factor (Φ_{FP}, Φ_{PF}, M, or I).

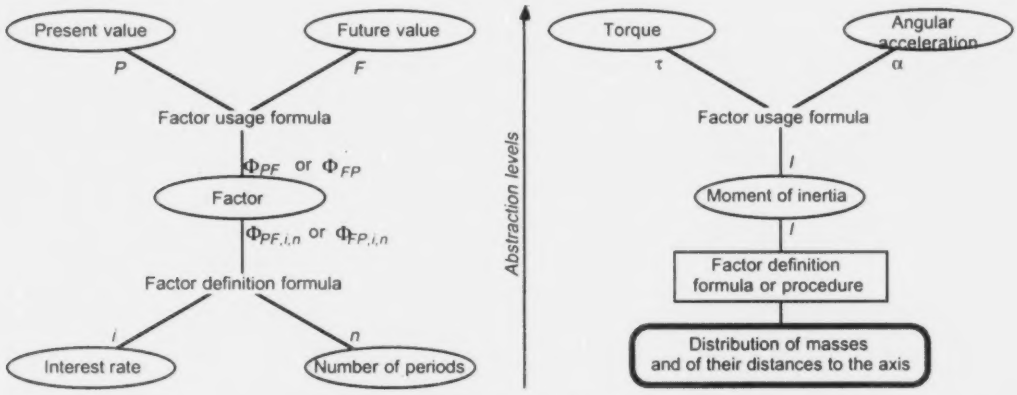


Figure 1 — Representation of a factor as a concept.

That intermediate status of the factor, originally just an intermediate variable in computations [see formulæ (2) and (3) or (6) and (7)], makes it appear as a pedagogically oriented concept, which clearly separates

- the computational, quantitative aspect of the factor definition,
- from the practical, qualitative aspect of the factor usage in a domain problem.

This follows the theory [Lenat & al., 1979; Malec, 1989] according to which the use of multiple *abstraction levels* eases the modelling process and simplifies inferences which may be made on the domain concepts.

Most interestingly, our scaffolding approach can be made more general, at least in certain domains, where we may present and use higher-level factors built upon these first ones. Indeed, in cost engineering, "above" Φ_{FP} and

Φ_{PF}, the factors used to express the present and future values of a series of identical amounts (and vice versa) are a first way to generalize this concept hierarchy. For example, the Φ_{AP} factor is indeed a sum of Φ_{FP} factors:

$$\Phi_{AP,i,n} = \sum_{k=1}^{n} \Phi_{FP,i,k} = \sum_{k=1}^{n} (1+i)^{-k} = \frac{(1+i)^n - 1}{i\,(1+i)^n}$$

where the last expression results from computing the geometrical series shown. This example constitutes a proof of (4), but also and mainly shows that the Φ_{AP} factor is at a higher level than Φ_{FP}. Note that this refers to a *complexity level* rather than an abstraction level, since it is due to the way the Φ_{AP} factor is defined and computed. Similarly, the moment of inertia of a complex body can be (and often is) computed as the sum of elementary moments of inertia, and therefore is at a higher complexity level.

3 Problem-solving knowledge

In order to describe the problem-solving knowledge, we now present the general characteristics regarding problem-solving knowledge modelling in a PS-ITS (section 3.1). As we did in section 2, we then examplify our model in the cost-engineering and physics domains (section 3.2).

3.1 General

The second type of knowledge is specific to PS-domains [Ganeshan & al., 2000; Gertner & VanLehn, 2000], henceforth to PS-ITSs. We call it *problem-solving knowledge* (PSK). It contains all inferential processes used to solve a problem resulting from the instantiation of a practical situation based on the domain knowledge [Kowalski, 1979; Patel & Kinshuk, 1997]. In other words, in order to be able to solve a problem, the problem-solving knowledge needs a theoretical background, which is found in the domain knowledge. The processes stored in PSK may be represented in various ways, using any or all of: logic [Kowalski, 1979], procedural networks [Brown & Burton, 1978], semantic networks with procedural attachments, (augmented) transition networks, production rules [Goldstein, 1979; Anderson & Reiser, 1985], etc.

The main system activities centred on this knowledge type are:
- providing the inferential tools for problem solving, by the system or by a student;
- providing the inferential tools for coaching a student in a problem-solving session.

The main advantage of separating the problem-solving knowledge from the domain knowledge is that it emphasizes the distinction between the domain itself and the skills used to solve a practical problem in that domain, thus simplifying the learning process. That knowledge separation into DK and PSK is common to all PS-domains; this is why we believe that PS-ITSs, which are aimed at helping the student to learn how to solve problems, should display the same knowledge separation.

Besides, following [Lelouche & Morin, 1997], we can use — we believe in a novel way — that separation between DK and PSK to define four *generic operating modes* in a PS-ITS, based on the type of knowledge involved (DK or PSK), and on who "generates" that knowledge (the system or the student).
- In *domain-presentation mode*, the student asks the system some information about a domain theoretical element, and the system reacts by transferring to the student the required information or knowledge. The knowledge involved in this category is always DK, system-generated.
- In *demonstration mode*, the student asks the system to solve a practical problem or to coach him/her while s/he solves a problem. In the first case, the problem typically comes from the student him/herself, whereas in the latter one the problem typically comes from the tutoring system. In either case, the main level of knowledge involved is PSK, system-generated.
- In *domain-assessment mode*, the system prompts the student to develop a domain element, and the student thus expresses his/her understanding of that element. If judged necessary, the system may then intervene to correct that understanding. The knowledge involved in this mode is essentially DK, student-generated.
- Finally, in *exercising mode*, the system prompts the student to solve a practical problem. The student then solves it step by step, showing what s/he understands of the involved problem-solving knowledge and of the associated domain knowledge. If necessary, the system may decide to intervene in order to help him/her reach his/her goal or to correct it. The knowledge involved in this mode is naturally PSK, student-generated.

3.2 Application to a few domains

Several problem-solving activities are domain-independent, like:
1. identify and instantiate the given problem data;
2. identify and instantiate the expected result(s);
3. apply a formula;
4. apply a theorem.

Every PS-domain also has its own domain-dependent activities. For example, in **cost engineering**, we have:

5. draw a temporal diagram to represent the relevant events;
6. compare amounts located at the same date;
7. compare amounts located at different dates;
8. add amounts situated at the same date;
9. add amounts situated at different dates;
10. choose a reference date;
11. move an amount from one date to another;
12. collapse a series of periodic amounts into one single amount;
13. explode an amount into a series of periodic amounts.

Similarly, in the subset of **mechanical physics** refered to above, some activities would be:

14. compute a torque;
15. compute an angular acceleration;
16. compute a moment of inertia.

In many cases, a PS activity can be rephrased into, restated as, a different one, of a lower *abstraction level*, because more immediate, more down-to-earth, closer to the problem to be solved. For example, in **mechanical physics**, assuming that the torque and the moment of inertia of a given solid body are known (either given or previously computed), the activity "compute the angular acceleration" (activity 15) would be expressed as, or translated into "apply formula (7)", an instance of the lower-level activity 3. A PS physics tutor is presented in [Gertner & VanLehn, 2000].

Sometimes, a PS task may also be divided into smaller ones, letting us use again the notion of *complexity levels* in these tasks. For example, in **cost engineering**, comparing two amounts situated at different dates implies:

- first, choosing a reference date at which to make the comparison;
- then, moving either (or both) amount(s) from its (their) present date(s) to the reference date;
- finally, comparing the amounts, now both located at the same reference date.

These subactivities (of types 10, 11, and 6 respectively in the sample list above) thus appear to be of a lower complexity level than the initial one (of type 7). However, it is interesting to note that, although activity 7 turns out to be more complex than activity 6 (the latter is part of the former), both are stated using the same *abstraction level*.

It may also happen that some lower-level activities can *only* appear as components of a higher-level one. For example, still in **cost engineering**, the activity "drawing a temporal diagram" (type 5 above) implies the following tasks, which can only be accomplished as part of that activity (hence their identification in this paper from 5a to 5d):

5a. draw a timeline to encompass all periods implied by the problem data;
5b. draw arrows representing the amounts involved in the problem data;
5c. if necessary, split an amount (or each amount in a series) to simplify the computations;
5d. qualitatively draw a special arrow to represent the expected result of the computations to be made.

In that case, activity 5 is both of a higher complexity level and of a higher abstraction level than any of its subactivities.

4 Tutoring knowledge

We now briefly present the *tutoring knowledge* (TK) in order to help the reader to better apprehend the relationships of that knowledge with DK and PSK. This third type of knowledge contains all tutoring processes enclosed in the ITS. It is not directly related to the teaching domain or to problem solving, but is there to help the student understand, assimilate, and master the knowledge included in DK and PSK [Gagné & al., 1992; Gagné & Trudel, 1996].

The main system activities using TK are:

- ordering and formatting the topics to be presented to the student;
- monitoring a tutoring session, i.e., triggering the various tutoring processes according to the system tutoring goal and the student's actions; such monitoring may imply giving explanations, asking questions, changing to another type of interaction, etc.;
- in a PS-domain, while the student is solving an exercise, monitoring the student's PS activities: understanding and assessing these activities, giving advice to correct or optimize them, giving hints or partly solving the exercise at hand (as required by the student or by the tutoring module), etc.;
- continuously analysing the student's progress in order to improve the efficiency of the tutoring process.

The advantage of separating the tutoring knowledge from the knowledge of the domain to be taught has been emphasized long ago [Goldstein, 1977; Sleeman & Brown, 1982; Clancey, 1986; Wenger, 1987], and lies in the reusability of TK in various domains. In the case of PS-domains, the domain to be taught clearly encompasses both DK and PSK; indeed, the term "domain knowledge" applies to DK if referring to the knowledge type, and to DK + PSK if referring to the knowledge to be acquired. Therefore, as shown in the introduction, in a PS-ITS, knowledge ends up being separated into three categories rather than two.

We believe that the tutoring processes are triggered by *tutoring goals* which depend on the current educational setting and learning context. The role of tutoring goals has been discussed in several works, some of the most recent ones dealing with task and instruction ontologies [Mizoguchi, 1999]. In the current state of our research, our assumption is the following: the underlying hierarchy or hierarchies governing the way tutoring processes interact with one another is not related to these processes *per se*, but rather to the *current goal* to be attained when they are invoked. The current goal varies during the session, depending on the student's actions or difficulties, following a dynamically built abstraction-based hierarchy. If our assumption turns out to hold, then the *dynamic structure of educational goals and subgoals* — which itself depends on the student's desires or abilities, the main underlying objective of the tutoring system, the student's state (e.g. of tiredness, etc.) and performance, etc. — will determine the succession of tutoring processes activated and tutoring interactions taking place. To our knowledge, the use of abstraction levels to induce a dynamic hierarchy of tutoring goals is new, as is the assumption that such a hierarchy will play a major role in activating the various tutoring processes and student–system interactions. Learning goals have been used by Towle [2000], but only for educational simulations, not for tutoring processes in general.

5 Educational interests of abstraction and complexity levels

In the above sections, we have sketched a complexity– and abstraction–level approach to help model the three types of knowledge involved in a PS-ITS. In this section, after clarifying these notions in section 5.1, we present the educational interests of our model. Sections 5.2 to 5.4 focus on the type of knowledge respectively presented in sections 2 to 4. Section 5.5 summarizes that discussion with some overall pedagogical interests of our approach.

5.1 An informal definition of abstraction and complexity levels

In the first three sections, we only refered to abstraction and complexity levels. Here, we try to define these notions better and in a more generally applicable way. Both notions are based on the common notion of *refinement*, but differ in how the refinement is made: in a general way, abstraction is based on, or refers to, *expressiveness* or *scope*, whereas complexity is based on, or refers to, the *number of components*.

For *concepts*, taking geometry as an example, a polygon has a higher abstraction level than a triangle or a square, because the number of sides in a polygon is indefinite, but a lower abstraction level than a set of segments, because these segments in a polygon are forced to be pairwise adjacent; a square has a higher complexity level than a triangle, because it has more sides, and also because there are constraints (re. size and angles) between these sides. In cost engineering, we saw that the factors Φ_{FP} and Φ_{AP} are expressed at the same abstraction level, although Φ_{AP} has a higher complexity level, because of the way it is defined and computed. A similar distinction between abstraction levels and complexity levels holds for the *relations* they express.

For *problem-solving activities*, we have similar distinctions, as shown in section 3.2 with several examples.

Finally, the same holds for *tutoring processes*, or student–system interactions. For instance, the ITS task of tutoring a student while s/he is solving a problem will turn out to be of a higher complexity level if the student encounters more difficulties, although the abstraction level of this process does not depend on the particular student being tutored or on the particular problem being solved. On the other hand, reacting to a student request for hint, or for explanation, is of a lower abstraction level than the previous one; however, there again, the complexity of that task will depend on the specific student request (some simply formulated questions may have quite complex answers!), and will eventually depend also on the way the student is or is not satisfied with the initial system response.

Such level-based distinctions have also been made, for example, by Mizoguchi [1999]. Note that, although the statement "A has a higher abstraction level than B" is clear and may be true, we think that the number of abstraction levels between A and B is not defined, because that number would depend on the modelling effected; for the same reason, it would be even more meaningless to try to assign a numeric value to these levels.

5.2 Domain modelling

The definition of concepts from the simplest to the most complex induces a long-time known *presentation order* for the subject matter. Similarly and in addition, the factor hierarchy described in section 2 for cost

engineering lets us derive an *order for the presentation of factors* to the student, from the lowest (simplest) level up to the highest, i.e. with increasing understanding complexity. That does not imply that such an order is unique, or even the best (e.g. a student's personal interests might make another order more motivating for him/her), but it is justified by our model. This presentation order may itself induce, like for domain concepts, a possible *order for prerequisites*; e.g., if a student experiments difficulties to deal with Φ_{AP}, has s/he well mastered Φ_{FP}, a conceptually simpler factor?

Moreover, the factor-induced intermediate abstraction levels will permit the ITS to exhibit a *sharper modelling of conceptual errors*. For example, the source of an understanding error concerning one of the two relations in equation (2) or (3) or (7) (see also figure 1) is much easier to identify using the corresponding factor, either as a definition error or as a usage error, than an error concerning the global equation (1), where the definition and application relationships are not made explicit, and therefore are impossible to distinguish. Similarly, an error using a Φ_{AP} factor may be diagnosed as possibly resulting from an insufficient mastery of the simpler factor Φ_{FP} as concept (which in turn will be diagnosed as related either to its definition, or to its usage). Similarly in physics, if the student stumbles on concepts like angular acceleration or moment of inertia, has s/he mastered the simpler although similar concepts of acceleration or mass?

Abstraction and complexity levels on domain elements (concepts and relations, possibly including factors) can then be used to introduce various abstraction levels of explanations. Such explanations can then be tailored to the student's questions, and adapted to the reminders possibly needed by the student.

5.3 Problem-solving modelling

The problem-solving activities briefly presented in section 3 naturally display abstraction and complexity levels. Indeed, a standard problem can usually be divided, possibly in more than one way, into major steps, which can then be split into simpler substeps. As explained in 5.1, each subactivity in that case may be either simpler (lower complexity level) or more concrete (lower abstraction level) than the original one, or both.

In a first development stage, these abstraction and complexity hierarchies, both for domain elements and for problems to be solved, can ease the *definition of exercise types* to be implemented into the ITS, and can ease the tutor module task of *choosing the exercise type* to challenge the student with. Later, once that basic system is operational, the same hierarchies can help develop an automatic *exercise generator* dealing with the domain elements to be mastered by the student. That approach will then help the student to acquire a better critical mind about the relative importance of *problem-solving* knowledge vs. *domain* knowledge.

As for domain elements, abstraction and complexity levels can be used to introduce various types of *explanations* about the problem to be solved, varying both in abstraction (focus level, terms used, references made) and in complexity (quantity of details, possible references to the problem substeps). Moreover, our approach will lead the student to focus specifically on the *activities* for which s/he needs more tutoring, with the abstraction and complexity levels appropriate to his/her individual case.

5.4 Tutoring modelling

Functioning mode		Domain-presentation mode	Demonstration mode	Domain-assessment mode	Exercising mode
Main type of knowledge involved		Domain knowledge	Problem-solving knowledge	Domain knowledge	Problem-solving knowledge
Student's main goal		To learn (acquire or improve knowledge)		To assess his/her learning	
Direction of the knowledge transfer		System → Student		Student → System	
Typical interaction	Trigger (start)	The student asks the system... some information about a domain theoretical element	to solve a practical problem or to coach him/her in problem solving	The system prompts the student... to develop a domain element	to solve a practical problem
	Knowledge exchange	The system presents... the requested element	a possible solution to the requested problem	The student presents his/her view of... the requested element	a possible solution to the given problem
	Result (closure)	The student expresses his/her understanding... of the element	of the problem solution	The system assesses the student's answers, and possibly corrects them	

Table 2 — Characteristics of the four typical operating modes of a problem-solving ITS.

As presented in section 3.1, the distinction between DK and PSK leads to the natural definition of four operating modes. Their main characteristics are recalled in Table 2.

The successive tutoring goals aimed at by the system (see section 4) are likely to result in a chain of recursive calls of the tutoring processes invoked. This recursivity will or will not be direct, depending on the tutoring interaction types being chained: the system might decide to temporarily change between interaction types, e.g. to respond to the student's actions or requests. However, the potential length of this chain is only apparent: because of the abstraction hierarchy of tutoring goals, each newly invoked process will be called with a *narrower scope* and/or a *lower complexity*, which eliminates the risk of "forgetting" the initial tutoring goal or of running into an infinite loop.

More generally, tutoring the student may take the form of explanations, guidance, hinting, or even partially solving the exercise on which the student is currently working. The level at which these will be conducted will depend on the current tutoring goal (see section 4). We think our approach is close to that of VanLehn and his colleagues [2000], although they focused their attention on fading and deepening (a particular result of the tutoring interactions) rather than on the current pedagogical goal (the cause for these interactions).

5.5 Overall interests of these abstraction and complexity levels

Abstraction levels are certainly not new. What we think is new is to use them in a systematic way to shed a uniformizing light on the ITS design and operation, and to make it more user-friendly once implemented.

First, they may help to give a better tailoring to the system tutorial interventions to fulfil the student's needs and the system tutoring goals, thus improving its conviviality and efficiency.

Then, all the capabilities presented above should result in smoother, more "natural", human-like interactions with the student. This improved ability to reproduce a human teacher's behaviour contributes again to make the system more user-friendly, and more likely to be used by the student.

Finally, although that aspect is not in the scope of this paper, our refinement of the three types of knowledge as described in sections 2 to 4 paves the way to the conception and the implementation of a structured error model, and eventually of a structured student model.

6 Conclusion

This presentation of a possible knowledge structure for PS-domains, which emphasizes the separation between domain knowledge and problem-solving knowledge, shows how a general functioning theory of such an ITS — namely the four operating modes described in sections 3.1 and 5.4 — can naturally be derived.

Moreover, the abstraction and complexity levels highlighted throughout this paper can be used as a common guideline to help finding an appropriate representation for each one of the three knowledge type, and thus can help creating more efficient ITSs. More generally, this guideline can shed a uniformizing light on the system design, although it has never been used in a systematic way in the design or implementation of an ITS.

We thus hope to bring some contribution to the general and important problem of finding a generic architecture for intelligent tutoring systems.

References

[1] Anderson John R.: *Cognitive Modelling and Intelligent Tutoring*. Washington, DC: National Science Foundation (1986).

[2] Anderson John R. & B. J. Reiser: "The LISP Tutor". *Byte* **10**, no. 4, p. 159-175 (1985).

[3] Brodie Michael L., John Mylopoulos & Joachim W. Schmidt, eds.: *On Conceptual Modelling, Perspectives from Artificial Intelligence, Databases, and Programming Languages*. New York: Springer Verlag (1984).

[4] Brown John S. & Richard R. Burton: "Diagnostic models for procedural bugs in mathematical skills". *Cognitive Science* **2**, p. 155-192 (1978).

[5] Clancey W. J.: "Qualitative student models". *Annual Review of Computer Science* **1**, p. 381-450 (1986).

[6] Clocksin William F. & Christopher S. Mellish: *Programming in Prolog*. Berlin: Springer-Verlag (1981).

[7] Findler Nicholas V., ed.: *Associative Networks*. Orlando, FL: Academic Press (1979).

[8] Frasson Claude, Gilles Gauthier & Alan Lesgold, eds.: *Intelligent Tutoring Systems*, Proc. of the *3rd International Conference, ITS'96*, Montréal (Canada), 12-14 June 1996. LNCS 1086, Berlin: Springer (1996).

[9] Gagné Denis & André Trudel: "A highly flexible student-driven architecture for computer-based instruction". [Frasson & al., 1996], p. 66-74 (1996).

[10] Gagné Robert M., Leslie J. Briggs & Walter W. Wager: *Principles of Instructional Design*, fourth edition (1st edition published in 1974). Orlando, FL: Harcourt Brace Jovanovich (1992).

[11] Ganeshan R., W.L. Johnson, E. Shaw & B.P. Wood: "Tutoring diagnostic problem solving". In [Gauthier & al., 2000], p. 33-42 (2000).

[12] Gertner A.S. & K. VanLehn: "ANDES: a coached problem-solving environment for physics". In [Gauthier & al., 2000], p. 133-142 (2000).

[13] Goldstein Ira P.: *The Computer as Coach: an Athletic Paradigm for Intellectual Education*. AI Memo 389, AI Laboratory. Boston, MA: Massachusetts Institute of Technology (1977).

[14] Goldstein Ira P.: "The genetic epistemology of rule systems". *International Journal of Man-Machine Studies*, Vol. 1, No. 1, p. 51-77 (1979).

[15] Gauthier Gilles, Claude Frasson & Kurt VanLehn, eds.: *Intelligent Tutoring Systems*, Proc. of the *5th International Conference*, Montréal (Canada), 19-23 June 2000. LNCS 1839, Berlin: Springer (2000).

[16] Kim Won & Frederick H. Lochovsky, eds.: *Object-Oriented Concepts, Databases, and Applications*. ACM Press, Reading, MA: Addison-Wesley Publ. (1989).

[17] Kowalski R.: *Logic for Problem Solving*. Berlin: North-Holland (1979).

[18] Lelouche Ruddy & Jean-François Morin: "Introduction of pedagogical concepts in domain modelling for an ITS". *European Journal of Engineering Education*, Vol. 23, No. 2, p. 255-271 (June 1998).

[19] Lelouche R. & J.-F. Morin: "Knowledge types and tutoring interactions in an ITS in a problem-solving domain". *FLAIRS 1997, Proc. of the 10th International FLorida Artificial Intelligence Research Symposium*, Daytona Beach (Florida, U.S.A.), 10-14 May 1997, p. 62-66 (1997).

[20] Lenat D., F. Hayes-Roth & P. Klahr: *Cognitive Economy*. Working Paper HPP-79-15, Stanford Heuristic Programming Project, 46 pages. Stanford, CA: Stanford University (June 1979).

[21] Malec J.: " Knowledge elicitation during dynamic scene description ". *ACM–SIGART Newsletter: special issue on knowledge acquisition*, No. 108, p. 162-163 (April 1989).

[22] Mizoguchi Riichiro: "Ontology-awareness for intelligent instructional systems". Invited talk. *Advanced Research in Computers and Communications in Education, Volume 1* (G. Cumming, T. Okamoto & L. Gomez, eds.), Proceedings of the *7th International Conference on Computers in Education, ICCE 99*, Chiba (Japan), 4-7 November 1999. Amsterdam, Netherlands: IOS Press, p. 45-52 (1999).

[23] Morin J.-F.: *Conception of an intelligent tutoring system in cost engineering: knowledge representation, pedagogical interactions, and system operation*. Master Thesis, Département d'Informatique. Québec, Canada: Université Laval (1998).

[24] Patel Ashok & Kinshuk: "Intelligent tutoring tools in a computer-integrated learning environment for introductory numeric disciplines". *Innovations in Education and Training International*, Vol. 34, No. 3, p. 200-207 (1997).

[25] Sleeman D. H. & John Seely Brown, eds. : *Intelligent Tutoring Systems*. London: Academic Press (1982).

[26] Sowa John F.: *Conceptual Structures*. Reading, MA: Addison-Wesley (1984).

[27] Towle B.: "Using student task and learning goals to drive the construction of an authoring tool for educational simulations". In [Gauthier & al., 2000], p. 173-181 (2000).

[28] VanLehn K., R. Freedman, P. Jordan, C. Murray, R. Osan, M. Ringenberg, C. Rosé, K. Schulze, R. Shelby, D. Treacy, A. Weinstein & M. Wintersgill: "Fading and deepening: the next steps for ANDES and other model-tracing tutors". In [Gauthier & al., 2000], p. 474-483 (2000).

[29] Wenger, Étienne: *Artificial Intelligence and Tutoring Systems*. Los Altos, CA: Morgan Kaufmann (1987).

Using Highly Sophisticated Middleware For Building Arbitrarily Distributed Teaching Environments

Christof Dallermassl, Heimo Haub, Harald Krottmaier, Klaus Schmaranz, Philipp Zambelli
{cdaller,hhaub,hkrott,kschmar,pzamb}@iicm.edu

Institute for Information Processing and Computer Supported new Media

This paper deals with the development of highly sophisticated teaching environments. We took a look at the requirements that such a system has to fulfill to meet the needs of our modern society and to remain easily adaptable to forthcoming, new technologies. The results of our research show that the cost for design and implementation of a distributed teaching environment can be dramatically reduced by using a middleware system. We thereto present the concepts of the Dinopolis middleware system which is highly modular and extendable and show how it may be used as the basis for the development of teaching environments. Using the Dinopolis middleware system not only eases the process of development but also guarantees that new technologies are becoming available without any further effort.

Keywords: **Distributed Teaching Environment, Middleware, Application Framework, Distributed Object System**

1 Motivation

We are living in times of ongoing rapid changes. New technologies support our everyday life in a way we could not even imagine a few years ago. New media are also disrupting our old fashioned way of thinking about education and pave the way for new visions [5].

Many different approaches for developing electronic teaching environments already exist. All of them have in common that they try to react on the changes taking place in our modern society. Acquired knowledge is becoming obsolete in a short amount of time and has to be updated and expanded. The term "Lifelong Learning" is becoming more and more important. Teachers and students are often no longer present at the same location. They are not even active at the same time. Therefore lectures have to be available whenever and wherever one likes. On the other hand new technologies have to be made available as soon as possible. As an example consider the new WAP protocol which could make it possible to pursue a course using a mobile phone. This implies a highly

extensible and expandable system.

Teachers preparing a course often want to use already existing data. This data might be distributed among the network and might only be available in proprietary formats. It is an unbearable effort to collect and extract this data to feed it into a teaching environment. It has to be possible to easily include existing data with no further effort. It has to be possible to add or manipulatable information at any time without knowing any details of the underlying systems. When updated information has become available, documents have to be replaced. Nevertheless replaced information should not be lost as it shows the history of a course and might be interesting for some research. Thus a version control mechanism is desired as well.

Students need easy access to the teaching system, no matter which system they use (platform, browser, etc.). The way in which information is provided has to be adapted to the user's special needs and interests. The users' skills have to be taken into account as well as the capabilities of the system used. As an example, consider the network bandwidth with which the user is connected. Lower bandwidth could be considered by sending images of a lower resolution and just sound without the video. Users of different skills need information prepared differently, which means that different applications are provided for novice and expert users. Thus the system has to be highly customizable, not only by the user but also automatically by the system itself. Different views at the information space are desirable as well. As an example the information could be provided in different languages or with different, localized examples.

Another important point is the use of background libraries [7] to clarify terms. This includes dictionaries, encyclopedias and glossaries which again have to be adopted to the user's needs. As an example native English speakers would need an explanation of an unknown English term in English, whereas German native speakers would like to get a German explanation.

Though students may be distributed among the world they need the ability to discuss certain topics with the teacher or among themselves. Collaboration and communication tools are therefore required. This includes chat, discussion forums, video conferencing tools, etc.. Another important aspect is the possibility to add annotations and make personal notes to a topic which may only be seen by a specified group of others, maybe even excluding the teacher. This directly leads us to another interesting aspect in a teaching environment: user and group access management. Information presented in a course as well as additional information has to be protected from unauthorized access. The more sophisticated the user management is, the more configurable the system becomes.

Obviously the best user access management system is not worth anything if the transmission via the network is not secure at all. Highly sensible data has to be additionally encrypted. Imagine companies teaching their personnel internal knowledge.

For performance reasons hybrid systems are often desirable. Most of the courseware comes along on a CD-ROM. Only the logical part of a course could reside on a server. Thus lessons can be arbitrarily constructed using the information stored on the CD-ROM. Only additional or updated information has to be

fetched via the net. This keeps network traffic low without omitting special kinds of media such as videos. Hybrid systems are also kept up-to-date more easily, since outdated information stored on the CD-ROM can be replaced dynamically by new data from the server.

Linking is a good way to increase the value of information if used for defining the course flow [6]. This makes it easier to add or replace information used in a course. That way even statically stored information (e.g. on a CD-ROM) can be dynamically restructured to meet different needs. Since links are often subject to change or become invalid (especially links to external resources), a highly sophisticated link management is required to keep the system consistent.

Developing a teaching environment that meets all the functionality described above implies a big effort for implementing the base functionality. Most of this functionality has little to do with a certain teaching concept pursued. It requires a lot of time to develop the system so far that the actual vision can be put into practice. This paper describes how the cost for developing can be reduced dramatically when using a middleware system. This offers more time to concentrate on the crucial points of new ideas. In the following sections we present the abilities of the Dinopolis [3] middleware system which is highly integrative, expandable and configurable and provides an easy-to-use interface for building distributed applications.

2 A Distributed Environment

As already mentioned, distance learning gets more important every day. Teacher and students do not have to be physically present in a classroom. The teacher for example holds online lessons in his office, while the students follow the lessons from at home or from some Internet terminal on the campus. It is important to recognize that the students do not only need to follow the lessons conducted by the teacher, but also need the possibility to interact or communicate with the teacher during and after the lessons.

Please note that not only human beings are separated in such a distributed environment but also resources can be spread across the network. As an example, the lecture notes can be stored on the teacher's laptop while a chat tool may be located on the university server.

The main task of modern teaching environments is to bridge this physical separation of teachers, students and resources. This can be supported by using the Dinopolis middleware system. A middleware system adds another layer to the teaching environment. It decouples the network and data form the actual teaching application. It somehow resides between them. The Dinopolis middleware system allows the integration of arbitrary systems and provides a uniform way of access. Applications using Dinopolis do not have to worry about where the data is located and which protocol has to be spoken to retrieve the data.

From an application's point of view there is no difference if the information resides on a web server, on a database server or just on the local file system. The underlying systems may even be exchanged transparently. An important point is that integration within the Dinopolis system is not done on a common

denominator basis but on the contrary, additional functionality is added when needed. As an example a file system can be combined with a database system to allow the storage of meta data which the file-system itself does not support.

The most intuitive way to access data on a remote Dinopolis system is by "merging" the two Dinopolis systems, since it allows transparent access to remote Dinopolis instances. In other words the middleware layer bridges the physical separation and applications can be written as if they would run on one single system. Nevertheless the Dinopolis *External Access Gateway* concept allows access in various forms. At the moment this includes HTTP, FTP, WAP, LDAP, CORBA, RMI, etc.. CORBA and RMI are remote object systems which enable the use of objects over the network. In the case of CORBA [8] the Dinopolis object system can be used by programs written in various programming languages.

Thus no matter how distributed teachers, students and resources are, the Dinopolis middleware system acts as if they were all local. For a more sophisticated discussion of middleware systems and Dinopolis see [2].

3 Data And Course Flexibility

As already mentioned information is subject to change and the amount of information grows dramatically nowadays. Data must not be stored within a static teaching environment providing no possibility to adapt the data. It is also desirable to change the course flow dynamically to increase the value of information. As an example it has to be possible to add actual information to a course at any time. Thus developing a teaching environment built on static information is not worth the effort.

The Dinopolis middleware system allows to add, exchange and modify data at any time without needing to know any specific details about the underlying heterogenous information space. Version controlling guarantees that no information is lost. The distributed concept of Dinopolis allows to store data at arbitrary places transparently. Applications do not have to worry about that. This makes it relatively easy to develop so called hybrid systems, which combine local statically stored data (e.g. on a CD-ROM) with dynamically retrieved data (e.g. from the web). Due to the network bottleneck hybrid systems have the advantage that they do not have to omit bandwidth consuming information, such as videos, since they can be retrieved locally. Only updated information has to be downloaded via the net.

The course flow is best modeled using links. This makes it possible to insert or remove any kind of information without having to construct a complete new course. The problem with links is that they often become invalid or point to unintentionally changed data. Dinopolis comes along with a fully featured consistent link management system. Links do not point to a location but to an object. Thus even if objects are moved in the Dinopolis system, links remain valid. It is also possible to add meta data to links to provide additional information. Again the possibility to set links does not depend on the abilities of the underlying systems. As an example imagine a courseware CD-ROM. Since

a CD-ROM is read-only it is impossible to add or modify links directly on that medium. Nevertheless Dinopolis adds this functionality using an external link database (e.g. Oracle). This database can easily be exchanged transparently which then leads to a completely new course or course flow.

Dinopolis is able to handle arbitrary document formats. This is achieved through the Dinopolis internal document model, which follows the *Document Object Model* (DOM) specification of the W3C [9]. DOM is a highly accepted standard which supports the exchange of data between various kinds of different document formats. The internal document model again makes the whole system independent from the underlying ones.

4 An Extendable And Exchangeable Environment

A modern teaching environment not only has to be flexible concerning the course data and course flow. As applications evolve new technologies and requirements arise which require modifications of existing teaching environments.

Dinopolis is built on a completely modular basis. This allows to add or replace arbitrary parts of the system without producing unexpected side effects on the remaining parts of the system. Since Dinopolis is completely written in *Java*, it is possible to load new modules via the network even at runtime. Statically designed systems would not only have to be completely rewritten but also have to be redistributed among all users. As an example for a newly available technology consider the WAP protocol which could make it possible to pursue a course using a mobile phone. Dinopolis only requires a small WAP speaking module to be added and all applications using Dinopolis are becoming WAP aware. This means new technologies are available without any further effort. By the way adding new functionality to an application by hand would also require to be familiar with all the underlying details, which might be unnecessarily time consuming. Since Dinopolis is an *Open Source* project it is also guaranteed that modules supporting new technologies will be rapidly available.

Dinopolis is not only modular concerning external communication gateways. Internal parts of the Dinopolis system may be exchanged or added transparently as well to meet different needs. As an example let's take a look at the *User Access Management* and *Security* system which will be explained in section 6 more in detail. For some systems it is sufficient to define simple read and write access rights for users. Other systems require a much more sophisticated mechanism, such as a rule based one which only grants access if certain complex conditions are fulfilled. As an example students who have already passed an exam might get access to the results which are protected otherwise.

Teaching environments transmitting highly sensible data might also require to encrypt the information sent over the network, while a public system would not require it. This implies a *Security Manager* that can easily be adapted to different strategies. This also includes that some systems demand a user authentication based on smart-cards, finger prints or retina scans.

Dinopolis makes it easy to exchange or adapt internal parts to meet different requirements without the need to write a new application or modify existing ones. Dinopolis even allows to exchange the internal data structure or communication protocol used. At the moment data is stored according to the XML standard [1] and communication between Dinopolis instances is done using RMI or CORBA. As soon as new technologies and standards become available they will be integrated as well.

5 A Highly Customizable Environment

In a modern teaching environment we expect the main parts of the system to be highly customizable. The whole system has to allow users to turn on and off certain features according to their needs and their systems' capabilities. On the other hand applications and tools have to be customized depending on personal settings. Additional communication tools have to be provided to support a better information flow between users. The Dinopolis system is highly modular which allows adding and removing of integral parts, features, and services at runtime.

The users should have the possibility to choose between a variety of tools and applications that support their studies, depending on the users' skills and the used network connection.

The Dinopolis system makes it easy to write distributed applications. Existing tools can be reused and adapted for certain lectures as needed. It is easy to configure the system with different applications at runtime and the Java Classloader allows starting applications which reside on the local terminal, a CD-ROM, or to download them from an application server.

It is important that only those applications are part of a certain course, which are actually necessary.

Next it should be possible to customize the applications and tools themselves. As an example consider a video-conferencing tool which can be run with different frame-rates and resolutions. On the other hand it has to be possible to turn on and off special features like, for example, strong data encryption. Applications written for Dinopolis can make use of certain features or not, according to the environment in which they are used.

Apart from the applications and tools used, such a teaching environment has to allow customizing the users' view on the data stored in the information system. As an example consider a teacher who wants to adapt the data representation according to the different skills and needs of the users.

Therefore the Dinopolis system provides so-called Views, which support different data-representations. Using a highly sophisticated link management (see section 3) the data representation can be customized in a very high degree.

Another considerable point is that it has to be possible to decide where the data is actually stored. So it could be desired to store certain data on a file-system on the users' terminal or in a central database. It should be possible to transfer these data from one storage medium to another. Since the Dinopolis system

uses an internal data representation which is independent from the medium it is stored on, it is possible to store the data on different devices according to the actual configuration of the system.

6 User Access Management And Security

All distributed application have in common that their reliability and consistency heavily depends on the security and user access management. Unauthorized access to certain resources has to be prevented. This is also appropriate for a teaching environment. Just imagine students modifying and corrupting course data or exam results.

There exist many different approaches to solve this security task. Which one is appropriate for a certain environment depends on the desired degree of security. As already described in section 4 a simple security system differentiating between read and write access rights may be sufficient for some applications. More sophisticated environments could require a rule based access control system or secure (encrypted) transmission over the network.

One of the main parameters to measure well designed software is its level of reusability. In this case this means that security strategies have to be exchangeable easily. As already mentioned replacing the Dinopolis security concept is no complex task due to its modular structure.

Another point of high interest concerning access management in a teaching environment lies in the fact that data is distributed among heterogenous systems, all of which coming along with different or even no security management. It has to be guaranteed that users are forbidden to access data which they would not be allowed to access otherwise. Additionally if a system does not support any access control (e.g. MSDOS file-system) it has to be possible to add a security functionality. Dinopolis allows to integrate existing security mechanisms transparently. It is also possible to add access control to systems which do not support that by themselves. Thereto Dinopolis uses its integrated link management system. Access rights and rules are simply assigned to users and data through links which may be stored in any arbitrary external database. This concept makes it even possible to assign access rights to read-only systems (e.g. CD-ROM). Last but not least Dinopolis supports mandatory as well as discretionary access control. This means that access rights may be assigned to users as well as to data, which allows highly sophisticated combinations of rights.

For a more in detail discussion of access management in distributed systems and in Dinopolis see [4].

7 Conclusion

The Dinopolis open source middleware system presented in this paper is a powerful tool for building arbitrarily distributed teaching environments. It allows to integrate data from heterogenous information space transparently and makes them available through a common interface. Thereby functionality is not re-

duced to a minimum but on the contrary, additional functionality is appended where needed.

The modular concept of Dinopolis makes it easy to adapt the system to specific needs without producing unexpected side effects on the remaining parts of the system. Its high customizability makes it possible to configure the system to meet personnel needs. Additional communication tools such as chat, video conferencing, etc. may be used together with the teaching software without any further effort.

Courses may be constructed using all available distributed resources which also eases the creation of hybrid systems. Easy access to the system is possible not depending on the clients' platform or desired protocol.

The conglomerate of Dinopolis' features presented allows developers of teaching environments to concentrate solely on the crucial points of their ideas. Thus we believe that Dinopolis is going to play an important role in the future development of distributed teaching environments.

References

[1] Bray T. et. al.: "Extensible Markup Language (XML) 1.0 (1998)", available online at `http://www.w3.org/TR/1998/REC-xml-19980210`.

[2] Dallermassl, Ch.: "Aspects of Integration of Heterogenous Server Systems in Intranets - The Java Approach", IICM (Institute for Information Processing and Computer Supported New Media) (1999)

[3] Dinopolis: "Homepage of the Dinopolis Open Source Project", available online at `http://www.dinopolis.org`

[4] Haub, H.: "Aspects of Access Management in Heterogenous Distributed Object Systems", IICM (Institute for Information Processing and Computer Supported New Media) (1999)

[5] Grudin, J.: "Groupware and Social Dynamics: Eight Challenges for Developers (1994)".

[6] Van Dyke, J.R. & Sollins, K. R.: "Linking in a Global Information System, World Wide Web Journal - A Publication of the W3C" (1995), available online at `http://ana-www.lcs.mit.edu/anaweb/pdf-papers/tr-659.pdf`.

[7] Marchionini, G. & Maurer, H.: "Digital Libraries as Components of Modern Computer Supported Learning Environments" in proceedings of ED-MEDIA 95. World Conference on Educational Multimedia and Hypermedia, Graz Austria 1995.

[8] Object Management Group, Inc.: "CORBA Language Specifications Summary", OMG (2000) available online at `http://www.omg.org/store/publications.html`.

[9] W3C: "Document Object Model (DOM) Level 1 Specification" (1998), available online `http://www.w3.org/TR/1998/REC-DOM-Level-1-19981001`

Xtrain: A GUI based tool for Multimedia Presentations, Instruction, and Research

Xiagen Hu* & Scotty D. Craig**
The University of Memphis
University of Memphis, Department of Psychology, Memphis, TN 38152-6400
(901) 678-3608
*E-mail: *xhu@memphis.edu, **scraig@memphis.edu*

Xtrain is a program for scripting and presenting multimedia displays. This program was developed in the Advanced Learning Technologies Laboratory at the University of Memphis and has been used in variety of psychological experiments. This program can combine such multimedia formats as Microsoft agent, Macromedia flash, director and many others that are available for scripting under a GUI Windows environment. Furthermore, Xtrain offers a variety of options for testing styles.

KEYWORDS: **Conversational agents, multimedia applications, Xtrain, Microsoft Agent**

1 Introduction

The idea of embodied conversational agents has generated considerable interest in the realm of HCI recently. Unfortunately, for the most part this has been metaphorical, because computers could not support the needed software. In order for the computer to fully support embodied conversational agents, they would need software that could produce and control many human-like characteristics, such as conversational behaviors, with the ability to mediate the flow of conversation by the use of such things as facial expressions, hand movements and voice intonations [1].

Microsoft made one such attempt at this with their Microsoft Agent program. Microsoft Agent is an interactive interface with conversational capabilities that are embodied in an animated character agent. One example of this is the helper agent in newer versions of Microsoft products such as Microsoft Word and Microsoft PowerPoint. Microsoft Agent is also an optional program for windows 9x operating systems and is available for free download at the Microsoft site. It is compatible with all MS Windows platforms starting with Windows 95. Thus, this agent is readily available for widespread use [5]. The purpose off this paper is not to review Animated Agents for a review, see Johnson, Rickel, and Lester [4].

Furthermore, recent research has shown that the correct use of multimedia presentations can enhance the learning and memory from presented materials. Multimedia in this case refers to any type of pictorial information presented with textual information. However, this form of learning works best with pictorial information shown as an animation that is then coordinated with a narration of any textual information that would be needed [6]. Under the cognitive theory of Multimedia learning, there are three main rules that should be considered for scripting of a multimedia presentation: Spatial contiguity, Temporal contiguity, and Modality. The spatial contiguity effect states that relevant and related concepts should be presented in the same general area of each other (e.g. labeled words should be closer to the object they label than other objects on the screen). The temporal contiguity effect informs us that the various forms of media used during a presentation should correspond with each other by occurring at the same time. Lastly, the modality effect says that if two types of information are presented in the same type of modes, it will hinder learning. However, this can be overcome by presenting information in two modalities. So, printed text and animation on a computer screen would be a hindrance to learning, but a narration and an animation would not [7; 8].

Since Microsoft launched the first version of Microsoft Agent, users and developers have provided a lot of resources for use with the program (e.g., some information can be obtained

from http://www.msagentring.org/agentringmain.html). There are several innovated approached both in the use and the scripting of Agents. For example, mash.exe (http://www.bellcraft.com/mash/) provide a very useful scripting tool for agent programming. Many of these programs have been examined, including Mash, and while they have the ability to control Microsoft Agent, they are lacking the ability to synchronize the Agent program with other forms of multimedia.

The Advanced Learning Technologies laboratory at the University of Memphis developed Xtrain as a way to incorporate embodied agents (Microsoft Agent) and other forms of multimedia into instruction, research, and presentations. Psychologists have used products such as Mel©and Super lab©to run experiments, but these programs cannot incorporate newer technology. Xtrain provides ways to script many different kinds of presentations, including Microsoft Agent, audio and video clips, HTML, Macromedia flash files, Macromedia Director files, and many graphics file formats [2, 3].

This software program serves a duel purpose. It is both an authoring tool and presentation tool. These work together to form a powerful and versatile tool for the presentation of various multimedia displays as well as data collection.

2 Authoring tool

The authoring side of the program has two levels (a) overall organization of frames and (b) detailed construction of individual frames. The overall methodology is similar to the SuperLab program used in experimental psychology. The Presentation is organized in terms of a tree structure with each node in the tree as a pointer to presentation frames. Each frame consists of the smallest unit of information and the frames are logically contingent upon each other. Such tree structure serves as basic navigation guidelines. However, the navigation path can be quite flexible depending on the needs of the user. The tree structure can be created using a user friendly GUI. Each frame corresponding to the tree nods can be any of several formats such as text art, pictures with hotspots, video/audio clips, agent interactions, and animations.

Xtrain has extensive options for frame editing. The program has been arranged so that the different editing functions displayed as individual property tabs. Each tab corresponds to a specific multimedia format. A description of the property tabs will follow.

Property Tabs

2.1 Frame Property Tab

The Frame property tab allows the basic outline of the frame to be determined. From here frame duration is set, alone with the frame' s properties, and the frame type. The duration can be anywhere from self-paced to any amount of time desired measured in milliseconds. The type of multimedia desired can be selected under a Frame properties drop-down menu. Under the Frame type dropdown menu, the type of frame can be specified: Normal, Title, Review, Test, or Interaction.

2.2 Agent Property Tab

This is the general tab that is used to control the agent. Each frame can have up to three agent actions assigned to it. These actions are denoted as agent1, agent2, and agent3. However, these can be assigned as needed for example one agent can be given as many as three actions or three agents can be given one action each. These are selected from the available agents using the Agent dropdown menu. Just below this dropdown menu is a dropdown menu that specifies when the agent will be used. For example, "Action over frame" can be selected so the agent is active while the rest of the frame is running. Just below this are three additional tabs that specify (a) the agent's position on the screen, (b) what the agent will say in each frame, and (c) balloon formatting, if the agent has this option. These are the Action and Gesture tab, Speak and Play tab, and Balloon Setup tab, respectively.

Of these tabs, the Speak and Play tab is of the most importance. This frame in its most basic form allows for text to be entered into a text box. The agent reads this text using a text to speech engine. However, this text box can also contain simple markup within the text. This markup includes such speech parameters as volume, emphasis, pitch and speed. These markup tags can be inserted into the text by inputting the

desired values into the box beside the parameter name on the right portion of the tab and then double clicking the name. This list of parameters also includes a few special tags that can control the flow of the information delivery. These tags permit the agent to skip to a specific frame in the tree structure (Show Frame), or to go to specific frames in a selected Shockwave Flash movie (Go to Frame in Flash Movie). The remaining tag option is Insert Special action. This set of tags allows the user to start, stop, and restart a flash movie, and provides a tag that terminates the program at the end of a presentation. The Speak and Play tab allows for assignment of actions to the selected agent. These actions vary according to the abilities of the selected agent, and can be assigned either at the beginning or the end of the text the agent speaks.

Similar to other agent scripting tool, such as MASH, this agent property editor uses all available Microsoft agents controls. In addition, Xtrain utilizes the bookmark function of MS Agent to control the overall flow of the presentation. In fact it is the use of these bookmarking functions that make it possible to control Multimedia synchronization, such as with Flash animation, which is lacking in the other agent programs.

2.3 Text Display Tab

The text display tab is used to insert text to be displayed on the screen. Doing this involves clicking on the display area, typing in the text to be displayed, and then clicking update. The text will then appear in the display area in the same way that it will be displayed on the screen during the presentation.

2.4 Multimedia Tab

The Multimedia tab allows you to assign audio files, movie files, and wallpaper to the frame. The program supports wave files (.wav) and Enhanced Linguistic files audio formats. If an Enhanced Linguistic file is used Microsoft Agent can be made to appear to speak the file. The movie files available from this tab are AVI (.avi) and Mpeg (.mpg). A Bitmap (.bmp) image can be set as a background that either covers the whole screen or centered.

2.5 Pictures Tab

Using the picture tab, a picture can be added to the frame and manipulated. Xtrain supports two types of graphic files: Bitmap (.bmp) and GIF (.gif). The picture can be located at any point on the screen, centered, or can move from point to point. A hotspot option can be added to the picture to be used to give commands to the agent or to play audio files. Each hotspot can have information, such as text and tagged markup, to be sent to any selected agent.

2.6 Shockwave Tab

Under this tab, there are two options: Flash Movie and Shock Wave Movie. Flash movies and shockwave animations are among the most frequently used multimedia format. Xtrain uses activeX control from macromedia so both types of movies can be manipulated. By loading flash movie from this tab, detailed frame information can be examined so Agents can navigate through the movie. In addition, Xtrain uses FSCommand of flash movie to control Agent and the tree navigation.

2.7 Frame Summary Tab

The frame summary tab gives summary information both at the scripting phase and at the presentation phase. At the scripting phase, it gives a brief overview of the selections made in the other tabs for that frame. If the frame is a test frame, it also contains the correct answers to the questions given in the test frame. After viewing on the other half of this frame, responses are shown. If it was a test frame, the student' s responses are listed along with whether the response was correct.

2.8 HTML Tab

The program allows for the incorporation of html documents into presentations. This allows greater flexibility in terms of specialized displays. The format allows for html documents that are locally saved in the Xtrain directory to be displayed and navigated during presentations.

2.9 Test Tab

One other important feature of Xtrain is the testing option. During the scripting phase, frames can be assigned as testing frames on the frame property tab. These frames can be used to capture information from the user. They allow input in such forms as multiple-choice questions, short answer questions, and even essays. At the end of the presentation phase, input from the participant is automatically saved as an ASCII text file. The agent can also be programmed to give dynamic feedback, when the participant gives wrong answers.

3 Presentation Tool

The presentation of the scripted material is as easy as selecting the run drop-down menu and selecting the run entire session option. Alternatively, the Xtrain presentation file (.xtr) can be ran by double clicking its icon in the strain folder. This action occludes all other objects on the screen: only the scripted presentation and a control bar are visible. This control bar is a flash file that allows for the following actions: go back, continue, help, and progress. The presentation continues forward until it reaches the end of the presentation.

4 Summary

Xtrain is a program that is able to integrate multimedia files into one presentation format. The authoring side of the program takes advantage of many Windows' standards for ease of use. It provides a standard Windows interface window with icon buttons and drop-down menus, such as File, Edit, Window, and Help. These offer such options as open and save in the File menu, as well as, cut, copy, and paste in the Edit menu. Xtrain also offers a special drop down menu labeled Run. This menu offers the options of running the entire session or of previewing a selected frame. See Figure 1 for a view of the program. The frames are structured in a tree format that is located on the left of the screen. This tree is created via buttons labeled Brother, for frames on the same level, and Child, for frames on a branching level. Each frame can be scripted using nine different property tabs: Frame Property, Agent Property, Text Display, Multimedia, Picture, Shockwave, Frame Summary, HTML, and Test. These tabs may be individually associated with each frame. It is from these components that the script is produced to set the required tone for the information to be presented. Microsoft agent can also be used to control the flow between frames, so that if the need arises the agent can direct the presentation to any frame in the tree. Furthermore, if a Shockwave Flash file is used, the agent also has the ability to direct the flash movie to any frame within the movie. These options allow for maximum flexibility for the user when scripting a multimedia presentation. In addition to this freedom in scripting, Xtrain offers an easy presentation method that either selecting run entire session from the run menu or by simply double clicking on the created Xtrain file.

References

[1] Cassell, J., Bickmore, T., Billinghurst, M., Campbell, L., Chang, H., Vilhjalmsson, H., Yan, H., "Embodiment in Conversational Interfaces: Rea." Proceedings CHI' 99. Pittsburgh: ACM. (1999).

[2] Craig, S. D., & Hu, X. Xtrain: Expert training and data collection system. Presented at the 1999 meeting of The Society for Computers in Psychology. Los Angeles, California. (1999, November).

[3] Hu, X. "Xtrain 1.0 [computer program]." The University of Memphis: Author. (1998).

[4] Johnson, W. L., Rickel, J. W. & Lester, L. Animated pedagogical agents: Face-to-face interaction in interactive learning environments. International Journal of Artificial Intelligence in Education, Vol. 11, in press, (2000).

[5] Microsoft. Microsoft Agent 2.0 [computer program]. (1998).

[6] Mayer, R. E. Multimedia learning: Are we asking the right questions? Educational Psychologist, 32, 1-19, (1997).

[7] Mayer, R. Using Illustrations to Promote Constructivist Learning from Science Text. Psychology of Science Text Comprehension. (Submitted).

[8] Moreno, R., & Mayer, R. E. Cognitive principles of multimedia learning: The role of modality and contiguity. Journal of Educational Psychology, 91, 358-368, (1999).

Proceedings

Content

▸Full & Short Papers (Teaching and Learning Processes)

A Code Restructuring Tool to help Scaffold Novice Programmers
A new method for efficient study of kanji using mnemonics and software
A Study of Networked Constructive CAI System Using Multiplication-Concept of
A Study on the Relation between Touch-typing Skill and Thinking-typing
An Assessment Framework for Information Technology Integrated Instruction
Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming
Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching
Collaboration and Communication: Staff Development for Teaching and Learning Online
Comparing computer anxiety by gender among technological college students
Computer anxiety and locus of control between preservice teachers in Taiwan and the United States-A cross-national comparison
Computer-Mediated Language Learning
Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.
EDASEQ - A log-file analysis program for assessing navigation processes
Evaluating educational multimedia: a case study
Evaluation of class organization in the computer literacy education
Evaluation of the Web-Based Learning System
Everything in Moderation? Developing successful collaborative projects between European initial teacher education students.
Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers
Facilitating examples understanding through explicit questioning
IT in Instrumental Music Teaching and Learning: Some Practical Ideas
Learning from the Learning of other Students
Making the Most of the Internets Potential for Education
Networked Constructive CAI System Putting Emphasis on Communication and Discussion - An Example of Proportion-concept in Mathematics of Elementary School
Online ESL Learning: An Authentic Contact
Organization of the introductory and motivational stage of activity in a computer tutoring system

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives

Strategies for Searching in the WWW

Student Learning Issues: factors to consider prior to designing computer-assisted learning for higher education

Students' Attitude toward WPSS in Supporting Classroom Learning

Students' thinking processes when learning with computer-assisted mass lectures

Telementoring in Surgery

The "Half-Life" of Knowledge in the University of the 21th Century

The analysis of social discourse in a network-based learning community----The GeoSchool Experience

The Artistic Interface - A Transition from Perception to Screen

The Design of CAI with Thinking Activity to Progress Constructive Teaching - An Example of Division-concept in Mathematics of Elementary School

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

The Distance Ecological Model to Support Self/Collaborative-Learning in the Internet Environment

The Good, the Bad, the Ugly or Interactive Learning Environments

The process of learning programming: a comparative study of students' reaction

The research on difficulty of asynchronous learning materials based on time distribution

Towards a model of using Information Technology in education for pre-service teacher education

TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP -COLLABORATION TYPE AND LOOSELY CONNECTED TYPE-

Using Virtual Environments for Studying Water Phases and Phase Transitions

Web-Based Subject-Oriented Learning Program on Geophysics for Senior High School

▲ HOME

A Code Restructuring Tool to help Scaffold Novice Programmers

Stuart Garner
Edith Cowan University
Pearson St., Churchlands 6018, Western Australia
E-mail: s.garner@ecu.edu.au

This paper concerns a new software tool called CORT (code restructuring tool) that has been developed by the author to help students learn programming. The paper begins by discussing the difficulties that students face when learning to program and the use of part complete solutions as a teaching and learning method that reduces the cognitive load that students experience.

CORT has been developed to support this use of part complete solutions and its features are outlined. When used by a student, a part complete solution to a given programming problem is displayed in one window and possible lines of code that can be used to complete the solution are displayed within another window. The lines can easily be moved between the windows in order to complete the solution and the solution then transferred to the target programming environment for testing purposes.

Finally, the use of CORT with both undergraduate and postgraduate students at Edith Cowan University is described, preliminary feedback from students indicating that CORT is easy to use and that they perceive that it is helping them in their learning of programming. Four different methods of using CORT have been identified and these will be the subject of future research.

Keywords: **Scaffolding, Programming, Flexible Learning**.

1 Introduction

Learning to write computer programs is not easy [3, 18] and this is reflected in the low levels of achievement experienced by many students in first programming courses. For example, Perkins, Schwartz et al [17] state that:

> *Students with a semester or more of instruction often display remarkable naivete about the language that they have been studying and often prove unable to manage dismayingly simple programming problems.*

and King, Feltham et al [8] state that:

> *even after two years of study, many students had only a rudimentary understanding of programming*

Over the years since the advent of high level programming languages in the 1960s, much has been written about the problems that students have in learning programming and many ideas and initiatives have been put forward for improvements in the teaching and learning process with varying degrees of success. In practice, the ways in which teaching and learning takes place in the domain of programming have changed little and many students still find the learning of programming a very difficult process. The challenge of learning programming in introductory courses lies in simultaneously learning: general problem solving skills; algorithm design; program

design; a programming language in which to implement algorithms as programs; and an environment to support the program design and implementation [6]. In addition, students need to learn testing and debugging techniques to validate programs and to identify and fix problems that they may have within their programs.

Additionally, we are moving ever more rapidly to use more student centred and flexible learning methods within the teaching and learning process. This means that our instructional design for programming courses needs to take notice of these moves and utilise these methods. Fortunately technological improvements have also been significant over the last few years enabling us to more easily produce engaging courseware that can help students studying in a flexible learning mode. As courseware designers, we can produce electronic scaffolds to help students in their learning processes when they are studying on their own with limited access to a human tutor.

2 Use of Worked Examples in the Teaching and Learning of Problem Solving and Programming

There are several methods used in the teaching and learning of programming and one of these is to utilise worked examples. Several researchers have experimented with the use of worked examples in place of conventional instruction and found strong advantages. In the domain of algebra, Sweller and Cooper [19] suggested that students would learn better by studying worked examples until they had "mastered" them rather than attempting to solve problems as soon as they had been presented with, or familiarised themselves, with new material. In their research, students studied worked examples and teachers answered any questions that the students had. Students then had to explain the goal of each problem together with the steps involved in the solution and then complete similar problems until they could be solved without errors. Sweller and Cooper found that this method was less time-consuming than the conventional practice-based model and that students made fewer errors in solving similar problems than students who were exposed to the conventional practice-based model of instruction. There was no significant difference between the "worked example" group and the "conventional" problem solving group when they attempted to solve novel problems and it was therefore concluded that learning was more efficient and yet no less effective when this worked example method was used.

Worked examples are heavily used within the "reading" method of learning programming. According to Van Merrienboer et al [22, 23] the reading approach emphasises the reading, comprehension, modification and amplification of non-trivial, well-designed working programs. However, they also suggest that presenting worked examples to students is not sufficient as the students may not "abstract" the programming plans from them, a plan being a stereotyped sequence of computer instructions as shown in figure 1.

"Mindful" abstraction of plans is required by the voluntary investment of effort and the question then arises as to how we can get students to study the worked examples properly. In practice, students tend to rush through the examples, even if they have been asked to trace them in a debugger, as they often believe that they are only making progress in their learning when they are attempting to solve problems.

Lieberman [10] suggests that students should annotate worked examples with information about what they do or what they illustrate. Another suggestion is to use incomplete, well-structured and understandable program examples that require students to generate the missing code or "complete" the examples. This latter approach forces students to study the incomplete examples as it would not be possible for their completion without a thorough understanding of the examples' workings. An important aspect is that the incomplete examples are carefully designed as they have to contain enough "clues" in the code to guide the students in their completion. It is suggested that this method facilitates both automation, students having blueprints available for mapping to new problem situations, and schemata acquisition as they are forced to mindfully abstract these from the incomplete programs [24].

In one study, two groups of 28 and 29 high-school students from grades 10 to 12 participated in a ten lesson programming course using a subset of COMAL-80 [24]. One group, the "generation" group, followed a conventional approach to the learning of programming that emphasised the design and coding of new programs. The other group, the "completion" group, followed an approach that emphasised the modification and extension of existing programs. It was found that the completion group was better than the generation group in constructing new programs. It was found that the percentage of correctly coded lines was greater and that looping structures were more often combined with correct variable initialisation before a loop together with the correct use of counters and accumulators within the loop. It would appear that the completion strategy had indeed resulted in superior schemata formation for those students within that group. In addition, the completion group used superior comments in connection with the scope and goals of the programs, indicating that they had developed better high-level templates or schemata. It was noted in the study however that both groups were

equal in their ability to interpret programs and that this might indicate that students in the completion group do not understand their acquired templates. It is then suggested that future completion strategies should include the annotation of the examples by students with details of what they are supposed to do and details of the templates (plans) that are being used.

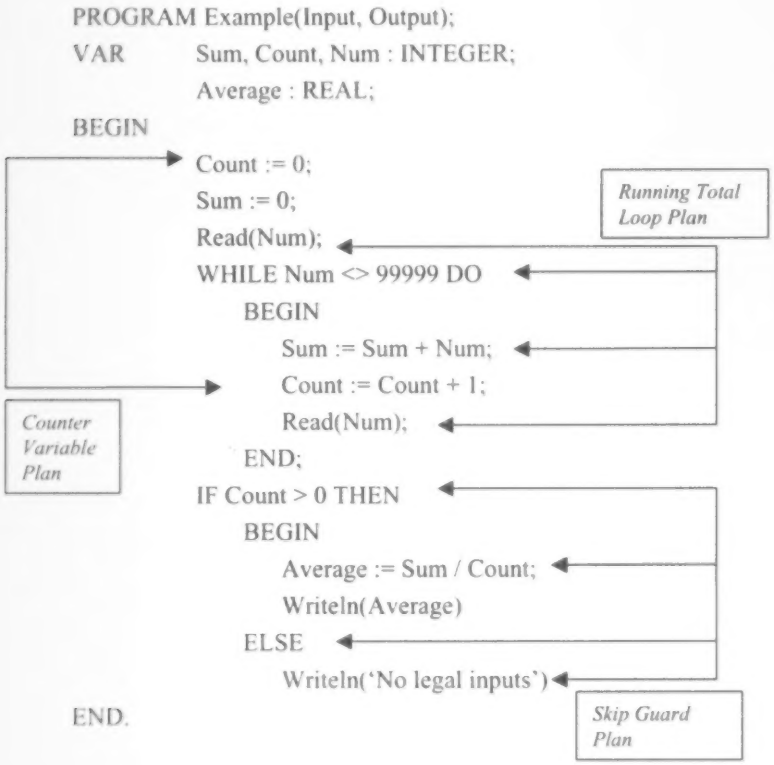


Figure 1

A side effect of the research was also noted. The drop-out rate from the completion group was found to be lower than for the generation group, particularly for female students with low prior knowledge. It was suggested that perhaps the generation of complete programs is perceived as a difficult and menacing task and that the completion strategy overcomes this difficulty.

The stimulation of the "mindful of abstraction" of schemata in students can possibly be improved further requiring them to also annotate the solutions with details of the scope and goals of the solutions and to answer questions on the inner workings of the solutions. The "degree" of completion of the solutions is an important aspect within the completion strategy and in some later work [23] examples are given of completion assignments that might be used early and later in a programming course. In an early part of a course, an example may indeed be complete and include explanations and a question on its inner workings. In the latter part of a course, the example may be largely incomplete and include a question on its workings and an instructional task. Between these two extremes, examples will have varying degree of completeness and in all cases, the incomplete examples are acting as scaffolds for the students.

3 The Cloze Procedure

A scaffolding tool called CORT (Code Restructuring Tool) has been produced that allows students to fill in lines of missing code from programs and this method is based upon the cloze procedure. The term is derived from "closure", a Gestalt psychology term referring to the human tendency to complete a familiar but not quite

finished pattern [2]. The use of cloze was first used to measure comprehension in English readability [9] however it has also been used in the teaching and learning of programming as a way of measuring student understanding of programs [7, 20]. Such program comprehension tests are constructed by replacing some of the "words" or tokens by blanks and requiring students to fill in the blanks during a test. The use of the cloze procedure in testing was found to correlate well with conventional comprehension, question – answer, type quizzes and is also much easier to create and administer, see for example the work of Cook, Bregar et al [2].

Other researchers have experimented with the testing of program comprehension by omitting complete lines of code from programs and requiring students to fill in those lines [5, 13, 14, 15, 16]. Norcio found that students were more likely to supply correct statements if they had been omitted within a logic segment rather than from the beginning of a segment. This is consistent with the chunking hypothesis [12] that specifies that the first element of a chunk provides the key to the contents of the entire unit. Ehrlich looked at the differences between experts and novices in filling in missing lines within various programming plans and, as expected, found that the experts filled in the lines correctly taking into account the surrounding plan whereas novices had more difficulty.

In the various experiments in program comprehension using the cloze procedure, the students had to fill in the lines of code without being given a selection of lines to choose from. In some work done in an area unrelated to programming, students were expected to create an essay using a file of statements, only some of which were relevant to the topic [4]. The students were expected to copy and paste only the statements which they believed to be relevant and then to link them with their own text and it was suggested that learners would consolidate their understanding of the topics by having to actively evaluate all possible statements. The file of statements was acting as a scaffold to student learning.

Although the literature suggests that the cloze procedure has only been used in measuring program comprehension, it appears that it could prove useful as a way of scaffolding student learning of programming. An incomplete solution to a programming problem could be given to a student together with a choice of statements that might be used in the solution. The student would then have to study the incomplete solution and the choice of statements and decide which statements to use and where to put them. CORT uses this idea making the mechanics of placing the statements into the incomplete solution very straightforward for the student and eliminating typing errors and therefore also syntax errors.

4 The Code Restructuring Tool (CORT)

CORT has been designed to support the "completion" method of learning to program and it was decided that the following features would be required in the first prototype:

- Support for part-complete solutions to programming problems. Such solutions help in schemata creation and also reduce cognitive load.
- A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution. This provides scaffolding for students.
- A facility so that students can add and amend lines of code. This would allow scaffolding to be reduced and for students to add more of their own code.
- For visual programming, a facility for students to easily view the target interface. The interface should be annotated with the various object names thereby reducing any split-attention effect and helping reduce cognitive load [1].
- A facility to access tutor created questions concerning the programming problems being attempted and for students to enter answers to those questions. This will promote reflection and higher order thinking.
- A facility to easily transfer a completed solution from CORT to the target programming environment.
- A facility to easily transfer programming code from the target programming environment back into CORT for further amendment.

4.1 The CORT Design

The user interface of CORT has been designed taking into consideration the three issues that have been suggested by Marcus [11] as being fundamental to interface design, namely development, usability, and acceptance. The interface for CORT is shown in figure 2.

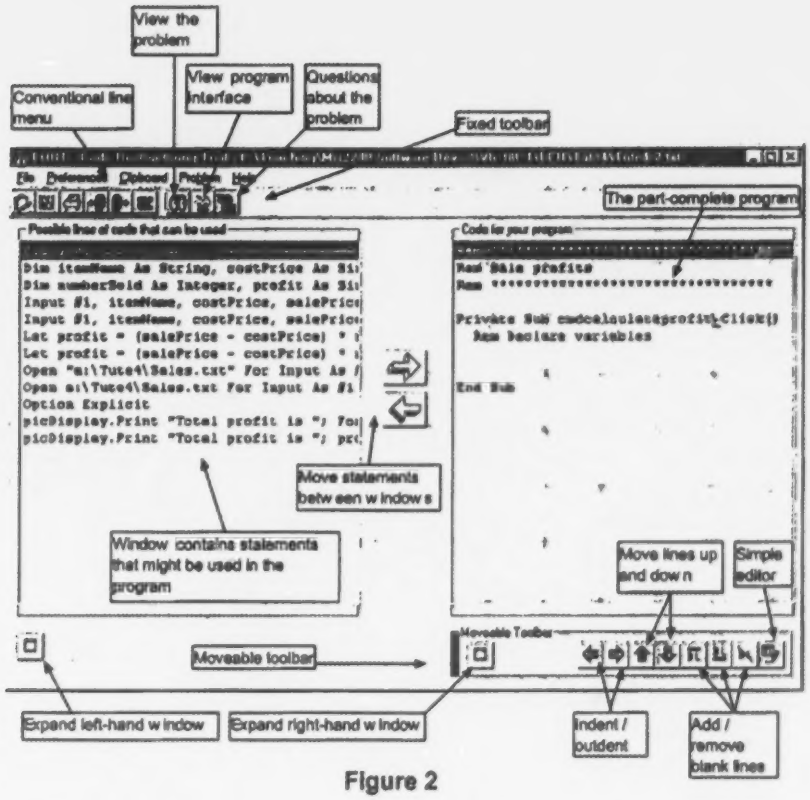


Figure 2

The ways in which the CORT design supports the list of required features are described in the following table.

Feature	Support in CORT Design
Support for part-complete solutions to programming problems	The part-complete solutions are automatically loaded into the right hand window and possible statements into the left hand window. Students load these from a file.
A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution	Two buttons in the middle of the screen will move lines between the windows. One line, or several lines can be selected and moved across.
A facility so that students can add and amend lines of code	A simple editor is provided so that students can add their own lines or amend existing lines.
For visual programming, a facility for students to easily view the target interface	Access to this feature is via a button on the fixed toolbar.
A facility to access tutor created questions on the workings of the programming examples and to enter student answers	Access to this feature is via a button on the fixed toolbar. Student answers are automatically saved.
A facility to easily transfer a completed solution from CORT to the target programming environment	This is provided by a button on the main toolbar. A single click will copy the contents of the right hand window to the Windows clipboard ready for pasting into the Visual BASIC programming environment.

A facility to easily transfer programming code from the target programming environment back into CORT for further amendment	This is provided by a button on the main toolbar. A single click will paste the contents of the Windows clipboard into the right hand window, overwriting what is there.

4.2 Use of CORT by Students

A student would typically use CORT as follows:

1. A student loads in a CORT file and the two windows display a part-complete solution to a problem together with possible lines to be used. There is a facility available for the contents of the two windows to be printed out.
2. The student can view the problem statement and the Visual BASIC solution interface by clicking on the appropriate buttons on the fixed toolbar. The problem statement may have already been provided to the student in the form of a handout, however there is also a facility to print it from within CORT.
3. The student moves certain lines from the left hand window to the right hand window in an attempt to complete the solution. Lines can be moved up or down, and indented or outdented in the right hand window. Some problems have too many lines in the left hand window, some of those lines being incorrect.
4. If necessary, the student can invoke a simple editor to amend, add or delete lines of code.
5. The student clicks on the appropriate button to copy the contents of the right hand window to the Windows clipboard.
6. The student invokes Visual BASIC and loads the file that contains the interface for the solution. This is in effect the Visual BASIC solution to the problem without the lines of code and was created by the tutor.
7. The student pastes the contents of the Windows Clipboard into the Visual BASIC editor and tests the program to determine if it works correctly. Use is made of the trace and debugging facilities of Visual BASIC. These facilities provide an insight to the workings of the notional machine.
8. If the student finds a problem with the working of the program, they can return to CORT and make the changes to the code there.
9. The student repeats steps 3 to 8 until they have a working program.
10. The student answers the tutor's questions concerning the programming problem that they have just attempted.

4.3 Initial Student Feedback

CORT has been used for one semester with both undergraduate and postgraduate students in the Faculty of Business and Public Management. The particular units are in the area of software development and the language that the students learn is Visual BASIC.

Each week the students have to undertake completion programming exercises using CORT and after each problem they were asked to comment on the use of CORT for the particular problem that they had just finished. The data was collected on-line through the Web and below are some of the comments that were received:

1. It's very helpful. I can see the interface of the program before actually running it.
2. I think CORT is a very useful tool to play around the codes. It saves me time copying and pasting.
3. Considering the increased workload as the semester progresses it is a bit of a relief that the exercises are much easier with the "fill in the gap" type format in CORT.
4. Without CORT, it's sure that I'll have a lot trouble with this particular problem, which focuses on arrays (a difficult topic). Thanks CORT...
5. CORT was useful in that the part solution helped to understand the logic of VB code
6. CORT is useful . However, I have used the unit text to try to understand the indentation format when writing the code. The directional keys are great for editing the code to meet the required format.

7. This was a challenge! I think that CORT is useful so long as I am not tempted to simply manipulate code until the program runs. If I were having to write programs from scratch I would use CORT so as to format and manipulate code and modules or sub procedures etc.

5 Conclusions

As can be seen from the above, the initial feedback on the use of CORT has been favourable. We have found that students can undertake two or three small programming problems within a one hour tutorial whereas without CORT they could only undertake one such problem. Also, without using CORT students often never manage to successfully complete their assigned problems and this certainly affected their motivation.

By using CORT, students do not have to be concerned with the design of programming interfaces which considerably reduces the cognitive load in the initial stages of learning programming. Also, the reduction of "split attention affect" by labelling all the objects with their names has been very popular with the students.

The above has described a preliminary study of the use of CORT and it has been undertaken to determine its suitability and to fine tune some of its features. CORT can be used in several ways and four distinct methods have now been identified. These will be the subject of further research. The four methods are as follows:

1. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are no extra lines displayed in the left hand window.
2. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are also additional lines displayed in the left hand window that are not required within the program. The extra lines are similar to the required lines, however they are incorrect and act as "red herrings".
3. **Some** of the lines that are required to complete a program are made available in the left hand window of CORT. Other lines that are required for the program completion need to be keyed in by the student.
4. **None** of the lines that are required to complete a program are made available in the left hand window of CORT. All of the lines that are required for the program completion need to be keyed in by the student.

References

[1] Chandler, P. and Sweller, J. (1991). Cognitive load theory and the format of instruction. Cognition and Instruction 8: 293-332.

[2] Cook, C., Bregar, W., et al. (1984). A Preliminary Investigation of the use of the Cloze Procedure as a Measure of program Understanding. Information Processing & Management **20**(1-2): 199-208.

[3] du Boulay, B. (1986). Some Difficulties in Learning to Program. Journal of Educational Computing Research **2**(1): 57-73.

[4] Edward, N. (1997). Development of a cost effective computer assisted learning (CAL) package to facilitate conceptual understanding. CAL97, University of Exeter, UK.

[5] Ehrlich, K. and Soloway, E. (1984). An Empirical Investigation of the Tacit Plan Knowledge in Programming. Human Factors in Compter Systems. J. Thomas and M. L. Schneider. Norwood, New Jersey, Ablex: 113-133.

[6] Fowler, W. A. L. and Fowler, R. H. (1993). A Hypertext Approach to Computer Science Education Unifying programming Principles. Journal of Multimedia and Hypermedia **2**(4): 433-441.

[7] Hall, W. E., III and Zweben, S. H. (1986). The Cloze Procedure and Software Comprehensibility Measurement. IEEE Transactions on Software Engineering **May 1986**: 608-623.

[8] King, J., Feltham, J., et al. (1994). Novice Programming in High Schools: Teacher Perceptions and New Directions. Australian Educational Computing(Sep 1994,): 17-23.

[9] Klare, G. R. (1974-75). Assessing Readability. Reading research quarterly(10): 63-102.

[10] Lieberman, H. (1986). An Example Based Environment for beginning Programmers. Instructional Science **14**(3): 277-292.

[11] Marcus, A. (1992). Graphic Design for Electronic Documents and User Interfaces. New York, ACM Press.

[12] Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity to Process Information. Psychological Review(63): 81-97.

[13] Norcio, A. F. (1980a). Comprehension Aids for Computer Programs. American Psychological Association Annual Meeting, Montreal.

[14] Norcio, A. F. (1980b). Human Memory Processes for Comprehending Computer Programs. Cybernetics and Society, Cambridge, Massachusetts.

[15] Norcio, A. F. (1981). Chunking and Understanding Computer Programs. Human-Machine Systems Symposium, Boston, USA.

[16] Norcio, A. F. (1982). Indentation, Documentation and Programmer Comprehension. Human Factors in Computer Systems, Gaithersburg, Maryland.

[17] Perkins, D. N., Schwartz, S., et al. (1988). Instructional Strategies for the Problems of Novice Programmers. Teaching and Learning Computer Programming: Multiple Research Perspective. R. E. Mayer, Hillsdale, NJ: Erlbaum: 153-178.

[18] Scholtz, J. and Wiedenbeck, S. (1992). The role of planning in learning a new programming language. International journal of man-machine studies **37**: 191-214.

[19] Sweller, J. and Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction **2**(1): 59-89.

[20] Thomas, M. and Zweben, S. (1986). The Effects of Program-Dependent and Program-Independent Deletions on Software Cloze Tests. Empirical Studies of Programmers: 138-152.

[21] van Merrienboer, J. J. G. (1990). Strategies for Programming Instruction in High School: Program Completion vs. Program Generation. Journal of educational computing research. **6**(3): 265-.

[22] van Merrienboer, J. J. G. and Krammer, H. (1987). Instructional Strategies and tactics for the design of Introductory Computer programming Courses in High School. Instructional Science **16**(3): 251-285.

[23] van Merrienboer, J. J. G., Krammer, H. P. M., et al. (1994). Automating the planning and construction of programming assignments for teaching introductory computer programming. Automating Instructional Design, Development, and Delivery (NATO ASI Series F, Vol. 119). R. D. Tennyson, Springer Verlag, Berlin.: 61-77.

[24] van Merrienboer, J. J. G. and Paas, F. (1990). Automation and Schema Acquisition in learning elementary computer programming. Computers in Human Behavior(6): 273-289.

A new method for efficient study of *Kanji* using mnemonics and software

Chris Houser*, Shigeki Yokoi and Takami Yasuda****
**Kinjo Gakuin University, Omori 2-1723 Moriyama-ku Nagoya 463-8521 Japan,*
houser@kinjo-u.ac.jp
***Nagoya University, Furo-cho Chikusa-ku Nagoya 464-8601 Japan*

Japanese children spend hundreds of hours, over nine years, studying some 2000 written characters called *kanji*. Incredibly, most foreign adults attempt to study the *kanji* using the *same* method. But without these hundreds of hours, their efforts generally fail. In *Remembering the Kanji*, James Heisig presents a radical method for studying *kanji*. In only 200 hours, Heisig claims, adults can learn the *kanji*. A wonderful improvement! But few students follow his method; most complain that 200 hours is still too long. This paper introduces a refinement of Heisig's technique, a refinement combining modern memory theory with software, a refinement reducing the required time to 40 hours. The first author, a forgetful *kanji* neophyte, learned the *kanji* with this method, studying an hour a day, five days a week, for two months. His recall exceeds 95%, approximating native Japanese. This paper targets both teachers and students of Japanese as a foreign language, providing the knowledge and software required to rapidly learn the *kanji*, and inviting them to participate in a wider experiment using these new technologies.

Keywords: **CALL, Kanji, SuperMemo, Efficient study**

1 The *Kanji*

Perhaps the most difficult part of learning Japanese is memorizing its enormous character set: the 2000-odd *kanji*. These characters were imported from China into Japan. Because each character was imported several times over the centuries, while the Chinese and Japanese languages were evolving, each character now has multiple readings and meanings. As a result, the Japanese writing system is arguably the world's most complex.

Japanese children study these *kanji* for hundreds of hours over nine years of schooling. They start studying when six years old, before they have developed the ability to abstract, and hence can learn the characters only by *muscle memory:* They write the characters repeatedly, typically 20 times each. This method works, but imperfectly: Even after all this study, and the review that comes with daily use, adult Japanese forget some characters.

Most foreigners studying Japanese as a foreign language (JFL) try to learn the *kanji* using the same method: They write the characters repeatedly, perhaps while verbalizing the character's meanings and readings [7]. But since few adult JFL students have the hundreds of hours this method requires, most fail [4].

2 Heisig's method for studying the *kanji*

Heisig [4] offers an alternative study method.
Goal. Heisig's method allows adult JFL students to learn the *writing* and a *single meaning* of 2042 *kanji*. This is a narrow goal: Students concentrate on learning this writing and single meaning, and postpone learning other meanings, all readings, and the multiple character compounds.
Method. Since Heisig targets adults, he is able to use a sophisticated method, a method beyond the grasp of six year olds. He is able to use a *rational* method for learning *kanji*. Heisig prepared his method by

1. assigning each character a *keyword* (its single meaning),

2. splitting each character into a handful of *parts*,
3. ordering the characters so that parts precede their uses, and
4. inventing a mnemonic story to help recall each character's parts.

The keyword is usually the most common of the several Japanese meanings. The parts come from various sources: Some are simpler *kanji*; others are *primitives* – collections of commonly occurring strokes. Some of these primitives were identified centuries ago by Chinese and Japanese linguists (who call them "radicals"); other primitives were simply invented by Heisig. In all, Heisig uses a few hundred parts. The crux of his method:

Each character is learned, not as a mass of random strokes, but as a logical collection of parts.

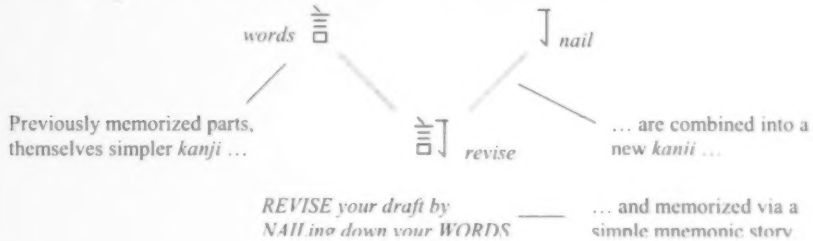
For example, consider the kanji with the keyword revise. This character has **nine meaningless strokes**, which prove quite a challenge to remember. But this same character has only **two parts** with the keywords *words* and *nail* – **meaningful** words which are much easier to remember. In effect, Heisig splits this character into these two parts, making a kind of equation: *revise* = *words* + *nail*. Most non-Japanese find this equation much simpler to recall than a meaningless jumble of nine strokes. When Heisig's students come to study *revise*, they have already learned the two parts – *word* and *nail* – since Heisig has sorted the *kanji* so that these parts precede their use in *revise*. By combining two previously learned parts, students easily remember this new character. But Heisig makes remembering even easier by providing a **mnemonic story**:

REVISE your draft by NAILing down your WORDS.

The image of "nailing down one's words" is so strong and logical that after students have read this mnemonic **once**, they will likely remember it for life.

This contrasts with Japanese students, who practice **writing** the character **repeatedly**, and may later forget it.

Heisig's main contribution is to **raise the level of abstraction** from strokes to parts. Rather than struggling to remember a large, sprawling jumble of meaningless jots and dashes, students effortlessly remember a simple story, calling to mind the few parts that compose a *kanji*:



Study. Heisig has done most of the work: He has assigned the keywords, identified the parts, invented the primitives, and sorted the *kanji*. Students need only read the keyword and story a few times to memorize each *kanji*. Heisig predicts study will require 200 hours – far less than Japanese children spend on rote repetition.

Analysis. Why is Heisig's method so effective? Here are three explanations.

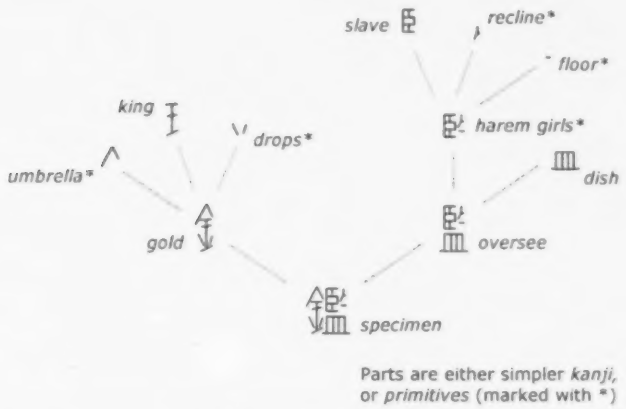
Simplicity. The stories are simpler than the *kanji*, simpler because they have fewer components. Each *kanji* consists of between 1 and 23 strokes; 75% of the *kanji* have more than seven strokes. But all have fewer than seven parts. Now human short-term memory can hold only about seven items [6]. Objects with more than seven known components cannot fit in short-term memory, and so cannot be remembered, or even recognized. This predicts that students learning strokes will remember 25% of the *kanji*, but students learning parts will remember 100%.

Abstraction. Practicing strokes engages only muscle memory: Most of the student's brain remains dormant. Heisig's stories engage the higher faculties of language, actions, settings, events, humor, and metaphor. Such meaningful symbolic processing engages more of the brain, and hence is more easily recalled, than mere orthographic syntax [8]. Humans recall abstract meanings and stories long after they forget specific examples and images [5].

Relations. When learned by rote, each *kanji*, indeed each stroke, must be learned anew: Nothing is connected to anything else. When learned by parts, each *kanji* is connected to previously learned *kanji*.

Heisig's method is rich in connections. When students learn a character, they are also reviewing its parts. In turn, most parts appear repeatedly, and hence are memorized easily.

As an illustration, consider the daunting 23 strokes of *specimen*. Stroke-by-stroke memorization is all but impossible. But *specimen* comprises only two parts: *gold* and *oversee*. It is easily recalled with a story such as *GOLD diggers OVERSEE their mineral SPECIMENS*. *Specimen* is studied after *gold* and *oversee* have been learned, from their own parts, with their own stories. So each step of study is small and simple, but the steps build on each other – primitives are woven into *kanji*, which are in turn used to build further *kanji* – until a vast web of rich connections is built up in the student's mind.



Problem: Still too difficult! Heisig's method is a great improvement over the Japanese method, but it is not perfect. For Heisig provides stories for only the first 500 of his *kanji*, and asks readers to invent their own stories for the remaining 1542. Faced with this burden, many of Heisig's students stop studying after 500 characters. And those who do continue need unusual discipline, need to painstakingly construct and review flash cards, need a scheduling system to study, review, and test.

3 Kanji Can

Kanji Can [3, 1] is a database with a *complete* set of 2042 mnemonic stories. The stories are excellent, surpassing even Heisig's first 500:

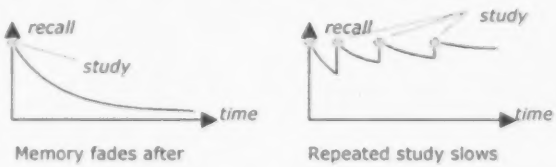
- Kanji Can's stories are shorter, and so easier to recall.
- Kanji Can's stories mention the parts in the order they are written.
  (Compare with Heisig's story for *revise* above, which reverses them.)

Kanji Can embraces Heisig's method, but extends his materials, and thus solves the problems mentioned above.

4 Flash Cards

The chief tool of most memorizers is the humble flash card. Flash cards are small paper cards with a *stimulus* written on the front side, and a *response* on the back. When studying foreign language vocabulary, the stimulus is typically a word in one's native language, and the response is the word in the foreign vocabulary. When studying *kanji* using Heisig's method, the stimulus is the keyword, and the response is the *kanji* itself.

Students read the stimulus and try to produce the response. They then check their response against the desired response on the back of the card. Cards that were correctly recalled are removed from the deck; cards not recalled are shuffled to the back of the deck, to be reviewed again. Used this way, flash cards combine self-testing with review. The cards catch mistakes and save them, allowing review until the student knows them all. Flash cards



are essential when following Heisig's method: Studying the stories is so easy that students will doubt they are really learning anything until they have been tested!

Problem: Inefficiency. Using flash cards takes a lot of time. Each card must be hand made. Then each card must be tested repeatedly, for only with repetition comes dependable memorization. Memory fades over time, but by reviewing partially forgotten material students extend their memories.

But how frequently should students review? Buzan [2] recommends review after ten minutes, a day, a week, a month, and then four months. But are these the best intervals for review? Testing too frequently wastes time reviewing material already well known. Testing too infrequently wastes time relearning forgotten material. The goal of flash cards is to "catch" learners just before they fall – to remind them just as they are about to forget. But the point of forgetting – and hence the optimal review interval – differs for each student, and even for each *kanji*: Some are easier to remember than others. How can we optimize study?

5 Super Memo

Super Memo is a general flash card program [9]. Like paper flash cards, these electronic cards can be used to review anything, including the *kanji*. Unlike paper cards, these electronic cards are neat and easily editable, but require a PC. Super Memo is better than paper flash cards because it contains a mathematical model of human forgetting: It can predict when a student will forget a *kanji*, and hence compute the best testing time. When testing with Super Memo, students tell the program how well they remember each *kanji*; the program uses this information to tune its model to each student, and to each *kanji*. The result closely approximates perfectly timed intervals, and hence maximum efficiency in studying.

Independent of the nature and amount of material they study, students using Super Memo all learn approximately 200 items/minute/year. This means that by studying one minute, every day, for a year, one can learn 200 items; or, by studying 10 minutes a day, 2000 items. This is much faster than many other study methods; in particular, Super Memo implies results in 1/5 of Heisig's time.

Super Memo's computerized scheduling provides more than optimal reviews. It also provides an incentive to study every day. A student using Super Memo runs the program every day and finds a list of items to review. If the student skips a day, the next day she will be confronted with twice as many items! This threat helps provide the discipline necessary in learning a large body of material, such as the *kanji*. (Unfortunately, this also means that if the student skips a week, she will be confronted with a mountain of review, and will likely quit altogether. Super Memo is not for the timid.)

6 New technology allows learning the *kanji* in only 40 hours!

This paper proposes a new method for learning the *kanji*, a method combining Heisig's novel ideas, Kanji Can's stories, and Super Memo's reviewing. Heisig provides the tractable goal and the idea of using mnemonic stories to recall the writing of *kanji* in terms of their parts. Kanji Can provides a complete set of these mnemonic stories. And Super Memo provides strict scheduling and efficient reviewing and testing. The combination of these three educational technologies provides a most efficient *kanji* learning method: the complete set of 2042 *kanji* can be learned in only 40 hours!

These 40 hours might be scheduled as 10 minutes a day, every day for a year, or an hour a day, five days a week, for two months. Memory manuals claim that an hour's study a day is optimal: Shorter study sessions waste time in frequent physical and mental preparation, longer study sessions induce fatigue, and both degrade efficiency [2, 5].

The first author learned the *kanji* in 40 hours by following this method.

Heisig has greatly accelerated *kanji* learning for adult JFL students. Kanji Can's complete set of stories enables students to concentrate on studying the *kanji*. Super Memo provides a well-documented speedup for any rote memorization. Combining these three technologies, we can learn the *kanji* in only 40 hours.

References

[1] Breen, J., *KanjiDic*, ftp://ftp.cc.monash.edu.au/pub/nihongo/00INDEX.html (2000).

[2] Buzan, T., *Make the most of your mind*, Pan, London (1977).

[3] Donaghue, M., *Kanji Can*, http://www.kanjisoft.com (2000).

[4] Heisig, J., *Remembering the Kanji I*, Japan Publications Trading Co., Tokyo (1977).

[5] Maddox, H., *How to study*, Ballantine, New York (1963).

[6] Miller, G., "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information", *The Psychological Review*, vol. 63, pp. 81-97, http://www.well.com/user/smalin/miller.html (1956).

[7] Sakade, F., Emori, K., Friedrich, R., Ohashi, S., *A guide to reading & writing Japanese*, Charles E Tuttle, Rutland, Vermont (1959).

[8] Schmidt, U. & Geyser, A., "How to study 2000 kanji in a few weeks", *Proceedings of ICCE 99*, pp. 595-598 (1999).

[9] Wozniak, P., *Super Memo*, http://www.supermemo.com (2000).

A Study of Networked Constructive CAI System Using Multiplication-Concept of "Transformation of Unity Quantity" on Elementary School

Pou-Yah Wu*, Shu-Fen Tsai, Yao-Quan Li, Jian-Zhi Lin, Jun-Rong Chen, and Xiang -Ting Huang

Department of Mathematics Education, National Tainan Teachers' College

33, Sec. 2, Su-Lin Street, Tainan, Taiwan 700

**Pou-Yah Wu's email:pywu@ipx.ntntc.edu.tw*

The feature of networked constructive CAI system lies in shaping the computer environment in which students clarify and construct the concept by ways of communication, discussion, and dialectics, utilizing the practical pedagogic content edited by the spirit of new curriculum in Taiwan at 1993. Because we stress the concept of "transformation of unity quantity" as main activity in teaching multiplication, students' comprehension of "unity quantity", "unity number", and "combined numbers" plays an important role in establishing networked constructive CAI system. We consider that the greatest difference between the networked learning environment and that of the general classroom pedagogy is the deficiency of interaction. Thus, analyzing the strategy of students' solving problems to establish the effective tool table of operation and judging the mode of the students' thought by checking the tools which students use will strengthen the interactive relationship of the system and the learners. Then, use the networked technology and the principle of the expert system to set up the CAI of constructive pedagogy, so that the learners can communicate with each other and the system can conduct dynamically which formally construct a wholly co-operative learning environment and will help the learners to form the whole mathematics concepts.

Keywords: **Constructive pedagogy, Elementary School, Multiplication of Mathematics, Networked CAI.**

1 Introdution

The characteristic of implementing new curriculum of mathematics at elementary schools in Taiwan now lies in the addition of spirit of constructivism, aiming at expecting students to construct knowledge positively. Thus, the teachers' role, in the process of pedagogy in new curriculums, changes into "problem poser", whereas students' learning activities in class attain socialized mutual sense, chiefly by communication, construct their own mathematical knowledge by way of mutual dialectics [5,6]. However, it takes pedagogy of construction longer than traditional pedagogy. The atmosphere and skill as to how the teacher directs students to construct knowledge and how the students discuss influence the effect of implementing new curriculum. In the light of the fact the trend of the times facilitates pedagogy of network to become widespread, the future construction of leased network lets us expect the popularity of "learning at home" and "long distance pedagogy". Therefore, the possibility of displaying a really approximate leaning setting of constructing pedagogy in the network environment becomes much higher. The establishment of the network system of pedagogy of construction, owing to the trend of current situation, is becoming imminent.

The aim of this study consists in designing a learning environment of network suitable for "multiplication concept in elementary school" . The greatest difference between the learning environment of network and that of the general classroom is the deficiency of mutual response [22,26]. And the pedagogy of construction hopes the communication and dialectics to bring about reflection, inspiring students to construct mathematics self-concept. Therefore, how to promote the mutual relationships between the system and the user is one of the considered points about constructing system in this study. Furthermore, how to develop the characteristic of pedagogy of

construction in the system and how to make the pedagogic contents of the new curriculum manifested in the system wholly and fluently is the second chief point taken into account. Aimed at the above two points, that we use network technology, letting the real-time communication proceeded between the learners, or between the learning and system make up a wholly cooperative learning environment. Furthermore, making use of the principles of the expert system to deal with the learning strategy of the problem solver, through the concepts manifested by the problem solver, the system will feedback suitably, and will communicate with the students properly, which can make the pedagogic activity proceed dynamically [19,25]. The design of the pedagogic content, expect considering the sprit of the new curriculums, the students' learning state, after the teachers' real pedagogy, is mainly considered about designing pedagogy. Hence, this system is much closer to the real situation of pedagogy them CAI sold in the market. And the activities of problem solving given to the learner by system would be more congenial to the learner's mode of thought.

2 Principles of system constructing

2.1 Base of learning theory

"Knowledge is positively constructed by the learner rather than being inculcated passively from outside," which is the fundamental proposition of constructing pedagogic paradigm. The students, with acquired knowledge, enter another stage as an active subject of recognition, with good theory by themselves, instead of ignorance and irrationality [16]. But pedagogy of construction does not mean the teacher's role is unnecessary. On the contrary, we realize the aim of pedagogy is to make children construct the activity types of solving problems. In the light of this, the teachers' role becomes "problem poser" rather than "problem solver" in the process of pedagogy. By way of the teachers' posing problems, children undertake the activity of solving problems by themselves; or children become "imitators" through the activity of solving problem provided by the teacher [4]. By these processes, students are provided sufficient experience of solving problems, and then construct the correct mathematics conceptions. Besides, what we must also pay attention to is the teacher and the learner grasp the intentions of each other aiming at the proceeding actives of each other, through trial and dialectics, until both of them relieve the pressure aroused by the interchange actives. The relief of pressure is limited by the fact if the problem is solved according to the activity, and is also influenced by the affectionate expression of them both present of them both present [24]. Therefore, in pedagogy of construction, socialized communication is an important feature [3].

2.2 Base of system establishing

This system is a learning environment constructed in the network, adopting three-tier client/server system architecture: that is, adding another service server on the original framework of the two-tier client/server system in this three-tier client/server system architecture, the management of Database Server charges learning data. Web Server is responsible for teaching, whereas the user of Client precedes all kinds of learning activities ivies through browser machine.

3 Pedagogic design of Multiplication using transformation of unity quantity

3.1 Concept of multiplication

Multiplication referred to by Davydov (1991) is the problem of transformation of unity quantity, that is, the transformation from composite unit to that of the single item [20]. And Clark and Kamii (1997) think that if children own the multiplicative thinking, they will simultaneously deal with lower level unit such as unit of one and the higher level unit different from unit of one [18]. Tzyh-Chiang Ning (1994) mentions that the so-called multiplication operation contains at least two kinds of relationship: (1)the coordinating relationship of two levels,(2)the part-whole relationship of two levels. The problem of multiplication is in reality that of the transformation of unity quantity, namely, the problem of transforming quantity from higher level unit to lower level unit [7,8,9].

3.2 Pedagogic design of multiplication using transformation of unity quantity

The recognition of new curriculums toward mathematics concepts specifies the activity types of solving problems of interiorization [17,23,26]. And he origin of mathematics knowledge embodies the activity of solving problems, instead of tangible objects [5]. Thus, the ideas of new curriculum do not emphasize the existence of calculating problems. The generation of all forms of calculation is entirely for the need of the practical contexts; also the measurement serves as the source of multiplication in the practical contexts [20]. Hence, the appearance of new curriculums in pedagogic content lets students have the necessary sense of owing multiplicative thinking rather than multiplication directed by "multiplication table" of old curriculums; whereas "transformation of unity quantity" is the pivotal point in designing teaching material of new curriculums, different from the viewpoints that look upon multiplication as "repeated addition" [21] in the design of multiplication of old curriculums. In other words, students' comprehending "unity quantity", "unity number" and "combined numbers" in the process of solving problems plays an important role in the design of material content of new curriculums. Tzyh-Chiang Ning (1993) [8]mentions that there are three classification of difficulty in the management of initiatory material of multiplication in new curriculums:(1)the students can tackle the problem of transformation of unity quantity (2)the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Therefore, in the design of pedagogy of multiplication, the arrangement of new curriculums lies in the fact the teacher set up a problem of multiplication in the practical contexts, and the students handle and record the problem by themselves after conveying the message of the problem. The students' knowledge is chiefly constructing from the consultation, inquiry and dialectic between the teacher and the peers; via the established learning by the concept of constructive pedagogy, the teacher should, in the process and record of the students' solving problems, help the students clarify the existence of "unity quantity", "unity number", and "combined numbers" in the problems. The students should also attain the unanimous compromise of the format of record; that is, the format of the students should wholly suggest "unity number ", "unity number", and "combined numbers". When the process of pedagogy arrives here, students have at least finished the level of the second difficulty mentioned by Tzyh-Chiang Ning. As to the application of multiplication sign, it is the flowing and economic problem of culture and communication. New curriculums, thus, undertake such a linguistic transformation of "a×b=>a lots of b=>b multiplied by a." and then bring multiplication sign serving as the operator of recording format. If the students can make use of multiplication symbol as the operator in the recording format, we may well say that they attain the level of the third difficulty. While the students reach that level, they are equipped with initiatory concept of multiplication; in other words, arrive at the formation of " multiplication" concept gradually through "experience"," perception" and "realization" [4].

4 Simulation of the process in the constructive pedagogy

Since our CAI system stresses the spirit of the constructive pedagogy, we hope that the whole computer environment would become more compatible with the real environment of pedagogy. What we must emphasize is the teacher himself/herself is the most important natural resource in the environment of pedagogy. All our set CAI would attain is how to let the computer simulate the mode of thought in the teachers' real lecturing, even to let the computer "realize" the mode of the students' thought. With a view to achieving such an effect, we design operation tools for users' use. We can discriminate the stages of students' thought by the users' choosing tools, which will let the computer analyze the students' mathematics competence through the stage of the students' operation, and simultaneously let the computer carry on dialectics, clarification and discussion by simulating the role of the teacher or that of the student. We can achieve a process of socialization on the computer by such a process of the design. And via such a process, the user can "experience"," observe", and "realize" the concept of multiplication, and finish three tasks of the stages: (1) the students can tackle the problem of transformation of unity quantity (2) the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Take Figure 1 as an example, students can move the bone to the bay by the mouse, then the computer system may judge whether does he/she understand the meaning of problem. We hope to make students gain more self-affirmation by manipulating. As show in Figure 2, our system provides the electric board and the tool table. User can simulate the situation in the class to solve the problem and record the format. In additional, system also supports the different operation tools for users. And the system can provide different solving method to help users constructing their operation by judging what kind of tools they choose. The system also can judge users' operation mode by checking their record format, then, the system will master students' learning condition well, and teach dynamically. Besides, the system also provides virtual students to communicate with users as showing in Figure 3. It will increase the users' learning interest. Virtual students that design for guiding user and make the environment of discussion can provide proper help but not answers in

fitting time.

5 Architecture and implementation of system

5.1 Environment of design and tool

This system uses Windows NT server as server. Developing languages include HTML, JavaScript, Active X, ASP (Active Server Page) and so on. ASP is used as the chief method of control, and ASP and ODBC (Open Database Connectivity) are exercised to match. The management of the teaching material's user becomes simplified. As to the edition of the curricular software, Authorware 5 is mainly used for developing tools.

5.2 Process of system

Process of the system we designs just as Figure 4 shows, the general elucidation is as follows,

1. Pedagogic situation of network construction

The system after the analysis of the pretest makes sure the sorts of the user's operation and then to pose problems according to the classification. The system will communicate and clarify the messages of the problems by the tools in tool table. After the sorts of tools by user to discriminate if he/she has grasped the messages of the problems, the system will provide tool table further, letting the user record by the tools. In this stage, along with level of the user's operation, the system will afford problems, via simulating the role of the student or the teacher to carry on the activities of dialects, clarification, and let the user reflect and modify his/her recording format to match the basic requirements of "unity quantity", "unity number" and "combined numbers" suggested in the recording format". Afterwards, adjust the next learning activity according to the learning state of the user until he/she can construct the concept of multiplication on the acquired basis and attain the learning level of the afore-specified third difficulty. Besides, the system can simulate the real learning environment on the network, letting the user's learning environment diverse.

2. 「Student model」 database

Student model consists mainly of three databases:

(1) Student basis database

It chiefly records the students' basis data such as name, age, the experience of using computers and so on.

(2) Database of learning.

It records the unit of teaching materials the student learned, the learning state of each unit and the duration of time, and the positive result of the students' learning.

(3) Database of learning achievement.

It records the students' assessment about answering and the stage of operation.

3. Database about "posing problems of constructive pedagogy"

The content of teaching material about constructive pedagogy include

(1) Phenomenal problem: this sort of problem can facilitate students to "experience" the mathematics concept.

(2) Psychological problem: this sort of problem can facilitate students to "observe" the mathematics concept.

(3) Sociological problem: this sort of problem can make students via discussion; attain the common sense of using recording, which would become the tool of communication.

(4) Anthropologic problem: this sort of problem can make the above – mentioned communicating tools and the correspondent expression in cultural become congenial.

4. Database of " problems"

This database is to store the problems for the pretest and the posttests.

5.3 Function of on-line communication

The system would establish a learning environment more congenial to real teaching situation thus the convenience for the user and for other users on the line to communicate, thereby setting up a network environment for undertake cooperative learning. The system designs a series of functions for on-line communication on the line, illustrated as the followings.

(1) Group of discussion

Group of discussion is an open but not synchronized function on the line. When the user encounters the difficulty in learning, he/she put up his/her questions in the group of discussion, letting other users put forth solutions to these questions.

(2) Room for discussion

As showing in Figure 5, the function of the room for discussion can improve the disadvantages of the personal computer learning CIA's failure to carry on communication, real-time discussion to a large extent, for it is an open and synchronous for communication. Besides calling the virtual teacher or student, the user can enter the room for discussion for help when he/she needs others' help to solve the questions.

(3) On-line Call

On-line call may be inputted simple information to communicate with other on-line users.

5.4 The operating process for the user on the system

When the user enters the system with the browser for the first time, the system will ask he/she to register as showing in Figure 6, thereby acquiring the basic data to establish the Database for "student model", and simultaneously letting the user accept pretest to discriminate the levels of the user's operation, and recording the situation of their answering, and the connection of active modification letting the user join the curricula suitably.

Afterwards, whenever the user enters the system, he/she must key in user name and password to make sure the identification. The system will continue the following activities according to the previous record of the user. The system would record each learning activity the user undertakes one by one, with the view of analyzing the fact if the learning state of the user will attain the expected aim. When the user encounters the line provided by the system: he/she can also check his/her learning state at any moment to grasp the learning progress.

6 Conclusions

The age of computer is that of knowledge explosion indeed. Undoubtedly, "Self-learning" is the best way to enrich self in the age of widespread information. With network becoming so widespread, it is not uncommon for the students of the elementary school to enter the network. It is incumbent on us to let the teaching environment of CAI congenial to the concepts of teaching nowadays. We hope our CAI system will become compatible with the social need now, breaking through the limitation of time and space and overcoming the barriers of learning environment now, giving the learner more space to exert himself/herself. At present, this system has finished the prototype, and plans to precede real teaching experiments and systematic assessment in a few months.

Reference

[1]周筱亭, "數學新課程的趨勢", 研習資訊, Vol. 11, No. 3, pp. 28-50, (1994).

[2]侯志欽, "教學設計的哲學省思—由客觀主義到建構構主義", 國民教育集刊, Vol. 17, pp. 221-229, (1999).

[3]南白強, "「根本建構主義」—認知研究的另一種架構", 師友月刊, 12 月號, pp. 30-32, (1987).

[4]南白強, "經驗、察覺、及了解在課程中的意義—由根本建構主義的觀點來看", 論文發表於國立台東師範學院八十一學年度國小理科教育學術研討會, pp. 191-197, (1992).

[5]南白強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看", 科學教育學刊, Vol. 1 No. 1, pp. 101-108, (1993).

[6]南白強, "「建構式教學法」之教學觀—由根本建構主義的觀點來看", 國教學報,Vol. 5, pp. 33-41, (1993).

[7]南白強, "單位量的轉換(一)正整數乘除法運思的啓蒙",教師之友, Vol. 34, No. 1, pp. 27-34, (1993).

[8]南白強, "新課程對乘法啓蒙教材的處理", 論文發表於國立嘉義師範學院八十二學年度數學教育研討會, 四月二十九日, (1994).

[9]南白強, "單位量的變換(二)—正整數乘除運思的融合", 教師之友, Vol. 36, No.5, pp. 35-44, (1995).

[10]南白強, "數學的格式與內容—皮亞傑對維高斯基", 論文發表於台北市立師範學院「皮亞傑及維高斯基的對話」百年校慶學術研討會, 元月二十五、六日, (1996).

[11]南白強, "劉裕誠的數概念", 1997 海峽兩岸幼兒教育學術研討會論文集, pp. 167-185, (1997).

[12]南白強, "涂景翰的數概念", 科學教育學刊, Vol. 6, No. 3, pp. 255-269, (1998).

[13]南白強, "顏淑茹的數概念", 國教育研究學報, Vol. 4, pp. 231-264, (1998).

[14]羅清水, "認知心理學理論對電腦輔助教學設計發展與成效之影響", 研習資訊, Vol. 15, No. 1, pp. 1-15, (1998).

[15]鍾靜, "從疑難問題談乘法文字題教學", 國教月刊, Vol. 36, No. 9,10, pp. 33-35, (1980).

[16]蘇育任, "建構主義式的教育的迷思與省思", 國民教育集刊, Vol. 5, pp. 121-139, (1997).

[17] Bridgaman, P. W.," The way things are", New Your: Viking Compass, pp. 83, (1959).
[18] Clark, F. B. & Kamii, C., " Identification of multiplicative thinking in children in grades 1-5", "Journal of Research in Mathematics Education", Vol. 27, No. 1, pp. 41-51, (1996).
[19] Dalgarno, B., "Constructivist Computer Assisted Learning: Theory and Techniques", http://services.Canberra.edu.au/~barney/articles/ascilite96/paper.htm (accessed on Oct. 21, 1997).
[20] Davydov, V. V., "A psychological analysis of the operation of multiplication", In L. P. Steff (Eds.), Psychological abilities of primary school children in learning mathematics, Soviet Studies in Mathematics Education Series, volume 6, pp. 9-85, (J. Teller trans.) Reston, VA: NCTM. (1991)
[21] Fischbein, E., Deri, M., Nello, M. S., & Marino, M. S., "The role of implicit models in solving verbal problems in multiplication and division", Journal of Research in Mathematics Education", No. 16, pp. 3-17, (1985).
[22] Hiltz, S. R., " Teaching in a Virtual Classroom", http://it.njit.edu/njIT/Department/CCC/VC/Papera/Teaching.html (accessed 1995).
[23] Piaget, J., "The Psychogenesis of knowledge and its epistemological significance", In M. Piatelli-Palmarini (Eds.), Language and learning: The debate between Jean Piaget and Noam Chomsky, Cambridge, MA:Harvard University Press, (1980).
[24] Steff, L. P. & Wood, T. (Eds.), " Transforming Children's Mathematics Education: International Perspectives", Hilsdale, NJ:LEA, (1990).
[25] Squires, D., "Can multimedia support constructivist learning?" http://www.spirit.net.au/ACEC96/papers/squir.htm (accessed on Oct. 21, 1997).
[26] Van Engen, H., "An analysis of meaning in arithmetic I & II", The elementary School Journal, pp. 321-329 & 395-400, (1949).
[27] Webb, G., " A Theoretical Framework for Internet-Based Training at Sydney Institute of Technology", http://ausweb.scu.edu.au/proceedings/webb/paper.html (accessed on July 5-9, 1997).

Figure 1:The clarification of the problem

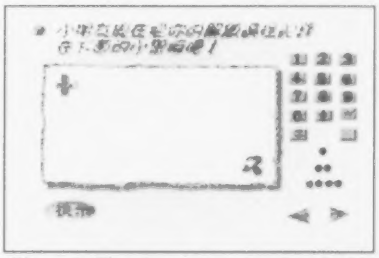


Figure 2: The electric board and tool table

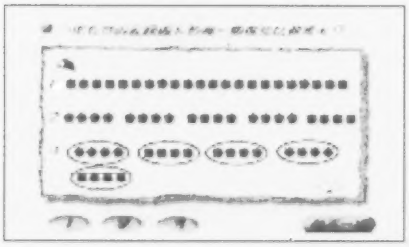


Figure 3:The strategies of virtual students

Figure 5:Room for discussion

Figure 6:The registration

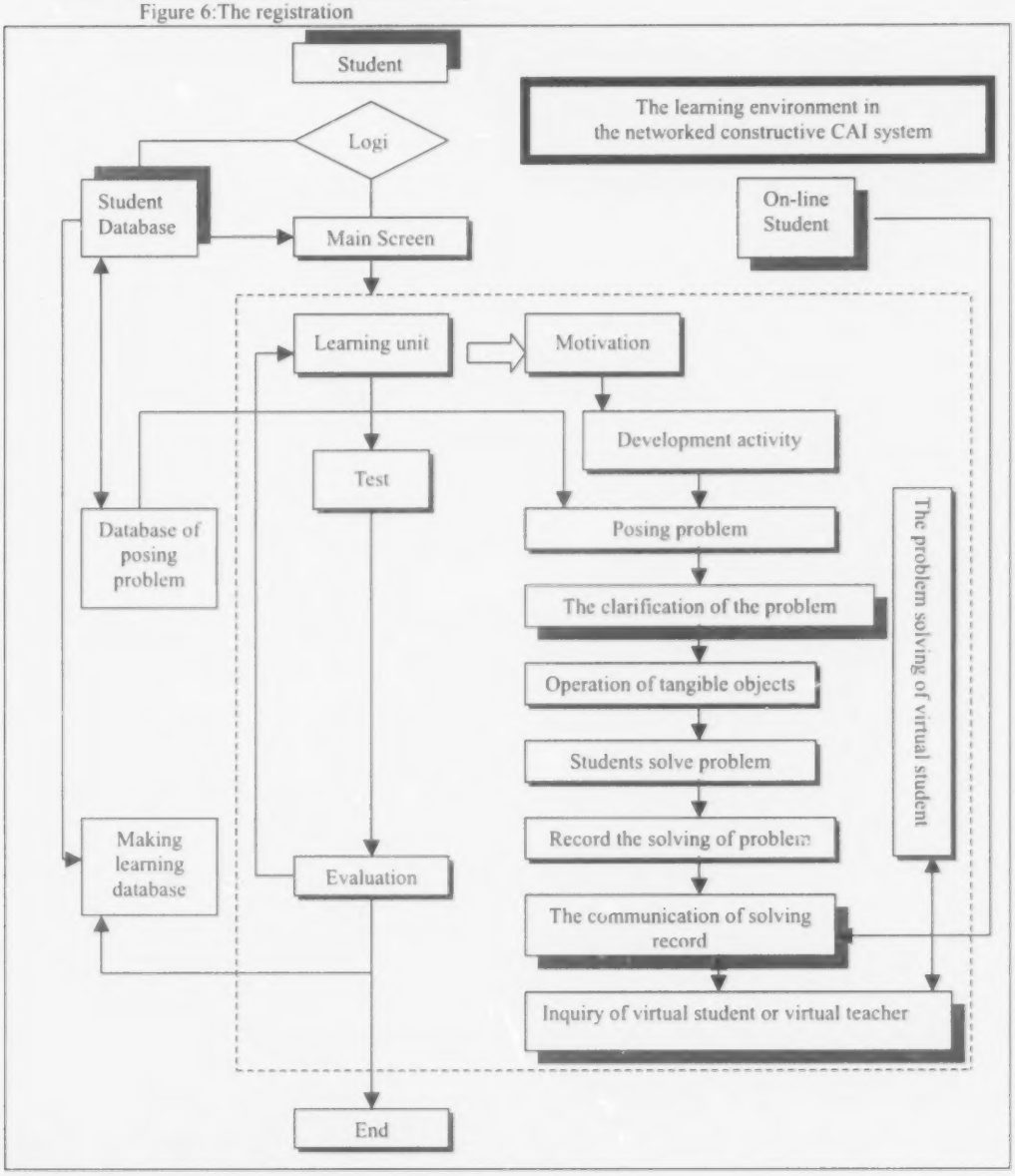


Figure 4: System flowchart

A Study on the Relation between Touch-typing Skill and Thinking-typing

Yuji YOHINAGA* and Hiroaki KAWABATA**
The Graduate School of System Engineering, Okayama Prefectural University
111 Kuboki, Soja, Okayama, 719-1197, Japan
*E-mail: *yoshinaga@mx3.tiki.ne.jp **kawabata@cse.oka-pu.ac.jp*

Word processor is more and more widely used as a tool of externalization and reflection of thinking in recent years in Japan. In that case, it will be necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). The experiments were made to study the relation between touch-typing skill and thinking-typing. The examinees were 46 non-computer majors of the university. The students were asked to type words or sentences appearing in their heads on 3 subjects. The touch-typing skill of the students was measured by touch-typing exercise software. The results suggested that a touch-typing speed of 2 strokes/second is necessary, at least, to type smoothly words or sentences appearing in the head. What's more, the results of the experiments suggested that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Key words **Thinking-typing, Touch-typing, Externalization, Self-evaluation, Analysis of variance**

1 Introduction

The methods for human beings to externalize their thinking are language expression, diagram expression, letter expression and so on [1]. Among these expressions, letters are widely expressed by word processors in recent years in Japan. The method of word processor's usage has been changed by the popularization of them. In other words, the method that uses a word processor to transcribe a manuscript written by handwriting, has been changed to the method that uses a word processor in the process of externalization and reflection of thinking. With the latter method, it is necessary to type smoothly words or sentences appearing in the head (hereinafter referred to as "thinking-typing"). Thinking-typing needs a certain level of typing skill. Although a number of studies have been made on typing [1][2], there are few studies on thinking-typing.

In the lesson of computer exercise at the university, the first author is raising the level of students' typing skill through touch-typing education and, at the same time, is raising the ability of the students' utilizing a word processor as a tool of externalization and reflection of thinking [4]. In the lesson, the experiments of thinking-typing by touch-typing were made to study the relation between touch-typing skill and thinking-typing. Touch-typing speed and self-evaluation of thinking-typing were adopted as the scale of thinking-typing level. The first experiment (Experiment 1) was made in July, 1999, and the second experiment (Experiment 2) was made in February, 2000. In this paper, results regarding Experiment 2, and comparison between Experiment 1 and Experiment 2 are reported, because results regarding Experiment 1 had been reported already [1][4].

2 Method

The experiments of thinking-typing by touch-typing were made in the lesson of the computer exercise for the first-year students at the university. In this study, the data of 46 students, whose data of Experiment 1 and Experiment 2 were complete, were analyzed. In the experiments, the students typed the following subjects by touch-typing.

【Subjects of Experiment 1】

Subject 1 Type words that you think with *shiritori* (a Japanese word chain game). Type them by *hiragana* (Japanese alphabet). The time limit is 3 minutes.

Subject 2 Type words that you image with "university". Type them by *hiragana-kanji* (Japanese alphabet – Chinese characters) translation. The time limit is 5 minutes.

Subject 3 Type sentences of your self-introduction. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

【Subjects of Experiment 2】

Subject 1 Same as Subject 1 of Experiment 1.

Subject 2 Type words that you image with "student life". Type them by *hiragana-kanji* translation. The time limit is 5 minutes.

Subject 3 Type sentences of your impression about the lesson of the computer exercise. Type them by *hiragana-kanji* translation. The time limit is 10 minutes.

After the experiment, the students evaluated themselves on the 3 subjects. In Experiment 2, the students evaluated themselves on whether they could think out words and sentences or not (thinking evaluation), whether they could type words and sentences by touch-typing or not (typing evaluation). The evaluation standard was divided into 6 levels "very good", "good", "a little good", "a little bad", "bad" and "very bad".

The touch-typing skill of the students was measured in the lessons before and after the lesson of the experiments. The measurement content is testing typing time of entering Japanese sentences of *hiragana* (about 240 strokes) that were displayed in a monitor at random, by *romaji* (Japanese Roman characters) input and touch-typing.

3 Results and Discussion

3.1 Relation between Touch-typing Skill and Thinking-typing Speed

Touch-typing skill in Experiment 2 was divided into 4 levels under 1 minute (Level under 1 minute), between 1 minute and 2 minutes (Level of 1 minute), between 2 minutes and 3 minutes (Level of 2 minutes), between 3 minutes and 4 minutes (Level of 3 minutes). The mean and the standard deviation of thinking-typing speed in each touch-typing level are shown in **Table 1**. Thinking-typing speed in each subject was calculated by the next equation.

$$s = \frac{L}{T}$$

s Thinking-typing speed in each subject

L Typing linage in each subject*

T Time limit in each subject (minute)

* Number of letters per line, after *hiragana-kanji* translation, is 40.

Table 1. Touch-typing skill and thinking-typing speed

Touch-typing skill	Number of persons	Thinking-typing speed (linage/minute)					
		Shiritori		Imagination		Impression	
		M	*SD*	*M*	*SD*	*M*	*SD*
Level under 1 minute	6	1.13	0.25	0.65	0.16	1.07	0.14
Level of 1 minute	23	0.84	0.23	0.52	0.14	0.72	0.19
Level of 2 minutes	12	0.59	0.11	0.35	0.06	0.47	0.11
Level of 3 minutes	5	0.51	0.13	0.28	0.09	0.42	0.10
All the examinees	46	0.77	0.27	0.47	0.17	0.67	0.25

One-way analysis of variance was used to test for significant differences in thinking-typing speed among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the 3 subjects(*Shiritori* $F=12.46$, $df=3$, $p<.01$ Imagination $F=11.31$, $df=3$, $p<.01$ Impression $F=23.55$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in thinking-typing speed among the 4 touch-typing levels or not. The results are shown in **Table 2**. Homogeneity subgroup is a group of similar levels whose difference is not significant. In the 3 subjects, there were significant differences of thinking-typing speed between the level under 2 minutes and the level over 2 minutes. These results show that reaching touch-typing level under 2 minutes in Experiment 2 was one of the conditions to type smoothly words or sentences appearing in the head.

Tabel 2. Tukey's multiple comparison of thinking-typing speed

	Touch-typing skill	Number of persons	Homogeneity subgroup		
			Gr1	Gr2	Gr3
Shiritori	Level under 1 minute	6	1.13		
	Level of 1 minute	23		0.84	
	Level of 2 minutes	12		0.59	0.59
	Level of 3 minutes	5			0.51
Imagination	Level under 1 minute	6	0.65		
	Level of 1 minute	23	0.52	0.52	
	Level of 2 minutes	12		0.35	0.35
	Level of 3 minutes	5			0.28
Impression	Level under 1 minute	6	1.08		
	Level of 1 minute	23		0.72	
	Level of 2 minutes	12			0.47
	Level of 3 minutes	5			0.42

p .05 *f*

3.2 Relation between Touch-typing Skill and Self-evaluation of Thinking-typing

Self-evaluation of Experiment 2 was divided into positive self-evaluation and negative self-evaluation to study the relation between self-evaluation and touch-typing skill. Positive self-evaluation is "very good", "good" and "a little good". Negative self-evaluation is "a little bad", "bad" and "very bad". As for self-evaluation point, positive self-evaluation is 1 point, and negative self-evaluation is 0 point. The mean of self-evaluation point of each touch-typing level is shown in **Table 3**.

Table 3. Touch-typing skill and self-evaluation

Touch-typing skill	Number of persons	Self-evaluation point					
		Shiritori		Imagination		Impression	
		Thinking	Typing	Thinking	Typing	Thinking	Typing
Level under 1 minute	6	0.50	1.00	0.17	1.00	1.00	1.00
Level of 1 minute	23	0.61	0.96	0.52	0.96	0.74	0.96
Level of 2 minutes	12	0.67	0.75	0.42	0.83	0.83	0.75
Level of 3 minutes	5	0.40	0.60	0.40	0.40	0.80	0.40
All the examinees	46	0.59	0.87	0.43	0.87	0.80	0.85

One-way analysis of variance was used to test for significant differences in self-evaluation point among the 4 touch-typing levels. As a result, touch-typing skill had main effect in the typing evaluation of imagination and in the typing evaluation of impression (typing evaluation of imagination $F=5.11$, $df=3$, $p<.01$ typing evaluation of impression $F=4.86$, $df=3$, $p<.01$). What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences about the typing evaluation of imagination and the typing evaluation of impression among the 4 touch-typing levels or not. The results are shown in **Table 4**. Typing evaluation of Level of 3 minutes in imagination was significantly lower than other touch-typing levels, and typing evaluation of Level of 3 minutes in impression was significantly lower than Level under 1 minute and Level of 1 minute. These results show that the students of Level of 3 minutes could not type smoothly imagination or impression, comparing with the students of other touch-typing levels.

Table 4. Tukey's multiple comparison of self-evaluation

	Touch-typing skill	Number of persons	Homogeneity subgroup	
			Gr1	Gr2
Typing evaluation of imagination	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.83	
	Level of 3 minutes	5		0.40
Typing evaluation of impression	Level under 1 minute	6	1.00	
	Level of 1 minute	23	0.96	
	Level of 2 minutes	12	0.75	0.75
	Level of 3 minutes	5		0.40

p .05 *f*

3.3 Relation between Learning of Touch-typing Skill and Change of Thinking-typing Speed

The mean of learning ratio of touch-typing skill and the mean of change ratio of thinking-typing speed in each touch-typing level of Experiment 2 are shown in **Table 5**. Learning ratio and change ratio were calculated by the next equation.

$$\alpha = \frac{T1}{T2} \qquad \beta? \frac{s1}{s2}$$

α Learning ratio of touch-typing skill
$T1$ Touch-typing time of Experiment 1 (minute)
$T2$ Touch-typing time of Experiment 2 (minute)
β Change ratio of thinking-typing speed
$s1$ Thinking-typing speed of Experiment 1 (linage/minute)
$s2$ Thinking-typing speed of Experiment 2 (linage/minute)

Two-way analysis of variance was used to test for significant differences in the 4 touch-typing levels and the 3 subjects about change ratio of thinking-typing speed in Table 5. As a result, main effect of the 3 subjects was significant($F=4.14$, $df=2$, $p<.05$). Main effect of the 4 touch-typing levels and interaction were not significant. What's more, Tukey's multiple comparisons test was applied to identify whether there are significant differences in change ratio of thinking-typing speed among the 3 subjects or not. As a result, there were significant differences of change ratio of thinking-typing speed between Subject 3 and other subjects. Next, correlation between learning ratio of touch-typing skill and charge ratio of thinking-typing speed is shown in Table 6. A moderate significant positive correlation was observed between learning ratio of touch-typing skill and change ratio of thinking-typing speed in Subject 3. So it can be said that learning of touch-typing skill is very effective on the increase of thinking-typing speed of Subject 3. What is the qualitative difference between Subject 3 and other subjects? It is the easiness of thinking. Thinking evaluation point in Table 3 expresses the easiness of thinking in each subject. Thinking evaluation point of impression (Subject 3) is higher than other subjects. So it is considered that words of impression (Subject 3) was easier to be thought out than other subjects. Therefore, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

Table 5. Learning ratio of touch-typing skill and change ratio of thinking-typing speed

Touch-typing skill	Number of persons	Learning ratio of touch-typing	Change ratio of thinking-typing speed		
			Subject	Subject 2	Subject 3
Level under 1 minute	6	1.69	1.35	1.61	2.03
Level of 1 minute	23	1.58	1.24	1.47	1.93
Level of 2 minutes	12	1.57	1.18	1.57	1.61
Level of 3 minutes	5	1.50	1.89	1.47	1.80
All the examinees	46	1.58	1.31	1.51	1.84

Table 6. Correlation between learning ratio of touch-typing skill and change ratio of thinking-typing speed

	Change ratio of thinking-typing speed		
	Subject	Subject 2	Subject 3
Learning ratio of touch-typing	0.245	0.089	0.565**

**p .01 f

4 Conclusion

From what has been discussed about the relation between touch-typing skill and thinking-typing speed, and relation between touch-typing skill and self-evaluation of thinking-typing, it can be concluded that a touch-typing level under 2 minutes is necessary, at least, to type smoothly words or sentences appearing in the head. The speed of 240 strokes in 2 minutes equals 2 strokes/second. 2 strokes are needed to input a *hiragana*. So the speed of 120 *hiragana* in 2 minutes equals 1 *hiragana*/second. The aim of touch-typing education for thinking-typing should be set at 2 strokes/second (1 *hiragana*/second). What's more, from what has been discussed about the relation between learning of touch-typing skill and change of thinking-typing speed, it can be concluded that learning of touch-typing skill is very effective on the increase of thinking-typing speed of the subject that is easy to be thought out.

References

[1] Y. Saeki, "New Computer and Education", Iwanami Sinsyo, pp.104-105 (1997).

[2] T. Ohno, "The Effect of the Typing Skill for the Typing Process", Research Report of Information Processing Society of Japan(Human Interface), 63-6, pp.31-36 (1995).

[3] C. Kogo, "Use of electronic mail in assignments, term paper and final examination in college courses, and relationships between grades of them and typing skill", Research Report of Japan Society for Educational Technology Conferences, 96-4, pp.1-4 (1996).

[4] Y. Yoshinaga and H. Kawabata, "Touch-typing education in considering of self-evaluation", Proceedings of the 2000 IEICE General Conference(Information and System 1), p219(2000).

[5]Y. Yoshinaga and H. Kawabata, "A Experiment Report about Thinking-Typing by Touch-Typing", Proceedings of the Federation of Cyugoku Branch Electronics and Information 1999, pp.366-367(1999).

[6]Y. Yoshinaga and H. Kawabata, "A Study on the Effect of Touch-Typing Skill for Thinking-Typing", Advanced Research in Computers and Communications in Education(2), pp.833-834(1999).

An Assessment Framework for Information Technology Integrated Instruction

Chuan-Shih Wang* and Chia-Chin Li**
The Institute of Information and Computer Education, National Kaohsiung Normal University
116, Heping 1st Rd., Kaohsiung, Taiwan, R.O.C.
** jason@icemail.nknu.edu.tw **april@ icemail.nknu.edu.tw*

Information technology integrated instruction is the education tendency in the future, and it is also an important issue in the development of education in Taiwan. An assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference. This article proposes an framework for assessing information technology integrated instruction. The framework includes kernel and periphery parts. Kernel part refers to the whole teaching process, including information technology, curricula, learning materials, instructional strategies, learning activities, and evaluation. Periphery part refers to the surroundings situation, including teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

Keywords: **information technology integrated instruction, technology integration, educational technology, evaluation**

1 Introduction

The rapid development of information technology (IT) has not only brought about major effect on economy and industry but also made a great impact on society and education. In particular, the prevalent use of computers and the rapid development of the Internet have gradually changed our life style and pattern, with their impact on education being unprecedented. Many educators and policy makers believe that technology can be a catalyst for educational reform [3,4,10]. They suggest that the use of technology in classrooms will shift the roles of teachers and students. Teachers will act more like facilitators by helping students access information, process it, and communicate their understanding [4].

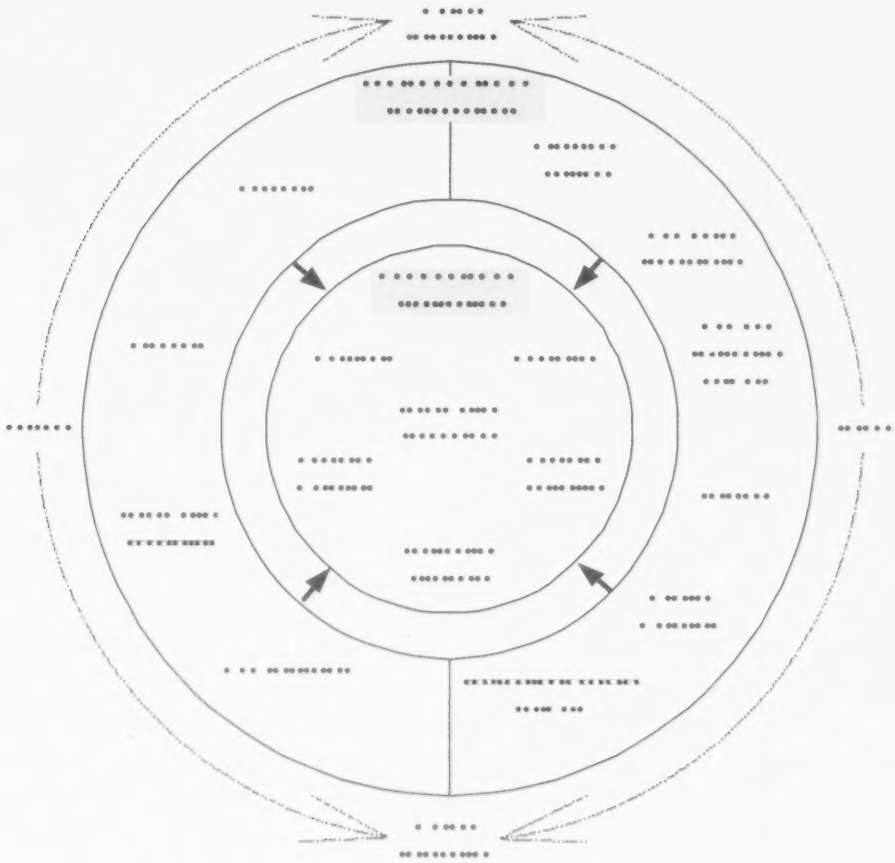
Beginning the 2001 academic year, Taiwan will implement phase-by-phase the nine-year integrated curriculum for its elementary and junior high schools [11]. To cultivate students' basic ability to "apply technology and information", the new curriculum will have to emphasize integrating IT into the teaching of various courses. Amid this major reform of curriculum, the Computer Center of the Ministry of Education has planned for the integration of information curriculum with other areas of learning [7]. At the same time, it has selected 18 elementary and junior high schools in which teaching experimentations will be carried out [1]. Therefore, an assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference.

2 The essence of information technology integrated instruction

The United States has implemented IT integrated instruction for years. Many educators are now actively using technology along with effective teaching strategies to integrate technology into their curriculum [9]. In contrast, IT integrated instruction is still a newly heard noun in Taiwan. Many teachers are unfamiliar with it, and some think of it as another name for computer-assisted instruction (CAI). Information technology has

developed rapidly, and the role of IT in education has changed over these years, from being an auxiliary to teaching to being an indispensable tool of education. Therefore, IT integrated instruction is distinguished from CAI.

In IT integrated instruction, information technology is an indispensable tool in the teaching environment because it is integrated into the curriculum, learning materials, teaching and learning [2]. Moreover, the traditional curriculum, materials, and teaching are transformed through the characteristics of information technology: the subject-based curriculum and materials become student-based; the teacher-driven teaching activities become student-centered. Information technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. It is not something one does separately; it is part of the daily activities taking place in the classroom [3].



F

igure 1. The assessment framework for information technology integrated instruction

Figure 1 depicts the assessment framework of IT integrated instruction. The assessment framework consists of two major parts: Kernel Part and Periphery Part. The kernel part primarily assesses the whole teaching process. Because the implementation of IT integrated instruction will bring about changes to teaching, the aspects to be assessed in this part should include not only the use of IT in teaching but also other perspectives of teaching: curricula, learning materials, instruction strategies, learning activities, and evaluation. The periphery part primarily assesses the teaching environment, learning resources, information equipment, personnel qualities, and administrative as well as professional support. All these factors will influence the outcome of teaching. In particular, IT integrated instruction is in need of supportive and coordinated environmental conditions. There are many perspectives of the periphery part that are related

with IT integrated instruction, and ten of them are carefully identified and included for assessment: teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

3 Assessing the kernel part

The kernel part refers to the whole teaching process, and Table 1 shows the perspectives and emphases to be assessed. The aspects of the kernel part are illustrated in the following paragraph.

Table 1. Emphases of the kernel part to be assessed

Perspective	Emphasis
Information technology	The use and role in instruction
Curricula	Subject-based separate curricula or Student-centered integrated curricula
Learning materials	Sequential or problem-based
Instructional strategies	Traditional expository approach or constructivist approach
Learning activities	Teacher-driven or student-centered
Evaluation	Traditional paper-and-pencil testing or multiple assessment

3.1 Information Technology

Information technology may refer to equipment or products, such as computers, network, peripherals, etc. It may also refer to the methods or processes in which the equipment of IT is used to help with the solution of problems. It is the purpose of implementing IT integrated instruction not only to enable students to use the equipment or products of IT but also to use the IT equipment to solve practical problems in learning and life.

In this perspective, we care about how IT is used in teaching and what role IT plays in teaching. The level of the use and role in instruction is developed:

- Nil (level 0): IT is not used and plays no part in teaching.
- Isolation (level 1): IT is used to teach students how to use IT (e.g. keyboarding, drill-and-practice, word-processing activities). There is no or little connection between IT and instruction content.
- Supplement (level 2): Teachers use IT to assist instruction and students use IT to aid learning occasionally. IT is viewed as a supplement to existing instructional program.
- Support (level 3): IT is needed to complete most learning activities. IT serves as a support to instruction.
- Integration (level 4): Students and teachers can use IT in every-day learning/teaching naturally, confidently, and actively. IT is expansively viewed as tool, process, method to find solutions to authentic problems in any time anywhere.

3.2 Curricula

For elementary and junior high schools, the curricular idea should be life-centered and be in compatible with the development process of students' physical and mental abilities; respect character development, inspire individual potential; cultivate civic qualities, respect the value diversified culture system; enhance science knowledge and skill, meet the requirements of modern life. The design of curriculum should be based on students, on practical experience, and devoted to cultivating the basic abilities required of modern citizens [11]. Therefore, the curriculum should be designed as student-centered integrated or interdisciplinary curriculum, not subject-centered separate curriculum.

IT is used as a tool to help students solve the problem. IT literacy should not be taught as an isolated subject, nor should activities with IT be isolated from other activities in the classroom [12]. Therefore, Taking the students to the computer lab once a week for 40 minutes is not necessarily integration [3]. The teachers should commit to designing student-centered integrated curriculum and integrate IT into the curriculum.

3.3 Learning Materials

Textbooks are the main materials for elementary and junior high schools and the primary learning materials of students. In traditional education, textbooks were unified, having only one version. They were based on subject systems and separate from students' living experience. Besides, it was difficult to innovate them,

they could not meet society's requirements for rapid transformation. In 1996 Taiwan implemented a policy which would partially allow publishers to edit and provide textbooks for elementary and junior high school so long as they are approved by the Ministry of Education. On February 3, 1999, VIII (2) of National Education Act was empowered, which unequivocally directs the full use of ministry-approved textbooks for elementary and junior high schools. A new epoch for textbooks was thus heralded in. Teachers should be able to exert their professional autonomy, and students should be allowed a flexible, autonomous learning leeway.

The presentation of learning materials should not be limited to static traditional books, but the characteristics of computer multi-media should be used to present these materials. Static words and pictures, animated pictures and films, voice, acoustic effect and music in combination would make teaching materials lively and motivate students to learn. Besides, they can help students to understand abstract concepts or knowledge and enhance learning effectiveness. If hyperlink technology is used, nonlinear learning materials can be designed so that what students see can be highly individual and not the same. As such, the content of learning materials is flexible, adaptive to individual difference, and compatible with the spirit of individualized learning.

In addition to textbooks, there are many resources on the Internet that can be used as learning materials. These resources can provide "instant", "living" information [8]. Teachers not only can search for information to be included in teaching materials but also can use the real-time information on the Internet to conduct teaching. Students not only can search for information on the Internet but also can conduct independent learning any time, any place by using the learning materials on the Internet.

The use of information technology can make learning materials diversified and lively, make their content flexible and integrated with life. Not only can teachers easily motivate students to learn, but students also can learn happily in a rich teaching situation.

3.4 Instruction Strategies

The teaching strategy of the traditional expository approach is teacher-centered. Students learn what is taught by the teacher, but are given a limited room for thinking, discussion, presentation and exploration. The teaching effectiveness is ostensibly good, and students' performance on examination seems impressive. Yet this approach contradicts the essence of education. In a series of meaningless learning process, what students learn is segmented memory that is extraneous to their experience and cannot be applied in practical situations of their daily life. Nor can they enjoy learning.

Constructive teaching strategy is student-centered. The teacher would first arrange a teaching situation to arouse students' motivation for learning and then would conduce students to explore and think. Through the interaction with peers, the students can gradually integrate the new knowledge into their own system of knowledge and make it an essential part of this system. By this constructive teaching, students must actively learn, while the teacher can only play the role of facilitator, auxiliary, and consultant.

When students use teaching software and browse for Internet resources, they must explore and think actively and construct their own knowledge through the interaction between machine and person and through social interaction. Therefore, the teacher is a "coach" for the student rather than a provider of knowledge. Self-directed learning is an attainable goal for both the student and teacher when IT is integrated in the various content areas [6]. That is, IT integration is most likely to occur in learner-centered classrooms in which the teacher acts as a facilitator [3].

3.5 Learning Activities

Traditional lecture-based and teacher-driven activities can no longer satisfy the needs of modern education. It is not only monotone, also lacks interaction between peers. Learning activities should be student-centered so that the learner can actively work to explore knowledge, clarify concepts, and gradually construct his/her system of knowledge. In addition, project-based and cooperative learning activities should be adopted to allow the learner the opportunity to produce high-level interaction with his/her peers. These activities not only can cultivate a respectful, responsible, and confident attitude and the abilities to express, communicate, coordinate, think, and create but also can increase learning effectiveness.

In cooperative learning activities, students can use computer to communicate and discuss, or use a certain

support cooperative work software to facilitate collaboration. Finally, multi-media would be used to present the learning effectiveness of students. Cooperative learning is not limited in local class. It can also be applied across schools, countries, and culture. Therefore, IT enriches the learning activity.

3.6 Evaluation

The traditional evaluation approach primarily depends on paper examinations and determines learning outcome by the scores on the test sheets. This type of evaluation measures only a dimension of knowledge, unable to reflect the wide spectrum of learning process. Future evaluation will become diversified; performance evaluation may be conducted along with paper evaluation; students' self-evaluation, peer evaluation and juried evaluation may be conducted along with teacher' s evaluation; in addition to evaluating learning outcome, the learning process should be evaluated; in addition to quantitative evaluation, qualitative evaluation should be adopted; in addition to evaluating cognitive domain, the evaluation of affective and skill areas should be included. Only such a comprehensive evaluation can re flect the learning process, not only be able to understand what the student has learned but also be able to understand how the learning has occurred.

IT integrated instruction is helpful to the implementation of diversified evaluation. For example, the electronic portfolio is an ideal means of integrating IT into the instruction. It gives the student and teacher an alternative form of assessment. Furthermore, electronic portfolios motivate students to produce quality work, and they also increase students' self-esteem by showcasing their best work [6].

4 Assessing the periphery part

The periphery part primarily refers to the surrounding situations. Table 2 shows the perspectives and emphases to be assessed. The following illustration is based on perspectives.

4.1 Teachers

The teacher is vital in leading teaching activities. Without sufficient information literacy and professional ability, he or she cannot apply information technology on teaching, let alone implement IT integrated instruction. Regarding professional ability, the teacher should be able to integrate IT, in addition to assessing software and digital materials. The attitude is another emphasis of assessment. If the teacher has a positive attitude toward computer, he/she can readily introduce and apply computer on teaching; if the teacher can accept the change in teaching status and role, the implementation of IT integrated instruction would not cause a great impact.

4.2 Students

Students are the chief character in education. In teaching, students should take the initiative to construct their own knowledge. In implementing IT integrated instruction, students can obtain from the process related knowledge and skill and steadily strengthen their information disposition. Gradually students should be able to use, naturally and confidently, computer equipment in active learning and to construct their system of knowledge.

4.3 Information specialists

Teachers are not information specialists. In extensive application of IT to teaching, they will definitely encounter many technical problems that can not be solved by them. In this case, information specialists can support teachers in solving such problems. It is much easier for information specialists with education background to integrate IT with education and guide classroom teachers to implement IT integrated instruction.

4.4 Administrators

Whether administrators feel important about IT integrated instruction is intimately related with the implementation of IT integrated instruction. In addition, if the classroom teacher can gain sufficient administrative support, he or she will be more willing to implement IT integrated instruction.

4.5 Classroom Settings

Generally speaking, teaching activities are conducted indoors. Therefore, the IT equipment in classroom is indispensable to the integration of IT into teaching [14]. The computer and peripherals should not be outdated. The operation system and application software installed in the computer should be appropriate for the use by students and suit the needs of teaching. Moreover, for a class of more than 10 students, a large display device or broadcasting teaching equipment is needed. Finally, it matters whether they are managed properly or whether the fair use by students is ensured.

Table 2. Emphases of the periphery part to be assessed

Perspective	Emphasis
Teachers	Information literacy and professional competency Attitude toward information technology and instructional change
Students	Information literacy Attitude toward information technology
Information Specialists	Professional competency Support for teacher
Administrators	Attitude toward information technology integrated instruction Support for teacher
Classroom Settings	Number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripherals (e.g. printer, scanner, digital camera) Broadcasting teaching facilities Management
Computer Laboratories	Number of computer labs, number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripheral (e.g. printer, scanner, digital camera) Broadcasting teaching system Management
Campus Instruction Network	Structure of campus network and network type Domain account File server and database server CD cabinet (perhaps made possible through software simulation)
Internet	Method and speed of Internet connection Actual connection speed Internet server (e.g. web server, proxy server, DNS server, mail server) The mechanism to filter out inappropriate information.
Digital Materials	Digital materials that can be used on the Internet Digital materials created by the teacher
Instruction/Learning Software	Quantity Adaptation

4.6 Computer Laboratories

In a situation in which IT is integrated into teaching, sometimes it is required that one person have one machine. Computer laboratories can justly meet this requirement. Therefore, the management of computer laboratories is an important assessment item and can decide whether the computer equipment can sufficiently support classroom teachers [14]. Moreover, computer laboratories can also provide the most appropriate places for teachers' advancement and students' training of information skill. The equipment in the computer laboratories should not be outdated. Furthermore, there must be a broadcasting system, enabling students to know the whole content of teacher' s lecture in a ready manner.

4.7 Campus Instruction Network

The planning and erection of campus instruction network aims not only to construct an instruction network on campus but also to enable every classroom on campus to connect to the Internet through the campus

network. After the campus network is erected, File Server and CD cabinet (perhaps made possible through software simulation) should be erected, in which the teaching software owned by the school is stored so that all the teachers of the school can access to it readily and can apply it to teaching. In addition, the establishment and management of network account is equally important, ensuring the safety of information [14].

4.8 Internet

There are unlimited, un-exhaustive teaching resources on the Internet. If computers can not be connected to the Internet, the application of IT to teaching is compromised. Therefore, it is very important to provide information settings of the Internet. In addition, it is needed to erect Internet-related Server, in particular, Web Server must be erected so that teachers' teaching information and the learning outcome of students can be stored on it to facilitate examination and simulation by teachers and students. Besides, Internet is full of erotic and violent information which is unsuitable to students. It is extremely important to build a mechanism to prevent students from seeing those inappropriate content [14].

4.9 Digital Materials

Digital materials may be presented through information equipment and be used in teaching activities. Therefore, plentiful digital materials should be able to help integrate IT into teaching of various subjects. Therefore many on-line materials on the Internet can be used for teaching purpose. To decrease the amount of time required for browsing and facilitate the use of the materials by teachers and students, on-line index and search systems are also required. In addition, if on-line materials are not appropriate for teaching needs, classroom teachers may create their own materials to be presented on information equipment or use materials created by colleague teachers with the approval from the original designer [14].

4.10 Instruction/Learning Software

Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) software is a help to teaching and learning. With more software, teachers are better equipped to apply IT to teaching. This software should be stored on the CD cabinet or File server on the campus network so that teachers can readily use it whenever needed. In addition, if existing teaching software available on campus is evaluated, further information can be provided to teachers [14].

5 Conclusions

That teachers and students can extensively use computers for teaching or learning purpose to heighten teaching qualities and learning effectiveness is the ultimate goal of the infrastructure construction of information education [5]. In other words, integrating computer into teaching of various subjects is the ultimate goal of the Ministry of Education in promoting information teaching [13]. What IT integrated instruction means is not merely to assist teaching by computer but work to integrate IT into curriculum, learning material and learning activities. At this point, the role of teachers begins to transform, from that of a main character to that of a support character. Therefore, the implementation of IT integrated instruction not only harmonizes with the u ltimate goal of information education but also prompt the reform of education so that learning becomes more effective, efficient, and meaningful.

IT cannot be successfully integrated overnight. It needs to take years to complete the process. The process should be carried out in order, stage by stage. Taiwan's IT integrated instruction is germinating. The assessment framework set forth in this article can be used not only to carry out practical evaluation but also serve as reference for development. Teachers' in-service education, pre-service training, administrative support, enriching IT equipment, developing appropriate digital materials and teaching software should be taken to strengthen the perspectives of the periphery part and to diversify the surroundings so that teachers can realize the benefits brought about by IT on education, Accordingly, teachers can apply IT to teaching, gradually infuse IT into learning activities, curricula, learning materials, and adopt student-centered teaching strategies and multi-facet evaluation. All this can lead to the fulfillment of the meanings of IT integrated instruction.

References

[1] Chang, H. Y., "1999 review of implementation of infrastructure construction plan for information education by the Ministry of Education", Ministry of Education Computer Center newsletter, No. 8810, pp. 1-8, (1999).

[2] Chiu, K. H., "Concepts and methods of computer-integrated instruction", Taiwan Education Review, No. 479, pp. 1-8, (1990).

[3] Dias, L. B., " Integrating technology: Some things you should know", Learning & Leading with Technology, Vol. 27, No. 3, pp. 10-13, 21, (1999)

[4] Dexter, S. L., Anderson, R. E., & Becker, H. J., "Teachers' views of computers as catalysts for changes in their teaching practice", "Journal of Research on Computing in Education", Vol. 31, No. 3, pp. 221-239, (1999).

[5] Han, S. M., "Infrastructure construction of information education – acceleration", Information and Education, No. 68, pp. 14-16, (1998).

[6] Hanfland, P., "Electronic portfolios: Students documenting their best work", Learning & Leading with Technology, Vol. 26, No. 6, pp. 54-57, (1999).

[7] Her, J. K., "Viewing the prospects of information education in elementary and junior high schools from the promoting strategy of information education of the Ministry of Education", Information and Education, No. 68, pp. 2-13, (1988).

[8] Lee, C. M., Wu, C. J., & Lin, M. C., "Erection of information education software and material resources center", Information and Education, No. 68, pp. 21-28, (1998).

[9] Levine, J., "Planning strategically for technology integration", Proceedings of Technology and Teacher Education Annual 1998 (SITE '98), Charlottesville, VA, pp. 293-295, (1998).

[10] Mehlinger, H., "School reform in the information age", Phi Delta Kappan, No. 77, pp. 400-407, (1996).

[11] Ministry of Education, "Tentative Guideline for Nine-year Integrated Curriculum for Elementary and Junior High Schools (first learning stage)", http://teach.eje.edu.tw (accessed on April 13, 2000).

[12] Sprague, D. & Dede, C., "If I teach this way, am I doing my job: Constructivism in the classroom", Learning & Leading with Technology, Vol. 27, No. 1, pp. 6-9, 16-17, (1999).

[13] Tu, A. P. & Lin, H. H., "Accelerating the infrastructure construction of Taiwan's information education: Alternative for expanding internal demand – special interview of Chen Li-hsiang, director of computer center of the Ministry of Education", Information and Education, No. 68, pp. 29-32, (1998).

[14] Wang, C. S., "Criteria for assessing information situation of information technology integrated instruction", Information and Education, No. 77, pp. 36-47, (2000).

Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming

Jun MORIYAMA
Department of Information and Technology Education,
Faculty of Education, Shinshu University
6 Nishinagano, Nagano City, Nagano, 380-8544, JAPAN
Phone: +81-26-238-4175
Facsimile: +81-26-232-5144
E-mail: junmori@gipwc.shinshu-u.ac.jp

The purpose of this study was to clarify the cognitive effects of collaborative learning on Junior high school students' Logo programming. Two experiments were implemented: *Experiment1* was an analysis of the relationships between interaction in pair activities and students' reflection. The effects of pair learning on students' promoting abilities of programming were analyzed in *Experiment2*. As the results of *Experiment1*, students' self-monitoring and self-control were supplemented each other through the interaction. Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

Keywords: **Collaborative Learning, Junior High School Students, Cognitive Effects, Logo Programming**

1 Introduction

In Japan, education about computer programming was placed in *Fundamentals of Information* of *Industrial Arts* at junior high school level from 1989. From 2002, programming, sensing and control will be placed in *Information and Computer* of *Technology* as an elective learning content (*Course of Study* published in 1998)[5]. Many technology teachers in Japan thought that teaching programming was not only for professional higher education. They didn't made points of understanding the function of software upon a computer system, but acquiring the problem solving skills through the programming activities.

Historically, many researchers suggested that one of the methods for acquiring the problem solving skills was collaborative learning. It was necessary for students to communicate and interact with someone who had same goal in collaborative environment (Deutsch 1949)[1]. In the recent past, it was supported that the experiences of solving the problem through the interaction made the processes of planning and decision making clearly each other, and would promote their self-control and self-monitoring when they would solve another problem all by themselves (SATOU 1996)[3]. In the case of learning about programming, KAGE (1997) suggested that 12-year old pupils showed vigorous verbal interaction, which led them to more sophisticated problem solving [4].

From these findings, it was predicted that acquiring the problem solving skills brought to promote students' programming abilities as a result of cognitive effects of collaboration.

The purpose of this study was to clarify the cognitive effects of collaborative learning on students' programming. For this purpose, two experiments by using Logo programming (Japanese Edition) were implemented. The aim of *Experiment1* was to clarify the relationships between interaction of collaborative learning processes and learners' reflection. The effects of collaborative learning on students' promoting abilities of programming were analyzed in *Experiment2*.

2 Methods

2.1 Experiment1

2.1.1 Subjects

Twelve 3rd grader Jr. high school students (6 males and 6 females) were divided into 6 pairs.

2.1.2 Instruments

"The Reflection Scale of Thinking Process on Computer Programming: RSTC"(MORIYAMA et al 1996) [2] and the modified LUTE (Link-UniT-Element) model (MORIMOTO et al 1997) [6] were used for measuring the level of reflection and analyzing the interaction, respectively. The RSTC was constructed from 4 factors as in Fig.1. Factor1 was the reflection of understanding the problems and enterprising how to make the program adequately. Factor2 was the reflection of designing the program and coding. Factor3 was the reflection of self-monitoring on each parts of the program on the local level. Factor4 was the reflection of self-monitoring on the whole program and renewal of problem representation.

Factor1 (6 items)	**Factor2** (6 items)	**Factor3** (5 items)	**Factor4** (3 items)
Semantic understanding of the problem	Setting up the keywords	Predicting the result of running	Analyzing the bug
Imaging the command and grammar	Division of the program	Testing walk through the list	Renewal of problem representation
Comprehending the image of program	Setting up the functional unit	Checking the clerical error	Seeking the bug
Rhetorical understanding of the program	Connecting the functional unit	Checking the syntax error	
Seeking the semantically-related knowledge	Coding the functional unit	Checking the logical error	
Seeking the rhetorically-related skill	Checking the sequences of each commands		

Fig.1 The Reflection Scale of Thinking Process on Computer Programming: RSTC

The modified LUTE model was shown in Fig.2. There were categories for analyzing interaction of collaborative learning in this model, and this model had three abstract levels: element, unit and link level. The items of element level were categories for functions of protocols. The unit and link level categories were for phases and contexts in their programming activities.

Element Level (5 categories)	**Unit Level** (6 categories)	**Link Level** (6 categories)
Proposed	Phase of Analysis	Link for Formation of plan
Agreement	Phase of Plan	Link for Modification of plan
Question	Phase of operation	Link for Implementation of plan
Opposition	Phase of Edit	Link for Check of Implementation
Supplementary explanation	Phase of Checking the program list	Link for renewal of plan
	Phase of Checking the result of running	Link for renewal of implementation

Fig.2 The modified LUTE (Link-UniT-Element) model

2.1.3 Procedures

Subjects were asked to make the Logo program which draw the "*House*" constructed from triangular shapes, square patterns, circles and lines in pair. Their activities were recorded on a VTR. After they finished the task, they answered RSTC individually. Their protocols were extracted from the VTR and were categorized by using modified LUTE model. The level of reflection and the relative interaction in the collaborating pair were analyzed by ANOVA on mean scores of frequencies of link level categories and Coefficient of Correlation (r) between the RSTC scores and frequencies of the element and unit level categories.

2.2 Experiment2

2.2.1 Subjects

Sixty 3rd grader junior high school students (30 males and 30 females) were divided into 2 groups learning Logo programming. One was collaborative learning group (pair), and the other was individually learning group.

2.2.2 Instruments

The achievement tests and the RSTC were prepared. The achievement tests included both the coding test and the debug test. The coding test asked to make a program drawing "*Scarecrow*" on an answer sheet. The debug test asked to find three types of error, clerical error, syntax error, logical error from the program list which drew "*Spaceship*".

2.2.3 Procedures

The procedure was shown in Fig.3. At first, subjects had a coding test which draws the easy "*flag*" as a pre-test. Next, subjects were asked to make the program, which draws the "*House*" such as *Experiment1* and answered RSTC in every group as a middle-test. Finally, they had the achievement tests and answered RSTC individually as post-tests. The effects of collaborative learning on students' promoting abilities of programming were analyzed by using ANOVA and Coefficient of Correlation (r) between the RSTC scores and the Achievement tests' scores.

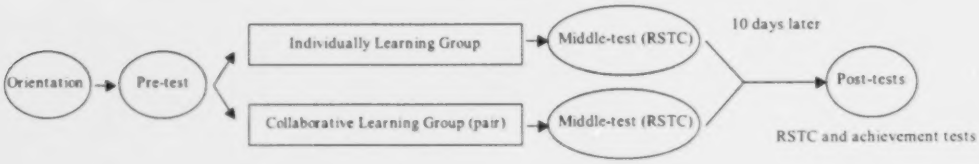


Fig.3 The procedure of *Experiment2*

3 Results and Discussion

3.1 Experiment1: Students' Reflections and Collaborative Programming

3.1.1 Contexts of Collaboration in the Pair Activities

There were differences of period of keyboard operation time in pair activities. In this analysis, long-operated learners were called *Learner A*, and the others (short-operated) were called *Learner B*. Mean scores of frequencies of link level categories were shown in Table.1.

Table.1 Frequencies of link level categories

Link Level Categories	Mean Score (S.D.)				ANOVA
	Learner A to B	*Learner B to A*	*Learner A to A*	*Learner B to B*	
Link for Formation of plan	1.75 (1.04)	2.00(1.77)	1.63(1.41)	3.50(2.73)	*n.s.*
Link for Modification of plan	3.35(2.12)	2.50(1.93)	0.25(0.46)	0.13(0.35)	$F(3,24)=8.397$, $p<.01$
Link for Implementation of plan	1.88(2.70)	15.63(5.80)	5.88(3.40)	2.75(2.49)	$F(3,24)=21.732$, $p<.01$
Link for Check of Implementation	3.75(1.49)	1.13(1.36)	1.00(1.07)	0.13(0.35)	$F(3,24)=13.055$, $p<.01$
Link for renewal of plan	0.38(0.52)	0.38(0.74)	0.13(0.35)	0.63(0.52)	*n.s.*
Link for renewal of implementation	0.63(0.92)	1.25(1.28)	0.25(0.46)	0.00(0.00)	*n.s.*

Results from Two-way Repeated Measures ANOVA showed that there were significant main effects of Links for Implementation of Plan from *Learner B* to *A* [$F(3,24)=21.732$, $p<.01$], and Links for Check of

Implementation from *A* to *B* [F(3,24)=13.055, p<.01]. Also, Links for Modification of Plan with interaction (*B* to *A* and *A* to *B*) were increased than that of individually links (*A* to *A* and *B* to *B*) [F(3,24)=8.397, p<.01]. These data indicated that the role of operation (*Learner A*) and the role of planning (*Learner B*) were shared in pair activities. However, it was suggested that consensus decision making through the interaction was important for building up their programming plans.

3.1.2 The Relationships between the Interactions and the Reflections

Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories were shown in Table.2. According to these data, when *Learner A* (operator) proposed something to operate, the reflection of designing the program (Factor2) was promoted in own thinking process [*r*=0.88, p<.01]. However, when *Learner B* (planner) proposed, the reflection of self-monitoring on each parts of the program (Factor3) was promoted in *Learner A*'s thinking process[*r*=0.88, p<.01]. Furthermore, opposition by *Learner A* correlated the reflection of self-monitoring (Factor3) in *Learner B*'s[*r*=0.71, p<.05]. Also, *Learner A*'s reflection of designing (Factor2) was promoted by the opposition of *Learner B*[*r*=0.77, p<.05]. These results indicated that the verbal communications on their interaction brought out their self-monitoring and self-control each other.

Table.2 Coefficient of Correlation (*r*) between the RSTC scores and frequencies of element level categories

Element Level Categories		Factor1		Factor2		Factor3		Factor4	
		Learner A	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*
Proposed	*Learner A*	0.41	0.26	0.88**	0.41	0.52	0.13	0.06	0.06
	Learner B	0.04	0.45	0.37	0.25	0.88**	-0.33	0.50	0.31
Agreement	*Learner A*	0.00	-0.10	0.31	-0.34	0.52	-0.66	0.26	-0.20
	Learner B	0.44	0.35	0.67	0.55	0.28	0.08	0.36	0.07
Question	*Learner A*	-0.32	0.56	0.27	0.28	0.56	-0.11	0.78*	0.23
	Learner B	0.40	-0.52	0.56	-0.29	0.00	0.02	0.03	-0.31
Opposition	*Learner A*	0.03	-0.30	0.27	0.08	0.13	0.71*	0.42	0.19
	Learner B	0.12	0.19	0.77*	0.23	0.52	0.27	0.68	0.00
Supplementary explanation	*Learner A*	0.72*	-0.35	0.61	0.13	0.03	0.40	-0.15	-0.01
	Learner B	-0.01	-0.34	0.32	-0.13	0.14	0.40	0.45	0.08

n=8, df=6, **p<.01, *p<.05

In addition, Coefficient of Correlation (*r*) between the RSTC scores and frequencies of unit level categories showed that, operation by *Learner B* as a planner conduced to *Learner A*'s self-monitoring on whole program[*r*=0.85, p<.01]. Also, task analysis by *Learner A* as an operator encouraged *Learner B*'s designing of the program[*r*=0.75, p<.05]. It was evident that one's reflective thinking was precipitated by the observation of the other's behavior which was supposed to be his own behavior.

These results of *Experiment1* suggested that students' meta-cognition (self-monitoring and self-control) were supplemented each other through the interaction of collaborative pair learning.

3.2 Experiment2: Effects on students' promoting abilities of programming

3.2.1 Acquisitions of Programming Abilities

In the pre-test, there are not significant differences between the pair learning group and the individually learning group [F(1,56)=0.65, *n.s.*]. Students who could get high scores were called *higher students* and the others were called *lower students* in this analysis (both 50% and n=30). In the middle-test, mean score of RSTC in the pair learning group (0.77) was higher than that in the individually learning group (0.56) [F(1,56)=32.40, p<.01]. This result supported findings of *Experiment1* because collaborative pair learning could promote students' reflections of thinking processes.

Mean scores of debug test were shown in Fig.4. Results from the ANOVA showed that the debugging scores of syntax error in the pair learning group was higher than that in the individually learning group [F(1,56)=4.75, p<.05]. But, there were not significant differences on the debugging scores of clerical and logical errors [F(1,56)=2.06 and F(1,56)=0.89, both *n.s.*]. These results indicated that collaborative pair learning could form students' debugging abilities against syntax errors, at least.

Mean scores of coding test were shown in Fig.5. The result from the Two-way Repeated Measures of ANOVA showed that there was significant interaction between *High-Low student* condition and *pair-individually* group condition [F(1,56)=10.46, p<.01]. Furthermore, from the results of Simple Main Effects Tests, the score of *lower students* in the pair learning group was promoted to the same level as *higher students* in both groups [F(1,56)=12.56, p<.01]. These results indicated that the coding abilities of Low-Ability students could be pulled up through the interaction with High-Ability students.

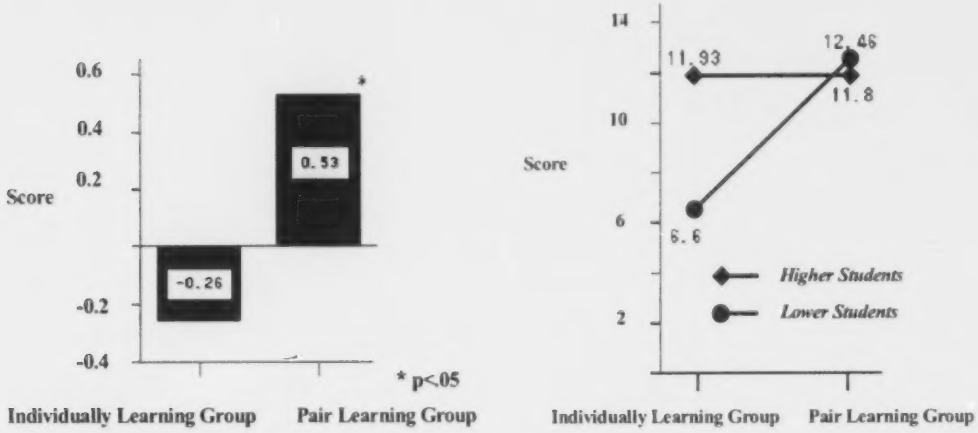


Fig.4 Mean scores of debug test (syntax error)

3.2.2 Acquisitions of Cognitive Strategies

Coefficient of Correlation (*r*) between the RSTC scores and the achievement tests were shown in Table3. According to these data, there were significant correlation between the coding test and the RSTC items: "Division of the program"(*r*=0.31, p<.05), "Coding the functional unit"(*r*=0.41, p<.01), "Connecting the functional units"(*r*=0.40, p<.01) and "Selecting the commands for each functional units"(*r*=0.40, p<.01) . Also, There were significant correlation between the debug test and the RSTC items: "Division of the program"(*r*=0.29, p<.05), "Checking the sequences of each commands"(*r*=0.33, p<.01). It was indicated that promoting these reflections were responsible for the development of the programming abilities. Furthermore, these items suggested the reflections of cognitive strategies for task division.

Table 3 Coefficient of Correlation (*r*) between the RSTC scores and the achievement tests

Items of RSTC	Achievement Tests	
	Coding Test	Debug Test
Division of the program	0.31 *	0.29 *
Coding the functional unit	0.41 **	
Connecting the functional units	0.40 **	
Selecting the commands for each functional units	0.40 **	
Checking the sequences of each commands		0.33 **

**p<.01, *p<.05

Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

4 Conclusion

In this study, it was clarified that students' meta-cognition and cognitive strategies could be acquired through the collaborative learning at junior high school level, also that the RSTC was useful for measuring students'

reflections in their programming activities. These findings will contribute to the researches of developments of collaborative learning systems.

For the future, learning processes and cognitive effects of more widely collaborative learning environment, for example, distributed programming by using CSCL system or long distance education for programming by using Internet, must be analyzed.

References

[1] Deutsch, M, An experimental study of the effects of cooperation and competition upon group process, *Human Relation*, 2: pp.199-232, (1949)

[2] Jun MORIYAMA et al, Structural Analysis of Thinking Processes on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 38-4: pp.255-262, (1996) (In Japanese)

[3] Kouji SATOU, Motivation for Learning and social context, *Cognitive Science 5: Learning and Development*, Tokyo University Press: pp.221-247, (1996) (In Japanese)

[4] Masaharu KAGE et al, Effects of Media and Learner Collaboration on Programming Education in Children, *Japan Journal of Educational Technology* 21-2: pp.93-105, (1997) (In Japanese)

[5] Ministry of Education, Science, Sports and Culture, Government of Japan, *Course of study for lower secondary schools in Japan*,(1989) (In Japanese)

[6] Shiro MORIMOTO et al, An analysis of Collaborative Discovery Learning Processes Based on Hierarchical Schema, *Cognitive Science* 4-2: pp.3-17, (1997) (In Japanese)

Note:

This study was revised and enlarged version of the following papers published in Japan:

Jun MORIYAMA, An Analysis of Collaborative Learning Process on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 41-4: pp.187-196, (1999) (In Japanese)

Jun MORIYAMA et al, Development of the students' abilities for Computer Programming through the Collaborative Learning, *Proceedings of the 42nd Annual Conference of Japanese Society of Technology Education*: p.21, (1999) (In Japanese)

Applied the Gray Relationship Matrix and Learning Obstacles Analysis on the Discovery Teaching

Chao-Fu Hong, En-Yih Jean, Pei-Chin Wu, Chien-Miing Lia and Tsai-Hsia Wu*
**Aletheia University, Nei-Li High School*
cfhong@email.au.edu.tw
No. 32 Chen-Li Str. Tamsui City Taiwan ROC
TEL:886-2-26212121-5536

At recently year the research of teaching method are trending to request the student for active learning, to avoid the student to learn the stuff knowledge. Therefore the number of researchers in the constructivism and cooperative learning etc fields are many. Even now how to estimate the student's learning attitude belong an active type, is a big problem. In our research, we recur to the simple method, adopt the discovery teaching. Because under the discovery teaching, the student does not only use his ground knowledge, but also need face the problem's stimulation and bring the solution. This method can mostly saturate the today's teaching trend. But how to analyze the student's learning obstacle area and supply the explanation to help him cross over the learning barrier is a net bottle in the discovery teaching. In this paper, connect the concept graph and the gray decision-making to issue the gray analyzing method of learning obstacle. This method has a flexible ability to point out the area of learning obstacle, it also can infer the student inbuilt concept or relationship on his knowledge structure. Finally, according to the expert's experiments rule to clearly distinguish the core of problem. Then the system obeys the inferring rules to bring the explanation and the similar question to stimulate the student to build his whole knowledge. This learning cycle will continue until the student completely finishes his learning.

Keywords: **Discovery Teaching• Gray Theory• Concept Graph• OO**

1 gray relational concept graph

a. The design of cognitive structure

Induct the student to learn the material, not only implant him a located knowledge, but also hope he can actively learn or construct the knowledge. Therefore, our system want to stimulate the student, and hope he use his langue or letter to descript his thinking. It like he uses his symbols to review the content and build his cognitive structure. Therefore in our system, our chapter designing does not like traditional, we use the proposition to build concept graph.

Table 1 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1					
Node 2					
Node 3					
Node 4					
Node 5					

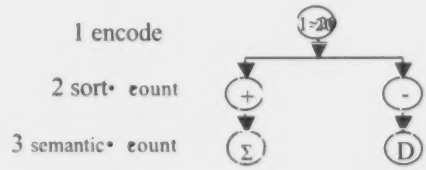


Fig. 1 Concept Garph

b. Relational concept graph

From the cognitive structure graph we can understand that the relation be assembled by node linking to other node, of course each relation also has its particular mean. And in our system the question is based on proposition, then accord with the problem' s subject the expert can distribute the weight to each node and each relation. These data can be consisted a matrix, and we call this matrix as the conceptual relationship matrix.

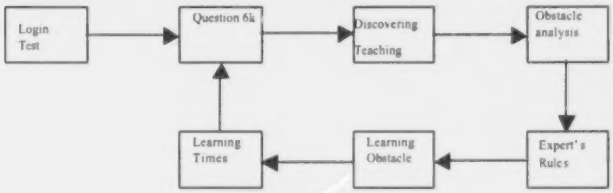


Fig. 2 System g:aph

As Fig.2, when the student log into the system, the system will give him some questions are selected from the question database. After the student transmit his answers to system, the system will start to analyze his learning obstacles. Of course, the student' s does not have much time for studying, the system hardly collect the enough data for analyzing by statistical recursive method. Because the statistical recursive has some limited: large data, the data distribution must like normal and the variants cannot too many. Consequently, the only way we can elect to adopt the gray theory to reduce the analyzing data. This matrix is called the gray relational conceptual matrix.

2 Gray relational learning obstacles analysis

The gray decision making system is meaning that the system includes some gray element (uncertainty or incomplete factor). In general case, the decision making space X is constituted by event sets S• {Sij} and efficiency sets R..

After the student interact with system, the system can collect his data to assemble the gray relationship' s matrix. The analysis method explains as following.

Table 2 the relationship matrix

relation / node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	0.5	0.5
Node 5	0	0	0	0.2	0.8

Table 3 the gray relationship' s matrix

relation node	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	0	0	0	0
Node 2	0	0	0	0	0
Node 3	0	0	0	0	0
Node 4	0	0	0	1	1
Node 5	0	0	0	0.2/0.8	1

1. According to the Grey formulate, can translate table 2 to table 3. The system can calculate each node' s average weight, and according these values to arrange their ranking.

Table 4

Node 1	Node 2	Node 3	Node 4	Node 5
0	0	0	1.25/2	2/2

2. If the nodes weight higher than the threshold value 0.3, the system can find the weight at node 4 and 5 are higher than 0.3, the system define these nodes are the learning obstacle nodes.
3. At the same time, according to the relation' s matrix (table 2), the relation 4-5 is 1 higher than • •cut (0.3) is the relation of learning obstacle.
4. According to the expert' s rules decide expanding or reducing the learning obstacle area.
   Use the aforementioned logic the system can reduce the relation 5-4 and relation 4-5 to infer the learning obstacle area is node 5

3 Conclusion

On the teaching the most afraid thing is to induct him learning the inert knowledge. Therefore, in all teachings methods the discovery teaching is the only one can avoid this problem that is why we adopt the discovery teaching to develop our system. But how to break through the discovery teaching' s net bottle, our issue are: integrate the concept graph and gray decision-making system to develop the gray analyzing method, and use it to discover the student' s learning obstacle. This analyzing has an ability to point out the learning obstacle area, and enhance the inferring ability to find the student' s learning obstacles or the incompletely knowledge, then pass through the expert' s rules, the crossing analysis method can find the problem kernel. Then system rely on this result to elect the problem saving content, let the student can learn it again and rebuild his knowledge structure until he can construct the whole knowledge.

Reference

[1] Chao-Fu Hong• [4]Yueh-Mei Chen[*]• [3]Yi-Chung Liu• [5]Tsai-Hsia Wu :Discuss 3D cognitive graph and meaningful learning,ICCE99.

Collaboration and communication: staff development for teaching and learning online

Linda Creanor* and Dr. Allison Littlejohn**
**Department of Learning and Educational Development, Glasgow Caledonian University, St Andrew House, 141 West Nile Street, Glasgow G1 2RN, Scotland, UK email: l.creanor@gcal.ac.uk*
***Centre for Academic Practice, University of Strathclyde, Graham Hills Building, 40 George Street, Glasgow G1 1QE, Scotland, UK*
email: ***allison.littlejohn@strath.ac.uk***

Recent advances in internet communications technologies offer great potential for university teachers wishing to enhance teaching and learning by incorporating dialogue. Since many university teachers are as yet unfamiliar with the pedagogical and practical skills required to implement these technologies in their teaching it is essential that they are supported by a coherent and comprehensive staff development programme allowing them to develop the required skills. This paper describes a collaborative programme offering support to university teachers wishing to implement dialogue through communications technologies. It offers an analysis of the impact of this programme in changing the teaching strategies of academic staff. The results of this study highlight several universal factors affecting the take-up of internet communication technologies for teaching and learning. This study will be of interest to staff developers planning to implement similar programmes within their own institutions.

Keywords: **staff development, internet communication, collaboration**

1 Introduction

In order to meet the needs of an increasingly diverse learner profile, universities worldwide are gradually shifting towards more flexible course provision. Advances in information and communication technologies (ICT) are being harnessed to support teaching and learning and to maintain the vital communication links between tutors and students both on- and off-campus. University teachers are being asked to rethink the teaching methods with which they are familiar [1] and to acquire the skills necessary to develop, manage and facilitate online courses with students whom they may meet only in a virtual environment [2, 3]. Thoughtful preparation is required for this demanding shift in teaching methodology and many universities are investigating how this can be supported.

In 1997, two universities in the West of Scotland were in the process of creating a new support framework for academic staff to encourage a greater acceptance of ICT as an addition to the teaching toolkit. Contact between the departments responsible for staff development in Glasgow Caledonian University and the University of Strathclyde had already been established through personal links, and as the two institutions were geographically close within the City of Glasgow, it was decided to capitalise on these links through collaboration.

One obvious area which is crucial to an effective online learning experience is that of communication. Dialogue is key to the development of a deep understanding and must be supported, either through a direct tutor/student conversational framework as described by Laurillard [4] or by learning vicariously from peers through asynchronous communication as advocated by Mayes [5]. Therefore the initial focus of attention was the implementation of dialogue. As workshop tutors we worked together to create an event which

would not only raise awareness of internet communication tools, but also emphasise the pedagogical implications of new technology and provide participants with the opportunity to experience online communication in its various forms. Tools used ranged from text-based bulletin boards and synchronous chat to desktop and full bandwidth videoconferencing. Participants were asked not only to learn to use the tools, but to move beyond the basic skills level to using them to learn as described by Voss [6] through discussing and debating real learning and teaching issues with their colleagues at the neighbouring institution.

The intention was to create a realistic scenario where internet communication was actually being used between two geographically separated sites and where academic staff would have the opportunity to experience this form of communication from both tutor and student perspectives. Through a combination of hands-on experience of the tools, discussion and presentations of case studies, participants were encouraged to reflect on the potential of these technologies for their own teaching, whilst gaining some insight into the student experience.

Evaluation data collected at the end of each workshop revealed a very positive response to this form of staff development with 75% of participants stating that they found the course "good, very good or excellent". However, since the aim of the workshop was to raise awareness of the potential offered by new technologies and help promote a change in teaching methods within these two institutions, further evaluation studies were necessary to ascertain what impact, if any, this form of staff development had made on teaching and learning in both institutions.

2 Analysis of staff responses

A more detailed online evaluation was carried out in November 1999. Out of a total of 104 participants working in academic and related posts (52 from Strathclyde and 54 from GCU) 68 were still employed by the two institutions. This was mainly due to the fact that many staff had been hired on short-term contracts of typically one to two years, so a number of them had subsequently taken up employment in other universities. 29% of the remaining staff responded to an online survey which was carried out using the Clyde Virtual University evaluation wizard (http://cvu.strath.ac.uk). While this low response rate cannot be fully representative, it nevertheless offers a revealing insight into the effects of this form of staff development.

While only 25% of respondents had implemented internet communication in their teaching, almost all respondents stated they were "planning or possibly planning" to implement technology based teaching in the near future. Subsequent responses revealed that the reason for this could be due to the fact that many of the course participants were academic related staff and did not yet have a teaching role. As one respondent stated,

"When I took part in the earlier communications workshop I was a contract researcher and had little in the way of teaching responsibilities. However, I have recently been appointed as a lecturer ... and would hope to be developing more in the way of on-line materials."

Perhaps the workshops presently fulfil the aim of "awareness raising" and the full impact in terms of "promoting changes in teaching methods within these two institutions" will take several years to filter through.

When questioned about the type of internet communication techniques implemented, text based discussions were most commonly used, followed by file transfer and videoconferencing. The main uses of these technologies were to "communicate remotely with students" and to encourage student interaction. This indicates not only a change in the medium for teaching but also a progression away from the didactic, information giving, lecture style of teaching to a more "constructivist" approach. This is in agreement with the thinking of Laurillard [4] who views lectures as 'a grossly inefficient way of engaging with academic knowledge' and of Mayes [7] who argues the importance of dialogue as an essential ingredient for learning, since it enables construction, discussion and reflection on concepts. Despite this there was a mixed response to whether or not the use of communications technologies actually enhanced particular teaching and learning situations. One respondent stated:

"Using the internet, while initially appealing, seems to be more trouble than it's worth. Many of the students do not like the lack of personal interaction"

While another concluded that the internet afforded students, *"an opportunity to share information more widely"*.

It seems that, although participants leave the workshops enthused about internet communication, there is a lack of momentum which they feel should come from departmental strategy. Of those respondents who stated they had not implemented internet communications technologies in their teaching the main barriers focussed around issues of time to implement new teaching strategies and a perceived lack of technical expertise. For example 40% of respondents indicated that they feel they have insufficient time to implement internet communication, 35% intimated a need for improved technical support, 20% stated their students required more IT training and 20% felt that improved university facilities were required. These results are in agreement with other studies [8, 9] .

When asked to comment on the statement "These learning technology workshops are effective in changing teaching and learning within the University", out of 16 responses to this question 8 agreed, 4 were neutral and 4 disagreed. Overall therefore, there was a positive response to this form of staff development. There was also a leaning towards subject based training, though accredited training, encouraged by recent government legislation in the UK [10] was not strongly favoured.

3 Summary of Results

The results of this study have revealed that:

- This form of staff development is highly effective in raising awareness of the potential of internet communications technologies;
- The full impact of this form of staff development in terms of changing teaching methods may not be realised for some time due to the fact that not all participants had a teaching role;
- Of those who had used internet communication there was a mixed response to whether or not it actually enhanced their teaching;
- Lack of time and technical expertise and student inexperience with technologies were listed as the main barriers preventing effective use of internet communication for teaching and learning;
- There was general agreement that this form of staff development is effective, though responses reveal a necessity for the implementation of teaching, learning and assessment strategies.

It is interesting to note that the effectiveness of the collaboration between the two institutions is less apparent, as although 50% found it enhanced the experience, 26% disagreed. This was a disappointing result, as it had been anticipated that sharing the learning experience would have featured more positively in the evaluation feedback. In contrast, all the tutors agreed that the synergy created in developing and presenting this joint event was extremely valuable, and indeed has led to further sharing of resources and expertise in cross institutional staff development provision.

Glasgow Caledonian and Strathclyde universities are two very different institutions, as the latter is a long established university and the former has only in recent years attained university status. Nevertheless respondents from both institutions have clearly expressed their need for a more strategic approach by university management. Comments included,

"I do think the University needs to think very carefully about policy and funding, and to ensure that the appropriate back-up services are there." (Strathclyde)

"The University needs to be explicit in its support for the use of technology in all that we do and to actively state that this is the 'expected' way forward -i.e. provide a clear vision." (GCU)

Clearly, a cohesive, structured, top-down approach is needed to complement the developments at departmental and faculty level in order to encourage academic staff to embrace new technologies in their teaching practices.

4 Conclusion

This case study , although limited in scope, has undoubtedly revealed several universal factors which can affect the take-up of learning technology, and of internet communication in particular. As the ICT revolution continues to impact on every area of higher education, providing support for both new and experienced university teachers is crucial to a successful shift to more flexible learning provision. The technology tools must become transparent to support effective teaching and learning, and this can only be achieved through practice, understanding of the pedagogy and awareness of the various options available [11]. This study has shown that by collaborating and sharing experiences and resources, universities can work together to create an effective staff development framework.

References

[1] Littlejohn, A.H. & Stefani, L.A.J. Effective Use of Communication and Information Technology: Bridging the Skills Gap ALT-J, 7.2, 66-76, (1999).

[2] Collis, B. Tele-learning in a digital world: The future of distance learning. London: International Thomson Computer Press, (1996).

[3] Harasim, L., Hiltz, S.R, Teles, L. & Turoff, M.,Learning Networks: a field guide to teaching and learning online, MIT Press, Cambridge, Massachusetts, (1995).

[4] Laurillard, D., Rethinking University Teaching: A Framework for the Effective Use of Educational Technology. London: Routledge (1993).

[5] Mayes, J.T. Dialogue With A Dumb Terminal, in the Times Higher Educational Supplement, October 10th, 1997 http://led.gcal.ac.uk/clti/papers/thes.html (accessed on 1 August, 2000)

[6] Voss, L., European Network of Innovative Schools, Proceedings of Euro Education 2000, February 8-10th Aalborg, Denmark, available on CD-ROM. (2000)

[7] Mayes, J.T., Learning Technology and Groundhog Day, Hypermedia at work: Practice and Theory in Higher Education, (Strang, W., Simpson, V., Slater, D., Eds) Canterbury, University of Kent Press (1995)

[8] Littlejohn, A.H. & Cameron, S., Supporting Strategic Cultural Change, ALT-J, 7.3, 64-75 (1999).

[9] Littlejohn, A.H., Stefani, L.J. and Sclater, N., Effective use of Technology, the Pedagogy and the Practicalities: A Case Study, Active Learning, 11, 27 - 30 (1999).

[10] National Committee of Inquiry into Higher Education, Higher Education in the Learning Society, London http://www.leeds.ac.uk/educol/ncihe/ (accessed on 1 August, 2000)

[11] Creanor L. & Littlejohn A.H., Preparing for Online Learning and Teaching: A Cross-Institutional Approach to Staff Development in Internet Communication, Journal for Computer Assisted Learning, 16,3, 271-279 (2000).

Comparing Computer Anxiety by Gender among Technological College Students in Taiwan

Shwu-yong L. Huang* and Yeon-Chaw Liu**

**Center for Teacher Education, National Tsing Hua University, Hsinchu, 30043 Taiwan*
Tel.:(03) 571-5131 ext. 4534
Syhuang1999@yahoo.com
***Jin Wen Institute of Technology Taipei, Taiwan*

This study investigates gender-related differences in computer anxiety and the variables related to male and female students' computer anxiety. Participants were 549 college of technology students, each was administered a revised Computer Attitude Scale. MANOVA results indicate that male students had significantly greater confidence and lower anxiety than female students. Male students rated more positively than female students on the following items: (a) I feel confident with my ability to learn about computers; (b) working with a computer would make me very nervous; (c) I am not the type to do well with computers; (d) I feel comfortable using computers; and (e) computers make me feel uneasy and confused. Multiple regression results reveal that male students' computer anxiety was influenced by their own locus of control and total number of computer courses taken. Female students' computer anxiety was influenced by the same two variables as well as by their subject majors. Age and grade level, however, showed no significant influence on these students' computer anxiety. Standard deviations were relatively large, suggesting there was a great variance among students responses. Educational implications of the findings are discussed in the paper.

Key Words: **Computer Anxiety, Gender Differences, Technology Education**

Gender as a differentiating variable in college students' computer use has been examined in a number of studies during the past two decades. Most of these studies are centered on students in colleges of liberal arts or teacher colleges. For example, Busch (1995) examined college students and documented gender differences in perceived self-efficacy regarding completion of complex tasks in both word processing and spreadsheet software, but not in simple tasks. Harris & Grandgenett (1996) found that gender is an attributing variable to teachers' anxiety in their use of networked resources. Very few research studies, however, have been specifically focused on students in technological colleges, assuming that these students receive adequate training in computer and technology, and are therefore least fear of using computer. It is important to understand the actual perceptions and needs of technological students and some influencing variables like gender on their computer use. Unrealistic assumptions may interfere the provision of educational programs that address their unique needs. Therefore, the purpose of this study is to investigate gender-related differences in computer anxiety, and to determine the variables related to male and female technological students' computers use.

1 Methods

The participants of this study were 549 college of technology students. Among them, 100 were male and 449 were female. These students majored in eight subject areas. About 96% of them were age 25 or younger.

About 86% of them had computers at home and over 60% of them had been working with computers for more than two years. Nearly 60% of them had taken two or more computer-related courses.

The instrument used in this study is the revised Teacher Computer Attitude Scale (Violato, Marini, & Hunter, 1989). It includes 10 items measuring computer anxiety and confidence on a 5-point Likert type scale. A score of 1 indicates that a student disagrees strongly to the statement and a score of 5 indicates that a student agrees strongly to the statement. The instrument has been found to be reliable and valid in previous studies (Huang, 1997; Huang & Padron, 1995; Liu, 1998). For the present study, the instrument was translated into Chinese for the use of participants in Taiwan. Content validity was verified by reversing the translation of Chinese survey into English by English teachers who had not seen the original English version. No revision was found necessary. The alpha reliability coefficient is adequate at .87. A few questions on students' demographic and computer background were also included in the survey.

The instrument was administered to students in mid of the academic year by experienced researchers. Students answered the questionnaire anonymously. Multivariate analysis of variance (MANOVA) was used to determine whether if there were significant differences in computer anxiety by gender. Follow-up univariate analysis of variance (ANOVA) was performed to determine where the differences were. A series of multiple regression was used to determine the variables related to male and female students' computer anxiety.

2 Results

The results indicate that college of technology students generally had above average confidence and below average anxiety in using computers. The item with the lowest score is "Computers make me feel uncomfortable," followed by "I get a sink feeling when I think of trying to use a computer". The item with the highest score is "I am able to do as well working with computers as most of my fellow university students".

MANOVA results indicate an overall significant difference in computer anxiety by gender ($F(10, 538) = 2.71$, $p < .01$). Male students had greater confidence and lower anxiety in using computers than female students. Table 1 presents the ANOVA results. Significant differences between male and female students were found in the following items: (a) I feel confident with my ability to learn about computers ($p < .05$); (b) Working with a computer would make me very nervous ($p < .05$); (c) I am not the type to do well with computers ($p < .05$); (d) I feel comfortable using computers ($p < .01$); and (e) Computers make me feel uneasy and confused ($p < .01$).

Table 1: Differences in computer anxiety between male and female technological college students

Indicator	Male		Female		ANOVA
	M	SD	M	SD	F
I fell confident with my ability to learn about computers	3.57	0.96	3.32	0.95	5.56*
Working with a computer would make me nervous	1.40	0.97	1.64	1.01	4.76
I get a sinking feeling when I think of trying to use computer	1.30	102	1.34	0.93	0.15
Computers make me feel stupid	1.42	1.13	1.41	0.99	0.02
Computers make me feel uncomfortable	1.24	1.06	1.33	0.89	0.78
I am not the type to do well in computers	1.66	1.05	1.94	0.98	6.63*
I feel comfortable using computers	3.58	0.90	3.26	0.79	12.84***
Computers make me feel uneasy and confused	1.46	1.17	1.79	1.13	6.76**

I think using computers would be difficult for me	1.39	0.94	1.42	0.80	0.42
I am unable to do as well working with computers as most of my fellow college students	1.36	0.94	1.42	0.80	0.42

* $p < .05$ ** $p < .01$ *** $p < .001$.

Multiple regression results reveal that students' locus of control of computer use, age, grade, year(s) of computer experience, computer(s) at home, subject majors, and number of computer courses taken have an overall significant effect on male ($F = 9.83$, $p < .001$) and female ($F = 30.86$, $p < .001$) students' computer anxiety. The R square value for male students equals to .43, suggesting that 43% of the variance in male students' computer anxiety may be explained by the seven independent variables. The R square value for female students equals to .33, suggesting that 33% of the variance in female students' computer anxiety may be explained by the seven independent variables. Stepwise regression results show that locus of control and the total number of computer courses taken have significant effects on male students' computer anxiety. On the other hand, students' locus of control of computer use, subject major, and total number of computer courses taken have significant effects on female students' computer anxiety.. Table 2 displays the regression results by gender.

Table 2: Multiple regression results of variables related to male and female students' computer anxiety.

Variables	Female		Male	
	Beta	p	Beta	p
Locus of control	.50	.0001	.58	.0001
Subject major	-.13	.0028	-.08	.4071
Age	.00	.9337	-.04	.6730
Grade	.02	.7176	.02	.8619
Length of computer use	.05	.2316	.07	.4361
Computers at home	.01	.7848	.08	.3368
Total number of computer courses	.18	.0001	.19	.0001

3 Discussion

The findings of this study indicate that there were significant differences in technological college students' computer anxiety by gender. Male students were more comfortable and had lower anxiety using computers than their female classmates. These findings support previous research on the impact of gender-related perceptions on computer anxiety among college and university students (Brosnan, 1998; Liao, 1999). Plausible explanations include that (1) female students majored in different subject areas than male students; (2) female students had taken fewer computer courses, and (3) social stereotype of computer proficiency. Computer and technology have been portrayed in the society as more appropriate for male than for female and thus influence male and female students' self-efficacy in using computers. Because freedom from anxiety has been found to be an attributing variable to computer achievement (Liu & Johnson, 1998), it is important to reduce computer anxiety among female students. This can be done by identifying the areas and sources of anxiety in computer use by female students, and design instructional technique that can reduce their computer anxiety (Ayersman, 1996; Ayersman & Reed 1995-86; Liu & Johnson, 1998; Presno, 1998). For example, Fitzgerald, Hardin, and Hollingsend (1997) developed a course in hypermedia authoring program and provided instructional strategies to help decrease participating education students' computer anxiety.

Findings of the present study have provided a better understanding of gender-related technological college students' computer anxiety, identifying several related variables, such as locus of control and courses taken. Future research needs to examine how these and other variables may be used to enhance equity among technological students' computer confidence and achievement.

References

[1] Ayersman, D. J. (1996). Effects of computer instruction, learning style, gender, and experience on computer anxiety. *Computers in the Schools*. 12 (4), 15-30.

[2]Ayersman, D. J., & Reed, W. M. (1996). Effects of learning style, programming, and gender on computer anxiety. *Journal of Research on Computing in Education*, 28, 148-161.

[3] Brosnan, M. J. (1998). The impact of psychological gender, gender-related perceptions, significant others, and the introducer of technology upon computer anxiety in students. *Journal of Educational Computing Research*, 18 (1), 63-78.

[4] Busch, T. (1995). Gender differences in self-efficacy and attitudes toward computers. *Journal of Educational Computing Research*, 12 (2), 147-158.

[5] Crable, E. A., Brodzinski, J. D., Scherer, R. F. (1994). The impact of cognitive appraisal, locus of control, and level of exposure on the computer anxiety of novice computer users. *Journal of Educational Computing Research*, 10 (3), 239-248.

[6] Harris, J, & Grandgenett, N. F. (1996). Correlates among teachers' anxieties, demographics, and telecomputing activity. *Journal of Research on Computing in Education*, 28, 300-317..

[7] Huang, S. L., & Padron, Y. N. (1997). Differences in prospective teachers' perceptions of computers: A cross-national study. In D. A. Willis & J. Willis (Eds.), *Technology and Teacher Education Annual*, 1997. Charlottesville, VA: Association for the Advancement of Computing in Education. 865-868.

[8] Huang, S. L., Waxman, H. C., & Padron, Y. N. (1995). Teacher education students' attitudes toward educational computing. In D. A. Willis, B. Robin & J. Willis (Eds.), *Technology and Teacher Education Annual*, 1995. Charlottesville, VA: Association for the Advancement of Computing in Education. 769-773.

[9] Liao, Y. K. (1999). Gender differences on computer anxiety: A meta-analysis. In the *Proceedings of the 10th International Conference of the Society for Information Technology and Teacher Education. Charlottesville*, VA: Association for the Advancement of Computing in Education. 1394-1399.

[10] Liu, L., & Johnson, D. (1998). A computer achievement model: Computer attitudes and computer achievement. *Computers in the schools*. 14 (3-4), 33-54.

[11] Liu, Y. C., & Huang, S. Y. (1999). Comparing technological and teacher college students' computer attitudes in Taiwan. In the *Proceedings of the 10th International Conference of the Society for Information Technology and Teacher Education*. Charlottesville, VA: Association for the Advancement of Computing in Education. 1406-1410.

[12] Presno, C. (1998). Taking the byte out of Internet anxiety: Instructional techniques that reduce computer/Internet anxiety in the classroom. *Journal of Educational Computing Research*, 18 (2), 147-161.

[13] Violato, C., Marini, A., & Hunter, W. (1989). A confirmatory analysis of a four-factor model of attitudes toward computers: A study of preservice teachers. *Journal of Research on Computing in Education*, 22, 199-213.

Computer Anxiety and Locus of Control – A Cross-National Comparison between Preservice Teachers in Taiwan and the United States

Shwu-yong L. Huang
Ed. D.Center for Teacher Education
National Tsing Hua University
Hsinchu, 30043 Taiwan
Tel.: (02) 2367-9500
syhuang1999@yahoo.com

This study compares computer anxiety of preservice teachers in the U. S. and Taiwan. Two research questions were addressed: (1) Are there significant differences in computer anxiety and locus of control between preservice teachers from the two places? (2) What are the factors that affect computer anxiety between preservice teachers in Taiwan and in the United States? Sample subjects were 355 randomly selected college of education students from both places. Two instruments were combined for data collection: Teacher Computer Attitude Scale and Computer Locus of Control Measure. Both instruments were tested for validity and reliability. MANOVA results reveal that there were overall significant differences in computer anxiety and locus of control between the two groups. In spite of college computer courses offered and mandated, preservice teachers in Taiwan demonstrated greater computer anxiety and lower locus of control than their counterparts in the United States. The results also show that locus of control and gender affect computer anxiety for preservice teachers in the United States. For preservice teachers in Taiwan, locus of control and length of computer experience have effects on computer anxiety. Plausible explanations include that students from Taiwan had fewer years of experiences working with computers, and greater needs to enhance their computer self-efficacy.

Key Words: **Preservice Teachers, Computer Anxiety, Locus of Control, Cross- Cultural Study**

Computer anxiety defined by Crable, Brodzenski, and Scherer (1994) is an anxious response by the individual to the anticipated or actual contact with computers. Most of the studies on teacher computer anxiety centered on investigating factors related to computer anxiety (Ayersman, 1996, Ayersman & Reed, 1995, Harris & Grandgenett, 1996; Huang, 1995) and ways to overcome resistance and fear of computer use (Jackson, 1997; Stone, 1998). Recent research has also documented that (a) computer anxiety has a debilitating effect on achievement in computer related learning (McInerney, McInerney, & Sinclair, 1994) and (b) computer achievement was a function of three attitude variables: enjoyment, motivation, and freedom from anxiety (Liu & Johnson, 1998). Few research studies, however, have focused on cross-national comparison of computer anxiety and locus of control among preservice teachers. It is important to examine computer anxiety cross-nationally because understanding the differences in computer anxiety among preservice teachers from other countries may enable teacher educators to reflect on their education system and teacher preparation programs and thus make necessary improvement. Such a comparative study may also identify universal variables and relationship between variables that are cross-culturally valid (Wubbels, 1993). Since individual's locus of control of computer use, whether the person is internally or externally focused, is closely associated with computer anxiety (Crable, Brodzenski, & Scherer, 1994), this study compares both computer anxiety and locus of control between preservice teachers in Taiwan and in the United States. More specifically, this study addresses two research questions:

1. Are there significant differences in computer anxiety and locus of control between preservice teachers in Taiwan and in the United States?

2. What are the factors that affect computer anxiety between preservice teachers in Taiwan and in the United States?

1. Methods

Subjects

The subjects were junior and senior students in education colleges from northern Taiwan and southern United States. Among all participants, 180 students from each place were randomly selected for study. Later on, five students' data from the United States found unusable and deleted, leaving 175 sample subjects for this group. Similar to the United States, most colleges offer introductory computer courses, and a computer related course is mandated for teaching certificate in Taiwan. The two groups of preservice teachers, however, varied significantly in their demographic variables. There were more male education students in Taiwan than in the United States. About 36% of preservice teachers from Taiwan were male whereas only 6% of preservice teachers from the United States were male. The preservice teachers in the United States were older than their counterparts in Taiwan. Nearly 60% of them were 25 years old or younger, whereas 85% of preservice teachers from Taiwan were in the same age category. Preservice teachers in the United States also had longer experience working with computers than their counterparts in Taiwan. Nearly 64% of them has two or more years of experience working with computers, but only 17% of preservice teachers from Taiwan had same length of computer working experience.

Instruments

Two instruments were combined for data collection: Teacher Computer Attitude Scale (Violato, Marini, & Hunter, 1989) and Computer Locus of Control Measure (Kay, 1986). Ten items from the Teacher Computer Attitudes Scale (Violato, Marini, & Hunter, 1989) were used to measure prospective teachers' anxiety and confidence in using computers. The Computer Locus of Control Measure (Kay, 1986) includes ten items measuring students' internal or external focus of computer use. All items are on a 5-point Likert-type scale. A score of 1 indicates "Strongly Disagree," a score of 2 indicates "Disagree," a score of 3 indicates "Neither Agree nor Disagree," a score of 4 indicates "Agree," and a score of 5 indicates "Strongly Agree" to the statement. In addition, a few questions about students' demographic background and computer working experience were also included.

The combined survey was translated into Chinese for the use of sample subjects in Taiwan. Content validity was verified by reversing translation of the Chinese survey into English by English teachers who had not seen the original English version. No revision was needed. Nonetheless, internal consistency test shows that three of the locus of control items were weakly correlated with other items and were deleted. The alpha reliability coefficient is .95 for computer anxiety and .79 for locus of control scale based on the sample subjects in the United States. The alpha reliability coefficient is .87 for computer anxiety and .61 for locus of control scale for the sample subjects in Taiwan.

Data Analyses and Procedures

The survey was administered at mid of the academic year to preservice teachers by experienced researchers in both nations. Multivariate analyses of variance (MANOVA) were used to compare all items responded by the two preservice teacher groups within computer anxiety and locus of control scales. Follow-up analyses of variance (ANOVA) were performed to determine where the differences are. Chi-square tests were used to determine whether there were significant differences in demographic variables between the two student groups. Finally, multiple regression analyses were used to determine variables significantly related to computer anxiety of the two groups of preservice teachers

2 Results

The MANOVA results reveal that there were an overall significant difference in computer anxiety (Wilks' Lambda = 0.4959, $F(10, 344) = 34.97$, $p < .001$) and in locus of control (Wilks' Lambda = 0.4018, $F(9, 347) = 73.76$, $p < .001$) between the two groups of prospective teachers. Follow up ANOVA tests reveal that the two preservice teacher groups differed significantly in nine out of the ten computer anxiety items and the seven locus of control items. The only item that shows no significant difference ($p < .01$) is "I am able to do as well working with computers as most of my fellow college students." Table 1 displays the comparative results for each item.

Table 1: Differences in Computer Anxiety and Locus of Control between Preservice Teachers in Taiwan and the United States.

Item	Taiwan		U. S.		ANOVA
	M	SD	M	SD	F
Computer Anxiety					
∗I feel confident with my ability to learn about computers	3.22	1.14	3.93	1.00	38.01**
∗Working with a computer would make me nervous	3.36	1.11	2.20	1.05	101.20**
∗I get a sinking feeling when I think of trying to use computer	3.42	1.00	1.34	1.06	143.04**
∗Computers make me feel stupid	3.44	1.12	2.11	1.08	128.39**
∗I am not the type to do well in computers	2.74	1.19	2.03	0.85	40.87**
∗I feel comfortable using computers	3.01	1.10	3.80	1.02	51.78**
∗Computers make me feel uncomfortable	3.31	1.09	2.30	1.16	71.70**
∗Computers make me feel uneasy and confused	3.41	0.92	2.25	1.10	115.81**
∗I think using computers would be difficult for me	3.46	0.87	1.19	0.88	250.94**
∗I am able to do as well working with computers as most of my fellow college students	3.77	1.01	3.56	0.96	5.53
Locus of control					
∗I could probably do just about anything I need to do with computers	2.63	0.99	3.37	1.05	46.77**
∗I can make the computer do what I want it to do	2.72	1.22	3.19	0.87	17.56**
∗I will probably never be able to work with computers effectively	3.64	1.12	1.91	0.80	209.20**
∗If I had a problem using the computer, I could solve it one way or another	3.18	1.00	3.47	0.95	7.84*
∗I would never use computers if someone wasn't pushing me to do so	3.33	1.46	2.05	0.90	113.79**
∗I would be able to determine how computers are used in my classroom	2.83	1.05	3.83	0.76	105.09**
∗When something goes wrong with the computers, I feel there would be little I could do about it	2.33	0.93	2.75	0.97	17.04**

* $p < .01$. ** $p < .001$.

A series of multiple regression was conducted using demographic (gender and age), length of computer experience, and locus of control as independent variables to explore their effects on the two student groups' computer anxiety. Table 2 displays the multiple regression results.

Table 2: Multiple Regression Results of Gender, Age, Length of Computer Experience and Locus of Control on the Computer Anxiety of the Two Preservice Teacher Groups

Variables	Taiwan		U. S.	
	Beta	p	Beta	p
Locus of control	-0.57	.0001	-0.77	.0001
Gender	-0.04	.4379	.012	.0102
Age	<0.01	.9707	-0.03	.4780
Length of computer use	0.28	.0001	-0.04	.4433

The results reveal that locus of control has a strong negative effect on computer anxiety for preservice teachers in the United States. The greater locus of control they had, the lower was their computer anxiety. In addition, gender has significant effect on preservice teachers in the United States. Female preservice teachers had greater computer anxiety than male preservice teachers. The R square value equals to 0.65, suggesting that 65% of the variance in preservice teachers' computer anxiety may be explained by the four independent variables. For preservice teachers in Taiwan, locus of control also has strong negative effects ($p < .001$) on their computer anxiety. Length of computer use, however, has positive effect on their computer anxiety. The R square value equals to 0.47, suggesting that 47% of the variance in preservice teachers' computer anxiety may be explained by the same four independent variables.

3 Discussion

The findings of the present study reveal that there were significant differences in computer anxiety and locus of control between preservice teachers in Taiwan and in the United States. In spite of the college computer courses offered and mandated, teacher education students in Taiwan demonstrated greater computer anxiety and lower locus of control of computer competency than their counterparts in the United States. Preservice teachers in Taiwan had less confidence in mastering computer whether through the help of others or by their own effort. This finding is consistent to previous research studies which reported that preservice teachers in the United States had more positive attitude towards computers than those in Taiwan (Huang, 1997; Liao, 1996). This may partially due to the fact that preservice teachers in Taiwan had less experience working with computers than preservice teachers in the United States. Frequency distributions show that nearly 11% of preservice teachers in Taiwan never used computers, 29% of them used for less than six months, 21% used for six months to one year, 21% used for one to two years, and only 17% used for two years or longer. Less than adequate experience often produce greater anxiety. Other socio-cultural factors may produced attitudinal differences (Sensales & Greenfield, 1995) and need to be examined.

Findings of this study have educational implications. Teacher educators in Taiwan need to enhance technology proficiency, computer self-efficacy, and strategies for reducing computer anxiety and increasing confidence. For example, Pina and Harris (1994) suggested several teaching strategies that have been used in computer literacy courses. Some of the strategies are to (1) find the friendliest computer system, (2) give students a tour of the system, (3) tell them how it works, (4) start with simplicity and success, (5) teach self-regulated learning strategies, (6) use cooperative learning system, (7) keep their hands on the wheel, (8) let them know what computers can not do, (9) provide peers as lab assistants, and so forth. Although length of computer experience is an influential variable, negative quality of computer experience may also create anxiety (Gos, 1996; McInerney, McInerney, & Sinclair, 1994). Teacher educators need to provide user friendly environment like easy access, expert support, good facilities, and quality computer courses to enhance education students' computer competency.

For future research, educational researchers need to (a) identify other beneficial and negative instructional techniques and behaviors that are related to students computer difficulty, including Internet anxiety (Presno, 1998), and (b) explore individual characteristics associated with learning to use computer in preservice teacher preparation (Ropp, 1999).

References

[1] Ayersman, D. J. (1996). Effects of computer instruction, learning style, gender, and experience on computer anxiety. *Computers in the Schools*. 12 (4), 15-30.

[2] Ayersman, D. J., & Reed, W. M. (1996). Effects of learning style, programming, and gender on computer anxiety. *Journal of Research on Computing in Education*, 28, 148-161.

[3] Crable, E. A., Brodzinski, J. D., & Scherer, R. F. (1994). The impact of cognitive appraisal, locus of control, and level of exposure on the computer anxiety of novice computer users. *Journal of Educational Computing Research*, 10 (3), 239-248.

[4] Gos, M.W. (1996). Computer anxiety and computer experience: a new look at an old relationship. *The Clearing House*, 69, 271-276

[5] Harris, J, & Grandgenett, N. F. (1996). Correlates among teachers' anxieties, demographics, and telecomputing activity. *Journal of Research on Computing in Education*, 28, 300-317.

[6] Huang, S. L., & Padron, Y. N. (1997). Differences in prospective teachers' perceptions of computers: A cross-national study. In D. A. Willis & J. Willis (Eds.), *Technology and Teacher Education Annual, 1997*, (pp. 865-868). Charlottesville, VA: Association for the Advancement of Computing in Education.

[7] Huang, S. L., Waxman, H. C., & Padron, Y. N. (1995). Teacher education students' attitudes toward educational computing. In D. A. Willis, B. Robin & J. Willis (Eds.), *Technology and Teacher Education Annual, 1995*, (pp. 769-773). Charlottesville, VA: Association for the Advancement of Computing in Education.

[8] Jackson S. B. (1997). Overcoming faculty's fear and loathing: one principal's approach. *T.H.E. Journal*. 25, 65-66.

[9] Kay, R. H. (1993). An exploration of theoretical and practical foundations for assessing attitudes toward computers: The Computer Attitude Measure (CAM). *Computers in Human Behaviors*, 9, 371-386.

[10] Liao, Y. K. (1995). A cross-cultural comparison of computer attitudes among preservice teachers. In D. A. Willis, B. Robin & J. Willis (Eds.), *Technology and Teacher Education Annual, 1995*. (pp. 61-65). Charlottesville, VA: Association for the Advancement of Computing in Education. Association for the Advancement of Computing in Education.

[11] Liu, L., & Johnson, D. (1998). A computer achievement model: Computer attitudes and computer achievement. *Computers in the schools*. 14 (3-4), 33-54.

McInerney, V., McInerney, D. & Sinclair, K. E. (1994). Student teachers, computer anxiety and computer experience. *Journal of Educational Computing Research*, 11 (1), 27-50.

[12] Pina, A. A., & Harris, B. R. (1994). Preservice teachers and computers: Strategies for reducing anxiety and increasing confidence. Paper presented at the Annual Conference of the Association for Educational Communication and Technology, Nashville, TN.

[13] Presno, C. (1998). Taking the byte out of Internet anxiety: Instructional techniques that reduce computer/Internet anxiety in the classroom. *Journal of Educational Computing Research*, 18 (2), 147-161.

[14] Sensales, G, & Greenfield, P. M. (1995). Attitudes toward computers, science, and technology: A cross-cultural comparison between students in Rome and Los Angeles. *Journal of Cross-Cultural Psychology*, 26(3), 229-242.

[15] Stone, C. (1997). Overcoming resistance to technology. *The Delta Kappa Gamma Bulletin*, 64 (2), 15-19.

[16] Violato, C., Marini, A., & Hunter, W. (1989). A confirmatory analysis of a four-factor model of attitudes toward computers: A study of preservice teachers. *Journal of Research on Computing in Education*, 22, 199-213.

[16] Wubbles, T. (1993). Cross-national study of learning environments. In D. L. Fisher (Ed.), *The study of learning environments* (pp. 112-120). Perth, Western Australia: Curtin University of Technology.

Computer-Mediated Language learning

Shu Ching Yang
Graduate Institute of Education, National Sun Yat-sen University
shyang@mail.nsysu.edu.tw

1 Introduction

The Web provides a new learning environment with a wealth of pedagogic possibilities. The colorful and visually engaging appearance, rich resources, online audio, video, and other interactive features, combine to make the Web an enormously valuable learning tool. Although it has been argued that web technology has the potential to provide a unique environment for teaching and learning, the psychological implications of its effects on learners' language learning has remained relatively unexplored. The current research does not present much empirical evidence to validate the instructional applications of web technology [1-6]. Furthermore, results of a meta-analytical study, Ayersman found that perceptions and attitudes toward technology are functionally important in promoting effective learning [7]. Therefore, more research needs to be conducted into learners' perceptions toward this new technology so specific guidelines for its successful implementation can be provided.

This study looked at learners' attitudes and perceptions as they conducted technology-augmented projects, and asked what were their affective attitudes and cognitive perceptions toward this tool. The study contributes to an understanding of language learning using the Web, and provides a basis for empirical studies of Taiwanese EFL learners performing real educational tasks with the Web. The insights gained in this small study will help EFL teachers design better learning environments with regard to classroom management, assessment and assignment.

2 Methodology

Participants

The 55 participants in this study were second year students, majoring in Applied English at a junior college. They had taken a 2-credit required course in Tourism English for two semesters.

Web-based Language Project

The goal of this project was to apply the language that the students had learned in an authentic context, to communicate, and to nurture students' global perspectives and information literacy. The project aimed to help students understand the Web with the ultimate goal of using it to create research projects about selected states in the U.S. Specifically, the objectives for the project were to: (1) provide students with background information about American culture, its separate states, cities, food, customs, people, history, travel information, etc. (2) provide students with an information-literate experience in web technology; (3) enhance students' discourse synthesis ability, namely, learning how to search, organize, and compose information for a research project. Students were asked to work on conducting a search of an assigned American state on the Web. Students could create their projects in whatever format they would like.

Instruments

A questionnaire was given to elicit relevant information on the participants' perception of, and attitudes towards, using the Web to complete their Web-based English projects. The first part of the survey pertained to background information. The second part consisted of 40 attitude and perception statements about learning experiences indicating levels of agreement or disagreement on a 5-point Likert-type scale with 5 standing for strong agreement. The Cronbach coefficient alpha of the survey was .87, suggesting the internal reliability to be quite acceptable. The third part included open-ended questions depicting their reflections about the project.

Data Collection and Analysis

After data collection, the quantitative and qualitative methods were performed. The qualitative analysis made from the student responses to the open-ended questions and the researcher's observation, provided the opportunity to uncover deeper issues than might have been apparent in a quantitative study. Results from the factor analysis (principal axis factoring with varimax rotation) yielded six factors accounting for 64.11 percent of the variance. Following are the interpretations of each factor: cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web.

3 Discussion and Conclusion

The study investigated second-year junior college students' attitudes and perceptions towards the web as an educational resource. Six main factors concerning the learners' perceptions were identified, including cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web. The study showed that the reaction of students to technology-augmented assignments was mixed. Analysis of the survey revealed a generally positive attitude towards the project pertaining to the enhacement of cultural awarenss and overall language learning. A few negative responses were noted, as learners experienced varying degrees of disorientation and cognitive overload. In particular, those learners who do not adjust well to reading on the Web appear to have much learning anxiety and cognitive disorientation, and correspondingly, have a lower overall perception of language learning.

Some frustration with the challenges and difficulties in relation to computers and language were found. On the one hand, students' encountered technical difficulties in relation to the use of computers. The problems they encountered were; malfunctioning of the system, the periodic slowness of Internet connections, poor design of web documents, searching complications, time constraints and the inconvenience of being required to work on the project on campus. On the other hand, students commented on the challenges of reading, selecting, processing and evaluating information. For example, some learners had not developed effective searching strategies for locating appropriate information and, further made qualitative judgments as to the accuracy and reliability of specific information. Given the fact that interest is the impetus of learning, and method is the key to knowledge, teachers should inform learners of effective learning strategies and design diversified learning enviroments by providing intellectual, entertaining and interesting assignmets to enhance learners enjoyment. From this study, it could be concluded that computer-learning networks have the potential to empower students in well-designed learning environments. It is emphasized that the central computer-mediated learning experience in Language Studies can not be achieved by itself simply by the introduction of the learner to the web technology. Those learners who show reluctance towards technologically oriented projects need careful guidance and support from the pedagogical and technological applications of this self-directed curriculum. Therefore, providing scaffolding, both in using Internet applications and in orienting the learners to the task, is vital to the successful implementation and integration of technology into the curriculum.

It is undeniable that, being situated at the turn of 21 century as we are, developing the learner's information literacy of the digital world is important. Learning to navigate and sift through huge amounts of information with speed and accuracy, as well as pursuing a critical level of understanding that goes well beyond literal or surface-level meaning, will prepare students for the challenges they will face as society delves deeper into the Information Age. The study calls for the learners' instrumental use of web technology to achieve language-specific goals. The project challenges learners to become both language and information literate in growing the following skills: awareness of global issues and concerns, the cross-cultural comparison, development of computer skills, enhancement of critical thinking and problem-solving skills, as well as specific communication skills such as arguing, persuading, or defending a particular point.

As the study shows, researching language instruction within a digital learning environment opens up a broader range of connections and meaning-making among learners. The present study is only a stepping stone on the way to examining learners' perceptions and attitudes toward the Web-based language project. Although this activity was conducted in a foreign language class, it could be adapted as an activity in a variety of disciplines to maximize the language dimension, such as social studies, global education, science, and cultural comparison [8]. The researcher believes that the possibilities for research in these powerful network environments will be conducive to broadening and refining language literacy.

References

[1] Bicknall, J., " Promoting writing and computer literacy skills through student-authored web Pages", TESOL Journal, Vol 8, No. 1, pp. 20-26, (1999).

[2] Green, A., "A beginner's guide to the internet in the foreign language classroom with a focus on the World Wide Web", Foreign Language Annals, Vol 30, No. 2, pp. 253-264, (1997).

[3] Garza, T., "The message is the medium: Using video materials to facilitate foreign language performance", Texas Papers in Foreign Language Education, Vol 2, No.2, pp.1-18, (1996)

[4] Lee, L., "Using internet tools as an enhancement of c2 teaching and learning", Foreign Language Annals, Vol 30, No. 3, pp. 410-27, (1997)

[5] Rankin, W., "Increasing the communicative competence of foreign language students through the FL chatroom", Foreign Language Annals, Vol 30, No. 4, pp. 542-546, (1997)

[6] Warschauer, M., "Computer-mediated collaborative learning", Modern Language Journal, Vol 81, No. 4, pp. 470-481, (1997)

[7] Ayersman, D., "Reviewing the research on hypermedia-based learning", Journal of Research on Computing in Education, Vol 28, No. 4, pp. 500-526, (1996)

[8] Moore, Z., " Technology and teaching culture in the L2 classroom: An introduction", Journal of Educational Computing Research, Vol 20, No., 1, pp. 1-9, (1999)

Do they do as they say? An exploration of the gap between the discourse and the application of socio-constructivist principles of pre-service teachers using ICTs.

Jacques Viens*, *Université de Montréal*, **Geneviève Légaré****, *Université Concordia*

*Jacques Viens
Faculté des Sciences de l'Éducation, Université de Montréal,
C.P.6128, succursale Centre Ville
Montréal (Québec) H2C 3J7
Tel.: (514) 343-7033
E-mail: viens@scedu.umontreal.ca

**Geneviève Légaré
Department of Education, Concordia University
1455, boul. De Maisonneuve Ouest
Montréal (Québec) H3G 1M8
Tel.: (514) 848-2030
E-mail: legare@vax2.concordia.ca

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centered approach to a more genuine learner-centered approach. Using student interventions in telediscussions and the pedagogical scenarios as data sources, we outlined two general trends. First, students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their constructivist values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply constructivist principles to their productions, where the learners are truly at the centre of their learning.

Keywords : **On-line education, teaching and learning processes, pre-service teacher education, socio-constructivism**

1 Introduction

The purpose of this short paper is to present the preliminary results of our exploratory research concerning the impact of information and computer technologies (ICTs) on students' perception about their role as future elementary school teachers. More specifically, we are trying to determine which factors, when ICTs are used as instructional support, are likely to facilitate the shift from a teacher-centred approach to a more genuine learner-centred approach. To do so, we are using, as data sources, the student interventions in telediscussions and the pedagogical scenarios (hereafter integrative scenarios) that were produced on the web.

2 Context

Students registered in our teacher education programme have to take a minimum of two courses about the integration of ICTs in the classroom. The first course (ETA1700) is a general overview of the various technologies that could be integrated in a given learning environment. The final assignment consists of producing, as a team, a complete and fully working integrative scenario that will be available on the Web, for the benefit of their colleagues and the teaching community. To develop their scenarios, the students have access to our instructional model that favours a scaffolding strategy. The creation of the scenario includes the following steps : needs analysis, development of the content, selection of a learning approach and the development of a lesson plan. In a socio-constructivist approach, students are free to choose the subject-matter, the grade level, the pedagogical approach, the teaching tools and medium. As the teams develop their integrative scenarios, individual members are invited to participate in telediscussions. For the course ETA1700, four themes are provided : the impact of ICTs on society, the effective use of ICTs in educational settings, the changing role of teachers and learners and continuing education of teachers. Since learning to use the technology is a sub-goal of the course, students are requested to make at least one contribution for each theme, as well as offer one reply to one of their colleague.

The second course, PED2000, is a full year course, offered to second or third year students and mostly at a distance. Team members are free to meet as they please. Using the same scaffolding approach, students have to produce a more comprehensive scenario for a situation of their choice. However, prior to designing their scenario, students have to contact an in-service teacher who will let the students conduct their intervention in his or her classroom. The field experiment allows the teams to conduct a formative evaluation of their project. PED2000 students also have access to electronic forums of discussion, with the difference that no themes have been pre-determined. It is the students who create and launch topics of discussion. An on-line tutor is available to guide the students in their creative process.

3 Description of the project

3.1 Object of research

As we mentioned earlier, our goal is to understand better the perceptions that students might have about the impact of technology on their future role as elementary school teachers. Ultimately, the research results will be used to improve an to enrich our scaffolding approach, in order to help the students not only discuss the socio-constructivists principles but adopt them in practice. To do so, we explored the links between the discourse held in the telediscussions and the application of the principles in the integrative scenarios.

3.2 Sampling

For this paper, we used only the one of the multiple sections of the ETA1700 course. We selected four integrative scenarios representing 18 students, who contributed 80 messages on the two relevant themes (perception about the role of the teacher and effective use of ICTs in the classroom). Since our goal is to explore the factors influencing the application of socio-constructivist principles, we retained the projects that demonstrated some interdisciplinary and collaborative flavour.

3.3. Criteria for analysis

3.3.1 Integrative scenarios

To assess the students' perceptions about their changing role as teachers, we referred to some of the criteria described in Viens (1993) [1], as well as the general constructivist principles (Lave & Wenger, 1991; Brown, Collins & Duguid, 1989) [2] [3]. Even though we used a Likert scale to evaluate each criterium, our intention was not to cumulate frequencies. We rather used the scales to guide our critical analysis of the constructivist aspects of each scenario. Consequently, the results are more descriptive in nature.

The criteria are as follows :
Learning strategies . Notwithstanding the specific learning strategy to be used, we assessed whether the learner' s during the instructional strategy was « directed », « guided », « rather guided », or «free ».

Team work. We examined whether the students planned to have their learners work individually, in teams but to conduct a fragmented task, or in teams to conduct a collaborative and collective task.
Content. Did the students determine a specific content or did they leave it completely opened for their learners to decide of their subject, as it is usually done in project-based learning?
Pedagogical goals. Aside from the usual well-stipulated instructional goals, did the students add other learning objectives such as transversal competencies? To what extent did they consider incidental learning?
Interdisciplinary. Did the students focus on one subject matter or did they use the opportunity to integrate several disciplines?
It is to be noted that all criteria were considered simultaneously in order to assess the global constructivist flavour of each scenario.

3.3.2 Forums

For the forums we proceeded differently. First, we focused on two aspects : the positive/negative attitude toward the ICTs. Secondly, we looked at the perception of the teacher's role. In addition, we attempted to assess the student's capacity to reflect critically, that is we observed whether the students were able to develop and support their thoughts rather than merely contributing an unsubstantiated opinion (Quellmaz, 1987; Ennis, 1987) [4] [5].

4 Preliminary results

4.1 Forums

Attitude towards ICTs

After conducting the preliminary analysis of the telediscussions for the course ETA1700, we noticed that the students positions about the integration ICTs in the classroom are not radical as one might expect. The majority seems relatively sensitive and cautious about technologies. In fact, several interventions were concerned about the fact that the computer will never replace the teacher and that the human factor is essential for the development of the pupils. In other words, aspects such as empathy, communication, emotional support are still essential for the learners development.

Perceptions of the role of the teacher

After listing all relevant interventions, we noted three recurrent themes that could constitute categories. Some interventions directly mentioned the role of the teacher, whereas others were more or less related to the topic, but still touched on the perceptions of the teacher's role. The third group of interventions were concerned about more specific tasks of the teacher. We chose to use these categories to present the results about the perceptions.

Although not all interventions under the theme « Perception of the role as teacher » referred directly to the subject, it is interesting to discover that the perception of the role is indeed changing. The students did mention that the ICTs will help shift from a traditional role of « content deliverer » to one that assumes more guidance, more facilitation. Terms such as « facilitator », « animator », « councillor », « advisor » were used relatively frequently. However, we discovered that the students limited their intervention at the opinion level. They only named or listed the role without providing an explanation or a definition of what they meant by « facilitator » for example. Furthermore, they did not establish a priori what they view as a « traditional role ». Very few went as far as mentioning « content deliverer » or « lecturer ». In other words, students talk about the changing role without defining their assumptions. No one proceeded to compare and contrast the two positions or provide an illustration to support their thought. Indeed, the participants merely identified keywords and did not attempt to engage in a more critical discussion.

Some interventions were also addressing the issue of the changing role, but indirectly. Some students talked about the fact, for example, that the ICTs will provide the opportunity for the pupils to be more active in their learning process. Here, the guiding role of the teacher is implied in the discussion. Participants mention the possibility that ICTs will encourage the active construction process and consequently, will contribute to a more significant learning experience. In fact, in those indirect interventions, the learners are considered to be at the centre of their learning, actively engaged in the construction of their own knowledge and experience.

In sum, those students seem to think that ICTs can be used to favour collaboration between the learners as long as the learners' needs are respected. It seemed that participants perceive the ICTs as an integrated tool to teaching that favours self-learning.

The same group of students also discussed a specific aspect of teaching that will be affected by the technology : the impact of a broader access to information. Some students recognise the fact that a wider access to information will bring new tasks for their learners. One student mentioned that their pupils will have to « clarify their own research goals, define their information seeking strategy, make choices in the information, and sort the information ». This type of anticipation regarding « transversal » competencies was certainly an interesting discovery.

However, the same students who demonstrated their critical thinking abilities, still perceived themselves as the authority figure for their students. In fact, they mentioned that it will be their responsibility to assess the quality of information gathered on the Web as well as to judge the relevance of the source. Instead of making the link between the role of guide or facilitator as it would be expected in a constructivist fashion, it seems that the higher cognitive skills required, such as analysis and evaluation, will remain in the mind of future teachers, as their own territory.

4.1 Integrative scenarios

Two interesting trends have been identified in this analysis. First, the students who are more able to support their opinions by providing examples, using the literature, explaining their thoughts, seem to be more capable of producing a scenario that uses a genuine constructivist approach. In fact, if all the constructivist criteria are applied whenever it is reasonable to do so, the tone used to describe the learning activity is more opened, more respectful of both the freedom of the teacher and the learners. Here, we noticed that teams who produced a constructivist integrative scenario, were constituted of at least two members who demonstrated critical thinking abilities.

In the second trend, it seems that the students who claim that the role of the teacher is changing but who do not support their opinion, do not apply their values and perceptions in their integrative scenarios. In the telediscussions, they claim to be constructivist, but they fail to transfer their thoughts in practice. As we anticipated, the majority of the scenarios produced were meant to be constructivist. Some teams for example, will have their students work in teams but in a fragmented fashion (individual students will provide parts that will make a whole); the content will be determined and not opened for change; the learner will be rather guided in the learning process.

Two sources or information reveal the lesser constructivist approach : the instructional goal statement and the description of the lesson plan. Statements of the instructional goals in those scenarios tend to be highly fragmented, clearly measurable, well stated. Often, the students will refer to the Ministère de l'éducation du Québec programme to write the goals. There is no reformulation of the goals to suit their situation or needs. Also, there is no interpretation or critical analysis or re-evaluation of the goals. The students just take them as they come.

The design of the lesson plan is another indicator that a scenario might not represent a good application of constructivist principles. Lessons plans tend to be very organised and directed as well. The outcomes, ensuing the instructional goals, are well planned. In fact, the pre-service teachers, remain perfectly in control of the predetermined outcomes. Despite their good intentions, the students remain in control of the learning process. The steps are not only too well defined, that are also not flexible. The outcomes of the intervention using ICTs are still pre-determined and nothing else, that is no incidental learning is considered.

5 Conclusions

In this exploratory research we highlighted two trends. Students who demonstrate critical thinking abilities in telediscussions are more likely to apply successfully their values and beliefs in their productions of integrative scenarios. Secondly, students who do not support their opinion in the telediscussions will be less able to apply the constructivist principles to their productions. They will remain in control of their pupils' learning. The

next logical step will be to determine how we could support the development of critical thinking skills in the telediscussions, in order to encourage a better transfer of the socio-constructivist principles to the development of integrative scenarios.

References

[1] BROWN, A. L. The advancement of learning. *Educational Researcher*, November, 4-12, (1994).

[2] BROWN, J.S., COLLINS, A. & DUGUID, P. Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42, (1989).

[3] COGNITION AND TECHNOLOGY GROUP AT VANDERBILT. Anchored instruction and its relationship to situated cognition. *Educational Researcher*, August-September, 2-10, (1990).

[4] DEAUDELIN, C. et VIENS, J. Éditeurs *Nouvelles technologies et formation : impacts sur les contenus et les stratégies d'enseignement/apprentissage*. Actes du colloque du CIPTE tenu au sein du 64e colloque de l'Acfas à l'université McGill. *Educatechnologiques* Volume électronique. http://www.fse.ulaval.ca/fac/ten/reveduc, (1997).

[5] ENNIS, R. H. A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company, (1987).

[6] GERVAIS, F., GARANT, C., MAINGUY É. et VIENS J. "Nouvelles formules pédagogiques en formation des maî tres : mise en commun." dans Gervais C., Garant, C., Gervais, Fl. et Hopper, C. Formation des maî tres entre cours et stages... un partenariat INTRA-universitaire? Sherbrooke : Éditions du CRP, (144 p.), p. 114-125, (1998).

[7] LAVE, J., & WENGER, E. *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press, (1991).

[8] QUELLMAZ, E. S. "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105, (1987).

[9] RIOUX, S. et, VIENS, J. Les télédiscussions comme outil de construction des connaissances dans la formation des enseignants. *In Guir, R. (Ed.), La formation des enseignants et des formateurs aux nouveaux usages et aux nouvelles pratiques des technologies de l'information et des réseaux, Volume 2: Les implications sur la formation des enseignants aux TIC*. Paris : Éditions De Boeck, (à paraî tre , automne 2000).

[10] VIENS, J. *Vivre une expérience d'auto-apprentissage collaboratif*. Seconde édition de l'INFODUC, le répertoire Internet de l'éducation. Québec : Septembre Média, p. 264-269, (1998).

[11] VIENS, J. Modelisa, a constructivist learning environment to foster collaborative self-learning and metacognition. In Hilding Sponberg, Zdena Lustogova & Stanislav Zelena (Eds.) *Telecommunications for Education and Training*. Prague : Charles Uninersity. p. 156-163, (1997).

[12] VIENS, J. Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106, (1993).

[13] VIENS, J. et RIOUX, S. À propos du forum de discussion comme pivot d'une formule bi-modale d'enseignement. *Distance*. Automne 2000. 16 p., (à paraî tre).

[14] Site des Scénaristes : http://facvirtuelle.scedu.umontreal.ca/scenaristes

For example:

[1] VIENS, J. (1993). Au-delà d'une certaine multidisciplinarité : Un prototype d'environnement informatisé permettant l'expérimentation d'outils pour la construction des connaissances. *Revue Educatechnologiques, 1*(2), pp.83-106.

[2] LAVE, J., & WENGER, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

[3] BROWN, J.S., COLLINS, A. & DUGUID, P. (1989). Situated cognition and the culture of learning. *Educational Researcher*, Jan.-Feb., 32-42.

[4] QUELLMAZ, E. S. (1987). "Developing reasoning skills" in *Teaching thinking skills: theory and practice*. J.B.Baron and R.J. Sternberg, Eds. New York: Freeman, pp. 86-105.

[5] ENNIS, R. H. (1987). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. J. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W.H. Freeman and Company.

EDASEQ – A log file analysis program for assessing navigation processes

Helmut M. Niegemann
Institute for Media and Communications, Ilmenau Technical University, P.O. Box 100565, 98684 Ilmenau (Germany). Email: helmut@niegemann.de

Research on the effects of hypermedia learning environments often suffers from a lack of systematic control of learning conditions, especially the sequencing of the content. While available tools for logfile analysis are confined to delivering frequencies and other figures, the tool to be presented (EDASEQ: Exploratory Data Analysis for Sequential Data) was developed to facilitate the analysis of the navigation paths of single learners as well as "average" paths of a group of learners. Because standard statistical procedures for handling sequential data are not suitable here, the tool is primarily founded on graphical methods. Navigation processes are represented by transition matrices, and with additional visualizations and trajectories. Apart from descriptive portrayals, the tool also allows for categorizing empirically found navigation patterns on the basis of theoretically defined prototypical patterns. Furthermore, it is possible to compare the patterns of single learners or groups. Results can be used to better explain the effects of self-regulated learning in hypermedia learning environments. Without knowing variables like sequencing, time-on-task, or the number and configuration of examples studied by learners, it is hardly possible to interpret the impact of external learning conditions on the learning outcomes.

Keywords: **learning processes, navigation, hypermedia, methodology, tool**

1 Introduction

A fundamental problem of research on self-regulated learning is the possible variation of learners' behaviors, especially regarding variables like the sequence of content, the time spent with studying different parts of subject matter, the number and arrangement of examples and exercises: Have they really worked through all the relevant information? How many examples were chosen, with what methods of representation and in what combinations? How many exercises were worked through, and to what result, resp. with mistakes of what kind? How long were the learners occupied with what contents? This is valid for every type of research on self-regulated learning, but especially for learning with hypermedia. Even with the same context conditions, quantitatively and qualitatively completely different courses of learning are possible and thus, in consequence, very different results. Even when the learner activities displayed are described exactly, there are differences with respect to the quality of the elaborative treatment; the external conditions of the learning processes, however, are principally controllable. Unfortunately, standard statistical procedures are not suitable to represent an "average path" in an educational hypermedia system: Mean times spent on looking to specific pages or mean frequencies of visits are often not sufficient to explain differences in learning outcomes.

2 Aims of the development of EDASEQ[1]

For the description and categorization of such processes there thus remain graph theoretical procedures. There were already attempts at implementing these some time ago; the best known is probably Flanders' (1970) procedure for the analysis of teaching (cf. also Canter, Rivers & Storrs, 1985). For the treatment and

[1] Supported by the Deutsche Forschungsgemeinschaft (German Research Foundation), grant Az. Ho 649/9-1,2,3).

evaluation of data on the basis of graph theoretical considerations there is, however, as yet no method which is relatively simple to use. It was therefore an aim of the development of methods within the framework of a six year research project on case-based hypermedia learning environments in vocational training to develop a procedure allowing recorded data of learning processes to be so prepared that a) a data reduction is brought about which allows those processes to be analyzed exploratively, b) a categorization of typical processes becomes possible, c) records of several processes can be aggregated and finally d). Comparisons are made possible between (1) single records of processes, in order to see differences and similarities, (2) an individual process and an aggregated one, in order to be able to study deviations of single learners from the typical route taken in their group, (3) two aggregated processes, in order to compare groups under different treatment resp. marginal conditions using experimental designs, (4) a single or an aggregate process with a prototype process that is produced artificially, in order to categorize processes of one or several prototypes within the framework of defined deviations, or to test hypotheses. Apart from the characteristics of the processes, it should also be possible to extract simple statistics: e.g. frequency of the calling up of specific screen pages, specific transition frequencies, length of stay etc.

3 Forms of representation

In order to represent hypermedia navigation processes, there are first of all two different but mathematically equivalent codes: transition matrices on the one hand and aligned graphs on the other. Whilst one can see conspicuous characteristics in the graphical representation, the matrix representation allows the calculation of indices. Since both forms of representation are practicable, both should be taken into consideration. One special feature of well designed hypermedia learning systems is a structured presentation of knowledge given in such a way that learners have the choice of either informing themselves superficially or of going deeper into the subject at any chosen place, or of combining both courses of action: first gaining an overview, then deepening their knowledge. In order to determine the extent of the "deepening" - assuming an appropriate structuring of knowledge in the medium -, two characteristic values, the mean "depth of elaboration" and the "variance of elaboration" have been developed. The depth of elaboration is a rating for every hypermedia occurrence, which is all the higher, the deeper the corresponding screen page goes into a specific subject. If, for instance, the highest level with the index number 1 is the term "statistics", then pages on the subject "inference statistics" or "descriptive statistics" would have the index number 2 and a page on the subject "log-linear models" would have, for example, the index number 5. The arithmetic mean of the values of all screen pages visited could then give an indication of the extent of the "deepening" or "elaboration" of the material; the measurement is completed by the elaboration variance ascertained analogously. Not least, characteristics of the chronological process should be portrayable.

4 Realization

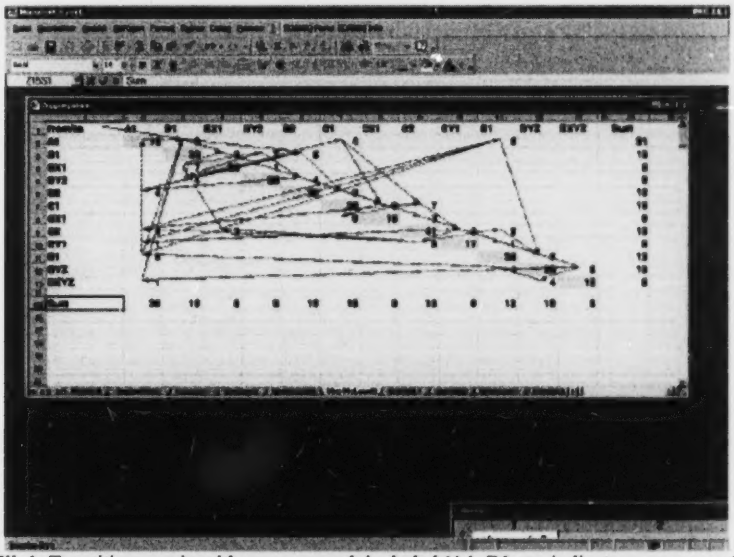
As the first step towards a reduction of process data in the Mannheim research project "Case-based learning problem" - in compliance with the demands - a software-technical evaluation procedure was developed. This enables processes to be transferred rapidly into transition matrices, so that firstly the simple frequencies of the consultation of specific pieces of information and of the transitions between offers of information can be ascertained. The learning programs developed in this project each encompass approx. 150 screen pages; learners need up to five hours to complete the given tasks and corresponding records comprise 3000 - 5000 single entries, each consisting of the time (in seconds after midnight) and the designation of the respective screen page. Log-files existing as ASCII text files are downloaded and converted into MS Excel files. For the simultaneous treatment of a larger amount of records it is also possible to stack them. Process data in the form of transition matrices can furthermore be compared to each other and also aggregated. In order to reduce data one can also stipulate that transitions which are more seldom than a specified threshold value should be ignored.

5 Examples of process representations and indices

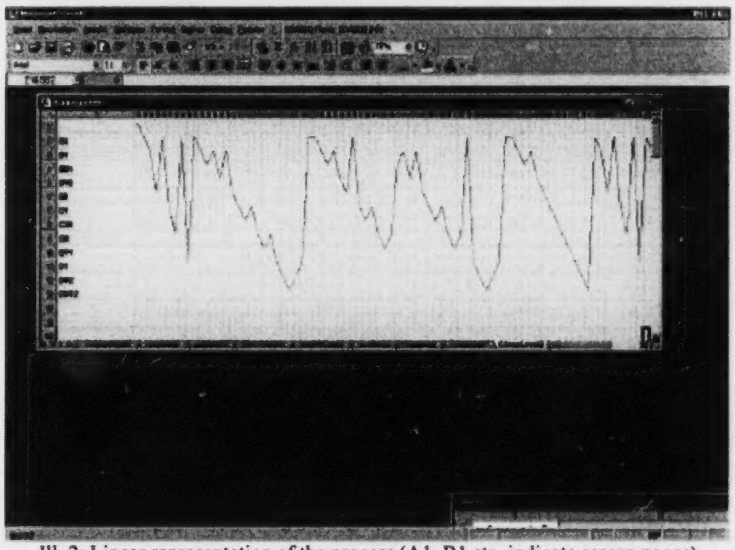
The following representations are based on fictitious data; i.e. records were produced with the specific aim of representing certain processes, in order to determine whether the corresponding characteristics are perceptible. Apart from this the size of these records was to be restricted, in order to enable a written account to be given. shows the evaluation as regards the frequency with which single screen pages were called up, as

well as the length of the stay there (absolute in seconds and relative to the complete time needed). Ills. 1 shows a transition matrix with aligned graphs of the process included (option). One alternative graphical representation ("chronological") is given in Ill. 2. Here, above all, recourses to previous steps are clearly to be seen: the test person would, in this case, have chosen a strategy whereby he/she began by choosing page B1 on the higher level, "deepening" from there straight to BX1, going back to B1, choosing another "deepening" (BY2) etc. The values in the main diagonal indicate how many time units the learner has here stayed on each separate page.

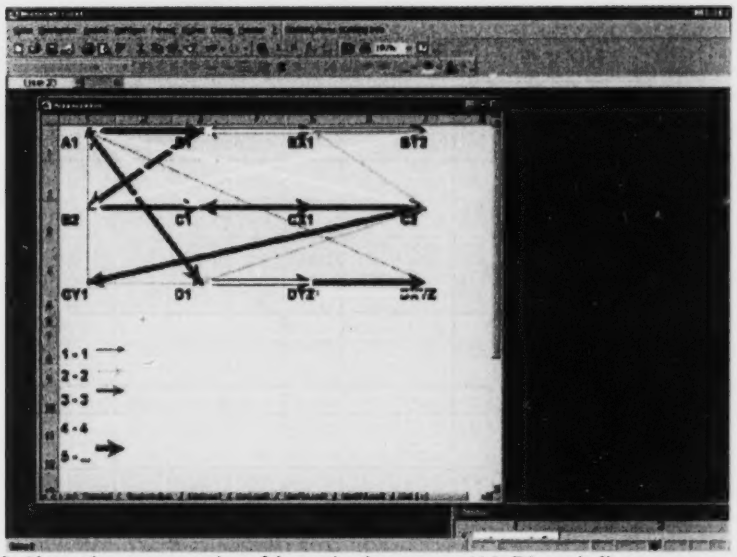
In a third, more concise representation of the process every node (page, screen, chapter etc.) is represented by one cell and the navigation process is shown by arrows between the cells. Analyzing aggregated data, the thickness of the arrows indicates the frequency of the transitions between two nodes. So, a sequence of thick arrows represent a "modal path", i.e. a path used by many users. (Ill. 3)



Ill. 1: Transition matrix with process graph included (A1, B1 etc. indicate screen pages)



Ill. 2: Linear representation of the process (A1, B1 etc. indicate screen pages)



Ill. 3: Alternative representation of the navigation process (A1, B1 etc. indicate screen pages)

6 Conclusion

The procedure which has been developed is first of all explorative, i.e. data are so prepared and represented that they allow categorizations and comparisons, thus offering a basis for the forming of hypotheses. Very extensive record files, in particular, are reduced. Although the procedure for the analysis of records on navigation was developed in hypertext, resp. hypermedia systems, it is also suitable for the treatment and analysis of data on the observation of teaching or other courses of communication.

References

[1] Bishir, J. W. & Drewes, D. W. (1970). Mathematics in the behavioral and social sciences. New York: Harcourt, Brace & World.

[2] Canter, D., Rivers, R. & Storrs, G. (1985). Characterizing user navigation through complex data structures. Behaviour and Information Technology, 4, no. 2, 93-102.

[3] Clarke, J. & Holton, D. A. (1994). Graphentheorie. Grundlagen und Anwendungen. Spektrum: Heidelberg

[4] Flanders, N. (1970). Analyzing teaching behavior. Addison-Wesley: Reading.

[5] Olson, G. M., Herbsleb,J. D., & Rueter, H. H. (1994). Characterizing the Sequential Structure of Interactive Behaviors Through Statistical and Grammatical Techniques. Human-Computer Interaction, 9, pp. 427-472

[6] Sanderson, P. M. & Fisher, C. (1994). Exploratory Sequential Data Analysis: Foundation. Human-Computer Interaction, 9, pp. 251-317

Evaluating educational multimedia: a case study

Elizabeth A. Kemp and Raymond H. Kemp
Institute of Information Sciences and Technology,
Massey University, Palmerston North, New Zealand
E.Kemp@massey.ac.nz, *R.Kemp@massey.ac.nz*

Following constructionist principles, postgraduate students who were studying a paper on Human Computer Interaction were required to build educational multimedia systems and then to evaluate those produced by their colleagues. The experience of developing a multimedia system, together with lectures and access to general material on the topic, enabled them to provide valuable insights into important issues. Nonetheless, the students were not, on the whole, able to transfer all that they had learned when building their own systems into an evaluation framework. The provision of scaffolding was recommended to facilitate transfer.

Keywords: **Multimedia, Evaluation, Constructionism**

1 Introduction

What are the criteria that should be used to judge the effectiveness of interfaces for multimedia tutorial systems? In an experiment with a class of postgraduate students studying Human Computer Interaction (HCI), they were asked to develop their own framework for evaluation. To give them some notion of what to look for and what to expect, they first had to form groups and construct their own multimedia tutorial systems. This approach is based on the idea of constructionism [6]. By collaborating in a group to develop some appropriate product, it is suggested that learners can come to a better understanding of the principles of a subject rather than by just being given the information by a teacher. This is in line with the wry comment from Jonassen *et al* [9] that the people who learn most from instructional materials are the designers.

The students were required to work together with one or two other classmates to produce their own small scale multimedia educational systems. Using the knowledge and experience they had gained, they then had to individually evaluate the interfaces of the other systems. There was no detailed specification about how to carry out these activities. The students had, however, been exposed to the main issues through lectures and discussions. They also had appropriate readings made available to them. The intention, therefore, was to see what the students, themselves, considered appropriate ways of evaluation in the light of their background and their experience in developing multimedia software. An assessment was then made of how much they had learned when building systems and how well the knowledge was applied to evaluating the systems of others.

2 Previous work

Interface evaluation can be carried out for many different purposes. The distinction is usually made between formative evaluation where improvements to a system under development can be determined and summative evaluation which assesses the overall performance [8]. There are a range of methods that can be used depending on the purpose of the study. Preece [12] categorises these purposes as analytic, expert, observational, survey and experimental. Analytic techniques are used to determine the complexity of the interfaces. Expert evaluation involves inviting people experienced with interface issues to identify usability problems. Observational, survey and experimental studies all have in common the involvement of what Preece terms "Real users." Users can be observed using software, provide feedback about the system through interviews or questionnaires or take part in experiments to test the impact of various features of the interface.

A common method of evaluation that does not involve users is expert evaluation where, as noted above, people

with some knowledge of interface issues detect possible problems. This process can be conducted in accordance with the guidelines formulated by Nielsen and Molich [11]. The following aspects of the interface are all considered in what is referred to by these authors as a heuristic evaluation: simple and natural dialogue; speaking the user's language; minimising user memory load; consistency; feedback; clearly marked exits; short cuts; good error messages; prevention of errors, and help and documentation.

An examination of the literature on multimedia reveals little mention of evaluation. Testing is usually discussed but not evaluation [4, 15]. Some important principles emerge, however. Alty [1, p33] points out that "A key question is when to use which media and in what combination to achieve the maximum effect." He also observes that success in multimedia depends more on the *combination* of media rather than on the provision of a rich set of media. Frater and Paulissen [5] note that interactive tutorials should allow the user to choose the starting point and allow the information to be accessed as often as required. They also offer this piece of advice. "Keep in mind that multimedia can make learning much more interesting when animation and sound files are used to explain the topic. Also a quiz is more fun when set up as a game" [5, p362]. Preece [12] points out that navigation, too, is an important consideration in hypertext/multimedia systems. Users, as she notes need to be able to know where they are, how they reached that point, where can they go next and how they get there. This as pect of interface design is actually covered by the first heuristic of Nielsen and Molich [11] which refers to "Simple and natural dialogue." This takes into account navigating through a system. Interface factors in interactive multimedia systems are also considered in Reeves and Harmon [13] and Tannenbaum [14].

One recent taxonomy in the literature provided by Heller and Martin [7] aims to help students on multimedia courses understand the forms of media as well as enabling them to evaluate the work of others. It has two dimensions - the media type and the means of expression (elaboration, representation and abstraction). This classification shows, for example, that text might be fully elaborated (large chunks of narrative), can be abbreviated (represented in bullet points) or might be abstract in nature such as text in a logo. Students are able to check whether a medium has been used in an appropriate fashion. As the authors state, though, the taxonomy takes no account of the effect of combining several media. Nonetheless, it is useful in focusing on the evaluation of each element. Detailed guidelines about how to use each medium, for example text, can also be found in Vaughan [15] and Collins [2].

3 Course structure

"Topics in Human-Computer Interaction" is a single semester paper for postgraduate students in Computer Science and Information Systems at Massey University. Most students have already completed a third year undergraduate paper "Human-Computer Interaction" in which the underlying theory is presented. These students will also have gained some experience in developing interfaces. The aim of this course is to consider issues of current interest such as computer supported co-operative work, innovative interfaces, different ways of evaluating the interface, multimedia systems and interfaces on the World Wide Web. Teaching is carried out through a mixture of lecturing, student seminars, discussion and demonstrations (of software such as Adobe Premiere and Macromedia Director). Students have available to them two books of readings which cover the material taught.

One assignment for this paper involved the students working in groups to develop a small multimedia system with an educational focus. The groups could choose any appropriate subject. Each student was then asked, individually, to evaluate the interfaces to all the other systems. A set of lectures had been given on the topic of multimedia including exposure to several life cycles for developing software of this kind. The topic of evaluation had also received considerable coverage in lectures and student seminars. Students were aware that interfaces can be evaluated for various purposes and in many different ways (for example by heuristic evaluation, interviews, questionnaires etc.)

Guidance on the life cycle that should be followed to develop the multimedia systems and the method of evaluation required was deliberately kept to a minimum. In the light of the teaching on the course and the material available to them, students were expected to make their own informed decisions. In particular, it was hoped that the students' own experiences in developing multi-media software would give them some insight into the criteria that should be employed when evaluating the interfaces to the other students' systems.

4 The student systems

Six groups each developed their own multimedia system. The systems were expected to offer instruction to their users and be interactive. A brief description of the systems follows.

Maori Language Tutoring

This system was designed to help students learn the Maori language. The study material was based on the philosophy that Maori be used wherever possible, with visual and aural stimuli to teach the vocabulary. Words were introduced via demonstrations using pre-recorded video clips. The system, however, also contained explanation in English for students who did not wish to completely immerse themselves in Maori. As well as learning new terms, students could choose to review vocabulary or test their comprehension. Maori music and designs were used in this system where the developers thought appropriate.

Learning the New Zealand Road Code

A written test on the New Zealand road code has to be passed before learner drivers can take their practical driving test. The aim of the road code system was intended to make the learning process more interesting. It was believed that by using animation, audio and video, the learning process would be enhanced. The system included tutorial material on aspects of the road code (for example, how to overtake or what to do when approaching a roundabout) as well as test material.

Earthquake Disaster System

The earthquake disaster system was developed to show people how to behave in the event of a serious earthquake. It included clips from a video developed by Civil Defence. Topics that were dealt with included planning for and coping with an earthquake. The opening screen showed a photograph of the devastation caused by a major earthquake. Music and animation chosen to reflect the theme of devastation accompanied the photograph.

Shape Recognition

The intention of the shape recognition system was to help children learn how to identify both two and three dimensional shapes in a lively and interesting way. Sound, animation and graphics were included in order to make the system appealing to children. Another goal of the developers was to make the system easy to use. There was a particular emphasis on the use of colour which was seen by the developers as making the system attractive to the intended users. The opening screen was designed to capture the attention of children with music and morphing shapes.

Introducing the Internet

This system, as its name implies, was intended to be introductory in nature. Its target group was school children who could find out about concepts such as email, newsgroups, file transfer protocol etc. This system made use of graphics and sound but also included lengthy textual explanations. As with the shape recognition system, there was an emphasis on the use of colour. Ease of navigation was also a major consideration.

Undergraduate Studies in Computer Science

This system allows students to find out about the staff and the papers they teach in a Computer Science department. Photographs of staff members were included. When browsing through the system, users were able to move from a staff page to obtain information about papers taught by the staff member. Contextual information about the location of the building where the Computer Science staff were housed was also provided. The opening screen of the system showed a picture of the university grounds. Other pictures could also be viewed.

5 Educational Issues

Although the course does not deal with issues of computer-based learning, this was the focus of the assignment and gave the students some context for the systems they produced. They were expected to choose an approach to teaching which was appropriate for the subject that was being taught and that they felt would be effective in a multi-media setting. They all propounded the philosophy of their systems during their presentations. It is interesting to compare the different approaches that the students chose for their systems and how this was reflected in the presentation styles.

The Maori language teaching system immerses the student in the subject and attempts to teach by example. As noted earlier, the system can be used without reference to English words or phrases. Maori, like various other languages such as Japanese is very much bound up in the culture of the people and so this approach seemed entirely appropriate. Maori songs, words and phrases in a commentary with accompanying visuals provided a backdrop that was both stimulating and educationally appropriate.

The road code system contains video clips produced by the students themselves which graphically illustrated both correct and incorrect procedures to be followed in various situations when driving. This could be regarded as teaching by presentation and illustration.

Like the road code tutorial, the earthquake disaster system has an emphasis on illustration using video clips and contains other factual information in an appropriate form.

Unlike the previous systems, the shape recognition tutor includes trial and error examples for the student to consider. It takes into account the answers the student gives and does not continue until it judges s/he has fully understood all the current concepts. It could be regarded as a mastery system from this point of view.

The internet system contains a great deal of information in a text-based format, but the presentation was enhanced with appropriate animations. Material is set out in an simple to follow form and subjects can easily navigate around the system to discover what they need to know.

The undergraduate studies in Computer Science system also allowed students to learn about the department of Computer Science in a discovery mode. In some senses this was the package that was the least like a tutorial system, since it just provided information in a non-instructional form.

The underlying objective of the assignment was to determine whether or not students had assimilated a fundamental principle of HCI - that issues concerning functionality should not be divorced from interface concerns. Given the experience of developing a multimedia system, it was hoped that students would take into account the educational aims of the system as well as the multimedia features. It was not the object of the exercise, however, to see whether effective learning took place. It was expected that some variation of expert evaluation would be followed. What was of interest were the criteria that students incorporated into their checklist. Issues it was hoped would be addressed (in the light of the literature on this topic) included the following:

- whether the interface reflected the educational objectives of the system;
- the suitability of the media selected;
- the user appeal of the systems;
- the interface concerns;
- evaluating the execution of the various media.

6 Results

Every student (thirteen in total) appraised all the systems developed by their colleagues. All the students provided a checklist of the criteria used for the evaluation - some were very detailed and others quite brief - from thirty items at one end of the scale to five at the other. The two students with the longest checklists evaluated whether the system fulfilled its objectives, the selection of multimedia components and the execution of the multimedia as well as detail of the interface such as the provision of feedback, ease of navigation etc. There were another three quite comprehensive taxonomies which covered many but not all of the relevant issues. Five students used Nielsen's [10, 11] guidelines for heuristic evaluation without adding to them to deal with the educational or multimedia aspects of the systems. The three students with the short checklists had incorporated rather broad categories such as ease of use, knowledge presentation, navigation, multimedia concerns and quality of knowledge which gave them reasonable but not complete cover of the relevant issues.

Expert evaluation can be carried out by anyone with appropriate skills and by more than one evaluator. In one case, two people evaluated the systems and combined their findings whilst on another occasion the student drew up the framework but did not carry out the heuristic evaluation himself. Some students scored the various items and averaged the results. This enabled systems to be ranked. Others did not attempt to provide an overall score for each system but left the findings to speak for themselves.

1. Did students check to see whether the interface reflected the educational objectives of the system?

In total, eight of the students included questions in their checklist which related to the educational nature of the system. Three of these explicitly mentioned the educational objectives of the systems under review before providing their assessment.

> *"This system is a multimedia tutor system designed to aid students in learning the Maori language. The system uses both visual and aural stimuli to teach words and concepts."*
> *"The system aims to provide information to undergraduate students."*
> *"It aims at helping children to learn a shape through playing which makes learning easy and fun."*

The eight students who considered the purpose of the system, that is its educational aspect, did not all ask the same questions. A variety of issues were covered as follows:

How does the system consider educational objectives?
Is the system suitable for intended users?
Who is the target audience?
Is the system aimed at the right audience?
Does the system have a reasonable informational content?
Is the quality of knowledge sufficient?

The evaluations included comments such as the following:

> *"Good way to teach a student with audio pronouncing the language and seeing the words on the screen."*
> *"Including some information on the properties of the different shapes and showing everyday examples of them would make learning the shapes a richer experience."*
> *"It does not really seem to be an educational system, more an informative system."*
> *"The current system does not seem to have a glossary page. A page for quick lookups and acronyms and jargon would probably be helpful."*
> *"It might have been good to have an option of telling users what the different shapes look like."*

Some of the students, however, not only evaluated the systems in accordance with their checklist but also in the light of their experience in appraising the programs. They mentioned, therefore, other important criteria in their assessments. One student centred her overall assessment around the suitability of a system for its purpose although this was not included in her criteria for evaluation. Two other students, also, mentioned educational issues such as whether the systems provided adequate content and comprehensible instructions.

> *"I had no idea what I needed to do and how the test was being processed."*

2. Did the students consider whether the mix of multimedia selected was appropriate for the stated purposes of the system ?

Only two students included in the guidelines for evaluation the need to consider whether suitable media were selected and used appropriately. One student asked the question "*Is the multimedia actually of use and not redundant?*" The other student checked that the mix of multimedia was used appropriately. This student noted not only occasions when a particular mix of media was ineffective but also when media was missing.

> *"The current system seems to rely too much on textual information. Improvements would be to make more use of video, diagrams and to provide more navigation options. These changes would give the user a more enriching learning experience."*

Many other relevant comments were made by the other students about an appropriate usage of multimedia, although they did not take the issue into account systematically.

"Of all the applications reviewed this has the most appeal due to its excellent usage of graphics and sound. The main area it could be faulted on is the large textual explanations given but these are offset by the following graphical examples."

"It uses multimedia such as sound and text making the system vivid and active."

Only one student fell into the trap of believing that a multimedia system had to incorporate all media. He would criticise a system that did not include video, for instance. No regard was paid to whether adding video would contribute to meeting the goals of the application.

3. Since educational systems have to be appealing to their users, did the students take this factor into account?

With regard to the appeal of a system, this issue was only expressly considered by four students. Related questions were as follows:

Is the system interesting and fun?
Does the user find the system visually appealing?
Has information been presented in an interesting manner?
Has the system an attractive presentation?

Comments made by these students include the following:

"Its creative design of the main menu ... and its appropriate use of the sound medium, make it enjoyable to use the system."
"There was no splash screen introduction. Whilst this may seem superfluous, good splash screens can be used to arouse a user's interest."

Three other students, however, did mention this issue. One of these was the student who did not carry out the expert evaluation himself. After watching the evaluation (according to Nielsen's guidelines as specified), he realised that the system he preferred obtained the lowest rating. He proceeded to base his overall assessment of the systems on whether they had an interesting and attractive interface. A second student also focused on the interest or lack of it in the programs. Of the Maori tutor, she said " *The welcome interface is impressive. The background and the music gives me some feeling of Maori culture.*" According to her, another system was a little bit boring.

An issue that relates to the appeal or attractiveness of a system is the appropriate use of colour. Four students included at least one item in their checklist concerning colour. Questions were as follows:

Are too few or too many colours used?
Is the colour in the system beautiful?
Does the use of colour help to make the displays clear?
Is the use of colour bad, normal, good or excellent?

One system was notable for its use of colour and several comments were made about this

"The very colourful shapes used are appropriate for the school based children as seen as being the intended users."
"The colour used in the system is beautiful."
"Good colour choice, relaxing."

This was not the only the system to make effective use of colour, however and one student observed in his conclusion that no-one made the mistake of using too many colours.

4. What typical interface factors were considered?

All of the students checked for at least one well-known interface concern such as consistency, clearly marked exits etc. Seven of them specifically included the guidelines for heuristic evaluation by Nielsen and Molich [11] or the updated version by Nielsen [10] in their checklist.

It was also expected when considering interface issues that the importance of navigation in interactive instructional systems should be recognised. It should not be just one more item in a checklist. Eleven of the 13 students took account of this issue.

"No stop, rewind or scroll bars for video."
"Gives reasonable freedom to navigate backwards and forwards."
"Not very flexible, very linear in its execution."
"It is very easy to get "lost " while navigating through the system. No "back" button provided."
"Clicking at various places in the window may move you to unexpected screens."
"With the test screens there is no title indicating this."
"Have no idea what I am supposed to do in the first screen."

Four of the students highlighted the importance of navigation. Three incorporated this into their framework as a high level criteria. A fourth not only checked how users moved around the system but whether or not the users would know where they were in the system.

5. Did the students evaluate the multimedia components of the system?

Four students evaluated the execution of the individual media. Two of these assessed the effectiveness of each component: video, sound, graphics, text etc. by rating them on a scale. The third student concentrated on text and icons. His section on text was quite detailed, checking the length of the sentence, whether it just focused on one issue, and whether there was sufficient white space around it. The fourth student checked that the multimedia was not "over the top".

"When the system explained the Maori words, text is well organised."
"I liked the use of Maori music with the splash screen."
"Liked the introduction - morphing shapes."
"Widely accepted icons are used to aid page-based navigation."
"The background music is excellent. The button clicking sounds great."
"Image excellent. When the system first starts, the animation is creative and attractive."

7 Discussion

Reflecting on the results of the assignment, it became clear that learning about multimedia evaluation took place at various points in time. Most of the systems developed by the students were stimulating to watch. As developers the students were clearly aware of the need to use appropriate media in suitable combinations [1] and of the requirement to navigate easily through the system [12]. Some of what they had learned was reflected in the checklists that they developed for evaluating the systems of others. There was a difference, however, between the criteria specified by students for evaluation and those actually used when making their overall appraisals. These sometimes took additional factors into account that had not been included in the stated checklist. The experience of evaluating the systems themselves, allowed further learning to take place. It will be the more complete list of factors that are considered in the remainder of the discussion since the experience gained from carrying out appraisals is important and should not be discounted.

Eleven students checked to see whether the interface reflected the educational objectives of the system and two of these also considered whether the mix of multimedia was appropriate for the stated purposes. All of the students considered at least one relevant interface factor (consistency, clearly marked exits, etc). Six of the students also realised the need to find out whether or not a system would appeal to users. Four students included assessment of media components in their appraisals, however none of their questions showed a deep understanding of media issues.

It was pleasing from an educational perspective that most of the students when carrying out their evaluations took account of the functionality of the system. This cannot be divorced from interface considerations as for many users the interface is the system and must deliver the appropriate functionality.

Interface issues, too, were seen as important by all of the students. Of these, 11 checked to see whether a user

could easily navigate around the program. This is an important issue in interactive multimedia systems and was recognised as such by the students. Eight of the students carried out a reasonably comprehensive evaluation of traditional interface concerns but for five it was rather rudimentary. This was surprising given the emphasis on the heuristic evaluation in the undergraduate and post-graduate courses.

Overall there were only two students whose evaluation was limited to just those interface issues covered by Nielsen [10, 11]. This meant that they excluded educational considerations, the appeal of the interface, an evaluation of the individual media and whether or not they were used in appropriate combinations.

A major weakness in the student evaluations' overall was the failure to consider whether the mix of multimedia selected was appropriate for the purpose of the system. Whilst the students did consider educational issues at a high level, they found it difficult to move to a detailed perspective, that is were suitable media selected and combined? This may involve greater knowledge of the potentialities and problems of the individual media than the students possessed. They tended, therefore, to have an overall impression of a system. This was reflected again in the failure of two thirds of the students to evaluate the exe cution of each media component.

Around 50% of the students did not take appeal/interest and fun sufficiently into account. This can possibly be attributed to the fact that they were not the intended users of the systems. If they had been drawing up a list of questions for users to answer they may have incorporated this. Nonetheless, it was an important omission as multimedia systems set out to interest and hold the attention of their users.

As the above discussion shows, students were particularly weak in considering what was to them the new area of multimedia. They did not appear to have the knowledge or experience to determine how to evaluate the media. They were given some exposure to these issues in lectures but do not appear to have followed them up. Whilst no one student came up with a complete checklist for evaluating multimedia systems, amalgamating the items in their checklists enables a comprehensive framework to be developed. See Appendix 1 for the main features of this. In future it may be preferable to provide students who have built a multimedia system with some scaffolding to help with the evaluation phase. Scaffolding [3] refers to supports that can be provided by a teacher to students. The main headings in the taxonomy outlined in the Appendix could be provided. The students could then be asked to develop appropriate questions for each area.

8 Conclusions

The students learned a great deal by building multimedia software and evaluating the systems of others. This was reflected in the perceptive comments of the students made in their written assignments. It was not always reflected, however, in the frameworks for evaluation that they developed, only two of which were comprehensive. Certain areas were handled well by the students, for example checking that each system was suitable for its purpose and the importance of navigation. Two significant issues, though, were only identified by a minority of the students – the need to choose appropriate media and to determine how well they had been produced. It appears that because the area of multimedia was new to the students, they needed more scaffolding in place to be able to learn from their own experiences. Instead of developing an evaluation framework from scratch, some initial information can be given to students in future that they then have to flesh out.

References

[1] Alty, J. L., Multimedia – "What is it and how do we exploit it?" In D. Diaper & N. Hammond. (Eds.), People and Computers VI, pp. 31-44, Cambridge: Cambridge University Press, (1991).

[2] Collins, A., "What different media do best", In The Six International Conference on Computers in Education, Beijing, (1998).

[3] Collins, A., Brown J.S., & Newman S. E., "Cognitive Apprenticeship: Teaching the craft of Reading, Writing and Mathematics", In L. B. Resnick (Ed), Knowing, Learning and Instruction, Hillsdale, New Jersey: Lawrence Erlbaum, (1989).

[4] England, E., & Finney, A., "Managing Multimedia", Harlow: Addison-Wesley. (1996).

[5] Frater, H., & Paulissen, D, "Multimedia mania : experience the excitement of multimedia computing", Grand Rapids: Abacus. (1993).

[6] Harel, I. (Ed.), "Constructionist Learning", Boston: MIT Press, (1990).

[7] Heller, R., & Martin, C. D., "A Media Taxonomy", IEEE Multimedia, 2(4), 36-45. (1995).
[8] Howard, S., & Murray, D. M., "A Taxonomy of Evaluation Techniques for HCI", In H. J. Bullinger & B. Shackel (Eds.), Human Computer Interaction. Interact' 87, pp. 453-459, Amsterdam: North Holland. (1987).
[9] Jonassen, D. H., Wilson, B. G., Wang, S., & Grabinger, R. S., "Constructivistic uses of expert systems to support learning". Journal of Computer Based Instruction, 20(3), pp. 86-94, (1993).
[10] Nielsen, J., "Enhancing the explanatory power of usability heuristic", Proc. ACM CHI'94 Conf. (Boston, MA, April 24-28), 152-158. (1994).
[11] Nielsen, J., & Molich, R., Heuristic Evaluation of User Interfaces. In J. C. Chew & J. Whiteside (Eds.), Proceedings of CHI' 90: Human Factors in Computing Systems, pp. 249-256, New York: ACM Press. (1990).
[12] Preece, J., "Hypermedia, multimedia and human factors". In C. Latchem, J. Williamson, & L. Henderson-Lancett (Eds.), Interactive Media, London: Kogan Page, (1993b).
[13] Reeves, T. C., & Harmon S., "Systematic evaluation procedures for interactive multimedia for education and training". In S. Reisman (Ed.), Multimedia Computing: Preparing for the 21st Century, London: Idea Group Publishing, (1994).
[14] Tannenbaum, R. S., "Theoretical Foundations of Multimedia", New York: Freeman, (1988).
[15] Vaughan, T., "Multimedia: Making it Work", Berkeley, Cal: Osborne McGraw-Hill. (2nd ed.). (1994).

Appendix 1

1. Does the system meet its objectives?
   - Who is the target audience?
   - Is the system suitable for the target audience?
   - Does the system include (in the case of educational systems) sufficient content?

2. Has an appropriate mix of multimedia been selected?
   - Have sound and text been used effectively together?
   - Have sound and graphics been used together effectively?

3. Will the program appeal to users?
   - Is the system fun?
   - Will the user find the system visually appealing?
   - Has the system a features that will pall over time e.g. an unusual sound or joke?
   - Has colour been used in an appropriate fashion?

4. Has the interface been properly constructed?
   - Is the interface consistent ?
   - Is help available when necessary?
   - Can users easily navigate around the system?
   - How does the user navigate around the system?
   - How does the user know where s/he is?
   - Is progression through the program logical?
   - Can the user start and stop as required?

5. Have the individual media been well-executed?
   - Is the text /graphics,/sound etc well produced?
   - Are the sections of text too long/too short?
   - Will the text be understood by the target audience?
   - Has text been expressed using elaboration, representation or abstraction?

Evaluation of class organization in the computer literacy education

Akira Harada*, Michio Nakanishi and Masashi Komori***
** School of Human Sciences, Osaka University*
Yamadaoka 1-2, Suita, Osaka 565-0871, Japan
E-mail: {harada, komori}@hus.osaka-u.ac.jp
*** Cybermedia Center, Osaka University*
Machikaneyama 1-30, Toyonaka, Osaka 560-0043, Japan
E-mail: naka@cmc.osaka-u.ac.jp

This paper compares two grouping strategies for teaching computer literacy at the university. The authors and their colleagues have been involved in the computer literacy education to 180 freshmen majoring in Letters and 150 freshmen majoring in Human Sciences for five years. In 1999, 180 students were organized into three classes at the early stage of the semester according to the student's wish, whereas 150 students were reorganized into three classes based on an achievement exam in the middle of the semester. The statistical analysis of exams and students' self-assessment showed that the early class organization was not so effective compared to the mid-term reorganization. The effect of mid-term reorganization was significant in the slow-learners class.

Keywords: **class organization, computer literacy education, self-assessment, teaching strategy**

1 Introduction

Computer literacy education in Japanese colleges and universities is facing a problem of diversity of students' computer skill levels. The reason for this is twofold. One is that very few high schools introduce the computer literacy education is into their curriculum. The other is that as computer price is falling down the number of students is increasing who have learned how to use word-processing or e-mails by themselves at home. This problem led us to study how to help our students learn this subject in good quality.

In Osaka University, the computer literary education has been a required subject for all freshmen since 1994. The computer literacy course consists of 15 sessions, and each session lasts 90 minutes, which includes demonstrations by a teacher and hands-on activities by students. Usually an assignment for each session is also given which will take an hour or two to complete. Three teachers including the authors have been teaching the computer literacy course to over 150 freshmen majoring in human sciences, and our three colleagues have been involved in teaching to 180 students majoring in letters.

In 1999, 150 students majoring in Human Sciences were organized into three parallel 50-student classes according to the enrollment order before the first session. In the middle of the semester, we gave an exam that includes hands-on work, such as word document processing, consulting online dictionaries, and finding web sites. Then we reorganized the three classes based on the exam score. Other background variables (age, gender and future academic field) were not considered for the class organization. The class organization aimed at ability grouping, that would provide non-experienced students with a slower work pace and allow high-achieving students to be sufficiently challenged by more demanding lessons. At the end of the semester, we again gave them an exam that would measure how they made progress.

As for the 180 students majoring in Letters, three parallel 60-student classes were reorganized according to the students' wish based on the questionnaire survey at the fourth session of the course. That is, the keywords of the three new classes, "slow and steady", "intermediate" and "intensive" were shown to students, and each student chose one of the classes.

In this paper, we begin with related work and a brief explanation of our computer literacy course, followed by the methodology of the class reorganization. Then, we present the statistical data analysis to show that class reorganization in the middle of the term was effective.

#1 Change this plain text file to rich text format, then change the font of the marked words to Ryumin 12 point, and place it in the center.
#2 Explain how to use Japanese Kana-Kanji translation and how to register your name in your own dictionary.
#3 Look up the three words (omitted here) in the following dictionaries: English-Japanese, Japanese-English, and Webster.
#4 Draw a tiny picture and insert it into this page.
#5 Find URLs of the National Diet Library and any two online book stores.
#6 Look into "/SharedLibrary/Literature/" and describe what's in it.
#7 What should be considered when you decide your password string?
#8 Find the specified string in the large file and copy the paragraph to the answer sheet.
#9 Describe how to cope with chain mails.
#10 Describe how to limit the line length to fewer than 65 characters in the body of an e-mail.

Table 1 Midterm exam sample in 1999

Touch typing	(poor) 1 2 3 4 5 (excellent)
Mouse operation (click, double click, drag)	(poor) 1 2 3 4 5 (excellent)
Window operation (resize, move, iconify, hide)	(poor) 1 2 3 4 5 (excellent)
Japanese Kana-Kanji translation	(poor) 1 2 3 4 5 (excellent)
File/Folder operation (move, rename, create)	(poor) 1 2 3 4 5 (excellent)
Word document processing (fonts, centering, insert graphics)	(poor) 1 2 3 4 5 (excellent)
Mail (MIME, signature, save to file, reply, delete, re-file)	(poor) 1 2 3 4 5 (excellent)
Web (search engine, book-mark)	(poor) 1 2 3 4 5 (excellent)
Use of online dictionary (Japanese, English)	(poor) 1 2 3 4 5 (excellent)
Canceling your printer job	(poor) 1 2 3 4 5 (excellent)

Table 2 Questionnaire survey for self-assessment

2 Related work

Although there have been much previous research on ability grouping, tracking, and class organization, they are mainly for K-12 school education, e.g. [4,9,10]. Furthermore, as far as the authors know, there has not been any research on class reorganization in the middle of a semester for computer literacy education. The authors have tried class reorganization for five years and presented its result obtained before 1998 in [5]. Our reorganization method is basically based on the exam score, but is not the same as cluster grouping.

3 Computer literacy education

Since the 1970s, the definition of computer literacy has evolved, and many researchers have discussed the courseware and teaching methodology of the computer literacy course, e.g. [2,3,4]. The authors believe that to learn details of word processing and spreadsheet application is not important but to grasp the concept and principal facilities of those applications is a key for students to become literate. Furthermore, the attitude to learn by himself or herself is also a key.

In the latest syllabus of the computer literary course in Osaka University, topics consist of two categories, "*Requisites*" and "*Options*".

Requisite category consists of the following items.

- File system, file operation, floppy disks
- Word processing, kana-kanji conversion (for Japanese characters)
- Concept of the Internet, network etiquette
- Electronic mail, web

- Draw and/or paint software
- Spreadsheet

Options are

- Net news
- LaTeX with graphics
- Writing HTML
- Mathematica
- SAS (Statistics)
- Script languages (perl, awk, shell, etc.)
- Computer ethics, social problems

Since one course session lasts 90 minutes and is held once a week, all topics of requisite category are the minimum competencies and are covered in about seven weeks. For the rest of one semester, teachers select some of the items from optional category depending on the students' majors. For example, LaTeX and Mathematica are selected for students majoring in Physics and Mathematics, while spreadsheets and SAS for Economics.

4 Class reorganization in the middle of a term

In this section, we explain the class reorganization method that we adopted in 1999. Then we show the examination scores and self-assessment scores of the three classes.

4.1 Reorganizing three classes by a hands-on performance exam

After we completed topics in requisite category, we set a mid-term examination that demands 1-hour hands on work, because there were differences between students how fast they got accustomed to computer operations in class. Table 1 shows the questions of the mid-term exam. We marked the examination papers out of 100 (each question of 10), and used the scores to reorganize the classes. The students who achieved more than 67 points were grouped into class A. The threshold between class B (50 students) and class C (50 students) was 52 points. The average total score was 60.3 (s=15.7).

The average scores of the new classes A, B, and C were 77 (s=7.4), 60 (s=3.9), 42 (s=7.5) points, respectively. The average score of class A students was more than 5.5 for all ten questions, whereas the students who were grouped into class C got only 2.2 and 2.3 for question #5 (web search) and #6 (file search), respectively, which were significantly lower than the other two classes.

4.1.1 Self-assessment by students

Before the mid-term exam, a questionnaire survey paper was distributed to the students. The survey consisted of 10 questions, which would measure students' mastery of competencies taught by that time (Table 2).

The answers to these questions were collected on a 5-point scale. The scores of the collected questionnaire showed a positive correlation between the exam and the students' self-assessments. That is, class A students felt good at the following competencies: inserting graphics into a document, operation of files/folders, and searching web site, whereas class C students answered that they had not mastered those topics. As for searching files from hierarchical file structure, class C students perceived that they were good at it; however, its exam score is poor. This indicates that class C students did not understand the file structure itself. Touch-typing and Email competencies were not statistically significant between three classes.

4.1.2 Curriculum after the class reorganization

The result of the exam and the questionnaire showed us what we should teach in the new classes after the class reorganization. We provided class C students with a slower work pace and revisited those competencies that they were not good at. For class A students, we gave lectures more extensively than other two classes and gave self-teaching assignment of LaTeX in the summer vacation.

In order to allow them to have an active participation in the shaping and augmenting of their learning, we also introduced self-teaching approach for learning spreadsheets in all classes. That is, after a brief explanation given by a teacher, students followed tutorials on the teacher's web pages. We had two teaching assistants each class, we asked them not to teach detailed step-by-step operations to the students but to help the students to find the way by themselves.

4.2 Evaluation of class reorganization

4.2.1 Statistical evaluations of exam and questionnaire

At the end of the course, we gave a self-assessment questionnaire survey followed by the term-end examination, which required hands-on work of about an hour. Here we begin with the analysis of the exam scores.

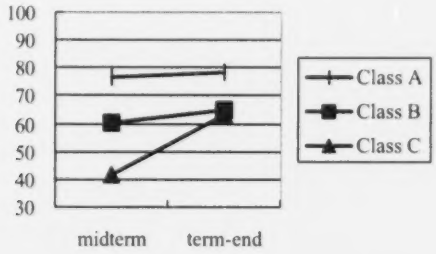


Figure 1 Total scores of midterm and term-end exams

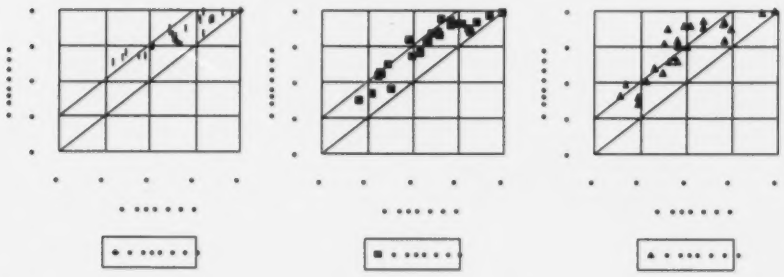


Figure 2 Scores of self-assessment

The total score and the scores of three questions (use of online dictionaries, OPAC search, and limiting line length of Mail body), which are similar in two exams, were considered in a two-way ANOVA. As a result, these four items showed an "interaction" between the two exams and classes ($p < 0.05$).

Figure 1 shows a comparison of the average scores of two examinations. It indicates the existence of the "ceiling effect", that is, the score difference between class A and other two classes decreased after the class reorganization.

As for spreadsheets, two sessions (which means 180 minutes) were assigned for class C, while one session was assigned for class A and B classes using self-learning web based text. But the scores were 8 points in class A and 5 points in class C. The score of writing HTML also supports this tendency. From this fact, it is proved that class A students had higher ability in computer operations than other two class students.

4.2.2 Analysis of self-assessment questionnaire

As for the 27 items that were included both mid-term and term end questionnaires, the average term end exam scores were higher than mid-term scores in all classes in 1998 and in 1999. In Figure 2, the x-axis

shows the midterm score, the y-axis shows the term-end score, and each scatter point in the graph represents the score of one item. Two years analysis showed same tendency.

We took the exam timing (midterm or term-end) and the classes as the factors of the two-way analysis of variance (ANOVA). The following four items of the questionnaire shows that there is an "interaction" between the exam timing and the classes ($p < 0.05$).

- Creating a new folder (directory)
- Editing a word document
- Browsing web pages
- Searching web site

We conclude that class C students perceived they were as self-confident in these items as the students in the other two classes.

Though the exam scores are not significantly correlated with students' self-assessments, we consider the class reorganization was effective for slow learners class students, because it is important for them to have confidence in their computer operations.

5 Comparison of class reorganizations

There is another attempt to reorganize classes. The 180 students majoring in Letters chose one of three classes whose lecture policy are "intensive (class A)", "intermediate (class B)" and "slow and steady (class C)". Teachers expected that computer literate students might choose class A, and novice would choose class C.

To evaluate two class organizations, we discuss the term-end exam scores and result of self-assessment.

5.1 Comparison of the term-end exam score

The students in six classes were given an examination at the end of the term. The full marks of each question were ten points. The following five questions are common to all classes.

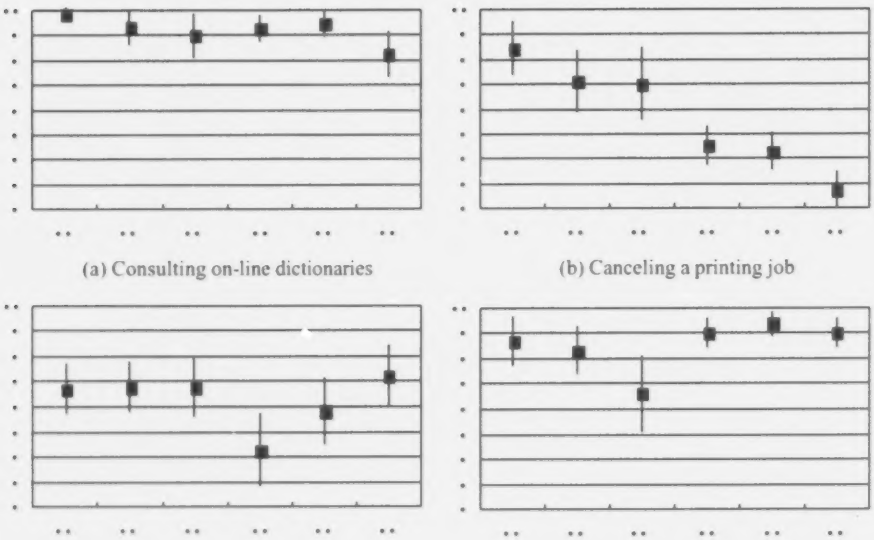
(a) Look a difficult Kanji word up in a Japanese online dictionary.
(b) Explain how to cancel a printing job.
(c) Find Yukio Mishima's book using online public access catalog of the university library.
(d) Explain why 2-byte special characters should be avoided in e-mails.
(e) Show URLs of the companies which sell cars on the web.

In Figure 3, the square(•) indicates the mean score of each class and the vertical line shows the 95% confidence interval of the mean score. To identify a particular class, we use H (for Human Sciences) and L (for Letters) as a subscript of the class name. For example, A_H denotes the "highest-score" class for students majoring in Human Sciences, C_L denotes the "slow-and-steady" class for students majoring in Letters.

The result of the "one-way ANOVA " and the "statistical multiple comparison" shows that questions (a), (b), (c) and (d) have statistical difference ($p<0.05$). Most of the confidence intervals of the class C are bigger than those of other classes, which means the variance of student competencies exists.
The score of the question (b) of "H" classes is higher than "L" classes. This might due to the fact that the operation was not taught in "L" classes.

5.2 Comparison of exam score and result of the self-assessment

Before the term-end exam, the same questionnaire survey was also distributed to the L classes. Figure 4 shows the distribution of self-assessment score of two items: consulting on-line dictionaries and canceling a printing job. The "one-way ANOVA " and the "statistical multiple comparison" show that the differences of mean scores among classes were significant in the Figure 4 (a) but not significant in the Figure 4 (b).



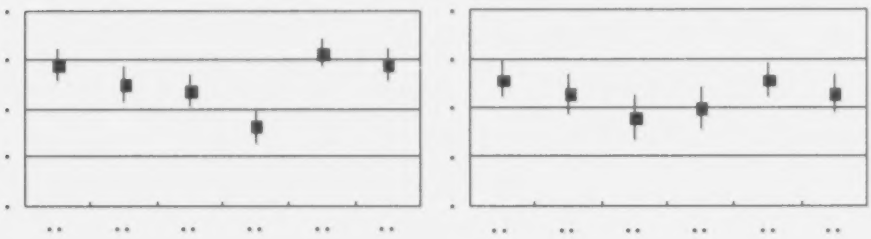
(a) Consulting on-line dictionaries

(b) Canceling a printing job

(c) Accessing on-line catalog of the library

(d) Explaining special characters

Figure 3 Distribution of the term-end exam scores



(a) Consulting on-line dictionaries

(b) Canceling a printing job

Figure 4 Distribution of self-assessment scores

The comparison between the exam scores and self-assessment shows that all of students who achieved high mark in the exam don't necessarily perceive that they were very good at it. For example, although the scores are high in Figure 3 (a), the result of the self-assessment is not good.

6 Conclusions

In the first half of the paper, we described the effect of class reorganization in the middle of a term, which has enhanced learning outcomes in computer literacy classes. The class reorganization is also a good tool for teachers to know the way to lead students to higher skill level.

Figure 1 and Figure 2 suggest that many students, especially for those who belonged to class C, have made progress during the latter half of the semester. The progress was brought by the two factors, that is, the students' internal motivation and the class reorganization. Moreover, the "interaction effect" of the two factors must be taken into account as a factorial effect. In order to measure the effect of two factors separately, an experiment based on ANOVA model is necessary. However, the score improvement of class C suggests the existence of the class reorganization effect.

In 2000, we will incorporate group work, discussion and presentation for high ability students after the class reorganization.

References

[1] Gilster, P., "Digital literacy", John Wiley & Sons (1998).

[2] Higdon, J., "The evolution of computer literacy for preservice teachers", Proc. of 6th Int. Conf. of the Society for Information Technology and Teacher Education (1995).

[3] Keizer, J. and Wright, V., "Constructivism implementation in undergraduate computer application classes", Proc. of 8th Inf. Conf. of the Society for Information Technology and Teacher Education (1997).

[4] Mills, R., "Grouping students for instruction in middle schools", ERIC Digest, EDO-PS-98-4 (1998).

[5] Nakanishi, M. and Harada, A., "Reorganizing computer literacy classes in the middle of a term", Proc. of 7th Int. Conf. on Computers in Education, pp.507-514 (1999).

[6] Nakanishi, M. and Harada, A., "Ability grouping for teaching computer literacy classes", Proc. of ED-MEDIA, pp785-790 (2000).

[7] Raiford, P. and Braulick, L., "Computer literacy class for preservice teachers at university of Texas at Austin", Proc. of 6th Int. Conf. of the Society for Information Technology and Teacher Education (1995).

[8] Rogers, K.B., "The relationship of grouping practices to the education of the gifted and talented leaner", http://www.ucc.uconn.edu/~wwwgt/rogers.html (1999).

[9] Weinbrenner, S. and Devlin, B., "Cluster grouping of gifted students : How to provide full-time services on a part-time budget", http://www.kidsource.com/kidsource/content2/cluster-grouping.html (2000).

[10] Wiggins, G.P., "Assessing student performance: exploring the purpose and limits of testing", Jossey-Bass Publishers (1993).

Evaluation of the Web-Based Learning System "The Basic of Digital Media Communication "

Liu Huifen, Yu Lei, Liu Fang and Bao Su
Department of Communication, Tsinghua University, Beijing 100084,P.R.China
Tel: 86-10-62788647 Fax: 86-10-62785736
E-mail: liuhf@tsinghua.edu.cn

The web-based learning system "The Basic of Digital Media Communication" creates an interactive learning environment, which includes all the knowledge and aspects needed for the course. During the course, each student can choose freely either In Class Learning (ICL) or Web-Based Learning (WBL). Based on the questionnaires after the course, the paper evaluates the courseware system from the view of teaching and learning processes, interactive learning environments and learning effects. After the comparing study between ICL and WBL, it can be concluded that better computer and Internet environment can promote the students to accept the way of WBL, and WBL can enhance students' ability of self-study. Compared with ICL students, WBL students take less time and get higher score, and they are usually more efficient and individualized. The impact of traditional way of learning and interpersonal communication will exist for a long time, and there should be multi-way of learning to meet the different students.

Keywords: **Web-Based Learning, Evaluation, Interactive Learning Environments, Teaching and Learning Processes**

1 Introduction

The course, "The Basic of Digital Medial Communication", is a combination of computer application, communication and art design and it consists of basic theories, applications and creative design. That is, the basic knowledge of this course is about how to use the computer to organize, edit and deliver multimedia information. During the course, students need to do a lot of design works on computer. Because the content is so practical nowadays, the course is very popular among students. But since the course opened in 1996,it has confronted different problems concerning education mode and content. Firstly, the registration of the course is always limited by classroom and computer laboratory. Secondly, some of the reading materials were renewed and expanded nearly every year. Thirdly, because of the characteristics of the course, the most efficient way of learning and teaching is with the help of multimedia and network. Therefor, in the process of education reform, the course has experienced three ways of teaching and learning mode, that is, traditional learning, multimedia-assisted learning and Web-Based Learning. While improving the course gradually, a web-based courseware • The Basic of Digital Medial Communication• have been developed[1]. This courseware system constructs a comprehensive and interactive learning environment. The data capacity of the courseware is about 1 Gega Byte totally, and it includes all information and aspects needed for the course, such as the schedule, learning materials, experiment instruction, reference materials, demonstration and examples, answering questions, homework handed in and feedback, discussions and so on.

The object of the courseware is to construct a new learning mode, which should inspire the students' creativity and innovation. While instructed by teacher and assisted with modern education technologies, the students should be the center in the teaching and learning process. The course is carry on in an open and interactive environment, and the main features are as following:

(1) Open Computer Laboratories of the University are opened for the students, and they can visit the courseware at anywhere and on anytime if they logon to Internet. All the information about the course is published on the courseware, and the latest news or notice is always renewed according to teaching and learning process. The students can ask questions and discuss them with others through the courseware.

(2) According to the schedule, the students should finish a serial of media design work step by step. All the works can be handed in through web. Not long after hand in, each student can look up the web and get the score and comment from the teacher for each design work. The excellent works and the teacher's comments will be published on the web on time, and the students can refer to and discuss about the works.
(3) In class lectures are based on the courseware, which will be projected on multimedia classroom. Discussing classes are arranged during the semester, which are also based on the courseware and projector. In this paper, we call this way of learning as In Class Learning (ICL).
(4) Except the ICL, the students can also choose the way of Web-Based Learning (WBL). In this way, the students need not attend the in class lectures, but they should finished all the design work and final test by self-leaning through the courseware system. The requirement of design work and final test are the same for both ICL and WBL students.

At first, the courseware system was used in a course composed of 30 students. Then, in the fall of 1999, it was used in a selective course opening to all the undergraduates and each student can freely choose the way of ICL or WBL, While the design work requirements and the test for both way are the same. At the end of the semester, two kinds of questionnaires were carried out among two group chose different learning modes. The questionnaires were designed in three aspects: the courseware system, the teaching and learning process and the learning effect. Compared and analyzed the feedback from the two groups, it can be concluded that, the web-based courseware system and learning mode have reached expected objects, and the learning effects have connection to the computer environment, the self-study ability of students and the impacts of traditional way of learning.

2 Web-Based Learning is the trend of modern education development

At the beginning of the semester, only 25% of the total 70 students chose the way of WBL. The others either chose ICL or couldn't make their mind yet. After a period of time, when they got more familiar with the courseware system, all the students uncertain and 18% of those chose ICL originally turned to WBL. Consequently, the WBL students have made up of 61% of the total students registered. According to the investigation, the students' choice could be affected mainly by three factors, that is, self-study ability, computer and Internet environment and the basic knowledge for the course.

Among all the students, 72% of the juniors and seniors chose WBL, while only 46% of the freshmen and sophomores chose WBL. Those who chose the WBL consider it a better way, because the place, time and learning schedule can all been controlled freely by themselves. This in turn requires the students to be of higher ability of self-study. Most juniors and seniors prefer WBL, for they are usually better at self-study. From this point of view, higher ability of self-study is needed for WBL, and WBL will improve their ability of self-study, which is also the basic ability for life-long learning.

In order to visit the courseware without the limitation of time and space, Internet logon is the basic environment for the students. There are about 500 computers connected to Internet in the Open Laboratory of our University, but it's always full of the students. More and more students have their own computers in dormitories, and more and more dormitories are connected to the Internet via high speed cable. From the investigation, most students chose WBL have better computer and Internet environment than those chose ICL. Therefor, the better the computer & Internet environment, the more the students who will accept WBL.

Because of the course's feature, computer is both the tool and object of learning the course. Compared to ICL group, most WBL students consider they had basic idea about the course at the beginning of the semester. That means that WBL students have basic ability of computer application, which could been called as digital literacy and it's the basic literacy demand in the information age [3]. So, the digital literacy is another factors that can affect their choices. In the process of WBL, computers and web are basic tools of learning, and it will definitely improve one's ability for computer application or digital literacy.

3 Web-Based Learning is of more efficiency and individuality

WBL has more advantages over traditional way of learning. WBL has changed the traditional relationship between teacher and students, where the teacher is the initiative disseminator and the students are passive receivers. The courseware enables the students to study individually. They can decide how long to visit the courseware each time and which part to concentrate on. What's more, they can do the homework or design work at the same time while reading the courseware, which is more efficient than traditional way of in class

lecture and then design work.

Take the learning procedure of one chapter in the course for an example. In the teaching schedule, 6 in class hours are planed to finish the chapter and the relative design work. Analyzing the percentage of students and the total hours used to finish this chapter' s learning and design work (Fig 1), the statistic result shows that the hours used by WBL students tend to be more changeable. The average hours used by WBL and ICL are 6.5 and 8 hours respectively, while the average scores of this design work are 77.7 and 79.8 respectively. That is, WBL group turns to be take less average time and get higher marks.

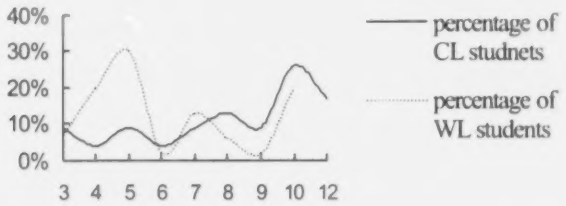


Fig 1: Percentage of students and the total hours used to learn chapter 7

Study the total time used for the course (Fig 2), it also shows that the ICL students tend to arrange their learning time according to teacher' s schedule, while WBL students tend to arrange their time individually. From the statistic of how WBL students read the courseware, only about 35% of them learn systematically and about 45% of them consult the courseware only if they need help. But WBL students' average total score is 84, higher than 80 of ICL students. Although scores are just one way to test the effect of learning, from all statistic results and analysis, it shows that WBL is of more efficiency and individuality.

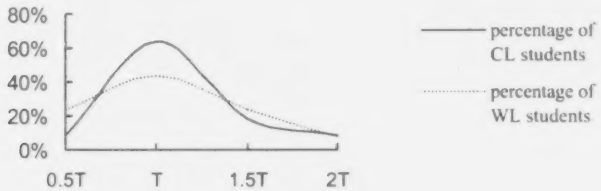


Fig 2: Percentage of students and the total time used for the course
(note: T is the total in class time of the course' s schedule)

4 The courseware system plays an important part in the learning process

The courseware is both the learning object and an effective learning tool, so it is very important in the learning process. At the beginning of the semester, teacher announces the schedule, homework requirement on the courseware. Then the Students can learn the knowledge from the courseware step by step according to the schedule, hand in their homework, ask questions and discuss relevant topics through the courseware. The answers to the common questions, the score and comment of everyone' s homework are also published on the courseware. The latest news on the courseware is renewed at least two times a week. Though parts of the learning materials are almost the same with the textbook, the courseware is more attractive because its multimedia, multiform and interaction.

The courseware is the main learning materials for the two groups, and more than one third of the students completed the learning only by the courseware. The top successful aspects of the course from the two group are showed in Table 1. When designing the courseware system, it was not expected that homework hand in and feedback by the courseware would be so popular among the students. The students whose excellent design work is published on the courseware are very proud about it, and the others would be greatly inspired and they will make their efforts to improve their own works too. So in the courseware, not only the database of learning material but also the interactive environment has played very important part in the teaching and

learning process. Both WBL and ICL students evaluate the course highly, and the courseware system has reached its expected objects.

	ICL	WBL
1	Get the latest news from the courseware	Web-based learning
2	Homework hand in and feedback via the courseware	Homework hand in and feedback via the courseware
3	Discussing class by projector	Get the latest news from the courseware
4	In class lecture by projector	

Table 1: Statistic of the top successful aspects of the course

5 There should be multi-way of learning to meet the different students

At the end of the semester, most students feel satisfaction to the learning mode they chose, no matter WBL or ICL. Meanwhile, they all have good evaluations to self-study abilities. The two groups have different options about "discussing class". 68% of the ICL students think the discussion is indispensable and should be emphasized, for they can have chance to communicate with others in person, while 21% of the WBL students think it's unnecessary, for they can "discuss" in the courseware. It's clearly showed that, ICL students tend to be more rely on the interpersonal communication, while WBL students tend to be more rely on network communication. The weakening of interpersonal communication is a new problem emerging in the information age, and it will influence learning effect[4].

Analyzed which is "the best way of learning in college", 27% of all the students accept WBL completely, while 58% consider the best way is combining WBL and ICL, that is what we have done in the course. This kind of combination is suitable for students with different basis. For those tend to WBL, they can learn individually by the courseware system and consult the teacher in discussing class when they want. For those tend to ICL, they can get systematical instruction from the teacher in classroom, and use the courseware resource after class. In a long term, coexistence of multi-way of learning is a practical solution, which will instruct the learning and motivate creativity of students simultaneously.

6 Conclusion

Web-Based Learning has many advantages over traditional way, while it will take a long period of time for it to be perfected. Web-Based Learning has not only changed the teaching and learning process, but also the education mode and teaching thoughts. Its success depends on the network hardware, courseware and the efforts of the teacher and the students. In the course "The Basic of Digital Media Communication", the students are so eager for knowledge and so interesting in the educational reform. In fact, the courseware system is developed and improved during the teaching and learning process.

Web-Based Learning is the trend of education in today's information age. This kind of learning is different from comp letely self-study. Though the interactive learning environments of the courseware system, the teacher instructs the students how to learn, and encourages them to study independently. Although the content is professional, the structure and learning mode of the courseware system have common sense for other courses. In order to satisfy different students and enhance their ability as well, the in class lectures will be decreased gradually, but discussing classes will be remained both for interpersonal communication and for answering the question face to face. In order to cultivate the higher qualified students in the information age, the education mode should stress the ability of acquiring knowledge and self-learning. This in turn, requires the teacher to be higher qualified too.

References:

[1] Courseware system "basic of digital media communication"• http://166.111.107.2/digit-media/index.htm

[2] Liu Huifen & Wang Yue• "The Design and Development of Web-Based Interactive Learning Courseware in High Education", Proceeding of ICCE '99, Advanced Research In Computers and Communications in Education , Vol 2, 1999, Japan.

[3] Liu Huifen, Zhang Xing & Wang Yong• "Education Structure and Method Study for Computer Mediated Communication" Proceeding of ICCE '98 ,Global Education On the Net, Vol. 3, 1998• Beijing.

[4] Liu Huifen• "The Impact of interpersonal communication in Distance learning" ,Proceeding of GCCCEY2K, May, 2000 Singapore

Everything in Moderation? Developing successful collaborative projects between European initial teacher education students

David Owen *, Brian Hudson*, Alison Hudson, Eila Jeronen***, Jan Morawski****, and Peter Schurz*******

**Pedagogy and New Technologies Research Group*
School of Education
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
Tel: +44 144 225 2448
Fax: +44 114 225 2324
D.H.Owen@shu.ac.uk *and* B.G.Hudson@shu.ac.uk

*** Centre for Multimedia in Education*
Learning and Teaching Institute
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
A.R.Hudson@shu.ac.uk

****Department of Teacher Education*
University of Oulu
P.O.B. 222
90571 Oulu
Finland
ejeronen@ktk.oulu.fi

*****Department of Education and Social Studies*
Hogskolan Darlana
S-781 88 Falun
Sweden
jmo@du.se

******Pädagogische Akademie des Bundes in Oberösterreich*
Kaplanhofstrasse 40
A-4020 Linz
Austria
schuerz@pa-linz.ac.at

Computer mediated collaborative projects have the potential to strengthen the European Dimension in teacher education whilst giving students an appropriate context to develop their computing and collaborative skills. This paper evaluates the success of such a project through the completion of a three-year action research enquiry involving student teachers from four European countries. The results of three cycles of development are presented. The project was evaluated using student questionnaire data, participation in tutor meetings, and analysis of students' web page development and bulletin board contributions. Results suggest that successful collaborative project work depends on ease of access to

reliable computer networks, giving equal weighting to resource production and levels of international communication, and effective moderation of the project by all tutors involved. The paper concludes by detailing future developments in European cooperation involving the partner institutions. These developments involve using the Ecoschool communication networks to discuss pedagogic and multi-media design issues involved in a cross-curricular CD-ROM which has been developed by the same group of partner institutions.

Keywords: **computer mediated communication, European co-operation, moderation.**

1 Introduction

This paper reviews a three-year cycle of telematics curriculum development and action-research in initial teacher education. The project has been made possible by funding via the SOCRATES European Module ECOSCHOOL (1997-2000). The project has two aims; to develop learning by using the World Wide Web (WWW) and email across Europe, and to learn about the social and economic aspects of the participant's home city. The outcomes of the project include the creation of a collaborative open learning course that teacher education students can follow as part of their training.

The Ecoschool developments originated from European collaboration on the EUROLAND project (1996-99). It brings together partners from Austria, England, Finland and the Netherlands in building the European Dimension into the curriculum of schools and teacher education courses (Hudson et al, 1997 and Hudson et al, 1999). Teacher education institutions and departments lead both projects in close collaboration with partner schools and teachers in each country. The resources that have been produced by both the Ecoschool and Euroland projects have been used as the basis for the development of pedagogic approaches with teachers on intensive in-service training courses, which have been supported under the Comenius 3.2 Action of SOCRATES.

The paper reports on four aspects of the Ecoschool project; the three year cycle of curriculum development, the tutor and student evaluation of the project, lessons learned regarding telematics pedagogy, and future developments that link the outcomes of the Euroland and Ecoschool projects.

1.1 Participants in the project

The participants are primary teacher education students from Linz and Sheffield together with students on an international teacher education course at Oulu. A more recent partner to this development is the University of Darlana in Sweden. This has led to the participation of a group of social studies student teachers from Falun in Sweden. English was used as the medium for communication and a total of eighty five students took part over the three years.

1.2 Collaboration and communication

A key aim of the project has been to promote the European Dimension and the use of Information and Communications Technology (ICT) in teacher education across Europe. The development of the European Dimension provides ample justification for collaborative communication but such projects can also reflect sound pedagogic principles. The pedagogical approach is based on a socio-cultural communicative perspective, which owes much to the works of Vygotsky (1987). Collaborative learning is at the heart of the Ecoschool project and has been used during the three cycles of student work. Many authors, including Hudson (1998) and English and Yazdani (1999) see such an approach as essential in developing students' learning skills when using ICT or learning without the aid of new technology.

2 Use of new technologies

The resources and tools being used are university email communications and the resources provided by the ProTo environment at the University of Oulu – *Project Learning Tools on the Web*. This is an open learning environment that has been developed at the University of Oulu. Students can access the ProTo system via

the World Wide Web. They have a password that allows them to create simple web pages and enter messages on a bulletin board. Students also created web pages using Netscape Composer and posted them on their home pages. In cycle three they used an electronic bulletin board as well as using ProTo and email.

Use of such technology is now a key focus in the education of teachers across Europe. Student teachers in England and Wales follow the National Curriculum for Initial Teacher Training (DfEE 1998). This curriculum requires students to show evidence of using and creating multi-media presentations, and of using web technologies to communicate with colleagues. In addition, recently published guidance detailing an ICT primary school curriculum (QCA, 1998), suggests that children aged ten should be able to design and evaluate simple multi-media presentations, and children aged eight should be able to take part in an email exchange. Clearly student teachers need the confidence and skills to develop these abilities in their pupils. The Ecoschool gives students this experience through their participation in a computer mediated collaborative project and by their evaluation of its potential use in their future educational roles.

2.1 Pedagogic approaches

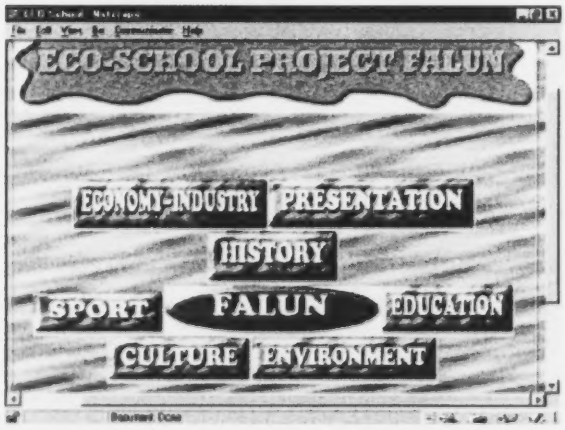
As previously stated the Ecoschool project uses a pedagogic approach that seeks to promote learning through 'electronic talk' in collaborative groups. These groups use a plan, do and review strategy as proposed by Kolb (1984) in his model of experiential education and by Schon (1987) describing the planning cycle used by reflective teachers and learners. The groups planned the construction of webpages, constructed and evaluated their own pages and those of other groups, then finally evaluated the whole project. Tutors developed their own pedagogy of distance learning during the project. The success of the tutors' approaches are analysed using guidance developed by McGee and Boyd (1995) to facilitate dialogue during computer mediated communication.

3 The three cycles of curriculum development

3.1 Cycle One

Focus : comparing students' home cities
Outcomes: web pages explaining local city

Figure 1: Work from the Swedish students posted to the ProTo learning environment.



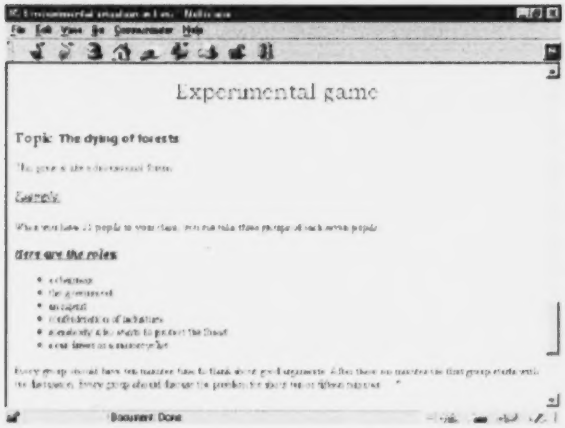
Students in each country worked in collaborative groups to produce a short illustrated report on one of the following aspects of their home city. This involved a general description of the city, an explanation of the environmental situation and the employment structure of the city, and an analysis of the regional or national education system.

Subsequently they presented these reports as web pages by writing them in to the ProTo learning environment. Figure 1 shows a page produced by the Swedish students. They also emailed their work to other students in the partner countries who were presenting the same topic. Once all web pages were complete, they read their partner's pages, asked questions and made comments about them on the bulletin board. Each group evaluated their work using the same criteria designed by the tutors in each country. The tutors then read each group's pages, assessed the pages and provided feedback to the each group. The students' work was assessed against the criteria and graded A to C. The tutors posted written feedback on the bulletin board.

3.2 Cycle Two

Focus : Comparing lesson planning
Outcomes: web pages giving examples of lesson plans

Figure 2: Teaching and learning about the environment in Lin

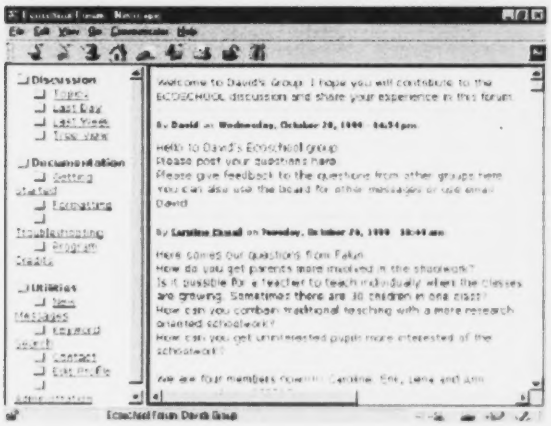


The aim of this round of co-operation was for students to share lesson plans and teaching ideas. Each group of students planned lessons with the aim of children learning more about their local town or city. Again, students presented these as web pages on the ProTo system or, in the case of the Swedish students, on their university home pages. Each group of students again evaluated the pages of their partner groups, responded to each other's questions, and received feedback from the tutors in each country. Students' work was again assessed.

3.3 Cycle Three

Focus: suggesting and solving educational problems
Outcomes: range of solutions to five educational problems

Figure 3 The Euroland and Ecoschool discussion and chat site.



The Ecoschool project ran during autumn 1999 with several new developments. The students were in internationally composed groups rather than from one single country and the focus of the project was to choose an educational problem and present a solution to this by co-operating using ICT. The students could use email, create their own web pages, use ProTo2 (a more sophisticated version), or use the Ecoschool bulletin board (see Figure 3). The majority of students chose to use the bulletin board to present their problem and solutions although some students did use the ProTo2 learning environment. Again tutors gave feedback to the students and responded to their questions although the work was not graded.

4 Methods of curriculum development and evaluation

Ecoschool developments have followed an action research model, as the aim of the project was to develop a successful curriculum for initial teacher education over the three years of the project. The Ecoschool curriculum was developed in face-to-face planning meetings and followed up by email communication between partners in Austria, Finland, Sweden and England. The results of student and tutor evaluation were fed into the curriculum planning at the end of each cycle. The following methods have been employed in gathering evaluation data:

BEST COPY AVAILABLE

Student evaluation questionnaire. All students completed a questionnaire by email or on paper. Many groups posted the results of their evaluation on the ProTo system or on the Ecoschool bulletin board. The questionnaire requested information on student expectations of the project, levels of interaction, the role of the tutor, use of new technology and ideas for the future.

Tutor evaluation. A tutor from each country completed a written evaluation of their experience at the end of each cycle and presented the document for discussion at the annual Ecoschool development meetings.

Web page analysis. The students created web pages of differing levels of complexity during cycles one and two. The web pages construction process is evaluated against the six components of infomedia literacy as proposed by Lee (1999, pp.147-149). These components are:

1. An understanding of the nature and functions of infomedia and their impact on individuals and society.
2. The development of critical thinking ability.
3. The skill of efficient searching and critical selection of information.
4. Knowledge of multi-media production using appropriate technology.
5. Aesthetic appreciation of hypertext, graphic design and visual images.
6. Social participation in influencing the development of infomedia technology.

ProTo communication log analysis. The record of tutor and student communication during cycles one and two was analysed using Boyd and McGee's (1995) guidance on facilitating dialogues using computer-mediated communication. They suggest that facilitators provide both technical and content-specific support; are responsible for regularly communicating with the group; communicate in ways that require a response; and model standards of high quality interaction

Ecoschool bulletin board observation. The Ecoschool bulletin board was set up in September 1999 and provided the student groups with a shared electronic space for presenting and discussing their ideas. Each group had a separate area for their own use. The frequency and quality of communication was analysed as well as the level of interaction between group members.

5 Evaluation Results

Student evaluation questionnaire data was collected from 12 of the 16 student groups over the three years. The key points arising were:

- In cycles one and two students who were apprehensive about using the technology felt that had been successful and the majority of students found that resource production was enjoyable and had developed their ICT skills.
- Communication between groups was successful in cycles one and two but sporadic in cycle three. This was attributed to pressure of work from other areas of their degree (Oulu), lack of clarity in terms of the aims of the project and technological problems in Linz and Sheffield.
- In cycle three, two of the five groups were critical of the lack of commitment of their partners.
- Students in Sheffield requested formal computer sessions where they could meet and use university facilities for the project. All students felt that their tutors had supported them in cycles one and two, but three groups wanted clearer guidance in cycle three.
- By cycle three the students from Falun and Oulu requested the use of chat and video conferencing technology in any future work. Individual students in Linz and Sheffield experienced technical difficulties during November 1999 due to network problems at their institutions.

Minutes of three *Tutor evaluation* meetings and five written reports state that:

- The role of the tutor was clear in cycles one and two but not in cycle three
- Cycle three was seen as a radical departure from previous work and was viewed as 'experimental'
- Students in Linz, Oulu and Sheffield were hampered by block teaching practices taking place during key times in the project.
- Tutors were pleased with the progress made by their students in cycles one and two and had discussed how work in cycle three could be improved.

Web page analysis using Lee's concept of infomedia literacy reveals:

- Only two groups took a critical approach to the sources they used when constructing pages about their

home city in cycle one.

- Three groups overtly discussed the problems of representing people and places on their web pages in cycle two.
- Four groups of students in cycle one saw the pages as similar to written text so did not exploit the advantages of hypertext fully.
- All students changed from passive users of web pages to active publishers of their own content.
- The students from Falun produced a website in cycle two that clearly demonstrated a collaborative approach and a high level of aesthetic appreciation in regard to page design.
- Students from Oulu and Falun were in general more adept at making critical comments about their own and other's work than the Linz and Sheffield students.

ProTo communication log and *Ecoschool bulletin board observation* using McGee and Young's guidance shows:

- In cycles one and two tutors adequately fulfilled the roles of moderator, mediator and facilitator.
- Tutors communicated with the participants by asking one or more questions, giving examples from their own experience to add to discussions and modelling high quality interaction.
- The cycle three work led to the production of questions and solutions but little discussion. In general tutors did not moderate the discussion effectively as they were unsure of their roles.
- The decision to limit the role of the tutor in cycle three had a negative effect on the level of interaction and quality of discussion. Student evaluations reveal uncertainty about technical issues as well as pleas for stronger leadership and rigid deadlines.

6 Discussion

The cycles of curriculum development and evaluation have identified many important features in the development of collaborative ICT projects. Establishing an international electronic community requires access to reliable technology for the students and also skill and commitment on the part of the tutors. Asynchronous communication is seen as one of the great advantages of electronic communication and university tutors may take their own ease of access for granted. In a study of barriers to student computer usage McMahon et al (1999) found that students identify real problems in accessing computers to complete course tasks. A Sheffield student reflects their conclusions when evaluating her experience in cycle three:

> *If we had been given time in our lectures to get together and a set routine with correspondence time every week then we would have got more out of it. As a group of people we are all in different (teaching) groups, so getting together is difficult and finding a PC when we have free time is also difficult.*

This highlights the question of computer access as well as the importance of study and group work skills in such a project. Very clear project goals and explicit expectations on student participation are also needed. Is it the students ' responsibility to meet and organise communication sessions during their own time, or will better levels of communication occur by booking computer access during student practical classes? If this is done are the benefits of asynchronous communication being demonstrated? An unexpected outcome of this project has been to highlight the importance of developing students' teamworking skills.

Once access is assured, the roles of the tutor as moderator, mediator and facilitator are crucial. A key finding from the evaluation is that communication was much more successful when the tutors had a strong moderating role in cycles one and two. When planning for cycle three, tutors limited the moderation role and gave the student groups much more independence. The majority of the students interpreted this as poor planning and one group described it as 'lack of leadership'. This highlights the complexity of the moderator's role and a recommendation from this project would be that the tutors spend time in the final evaluation meeting exploring their experiences in this role.

Developing a successful collaborative curriculum is dependent on creating a fine balance between resource production and communication. In cycle one the web pages produced were basic, but quality of interaction between students was high. In cycle two the web-based products were much more sophisticated but students paid less attention to communication, perhaps because more academic credit was gained for page development rather than communicating with fellow students. Student's work in the final cycle showed some evidence of sound international cooperation, but less in-depth critical analysis. Experiences gained

during the three cycles have led to the development of a formal curriculum unit (see http://www.shu.ac.uk/schools/ed/teaching/dho/). Students will gain high grades only by giving equal weighting to communication, resource production and critical evaluation in their group work.

Finally, teacher education students need to transfer their learning to a classroom situation. One student has already set up a similar project whilst on teaching practice. In this example infant school children communicated via email with children in Bermuda and compared their localities, hobbies and homes as part of English and geography learning. Tutors need to set up opportunities for students to use their newfound confidence and skill in the classroom. Nook Lane Primary School in Sheffield is now linked with partner schools in Linz and Oulu as a result of the project, and students can now contribute to the development of this partnership.

6.1 Future developments

As a result of ongoing evaluation the following developments have been planned for 2000-2001. A chat facility had been added to the Euroland/Ecoschool discussion area in addition to the bulletin boards. Building on the success of a trial video-conferencing session held in November 1999, students will be able to use this form of communication from September 2000 in all countries. Students and teachers can also now access the communication tools via the Hallam Geography Education web site as well as from the Euroland web pages. Finally, with the imminent completion of the Euroland CD-ROM, the two projects will be brought together. Students and teachers will be able to use the CD-ROM as a focus for collaboration and discussion in the areas of infomedia literacy and multi-media development, the pedagogy of computer-mediated collaboration and the comparison of European social and environmental learning.

7 Conclusion

The Euroland and Ecoschool projects represent successful examples of how an international perspective can be developed in the university and school curricula. Sustained and effective communication is the key to such initiatives, alongside ease of access to computing facilities and a focus on the crucial role of the tutor as moderator. Both projects have provided tutors, students and pupils with membership of an expanding European network, which is a solid platform for the development of further collaborative work.

8 References

DfEE (1998) High Status: High Standards Circular 4/98. HMSO.

English, S and Yazdani, M. (1999) Computer-supported co-operative learning in a Virtual University. *Journal of Computer Assisted Learning*, 15, 2-13.

Hudson, B. (1998) A social perspective on learning in the context of Computer Mediated Communication in teacher education. *Proceedings of ICCE 98: International Conference on Computers in Education*, Beijing, China, 14-17 October 1998, 627 – 632.

Hudson, B., Hudson, A. & Schürz, P. (1997), Euroland: A Collaborative European Cross-Curricular Project using CD-ROM. *Proceedings of ICCE 97: International Conference on Computers in Education*, Kuching, Sarawak, Malaysia, December 1997, 1006-1007.

Hudson, B., Schürz, P. and Hudson, A. (1999), The Euroland/Ecoschool projects: Promoting Collaboration in a European context using CD-ROM and the WWW, Paper to Subnetwork D: Powerful Learning Environments in Teacher Education. *Conference of the Thematic Network on Teacher Education in Europe (TNTEE)*, Lisbon, 1999, http://tntee.umu.se/lisboa/

Kolb, D.A. (1984) *Experiential Education: Experience as the source of learning and development*. Prentice-Hall.

Lee, A.Y.L (1999) Infomedia Literacy: An educational basic for young people in the new information age. *Information, Communication and Society*, 2, 2, 134-155.

McGee, P.A. and Boyd, V (1995) *Computer-Mediated Communication: Facilitating Dialogues* at http://www.coe.uh.edu/insite/elec_pub/html1995/173.htm. Visited 4/10/00.

McMahon, J. , Gardner J., Gray, C., and Mulhern. G. (1999) Barriers to student computer usage: staff and student perceptions. *Journal of Computer Assisted Learning*, 15, 302-311.

Schon, D.A. (1987) *Educating the Reflective Practitioner: towards a new design for teaching and learning in the professions*. Jossey-Bass.

QCA (1998) Information *and Communications Technology: A Scheme of Work for KS1and KS2*. QCA.
Vygotsky, L.S. (1987) *The Collected Works of L.S.Vygotsky*, Vol.1 Plenum Press, NY.

http://www.shu.ac.uk/services/lc/cmeweb/Euroland/chatgroups.htm
The Euroland and Ecoschool discussion and chat fora.
http://ProTo.oulu.fi/
The ProTo open learning environment.
http://www.du.se/~lmh98lae/
Ecoschool pages created by students form Falun, Sweden.
http://wwwedu.oulu.fi/homepage/ejeronen/eco/index.htm
All cycle one and cycle two work can be viewed at this location.

Everything in Moderation? Developing successful collaborative projects between European initial teacher education students

David Owen *, Brian Hudson*, Alison Hudson, Eila Jeronen***, Jan Morawski****, and Peter Schurz*******

**Pedagogy and New Technologies Research Group*
School of Education
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
Tel: +44 144 225 2448
Fax: +44 114 225 2324
D.H.Owen@shu.ac.uk *and* B.G.Hudson@shu.ac.uk

*** Centre for Multimedia in Education*
Learning and Teaching Institute
Sheffield Hallam University
Sheffield S10 2BP
United Kingdom
A.R.Hudson@shu.ac.uk

****Department of Teacher Education*
University of Oulu
P.O.B. 222
90571 Oulu
Finland
ejeronen@ktk.oulu.fi

*****Department of Education and Social Studies*
Hogskolan Darlana
S-781 88 Falun
Sweden
jmo@du.se

******Pädagogische Akademie des Bundes in Oberösterreich*
Kaplanhofstrasse 40
A-4020 Linz
Austria
schuerz@pa-linz.ac.at

Computer mediated collaborative projects have the potential to strengthen the European Dimension in teacher education whilst giving students an appropriate context to develop their computing and collaborative skills. This paper evaluates the success of such a project through the completion of a three-year action research enquiry involving student teachers from four European countries. The results of three cycles of development are presented. The project was evaluated using student questionnaire data, participation in tutor meetings, and analysis of students' web page development and bulletin board contributions. Results suggest that successful collaborative project work depends on ease of access to

reliable computer networks, giving equal weighting to resource production and levels of international communication, and effective moderation of the project by all tutors involved. The paper concludes by detailing future developments in European cooperation involving the partner institutions. These developments involve using the Ecoschool communication networks to discuss pedagogic and multi-media design issues involved in a cross-curricular CD-ROM which has been developed by the same group of partner institutions.

Keywords: **computer mediated communication, European co-operation, moderation.**

1 Introduction

This paper reviews a three-year cycle of telematics curriculum development and action-research in initial teacher education. The project has been made possible by funding via the SOCRATES European Module ECOSCHOOL (1997-2000). The project has two aims; to develop learning by using the World Wide Web (WWW) and email across Europe, and to learn about the social and economic aspects of the participant's home city. The outcomes of the project include the creation of a collaborative open learning course that teacher education students can follow as part of their training.

The Ecoschool developments originated from European collaboration on the EUROLAND project (1996-99). It brings together partners from Austria, England, Finland and the Netherlands in building the European Dimension into the curriculum of schools and teacher education courses (Hudson et al, 1997 and Hudson et al, 1999). Teacher education institutions and departments lead both projects in close collaboration with partner schools and teachers in each country. The resources that have been produced by both the Ecoschool and Euroland projects have been used as the basis for the development of pedagogic approaches with teachers on intensive in-service training courses, which have been supported under the Comenius 3.2 Action of SOCRATES.

The paper reports on four aspects of the Ecoschool project; the three year cycle of curriculum development, the tutor and student evaluation of the project, lessons learned regarding telematics pedagogy, and future developments that link the outcomes of the Euroland and Ecoschool projects.

1.1 Participants in the project

The participants are primary teacher education students from Linz and Sheffield together with students on an international teacher education course at Oulu. A more recent partner to this development is the University of Darlana in Sweden. This has led to the participation of a group of social studies student teachers from Falun in Sweden. English was used as the medium for communication and a total of eighty five students took part over the three years.

1.2 Collaboration and communication

A key aim of the project has been to promote the European Dimension and the use of Information and Communications Technology (ICT) in teacher education across Europe. The development of the European Dimension provides ample justification for collaborative communication but such projects can also reflect sound pedagogic principles. The pedagogical approach is based on a socio-cultural communicative perspective, which owes much to the works of Vygotsky (1987). Collaborative learning is at the heart of the Ecoschool project and has been used during the three cycles of student work. Many authors, including Hudson (1998) and English and Yazdani (1999) see such an approach as essential in developing students' learning skills when using ICT or learning without the aid of new technology.

2 Use of new technologies

The resources and tools being used are university email communications and the resources provided by the ProTo environment at the University of Oulu – *Project Learning Tools on the Web*. This is an open learning environment that has been developed at the University of Oulu. Students can access the ProTo system via

the World Wide Web. They have a password that allows them to create simple web pages and enter messages on a bulletin board. Students also created web pages using Netscape Composer and posted them on their home pages. In cycle three they used an electronic bulletin board as well as using ProTo and email.

Use of such technology is now a key focus in the education of teachers across Europe. Student teachers in England and Wales follow the National Curriculum for Initial Teacher Training (DfEE 1998). This curriculum requires students to show evidence of using and creating multi-media presentations, and of using web technologies to communicate with colleagues. In addition, recently published guidance detailing an ICT primary school curriculum (QCA, 1998), suggests that children aged ten should be able to design and evaluate simple multi-media presentations, and children aged eight should be able to take part in an email exchange. Clearly student teachers need the confidence and skills to develop these abilities in their pupils. The Ecoschool gives students this experience through their participation in a computer mediated collaborative project and by their evaluation of its potential use in their future educational roles.

2.1 Pedagogic approaches

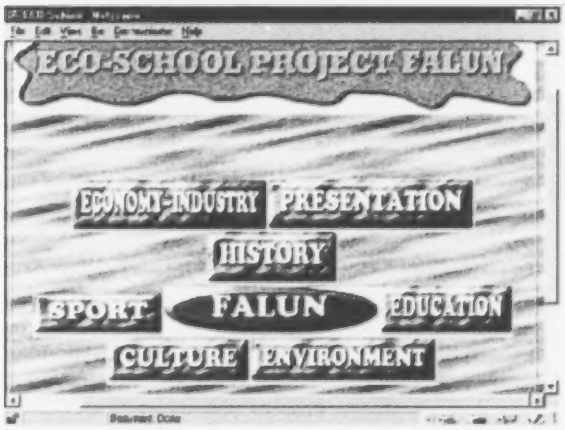
As previously stated the Ecoschool project uses a pedagogic approach that seeks to promote learning through 'electronic talk' in collaborative groups. These groups use a plan, do and review strategy as proposed by Kolb (1984) in his model of experiential education and by Schon (1987) describing the planning cycle used by reflective teachers and learners. The groups planned the construction of webpages, constructed and evaluated their own pages and those of other groups, then finally evaluated the whole project. Tutors developed their own pedagogy of distance learning during the project. The success of the tutors' approaches are analysed using guidance developed by McGee and Boyd (1995) to facilitate dialogue during computer mediated communication.

3 The three cycles of curriculum development

3.1 Cycle One

Focus : comparing students' home cities
Outcomes: web pages explaining local city

Figure 1: Work from the Swedish students posted to the ProTo learning environment.



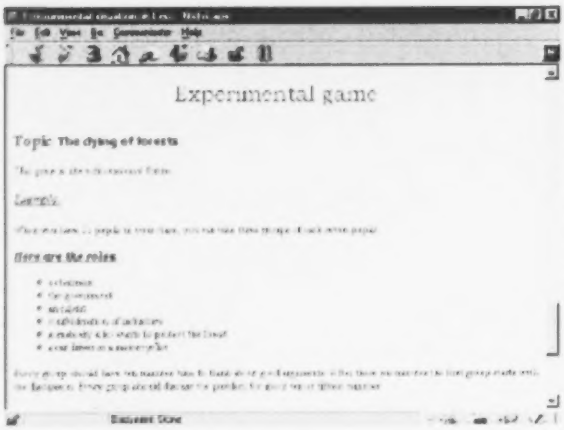
Students in each country worked in collaborative groups to produce a short illustrated report on one of the following aspects of their home city. This involved a general description of the city, an explanation of the environmental situation and the employment structure of the city, and an analysis of the regional or national education system.

Subsequently they presented these reports as web pages by writing them in to the ProTo learning environment. Figure 1 shows a page produced by the Swedish students. They also emailed their work to other students in the partner countries who were presenting the same topic. Once all web pages were complete, they read their partner's pages, asked questions and made comments about them on the bulletin board. Each group evaluated their work using the same criteria designed by the tutors in each country. The tutors then read each group's pages, assessed the pages and provided feedback to the each group. The students' work was assessed against the criteria and graded A to C. The tutors posted written feedback on the bulletin board.

3.2 Cycle Two

Focus : Comparing lesson planning
Outcomes: web pages giving examples of lesson plans

Figure 2: Teaching and learning about the environment in Lin

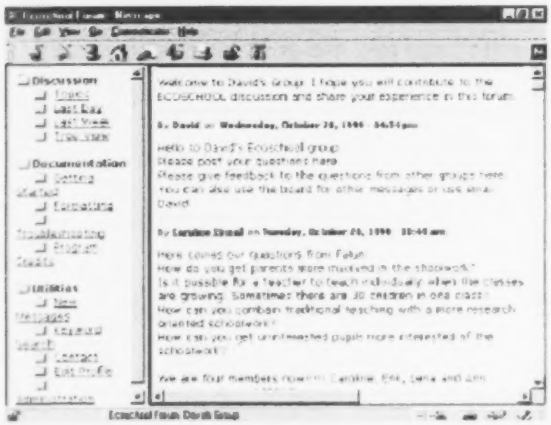


The aim of this round of co-operation was for students to share lesson plans and teaching ideas. Each group of students planned lessons with the aim of children learning more about their local town or city. Again, students presented these as web pages on the ProTo system or, in the case of the Swedish students, on their university home pages. Each group of students again evaluated the pages of their partner groups, responded to each other's questions, and received feedback from the tutors in each country. Students' work was again assessed.

3.3 Cycle Three

Focus: suggesting and solving educational problems
Outcomes: range of solutions to five educational problems

Figure 3 The Euroland and Ecoschool discussion and chat site.



The Ecoschool project ran during autumn 1999 with several new developments. The students were in internationally composed groups rather than from one single country and the focus of the project was to choose an educational problem and present a solution to this by co-operating using ICT. The students could use email, create their own web pages, use ProTo2 (a more sophisticated version), or use the Ecoschool bulletin board (see Figure 3). The majority of students chose to use the bulletin board to present their problem and solutions although some students did use the ProTo2 learning environment. Again tutors gave feedback to the students and responded to their questions although the work was not graded.

4 Methods of curriculum development and evaluation

Ecoschool developments have followed an action research model, as the aim of the project was to develop a successful curriculum for initial teacher education over the three years of the project. The Ecoschool curriculum was developed in face-to-face planning meetings and followed up by email communication between partners in Austria, Finland, Sweden and England. The results of student and tutor evaluation were fed into the curriculum planning at the end of each cycle. The following methods have been employed in gathering evaluation data:

BEST COPY AVAILABLE

Student evaluation questionnaire. All students completed a questionnaire by email or on paper. Many groups posted the results of their evaluation on the ProTo system or on the Ecoschool bulletin board. The questionnaire requested information on student expectations of the project, levels of interaction, the role of the tutor, use of new technology and ideas for the future.

Tutor evaluation. A tutor from each country completed a written evaluation of their experience at the end of each cycle and presented the document for discussion at the annual Ecoschool development meetings.

Web page analysis. The students created web pages of differing levels of complexity during cycles one and two. The web pages construction process is evaluated against the six components of infomedia literacy as proposed by Lee (1999, pp.147-149). These components are:

1. An understanding of the nature and functions of infomedia and their impact on individuals and society.
2. The development of critical thinking ability.
3. The skill of efficient searching and critical selection of information.
4. Knowledge of multi-media production using appropriate technology.
5. Aesthetic appreciation of hypertext, graphic design and visual images.
6. Social participation in influencing the development of infomedia technology.

ProTo communication log analysis. The record of tutor and student communication during cycles one and two was analysed using Boyd and McGee's (1995) guidance on facilitating dialogues using computer-mediated communication. They suggest that facilitators provide both technical and content-specific support; are responsible for regularly communicating with the group; communicate in ways that require a response; and model standards of high quality interaction

Ecoschool bulletin board observation. The Ecoschool bulletin board was set up in September 1999 and provided the student groups with a shared electronic space for presenting and discussing their ideas. Each group had a separate area for their own use. The frequency and quality of communication was analysed as well as the level of interaction between group members.

5 Evaluation Results

Student evaluation questionnaire data was collected from 12 of the 16 student groups over the three years. The key points arising were:

- In cycles one and two students who were apprehensive about using the technology felt that had been successful and the majority of students found that resource production was enjoyable and had developed their ICT skills.
- Communication between groups was successful in cycles one and two but sporadic in cycle three. This was attributed to pressure of work from other areas of their degree (Oulu), lack of clarity in terms of the aims of the project and technological problems in Linz and Sheffield.
- In cycle three, two of the five groups were critical of the lack of commitment of their partners.
- Students in Sheffield requested formal computer sessions where they could meet and use university facilities for the project. All students felt that their tutors had supported them in cycles one and two, but three groups wanted clearer guidance in cycle three.
- By cycle three the students from Falun and Oulu requested the use of chat and video conferencing technology in any future work. Individual students in Linz and Sheffield experienced technical difficulties during November 1999 due to network problems at their institutions.

Minutes of three *Tutor evaluation* meetings and five written reports state that:

- The role of the tutor was clear in cycles one and two but not in cycle three
- Cycle three was seen as a radical departure from previous work and was viewed as 'experimental'
- Students in Linz, Oulu and Sheffield were hampered by block teaching practices taking place during key times in the project.
- Tutors were pleased with the progress made by their students in cycles one and two and had discussed how work in cycle three could be improved.

Web page analysis using Lee's concept of infomedia literacy reveals:

- Only two groups took a critical approach to the sources they used when constructing pages about their

home city in cycle one.

- Three groups overtly discussed the problems of representing people and places on their web pages in cycle two.
- Four groups of students in cycle one saw the pages as similar to written text so did not exploit the advantages of hypertext fully.
- All students changed from passive users of web pages to active publishers of their own content.
- The students from Falun produced a website in cycle two that clearly demonstrated a collaborative approach and a high level of aesthetic appreciation in regard to page design.
- Students from Oulu and Falun were in general more adept at making critical comments about their own and other's work than the Linz and Sheffield students.

ProTo communication log and *Ecoschool bulletin board observation* using McGee and Young's guidance shows:

- In cycles one and two tutors adequately fulfilled the roles of moderator, mediator and facilitator.
- Tutors communicated with the participants by asking one or more questions, giving examples from their own experience to add to discussions and modelling high quality interaction.
- The cycle three work led to the production of questions and solutions but little discussion. In general tutors did not moderate the discussion effectively as they were unsure of their roles.
- The decision to limit the role of the tutor in cycle three had a negative effect on the level of interaction and quality of discussion. Student evaluations reveal uncertainty about technical issues as well as pleas for stronger leadership and rigid deadlines.

6 Discussion

The cycles of curriculum development and evaluation have identified many important features in the development of collaborative ICT projects. Establishing an international electronic community requires access to reliable technology for the students and also skill and commitment on the part of the tutors. Asynchronous communication is seen as one of the great advantages of electronic communication and university tutors may take their own ease of access for granted. In a study of barriers to student computer usage McMahon et al (1999) found that students identify real problems in accessing computers to complete course tasks. A Sheffield student reflects their conclusions when evaluating her experience in cycle three:

> *If we had been given time in our lectures to get together and a set routine with correspondence time every week then we would have got more out of it. As a group of people we are all in different (teaching) groups, so getting together is difficult and finding a PC when we have free time is also difficult.*

This highlights the question of computer access as well as the importance of study and group work skills in such a project. Very clear project goals and explicit expectations on student participation are also needed. Is it the students ' responsibility to meet and organise communication sessions during their own time, or will better levels of communication occur by booking computer access during student practical classes? If this is done are the benefits of asynchronous communication being demonstrated? An unexpected outcome of this project has been to highlight the importance of developing students' teamworking skills.

Once access is assured, the roles of the tutor as moderator, mediator and facilitator are crucial. A key finding from the evaluation is that communication was much more successful when the tutors had a strong moderating role in cycles one and two. When planning for cycle three, tutors limited the moderation role and gave the student groups much more independence. The majority of the students interpreted this as poor planning and one group described it as 'lack of leadership'. This highlights the complexity of the moderator's role and a recommendation from this project would be that the tutors spend time in the final evaluation meeting exploring their experiences in this role.

Developing a successful collaborative curriculum is dependent on creating a fine balance between resource production and communication. In cycle one the web pages produced were basic, but quality of interaction between students was high. In cycle two the web-based products were much more sophisticated but students paid less attention to communication, perhaps because more academic credit was gained for page development rather than communicating with fellow students. Student's work in the final cycle showed some evidence of sound international cooperation, but less in-depth critical analysis. Experiences gained

during the three cycles have led to the development of a formal curriculum unit (see http://www.shu.ac.uk/schools/ed/teaching/dho/). Students will gain high grades only by giving equal weighting to communication, resource production and critical evaluation in their group work.

Finally, teacher education students need to transfer their learning to a classroom situation. One student has already set up a similar project whilst on teaching practice. In this example infant school children communicated via email with children in Bermuda and compared their localities, hobbies and homes as part of English and geography learning. Tutors need to set up opportunities for students to use their newfound confidence and skill in the classroom. Nook Lane Primary School in Sheffield is now linked with partner schools in Linz and Oulu as a result of the project, and students can now contribute to the development of this partnership.

6.1 Future developments

As a result of ongoing evaluation the following developments have been planned for 2000-2001. A chat facility had been added to the Euroland/Ecoschool discussion area in addition to the bulletin boards. Building on the success of a trial video-conferencing session held in November 1999, students will be able to use this form of communication from September 2000 in all countries. Students and teachers can also now access the communication tools via the Hallam Geography Education web site as well as from the Euroland web pages. Finally, with the imminent completion of the Euroland CD-ROM, the two projects will be brought together. Students and teachers will be able to use the CD-ROM as a focus for collaboration and discussion in the areas of infomedia literacy and multi-media development, the pedagogy of computer-mediated collaboration and the comparison of European social and environmental learning.

7 Conclusion

The Euroland and Ecoschool projects represent successful examples of how an international perspective can be developed in the university and school curricula. Sustained and effective communication is the key to such initiatives, alongside ease of access to computing facilities and a focus on the crucial role of the tutor as moderator. Both projects have provided tutors, students and pupils with membership of an expanding European network, which is a solid platform for the development of further collaborative work.

8 References

DfEE (1998) High Status: High Standards Circular 4/98. HMSO.

English, S and Yazdani, M. (1999) Computer-supported co-operative learning in a Virtual University. *Journal of Computer Assisted Learning*, 15, 2-13.

Hudson, B. (1998) A social perspective on learning in the context of Computer Mediated Communication in teacher education. *Proceedings of ICCE 98: International Conference on Computers in Education*, Beijing, China, 14-17 October 1998, 627 – 632.

Hudson, B., Hudson, A. & Schürz, P. (1997), Euroland: A Collaborative European Cross-Curricular Project using CD-ROM. *Proceedings of ICCE 97: International Conference on Computers in Education*, Kuching, Sarawak, Malaysia, December 1997, 1006-1007.

Hudson, B., Schürz, P. and Hudson, A. (1999), The Euroland/Ecoschool projects: Promoting Collaboration in a European context using CD-ROM and the WWW, Paper to Subnetwork D: Powerful Learning Environments in Teacher Education. *Conference of the Thematic Network on Teacher Education in Europe (TNTEE)*, Lisbon, 1999, http://tntee.umu.se/lisboa/

Kolb, D.A. (1984) *Experiential Education: Experience as the source of learning and development*. Prentice-Hall.

Lee, A.Y.L (1999) Infomedia Literacy: An educational basic for young people in the new information age. *Information, Communication and Society* , 2, 2, 134-155.

McGee, P.A. and Boyd, V (1995) *Computer-Mediated Communication: Facilitating Dialogues* at http://www.coe.uh.edu/insite/elec_pub/html1995/173.htm . Visited 4/10/00.

McMahon, J. , Gardner J., Gray, C., and Mulhern. G. (1999) Barriers to student computer usage: staff and student perceptions. *Journal of Computer Assisted Learning*, 15, 302-311.

Schon, D.A. (1987) *Educating the Reflective Practitioner: towards a new design for teaching and learning in the professions.* Jossey-Bass.

QCA (1998) Information *and Communications Technology: A Scheme of Work for KS1and KS2*. QCA.
Vygotsky, L.S. (1987) *The Collected Works of L.S.Vygotsky*, Vol.1 Plenum Press, NY.

http://www.shu.ac.uk/services/lc/cmeweb/Euroland/chatgroups.htm
The Euroland and Ecoschool discussion and chat fora.
http://ProTo.oulu.fi/
The ProTo open learning environment.
http://www.du.se/~lmh98lae/
Ecoschool pages created by students form Falun, Sweden.
http://wwwedu.oulu.fi/homepage/ejeronen/eco/index.htm
All cycle one and cycle two work can be viewed at this location.

Explorers or Persisters? Evaluating Children Interacting, Collaborating and Learning with Computers

ROSEMARY LUCKIN AND BENEDICT DU BOULAY,
School of Cognitive & Computing Sciences
University of Sussex
Brighton BN1 9QH UK.
E-mail: *rosel@cogs.susx.ac.uk* and *bend@cogs.susx.ac.uk.*

In this paper we discuss our observations of a group of 10 and 11 year old children using an Interactive Learning Environment called the Ecolab. The design of this software was informed by our interpretation of Vygotsky s Zone of Proximal Development in which *Interaction* and *Collaboration* are definitive characteristics. The relationship between the differences in interaction/collaboration style and the learning gains made by the children are discussed. The results show that children can be grouped into profiles according to the differences and similarities in their use of the system and that common interaction features are influenced by the design of the software being used. We suggest that children are poor at managing their own learning experience with technology even when the software offers both opportunities to complete challenging activities and support to ensure success. The children in this study needed explicit direction towards activities which were beyond their ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity: a suggestion from the system about what and how to proceed is often sufficient.

Keywords: **Interaction, Collaboration, ZPD, ILE.**

1 Introduction

Computers are now an accepted part of classroom life for most young learners whether they are used for communication, visualization, simulation experience or simply for fun. But how do children actually interact with computers? Does the nature of their interactions vary from child to child in a way that could inform the design of the software which engenders these interactions? This paper explores children s use of an Interactive Learning Environment (ILE) called the Ecolab which was designed to help children learn about ecology. The system attempts to fulfill the role of a more able learning partner for the child and invites collaborative interaction. The collaboration is thus between the system and the child and not between children. Here we describe the nature of the interactions that a class of children had with this system. The nature of these interactions is considered in the light of pre- and post-test learning gains to explore the relationship between learning and interaction style. The Ecolab software has been designed using a framework derived from our interpretations of the Zone of Proximal Development (ZPD) [10, 11]. The ZPD describes the most fertile interactions which occur between the more and less able members of an educational culture and focuses attention on how the more able can help learners to learn. The ZPD offers a theory of instruction which emphasizes the inseparability of the teaching and learning processes and thus recognizes the inherent interactivity of children s learning with computer software. It also stresses the need for learners to have the help of a collaborative learning partner in the form of a peer, a teacher or in the case of the Ecolab, a computer. Within a Vygotskian, socio-cultural model of education human activity is mediated by tools and sign systems that have arisen through social interaction. Developmental explanations are used to address the complex internalisation process by which the interpsychological relations between partners in social interaction becomes intrapsychological

within the individual learner. Interaction and Collaboration are therefore definitive characteristics of the ZPD which form the linchpin of the socio-cultural framework and thus form the focus of our investigations of children using the software.

In this paper we provide a brief description of the Ecolab software before discussing an evaluation study of its use. We report the results with particular emphasis upon the nature of the Interaction and Collaboration profiles we were able to construct from our records of system use. We provide examples of individual learner s use of the system and discuss the relationship between the nature of the interactions and the learning gains recorded after system use.

2 Ecolab Software

Ecology is a subject that involves the study of relationships between organisms within our environment. These relationships can be extremely complex; they can also be introduced in a simplified manner through concepts such as food chains and food webs. These form the foundations of more complex ecosystems and are part of the curriculum for primary school children in the United Kingdom. The Ecolab software provides 10 and 11 year old children with the facilities to build, activate and observe the ecological relationships which exist between members of a simple food web in a woodland ecosystem. It provides a simulated ecology laboratory environment into which the child places the animals and plants of her choice. This environment can be viewed by the child from several different perspectives or *views*, including:

World - a picture of a woodland environment and the organisms the child has chosen to place within it.
Web - a traditional text book style diagram of the organisms in a food chain and food web.
Energy - a graphical representation of the energy levels of the organisms currently alive in the Ecolab.
History - a linear narrative of what has happened in the Ecolab world to date, which animal has eaten which other animal for example.

As we have already stated the nature of the relationships that can exist between organisms in the real world can be very complex. We wished to allow each of the children using our system to learn about relationships at a level of complexity that was appropriate to them. We therefore built the learning environment in a manner that would allow children to learn about relationships ranging from the simplest, between just two single organisms, to the much more complex network of relationships that could exist in a very simple ecosystem involving populations of organisms. The complexity of the relationships represented within the Ecolab can be varied at any stage during the child's interaction with it. It is also possible to alter the abstractness of the terminology used to describe the organisms in the Ecolab so that a snail, for example, can be described by the words "herbivore", "primary consumer", or "consumer" as well as the word "snail".

In addition to this simulated laboratory environment, the system acts as a collaborative learning partner for each learner which can provide assistance of the following sorts:

Extension of the learner s knowledge through increasing the complexity of the relationships she is asked to study and/or the abstractness of the terminology used to describe what is happening in the Ecolab.

Collaborative Support which can take the shape of *Activity Differentiation:* in the form of alterations to the difficulty of the activities the learner is asked to complete, or context sensitive *Help* of variable levels of quality and quantity.

At the start of this paper we discussed our use of the Zone of Proximal Development to underpin our system design and the importance of *Interaction* and *Collaboration*. In order to explore the nature of the interactions children had with our software, the collaboration that might occur between system and learner, and the relationship between interaction, collaboration and the changes in learning outcome recorded after system use, we varied the manner in which collaboration from the system was offered to the learner. The Ecolab consists of three system variations: VIS (Vygotskian Inspired System), WIS (Woodsian Inspired System) and NIS (Non-theoretically Inspired System). These three system manipulations implement different design elements in order to adjust the assistance they provide (see [4] and [5] for more detail). The way in which each of the system variations adopts a different approach is summarised in Table 1. In particular, VIS makes more decisions than WIS which makes more decisions than NIS. In other words NIS gives the learner most freedom of choice to the learner and VIS the least.

3 Interactions with the Ecolab

An exploratory evaluation of the Ecolab software was conducted with a class of children aged 10 and 11 years. We wanted to investigate the extent to which the system would be able to adjust to learners of differing abilities, and also the ways in which the interactions and collaborations between user and system varied with users of different abilities. The children's school assessments were therefore used to allocate each child to one of three ability grouping: High, Average and Low. Prior to using the software each child completed a written and a verbal pre-test, the latter of which was in the form of a structured interview recorded on audio tape. Each child used the Ecolab software as an individual for a total of 60 minutes over two sessions. In addition, a 20 minute initial session with a smaller 'demo' versionensured that all children were comfortable with the mouse skills required and the interface. After the system intervention subjects were given a written and verbal test, identical to the pre-test, and a short additional extension interview. A delayed post-test was conducted 10 weeks after the end of the original post-test. Of the 30 children who started the study only 26 completed all sessions between, and including, pre and post-test. The four who did not complete these sessions had either left the school or been absent during the evaluation period. Only 24 completed all sessions including the delayed post-test. Once again the reason for non-completion was absence from school.

Table 1 Collaborative Support within Ecolab

Collaborative Support within Ecolab			
	VIS	**WIS**	**NIS**
Levels of Help Available (different levels provide differing qualities of help - 5 represents the greatest and 1 the least)	5	5	2
Decision about Level of Help made by	system	system and child	child
Levels of *Activity Differentiation* Available	3	3	3
Decision about type of Activity and Differentiation level made by	system	child - system makes suggestions	child
Extent of Learner Model maintained by the system and used to make decisions about the support to be offered to the learner.	Bayesian Belief Network (BBN) of values representing the system's beliefs about child's ZPD formed from its knowledge about the amount of collaborative support used to date.	Record of help used to enable contingent calculation of next help level. Record of curriculum nodes visited maintained to permit suggestions.	Record of Curriculum nodes visited maintained to help child keep track.
Abstractness of Terminology selected by	system	child	child
Area of the Curriculum and complexity of the next activity selected by	system	child - system makes suggestions	child
Ecolab View selected by	mostly child	child	child

The results of the pre- and post-test were used to assess the efficacy of the three variations of the Ecolab software. This work is reported elsewhere [4, 5] and is not the main focus of the current paper. It is the character of the interactions between each child and the system that we will focus upon here. We wanted to investigate what sorts of interactions had resulted in the greater learning gains and which systems had supported and encouraged various types of interaction and collaboration in order to inform the design of our next system. For each child a summary record of their interactions was produced from the detailed logs maintained during their two sessions of system use and this was used to build up a picture of the types of interactions each child experienced with the system (for full information see [4]).

Cognitive or learning styles have been a subject of active interest in recent years [1, 3, 6, 8], for a brief review see [9]. The influence which a learner's style can have upon the way they interact with technology has also been

recognised [7]. Within this literature there are examples of classification systems which differentiate learners according to their learning preferences; for example, as serialists or holists [6]. The analysis of the annotated interaction summaries of children's experiences with the Ecolab software takes a fresh perspective on classification using only the styles of interaction or *Profiles* which can be found in the records of each child's system use and emphasizing our interest in the nature of *Interaction* and *Collaboration*. Characteristics were identified and children categorised through:

- **Interaction Profiles** according to the character of their interactions with the Ecolab.
- **Collaboration Profiles** according to the nature of the collaborative support provided by the system for the child.

4 Results

One aspect of the evaluation looked at whether the different variations of the Ecolab had been more or less effective in increasing the child's learning gain in terms of her understanding of the feeding relationships which exist in a food web as reflected in the pre- and post-test data. This indicated that the system variation (VIS, WIS or NIS) which the child used was relevant to her subsequent learning gain and a detailed discussion of these results can be found in [5]. Here we wish to concentrate upon the analysis of the records of interaction which was used to try and pinpoint the elements of VIS and WIS which led to their superior performance with particular ability groups.

4.1 Interaction profiles.

There were two characteristics which could clearly be seen as either present, or largely absent within the children s interactions. These were referred to as:

- **Busyness** and
- **Exploration**

Busyness was considered to be a characteristic of interactions in which the children completed an average or above average number of actions of any type, such as adding an organism to their Ecolab world or making one organism eat another. The interaction summaries of these children contained an above average number of events. The opposite of Busyness is referred to as **Quietness**.

Exploration was considered to be a characteristic of an interaction if the child had been involved in some sort of action which allowed her to experience more than one level of complexity or more than one level of terminology abstraction, beyond her initial starting levels. The opposite of Exploration is referred to as **Consolidation**.

Some children also switched frequently from one type of interaction to another. For example, they might switch from attempting to make one animal eat another, to looking at their organisms in a different view (i.e. perspective), to accessing a new activity entirely. Their interactions contained no or few series of repeated actions of the same type. They were particularly prone to frequent changes of view. These users have been characterised as **hoppers**. Other learners exhibited a more persistent approach, with sets of actions of a similar type grouped together. These users have been referred to as **persisters**.

These characteristics allow the children to be categorised , in principle, into 1 of 8 (2x2x2) possible Interaction Profiles.

The three parameters of categorisation: Busy/Quiet, Exploration/Consolidation and Hopper/Persister bear some similarity to features found in other categorisation systems. Pask's [6] differentiation of tendencies in learners towards being either "top-down" holists or being "bottom-up" serialists shares some common ground with the Hopper/Persister characteristic, for example. The differentiation of exploration from continuing activity at a level of consolidation is likewise similar to the challenge/safety division of [2]. However, the motivation for the analysis reported in this paper was not the presentation of a generally applicable categorisation system. The aim was twofold:

- To investigate the relationship between interaction style and learning gain.
- To examine how each of the system variations (VIS, WIS and NIS) of the Ecolab supported and encouraged particular learning styles.

Children fell into 6 of the 8 possible Interaction Profile groups. The distribution within these groups is illustrated in Table 2.

Table 2 Interaction Profile Membership

Profile Description	% of children in Profile group
Busy - Exploring - Persister (BEP)	28%
Busy - Exploring - Hopper (BEH)	12%
Busy - Consolidating - Persister (BCP)	8%
Busy - Consolidating - Hopper (BCH)	12%
Quiet - Consolidating - Persister (QCP)	20%
Quiet - Exploring - Persister (QEP)	20%

4.1.1 Examples of User Interaction Profiles

S10 (Gene) was a typical example of the *Busy - Exploring - Persister* style of interacter. Her first action was to switch from world view to energy view and then back to world view. She then added 15 organisms to the Ecolab and visited energy view again. Upon switching back to world view she made one of her organisms eat another, switching to energy view to see the effect. This pattern of making organisms act, either eating or moving and looking at the effect in an increasing number of different views continued. Introductory, investigative and rule-definition activity types were completed for the first two nodes in the curriculum before her first session drew to a close. She chose not to save her current Ecolab world which meant that at the start of her next session her first actions were the addition of organisms. Once again she added all 15 and then moved into the next phase of food web complexity and used more abstract terminology to view her organisms. Whilst the nature of the actions she completed was now more advanced and several instances of help were used, her pattern of activity remained one of initiating an action or actions appropriate to the evident goal. Actions were often completed in pairs and were followed by viewing the result from different perspectives (most commonly, energy, web and world). She did not experiment with writing a program or attempt to escape from completing the activities offered to her.

This profile group contains only high and average ability children from the VIS and WIS system user groups. In terms of performance at post-test there was a tremendous spread: A *Busy - Exploring - Persister* style learner attained the lowest learning gain, another, the second highest learning gain. The high ability children within the group all achieved an above average learning gain, but within the average ability children there was a wider spread of learning gain scores. Membership of this group was limited to VIS and WIS users, of whom the VIS users all achieved above average post-test learning gains, including the highest learning gain within this user group.

4.2 Collaboration profiles.

Two characteristics were found to be the most useful for differentiating collaborative style within the interactions: Amount of support and Depth of support used. These collaboration characteristics were used to group the children into one of four Collaboration Profile groups.

Amount of support: the average amount of activity differentiation (i.e. the degree to which the activity is presented in a simpler form) and the average number of help instances for the experimental group was calculated. An above average amount of either activity differentiation or instances of help was the criteria necessary for a child to be considered as using 'Lots' of collaborative support.

Depth of support: this characteristic was based upon the level of help and level of differentiation used. Once again the average levels used within the experimental group were calculated. Help or differentiation above the average level resulted in a child being considered as using 'Deep' or higher level support.

Interactions could be grouped into all 4 of the possible Collaboration Profiles. The first group was the largest and was further divided in accordance with the type of support which was most prevalent. The distribution of children into these groups is illustrated in Table 3.

Table 3 Distribution of children within Collaboration Profile groups

Profile Description	% of children in Profile	Profile sub-group Description	% of children in Profile sub-group
Lots and Deep (LD)	53%	Differentiation and Help	19%
		Differentiation	19%
		Help	15%
Lots and Shallow (LND)	12%		
Little and Deep (NLD)	16%		
Little and Shallow (NLND)	19%		

4.2.1 Examples of User Collaboration Profiles

S1 (Jason's) use of the available support was typical of the *Lots and Deep* profile group and of a user of above average amounts of both help and activity differentiation. He used level 4 help early in his first session of system use to achieve success in making organisms eat each other. His initial activities were completed with maximum differentiation of level 3. This was gradually reduced and then increased again. During his first session of system use he completed a range of activities for three nodes in the first phase of the curriculum. All instances of successful help were at level 4 or level 5. Fewer activities were completed during his second session. However, these activities were at a lower level of differentiation and there were fewer instances of help.

This Collaboration Profile group was the largest and was subdivided to account for the type of support used. Only VIS and WIS system users shared the profile. Jason was a member of the subgroup which used above average amounts and levels of both activity differentiation and help. This subgroup again consisted only of high and average ability children whose mean learning gain is above the average for the whole class (16% as compared to the class average of 11.5%). The subgroup of children who used greater levels of differentiation than help contained children from all ability groups. This second subgroup also produced above average learning gains at post-test (18% as compared to the class average of 11.5%). The last subgroup of children, who used greater amounts of help than differentiation, were all average ability children. Their average learning gain was well below the class average (3.9% as compared to the class average of 11.5%).

System variation had a greater impact upon the nature of the Interaction and Collaboration profiles than ability. A Pearson Chi-squared statistical test was also used to assess the relationship between the Ability groups, System Variation Groups, Interaction Profile Groups and the Collaboration Profile Groups. There was a significant association between System variation membership and Collaboration Profile membership (X^2 = 28.52, df = 6, $p < .0001$), and also between System variation membership and Interaction Profile membership (X^2 = 25.79, df = 10, $p < .01$).

So far little has been said about the NIS user group, they have not belonged to either of the Profiles used in the examples. In fact, all the NIS users belonged to a Consolidating Interaction profile; there were no explorers in this system user group. In addition, and as has previously been mentioned, no NIS users were in the Lots and Deep Collaboration profile group.

S9's (Tim's) Interaction profile which was that of a Quiet, Consolidating Persister, was typicalof a NIS system user. His initial session consisted of adding a single snail and then making 11 view changes to look at this organism from all perspectives. This initial stage was followed by a series of organism additions (commonly in blocks of 4); single actions, such as move or eat commands, in blocks of 1 to 5; and view changes which were almost always in pairs. In session 2 he adopted the commonly seen approach of adding a considerable number of organisms to start (in this case 12) and then once again completing single actions and view changes.

Likewise S26 (Karlie) s Collaboration profile reflecting low use of all types of help (Little and Shallow: NLND) was typical. She placed herself at the far extreme of food web complexity and started dealing with populations of organisms straight away. She only completed one type of action during both sessions of computer use: she built food webs using the *build web* command. Initially she made errors and used only occasional low level feedback, persisting until successful. The children in this profile group were all of high or average ability, but their average learning gains were well below average (5.2% as compared to the class average of 11.5%)

A further difference found within the NIS user group relates to the relationship between ability and learning gain. In the VIS and WIS user groups it was the higher ability children who achieved the greatest learning gains. By contrast, amongst the NIS users none of the high ability children made an above average learning gain, in fact the only learners who made above average learning gains were the low ability children. Whilst the numbers are small and the study exploratory this result is interesting and is certainly informing our current research. We had expected that of all three systems, the one which left most control within the hands of the learner would be most effective with the more able learners. Our results indicate that the opposite was in fact the case in our study.

5 Conclusions

This is an initial exploratory study with small numbers of children. However, there are several observations which are informative in building up a picture of the sorts of interactions which children experienced with the version of the system they used. VIS was the system which explicitly selected the next curriculum area for the child to complete and controlled the complexity and abstractness of the learning environment. Not surprisingly, all VIS users were members of profile groups with the 'Exploring' characteristic present. The split between 'Busy' and 'Quiet' was almost even. Only two of the VIS users scored a below averagdearning gain at post-test and both were in the same 'Quiet, Exploring, Persister' profile group. The majority ofWIS users were also 'Exploring' profile group members and only one did not belong to a 'Busy' profile group.However, whilst all the WIS above average learning gain achievers were members of 'Exploring' profile groups, the below average achievers were all members of different profile groups, with no common features between all of them. The WIS system variation did not set the curriculum area for the users, but did make suggestions which resulted in it being easier for a WIS user to avoid being an 'Explorer' thana VIS user. The NIS users were the children with the greatest freedom and the least finely tuned help system. It is perhaps not surprising therefore that none of them belonged to a profile group with the 'Exploring' characteristic. They were evenly split between being 'Busy' and 'Quiet' and the majority were 'Persisters'. Only two NIS users achieveabove average learning gains and unlike the WIS and VIS users, both were in profile groups which shared the 'Comfortable' characteristic, they were also both in the low ability group.

These results suggest that simply providing children with the means for extension through becoming involved in challenging activities is not enough to ensure that these challenging activities are undertaken. The child needs also to be explicitly directed towards activities which are beyond her ability. However, caution with regard to this provision of *direction* is important to ensure that the child is also offered opportunities for creativity. The success of WIS indicates that a suggestion about what and how to proceed is often sufficient. The consistency within the high and average ability groups across the different systems for above average learning gain achievement to be linked to the 'Exploring' profile characteristic isnot reflected in the low ability group. The definition of the 'Exploring' characteristic may of coursebe too crude to encompass the possibility that the low ability children were 'Exploring' within interactions in a single phase of the Ecolab.

The manner in which each variation of the system collaborates with the child is a design feature of that variation and as such a big influence upon the resultant user Collaboration Profile. It was no surprise, therefore, that there was a significant association between system variation and collaborative support profile membership. However, it is possible, in principle, for a user of any of the variations to interact in line with any of the Collaboration Profiles described. In reality Collaboration Profile 'Lots and Deep' was exclusive to VIS and WIS users, whereas Collaboration Profiles 'Lots and Shallow' and'Little and Deep' were exclusive to WIS and NIS users. The only system which allocated both help and differentiation to users was VIS, so the fact that VIS users all used a high quantity and quality of help is unsurprising. WIS users often used a high level of assistance too, but in smaller quantities, they all belong to profiles where the support used was of a high level. In contrast, all NIS users are in profile groups in which the level of support is low. The choice of help

available to NIS users was admittedly more limited being of only two levels, however none of the users ever chose to use the higher level of help offered.

The absence of some forms of assistance from the interaction summaries of the less successful users offers support for the suggestion that it is the combination of being challenged, or extended, plus the provision of ample quantities and qualities of support which is important for learning. The lower ability children present a somewhat different picture as there is no apparent consistency between the use of collaborative support and learning gain. The only tentative conclusions are that this group responded to interactions in which the extent of the challenge was limited and that the nature of the assistance the system could offer was not effective for them. Those who were successful took up less different types of assistance and tackled less of the curriculum than their successful more able peers. There is also evidence that these children were not good at managing their own learning. The NIS Interaction and Collaboration profiles in particular would suggest that children who are given control for their own learning experience are not good at setting themselves challenging tasks or indeed seeking collaborative support. Our current work with children is investigating this issue in more depth.

Acknowledgments

This research was sponsored by the Economic and Social Research Council. Thanks are also due to David Wood and Yvonne Rogers for useful discussion and insightful comment upon this work, and to the children and teachers of Blacklands School, Hastings for being enthusiastic participants in the evaluation study.

References

[1] Goodyear, P. Njoo, M., Hijne, H. and van Berkum, J. J. A., Learning processes, learner attributes and simulations , *Education and Computing*, Vol. 6, No (3/4), pp. 263-304, (1991).

[2] Groat, A. &. Musson, T., Learning styles: individualising computer-based learning environments , *Association for Learning Technology Journal*, Vol. 3, No. 2, pp. 53-62, (1995).

[3] Kolb, D. A., *Experiential learning: Experience as the source of learning and development* , Englewood Cliffs, NJ: Prentice-Hall, (1984).

[4] Luckin, R., *Ecolab: Explorations in the Zone of Proximal Development* , (CSRP No. 486). School of Cognitive and Computing Sciences, University of Sussex, (1998).

[5] Luckin, R. & du Boulay, J.B.H., Ecolab: The Development and Evaluation of a Vygotskian Design Framework , *International Journal of Artificial Intelligence and Education*, Vol.10, No. 2, pp. 198-220, (1999).

[6] Pask, G., Styles and strategies of learning , *British Journal of Educational Psychology*, Vol. *46*, pp. 128-148, (1976).

[7] Riding, R. &. Rayner., S., The information superhighway and individualised learning , *Educational Psychology*, Vol. 15, No. 4, pp. 365-378, (1995).

[8] Riding, R. &. Read, G., Cognitive style and pupil learning preferences , *Educational Psychology*, Vol. 16, No. 1, pp. 81-106, (1996).

[9] Valley, K., Learning styles and courseware design , *Association for Learning Technologies Journal*, Vol. 5, No. 2, pp. 42-51, (1997).

[10] Vygotsky, L. S., *Mind in society: the development of higher psychological processes* , (M. Cole, V. John-Steiner, S. Scribner, E. Souberman, Trans.). Cambridge, MA: Harvard University Press, (1978).

[11] Vygotsky, L. S., *Thought and language* , Cambridge, MA:MIT Press, (1986).

Facilitating Examples Understanding through Explicit Questioning

Isaac P.W. Fung and R.H. Kemp
Institute of Information Sciences and Technology
Massey University
Palmerston North, New Zealand
Fax: +64-6-3502259
P.W.Fung@massey.ac.nz; R.Kemp@massey.ac.nz

This paper describes a novel approach for promoting understanding of examples through explicit questioning. Whether being asked by the teachers or self-motivated, studying worked examples is an indispensable step for learners to acquire domain knowledge. The issue is: how could students use examples in the most effective way? Research findings indicate that the utility value of examples among different groups of learners varies dramatically. Effective learners keep self-explaining the solution statements when studying the examples while less effective learners often take each step of the statements for granted. In order to facilitate better understanding of examples, we propose to question the students explicitly on the examples content in order to stimulate their self-explanations. This paper presents the underlying computer model for generating different categories of questions from specific examples. The questions are subsequently used by a case-questioner to test the students on what they have read.

Keywords: **Artificial Intelligence, Conceptual Graphs, Intelligent Tutoring Systems, Case-based Reasoning**

1 Introduction

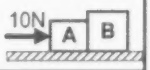
This paper presents a novel approach to facilitate the understanding of learning materials through explicit questioning. The notion we put forward in the paper forms one distinct feature of our current project: providing problem-solving advice in terms of relevant worked examples. When mapping out the project specification, there is an issue we are particular concerned with: to what extent the students benefit from the examples remains unknown. In her seminal work [2] Chi discovered the phenomenon of self-explanation among effective learners when they are presented with worked examples. Among this group of learners, they have a strong tendency to explain each example statement to themselves before moving on whereas the less effective learners tend to take the example statements for granted. In a follow-up investigation [3] Chi exploited her previous discovery in the context of learning. Not surprising, when students are deliberately prompted for self-explanation, they have shown a dramatic improvement in acquiring the knowledge. We believe the implication of Chi's study is very significant. Not only do the results shed light on understanding different learning behaviours, but the study also challenges instructors that merely informative examples do not guarantee good learning results. How the students use examples is a crucial factor in determining if they are really helping the students understand the subject domain.

As we are concerned with how the students use the examples presented, we decided not to take the present-and-go approach. Once a case (i.e. a relevant worked example) is retrieved for presentation, a case questioner will be automatically invoked to challenge the student's understanding on the knowledge embedded in the case. The questions generated are not explicitly stated in the problem statement. The rationale of this proposal involves encouraging the students to think more deeply while studying the worked examples. If the students have, in fact, understood the examples or related concepts within the domain, they should be able to answer the questions posed by the system. If not, the questions can trigger their attention towards certain aspects of the problem and stimulate their knowledge acquisition process.

2 Promoting Comprehension through Questioning

When studying worked examples, it is quite common for the students to take many solution statements for granted without trying to dig out the embedded tacit knowledge. Even if the students have the intention, they may lack the knowledge structure to find out the tacit knowledge. To put it simply, the student may know that it is helpful to self-explain the statements, but the problem is explaining what? There is research (e.g. [1], [4] and [7]) which indicates that questioning plays a significant role in understanding narrative text and therefore we argue that the same principle should also be applied in comprehending example solutions. If this argument is valid, one potentially pedagogically fruitful approach to tutoring in terms of providing examples is to question the learners on the content of the examples in a systematic way. Once the example is presented, the students will be asked questions driven by physical principles in order to detect what they know about the example and to help them discover meaningful relationships. To illustrate the argument, we consider the mechanics example shown in Figure 1.

Two blocks A & B are resting on a frictionless horizontal plane as shown. If an external force of 10N is acting on A, what is the acceleration of the blocks and the force of contact between them? (The masses of A and B are 3kg and 7kg respectively).



Solution :

$$\text{Net Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B} \quad \textit{(Applying Newton's 2nd Law on A\&B)}$$

$$\text{External Force}_{A\&B} \quad 10 = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$$

$$\text{Acceleration}_{A\&B} = (3 + 7)\ \text{Acceleration}_{A\&B}$$

$$= 1\ \text{m/s}^2$$

$$\text{Net Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A} \quad \textit{(Applying Newton's 2nd Law on A)}$$

$$\text{External Force}_{A} + \text{Contact Force}_{A} = \text{Mass}_{A} \times \text{Acceleration}_{A}$$

$$10 + \text{Contact Force}_{A} = 3 \times 1$$

$$\text{Contact Force}_{A} = -7\text{N}$$

$$\text{Net Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B} \quad \textit{(Applying Newton's 2nd Law on B)}$$

$$\text{Contact Force}_{B} = \text{Mass}_{B} \times \text{Acceleration}_{B}$$

$$\text{Contact Force}_{B} = 7 \times 1$$

$$\text{Contact Force}_{B} = 7\ \text{N}$$

Figure 1: A typical Newtonian mechanics example and its solution

When presenting this example, the author must have already made many assumptions regarding the knowledge state of the reader. For instance, it will be assumed the reader knows that the weights of blocks are being cancelled by the reactions from the ground and thus the weights are not included in the calculation; the reader is also assumed to know that the acceleration of the whole system is the same as the acceleration of individual components; and that the external action on A is the same as the external action on the system as a whole in this case. However, these points may not have been mastered by some students. From the perspective of problem-solving, the solution presented is not the only way of tackling the problem. For instance, the contact force on B can be evaluated immediately by relating it to the contact force on A with which is formed an action-reaction pair. Alternatively, the problem can be tackled by solving three simultaneous linear equations with variables a, f_A and f_B which stand for the unknown physical quantities which are sought. This knowledge is not explicitly shown in the solution statements and the students whose self-explanation is less active may miss these knowledge units. Therefore, a fruitful tutorial dialogue can be created by conducting a series of question-answering episodes on the example presented.

3 A Taxonomy for Different Types of Questions

Before asking a question, the questioner must perform two steps: the first is to decide the *content of the enquiry*; and the second is to compose the *style of the queries*. To pose appropriate questions to the comprehender, the question designer must have a semantic category of questions. We have adapted the taxonomy for questions in narrative understanding originally developed in [8] into the context of physics problem-solving, and this is summarized below in Table 1. Note that except for question No.4, all the

questions are relevant to the example shown in Figure 1.

CATEGORY	SPECIFIC EXAMPLES IN THE DOMAIN OF PHYSICS
1. Verification	*Is the system in equilibrium?*
2. Disjunctive	*Is force a vector or a scalar?*
3. Concept Completion	*What is FORCE?*
4. Feature Specification	*What does a convex lens look like?*
5. Quantification	*How many external forces are acting on block A?*
6. Causal Antecedent	*What caused the blocks to accelerate?*
7. Causal Consequence	*What are the consequences of the external force acting on the blocks?*
8. Goal Orientation	*In the 4th line of the solution, why are the masses of A and B summed?*
9. Enablement	*The blocks have weights; what is needed to prevent them from moving downward?*
10. Instrumental/ Procedural	*How was the acceleration of the blocks evaluated?*
11. Expectational	*What will be the magnitude of the contact force acting on A, if the mass of B is increased but the external action remains unchanged?*
12. Judgmental	*Do you think the solution presented is the only possible method?*

Table 1: Twelve Semantic Categories in Question Taxonomy (Adapted from [8])

4 Questions Generation

4.1 Based on the Definition of Concept Types

The questions in the categories 1, 2 and 3 are related to the definition of some domain-specific terminology and hence are grouped together. These categories of questions require the comprehender to grasp the definition of the focal content of the questions. For the question "Is the system in equilibrium?", the focus is on testing the readers on the precondition of a system being described as "in equilibrium". The question "Is force a vector or a scalar?" assesses the student's knowledge of the difference between vector and scalar quantities. There are two ways of generating these categories of questions: by *traversing the type hierarchy* and by *projecting* the definitional graph of the focus type into the conceptual graph [9] representing the example [5]. Based on these methods, the following scenarios can be developed. Question: "Why is the system not in equilibrium?" If the student successfully answers the net force acting on the system is not zero, another question can be generated such as "Then how can it be put into equilibrium again?"

4.2 Based on the Chaining of the Graph Nodes

In Newtonian mechanics, there are causes that are well-defined, such as the cause of acceleration being a non-zero net force; the cause of a change in velocity being non-zero acceleration; the cause of a change in position being a non-zero velocity, etc. The whole process of deriving values for unknown variables from available data can be modelled as a node chaining process, a kind of causal chaining. Figure 2 shows two subgraphs that represent the corresponding example statements:

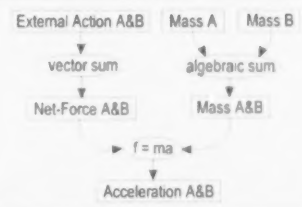
Solution Steps	Corresponding Conceptual Graphs
$\text{Net Force}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$ $\text{External Action}_{A\&B} = \text{Mass}_{A\&B} \times \text{Acceleration}_{A\&B}$ $10 = (3 + 7) \times \text{Acceleration}_{A\&B}$ $\text{Acceleration}_{A\&B} = 1\ m/s^2$	

Figure 2: Part of the solution steps and its corresponding conceptual graphs

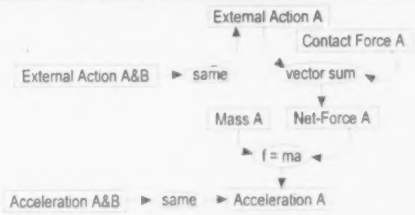
Solution Steps	Corresponding Conceptual Graphs
Net Force $_A$ = Mass$_A$ × Acceleration $_A$ External Action $_A$ + Contact Force $_A$ = Mass$_A$ × Acceleration $_A$ 10 + Contact Force $_A$ = 3 × 1 Contact Force $_A$ = - 7N	

Figure 2 (cont'd): Part of the solution steps and its corresponding conceptual graphs

The graphs shown on the right hand side of Figure 2 provide ample material to generate questions to test students' understanding of the solution steps such as "How was the acceleration of the system evaluated?"; "How many external forces act on the block A?"; "What is the relation between the acceleration of A and the acceleration of the whole system?"; "How was the contact force on B evaluated?", etc.

4.3 Based on Propagating Qualitative Values across the Graph

Regarding the expectational question depicted in the 11th category, one should see that it belongs more to the area of qualitative reasoning (QR) [11] and this kind of question is very common in testing the knowledge of students. A QR technique had been developed in [6] and the following type of questions are successfully generated. "If the external action decreases, what would be the contact force?" "If the bottom of block A is made rough to create friction between A and the ground, what would be the acceleration of the system and the contact forces?"

5 Conclusions

This paper proposes a questioning approach to handling examples, which is intended to stimulate the student's cognitive process of self-explanation. Representing worked examples by CG allows the system to generate different categories of questions during the questioning process. We have shown that definitional, procedural and qualitative questions can all be posed to students for tutorial purposes. Due to space limitation, we have not covered all categories of questions; for instance, feature specification and enablement. At the moment, this part of the work derives only from a computational perspective and lacks empirical support. The next phase of our project is to test posing the questions to students to see if this approach would stimulate self-explanations and subsequently enable them to acquire a better understanding of the subject domain.

References

[1] Anderson, R.C. & Biddle, W.B., "On asking people questions about what they are reading." In G. Bower (Ed.) The Psychology of Learning and Motivation (Vol. 9), NY: Academic Press, (1975).

[2] Chi, M.T.H. et al., "Self-Explanation: How students study and use examples in learning to solve problems, Cognitive Science, Vol.13, pp. 145-82, (1989).

[3] Chi, M.T. H. et al., "Eliciting self-explanation improves understanding" Cognitive Science, Vol. 18, pp.145-82, (1994).

[4] Dillon, J.T., "The multidisciplinary study of questioning" Journal of Educational Psychology, Vol. 74, pp. 147-65, (1982).

[5] Fung, P.W. "Designing an case-based intelligent learning environment in physics with conceptual graphs" Ph.D. Thesis, Dept. of Computation, UMIST, England, (1996).

[6] Fung, P.W. "Generating qualitative predictive problems in a case-based physics tutor" In Proceedings of AI-ED97, World conference on artificial intelligence in education, Kobe, Japan, (1997).

[7] Graesser, A.C. & Black, J.B., "The psychology of questions" NJ: Lawrence Erlbaum Associates, (1985).

[8] Graesser, A.C. et al. "A taxonomy for question generation" Questioning Exchange, Vol. 2, pp. 3-15, (1988).

[9] Sowa, J. "Conceptual structures: Information processing in mind and machine" Reading: MA: Addison-Wesley, (1984).

[10] Trabasso, T., et al. "A model for generating questions that assess and promote comprehension" Questioning Exchange, Vol. 2, pp.25-38, (1988).

[11] Weld, D.S. & deKleer, J. "Readings in qualitative reasoning about physical systems" CA: Morgan Kaufmann Publishers, (1990).

IT in Instrumental Music Teaching and Learning: Some Practical Ideas

Barry Kwok-yeung Lee
Department of Information & Applied Technology,
The Hong Kong Institute of Education,
10 Lo Ping Road, Taipo, N.T., Hong Kong.
Phone: +852 2948 7724; Fax: +852 2948 7726
E-mail: blee@ied.edu.hk

This paper describes the potential use of information technology (IT) in practical music teaching and learning. The incorporation of IT into instrumental music curriculum can open up an entire music context for both teachers and students. IT integration in the instrumental music curriculum offers the potential to provide students with unique musical experience that was not possible in the last decade. IT can broaden the spectrum of instrumental instruction, providing more information, more resources, and a better understanding of the subject area. There have been substantial reports of success about the enhancement of traditional music teaching with IT. Based upon these experiences, current orchestral instrumental teaching practice has been examined to explore opportunities for technology integration. Areas appropriate for integration were identified with specific reference to current practice in instrumental instruction. Examples of technology-based instrumental music instruction were discussed and analyzed, providing reference for further investigation.

Keywords: **IT Integration, Music Technology, Instrumental Teaching**

1 Introduction

Throughout the world, IT is changing the way music is taught in the school music curriculum. Many music teachers have already incorporated IT in general group music teaching in the classroom. It is obvious that IT has the potential to radically change the fundamental processes involved in the teaching and learning of orchestral instrument that is more adhered to small group or individualized teaching.

A review of literature about music education oriented IT application indicated that IT has been used in a variety of classroom activities such as composition, group keyboard lessons, music theory, rhythm training, aural training, music reading, harmony, music appreciation and music accompaniment etc (see [1], [4], [5] & [12] for more details). Based upon successful instances of classroom applications in IT cited in the literature, consideration is being made to incorporate IT in instrumental music teaching and learning.

2 IT opportunities in Orchestral Instrument Instruction

Rudolf [12] noted that "the best way to select the ideal use for technology is to first focus on the desired goals and educational outcomes and then select the materials or devices best suited to accomplish the stated goals" (p. 76). In fact, as pointed out by Willman [13], "some portions of the curriculum may be enhanced greatly through the use of technology; others may be taught best using more traditional techniques" (p. 33). In this regard, the practical aspects of instrument instruction should be taken into account when considering the integration of IT in instrumental teaching. Instrumental teachers must choose IT that can match their instructional goals. IT applications should therefore be determined by the desired instructional activities that can be best supported through IT strategies.

In general, a typical instrumental lesson can be divided into four sections, namely the (a) technical studies, (b) pieces, (c) scales and arpeggios, and (d) sight-reading and aural. A review of the contents of syllabuses of major international practical music examination revealed that technical works - scales and arpeggios, studies, repertoire pieces, aural training, sight-reading, and general knowledge of individual instrument are key learning areas. As a considerable number of music software are now available, capable of catering for a wide variety aspects of music education; coupled with the software's versatility and flexibility, information technology can be applicable to the instruction of most these areas.

With the substantial reduction of the cost of multimedia notebook computers, instrumental teachers can carry not only his/her musical instrument, but also a computer that can be put inside his/her briefcase. For instrumental teachers, software such as sequencing, ear training, and multimedia CD-ROM are specially useful. In particular, sequencing software, like Cakewalk for example can serve a number of purposes in instrumental teaching.

Firstly, sequencing software can be used as an interactive staff board, teachers can write notes, chords, melodies or rhythmic patterns freely on the staff. With the simultaneous tone reproduction function, pressing either the "Scrub" or "Play" button will output the sound of individual notes, chords, melodies or rhythmic patterns. As a comprehensive list of western musical instruments is available for output selection, this function can virtually support the teaching of almost all instruments. The teaching of tuning, rhythm, ornaments, scales and arpeggios can also be supported. In teaching tuning, computers can provide a secondary sound source of, or other than, students' instrument to develop their ability to identify unmatched sound so that their competence in playing in tune can be attained. For the teaching of rhythm, ornaments, scale and arpeggios, teachers can create the required note patterns prior to the lesson. With the assistance of computers to illustrate these note patterns during the lesson, a more precise illustration can be provided. Coupled with the close to real play back function at the desire speed, students can have a much clearer view and a better grasp of the idea of these fundamentals. Although teachers can provide the demonstration that can never be replace, with the assistance of computers, teachers can be more attentive to students' performance; while instant interaction, feedback and instruction can be given.

Secondly, sequencing software can provide accompaniment, either orchestral or piano, to the music pieces to be performed. In general, pieces are usually performed with accompaniment. Teachers can prepare the respective piano or orchestral accompaniment in the form of MIDI for play back during lesson through the multimedia audio device of the computer. With the introduction of computer accompaniment, the time, cost and effort to organize a piano accompanist can greatly be reduced as the physical piano accompanist is only required for the last few rehearsals. Of course, instrumental teachers can also act as piano accompanists to a certain extend. However, in most cases, instrumental teachers may not be good pianists or the accompaniment part is just beyond the ability of the instrumental teachers. In addition, the piano may not readily be available in the room where the instrumental lesson is conducted. Moreover, if the pieces are to be accompanied by an orchestral group, computer-generated accompaniment can provide a more realistic simulated circumstances for students' practice, which is particular difficult to organize in real life, it will be very costly to organize an orchestral accompaniment group. In teaching the repertoire pieces with computer mediated accompaniment, teachers are able to watch the performance of the students at all times and evaluate students' performance. The presence of computer-mediated accompaniment enables instrumental teachers to focus more on students' performance in terms of expression, dynamics, tempo and interaction with the accompaniment part. Also, if students have their own computer, students can be given the floppy disk containing the orchestral or piano accompaniment file so that more accompanied individualized students' practice is possible. Undoubtedly, computer-mediated accompaniment provides students at all levels with a complete musical context for solo practice.

One of the important aspects of instrumental teaching is demonstration. Teachers' demonstration provides students with a model for imitation. Demonstrations provided students with an over picture about the pieces to be learned including style, speed, touch and rhythm. In addition to teachers' live performance demonstration that can provide a more detailed interpretation of music and pieces to be learned can be played back with the multimedia digital audio and video facilities of the computer. Compact Disc (CD) and Video Compact Disc (VCD) recordings of music performed by maestro can be played back and will be helpful in assisting students to appreciate and analysis the pieces, and produce direct interaction and influence.

For aural training, there is a wide variety of software available that provides computer-aided drill-and-practice instruction for ear training. Teachers can conduct drills such as interval dictation, rhythmic

dictation, melody recognition etc. during instrumental lessons. As ear-training software are becoming popular and relatively inexpensive, some can even be downloaded for free or only at a minimal cost from certain web sites in the Internet. Students can practice on their own outside the normal lesson hours. As most of the aural tests are conducted with the sound of piano, if teachers are not comfortable with the pre-determined contents of these software, teachers can use sequencing software to tailor make some aural training materials that adhere more to the level and needs of individual students.

For the teaching of general knowledge, there is a large and ever increasing number of multimedia resources in the form CD-ROM available that could be an ideal media to support instructional delivery. Multimedia CD-ROMs provide teachers with a context that is rich in digitized audio-visual resources including sound, text, graphics and video. Teachers can make use of these CD-ROM to illustrate information about a musical instrument such as physical structure, method of tone generation, members of same family, and the development and evolution of a particular instrument. By playing back musical extracts, tone colors of instruments constructed in different periods can be heard and compared. To introduce a piece of music composed in a particular period, information about the composer such as biographical details can easily be displayed. By playing back music of the same period composed by same composer or other contemporary composers, musical styles of a particular period or particular composer can better be illustrated and analyzed. This is particular useful for students who need to perform a piece of music that was composed in earlier musical periods, with students able to have a better ideal of the musical styles of that particular period. These CD-ROM titles not only provide students with the musical styles that can be heard or visualize from audio or video CD, but also a concrete historical, cultural and social background of music from different periods.

3 Conclusion

With the sophisticated software and hardware that are now accessible at affordable prices to both teachers and students, information technology has a great potential for supporting instrumental music teaching. IT applications in instrumental lessons provide a computer-mediated environment which can stretch out the limit of traditional delivery system. Limitations encountered under traditional delivery systems due to unfavorable mode of information retrievals and dissemination could be reduced or even eliminated, so that the teaching of key areas in instrumental instruction can be much enhanced. Coupled with instrumental teachers' professional knowledge, a much favorable learning environment can be created, enabling the music experience provided to students be further heightened. More importantly, with the support of IT, students' learning can occur in a real musical context that is full of musical facts, knowledge and a virtual space in which musicianship can be developed that adheres more to a professional performer.

Reference

[1] Altiere, L., "Teaching Idea" in Stinson, C. (Ed.), Technology-rich teaching. Teaching Music, vol. 4, no. 2, pp. 30-32 (1997).
[2] Booty, C. Ed., "TIPS: Technology for Music Educators", Music Educators National Conference (1990).
[3] Bray, D., "CD ROM in music education", British Journal of Music Education, vol. 14, no. 2, pp. 137-142 (1997).
[4] Carpenter, R., "Technology in the Music Classroom", Alfred (1991).
[5] Dunnigan, P., "The Computer in Instrumental Music", Music Educators Journal, vol. 80, no. 1, pp. 32-37, 61 (1993).
[6] Klinger, M., "The One-Computer Music Classroom", Teaching Music, vol. 3, no. 3, pp. 34-35 (1995).
[7] Lee, B.K.Y., "Technology Based Music Instruction: Multimedia Applications in Music Teaching" in Volk, K.S. (Ed.), Science & Technology Education Conference '98 Proceedings, pp. 244-252, Hong Kong Institute of Education. (1998).
[8] Lee, B.K.Y., "IT Opportunities in Primary Music Curriculum in Hong Kong: Potentials and Obstacles". In Cumming, G; Okamoto, T & Gomez, L eds, Advanced Research in Computers and Communications in Education (Amsterdam: IOS Press), pp 86-89 (1999).
[9] Muro, D., "Technology: A tool for music education", Teaching Music, vol. 4, no. 5, pp. 28-30 (1997).
[10] Murray, A., "The Music IT Pack", National Council for Educational Technology, UK (1997).
[11] National Council for Educational Technology, UK, "Primary Music: a Pupil's Entitlement to IT", Author (1996).

[12] Rudolph, T.E., "Teaching music with technology", Chicago, Ill.: GIA (1996).
[13] Willman, F., "New Solutions to Curricular Problems", Music Educators Journal, vol. 79, no. 3, pp. 33-35,68 (1992).

Learning from the Learning of other Students

Stuart Garner
Edith Cowan University
Pearson St., Churchlands, 6018, Western Australia
email: s.garner@ecu.edu.au

This paper concerns the use of dialogues in student learning and how such dialogues can be captured for subsequent use by other learners. The process of learning by observing another person' s learning is known as vicarious learning. The paper begins by discussing the movement towards more flexible types of learning and the belief by many that traditional dialogue has been omitted from a lot of today' s courseware. Dialogue can be considered as one of the stages in the learning cycle and to support it there is a need to create tertiary courseware, this being the third stage in the cycle. Some of the research that has taken place into vicarious learning is described and this has shown that it has some benefit to learning and also produces positive feelings in students of being part of a learning community. Finally the vicarious learning resources that have been produced within a software development course at Edith Cowan university using a dynamic screen capturing tool are discussed together with a possible dissemination system.

Keywords: **Distance Education, Flexible learning, Vicarious Learning, Programming**

1 Introduction

Universities and colleges today have record numbers of students and yet the cost being spent per student is steadily decreasing as budgets are cut and universities become ever more competitive. One of the consequences of this is that many managers are turning to the Internet as a means for delivering courseware to students in a supposedly cost-effective manner. Students are also demanding more flexible learning with learners being able to earn when they want (frequency, timing, duration), how they want (modes of learning), and what they want (that is learners can define what constitutes learning to them) [14].

The situation has therefore arisen that students spend more time away from a traditional campus and technology is being used to provide the necessary flexibility with computer networking empowering connectivity and communication, allowing synchronous and asynchronous one-to-one and one-to-many communication [13]. However, such technology does not necessarily support some of the learning situations that are necessary in higher education. Laurillard [6] points out that learning in many educational contexts, particularly in higher education, requires learning about descriptions of the world, knowledge derived from someone else's experience, and from understanding someone else's arguments. She states that:

> *We cannot claim to have sorted out once and for all what students need to be told if they are to make sense of topic X. No matter how much detailed research is done on the way the topic is conceptualised, the solution will not be found in new ways of putting it across. The new way of telling may sort out one difficulty, but it may well create others. All we can definitely claim is that there are different ways of conceptualising the topics we want to teach. So all we can definitely conclude is that teachers and students need to be aware of those differences and must have the means to resolve them.*

The main way this has been done in the past has been by students participating in dialogue with fellow students and their tutors. We do have email and synchronous "chat" available to support dialogue to some extent but it may well be argued that this is insufficient to support the above.

2 The Learning Cycle

Dialogue can be considered as a crucial part of the learning cycle [9]. The cycle is shown in figure 1.

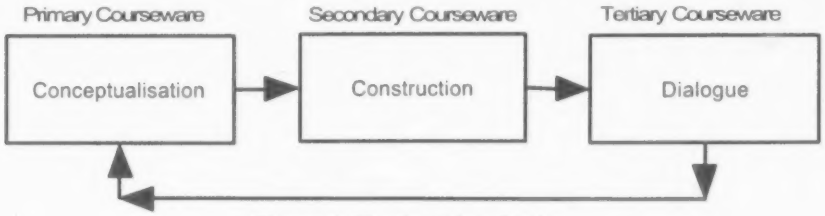


Figure 1: The learning Cycle

It can be considered to comprise:

- conceptualisation which comes from interacting with the primary content and relates to a learner's current state of understanding.
- construction and the use of knowledge occurs with the use of secondary courseware tools such as concept mappers. It involves picking out particularly relevant material, putting the information together in ways which have meaning for the learner, and relating old and new material into a coherent whole.
- dialogue which involves the testing of understanding and can possibly be facilitated with tertiary courseware.

Mayes et al [9] suggest that the third section of the learning cycle, dialogue, can itself be broken up into three stages, these being discussion, reflection and reification. Mayes et al agree with Laurillard that discussion is fundamental to effective education and that a deep understanding is promoted far more effectively and efficiently during discussions. Reflection has always been thought to be an important aspect of learning and can be considered as the testing of new knowledge against the schemata that hold our existing knowledge. And finally reification is a term put forward by Mayes et al and concerns the structuring of newly acquired knowledge into a new object of thought integrated with other knowledge.

The question then arises as to what sort of tertiary courseware can be produced and utilised to support the dialogue aspect of the learning cycle bearing in mind that the material will have to be used in flexible learning environments. One particularly interesting line of research has been into recording of discussions and making them available to other students in a flexible mode. This concept is known as vicarious learning where this is defined as [2]:

> *The potential benefit to learners of being able to observe or 'listen in' on experts or their peers as they discuss a new topic.*

The following can be considered to be vicarious resources:

- Frequently asked questions (FAQs). Here students can learn from the answers to typical questions posed by other students.
- Listservers. These promote vicarious learning as students receive the text dialogues that take place between various subscribers. The term "lurker" is often used for the person who does not participate in dialogues but prefers to simply observe.
- Bulletin boards. These provide the means for asynchronous dialogues and again can be used by "lurkers".
- Chat rooms. These provide the means for synchronous dialogues.

3 Research into Vicarious Learning

Research initiatives are in two main areas, the first attempting to determine if vicarious learning is of benefit to students and the second looking at how such dialogues might be made available as tertiary courseware for re-use by other students.

There are several interesting questions that might be worthy of investigation in the first area. Cox et al [2] suggest that we need to determine who are useful models for the vicarious learner, experts or novices. It might be better to observe experts as skilled behaviour would hopefully be modelled in a clear way, although this is not of course always true as many experts find it difficult to make their knowledge explicit. It could be argued that student – student dialogues would be better to observe as the observing student would be better able to identify with other students. Also the students participating in the dialogue might use more appropriate language and also ask questions of each other that they may not have wished to ask their tutor. Cox et al also point out that observing unskilled behaviour may also prove to be of benefit as the observing student would determine from the dialogue what sort of errors to avoid without having to make those errors themselves. Also of course, the dialogue type to observe may depend on the type of student who is the observer. It might be more appropriate for a strong student to observe experts and for a weak student to observe novices.

In one particular piece of research on vicarious learning [7] benefits were found that were both cognitive, with an increase in knowledge and understanding in the particular curriculum area, and social with exposure to peer discussion creating positive feelings of being part of a learning community.

Lee et al [7] carried out research within an on-line Masters level course in Computers in Teaching and Learning. They created task-directed discussions (TDDs) in order to capture good learning dialogues amongst students and to overcome the "barriers of silence" that might otherwise occur. Over 30 hours of discussions among students, and between students and a tutor (the expert), using the TDDs were videoed.

An architecture called the Dissemination System (DS) was created from primary instructional materials and integrated clips taken from the videos. The DS allows a multimedia database of video and audio clips, text transcriptions, and annotated graphics to be integrated with primary expository teaching material and delivered via the Web. The system was then used in an experiment to investigate the vicarious resources in a controlled laboratory setting.

The experiment used a section of the course on Models of Learning with Technology. Two sets of learning materials were created, the first comprising primary learning materials (approximately 45 web pages) and the second comprising both primary learning materials and an integrated set of vicarious learning resources. The vicarious resources had been obtained from the videoed dialogues and comprised 108 video clips, 13 audio clips, 43 text transcriptions, and 27 audio annotated graphics. The resources were accessible by either clicking on highlighted keywords or by a search mechanism.

Two groups of students took part in the experiment, one using only the first set of learning materials whilst the other used the second set of learning materials which included the vicarious resources. The conclusions that Lee et al drew from the experiment were that there were some benefits in learning and substantial positive changes in attitudes and discussion behaviour for the students who used the vicarious learning resources. The researchers also make the point that although some people claim that learning can only take place when students are personally engaged in discussion, the evidence suggests that observing peer dialogues can, on the contrary, provide a useful source for learning, both cognitively and socially. The researchers have in fact suggested that such vicarious learning may sometimes be more beneficial than being a participant, depending on the state of the learner [11].

The web based materials used in the experiment are available at http://www.hcrc.ed.ac.uk/Vicar/TT/. They are fairly slow to download from the Web but realistically they could be put onto a CD ROM for use with distance learners. The audio dialogues that are available are played whilst a static graphical image is displayed to the learner. Such a dialogue concerns the graphic being displayed and I felt that something was lost in this type of dialogue and that it would have proved to be more useful and meaningful if objects on the graphic could have been "pointed to" in order to draw the observer' s attention to the important aspects of the graphic.

4 Creation of Vicarious learning Resources with Dynamic Screen Capturing Tools

During the summer school of 1998 at Edith Cowan University, I made use of Lotus ScreenCam for student-tutor dialogues within a Software Development unit. Between lectures and laboratory sessions, students had

no contact with me as I was off campus, however I did have access to email at home enabling students to send me ScreenCam movies of any programming problems that they were having. In addition to movies, students would also send the programming code enabling me to use this when making a "reply" movie. An example of a screenshot taken from a movie, which was sent to me by a student, is shown in figure 2.

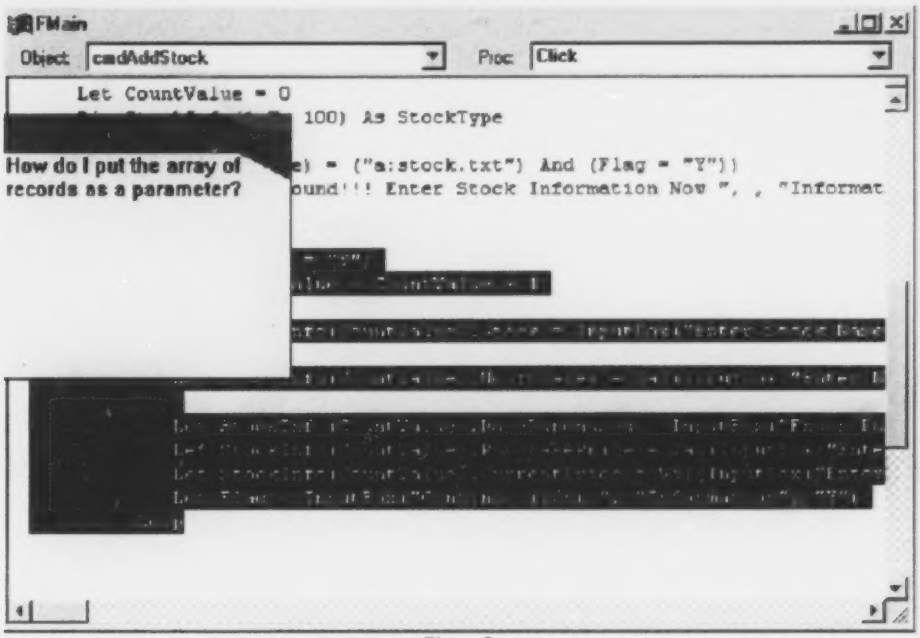


Figure 2

The movie had several text captions and concerned a problem that this student was having with passing arrays to subprograms in Visual BASIC. A screenshot taken from the movie, which I made and subsequently sent back to the student, is shown in figure 3.

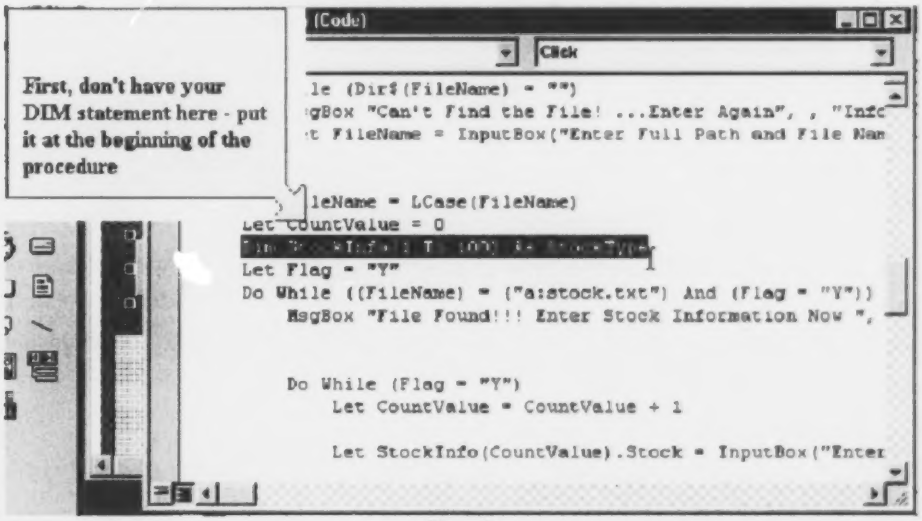


Figure 3

The screenshot in figure 3 includes a text caption that has nothing to do with the original student problem. It

BEST COPY AVAILABLE

is the sort of comment that I would make if I were looking at the code that a student had produced in a laboratory session. In the rest of the movie, I was able to make suggestions on how to overcome the original problem and I also included a captioned comment about the lack of comments within the student's programming code. By using ScreenCam, I had been able to engage in a richer asynchronous dialogue with the student than I would otherwise have done by conventional means. In addition, as a side effect, I was building up vicarious learning resources for use in future semesters.

In addition to capturing asynchronous dialogues as described above, Lotus ScreenCam can be used to provide rich feedback to students on their assignment work. Simple "low-tech" audio tapes have been used in student feedback [1] and it is suggested that such feedback adds a social dimension to the commentaries with the tutor being able to talk personally to each student, whereas written comments lacked context and sounded impersonal.

I produced a set of such movies for the small group of campus-based students that were involved in the 1998 summer school session mentioned earlier. Each week the students attempted a small programming problem and handed in the relevant programming code together with a small text -captioned movie explaining their program. I then made a feedback movie for each student. Each feedback movie had audio commentaries to keep the production time to a minimum and the movies were placed onto ZIP disks that had been provided by the students. I was able to go through the programming code on the screen, highlighting areas of interest with the cursor whilst making comments and in addition run the student programs with a variety of data whilst passing comments about both the good and the bad points of the programs.

The sets of movies that the students handed in and that I produced have now become another vicarious learning resource for use by students in subsequent semesters. Each week, students are given a small programming problem to attempt and they can then use the movies to view the student – tutor interactions for a similar programming problem. In practice, students have commented on how useful they have found these resources. Feedback was elicited on-line and some of the comments follow:

- I found it helpful and interesting in giving clear visual instructions or explanations.
- All the other students solutions were very helpful. And they were informative.
- Only used the movies once, but they do provide a good resource for students experiencing difficulty.
- Pick up other students mistakes.
- Always forgot how to get to them
- Probably slack, but using the sound was too much hassle.

5 Delivery Mechanisms for Vicarious Resources

The last two student comments above indicate that there is a need for some form of technological delivery mechanism for the vicarious resources that have been produced that is simple and easy to use. Students need to be able to quickly find movies that are appropriate for the programming problem that they are attempting and then view the movie. We have experimented using the Web to deliver the movies however this has been a problem as movies with audio are of the order of 1MB in length per minute and take too long to download. Realistically it is necessary to make the movies available on CD ROM and we will be using a Windows Help file as a way of delivering the movies. There are several Help file authoring tool available and one that I have used extensively is ForeHelp [4]. A Help file can be produced with the usual contents and index pages with little effort and programs can be launched seamlessley thereby permitting the running of ScreenCam movies.

6 Discussion

It would appear that the use of vicarious learning resources by students can benefit learning and also provide positive feelings of being part of a learning community. However the creation of such resources needs to be done very carefully so that they are relevant and of interest to learners. If a synchronous dialogue is to be recorded by the use of video or audio then it is important to use task directed discussions [7] to ensure that a relevant dialogue ensues. Asynchronous dialogues usually take place by email or bulletin boards, however

they can be made richer if a dynamic screen capturing tool is used. Finally the vicarious learning resources that have been collected need to be made available to other learners and to this end Lee et al created a web based dissemination system. Another approach is to use a Windows Help file for disseminating such resources assuming that delivery is to be by Wintel hardware only.

In the future I intend to look at capturing synchronous dialogues using a dynamic screen capturing tool. These would be both student – student and student – tutor where the two participants sit in front of a PC whilst having a dialogue concerning a program that is being displayed.

References

[1] Anson, C. M. (1997). In Our Own Voices: Using Recorded Commentary to Respond to Writing. New Directions for Teaching and Learning, Spring 1997(69), 105-113.

[2] Cox, R., J. McKendree, et al. (1998). Learning vicariously from educational dialogue and discourse. 20th Annual Conference of the (US) Cognitive Science Society, Madison, Wisconsin.

[3] Domingue, J., & Mulholland, P. (1997). Teaching Programming at a Distance: The Internet Software Visualization Laboratory. Journal of Interactive Media in Education (http://www-jime.open.ac.uk), 1, 1-28.

[4] ForeHelp User's Guide (1995). ForeFront Incorporated

[5] Garner, S. (1997). Cost Effective Multimedia Production for Frequently Updated Courseware. Paper presented at ASCILITE 97, Curtin University, Perth.

[6] Laurillard, D. (1993). Rethinking University Teaching: A Framework for the Effective use of Educational Technology, London Routledge.

[7] Lee, J., F. Dineen, et al. (1999). Vicarious Learning: cognitive and linguistic effects of observing peer dialogues. American Educational Research Association (AERA '99), Montreal, Quebec.

[8] Lotus Corporation. (1997). White Paper (Technical) http://www.lotus.com/home.nsf/welcome/screencam, (accessed on June 23, 1999)

[9] Mayes, J., J. McKendree, et al. (1996). The Vicarious Learner: Rethinking the use of dialogue in teaching and learning, http://www.hcrc.ed.ac.uk/gal/vicar/VicarPapers/vicar.html (accessed on Aug 4, 2000).

[10] Mayes, J. T., & Neilson, I. (1996). Learning from other People's Dialogues: Questions about computer-based answers. In B. Collis & G. Davies (Eds.), Innovating Learning with Innovative Technology . Amsterdam: North-Holland.

[11] McKendree, J., K. Stenning, et al. (1998). "Why observing a dialogue may benefit learning." Journal of Computer Assisted Learning **14**: 110-119.

[12] Neville, L. (1995). Sense-making and Sensitivities: New Pedagogies? New Practices? New Acceptance of Old Ways of Learning? Australian Educational Computing (May 1995), 15-19.

[13] Nikolova, I. and B. Collis (1998). "Flexible learning and design of instruction." British Journal of Educational Technology **29**(Jan. '98): 59-72.

[14] Van den Brande L (1993). Flexible and distance learning John Wiley, Chichester, UK

Making the Most of the Internet for Potential for Education

John Wang* and Dilek Sanver**
**RS Information Systems, Inc./university of California, Berkeley*
3402 Sepulveda Blvd, #421, Los Angeles, CA 90034, USA
Telephone: (805) 982-3312
Fax: (805) 982-2659
Email: jgwang@csua-berkeley.edu
***University of California, Irvine*
Irvine, CA 92697,USA
Telephone: (310)390-7429
Email: dsanver@uci.edu

Who is building Web sites today? Entrepreneurs, writers, hobbyists, educators and students from the elementary grades and up are building them, not Java programmers, In fact, very few Web sites are actually built by professional programmers That is why strategies for making the most of Internet' s potential for education is important: It brings the power of Internet to non-programming Web-builders like teachers and their students. Internet is an exciting, dynamic technology that is challenging for education. With new specifications, new classes, and general updates, one must accept the fact, when integrating Internet Technology into instruction, that the course will never be the same because the subject matter is in a never-ending state of change. In today' s technological environment, curriculum development must be iterative; in other words, it is an ongoing repetitive process that is required due to the constant change of the subject matter and the technology. In order to be making the most of Internet's potential for education, we proposed these six basic phases--- understanding, planning, research, development, refinement and implementation. This article describes how to effectively use this six-phased approach Follow these phases, the educators and learners can collaborate to enhance existing material and produce new innovations for education.

*The paper was not available by the date of printing.

Networked Constructive CAI System Putting Emphasis on Communication and Discussion—An Example of Proportion-concept in Mathematics of Elementary School

Pou-Yah Wu*, Yi-Ling Lu, Ruey-Chuan Wu, Hsiao-Yun Wu and Shin-Pey Chen**
Department of Mathematics Education, National Tainan Teachers' College, Taiwan
E-mail: *pywu@ipx.ntntc.edu.tw **a8817209@wwes.tnc.edu.tw

New courses in mathematics of elementary school in Taiwan emphasize constructive pedagogy about solving problems, reflection, studying and learning, communication and discussion. The development of computer technology provides the environment of discussion, facilitating the convenience for communication. This study adapts itself to the change of teaching material for new courses, establishing connection by the operation of lineal graph. As far as the system is concerned, via elucidating the process of solving the problems, the system attain the effect of reflection; it establishes the virtual students and room for on-line discussion to achieve the aims of studying and learning, communication and discussion; letting the platform to the students to fulfill the concept of constructive pedagogy. After the future leased network become more popular and the computer interfaces become more humanized, we believe that the effects of communication and discussion will become better. Besides, the norms of discussing the order in this system will leave much to be desired.

Keywords: **CAI, mathematics of elementary school, proportion concept, Web-based learning.**

1 Introduction

New mathematics courses of elementary school in Taiwan adopting constructive pedagogy in 1993, thinking that the learning of mathematics knowledge is cultivated gradually in the processes of solving the problems, reflection, discussion and modification. Mathematics' meaning is formed individually, but the accumulated thoughts of the wholly social mass and cooperation can provide the best learning environment of mathematics. We hope that we can provide the learning environment of mathematics from the accumulated thoughts and cooperation by means of the networked constructive learning environment. The constructive pedagogy of new courses aims at the communication and discussion between the students[1]; however, communication and discussion waste much time. Thus, there is deficiency of time in teaching in the real pedagogy; nevertheless, the discussion of the virtual students and networked on-line learning can well make up the limitation of time and space, owing to the fact that the learning activities can be carried on at any moment and at any place through the network. The need of clarifying the concepts to communicate and discuss between emphasized by new courses can also come true. This study aims to associate the virtual students and networked learning, designing networked constructive learning environment, providing a environment for communication and discussion, helping students construct the concept of proportion, letting the communication can be undertaken immediately between the learners, between the learners and the virtual students, making up a wholly cooperative learning environment, thereby facilitating the students to clarify and to develop mathematics concepts.

2 Principles of System Construction

2.1 Basis of Learning Theory

Constructive pedagogy let the students establish his conceptual structure with new things; the teacher helps the students construct knowledge only. Thus, the teacher plays the role of posing the problems; the real solver of the problems is the student. Basically constructivism stresses the concept of learner-centeredness. With a view to fulfilling the educational ideal of child-centeredness, new courses emphasize the students' natural thought and the individual difference[1]. Why the students' natural thought be stressed? Because the learner has to construct knowledge positively, and he constructs the knowledge on his own natural thought. To adapt the various natural thoughts, in addition to "time difference" of the individual difference in the process of the students' learning, the so-called "route difference" is added [3]. Thus, the learner may adopt different ways of solving problems to form various records. New courses stress the activity of solving problems and reflection to accumulate related experiences of activities to serve as the foundation of upholding mathematics knowledge. Thus, the issued culture within the class in the lower grade courses, then, emphasizing discussed culture in classes of higher grades, partly discussing students via classes, and partly reflecting his own thoughts about solving questions[1].

2.2 Basis of Course Content

Old courses in 1975 emphasize the processes manifested; therefore, what the old courses lay stress on the proportion concepts is the exercise of the abstract meaning on ratio, thus looking upon the definition of "ratio" as the multiplicity relationship between comparative amount and that of standard, and using the viewpoint on "A• B=A ÷ B =A/B" to look at the questions of ratio; while what new courses emphasizes is the process that children construct mathematics concepts, therefore new courses think radio is two amounts A and B, causing the match relationship owing to some reason, calling these number A and B have equal relationship., and using "radio" is "A• B" to record the equal relationship between A and B, considering the question of ratio is based on equal relationship and transfer to another equal relationship of the same value, via the simultaneous repetition and the equal cut activity of the two amount of the equal relationship [2]. The previous activity of ratio problems in new courses in 1993 is that of exchange, and the solving tools of ratio problems are the graph of ratio line. Owing to the operation of lineal graph, we can grasp the relationship of radio to further the activity meaning of transference.

2.3 Basis of System Establishment

The system is a learning environment in the internet, adopting three-tier client/server system architecture, namely adding a layer of Service Server to the original structure of two -tier client/server system architecture. In the three -tier client/server system architecture, the management part of learning data is in the charge of Database Server, Web Server assumes the responsibility for teaching; whereas the client user is carried on by all kinds of learning activities through browser.

3 Simulation of Networked Constructive Pedagogy

In order to grasp the "route difference" of the students' mature concept, the system must recognize clearly how the students think about the problems and how they solve the problems so as to adjust the next activity according to the students' thought and to help children clarify the concepts by using the communication of solving the problems and mode of discussion, so the learner's mathematics knowledge can be upheld accordingly[4,6]. Thus, the system designs operation tool table (as in Figure 1), in which all sorts of tools represent various modes of thought. The students have to utilize these tools to solve the problems; owing to the different tools, the system can grasp the students' process of solving the problems and thought. The flowchart of teaching in this system (as in Figure 2) starts with posing the problems as far as the pedagogic process of any problem, then it is up to the children to decide if they need to be provided clues or graphic emblems to help comprehend the messages of the problems. If necessary, the system has to check out the problems of the same lineal graph as number of ratio problems from database of "ratio lineal graph" and the lineal emblem (as in Figure 3); if the students have comprehended the messages of the problems, enter the students' solving the problems. The students solve the problems with all sorts of tools in tool table; then the system judge the mode of solving by the difference of thought of tools• strategy 1, strategy 2,.•. •Different types of solving enter various tableau, and ask the students explicate the process of solving. The system designs some problems according to the types of solving, helping the students reflect. Through the issue and clarification, the spirit of "mode of communication in the process of solving" would come true. After reflecting the process of solving, the students can choose to study and learn the virtual students' other ways or discuss and communicate with others on the line (as in Figure 4). In case there are students, they can enter discussion room for discussion (as in Figure 5); if there is no student on the line or no one wants to study and learn from the perspectives of others, you can enter the virtual students' various ways and elucidation (as in Figure 6)[5].

4 Architecture and Implementation of System

4.1 Design Environment and Tools

This system uses Windows NT server as server as platform. The developing languages include HTML, JavaScript, Active X, ASP (Active Server Page) and so on. ASP is used as the chief way of control and ASP and ODBC (Open Database Connectivity) are also exercised to go with them. The management of teaching material and the users become simplified. As far as the editing course software, Authorware 5 is mainly utilized as the developing tool.

4.2 System flowchart

• (1) Pedagogic situation of networked construction

The flowchart of pedagogic system on the networked construction is manifested in the Figure 7 and the explanation is as follows. The system, through the previous analysis in advance of the class, judges the students' a priori knowledge, by which the system poses the problems, letting the learner solve the problems by themselves. While the students encounter the bottleneck of solving, he can choose the types of the basic lineal graphs or the lineal graphic emblems, and he may discuss and communicate with the students on the line or with virtual students; if the student solve the problem successfully, demand the process of solving and explain those of solving (reflection), then discuss and communicate with the students on the line or with the virtual students. Afterwards, ask the students to record again and explain the process of solving the problem, exploring if the student canuse and repeat the strategy of solving in an even simpler and more abstract method, meaning to judge whether the students can comprehend others' methods of solving to proceed the overall assessment finally. Before putting an end to the system, a test about ratio level of thought development as nonroute subject will be exercised on the students, thereby the director will reach a deeper realization of the students' development.

• (2) Database for "student model": Student modelconsists mainly of four databases, recording the students' basic data, analyzing their process of solving the problems, the routes of learning and the constructive concepts so as to comprehend their learning state for the reference of posing the problems, by which to understand the students' bottlenecks in learning in order to help them.

• (3) Database of "posing problems of constructive pedagogy": It saves the teaching content of constructive pedagogy, which contains various types of pedagogic processes, providing the system with sufficient competence to adjust pedagogy positively.

• (4) Database of "questions for tests": It stores the questions for pretest and posttest. The pretest is used to comprehend the students' acquired knowledge, whereas the backward test, according to the various aims, can be divided into two kinds--formed test and overall test, adopting the proper mode of test.

4.3 Functions of On-line Communication

• (1) Discussion group: This is an open, instead of being a synchronous, discussing place, letting the learner put up the problems on the cooperative notebook while encountering difficulty; other users can answer these problems.

• (2) Discussion room: It provides a synchronous and open discussing place, in which the learner can put forth the explanation, suggestion and exchanging viewpoints as to the difficulty aroused in learn ing or as to various strategies for solving the problems.

• (3) On-line call: It belongs to the way of one-to-one realtime communication, providing the user with a brief piece of information immediately, to other users on the line or even the teacher, asking them to undertake discussion in Discussion Room.

4.4 Operation flowchart

When the user enters the system by using browser for the first time, the user has to register in advance (as in Figure 8), by which the system acquires the user' s related basic data, so as to proceed to analyze and check. Then take the pretest about background knowledge of learning point to understand if the software content meets the students' need. The system will set the problems according to all types in the problem database (in order to avoid repetition, each type of problems are given at random), and record the state of the learner' s study, according to which, the system would produce routes of connection automatically; and it changes the original learning routes by means of the artificial intelligence. It undertakes the proper learning route according to the students' learning state. Later on, whenever the user enters by using browser for the first time, he has to key in the user name and password. The system can proceed to check, and after making sure, the system will continue the previous learning in accordance with the learning record left in advance. When the learner surveys each teaching activity, the system can record the learning process serving as the analysis of learning. The learner can utilize the function of check to understand hie own state of learning. After each learning is finished, the system will demand each learner record the process of solving and then pose the problems again to give the learner the test; according to the learner' s answering state,

which pedagogic activity will be decided to be carried on actively accordingly.

5 Conclusions

Constructive learning theory will be developed far better if it is carried on network by constructive pedagogy, because networked learning can provide an excellent environment for discussion, upholding the convenience for communication; networked learning can attend to the individual difference, because each student is a leading role. The learner can control the progress of learning by himself, achieving the suitable learning. Networked learning the students' social circles of interaction become larger, not confined to the group of his own class. However, if the real situation by simulation can be added, it is believed that it will draw much attention from students' learning, promoting the learning effect.

References

[1] The seminar of Taiwan Elementary Teachers . (1996). Teacher Handbook of Experimental Textbook in Mathematics of Elementary School, Volume 9.

[2] Chu-Tsun Chen. (1998). "The Equal Relationship and Lineal Graph", Collected Issue of Elementary Education. Taipei: The seminar of Taiwan Elementary Teachers .

[3] Ning, Tzyh-chiang. (1993). "Spirit and Innovative Trend of New Course in Mathematics for Elementary Education —Seen from Perspective of Constructivism", Scholarly Magazine for Scientific Education, Vol. 1 No. 1, pp. 101-108.

[4] Dalgarno, B. (1997). Constructivist Computer Assisted Learning: Theory and Techniques. WWW. 21 Oct. 1997. Available: http://services.canberra.edu.au/~barney/articles/ascilite96/paper.htm

[5] Hiltz, S. R.. "Teaching in a Virtual Classroom. 1995 International Conference on Computer Assisted Instruction ICCAI'95 Hsincku, Taiwan". http://it.njit.edu/njIT/Department/CCC/VC/Papers/Teaching.html (1995).

[6] Squires, D. "Can multimedia support constructivist learning? WWW, 21 Oct. 1997. Available" http://www.spirit.net.au/ACEC96/papers/squir.htm (1997).

Figure1. Operation tool table.

Figure2. The flowchart of teaching in the system.

Figure3. Lineal emblem.

Figure4. To discuss and communicate with the virtual students or on-line students.

Figure5. The room for discussion.

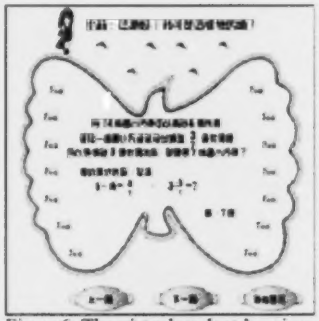


Figure6. The virtual students' various strategies.

BEST COPY AVAILABLE

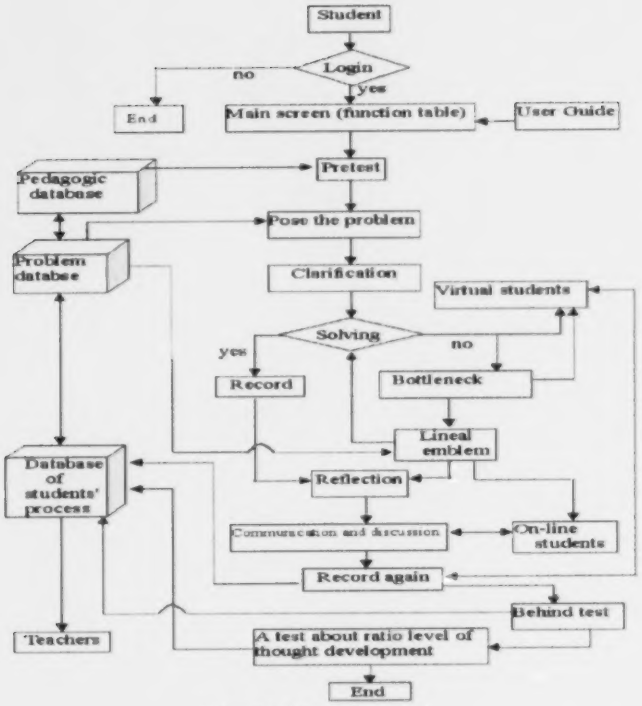


Figure 7. System flowchart.

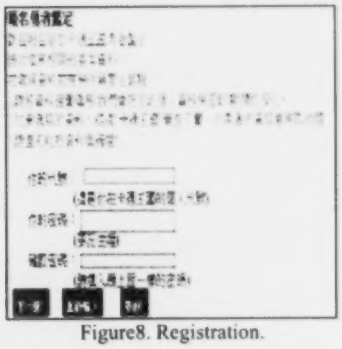


Figure8. Registration.

Online ESL Learning: An Authentic Contact

Yu-Chih Doris Shih* and Lauren Cifuentes**
**Department of Educational Curriculum & Instruction, Texas A&M University*
4205 Boyett St., #C, College Station, TX 77801, USA
E-mail: dorisshih@hotmail.com
*** Department of Educational Psychology, Texas A&M University*
College Station, TX77843, USA
E-mail: laurenc@tamu.edu

As communication via telecommunications become easier, learning through online technologies is made possible. In a telecommunications project among US preservice teachers and Taiwanese English as a Second Language learners, Taiwanese students practiced English language and discussed cultural information with US partners who served as online tutors. Data revealed that Taiwanese ESL learners perceived online learning of English language and American culture to be valuable for its authenticity. Instructions on intercultural communication skills were found to be necessary prior to the connection in order to help eliminate misunderstandings between participants of two countries. The success of online learning depended on several factors such as participants' motivation, participants' attitudes, technology, preparation, and support services. Furthermore, Taiwanese learners who had successful experiences applied ten strategies to their ESL learning. These strategies were employed during a circular process of online learning.

Keywords: **ESL, Online Learning, Telecommunications, Intercultural Computer-Mediated Communications**

1 Introduction

The purpose of this research was to investigate a telecommunications project for Taiwanese students to learn the English language and acquire cultural information through online technologies. Preservice teachers (PSTs) at a state university in the United States worked with Taiwanese learners of English as a Second Language (ESL) at a Taiwanese university. The goal of the research was to study intercultural online learning.

In Taiwan, many scholars have been discussing the need for educational reform and change of instructional methods [7][36]. One change under consideration is increased use of online instruction. Taiwanese researchers suggested that the educational reform should include the adoption of methods proposed in the West (i.e., the United States, Great Britain, Australia, and other English-speaking countries), such as involving students in active learning, teaching critical thinking skills, and incorporating individualized instruction [4][25]. Harasim (1990) and Owston (1997) believed that instruction could be enhanced by online teaching. They have stated that online instruction allows for active learning, idea generating, idea linking, and idea structuring as well as helps the students to develop skills in critical thinking and problem solving. Individualized instruction is supported because both synchronous and asynchronous modes of instruction are workable through technologies.

When online teaching is used as a language instructional method, it remedies Taiwan's geographical isolation as an island and provides opportunities for ESL learners to communicate in an authentic English environment. Successful second language (L2) learning includes not only knowing the linguistic features of the language but also understanding the cultural concepts [14]. Sayers and Brown (1987) remarked, "foreign language students

need authentic contacts with native speakers and much practice in a range of language skills -- including reading and writing -- if they are to develop cultural awareness and communicative competence" (p. 23). L2 learners learn language and culture if instruction is facilitated by supportive individualized learning activities [13]. These activities must address the learner's current language level (Krashen's stage of i) and the level beyond the present language and literacy capacities (Krashen's stage of i + 1) [21]. Telecommunications can help overcome the limitations of Taiwanese isolation by providing for supportive and authentic language instruction.

2 Literature Review

Learning through telecommunications has evolved during the 1990s in the West and has proved to be successful [1][8]. To bring more applications into Taiwan, we need to first explore Taiwanese students' needs and attitudes in the use of such technology. Some scholars stated that Asian students employ different learning strategies than students in the West [17][32]. Cheng (1980) pointed out that the educational system in Taiwan has adopted many different educational methods developed in the West; however, utilization has been non-systematic and inappropriate for societal needs in Taiwan. Furthermore, Stewart (1985) and Dooley (1995) noted that the applications of educational technology in other countries besides the United States may be unsuitable because of cultural non-transferability. For instance, other cultures may value a different set of learning and teaching modes when compared to the United States, or they may have insufficient equipment for advanced technological applications. Taiwanese scholars have also urged that future investigations must be done specifically on distance-learning courses in Taiwan [6][37]. Therefore, close examination must be carried out prior to fully adopting new telecommunication technologies as learning tools in Taiwan.

As technology advances, communication over a distance and across cultures becomes easier and inevitable. However, very little can be found in the literature that addresses issues of online intercultural communication and the design considerations that would enhance such interaction. Lee (1999) urged designers and instructors of computer-based instruction to take cultural issues into consideration when developing learning environments and technology integration within curricula. Caution must be taken, especially when intercultural contacts occur in an online learning context, because communicators may not be who they seem to be online [28].

Collis and Remmers (1997) pointed out that to allow successful online cross-cultural contact, at least four issues have to be taken into consideration: communication and interaction, language, content, and representation form. First, communication and interaction are easily misinterpreted across cultures. According to the two researchers, more communication and interaction are not necessarily better than less, and well-structured communication may be preferable for wider audiences. Second, because language includes verbal and nonverbal cultural communication, those developing cross-cultural online instruction must be sensitive to cultural differences in communication styles. Third, designers must choose cross-cultural course content. Last, visuals can overcome problems associated with text-based language. However, one must be sensitive to cultural differences in the acceptability and interpretability of various aspects of visualization.

Research on online connections has been conducted in many areas during this decade. Projects connecting students with teachers or other students in multiple locations were implemented in many subject areas such as science [22], history [3], teaching [27], and language arts [35]. Similar projects in the area of foreign language learning are found in the teaching of Portuguese [20], Russian [30], Spanish [24], and ESL [19][33]. The results of these studies mainly stated how the participants at different sites benefited from the connection in increased technical competence, personal development, language improvement, and more meaningful cultural exchanges. No research has been found that explores the learning strategies used by students while learning a L2 online and the issues encountered during their online intercultural communications.

3 Purposes and Research Questions

There were three purposes of this study: first, understanding the Taiwanese ESL learners' perceptions of learning through distance technologies; second, exploring issues related to online intercultural communication; and third, identifying the learning strategies the Taiwanese learners employed during distance learning to accomplish the

acquisition of ESL and understanding of American culture. The three research questions guided the study were:

(1) How do ESL learners in Taiwan perceive language acquisition and cultural understanding via distance learning technologies after the experience?
(2) What intercultural phenomena can be observed in online learning for Taiwanese students?
(3) What online learning strategies do the Taiwanese use while learning the English language and learning about American culture?

4 Method

This study employed a qualitative research design. This design enabled the researcher to inquire, comprehend, and describe the experiencing world of the participants and the meaning of these experiences [2][26].

4.1 Participants

The project involved students in two different countries: US and Taiwan. There were 40 PSTs in the United States who took either *EDTC 305: Instructional Technology: Theory and Practice* or *INST 462: Language Acquisition and Development* at a state university. These were PSTs being prepared to teach English, ESL, political science, and history at the elementary or secondary level. The same number of participants in Taiwan were students who study in the Department of English Language and Literature at a university in Taipei, Taiwan. They were members of *English Composition and Conversation* classes at either sophomore or junior levels. The US and Taiwanese students participated in this research because their instructors included this online connection project as part of their course requirement. The participants in the United States ranged from the ages of 20 to 22, while the students in Taiwan ranged from the ages of 19 to 20.

In addition, the three professors in Taiwan whose students were project participants were also involved as research subjects. They were interviewed by the researcher in regard to their students' perceptions of online experiences, students' improvement in the English language as well as other types of knowledge through the connection.

4.2 Procedures

To carry out the study, US PSTs corresponded with Taiwanese university-level ESL learners for ten weeks. These PSTs served as tutors of the English language and American culture. The participants in both countries were matched one-on-one randomly prior to the connection. They were also given instructions and orientations on the utilization of e-mail systems and on online learning/teaching. The PSTs were provided with a lecture, discussion, supportive readings, example tutorial correspondences, and a web site of resources. The web site included a downloadable lecture about online learning, the expected online correspondence process guidelines, a midterm survey, sample correspondence, and previous participants' reflections (http://www.coe.tamu.edu/~lcifuent/classes/edtc305/online.htm). They also read on topics such as effective facilitation of computer conferencing [9], computer-mediated communication [18], interactivity in online environments [15], online teaching strategies [8], and cultural differences in teaching and learning [17].

Similarly, the students in Taiwan were supplied with an orientation where the project is introduced to them along with rules and regulations. Sample correspondence, results of previous connections, and suggestions for online learning and discussion topics were presented at their departmental website (http://www.eng.fju.edu.tw/cultural_connections.htm).

Every participant received a welcome letter to encourage them to open themselves up to this new experience. The PSTs were given a rubric with expected number grades to help them accomplish the requirements for their part of the connection. The Taiwanese students initiated the connection by sending out their first e-mail message to their US partners. The US PSTs analyzed their student's language level and started to instruct him or her according to that level through e-mail.

Mid-way during the ten-week connection, the PSTs were asked to fill out an online midterm survey. In Taiwan, the students submitted a brief report to their instructors every two weeks to keep track of their connection progresses.

At the end of the connection, the PSTs and their Taiwanese students filled out a post-connection survey. The PSTs also handed in all of their e-mail printouts and personal journals that reflected their online teaching and learning experiences. Similarly, the Taiwanese students handed in their final reports to their Taiwanese instructors. Two weeks after the end of the connection, the researcher traveled to Taiwan to conduct interviews with 12 Taiwanese students and the three Taiwanese professors. The interviews included open-ended questions.

4.3 Data Collection and Analysis

There were eight data sources: (a) printouts of correspondence; (b) the PSTs' midterm survey; (c) the PSTs' post-connection survey; (d) the Taiwanese students' post-connection survey; (e) the PSTs' reflective journal entries; (f) the Taiwanese students' final reports; (g) transcripts of the interview with the Taiwanese students; and (h) transcripts of the interview with the Taiwanese professors.

Data analysis in qualitative studies is an ongoing process during the research; it is best done simultaneously with the data collection [26]. Each time data are gathered, information was analyzed using procedures proposed by Emerson, Fretz, and Shaw (1995). The steps included close reading, open coding, writing memos, noting themes and patterns, and focused coding.

5 Results

Data analyses revealed remarkable information on the areas of (a) learner perception, (b) intercultural communication, (c) factors affecting online connection, (d) online learning strategies, and (e) online learning processes. First, this particular group of Taiwanese ESL learners was positive about L2 and cultural learning in an online setting. The results of a post-connection survey showed that participants more or less agreed that (a) E-mail connections have a positive place in ESL classrooms (mean of 3.71); (b) the Web-connection has a positive place in ESL classrooms (mean of 3.51); (c) they would participate in another online connection if given the opportunity (mean of 3.58); and (d) they would suggest their other friends or classmates participate in a similar project (mean of 3.85) (see Table 1). Even though the response to the question "Overall, my connection was successful" was not very high (mean of 3.26), learners who had an unsuccessful connection held positive attitudes toward the project. One student wrote in her final report, "My pal does not respond to me so often. I didn't learn much through this project this semester. But that doesn't mean this project is not good. I hope school brothers or sisters can still have the chance to get in this project."

Table 1. Taiwanese Students' Responses Toward the Online Connection

Questions	M	SD
The **E-mail connection** has a positive place in ESL classrooms.	3.71	0.67
The **Web-board connection** has a positive place in ESL classrooms.	3.51	1.50
I would participate in another online connection if given the opportunity.	3.58	1.13
I would suggest other friends or classmate participate in a similar project.	3.85	0.78
Overall, my connection was successful.	3.26	1.07

Note. Participants responded on a 5-point Likert scale (1= Strongly Disagree; 5 = Strongly Agree). The survey was complete by 37 participants.

Second, intercultural communication issues cannot be ignored. A lot of Taiwanese learners interpreted that their tutors were angry with them when they did not receive messages over a week. In addition, learners read what wasn't intended in the messages. They constantly apologized to the PSTs for being an inconvenience. Several learners ceased active interaction with the PSTs due to these personal interpretations. The Taiwanese professors suggested that acquainting learners with different thinking patterns and expression styles is necessary in future connections.

Third, factors that affected online connections included participants' motivation, attitudes toward each other, participants' fields of experience, frequency and quality of interactions, technology, preparation, and support

services (figure 1). Any missing component would hinder the success of the connection. Other resources such as teachers, peers, family members, libraries, and web resources provided extra assistance to the participants.
Fourth, during the correspondences, ten learning strategies were found to be used by the learners in their messages. These were paraphrasing, translation, Q&A from tutor to student, Q&A from student to tutor, explanation, elaboration, decision-making, self-reflection, metacognition, and transfer. The learners in the more successful pairs tended to use a variety of the ten strategies.

Finally, data indicated these ESL learners went through a series of processes for successful learning (figure 2). Motivated learners set learning goals for themselves with the PSTs' help. Those who prepared themselves well by finding topics of discussion or information in the libraries, the WWW, and traditional learning environment aimed for frequent and quality interactions via e-mail with the PSTs. After each interaction, a review period prompted learners for more interactions. Learners who went through these stages concluded that they had learnt new information and increased their confidence in using English reading and writing skills. Needless to say, this result increased their motivation to learn and thus encouraged the start of another learning cycle.

6 Discussions and Conclusion

This study is significant to both distance-learning educators and language-learning educators. There are at least three reasons for this significance. First, the study provides insights for distance educators, both for those in Taiwan and for those in other countries who have Taiwanese students enrolled in courses that are delivered via telecommunications. The results of the study help these instructors to further understand Taiwanese students' positive perceptions of L2 learning through online technologies, identify suitable conditions and environment for these learners, and decide the extent to which this mode of instruction is applicable to students from this cultural background.

Second, the online intercultural communications issues explored in this study assist telecommunications users with more effective communication. They help users become aware of and anticipate problems when coming into contact with people of other cultures via distance technologies. Even without using online technologies, intercultural communication is already complex. Therefore, interaction may be hindered further when technology is the transmission medium. Understanding the barriers and facilitators of online intercultural communication leads to better and more successful intercultural interactions.

Third, the identified ten online learning strategies and online learning processes will add to the literature on language learning and teaching. Such research is in demand because ESL programs in the United States are planning to deliver more ESL courses to foreign countries via distance learning technologies.

In summary, most Taiwanese ESL learners had a positive experience with the online connection. The few connections that failed were due to lack of participants' response, lack of participants' motivation, and technical failure. Nevertheless, providing L2 instruction to learners over cyberspace is a method that should not be ignored. Learners need to be prepared with adequate intercultural communication skills and online learning strategies.

Follow-up investigation of online ESL acquisition might include specific amount of improvement on learners' writings and learning via synchronous technologies such as chats, interactive videoconferences, and desktop videoconferences.

References

[1] Bates, A. W., "Technology, open learning and distance education", Routledge (1995)
[2] Bogdan, R. C., & Biklen, S. N., "Qualitative research in education: An introduction to theory and methods", Allyn & Bacon, 3rd ed (1998).
[3] Butler, W. M., "Writing to learn history on-line", The Clearing House, Vol. 69, No. 1, pp. 17-19 (1995)
[4] Chang, H-J., "Trends of instructional methods", Social Change and Educational Development, pp. 483-522, Taiwan Bookstore (1991)

[5] Cheng, S-H., "Chinese contemporary history of education", San-Ming bookstore (1980)
[6] Chou, C., Chou, J., & Tyan, N. N., "An exploratory study of Internet addiction, usage and communication pleasure - The Taiwan's case", International Journal of Educational Telecommunications, Vol. 5, No. 1, pp. 47-63 (1999)
[7] Chu, C-C., "Social change and current educational system", Social Change and Educational Development pp. 37-65, Taiwan Bookstore (1991)
[8] Cifuentes, L., & Shih, Y-C D., "Teaching and learning online: A collaboration between U.S. and Taiwanese students", Journal of Research on Computing in Education, Manuscript accepted for publication (2000)
[9] Cifuentes, L., Murphy, K.L., Segur, R., & Kodali, S., "Design considerations for computer conferences", Journal of Research on Computing in Education, Vol. 30, No. 2, pp.172-195 (1997)
[10] Collis, B. & Remmers, E., "The World Wide Web in education: Issues related to cross-cultural communication and interaction", Web-based instruction, pp. 85-92, Educational Technology Publications (1997)
[11] Dooley, L. M., "Problems and issues in distance learning using interactive video between the U.S. and selected African countries", International Journal of Educational Telecommunications, Vol. 1, No. 1, pp. 93-104 (1995)
[12] Emerson, R. M., Fretz, R. I., & Shaw, L. L., "Writing ethnographic fieldnotes", The University of Chicago Press (1995)
[13] Enright, D. S., "Supporting children's English language development in grade-level and language classrooms", Teaching English as a Second or Foreign Language, pp. 386-402, Heinle & Heinle (1991)
[14] Fantini, A. E., "Bilingualism: Exploring language and culture", Language, culture and cognition, pp. 110-119, Multilingual Matters (1981)
[15] Gunawardena, C. N., "Changing faculty roles for audiographics and on-line teaching", The American Journal of Distance Education, Vol. 6, No. 3, pp. 58-71 (1992)
[16] Harasim, L. M., "Online education: An environment for collaboration and intellectual amplification", On line Education Perspectives on a New Environment, pp. 39-64, Praeger (1990)
[17] Hofstede, G., "Cultural differences in teaching and learning", International Journal of Intercultural Relations, Vol. 10, pp. 301-320 (1986)
[18] Jonassen, D. H., Davidson, M., Collins, M., Campbell, J., & Haag, B. B., "Constructivism and computer-mediated communication in distance education", American Journal of Distance Education, Vol. 9, No. 2, pp. 7-25 (1995)
[19] Kamhi-Stein, L., "Promoting EFL teacher development through e-mail instruction", Computer-Assisted English Language Learning Journal, Vol 7, No. 4, pp. 14-19 (1997)
[20] Kelm, O. R., "The use of synchronous computer network in second language instruction: A preliminary report", Foreign Language Annals, Vol. 25, No. 5, pp. 441-454 (1992)
[21] Krashen, S. D., "The fundamental pedagogical principle in second language teaching", Studio Linguistica, Vol. 35, No. 1-2, pp. 51-70 (1981)
[22] LeBaron, J., & Teichmaun, V., "KITES: A middle school environmental science telelink to West Germany", Educational Technology, Vol. 29, No. 6, pp. 51-53 (1989)
[23] Lee, C. D., "Towards a framework for culturally responsive design in multimedia computer environments: Cultural modeling as a case", Paper presented at 1999 American Educational Research Association Convention at Montreal, Canada (1999)
[24] Leh, A. S., "Electronic mail in foreign language learning: Communication and culture", ERIC Document Reproduction Service No. ED409851, Association for Educational Communications and Technology (1997)
[25] Lin, S-C., "Current social change and instructional reformation in Taiwan", Social Change and Educational Development, pp. 459-482, Taiwan Bookstore (1991)
[26] Lincoln, Y. & Guba, E., "Naturalistic inquiry", Sage (1985)
[27] Lowry, M., Koneman, P., Osman-Jouchoux, R., & Wilson, B., "Electronic discussion groups: Using E-mail as an instructional strategy", Tech Trends, Vol. 39, No. 2, pp. 22-24 (1994)
[28] Newbold, W. W., "Transactional theory", http://www.bsu.edu/classes/newbold/htx/theory.htm (accessed on July 20, 1999).
[29] Owston, R. D., "The World Wide Web: A technology to enhance teaching and learning?" Educational Researcher, Vol. 26, No. 2, pp. 27-33 (1997)
[30] Samsonov, P., "Russian translation via e-mail", IALL Journal of Language Learning Technologies, Vol. 30, No. 3, pp. 39-42 (1998)

[31] Sayers, D., & Brown, K., "Bilingual education and telecommunications: A perfect fit", The Computing Teacher, Vol 15, No. 8, pp. 23-24 (1987)
[32] Smith, P. J. & Smith, S. N., "Differences between Chinese and Australian students: Some implications for distance educators", Distance Education, Vol. 20, No. 1, pp. 64-80 (1999)
[33] Soh, B-L, & Soon, Y-P., "English by e-mail: Creating a global classroom via the medium of computer technology", ELT Journal, Vol. 45, No. 4, pp. 187-292 (1991)
[34] Stewart, A., "Appropriate educational technology: Does 'appropriateness' have implications for the theoretical framework of educational technology?" Educational Communication and Technology, Vol. 33, No. 1, pp. 58-65 (1985)
[35] Traw, R., "School/university collaboration via e-mail: A unique approach to teaching reading and language arts", Tech Trends, Vol. 39, No. 2, pp. 28-31 (1994)
[36] Wang, C-Y., "Social science education in social change", Social Change and Educational Development, pp. 147-164, Taiwan Bookstore (1991)
[37] Young, S., "A field study of the implementation of a synchronous distance course with asynchronous Internet-supported telecommunications technologies in Taiwan, R. O. C.", International Journal of Educational Telecommunication, Vol. 5, No. 2, pp. 111-125 (1999)

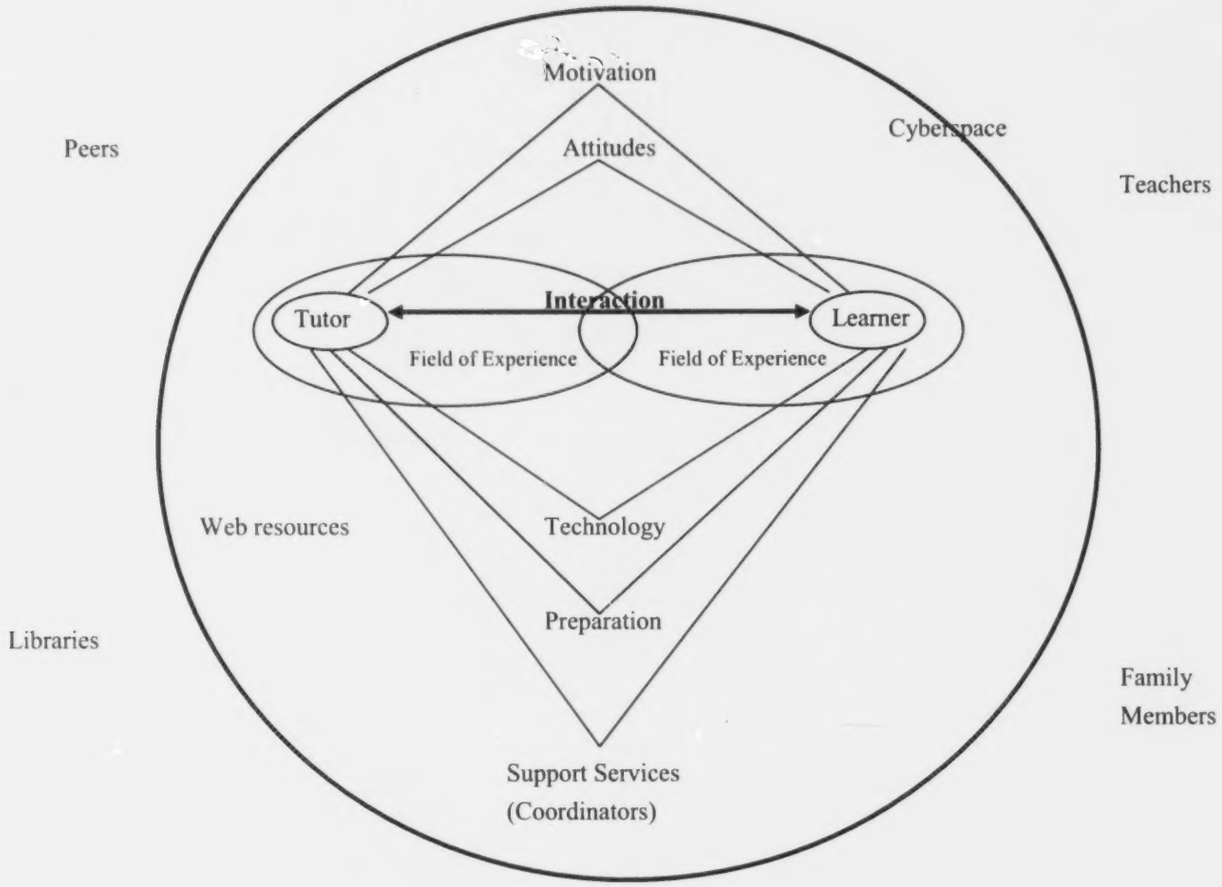


Figure 1. Factors Affecting Online Connections

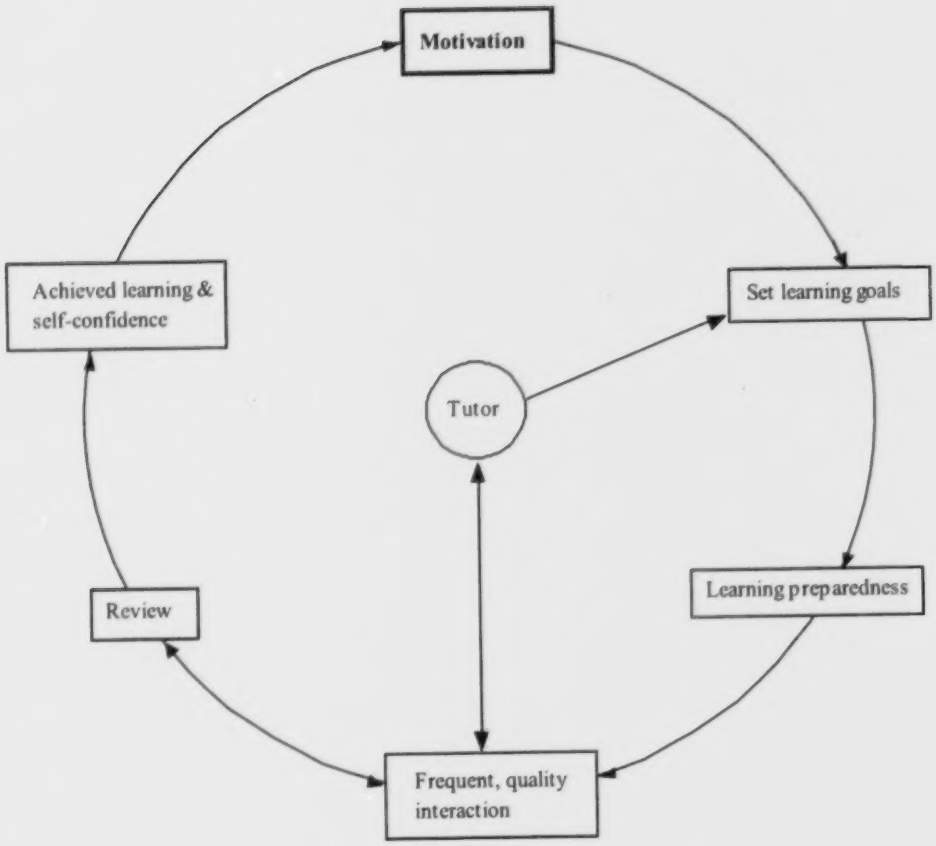


Figure 2. Online Learning Processes in the United States-Taiwan Connection.

Organization of the introductory and motivational stage of activity in a computer tutoring system

Gennadiy Atanov and Vladimir Laktiushin
Donetsk Institute of Social Education; DISO, Donetsk, 83000, Ukraine;
E-mail: atanov@dongu.donetsk.ua

1 The activity approach in education

From the point of view of modern didactics, the final aim of instruction is not gaining knowledge but forming the way of acting being realized via skills [3]. It may be only done in the process of activity, namely learning activity. In this sense, any instructional process represents guidance, operative management of learning activity. It is management that is mechanism of teaching but not passing knowledge. Learning activity is a product of teaching because it is the aim of teaching. Knowledge is necessary, so far as the way of acting is worked out by means of operating with knowledge. On the other hand, knowledge is formed only in the process of activity []. Thus content of teaching includes subject to mastering and knowledge on which based this activity. From the point of view of organization, activity has three stages: 1) of introductory and motivation, 2) of operation and cognition, 3) of control and estimation.

An action is a unit of activity. The way of acting is a system of operations that provides solving of problems of a definite kind. The way of acting has three functional parts: (1) orientating one that provides preparation the student to activity; (2) executive one providing transformation of the objects of activity; (3) control one that provides check-up of rightness solving the problems and comparison the factual products of activity with desired ones, that is, the aim of activity [2].

Many authors of computer technologies attribute them to the ones based on activity (learning by doing) only because of work specificity with a computer but not because they realize principles of the theory of activity. In accordance with it, projecting a computer tutoring system means, first of all, projecting learning activity, not knowledge. Knowledge is projected after actions. Only on determining actions, it is possible to pick out knowledge providing formation of these actions.

Development of activity my be schematically represented in the following way: *need – motive – aim – subaims – problems – subproblems – actions – operations – product.* The introductory and motivation stage of activity, especially for learning activity, is the most important one because it is the initial stage of activity. It is called to settle questions of "lead-in" of students in activity, their adaptation to future activity, that is, questions of orienting and motivation.

In the orientating part of the way of acting, they pick out two components (Mashbits, 1988). The first one – general orienting – provides picking out those properties and qualities of the objects of activity that are essential for their transformation. The second one – orienting for the executive part – provides working out a plan of activity. Only the executive part of the way of acting providing immediate transformation of the objects is the direct product of the traditional teaching. There is the only way to do this – solving problems.

2 Organization of the introductory and motivational stage

The introductory and motivational stage plays an important psychological and didactical role in teaching in general; while using a computer, its role increases repeatedly. Nevertheless, to meet a tutoring system in which due attention would spare to this stage is a very rare thing. We organized it in tutoring systems in physics [1]. The tasks of the introductory and motivational are realization and understanding by the students: 1) aims and problems of the system; 2) physical character of processes and phenomena, as well as principles of operation of the installations that are the subjects of the system's activity; (3) knowledge necessary to

reach the aim put the system. According to the theory of activity, it is operating with this knowledge that leads to forming first skills necessary for solving a particular problem and then the way of acting in aggregate.

The approach of problems that is realized in our systems is based on solving a separate problem whose complication increases that of problems being solved usually. This approach is more preferable from the point of view of activity. Firstly, it allows easily and effective organize learning activity and, secondly, it gains essentially in motivation as presupposes achievement of a practically significant aim. In many systems, this aim is even submitted in their titles, for example, "Hit the Target", "Rescue the Friends", "Render Harmless of the mine", "Determine the material". It is a very effective means to increase motivation, as the student becomes a subject of activity, the main acting person of the events expanded. Various methods of realization of this stage are used, for example, mimicking processes and phenomena, "assembling" installations from their separate parts, discussion their purposes and peculiarities of operating the installations, test tasks of the closed and open types, ones for accordance and ones for correct sequence.

Let us consider as an example systems "Internal Combustion Engine". The aim of it is determination of power and efficiency of an engine in accordance with its constructive parameters. As one can see, the title of this system does not promote increase of motivation because of the lack of the personal orientation. This is achieved by another method. A list of cars with demonstration of their outward appearance is offered to students. Students choose a car that they like and then carry out calculations for the engine of their own car.

Let us describe in what way a test task for accordance is realized in these systems. A "dumb" scheme of an installation without pointers of its component parts is shown on the screen. A list of its component part is placed next to it. Activity of students consists in the following. Separate elements of the scheme are pointed sequentially by chance, and students have to put for each element of the scheme corresponding one of the list. If the title of the pointed component part is determined correctly, another element is pointed, and so on. The determined parts acquire their numbers, and as the result, the "dumb" scheme is transformed into a "live" one. In such a way an orienting support of activity is created.

Further development of the introductory and motivation stage in the system above proceeds in the following way. The system demonstrates work of the engine during a whole cycle with replacement of the piston, opening and closing the exhaust and inlet valves, ignition of a air and gas mixture. Students may start such a demonstration several times independently. Now students see interaction of the component parts of the engine already well known to them, now they unit in their consciousness not simply mechanically but functionally reflecting physics of the processes occurring in the engine.

Subsequent deepening of orienting passes by discussion of what students have seen. It is very convenient to use the so-called active prompts with this purpose. Active prompt is built as a test task of the open type. It represents a phrase, in which a keyword is missed; this word has to be entered by students. If students do not know it, they may address to the system for help, and it will show this word on the screen. In order to keep the students' active position, the system offer the same active prompt repeatedly, and students must enter this already well known word themselves. Examples of active prompts are phrases: "The inlet valve is open when the piston goes down(wards)", "The spark springs up when the piston is at the upper extreme position" (the missed words are in italic). The main thing here consists in not completeness of these tasks but in importance of ascertaining these (and other) facts for forming the orienting base of the future activity.

The elements of the introductory and motivational stage are distributed throughout a system, their task is to prepare students to performing subsequent separate actions. If, for example, there is a necessity of using some formula, it is very convenient to remind it by a test task of the closed type. Students are offered several formulas, and they have to choose the necessary one. If students make mistakes, a short dialogue should be organized so that students could understand the nature of the mistakes. Then the task should be given again, the search of the answer becoming more sensitive. And the answer will be obtained without fail.

If the development of an action demands using exact wording (of laws, principles, theorems, definitions of concepts, and so on), it is expediently to employ a test task for the correct sequence. In the chosen wording, all the words are missed by chance (this does the system), and the task of students consists in that the words must be arranged correctly with the help of the mouse. It is a very creative and constructive work, it thrills, in the first place, because the sense appears little by little. Everyone can reach the sense even if he/she is not familiar with it at all.

References

1. Atanov, G.A., Kandrashin,G.V., Laktiushin,V.V. Computer Tutoring Systems for Science Education Based on the Activity Approach. New Media and Telematic Technologies for Education in Eastern European Countries. Eds. P.Kommers, A.Dovgiallo, V.Petrushin, P.Brusilovsky. Enshede: Tvente University Press. Pp. 75-79. (1997)
2. Gal' perin, P.Ya. Psychology of Thinking and Doctrine about Step by Step Forming Mental Actions. Moscow. (1966) (in Russian).
3. Mashbits,E. Psychological and Pedagogical Problems of Computating in Education. Moscow, Pedagogika (1988) (in Russian).

Reflections on Educational Technology from Female Asian Faculty's (FAF) Perspectives

Doris Lee*, Amy S.C. Leh, Mei-Yan Lu*** and Mei-Yau Shih******
**Pennsylvania State University -Great Valley, School of Graduate Professional Studies 30 East Swedesford Rd., Malvern, PA 19355, USA, YDL1@psu.edu*
***Instructional Technology, California State University, San Bernardino, San Bernardino, CA 92407, USA, aleh@csusb.edu*
****Instructional Technology, San Jose State University, San Jose, California 95192-0076, USA, meiyan@email.sjsu.edu*
*****Center For Teaching, University of Massachusetts Amherst, Amherst, MA 01003, USA, mshih@acad.umass.edu*

Four panelists in this panel session will briefly present their perspectives on how the instructional technology field has influenced current Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Presenters will address their challenges as female Asian faculty in Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Suggestions and solutions will be discussed during the panel session.

Keywords: **Faculty development, Corporate training, In-Service teacher education, Pre-service teacher education, reflection, and perspectives**

Introduction

Each panelist will offer their unique perspectives in the field of instructional technology. Our focus questions are:

1) Has instructional technology field influenced current:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S. C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

2) What are the challenges do female minority faculty encounter in:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S.C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on In-service teacher education (Dr. Amy S.C. Leh)

Technology advancement is altering our society and our education. New technology standards grant opportunities, and policy reflect the change currently happening in our education. In September of 1997, the National Council for Accreditation of Teacher Education (NCATE) released a report addressing the importance of integrating technology into instruction. New technology standards clearly indicate that teachers must be competent of using technology in their teaching. Moreover, the Department of Education (DOE) has spent millions of dollars on grants to support teachers' training. The grants have brought many

university faculty members, school district administrators, and school teachers together to work on the task –technology integration. In the annual conference of Association for the Advancement of Computing in Education (AACE) 2000, Tom Carrell, director of PT3 grants addressed the influence of technology on our education and the need for organizational change. Some schools, for example, decided to only hire teachers who are competent of the use of technology.

At present, training teachers the use of technology has become a strong nation-wide movement and in-service teachers are expected to become technology literate through in-service training. The strong demand of teachers' training has invited many international scholars to participate in the movement of training US teachers the use of technology. The international scholars were mostly born outside of the United States, came to the USA for their higher education, e.g. Ph.D. degree, and are currently university faculty members at US universities.

The international faculty' participation brought new blood and tremendous strength into US in service teacher education due to their educational experiences in both the USA and their native countries. Their experience with both educational systems allows them to compare how students learn in two different nations and to employ the strengths of each nation in the USA. For example, how an Asian student learns math is different from how a student in the USA. Asian students' math practice involves word problems (concepts) while the USA students' practice focuses on page after page calculation. An Asian Mathematics faculty, who was differently trained, might use a variety of effective teaching strategies due to the exposure to different ways of learning. Similarly, international Instructional Technology faculty may provide different perspectives in in-service teachers training. Because they are foreigners in the USA, they encounter challenges, especially international female faculty. Reports show that the percentage of female faculty in higher education is low. Some reports even indicate that they encounter more challenges than male faculty, e.g. in promotion. In this case, international female faculty would be minority within a minority and consequently encounter greater challenges. Below are examples of challenges:

"I felt that my viewpoints were not valued." (from an international male faculty)

"I felt that I was transparent in many meetings. They didn't seem to see my presence." (from an international female faculty)

"She [an international female faculty] couldn't get tenured because she was a foreigner." (from a US female faculty)

"You [an international female faculty] are double minority. You're female and foreign..You need to be firm and stand up for yourself." (from a US female faculty)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Corporate Teaching (Dr. Doris Lee)

Today, employees in the corporate settings operate in a rapidly changing, high tech environment. Each employee, in order to accommodate the increasingly rapid rate of technology change, must continually re-tool and upgrade his or her skill sets through life-long learning. The delivery medium for life-long learning, most likely, will use instructional technologies. Instructional technologies refers to computer technologies that can integrate texts, graphics, audio, video, animation, or film clips for the creation of instructional or training packages. Recently, instructional technology also includes the use of the World Wide Web, WWW, in which instruction can be delivered over public or private computer networks and can be displayed by a web browser. Dr. Doris Lee, one of the panelists has taught corporate trainers for more than 10 years in the areas of instructional technologies and design and development of computer-based and web-based training. Based on such an experience, Dr. Lee's discussion in this panel will focus on the impact that the instructional technologies have on corporate training, and what are the challenges and perspectives that she faces as a female instructor for corporate trainers. Below details her experiences and views on these topics.

Generally, most corporations believe that the use of instructional technologies would provide an additional tool to the face-to-face training, can be designed to integrate multiple options including video, audio, and text to accommodate employees' preferred learning styles, and is valuable in providing consistent and current training to employees. In addition, the use of instructional technologies to deliver training can be time and place independent and therefore, costs associated with employees' travel and classroom training can be reduced. However, some companies express concerns in using instructional technologies. These concerns include employees' lack of computer and/or Internet skills, the design and development issues, and the software and hardware limitations.

To convince my students, who are corporate trainers, to consider all the important organizational factors and design issues while using instructional technologies is the biggest challenge. Most of the corporate trainers are female and work in a male-dominate environment. It is imperative for a female faculty to emphasize the importance of front-end analysis even if the analysis is not desirable by their male supervisors. When a company is considering using instructional technologies, a female trainer should never feel intimated to ask important questions including human, machine and political readiness. Questions such as, are the employees comfortable with computers and are they ready to learn, need to be asked. Next, technology readiness is another factor. Hardware, software, and the availability of a technical support staff are some examples of the areas that need to be evaluated. Also, financial readiness pertains to budgeting for upgrades to hardware and software, the purchase of courseware, and developing staff. Plus, political readiness concerns the support of instructional technologies by upper management, middle management, employees, and the training department. Finally, skill readiness looks at whether the staff involved with supporting and developing the training has the skills necessary to do so.

Reflection on educational technology from female Asian faculty's (FAF) perspectives on Pre-service Education (Dr. Mei-Yan Lu)

Educational technology has played a major role in influencing pre-service education. For example, In the 60s, 70s, it was the audio-visual education. In the 80s it was computer assisted instruction (CAI), BASIC programming and Logo programming. In the 90s, it was multimedia, web-based learning.

As a female Asian faculty who has taught in major teacher training Institutes, I would like to share some of the unique challenges for preparing future teachers (per-service teachers) the past 16 years.

Challenge no. 1: Most pre-service teachers are young female white adults. Many of them do not have experiences in working with Asian faculty. For example, a typical K-12 school in San Jose, California, has mainly white teachers/administrators, in many cases, 100% white teachers/administrators while many of their students are from a diverse cultural background. Sometimes, a school student body is from 72 different language and cultural background.

Challenge no. 2: Most teacher preparation institute has mainly white faculty. For example, in the College of Education at San Jose State University which graduate, on the average, 600 credential teachers annually, has about 110 full time faculty. Out of the 110 full time faculty, only 6 are Asian faculty (Chinese, Japanese, and Korean).

Challenge no. 3: Most Asian female faculty are "foreign born'. The fact that we are different can offer unique perspectives to our students and colleagues. However, sometimes, our background and cultural differences can be barriers as well. For example, the accent issue. Some students and faculty complain that Asian faculty have heavy accent. However, they rarely complain the European Born faculty who has heavy European accent. Many times, they found European accent charming, while Asian accent distracting.

Challenge no. 4: The field of educational technology generally does not pay attention to solutions and strategies in designing instruction for audience from diverse cultural background. For example, in 1999 AECT convention, there were only two presentations in the entire conference program addressed the issue of designing for international and diverse cultural audience. As one of the popular instructional media – World Wide Web and distance learning is gaining more attention, we as instructional designers/faculty should pay more attention to the international audience.

My goal is to prepare technologically competent teacher candidates that are also culturally sensitive to work with diverse student population. With this goal in mind, I like to recommend:

1. Increase the representation of diverse student body in the field of educational technology both within the United States and outside of the United States.
2. Recruit more faculty of color. Therefore, students will have opportunity to work with both faculty and students from different cultural background.
3. Look beyond the "accent" issue. The point that I am trying to make is that more of the main stream Americans have no trouble "comprehend" accented English. They just do not like the way it "sound". In addition, people who speak with an accent are capable of speaking more than one language and be able to function effectively in another culture. Why not take their unique experience and learn how to design instruction for an international audience?

4. Encourage more educational technologists to research the cultural issues in designing instruction such as in the area of World Wide Web and distance learning.

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Faculty Development (Dr. Mei-Yau Shih)

The use of instructional media in the classroom has long been identified as a "fourth revolution" in education (Ashby, 1967). It has the potential to reshape the role of the instructor from a knowledge conveyer to a guide and coach, while students take a more active role in the learning process. No longer are the textbook and instructor the sources of all knowledge; instead, the faculty member becomes the director of the knowledge-access process (Heinich 1996 et al,). Instructional technology refers not only the actual use of technological tools it also stresses the importance of the process of developing overall goals and strategies for enhancing teaching and learning. At its best, technology-based learning can help teachers support a wider range of learning styles, facilitate active learning in the classroom, use faculty time and expertise more effectively, and familiarize students with technology that will be vital for their futures in the world of work.
In our experience, university faculty are both greatly excited and daunted by the promise and power of teaching technologies. Our students have grown up in a "high technology" environment and are well adept at the use of TV, videotape, computers, and the Internet as information exchange tools. Many faculty, on the other hand, struggle to learn new technologies and to see how they might be useful to them as teachers (Shih & Sorcinelli, 2000). . The higher education is encountering the new trends of the changing student body, teaching practices, and the new roles and identities of faculty in universities. It is imperative, therefore, to remains a holistic view while helping faculty develop their technological skills with an understanding of the educational values and systems where the teaching and learning take places.

The perspectives from a foreign born female faculty developer, whose first 20 years of educational training differs massively from the majority of US university faculty on educational technology, reflect not only a personal challenge, they also underscore the important tasks of any faculty develop who serves as the chang agent in helping the transformation of teaching practice with instructional technology. These tasks include, first, effectively represent the instructional technology to faculty to help them see the integration of technology involves more than physical setup and technical support; it requires some curricular modifications and instructional strategy shifts; second, take in the cultural and educational differences in educational systems to design the strategies in energizing faculty and inspiring them trying innovative ways of teaching, and made them conscious about their purposes in the classroom; third, establish credibility and earn trust of the faculty to represent effectively the benefits of using technologies for teaching and learning; forth, remain alert and sensitive to the campus culture to help enhance the collegiality on campus, and maintain a supporting network of "exemplars" who would be eager to take risks and become "mentors" to colleagues who express interest in instructional technologies. Of most importance task as an Asian, female developer working for rising faculty technological skills is to help faculty recognize the diversity in college classroom, to make them conscious of the various student learning styles, ages, genders, race and ethnicity, and digital have's and have-not's issues in classroom. Effectively carry out these tasks is the means to the ends to help best researchers use and understand the instructional technologies to become a better and effective teacher in the 21st century.

REFERENCES

[1] Ashby, E., (1967). "Machines, Understanding, and Learning Reflections on Technology in Education." The Graduate Journal, 7, pp. 359-373.

[2] Heinich, R., Molenda, M., Russell, J. & Smaldino, S. (1996). Instructional Media and Technologies For Learning. 5th Edition. Englewood Cliffs, New Jersey. Prentice-Hall, Inc.

[3] Shih, M. Sorcinelli, M.D.. (2000). "TEACHnology: Linking Teaching and Technology in Faculty Development." To Improve the Academy. V(18). POD Network. Anker Publishing Company, Inc. Bolton, Massachusetts.

Strategies for Searching in the WWW

Meng-Jung Tsai
Center of Teacher Education, Tunghai University
181, Sec. 3, Taichung-Kang Rd., Taichung, Taiwan 407
Tel: +886-4-3590121
Fax: +886-4-3580601
E-mail: mjtsai@mail.thu.edu.tw

Searching information in the WWW effectively and efficiently is an important vehicle for 21st century citizens to become lifelong learners. This study was to identify effective information-seeking strategies by comparing the strategies employed by the Internet novice user and those by the expert user. A searching task followed by an interview were undertaken in order to observe the strategies used by the subjects. Pre-task and post-task surveys were also administered to collect data relating to subjects' background and self-efficacy toward using the Internet. Protocol analysis was used to analyze the verbal data collected in this study. The results showed that the expert and the novice employed different information-searching strategies in the following six aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving.

Keywords: **Searching Strategies, Lifelong Learning, WWW**

1 Introduction

Lifelong learning has been recognized as an important goal of education in the twenty-first century [14]. With increasingly tremendous information to face everyday, searching desired information effectively and efficiently becomes a necessary skill for learning in such an information age [4, 6]. Due to its efficiency and popularity, the World Wide Web (WWW) is becoming a powerful vehicle for reaching the goal of lifelong learning.

However, it seems not easy for Internet novice users to search information effectively and efficiently via the web. For example, disorientation was reported as a problem that the novice explorers might have while navigating within a hyperspace [2]. It was often to lose directions if they were lack of self-conscious in searching motivation, strategies, results, and meanings. Borgman suggested future research to compare novice and expert users' cognitive behaviors while they are doing a specific searching task in order to find the key factor to accomplish the task [1].

Prior research indicated that users' metacognitive ability, orientation conscious, system knowledge, domain knowledge, and system design influenced users' searching strategies while navigating in a hypermedia environment [6, 10]. Users' computer knowledge and information processing skills were particularly emphasized as important factors to determine a successful searching [4]. Except by improving the system design to help users perform self-reflection during the information-seeking process [9, 7], future research was suggested to evaluate the application of metacognitive skills in an Internet-based learning context [4, 5].

According to the literature about metacognitive strategies [12, 16], learners need not only to have self-conscious about their own learning but also have to know what strategies they can use and how to use them in order to enhance their metacognitive abilities. In addition, it is more important for students to know how to learn than what to learn in order to reach the goal of lifelong learning [14]. Teaching students about how to learn has been demonstrated to be effective to improve students' achievement and attitudes in various learning domains [8, 13]. However, little research explored the strategies specifically for searching information in the WWW.

Hill [5] described a conceptual framework for how users formulate and employ information-seeking

strategies in open-ended information systems (OEISs), e.g. the Internet. Two stages of information seeking were presented in this model. The first was navigational stage, which included the following processes: purposeful thinking, acting, and system responding. The second was process stage, including evaluation, transformation and integration, and resolution. With limited metacognitive ability and unawareness of computer application skills, novice users tended to suffer information overloading. They often repeated the behaviors which were recognized in the navigational stage, but seldom performed the actions belonged to the process stage. However, experienced users were able to utilize the searching strategies that were recognized in both stages [5]. They also showed how to control and manage their searching process. It seemed that users' self-awareness about their own searching ability, self-reflection, self-control and self-management about their searching process were keys for successfully seeking information on the Internet.

In order to become lifelong learners, all citizens of the next century must know what strategies they can use for searching information effectively and efficiently on the WWW and how to use them. If the Internet is an important vehicle for lifelong learning, then identifying effective WWW searching strategies should be the first step to reach the goal.

2 Purpose

The purpose of this study was to identify effective WWW information-seeking strategies by comparing the strategies used by Internet novice users and experienced users. Therefore, the research question of this study was: What are the differences between the strategies used by Internet novice users and those used by Internet experienced users while searching information on the WWW?

3 Methodology

Two in-deep case studies followed by a between-case comparison were used to answer the research question. A college freshman, as an Internet novice user, and a college graduate working at a computer technology company, as an Internet expert user, were volunteered to participate this study. Both subjects were asked to perform a searching task alone through the WWW by using a web browser, Internet Explorer. The goal of the task was to find a freshmen course schedule of a specific department in a large university in Taiwan. The searching processes were both videotaped for observing subjects' searching paths, number of websites visited, and the time spent on each site. During the search, subjects were asked and continuously reminded to perform think-aloud in order to collect verbal information for protocol analysis [3] of their searching strategies. Pencils and blank answer sheets were issued to subjects for taking notes or answers.

Before searching, a survey was administered to collect subjects' Internet background, including their Internet using history, frequencies of Internet access, Internet access availability at home, Internet courses taken before, and self-efficacy about searching information on the WWW. Right after the searching task, subjects were given another survey to reflect their self-satisfaction toward their performance in the task. Subjects were further interviewed by the researcher if there was a need to clarify on the videotape. Subjects' searching paths, actions, responses, and think-aloud protocols were analyzed for each case and then compared between cases.

4 Results

Comparing the data collected from pre-task and post-task surveys, searching paths, verbal scripts and blank answer sheets, several different characteristics showed between the Internet novice user and expert user. First of all, the expert finished the task and got desired information after visiting 30 in 18 minutes, whereas the novice visited 19 websites in 24 minutes with a blank answer. Except for different searching results between the cases, this also showed that the expert's navigating speed was as about twice as the novice's. In addition, the expert spent less than one minute on each website, whereas the novice spent more than one minutes on five websites. This indicated that the expert processed and evaluated the information shown on computer screen much faster than the novice.

Besides, verbal scripts to complaint about system like "I hate it! It is so slow..." or to critique the website

design like "This is a poor website full of redundant information..." showed 9 times during the expert's searching and 0 during the novice's; however, anxiety or worrying responses like "How come I cannot find it..." or " I cannot..I cannot..I just cannot find it..." showed 12 times during the novice's searching but 0 during the expert's. This suggested that the expert was confident to and believed being able to find the desired information; however, the novice users were coping with tremendous amount of anxiety toward reaching the goal of the task. This was concurred with their reflections in pre-task survey about their self-efficacies toward using computer technology.

Furthermore, navigation disorientation and system problems did not happen during the expert's searching process, but happened in the novice's searching process. The novice responses with "I understand it but just don't know where to start..." "How did I get here..." and "Oh! My god. I made a mistake. What's wrong with this?" This revealed that the novice user tended to get lost and became nervous after an error occurred. However, the expert showed confidence in controlling and regulating their searching process no matter what happened in the process.

Finally, the expert was familiar with how to use search engines and data base query systems; however, the novice showed some problems with them. This implied that knowing how to use helpful searching tools on the WWW is an important issue for successful searching. Besides, the novice showed little try-and-error strategies when problems occurred; however, the expert used this strategy a lot when a bottle net occurred. This indicated that try-and-error was an important problem solving skill for a successful searching in the WWW.

5 Discussions

Based on the results of this study, the differences of strategies utilized by the Internet novice user and the expert user can be summarized as following six aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving. Computer self-efficacy [11] means how users perceived their abilities toward utilizing computer technology. The expert user tended to have higher computer self-efficacy than the novice user. This strategy relates to users' prior computer experience and believes about learning computers. Changing the novice users' views or believes about their computer abilities might be a solution to enhance their searching effectiveness and efficiency.

Task anxiety refers to worrying about not being able to reach the goal of a searching task. This strategy relates to environmental expectation and support. Group searching task with peer support might be a solution to help the novice search information on the WWW. Search aids indicates to users' knowledge and abilities to use tools that help search on the WWW, e.g. search engines and data base query systems. This relates to users' prior-knowledge and experience of using a data retrieval system. Providing a metaphor of such a system and practicing the query skills could enhance the novice users' abilities in this aspect.

Information processing refers to the ability to read in information from computer screen, select main ideas, evaluate, transfer, and integrate the information, and finally make decisions for the next destination. Strategies like looking through headlines and hyperlinks immediately after visiting a web page could help novice users to encode web information. Except encoding, many other strategies belong to this aspect. They include differentiating, monitoring, formulating, integrating, extracting, angling, collecting, controlling, decision-making, and reflecting [5]. In addition, this study shows evidence to support Hill's [5] conceptual framework of seeking information in an open-ended information system. Because the novice did repeat the behaviors of the navigational stage [5], but seldom performed the actions belonged to the process stage [5]; however, the expert in this study did perform the actions of both stages and show how to control and manage his searching process.

Concentration means the ability to keep attention on the searching task. The novice was easy to be interrupted by unrelated program messages or outside interferes. Have the mouse pointing to text which is currently being processed or read the text loudly might help the novice concentration on searching task. Problem solving means the ability to use try-and-error strategy when problems occur during searching. This strategy relates to users' creativity and problem solving styles. This strategy may be enhanced by successful practice experience.

6 Conclusions

The Internet novice users and expert users utilize different strategies to seek information in the WWW, an open-ended information system. Although the system design and users' system knowledge and domain knowledge may influence users' searching efficacy, users' metacognitive searching strategies may be enhanced through teaching and practice. By comparing the novice's and the expert's strategies used for seeking desired information through the WWW, this study identified six different aspects: computer self-efficacy, task anxiety, search aids, information processing, concentration, and problem solving. Future research should further investigate each aspect and examine the effects of the training of these strategies on users' searching efficacy.

References

[1] Borgman, C. L., "Why are online catalogs hard to use? Lessons learned from information-retrieval studies", Journal of the American Society for Information Science, Vol. 37, No. 6, pp. 387-400, (1986).

[2] Dias, P., Gomes, M. J., & Correia, A. P., "Disorientation in hypermedia environments: mechanisms to support navigation", Journal of Educational Computing Research, Vol. 20, No. 2, pp. 93-117, (1999).

[3] Ericsson, K. A., & Simon, H. A., "Protocol analysis: Verbal reports as data", Cambridge, MA: MIT Press, (1984).

[4] Hess, B., "Graduate student cognition during information retrieval using the World Wide Web: a pilot study", Computers & Education, Vol. 33, pp. 1-13, (1999).

[5] Hill, B., "A conceptual framework for understanding information seeking in open-ended information systems", Educational Technology Research & Development (ETR&D), Vol. 47, No. 1, pp. 5-27, (1999).

[6] Hill, J. R., & Hannafin, M. J., "Cognitive strategies and learning from the World Wide Web", Educational Technology Research & Development (ETR&D), Vol. 45, No. 4, pp. 37-64, (1997).

[7] Kashihara, A., Uji'I, H., & Toyota, J., "Reflection support for learning in hyperspace", Educational Technology, September-October, pp. 19-22, (1999).

[8] King, A., "Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain", American Educational Research Journal, Vol. 31, No. 2, pp. 338-368, (1994).

[9] Lin, X., Hmelo, C., Kinzer, C. K., & Secules, T. J., "Designing technology to support reflection", Educational Technology Research & Development (ETR&D), Vol. 47, No. 3, pp. 43-62, (1999).

[10] MacGregor, S. K., "Hypermedia navigation profiles: cognitive characteristics and information processing strategies", Journal of Educational Computing Research, Vol. 20, No. 2, pp. 189-206, (1999).

[11] Oliver, T. A., & Shapiro, F., "Self-efficacy and computers", Journal of Computer-Based Instruction, Vol. 20, No. 3, pp. 81-85, (1993).

[12] Pressley, M., & Wolshyn, V., "Cognitive strategy instruction that really improve children's academic performance", Cambridge, MA: Brookline Books, (1995).

[13] Rosenshine, B., Meister, C., and Chapman, S., "Teaching students to generate questions: A review of the interaction studies", Review of Educational Research, Vol. 66, pp. 181-221, (1996).

[14] Titmus, C. J., "Lifelong education for adults: An international handbook", Elmsford, NY: Pergamon Press, (1989).

[15] Weinstein, C. E., & Hume, L. M., "Study strategies for lifelong learning", Washington, DCL American Psychological Association, (1998).

[16] Weinstein, C. E., & Mayer, R. E., "The teaching of learning strategies", Handbook of research on teaching, NY: MacMillan, 3rd Ed., pp.315-327, (1986).

Student Learning Issues: factors to consider prior to designing computer-assisted learning for higher education.

Paul Wilson* **and George Coghill****
Christchurch Polytechnic, PO Box 22-095, Christchurch, New Zealand
Email: wilsonp@cpit.ac.nz
***The University of Auckland, Private Bag, Auckland, New Zealand*
Email: g.coghill@auckland.ac.nz

Significant research has shown that most computer assisted learning systems in higher education are failing to meet the expectations of the developers, and students learning needs. The use of computer assisted learning systems is still not commonplace and there are factors negating increased usage. This paper reviews a number of human development and learning theories that should be considered before design of any learning experience. The major focus is on the behavioural and cognitive approaches that are believed to have the most importance when considering the design of computer assisted learning systems. Current research in student learning in higher education is included as is an outline of individual variations in learning experiences. It is concluded that an awareness of the behavioural learning processes and cognitive theories when designing CAL systems in the various categories could provide enhanced learning opportunities for the students using the systems. The application and use of appropriate learning strategies to improve student learning outcomes is in accord with current research in traditional teaching areas

Keywords: **learning theories, higher education, computer assisted learning system design**

1 Introduction

A study of 104 projects using information technology (IT) in developing course material for use in higher education found that many students learned less from IT programs than from face-to-face teacher contact; "fewer than a third of programs offered through information technology improve student learning"[2]. The report went on to say, "that while many of the projects did benefit students and academics, inadequate staff development and students' unsophisticated understanding of learning meant IT was not always being put to maximum use". While this study is confined to IT projects in Australian universities it is thought likely that similar dire results would be obtained in most other countries and learning environments.

Despite more than two decades of research and development in the area of computer assisted learning (CAL), the usage of these systems is still not common place in any more than a few isolated areas; "few have survived the realities of large-scale implementation in typical classrooms and those that have report significant implementation problems"[7]. Two of the major contributing factors negating the wide spread acceptance and use of computer technology are the high resource cost, for both hardware procurement and courseware development, and the low level of enabling teacher development to allow them to use this new resource to its maximum potential.

CAL is the most popular term in Europe while Computer Aided Instruction (CAI) is more often used in North America and Asia. The use of the word instruction has a special significance. It usually means that the package is not only conceived and designed by a teacher but that the effective control remains with him/her at every stage. The content and its delivery, including the degree of elaboration, the rate of flow of information and the order of presentation are decided by the teacher only. Being teacher-centred, the design is expository rather than explanatory in nature.

In contrast, CAL is designed to have student-centred activities. The student decides how much she/he needs to learn, in what sequence, to what depth and at what rate. The learning process is usually exploratory. Theoretically, the need to take care of individual differences amongst students is much higher in designing a CAL package than in a CAI package.

Significant scope remains for research and development of CAL in the higher education context, just as it does in the junior and senior school environments. "We need to understand better the relationship between technology, pedagogy, project oriented curricula, and student learning" [9]. It is believed that one of the more crucial areas required for success in development of any teaching / learning package, be it traditional or computer assisted, is an understanding of student learning issues in the higher education context.

In this paper the major human development theories are briefly outlined with respect to research in student learning. This work allows student learning theories and approaches to be discussed in more detail, especially with respect to student learning in the higher education environment. Some of the more important variations that may impact on the overall outcomes of the students' learning are then outlined. The final contribution of the paper is to integrate relevant issues from the various student learning theories and recent research with respect to systematic design of CAL systems.

2 Human Development

The major theorist in this area is the Swiss psychologist Jean Piaget who formalised a theory of cognitive development based on four discrete stages. These four stages, with approximate relevant ages are (adapted from Woolfolk [13]);

1. Sensorimotor, from 0 to 2 years of age.
   Involving the senses and motor activity. Concepts of object permanence and goal-directed actions.
2. Pre-operational, from 2 to 7 years of age
   The stage before a child masters logical mental operations. Develops language and ability to use symbols to represent actions or objects mentally.
3. Concrete Operational, from 7 to 11 years of age
   Able to solve 'hands-on problems' in logical fashion. Able to classify, arranges objects in sequential order, and understands concepts of conservation and reversibility.
4. Formal Operational, from 11 to 15 years of age.
   Able to solve mental tasks involving abstract thinking and co-ordination of a number of variables.

Most psychologists agree that there is a level of thinking more sophisticated than concrete operations, but the question of how universal formal-operational thinking actually is, even among adults, is a matter of debate. According to some, the first three stages of Piaget's theory are forced on most people by physical realities [8]. Formal operations are not, however, so closely tied to the physical environment.

It is essential to realise that although a student might be participating in a higher education experience, that it is not necessarily congruent that they are able to think hypothetically about every problem that is presented to them. In many cases the students may be in a higher education environment only because of their ability to memorise formulas or lists of steps. "These systems may be helpful for passing tests, but real understanding will take place only if students are able to go beyond the superficial use of memorisation – only if, in other words, if they learn to use formal-operational thinking"[13].

Before continuing, it is worth noting that there have been a number of adaptations and alternatives proposed by psychologists to Piaget's theory of cognitive development in children. Most of these have come about in relatively recent research work that is well documented in Woolfolk[13]. One major alternative viewpoint is that culture shapes cognitive development in a child by determining what and how the child will learn about the world. The major spokesperson for this view is that of the Russian psychologist Lev Vygotsky who died more than 50 years ago. Recent translations of his work show that he provided an alternative to many of Piaget's ideas [13]. The concept of culture shaping learning styles is also supported in more recent studies [12].

3 Learning Theories

There are two main approaches to the study of learning: the behavioural and cognitive perspectives.

3.1 Behavioural Approach

The behavioural approach to learning assumes that the outcome of learning is a change in behaviour and emphasises the effects of external events on the individual. All behavioural learning theories are thus explanations of learning that focus on external events as the cause of change in observable behaviours. The four major behavioural learning processes are: contiguity, classical conditioning, operant conditioning, and observational learning.

3.1.1 Contiguity

This principle was the foundation for research in learning in the early parts of the twentieth century. The principle of contiguity states that whenever two sensations occur simultaneously and repeatedly, they will be become associated. If at some time later only one of the sensations occurs (a stimulus), the other will be recalled (a response). Learning by association, or the repetitive pairing of a stimulus and correct response, can be found in many educational contexts – consider for example spelling drills and multiplication tables.

3.1.2 Classical Conditioning

An extension of the contiguity principle is found in the theories of classical conditioning discovered by Ivan Pavlov in the 1920's. Classical conditioning allows for the association of automatic responses with new stimuli. Pavlov determined that in the first instance an unconditioned stimulus produces an unconditioned response. After conditioning (or 'learning'?) a previously neutral stimulus becomes a conditioned stimulus that can produce a conditioned response to the same extent that occurred with the unconditioned stimulus and unconditioned response pair. Pavlov's work also identified that conditioned responses are subject to the processes of generalisation, discrimination, and extinction. In many cases the emotional reactions to various learning situations are themselves learned in part through classical conditioning. We must acknowledge that emotions and attitudes are learned as well as facts and ideas in any learning environment.

3.1.3 Operant Conditioning

Contiguity and classical conditioning both focus on involuntary or automatic actions in response to stimuli. These involuntary actions are also referred to as respondents. It is obvious that not all human learning is automatic and that in many cases people actively operate on their environment to reach particular goals or cause certain effects. These deliberate, goal directed actions are called operants and the learning process involved in changing operant behaviour is called operant conditioning.

In operant conditioning people learn through the effects of their deliberate responses to their environment and as such is most applicable to classroom type learning environments. For an individual, the effects of consequences following their action may serve as reinforcement or punishment. Positive and negative reinforcement will strengthen the response while punishment may decrease or suppress the response. The scheduling of reinforcement can influence the rate and persistence of responses. Ratio schedules encourage higher rates of responses while variable schedules encourage persistence of responses [13].

3.1.4 Observational Learning

Social cognitive learning theorists emphasise the role of observation in learning and in non-observable cognitive processes. There are two main modes associated with observational learning. First, learning through observation can occur through vicarious conditioning. This is when a student sees others being rewarded or punished for various behaviours and so modifies their behaviours as if they had received the consequences themselves. Second, the observer imitates the behaviour or actions of a model even though the model receives no immediate reinforcement or punishment while the observer is watching. This mode is when the model is demonstrating something that the observer wants to learn and expects to be rewarded for mastering. There are four major elements associated with observational learning; paying attention, retaining information or impressions, producing behaviours, and being motivated to repeat the learned behaviours [13].

3.2 Cognitive Approach

The cognitive approach to learning emphasises how students perceive, remember, and understand

information. Cognitive psychologists focus on changes in knowledge and believe that learning is an internal mental activity that cannot be observed directly. There is no single combining theory and thus the cognitive view of learning can best be described as a generally agreed-upon philosophical orientation [13].

Under the cognitive approach, knowledge is categorised into different types (after [13] and [5]):

- General knowledge is information that is useful in many kinds of tasks or that may be applied to many different situations.
- Domain-specific knowledge is information that is useful in only a particular situation or that applies to only one specific topic.
- Declarative knowledge is *knowing that* something is the case, facts, beliefs, theorems, opinions, names, rules, poems, and the like. This type of knowledge has a tremendous range and may be organised into small units or larger units, which themselves may consist of several well-organised smaller units.
- Procedural knowledge is knowledge that is demonstrated when performing a task, that is *knowing how*.
- Conditional knowledge is *knowing when and why* to apply declarative or procedural knowledge.

The most influential and thoroughly studied model of cognitive research is the information processing model that provides an explanation of the cognitive processes involved in learning. It has grown from the work of a number of theorists (e.g. [3] and [6]).

3.2.1 Information Processing

In the information processing model the learning is approached primarily through a study of memory. A schematic representation of a typical information processing model of learning is shown in Figure 1(after [[13] and [5]).

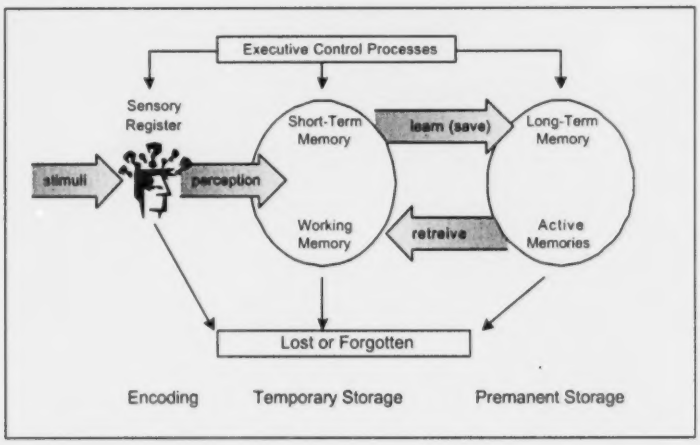


Figure 1 – The Information Processing Model

The three stages of the information processing system are the sensory register, short term memory and long term memory. The sensory register encodes some or all of the information received from the senses. Some of the information is not registered at all, some is ignored and some is simply forgotten. Perception determines what will be held in short term memory for further use.

The working memory only has a limited capacity so the information must be processed immediately or it will be forgotten. For information to be retained for longer than a few seconds it must be actively learned and stored in the long-term memory. Retrieval is the process of locating and recalling information to short-term memory.

The executive control processes guide and direct the processes involved in transferring information from the external environment to the long-term memory. These processes include directing attention, selecting strategies, and monitoring progress towards goals and motives.

Learning in the information processing model involves the construction of information in the memory, rather than the direct transfer of information from external environment to long-term memory. Learners use learning or cognitive strategies to actively acquire and manipulate information from the environment and their memory.

3.2.2 Metacognition

Metacognition literally means knowledge about cognition and has two aspects. The first aspect refers to an awareness of, and knowledge about, cognition. It includes the *declarative* and *procedural* knowledge of the skills, strategies, and resources needed to perform a task effectively, and the *conditional* knowledge needed to ensure successful completion of the task [13].

The second, and more important aspect, relates to the control and regulation of cognition, as this is the aspect that controls and regulates the use of strategies that are known by the learner. The control and regulation aspect includes three general processes: planning, monitoring and self-evaluation. Planning helps learners decide which strategies to use and how to process information effectively. Monitoring helps learners understand the information and integrate it with their existing knowledge. Self-evaluation helps learners check and correct their learning behaviour as they work through a learning task.

3.3 Constructivist

The constructivist approach to learning emphasises that people construct knowledge for themselves as a result of their interactions with their environment. Through this construction process, individuals build their own understandings and ways of looking at the world and the information sources in it. This does not mean that each person constructs knowledge in their own way that may be totally different from others. In most cases knowledge and understanding are constructed in an agreed and shared social context.

The constructivist approach subsumes a variety of theories, including information processing and social cognitive theories. The principal theorists in this area are Gagne [6], and Brown et al. [4].

Constructivist views of learning are important because they inform teachers of where to direct their effort in order to promote effective learning. The important features include the basic cognitive processes, strategies to guide these processes, knowledge about those strategies and one's own thinking processes, knowledge about the world in general, motivational beliefs, goals and overall cognitive style.

The immediate implications for learning are that students must be active learners and must be able to use a variety of learning strategies that will help them learn with understanding [5].

4 Variations

Learning is a complex multivariable phenomenon with respect to both process and outcomes [10]. Each student will be subject to intrinsic and extrinsic factors and driving forces that will impact on their learning. These factors and driving forces must be acknowledged and, if possible, allowed for in both traditional and computer assisted teaching environments. The first three of the factors outlined below are referred to as the 'big three' of student learning behaviours and essentially explain contrasting individual forms of engagement with the content and context of learning. The remaining factors can be used to construct more complex multivariable models for individual approaches to learning.

4.1 Intention

All students have some objective in mind when they start a course of study in higher education, the *what* question. Each student's individual response to this question may reflect a variety of contrasting intentions, or even a multiple intention. The most basic distinction is between the internal transformation of information into knowledge (construction of personal meaning), and the accumulation and reproduction of information (storage and recall). Other strategic intentions may be focused on the outcomes of higher education.

4.2 Motivation

Closely coupled with intention is the motivation for learning, the *why* question. Students are motivated by a wide range of feelings that traverse the entire spectrum of human experience. Abraham Maslow has had a great impact on the psychology of motivation and his hierarchy of needs model sets the foundation for research into human motivation. Other aspects to be considered in student motivation are arousal, goals, attribution, and beliefs [13].

4.3 Process

A materialistically motivated strategic intention to achieve high marks, for example, will not guarantee that high marks will be achieved. At even the most basic level in higher education some type of organised cognitive process or learning method will be required, the *how* question. Process is not simply a mental consideration in learning activity; it is at least partially influenced by the underlying intention and motivation.

4.4 Context

A students learning behaviour will be shaped by perceived circumstances or situational demands. Correctly identifying and applying the cues embedded in the context of learning (especially those related to task demands) are an important part of what might be called 'skill in learning' [10]. Perceptions that students form about the context of learning are closely associated at the individual process level with other sources of variation.

4.5 Regulation & Locus of Control

It has been demonstrated that various forms of regulatory mechanisms, such as those that clarify and direct learning activities, can help explain individual learning variations [11]. Individuals also vary to the degree to which they perceive causal attribution for academic success to be within, or beyond, their control [10]. Studies have determined the importance of locus of control as a determinant of learning outcomes in higher education.

4.6 Student Conceptions

Students differ considerably in their conceptions of what learning is. In broad terms the conceptual distinction lies between accumulative, the quantitative collection of knowledge for possible future use, and transformative, the use of knowledge to internally rearrange and construct new knowledge for developing personal meaning. These contrasting conceptions of learning are associated with differing forms of learning behaviour [10].

4.7 Cultural Factors

Recent research in the area of cultural impact on student learning has demonstrated that there is danger in assuming a culture-free interpretation of basic learning processes [10]. Indeed, culturally embedded values and practices must also shape any student learning behaviour model.

4.8 Gender

"The issue of gender related differences in learning behaviour does create some controversy" [10]. However, recent work in this area has shown that basic sources of variation used in student learning model construction may be defined differently in terms of gender specific responses – which, as a logical consequence, raises the possibility of gender specific models of student learning.

4.9 Discipline Specificity

The possible causes of variations outlined to this point have one thing in common; they are all general in nature and should be considered for any learning situation. As most learning in a higher education setting is essentially content focused there is an obvious need to address variations that may be specific to a particular discipline. These variations may be either a function of the content itself (for example higher level

mathematics) or the broader context in which they are embedded and is perceived to be a part of (for example higher mathematical concepts in an electrical engineering course).

5 Student Learning Issues of Importance in the Systematic Design of Computer Assisted Learning Systems

Other researchers in the field of CAL have recognised the relevance of considering issues from cognitive psychology in the design of CAL systems. The areas of cognitive theory concerning perception and attention, memory, comprehension, active learning, motivation, locus of control, transfer of learning, and individual differences have previously been identified as being most important to CAL design [1].

However, it is believed that the consideration of cognitive theory to the exclusion of other learning issues can only lead to an incomplete analysis of the wider learning issues affecting all students in a higher education environment. Of even more concern is the concept of a CAL system being designed with no consideration given to any of the student learning issues. This could be a partial explanation for the poor results reported in the survey of Alexander & McKenzie [2].

Issues considered to be of importance in the systematic design of CAL are as follows:

5.1 Use of Formal-Operational Thinking

There are few instances in CAL in higher education where students are not required to proceed beyond the superficial use of memorisation. Therefore it is vital that a CAL system design ensure that the students are required to use formal-operational thinking to achieve the learning required.

5.2 Cultural Aspects

With the increasing globalisation of education there are many instances in a higher education environment where there may be several cultures in any particular group of students. The design of a CAL system must not allow one cultural group to be advantaged, or disadvantaged, at the expense of others due to the predominance of a particular learning style or cultural influence in the system.

5.3 Behavioural Influences

CAL systems may include learning experiences ranging from simple drills to complex simulations. An awareness of the behavioural learning processes when designing CAL systems in the various categories could provide enhanced learning opportunities for the students using the systems. Of most benefit are the operant conditioning and observational learning processes. Research from operant conditioning shows that the scheduling of reinforcement, or CAL system feedback in this particular instance, must be designed to ensure that the aim of the system is achieved – that is, higher rates of responses or persistence of responses. Research from observed learning shows that mastery can be achieved through observation – how this observation can be achieved in a CAL system needs careful consideration during the design process.

5.4 Cognitive Influences

The work of Alessi & Trollip [1] has gone some way towards setting a base for the use of cognitive theory in designing CAL systems. Recent research has increased the awareness, and importance, of metacognition in student learning. The control and regulation of the cognition aspect of metacognition shows the importance of considering this aspect when designing CAL systems. The application and use of appropriate learning strategies to improve student learning outcomes is in accord with current research [5]. Just because a student is 'learning' from a computer does not mean that they would not benefit more from an increased awareness of learning styles and strategies.

5.5 Constructivist Approaches

The constructivist approach to student learning also has a great deal to offer designers of CAL systems. In this approach, students must positively interact with their environment – they must become 'active learners'.

One of the most enabling features of properly designed CAL is its ability for interaction with the student. However, too much of one thing can soon become tiring and thus eventually negatively motivating, therefore this is one area that needs more research to ensure the much heralded benefits of CAL systems eventuate.

5.6 Individual Variations

Meyer [10] notes that learning is a complex multivariable phenomenon with respect to both process and outcomes. Alessi & Trollip [1] also note that the often praised and supposed advantage of CAL to individualise is, just like interactivity, not often taken advantage of. All of the outlined individual variations must be at least considered when designing a CAL system. The big three of intention, motivation and process should always be factored into CAL system design. Context, regulation and locus of control, and discipline specificity may provide significant opportunities for the CAL system designer to truly individualise the system for the learners.

6 Conclusions

Many of the learning issues outlined in this paper are only now starting to be recognised as important aspects for students in higher education [5], [10]. With an increasing reliance on computer and information technology in higher education it is now imperative that the opportunity is taken to consider learning issues as a first step in the systematic design of computer assisted learning systems.

This paper has outlined some of the more important human development, learning theories, and learning approaches considered relevant to the systematic design of CAL systems. Significant research effort is being undertaken in applying these theories and approaches to 'traditional', or face-to-face, teaching in higher education. As any CAL system is no more than an extension of the existing traditional methods it is imperative that similar research work is conducted in the CAL design area.

Work remains to be carried out in developing a systematic approach to integrating teaching concepts, in addition to that completed in this paper on learning issues, in the design of CAL systems.

It is concluded that only once a complete understanding of those learning and teaching issues in higher education are mastered, will a comprehensive and systematic design approach for CAL systems be able to be developed.

References

[1] Alessi, S.M. & Trollip, S.R.,. "Computer based instruction: methods and development", Englewood Cliffs: Prentice Hall, (1985).

[2] Alexander, S. & McKenzie, J., "An evaluation of information technology projects for university learning", Canberra: Australian Government Printing Service. (1999).

[3] Atkinson, R.C. & Shiffrin, R.M., "Human memory: A proposed system and its control processes", in K Spence & J Spence (Eds.), "The psychology of learning and motivation", Vol. 2, New York: Academic Press, (1968).

[4] Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. "Learning, remembering and understanding", in P.H. Mussen (Ed), "Handbook of child psychology", Vol. 3 (4th Edn, pp.77-166), New York: John Wiley & Sons, (1983).

[5] Chalmers, D. & Fuller, R., "Teaching for learning at university", London: Kogan Page, (1996).

[6] Gagne, R.M., "The conditions of learning", 4th Editiion, New York: Holt, Rinehart and Winston, (1985).

[7] Ladewskii, B.G., Krajcik, J.S., & Harvey, C.L., "A middle grade science teacher's emerging understanding of project based instruction". Elementary School Journal, Vol. 94, pp. 499-515, (1994).

[8] Neimark, E., "Intellectual development during adolescence", in F.D. Horowitz (Ed.), "Review of Child Development Research", Chicago: University of Chicago Press, (1975).

[9] Mergendoller, J.R., "Moving from technological possibility to richer student learning: revitalised infrastructure and reconstructed pedagogy", Educational Researcher, Vol.25, No. 8, pp. 43-46, (1996).

[10] Meyer, J.H.F., "A medley of individual differences" in B. Dart & G. Boulton-Lewis (Eds.), "Teaching & learning in higher education", Melbourne: Australian Council for Education Research Ltd., (1998).

[11] Vermunt, J.D.H.M, & Van Rijswijk, F.A.W.M., "Analysis and development of students' skill in self regulated learning". Higher Education, Vol. 17, pp. 647-682, (1988).

[12] Watkins, D. "Assessing approaches to learning: A cross-cultural perspective" in B. Dart & G. Boulton-Lewis (Eds.), "Teaching & learning in higher education", Melbourne: Australian Council for Education Research Ltd., (1998).

[13] Woolfolk, A., "Educational psychology", 5th Edition, Needham Heights, Ma: Allyn & Bacon, (1993).

Students' Attitude toward WPSS in Supporting Classroom Learning

Hsiu-Ping Yueh
Department of Agricultural Extension, National Taiwan University,
#1, Sec. 4, Roosevelt Rd, Taipei 106, Taiwan
Tel: 886-2-23630231-2750
FAX: 886-2-23647221
Email: yueh@ccms.ntu.edu.tw

While the web-based learning environment has become more flexible and has more functions than traditional instructional media as well as many computer-assisted instruction, the EPSS has also become an expanding area within the field of education. This paper first describes the features of and rationale behind electronic performance support system as well as web-based performance support system; demonstrates the implementation of the web-based performance support system in assisting students' learning in a real-time multicast distance classroom; discusses the research methodology; explores the effectiveness of the use of the web-based performance support system in supporting students' learning; and provides conclusions and implications for the filed of education.

Key Words: **Distance Education, Electronic Performance Support System (EPSS), Web-based Performance Support System (WPSS)**

1 Introduction

Electronic Performance Support System (EPSS) was originally defined as a system that provides just-in-time information, advice, learning experiences, and tools in the form of electronic to help people perform a task with the minimum support from other people [3]. Based on the early definition, EPSS was perceived by many people as an interactive computer-based environment which attempts to facilitate or improve human performance such as problem solving abilities within some target application domain. To help organizations design and develop EPSS with a broader systems thinking approach, Raybould (1995) proposes that an EPSS is "the electronic infrastructure that captures, stores and distributes individual and corporate knowledge assets throughout an organization, to enable an individual to achieve a required level of performance in the fastest possible time and with the minimum of support from other people"(p.66)[6].

A number of existing technologies have been selected and integrated into design and development of an EPSS, such as artificial intelligence (AI), hypermedia, computer-based training (CBT), intelligent tutors and microworlds [5]. With the impact of the growth and development of network technology, internet or intranet has become one of the most important delivery vehicle for the EPSS. A Web-based Performance Support System (WPSS) is an innovative approach by utilizing the technologies of the world-wide-web (WWW). For a WPSS, the web is not only a delivery medium, it also provides contents and serves as subject matter experts (SMEs) as well. The DISTED (Distributed Information System & Training for Educators at a Distance Education) as an example of a WPSS has successfully functioned as a system which helps educators design, delivery and evaluate teaching in the interactive distance education [7]. The WPSS has been proved to be a better design than the traditional EPSS in terms of it's features such as cost-effectiveness, open architecture, universal acceptance and pervasive delivery [2].

Many training experts contended that Electronic Performance Support Systems are the learning tools of the 21st century [4]. While most of the major developments and applications of EPSS were designed for industrial and

commercial settings, more and more educators in many academic organizations have begun to adopt the concept and implement EPSSs in their classes. As the educational environment becomes more dynamic, the possibility of adequately imparting necessary knowledge to learners within a limited instructional schedule is increasingly challenging. Considering that our knowledge base is expanding rapidly and information is being updated at the speed of telecommunications, some educators therefore started to employ an integrated use of EPSS to facilitate learners' information retrieval. For example, Schwen, Goodrum, & Dorsey (1993) used the EPSS to create an enriched learning and information environment [8]; Law (1994) employed the metaphor of "cognitive training wheels" to describe EPSS as it facilitates learners' acquisition of skilled performance.

According to the early definition of EPSS, there are usually four major components embedded in a performance support system which includes information, training, advice and tools. To improve the functions and the design and development of a better performance support system, many researchers proposed different models of putting together an EPSS with necessary components. Gery (1991) listed three levels of functionality with four components at each level, they are user interface, help, coach/advisor, and tutor [3]. McGraw (1995) suggested that the components of an EPSS should include the human-computer interface, the help system, the coaching/advisor system, and the tutor component [5]. Baker and Banerji (1995) proposed an approach to design and implement of EPSS facilities based upon the use of a multi-layered model containing four basic levels including human-computer interface, generic tools, application specific support tools, and application domain [1]. In general, an EPSS should have four typical components including tools, information base, advisor, and learning experiences [9] to be able to support performance.

While we are moving into the resource-based learning environment in the field of education, the way of teaching and instruction has been changed accordingly. Teachers are no longer experts but facilitators or guilders; textbooks is also instead by a variety of learning resources and media. Internet is a very good tool in terms of providing the resource-based learning environment. The world-wide web with hypertext markup language (HTML) provides an easier way to present large volumes of text electronically, using efficient client/server architecture to transfer different kinds of data, such as texts with fancy fonts, colorful graphics, even sound and video clips in packets across the internet. As an integrated tool, WWW allows users to share and transfer data files easily, as well as communicate and interact more effectively. Also as a self-directed learning tool, a WPSS provides a rich environment with up-to-date information, real-world learning experiences, as well as worldwide learning resources, with which students can self-pace, monitor, and evaluate their learning.

2 Method

The purpose of this study were to investigate the effectiveness of the WPSS in supporting students' learning as well as to understand students' attitude toward this system. The target population for this study is a class of students (82 students totally) registering in the distance education course titled "Web-based Instruction and Training" in Spring 1999. A WIT Web Site was designed and developed as a web-based performance support system to assist students' learning of this course. At the end of the semester, a copy of questionnaire was also designed and distributed to students to collect their perception toward this Web Site. Moreover, students' answers to a posttest essay of the final exam were reviewed for the purpose of evaluation. The data collected were analyzed by means of Descriptive Statistics, correlation, and regression study.

3 Results

For the attitude survey, most students showed positive attitude toward content information (usefulness, richness, helpfulness), format design (screen design, visual images design, layout consistency, links arrangement), and composition (organization, presentation, delivery, references) of this WIT Web Site. Besides, students' comments also showed that most students thought this Web Site is a useful tool in general especially it meets different learning needs of students. Furthermore, the results showed that there is a moderate correlation between students' attitude with their final exam scores. And findings suggest that most students are willing to use this kind of supporting system in their learning if other courses could provide in the future.

4 Conclusions

1. Evidence from students' attitude survey and feedback comments shows that the web based performance support system is a powerful tool in terms of assisting learning especially in the distance education learning environment. It serves as a self-directed learning tool with which students can self-pace, monitor, and evaluate their learning, which may in turn facilitate students in developing life-long learning skills.

2. Results of this study also shows that the WIT Web Site provides a powerful communication channel between instructor and students, as well as students at different learning sites in the distance education course. More specifically, the web-based discussion boards were claimed by students to be a very useful tool to expand the interaction and communication outside classroom.

3. Most Electronic Performance support Systems were used in the industrial settings in the past, however, results of this study has approved that a WPSS can also be an excellent tool for providing just-in-time assistance in the learning environment of formal education. Students perceived it as a good learning tool in many aspects including the application to future study in other contexts or subject areas. This experience of facilitating students learning on the internet can be applied in other curriculum at different levels of schools.

Reference

[1] Baker, P., & Banerji, A., "Designing electronic performance support systems, Innovations in Education and Training International, 32(1), 4-12. (1995)

[2] Chang, C. C. (1999). Designing, developing and evaluating an electronic performance support system for performing and learning instructional designing tasks. In G. Cumming et al. (Eds.), Advanced Research in Computers and Communications in Education (Vol. 2, pp. 423-426). Ohmsha: IOS Press.

[3] Gery, G., "Electronic performance support systems: How and why to remake the workplace through the strategic application of technology". Tolland, Mass: Gery Performance Press. (1991).

[4] Hoyt, B.R., Stockman, M., & Thalmann, J., "Design and implement custom electronic performance support systems (EPSS) for training in project based classes. ASCUE Proceedings, 100-107. (ED document 410925) (1997)

[5] McGraw, K.L., "Selecting appropriate functionality and technologies for EPSS, Innovations in Education and Training International, 32(1), 13-22. (1995).

[6] Raybould, B., "Making a case for EPSS, Innovations in Education and Training International, 32(1), 65-69. (1995)

[7] Pemmers, E. (1998). Guidelines for WWW-based support environments for education professionals . URL: http://mw75.student.utwente.nl/~elka/litstudy/

[8] Schwen, T. M., Goodrum, D.A., & Dorsey, L. T., "On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), 5-9. (1993)

[9] Yueh, H., Liu, F., & Wang, P., "Assessing the effectiveness of a web-based EPSS. Paper presentated at the Annual Conference of the Association for Educational Eommunication and Technology, St. Louis, MO. (February, 1998).

Students' Attitude toward WPSS in Supporting Classroom Learning

Hsiu-Ping Yueh
Department of Agricultural Extension, National Taiwan University,
#1, Sec. 4, Roosevelt Rd, Taipei 106, Taiwan
Tel: 886-2-23630231-2750
FAX: 886-2-23647221
Email: yueh@ccms.ntu.edu.tw

While the web-based learning environment has become more flexible and has more functions than traditional instructional media as well as many computer-assisted instruction, the EPSS has also become an expanding area within the field of education. This paper first describes the features of and rationale behind electronic performance support system as well as web-based performance support system; demonstrates the implementation of the web-based performance support system in assisting students' learning in a real-time multicast distance classroom; discusses the research methodology; explores the effectiveness of the use of the web-based performance support system in supporting students' learning; and provides conclusions and implications for the filed of education.

Key Words: **Distance Education, Electronic Performance Support System (EPSS), Web-based Performance Support System (WPSS)**

1 Introduction

Electronic Performance Support System (EPSS) was originally defined as a system that provides just-in-time information, advice, learning experiences, and tools in the form of electronic to help people perform a task with the minimum support from other people [3]. Based on the early definition, EPSS was perceived by many people as an interactive computer-based environment which attempts to facilitate or improve human performance such as problem solving abilities within some target application domain. To help organizations design and develop EPSS with a broader systems thinking approach, Raybould (1995) proposes that an EPSS is "the electronic infrastructure that captures, stores and distributes individual and corporate knowledge assets throughout an organization, to enable an individual to achieve a required level of performance in the fastest possible time and with the minimum of support from other people"(p.66)[6].

A number of existing technologies have been selected and integrated into design and development of an EPSS, such as artificial intelligence (AI), hypermedia, computer-based training (CBT), intelligent tutors and microworlds [5]. With the impact of the growth and development of network technology, internet or intranet has become one of the most important delivery vehicle for the EPSS. A Web-based Performance Support System (WPSS) is an innovative approach by utilizing the technologies of the world-wide-web (WWW). For a WPSS, the web is not only a delivery medium, it also provides contents and serves as subject matter experts (SMEs) as well. The DISTED (Distributed Information System & Training for Educators at a Distance Education) as an example of a WPSS has successfully functioned as a system which helps educators design, delivery and evaluate teaching in the interactive distance education [7]. The WPSS has been proved to be a better design than the traditional EPSS in terms of it's features such as cost-effectiveness, open architecture, universal acceptance and pervasive delivery [2].

Many training experts contended that Electronic Performance Support Systems are the learning tools of the 21st century [4]. While most of the major developments and applications of EPSS were designed for industrial and

commercial settings, more and more educators in many academic organizations have begun to adopt the concept and implement EPSSs in their classes. As the educational environment becomes more dynamic, the possibility of adequately imparting necessary knowledge to learners within a limited instructional schedule is increasingly challenging. Considering that our knowledge base is expanding rapidly and information is being updated at the speed of telecommunications, some educators therefore started to employ an integrated use of EPSS to facilitate learners' information retrieval. For example, Schwen, Goodrum, & Dorsey (1993) used the EPSS to create an enriched learning and information environment [8]; Law (1994) employed the metaphor of "cognitive training wheels" to describe EPSS as it facilitates learners' acquisition of skilled performance.

According to the early definition of EPSS, there are usually four major components embedded in a performance support system which includes information, training, advice and tools. To improve the functions and the design and development of a better performance support system, many researchers proposed different models of putting together an EPSS with necessary components. Gery (1991) listed three levels of functionality with four components at each level, they are user interface, help, coach/advisor, and tutor [3]. McGraw (1995) suggested that the components of an EPSS should include the human-computer interface, the help system, the coaching/advisor system, and the tutor component [5]. Baker and Banerji (1995) proposed an approach to design and implement of EPSS facilities based upon the use of a multi-layered model containing four basic levels including human-computer interface, generic tools, application specific support tools, and application domain [1]. In general, an EPSS should have four typical components including tools, information base, advisor, and learning experiences [9] to be able to support performance.

While we are moving into the resource-based learning environment in the field of education, the way of teaching and instruction has been changed accordingly. Teachers are no longer experts but facilitators or guilders; textbooks is also instead by a variety of learning resources and media. Internet is a very good tool in terms of providing the resource-based learning environment. The world-wide web with hypertext markup language (HTML) provides an easier way to present large volumes of text electronically, using efficient client/server architecture to transfer different kinds of data, such as texts with fancy fonts, colorful graphics, even sound and video clips in packets across the internet. As an integrated tool, WWW allows users to share and transfer data files easily, as well as communicate and interact more effectively. Also as a self-directed learning tool, a WPSS provides a rich environment with up-to-date information, real-world learning experiences, as well as worldwide learning resources, with which students can self-pace, monitor, and evaluate their learning.

2 Method

The purpose of this study were to investigate the effectiveness of the WPSS in supporting students' learning as well as to understand students' attitude toward this system. The target population for this study is a class of students (82 students totally) registering in the distance education course titled "Web-based Instruction and Training" in Spring 1999. A WIT Web Site was designed and developed as a web-based performance support system to assist students' learning of this course. At the end of the semester, a copy of questionnaire was also designed and distributed to students to collect their perception toward this Web Site. Moreover, students' answers to a posttest essay of the final exam were reviewed for the purpose of evaluation. The data collected were analyzed by means of Descriptive Statistics, correlation, and regression study.

3 Results

For the attitude survey, most students showed positive attitude toward content information (usefulness, richness, helpfulness), format design (screen design, visual images design, layout consistency, links arrangement), and composition (organization, presentation, delivery, references) of this WIT Web Site. Besides, students' comments also showed that most students thought this Web Site is a useful tool in general especially it meets different learning needs of students. Furthermore, the results showed that there is a moderate correlation between students' attitude with their final exam scores. And findings suggest that most students are willing to use this kind of supporting system in their learning if other courses could provide in the future.

4 Conclusions

1. Evidence from students' attitude survey and feedback comments shows that the web based performance support system is a powerful tool in terms of assisting learning especially in the distance education learning environment. It serves as a self-directed learning tool with which students can self-pace, monitor, and evaluate their learning, which may in turn facilitate students in developing life-long learning skills.

2. Results of this study also shows that the WIT Web Site provides a powerful communication channel between instructor and students, as well as students at different learning sites in the distance education course. More specifically, the web-based discussion boards were claimed by students to be a very useful tool to expand the interaction and communication outside classroom.

3. Most Electronic Performance support Systems were used in the industrial settings in the past, however, results of this study has approved that a WPSS can also be an excellent tool for providing just-in-time assistance in the learning environment of formal education. Students perceived it as a good learning tool in many aspects including the application to future study in other contexts or subject areas. This experience of facilitating students learning on the internet can be applied in other curriculum at different levels of schools.

Reference

[1] Baker, P., & Banerji, A., "Designing electronic performance support systems, Innovations in Education and Training International, 32(1), 4-12. (1995)

[2] Chang, C. C. (1999). Designing, developing and evaluating an electronic performance support system for performing and learning instructional designing tasks. In G. Cumming et al. (Eds.), Advanced Research in Computers and Communications in Education (Vol. 2, pp. 423-426). Ohmsha: IOS Press.

[3] Gery, G., "Electronic performance support systems: How and why to remake the workplace through the strategic application of technology". Tolland, Mass: Gery Performance Press. (1991).

[4] Hoyt, B.R., Stockman, M., & Thalmann, J., "Design and implement custom electronic performance support systems (EPSS) for training in project based classes. ASCUE Proceedings, 100-107. (ED document 410925) (1997)

[5] McGraw, K.L., "Selecting appropriate functionality and technologies for EPSS, Innovations in Education and Training International, 32(1), 13-22. (1995).

[6] Raybould, B., "Making a case for EPSS, Innovations in Education and Training International, 32(1), 65-69. (1995)

[7] Remmers, E. (1998). Guidelines for WWW-based support environments for education professionals. URL: http://mw75.student.utwente.nl/~elka/litstudy/

[8] Schwen, T. M., Goodrum, D.A., & Dorsey, L. T., "On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), 5-9. (1993)

[9] Yueh, H., Liu, F., & Wang, P., "Assessing the effectiveness of a web-based EPSS. Paper presentated at the Annual Conference of the Association for Educational Eommunication and Technology, St. Louis, MO. (February, 1998).

Students' thinking processes when learning with computer-assisted mass lectures.

Nopphol Pausawasdi* and Dr Lyn Henderson**
School of Education, James Cook University,
Townsville, Queensland 4811, Australia
Phone: 617 4781 6984
Facsimile: 617 4725 1690
*Email: *Nopphol.Pausawasdi@jcu.edu.au,*
***Lynette.Henderson@jcu.edu.au*

This paper presents findings from a research project that examined students' thinking during mass lectures that utilized interactive multimedia (IMM). The data were obtained from six second year Thai medical students via stimulated-recall interviews. The reported thinking (or mediating) processes engaged in by the students during the mass lectures that related to the academic content of the physiology subject are detailed and discussed. We identified 18 different types of thinking skills including generating, anticipating/predicting, linking, metacognition, analyzing, and categorizing. These ranged from a high usage frequency (generating) to a low usage frequency (categorizing). Being able to understand such student thinking may result in more effective use of IMM in mass lectures. The data are also compared with studies that provided students' reported thinking processes when studying with the WWW, IMM, and text-based material. The significant differences in the mediating processes between using IMM in computer-assisted mass lectures, where the students did not directly interact with the IMM, and hands-on use of IMM, the WWW, and text-based material are discussed.

Keywords: **Thinking skills, Computer-assisted mass lecture, IMM, medical education, Thai medical students**

1 Introduction

There is increasing use of IMM in mass lectures in universities for teaching and learning. Yet IMM supported lectures do not guarantee better content learning or higher-order thinking than do traditional instruction methods. There is much research and literature concerning instructional design, the characteristics of IMM, and learning: for instance, the use of educational technology [1] and the effects of colors [2], animations [3], and interactivity [4]. Research has neglected how students engaged with the new technology in lectures. The research by Nowaczyk, Santos, and Patton [5] examined student perceptions of various characteristics of multimedia such as color transparencies, video, and PowerPoint in tutorials and mass lectures. However, they did not investigate students' thinking processes about the academic content. The research by Faraday and Sutcliffe [6] examined visual attention and comprehension of multimedia presentations. Research by Putt, Henderson, and Patching [7] and Henderson, Putt, Ainge, and Coombs [8] examined learners' mediating process about the academic content of IMM and WWW courseware, respectively. However, these did not focus on an IMM mass lecture context.

Studies report that IMM can be effective in encouraging higher order thinking skills when learners work with IMM individually or, better still, in pairs or small groups [9, 10, 11]. However, in a mass lecture, the IMM is controlled by the lecturer. Learners play a passive-receiver role. Are they focused on the content? What sort of thinking about the content do they engage in?

Heeding current literature in the field [1, 12, 13], the study does not aim to ascertain whether learningwith

IMM supported lectures produces better learning or test outcomes than traditional lectures. Rather, it utilizes qualitative methodologies to ascertain the students' thinking skills as they learned in the authentic context of a lecture theatre. Thus the study sought to:

(a) identify and categorize the thoughts concerning the content of the IMM supported lectures that were reported by the students;

(b) compare the mediating processes reported in the computer-assisted mass lecture study with those reported in research which identified the reported mediating processes that occurred in three studies where students had hands-on use of IMM software, WWW courseware, and text-based materials respectively; and

(c) with respect to (b), evaluate our hypothesis that the type of interaction with the learning materials would be a significant factor, that is, the lack of direct manipulation of the learning materials would result in lower percentage frequencies of reported mediating processes (our study) compared with those reported in the other studies that had direct hands-on interaction.

2 Methodology

Much existing research data regarding the efficacy of computer mediated environments is anchored in the process-product paradigm. The paradigm is based on the assumption that instructional stimuli give rise to learning outcomes. Recognition of the simplistic nature of this general cause-effect paradigm when applied in education, led to the adoption of the mediating process paradigm that focuses on student thought processes that mediate, or come between, instructional stimuli (the IMM supported lecture) and learning outcomes [14]. Mediating processes can be viewed as the fine-grained elements of cognition through which, and by which, learning outcomes are realized. Thus, learning outcomes are the function of the mediating processes activated by instructional tasks and other learning activities. Salomon [11] describes the contrast between analytic research that is focused on isolating effective instructional treatments and systemic research focused on understanding how instructional treatments work in practice. This study embraced systemic research focussing on the sorts of thinking that tertiary students engaged in during IMM supported lectures.

It is a qualitative study utilising stimulated recall interviews to ascertain students' thinking in authentic contexts. Learning is related to the quality and quantity of thinking undertaken by learners [15]. To categorize and tabulate students thinking skills, a process-tracing methodology is utilized. It involves appropriate self-reporting techniques through using a video to stimulate recall of cognitive processes engaged in during a learning/study session. The stimulated recall interview technique follows strict guidelines [14]. Triggered by such things as the students' non-verbal actions or what is appearing on the computer screen, non-leading questions are asked, such as: "You seemed to frown; can you tell me what you were thinking?" and, in order to confirm that the reported thought occurred during the learning session and not while being interviewed, "Did you think that then or just now?" Both the interviewer and students can stop the video when they believe something is significant and, for the student, when the video triggers a thought that he/she had had during the initial study session. This method has been used in different settings with different mediums and with individuals, pairs, and small groups [7, 8, 16, 17, 18].

2.1 Context, Participants and Data collection

The research context and methodology capitalize on authenticity [11]. The students' thinking processes were obtained in realistic, ecologically-valid situations as the data were collected from students working in their regular environment. Thus for the current study, the research was conducted with a physiology class in a mass lecture theatre, Faculty of Medicine Siriraj hospital, Mahidol University, Bangkok, Thailand. The lecturer used A.D.A.M., The interactive physiology-muscular system [19] in the one hour lectures. Two lecture sessions were video recorded. Six students volunteered to participate in the stimulated-recall interviews. There were four males and two females with ages ranging from 17 to 19 years. They were in the third semester of a six year Medical degree. The six participants self selected into 3 pairs, 2 male pairs and 1 female pair. Working in pairs was the favored study practice of these Thai medical students. The first male pair was interviewed after the first lecture session; the others after the second lecture session. The content of both lectures was the same topic and used the same IMM. All six participants attended both lectures.

The interviews were conducted with one pair at a time. The interviewer and each pair of participants together viewed a videotape of the lecture and a synchronized computer screen showing the A.D.A.M. IMM software that was used in the lecture. The video picture included the lecturer's verbal and non-verbal behaviors and the content of the computer-assisted lecture. The computer screen showed the A.D.A.M. IMM

software content which appeared on the videotape. Both videotape and computer screen facilitated the participant's recall and verbalization of their thinking during the lecture. The three stimulated recall interviews, one hour duration for each interview, were conducted immediately after the lecture sessions and were audio taped for later transcription and analysis.

3 Results

From the interview transcripts of the students' stimulated recall interviews, their thinking skills were identified, categorized, and then analyzed. Both authors together identified the thoughts from the first transcript. The others, they did individually. Then the data from each researcher were compared and discussed. Consensus was achieved when disagreement occurred. The data that were considered invalid, such as student's thinking that did not occur during the study session, the reports of students' activities that were not related to their thinking, and answers where the interviewer had led the student, were identified and discarded. Only students' thinking that occurred during the study session were identified as useable data.

The students' thinking data reported by participants were classified according to the mediating processes identified by Henderson, et al. [8]. The 18 mediating processes identified in our study are listed in Table 1 which provides a definition for each thinking skill and a clarifying example of each from the data.

Type	Description	Example
	Mental activity in which a student -	
Affect	reports feelings aroused by content during study	"He [the lecturer] clicked A. I was glad. My answer was correct."
Analyzing	Reduce, breaks down whole (e.g., problem, task) into parts	"I've learned that content. There were some new parts adding to it. The rest was old."
Anticipation	predicts or states expectations that problem, question, or textual feature will be encountered; wonders about: the possibility of an event, relevance of material, content	" He [the lecturer] was talking about timing. So, I thought ahead that it must higher. And when stimulated, a bit slower - it would be lower."
Applying	Considers the use of an idea, tactic in a different context.	"When I saw the clearer image, I thought they should use this technique in the textbook because it can't use animation."
Categorization	Sorts items, ideas, skills into different groups	"I thought I already noted this as asynchronous."
Comparison	identifies similarities, differences between two statements, concepts, models, situations, ideas, theories, points-of-view, etc.	"From the graph shown on screen, I thought it would appear in another way."
Confirmation	judges that ideas in text support one's own beliefs, practices, tactics	"When he [the lecturer] clicked, I just thought that one is correct."
Deduction	reasoning process by which a specific conclusion necessarily follows from a set of general premises	"I felt the image doesn't look real because the vesicle [4small bags within a larger bag] has just 4 bags and the water filled this space."
Deliberation	engages in "thinking" about a topic, prose segment, etc. (type of thinking not disclosed)	"I was thinking about the question."
Diagnosis	identifies strengths and weaknesses in idea, strategies, points-of-view	"I thought it made me understand better by cropping and enlarging the picture. So I can see it clearly"
Evaluation	makes judgments about the value, worthwhileness of textual materials, activities, in-text questions, own position or point-of-view	"I thought the topic shown at the top was good. It told me what I was going to learn."
Generating	formulates one's own questions, examples, ideas, or problems; interpolating; going beyond the data	"What does the handle look like? Stimulate by hands! Do we use hands to do that?"
Imaging	creates a mental image of an idea in text in order to gain a fuller understanding	"I thought about the real muscle and how it should look if I cut it"
Linking	associates or brings together two or more ideas, topics, experiences, tasks	"I thought about the frog's leg in the laboratory."
Metacognition	thinks about, reflects on, evaluates or directs own thinking	"I couldn't see the shrink in the first animation. I thought I need to focus more on the next one"
Recall	brings back into working memory an idea, opinion, fact stored in long-term memory	"This picture, I thought I learned it before."
Reflection	general indication of careful consideration or thought over past action and response; tries to establish the reason or causal link between the action and its response	"When this graph was shown, I thought the latent period is narrow. At first, I thought it would be wide and red like the previous one."

Strategy Planning	plans ways of processing or handling content material during study or learning sessions	"When I saw these, I would open the textbook. I did not wait. I would note the additional information in the textbook."

Table 1: Mediating Processes Identified in the Present Study

Note: Descriptions are adapted from Marland, et al. [14] and Henderson, et al. [8]; examples are from the current study.

The frequencies for each type of mediating process were tallied (Table 2). The data in Table 2 indicate the frequency of the 18 identified mediating processes. The data shows the different frequency of mediating processes between three pairs and the variation in the frequency of occurrence of mediating processes. These ranged from

Categories of classification	*Mediating Process (i.e., thinking skills)*	*Frequency (1st male pair)*	*Frequency (female pair)*	*Frequency (2nd male pair)*	*Total*	*Percentage (%)*
Content	Generating	3	19	11	33	14.5
	Anticipating/Predicting	1	10	20	31	13.7
	Linking	2	14	11	27	11.9
	Metacognition	11	7	6	24	10.6
	Evaluating	6	7	7	20	8.8
	Strategy Planning	0	6	10	16	7.0
	Recalling	8	3	4	15	6.6
	Affective	3	2	9	14	6.2
	Confirming	0	4	5	9	3.9
	Deliberating	1	2	6	9	3.9
	Diagnosing	6	1	2	9	3.9
	Imaging	0	0	7	7	3.0
	Reflecting	1	6	0	7	3.0
	Comparing	0	3	1	4	1.4
	Applying	1	1	0	2	0.9
	Deducing	1	0	1	2	0.9
	Analyzing	1	0	0	1	0.4
	Categorizing	0	0	1	1	0.4
	Total thoughts	45	85	97	227	100
	Mean number of mediating processes per pair from 3 pairs		76		based on responses	

Table 2: Frequency of Mediating Processes Related to Academic Content.

14.5% for "generation" to 0.4% for "analyzing" and "categorizing". A total of 227 mediating processes were identified from the transcripts. The mean number of reported mediating processes per pair was 76. The first male pair who were interviewed after the first lecture reported 45 mediating processes. The other male and the female pair who were interviewed after the second lecture reported 97 and 85 mediating processes, respectively. Familiarity with content and presentation probably influenced the higher number of thinking processes during the second lecture.

Mediating processes	*This study:* IMM in mass lectures (%)	*Study by Henderson, et al.. (1997):* IMM study (%)	WWW study (%)	Text-base study (%)
Generating	very high (14.5)	high (8.4)	very high (10.1)	Low (3.6)
Anticipating/Predict.	very high (13.7)	high (7.8)	very low (1.4)	high (5.9)
Linking	very high (11.9)	very high (11.4)	very high (11.5)	very high (10.4)
Metacognition	very high (10.6)	very high (19.8)	high (9.4)	very high (12.4)
Evaluating	high (8.8)	very high (18.0)	very high (26.5)	very high (18.6)
Strategy Planning	high (7.0)	very low (1.8)	high (7.7)	very high (16.8)
Recalling	high (6.6)	high (6.6)	very low (1.0)	low (4.1)
Affective	high (6.2)	very high (14.4)	high (9.4)	high (7.8)
Confirming	low (3.9)	Very low (1.8)	low (4.5)	very low (2.8)
Deliberating	low (3.9)	very low (1.8)	very low (2.8)	none (0.0)

Diagnosing	low	(3.9)	none	(0.0)	low	(3.1)	low	(0.26)
Imaging	low	(3.0)	very low	(0.6)	very low	(2.4)	none	(0.0)
Reflecting	low	(3.0)	none	(0.0)	very low	(0.003)	none	(0.0)
Comparing	very low	(1.4)	low	(4.8)	very low	(2.1)	very low	(1.5)
Applying	very low	(0.9)	none	(0.0)	none	(0.0)	none	(0.0)
Deducing	very low	(0.9)	none	(0.0)	very low	(1.4)	none	(0.0)
Analyzing	very low	(0.4)	very low	(2.9)	none	(0.0)	very low	(1.1)
Categorizing	very low	(0.4)	none	(0.0)	very low	(1.0)	very low	(0.005)

Table 3:Comparative students' mediating processes frequency between this study and the study by Henderson, et al. [8]

The data in Table 3 show the variation in the frequency of occurrence of mediating processes in our study and that by Henderson, et al. [8] which reports data from three different studies. In these three studies, the tertiary education students had hands-on control of the IMM software, the WWW courseware, and the text-based materials. (Our research was not aimed at arguing that one type of learning material [the IMM in mass lectures, the hands-on IMM study, the WWW study, or the text-based study] was better educationally. Our intention with the comparison frequency of thinking processes was that, if the quality and quantity of reported thinking skills was comparable with those reported in the other three studies, and if hands-on interactivity did not appear to be a crucial factor, then lecturers would feel a level of confidence in using IMM in mass lecture.)

Based on four level divisions used in the Marland, et al. [14], Putt, et al. [7], and Henderson, et al. [8] studies, the frequency of occurrence is divided into very high, high, low, and very low in order. In all studies, the 3% and 10% cut-off figures were arbitrarily chosen, whereas 5.5% (100/18), the cut-off for the "high" category, was the average percentage frequency across all 18 categories.

In Table 3, the categories of generating, anticipating/predicting, linking, and metacognition have the highest frequency (f>10) in this study. According to the study by Henderson, et al. [8], linking was rated very high in learning with the WWW, IMM, and text-based materials as well. However, while anticipating/predicting rated as very high in this study, it rated as low in the WWW study and high in the IMM and text-based studies. Evaluating was reported often in all four studies. It was rated as high in this study and very high in the other three studies. Interestingly, strategy planning was very low (f<3) in the IMM study, but it rated as high in this study and the WWW study and very high in the text-based study. Recalling rated as high in only the two studies that used IMM. Comparison of the results show that ten mediating processes (confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing) occurred in the low to very low frequencies in all four studies.

4 Discussion

The following discussion focuses on the comparison of mediating processes that were reported by students during their learning sessions. In the computer-assisted mass lectures, the A.D.A.M. IMM software was used as a teaching-learning tool. It played a major role in the lectures. However, the students were not in a position that allowed interaction with the IMM. They were a group of passive-receivers who possibly consumed the content provided by the lecturer via the IMM features. Therefore, the data obtained in our study concerns the reported mediating processes of students who learned with IMM without direct hands-on interaction. The comparison data between our study and that reported by Henderson, et al. [8] reveals factors that influenced students' mediating processes while learning with different mediums. Moreover, it also revealed the differences in the quantity and quality of the reported thinking skills when students had direct hands-on interaction versus receiver interaction.

The top frequency percentages for the four studies are 26.5% (WWW), 19.8% (IMM), 18.6% (text-based), and 14.5% (our study). The data reveal a higher percentage frequency of the most reported thinking skills in the studies where students had hands-on interaction control. If we add the percentages of all mediating processes in the "very high" category for all four studies then the differences are 63.6% (IMM), 58.2% (text-based), 50.7% (our study), and 48.1% (WWW). Nevertheless, even though the students in the hands-on WWW study had the fewest reported mediating processes in the very high frequency range, there was only a small percentage difference (2.6%) between it and our study. In terms of these criteria, the data generally tends to support our hypothesis. The students in the hands-on IMM study obviously reported more mediating processes than those in the IMM computer-assisted mass lectures. However, when the number of mediating

processes per person in all four studies is averaged, the results are 38 per person for our study, 16 per person for the IMM study, 36 per person for the WWW study, and 28 per person for the text-based study. The low hands-on IMM number was affected by having learner groups of more than two students; beside two groups of two students there was one of three and one of four students in the stimulated recall interviews [20]. Nevertheless the highest number was in our study where students did not have hands-on control. Moreover students in our study reported more types (18) of mediating processes during learning. Students in the WWW, IMM, and text-based studies reported 16, 14, and 13 different types of mediating processes respectively. The students in the WWW study did not report applying and analyzing. The students in the IMM study did not report reflecting, applying, deducing, and categorizing. Those in the text-based study did not report deliberating, imaging, reflecting, applying, and deducing (Table 3). Breadth, that is, the number and type of different mediating processes are relevant to engaging meaningfully with the content as is the number per individual. Thus hands-on control does not seem to be the crucial factor here. The following discussion examines these issues concerning our hypothesis by singling out various mediating processes for analysis and reveals that our hypothesis is tenuous.

The top four mediating processes in our study were generating, anticipating/predicting, linking, and metacognition in descending order. "Generating" encompasses one or more of the following: (a) formulation of one's own questions, examples, ideas, opinions, problems, and answers; (b) interpolation by adding new knowledge through the elaboration of existing knowledge within a given framework; and/or (c) extrapolation which adds new knowledge by extending an existing framework and going beyond the data. The reason for the very high percentage for generating is because of the cause-effect relationship between their thoughts and the animation features of A.D.A.M., which led the students to focus on the content [21]. Generating has a very high frequency (14.5 %) in our study, a high frequency (8.4%) in the IMM study, a very high frequency (10.1%) in the WWW study, and a low frequency (3.6%) in the text-based study. Therefore, direct hands-on interaction might have caused the lower frequencies of generating in the hands-on study. Students in the three studies reported by Henderson, et al. [8] might have engaged in the jobs they needed to do to control the IMM and the WWW materials and underline or take verbatim notes from the text materials. Thus resulting in less focus on the content. Students in the computer-assisted mass lectures just followed the lecturer's presentation, which may have allowed them to allocate more time to focus on the content.

"Anticipating/predicting" includes predicting, looking forward to, speculating about, and expecting the likelihood of encountering problems, types of content, and features of the medium. Anticipating/Predicting is the second highest ranked mediating process having a very high frequency in our study. It had a high frequency in the other IMM study. A possible explanation for this finding is that the lecturer was the only person who controlled the A.D.A.M. IMM software, thus the students anticipated and predicted what the lecturer decided to present and what would emerge in the A.D.A.M. presentation. Students in the IMM study had direct interactive hands-on control of the IMM. Therefore, it is possible that they automatically clicked the mouse to move to the next page, clicked for the answer to embedded questions, and clicked to control the animation without allowing time for anticipation or prediction. The very low score (1.4%) for the WWW study appears to be an anomaly. Perhaps the content, particularly the instructional design of the content, did not promote these thinking skills. Or perhaps the students used the hypermedia functions of the WWW and engaged in thoughts such as "I will click on this link" rather than wondered what content ideas would be presented embedded in that link. In our study, students in the computer-assisted lectures had to wait for lecturer interaction. Thus, during waiting, they had more time to anticipate or predict the coming content.

"Linking" had a very high frequency in all four studies. It is defined as the process of associating, or bringing together in the mind, two or more ideas, topics, contexts, personal experiences, words, and so forth. From this finding, linking occurred easily when text, picture, graphic, or animation that illustrated the concept prompted recall of an associated item in the student's memory. Therefore, it is not surprising that linking occurred very often in all studies because they contain those elements that influenced students to consider how the information related to their experiences. This also shows that, in comparison with our study, direct hands-ôn interaction did not influence the linking processes.

Mediating processes classified as "metacognition" are those in which students reported awareness of, reflecting on, evaluating, or directing their own thinking. This definition reflects a widely accepted view of metacognition as referring to students' knowledge about, and control over, their cognitive processes. The findings show that metacognition had the fourth highest frequency of mediating processes in this study. The students were able to engage with the content and thinking about their own thinking as it related to the content, and were less inclined to be sidetracked by the features of IMM, the lecturer, and

student-idiosyncratic factors [21]. Metacognition had very high and high frequencies in the four studies (see Table 3). In three studies the percentage frequencies were similar: our study (10.6%), the WWW study (9.4%), and the text-based study (12.4%). However, there was a significant gap between these and that for the hands-on IMM study (19.8%). A factor that possibly made the gap is that the hands-on IMM study contained embedded questions that forced students to interact in order to receive feedback and to be able to move to the next section. In our study, the A.D.A.M. software also offers the same feature, but the students did not have hands-on control. The text-based study also provided embedded questions, but did not provide feedback and also did not "force " the students to answer those questions. The WWW study did not provide embedded questions. This comparison shows that the different pedagogical instructional design in conjunction with the hands-on control is a crucial factor that influenced metacognition. Nevertheless, it is still significant that students engaged in metacognition, which is a type of thinking that is considered to be one of the highest types of cognitive processes [22].

"Evaluating" is defined as the mental process in which a judgement is made about the value or worth of some aspect of the content of the instructional material. Evaluating had a high frequency (8.8%) in this study. The percentage of reported evaluative thoughts about content is very high in the other three studies (18.0%, 26.5%, and 18.6%). The gap between our study and the other three studies is significant. The students in the other three studies used the learning tools by themselves. Thus, it would seem that hands-on experiences and, hence, control over their own pacing and navigated sequencing with the learning tools produced more evaluative thoughts. In computer-assisted lectures, the students may not have had enough time to evaluate the content as well as generate new ideas, link to their past experiences, or metacognise. Perhaps, the students in our study rationalized that if the lecturer had purposely selected out this particular IMM A.D.A.M. material then it was important. In the hands-on studies, the students had to make the evaluative decision as to what content was worthwhile or relevant to their individual goals.

"Strategy planning" refers to thought processes in which students plan ways of processing or handling instructional material or activities during study or learning sessions. There is a dramatic gap between the frequency percentage for IMM study (1.8%) and the other three: our study (7.0%), the WWW study (7.7%), the text-based study (16.8%). The students in our computer-assisted mass lecture study had to follow the lecturer's presentation. One could therefore assume that the frequency rate would be "very low"; but why then the very low score for the IMM study? There appear to be three explanatory factors. The first factor suggests, as is the case with lectures in general, in our study students planned how to deal with the information and process the content through note-taking, drawing graphs, and deciding whether to annotate the textbook or attempt to draw or describe the animations that they cannot control. The second factor is that the students in the IMM study when interacting with IMM, did not appear to spend time thinking about how they would process the material but instead just followed the linear sequence programmed as the "default" choice [8]. The third factor is that, in comparison with the IMM study, in which assessment was not a factor, the students in the computer-assisted mass lectures, the text-based, and the WWW studies knew that the content was assessable. This might have influenced the students' strategy planning.

"Recalling" is defined as bringing back into working memory ideas, opinions, and facts previously stored in long-term memory. It has a high frequency (6.6%) in both studies that used IMM while it was rated very low (1.0%) in the WWW and low (4.1%) in the text-based studies. The gap between the studies that used IMM and those that did not use IMM is substantial. It is possible that the features of the IMM products, such as animation and enforced embedded questions, encouraged students to recall their previous knowledge and experiences during learning.

It is interesting that confirming, deliberating, diagnosing, imaging, reflecting, comparing, applying, deducing, analyzing, and categorizing were rated as low or very low (see Table 3) in all four studies. The type of interaction (hands-on or receiver), the mediums and their features did not seem to influence these types of mediating processes. This implies that factors that should be considered are the content and whether its instructional design prompted these types of thinking skills.

5 Conclusion

It has been argued that IMM is more useful as a learning tool when used individually or with others rather than in mass lectures where students could be seen as merely passive receivers. Our study shows that hands-on interaction does not appear to be such a crucial variable. Indeed in our study, the quantity, quality and range in type of mediating processes were greater than, or comparable to, the other studies. Therefore, the authors argue that IMM can be used as a cognitive tool in mass lectures to enhance various thinking

shills. This study draws the attention of instructional designers and lecturers to the existence, types, and relative frequencies of mediating processes in which students engage with while learning with computer-assisted mass lectures. They were not passive receivers but active receivers. Our study highlights the need for instructional designers to plan educational materials that will activate desired mediating processes as part of student learning in computer-assisted mass lectures.

References

[1] Glenna, T. K. & Melmed, A. (1996). Fostering the use of educational technology: Elements of a national strategy. A Rand Report. Santa Monica, CA: Rand. [Also Online] http://www.rand.org/publications/MR/MR682/contents.html Accessed 31 March 2000.

[2] Chapman, W. (1993). "Color Coding and the Interactivity of Multimedia," Journal of Educational Multimedia and Hypermedia, pp.3-23.

[3] Rieber, L. (1991). Theoretical foundations of instructional applying of computer-generated animated visuals," Journal of Computer-Based Instruction, 18(3), 83-88

[4] Sims, R. (1998) Interactivity for effective educational communication and engagement during technology based and online learning, [On line] http://wwwtlc1.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/rs/sims1.html. Accessed 3 March 2000.

[5] Nowaczyk, R., Santos, L., & Patton, C. (1998). Student perception of multimedia in the undergrad classroom. International Journal of Instructional Media, 25(4), 367-382

[6] Faraday, P., & Sutcliffe, A. (1996). An Empirical study of Attending and Comprehending Multimedia Presentations. London: City University, pp 265-275.

[7] Putt, I., Henderson, L., & Patching, W. (1996). Teachers' thinking elicited from interactive multimedia professional development courseware. Educational Technology Research & Development, 44(4), 7-22.

[8] Henderson, L., Putt, I., Ainge, D., & Coombs, G. (1997). Comparison of student thinking process when studying with WWW, IMM, and Text-based material.

[9] Park, I., & Hannafin, M. (1993). Empirically-based guidelines for the design of interactive multimedia. Educational Technology Research & Development, 41(3), 63-85.

[10] Simpson, M. (1994). Neurophysiological consideration related to interactive multimedia. Educational Technology Research and Development, 42(1), 75-80.

[11] Salomon, G. (1998, February). Novel constructivist learning environments: Some issues to be concerned with. Paper presented at Thinking in Teaching and Learning Conference, Jerusalem.

[12] Clark, R. E. (1994). Media will never influence learning. Educational Technology Research and Development, 42(2), 21-29.

[13] Reeves, T. (1997). Pseudoscience in qualitative research. [Online] ITFORUM listserv. ITFORUM@UGA.CC.UGA.EDU Access date: 3 March 2000.

[14] Marland, P.W., Patching, W.G., & Putt, I. (1992). Learning from text: Glimpses inside the minds of distance learners, Townsville: James Cook University.

[15] Litchfield, B. C. (1992). Evaluating 0f inquiry-based science software and interactive multimedia programs. Computing Teacher, 19(6), 41-43.

[16] Galluzzo, G.R. (1984, April). A study of student-teacher thinking. Paper presented at Annual Meeting of American Educational Research Association, New Orleans

[17] Mostert, M.P. (1996). Contextualized thinking about teaching: Special educators' metaphorical representations of practical knowledge. In L. Bouton (Ed.), Pragmatics and language learning (pp. 189-213). Urbana-Champaign, Ill: University of Illinois.

[18] Norton, R.A. (1987 April). Divining and defining a problem space: An investigation of preservice teachers' interactive thinking. Paper presented at Annual Meeting of American Educational Research Association, Washington, DC.

[19] Branstrom, M. (1996). A.D.A.M. The interactive physiology-muscular system [CD-ROM], A.D.A.M. Software, Inc. and Benjamin & Cummings Publishing, Atlanta, GA

[20] Patching, B., Henderson, L., & Putt, I. (1994, February). Interactive and Thinking: A report on research in progress. Paper presented at Second International Symposium on Interactive Multimedia, Perth.

[21] Pausawasdi, N., & Henderson, L. (2000, June-July). Students' Engagement Behaviors in Computer-Assisted Mass Lectures. Paper presented at World Conference on Educational Multimedia, Hypermedia, and Telecommunication, Montreal.

[22] Osman, E. M., & Hannafin J. M. (1992). Metacognition Research and Theory: Analysis and Implications for Instructional Design. Educational Technology Research and Development, 40(2), 83-99.

Telementoring in Surgery

U Kyaw Tin Hla* and Soe Soe Nwe**

**Department of Surgery , Kulliyyah of Medicine, International Islamic University Malaysia IIUM, Jalan Hospital 25150,Kuantan, Pahang Darul Makmur, MALAYSIA, Tel:609-5132797 ext 3437 Fax: 609 -5133615 Email ukyaw@iiu.edu.my, kthla@hotmail.com, kthla@pd.jaring.my,*

***UNIMASClinic, Kota Samarahan, 94300,Sarawak, Malaysia, Email snsoe@mailhost.unimas.my*

1 Introduction

Mentoring or supervision in surgical operations is very labour-intensive. Hands-on learning is part of the method of teaching and learning in operative surgery. This requires one-to-one learning in the presence of an instructor or guru. This is expensive and time consuming yet necessary if the student is to learn effectively and their ability accurately assessed.

Telementoring in surgical operations in remote areas of Malaysia, as in inaccessible parts of the rest of the world, could become a reality by using existing hardware/ software solutions and facilities over the World Wide Web in a cost effective way. This is being developed and tested by the authors and a group of students.

The first stage of the project has shown that this new development in pedagogy can be used effectively and has the potential for many useful future applications. With further extensions it will be a useful new educational method for distance learning students and less-experienced colleagues. Expansion of this approach, the second stage of the project, will enable real-time supervision of the teaching -learning process of students of surgery. This will mean it will be as if the guru is beside the learner at all times; saying " stop" when the mentor wants the student/ learner to reconsider, (either when undertaking a procedural step or during the operation), and then giving instructions on how to carry out the correct operative steps at the very moment required. Such corrections will be under the supervision and direct vision of the guru who, despite his remote location from the operation, will have everything under his control .

The first stage of the project was undertaken in Sarawak, where many rural people, as in other parts of Borneo, have problems in accessing specialists in an emergency due to the rough terrain which mkes immediate transfer of patients impossible. Although helicopters are employed they cannot operate after 6pm or in bad weather and they are costly. When the second stage of the project is completed, health authorities with such remote populations will have an affordable option to improve access to specialists for its citizens by providing mentoring to junior doctors.

Such technology could save lives in areas were speedy evacuation of patients is not an option. It is also a cost-effective way of training medics and other health care providers in remote areas.

2 Hypotheses and Rationales

Telementoring in surgical operations in remote areas of Malaysia, or the rest of the world, could be made a reality by making use of existing hardware/software and the facilities over the WWW in a cost effective way, at the same time as achieving acceptable resolutions for clinical use for decision making and supervision during surgical undertakings

3 Objectives of Project

The project consists of two stages each with its own set of objectives. These are:

Stage 1

a. To test if the best quality recordings of surgical operations, performed by the author during his weekly surgery

in Sarawak General Hospital, were clinically acceptable after digitizing them for video streaming.

b. To determine if images could be transfered over the intranet, later the internet, using easily available existing hardware and software solutions.

c. To evaluate the acceptability of the output for clinical decision making with regards to clarity, resolution, speed and voice clarity and quality.

Stage2.

a. To develop real-time videostreaming of surgical undertakings by incorporating the output from stage one into an improved version of a web-based module previously developed by the author.

b. To test the outcome

4 Materials and Method (Stage 1) TELEMENTORING OVER THE INTRANET

Recordings were made using a Sony TRV 301E Digital camera on Sony Hi 8digital tape while surgery was carried out by the author. The video recordings were turned into digital clips of approximately 100 Megabytes AVI on a Sony VAIO Laptop Personal Computer, PCG-F360, using video-capturing software DVGate Motion from Sony. Firewire Link IEE 1394, three metre in length was used for fast transfer at 200MB/ second rate in real time. A laptop PC was used as it has the added advantage of being mobile and therefore could be used anywhere where there was a www connection. This would enable supervision of emergency surgery from a mobile unit.

The clips of approximately 100 Meg made on ***DV Gate Motion*** were first converted into raw AVI uncompressed using software **MainActor**. The resulting AVI produced were turned into a media file compatible with Microsoft Media Player using on **Demand Producer**, a Window 2000 Professional product. Media clips of similar size were then produced by using Real **Producer** which were subsequently played on Real Player G2.

Each of these clips were transferred over to another PC over the Local Area Network (LAN) and viewed using widow Media Player (Microsoft 2000 Professional Beta product) and Real Player G2 (freeware). The video quality was evaluated by the author and two other independent viewers for clarity, definition, resolution, speed and sound quality and whether it was acceptable for clinical decision making. The first testing was done over the local area network on UNIMAS' s campus.

5 Results

Findings -.The evaluations as shown in the table for the three available digital capture format and viewers , showed comparable results on all test- runs . Same video clips of operation on total thyroidectomy was used. for standard comparison.

Sony avi	RealG2	Media player	
+++	+++	+++	**Clarity**
+++	+++	++	**Definition/Resolution**
++	++	++	**Speed**
++	++	++	**Voice**

6 Conclusion

The project was found to be viable using just the available facilities. An acceptable resolution, clarity and definition was achieved for both clinical decision making and supervision during surgery.The three objectives of the first stage were met. This is an interim report of our encouraging results. This was a necessary pilot project to test the standard of the video produced before developing the desired application of real-time videostreaming and telementoring of surgical applications over the WWW. This second stage will use an improved version of a web-based module previously created by the author and presented at ICCE 99 held in Chiba, Japan. Production of this module used Pinnacle' s MP10 hardware software solution which, together with the use of a digital camera, helped to eliminate this intermediate and time consuming steps of initial conversion to raw AVI clips before it could be used on a Real server is used for streaming later .To be reported later. **TELEMENTORING IN SURGERY** using this innovative and value-added tool a junior medical officer in a distant district hospital, such as Kapit or Belaga in Sarawak, or Jeruntut in Pahang will definitely benefit from the instruction given in real-time by a senior surgeon in a specialist hospital using this innovative but inexpensive tool. *Telementoring is likely to become t*he very back-bone

of **teleconsultation** , one of Malaysian Telemedicine Project, *as it will go beyond advice on clinical diagnosis and decision making to transferring surgical skills from the specialist to the novice.*

7 Bibliography

[1] Alaska Telehealth SystemAlaska Telemedicine Project.www.telemedicine.alaska.edu/, (1999).

[2] Davis Chapman,. Web Development With Visual Basic 5, 1st Edition.Que Corporation. (1997)

[3] Devzone RealNetwork, http://www.realnetworks.com/devzone/index.html(1999)

[4] GRiNS Editor Pro for RealSystem G2http://www.realnetworks.com/promos/bndl2.html(1999)

[5] Hla, Kyaw Tin, "New Paradigm of Facilitating Problem - Based Learning (PBL) over the World Wide Web in University Malaysia Sarawak", Advanced Research in Computers and Communications in Education,IOS Press, Amsterdam,/ Proceedings of 7th International Conference on Computers in Education (ICCE 99), Chiba, Japan,November 4-7,pp 819-820 (1999)

[6] Hla, Kyaw Tin," Problem - Based Learning over the Internet", Proceedings of 5th International Conference on
Computers in Education(ICCE 97), Kuching, Sarawak,Malaysia December 2-6,pp 1018-1020(1997)

[7] PinnacleSystemsInc,MP10http://www.pinnaclesys.com/frameset.asp?state=HomeVideoProduct&content=4 (1999)

[8] Pinnacle Systems Inc, MP10, http://www.pinnaclesys.com/frameset.asp?state=main(1999)

[9] Real Producer http://www.realnetworks.com/promo s/nprd2.htmlSheilagh Galanger, Objectives and the Characteristics of Problem Based Learning (1997).

[10] Streaming Media StarterKit http://www.realnetworks.com/promos/starterkit/index.html?src=home (1999)

[11] Streaming Media Starter Kit,http://www.realnetworks.com/promos/bndl1.html(1999)

[12] Yale University of Medicine (1999). Telemedicine URL: http://info.med.yale.edu/yfp/about.html(1999)

The analysis of social discourse in a network-based learning community --The GeoSchool Experience

Fe-ching Chen *and Huo-Ming Jiang**
**Center for Teacher Education National Central University*
Chung-Li, Taiwan 320
E-mail: fcc@cc.ncu.edu.tw
***Institute of Atmospheric Science National Central University*
Chung-Li, Taiwan 320
E-mail: Jiang@front.atm.ncu.edu.tw

This paper is the first of a series of papers introducing the GeoSchool Project, a complex study to construct a network-based Earth Science learning environment for high school students. The set of papers will cover the following topics: (1) the theoretical foundations and research methodology; (2) data collecting and investigation software tools for visualization and quantitative analysis; (3) the project-based learning model; (4) issues raised by network-based learning experiences versus traditional classroom experiences; (5) the learning portfolio and social discourse; (6) the results and their implications. While in this paper we are focused on the analysis of social discourse and its implications in the GeoSchool experiences. 2685 articles were analyzed to discover the characteristics of the social discourse in the learning activity on the web. These articles were posted by 15 high school students and 10 mentors during a 15-day study on atmospheric science on the web. This is a study of the learners' authentic interactive process. The examination of the actual initiation and diminishing of threads in the social discourse reveals not only the characteristics of a network-based learning community mainly consisted of high schools, but also important scaffolding issues in the inquiry process. The paper looks into the following issues: What were the major categories of the 2685 posted articles? What kind of questions the learners asked? What kind of questions brought in replies and what didn't? What were the major categories of the mentors' articles? How could the mentor's scaffolding be helpful? What were the characteristics of the longer discussion threads? How could the learners scaffold each other? ... etc. After answering these questions we could then look into the broader aspects of a network-based learning community, namely, what influences did the network based learning environment have on the inquiry-based learning process of the high schools, what could we learn from the mentor-learner interactions, when did meaningful learning actually take place.

Keywords: **learning community, scaffold, mentor, Geoschool, social discourse posted articles**

1 Introduction

The thought that network-based learning environment facilitates learners to construct their own knowledge, to be reflective, and to be socially interactive has been fruitfully applied to science learning. The implication of inquiry learning in network-based learning environment also presents a number of significant challenges (Edelson, Gordin, & Pea, 1999). However, research on this field seldom showed a picture in detail of learners' interactions in such a technology-supported environment. Our goal has been to explore realistically what is the shared learning experience high school students might have and how do they articulate their own understanding, comment on each other's thoughts, and bear distributed expertise.

In this paper, we will describe and classify the articles posted on the network by both the learners and the mentors into categories in order to reveal the underlying learning styles, obstacles and scaffolding strategies. We discovered a number of characteristics of the learners' learning style and the social discourse in the network-based learning community.

2 THE PROJECT-BASED LEARNING MODEL

Over the past 3 years, the authors have been engaged in the development of cooperative project-based learning (PBL) environment of GeoSchool (http://geoschool.ncu.edu.tw). According to the definition of Krajcik (Krajcik, et al, 1998), the features of PBL learning include (a) a driving question; (b) investigations and artifact creation; (c) collaboration; (d) use of technological tools. The PBL in our GeoSchool is designed to facilitate five stages of inquiry and three steps of Co-op Jigsaw II (Kagan, 1992) teamwork. The five stages of inquiry are: problem definition, deciding variables to use and the procedures to take, data collection, data analysis and interpretation, drawing conclusions and presenting the findings. The three steps of teamwork are to form teams, to form expert groups to develop individual expertise, and then to go back to the team to share expertise. Figure 1 depicts this PBL learning model.

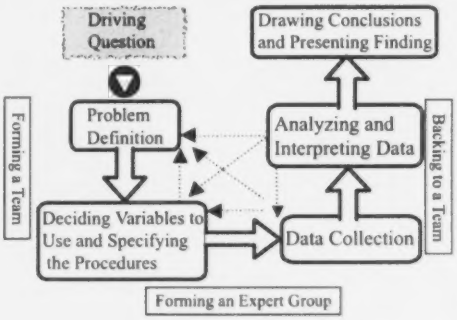


Figure 1. Cooperative PBL model

3 ROLE OF DISCOURSE IN SCIENCE LEARNING

The two major contemporary thoughts on science education are constructivism and the reflective practice. The constructivist approach involves heavy social discourse and interactions in its problematic, action taking, and reflective stages. Although reflection can be an individual activity, it can also be a social activity to be influenced by a community. Therefore the role of social discourse in science learning is gaining more importance than before. The social discourse can be helpful throughout the inquiry based learning process. For example, the learners could be inspired in the social discourse to revise and refine their original low-level factual problem definitions for higher-level abstraction; social discourse could also lead the learners to become aware of the inconsistency between their problem definitions and the conclusions they are trying to draw.

4 METHOD

4.1 Participants and Design

Participants were 15 high school students (10 girls and 5 boys), aged 16 to 17 years old, enrolled in 9 different senior high schools located in north, middle, and south part of Taiwan separately. In addition to the students, 10 university graduates and professors majored in atmospheric science also joined and served as mentors in the inquire process. Every three students formed a team by selecting one of the several driving questions they were interested in. No more than one member can come from schools in the same area so that they would be forced to communicate through the network-based learning environment. The assignment to the teams is to investigate and answer the assigned problem with justification. At the second step, each

member of a team was assigned to one of the three different expert groups. A member should go on-line to his respective expert group to inquire knowledge and to bring back to his team to finish the assignment collectively as the third step. The students were given a database of primary knowledge source on CD containing background theories and factual data but not the plain answers to the assigned problems. They were also allowed to acquire knowledge outside of either resource.

The five assigned investigative problems were (1) while a cold front is passing through Taiwan, would it be colder in the north than in the south, (2) would a stationary front lingering on the east coast cause heavy rain falls, (3) what the influences of a storm cold front passing through Taiwan on the amount of rain falls in the north and in the south respectively, (4) would the amount of rain falls brought in by 'Spring-rain stationary front' be more than that brought in by 'Mei-yu stationary front', (5) after a cold front passed through, would the temperature in high mountains be lower than that on the level ground. While the three expert groups were scaffolding knowledge on (1) climatic factors, (2) weather map, (3) high altitude atmospheric exploration, respectively.

4.2 Procedure

The complete network-based learning program ran through a 2-week period. The learners in the study were instructed to follow the curriculum set for each team and the instructions were supplemented with on-line 'tour-guide'. Before the learning program took place, the students were gathered on one-day workshop on operational knowledge. They were tutored on concept map, PBL model, the usage of database of primary sources, the know how about getting on-line and to participate in the GeoSchool network-based learning environment. Returning home from the first day gathering, the learners did not meet face-to-face in the following 14 days except on the web in their respective team area in GeoSchool. The mentors worked with the learners every day on the web. After the conclusion of their problem assignment, all the participants did meet at the last day of the program to reflect and share their experiences through this network-based learning program.

4.3 Data collection and analysis

We used a portfolio of artifacts including assignments, concept maps, reports, and posted articles to create the study on how the learners engaged in the social discourse during the network-based learning period. Each learner's posted articles were recorded by the web-BBS/DNEWS system in the GeoSchool environment for analysis.

Data were analyzed in several phases. First, DNEWS record file was transformed into Excel format and the posted articles were displayed in table format. Then, the nature and contents of each article was analyzed and the columns of qualitative descriptors in the table were checked as the classification of this article. In addition to the categorization of the articles according to their nature and contents, the insight of the social discourse were also looked into in order to discover the characteristics of (1) the interaction between mentors and learners, as well as among learners, (2) the initiation and diminishing of the threads in the social discourse, particularly threads with questions included that sustained more than 5 thematic discussions (re-posts), and (3) the correlation between style and responses.

4.4 RESULTS

The results are presented here in five parts. They are the statistics of the classification of the articles posted by the learners and the mentors, the content properties of the social discourse and the questions raised in the posting, and the effectiveness of the scaffolding strategies applied by the mentors.

4.4.1 The Classification of the Articles Posted by the Learners and the Mentors

Table 1. Classification of Articles Posted by Learners

No.	Category	Frequency	Percentage
3	Social interaction	906	38.5
6	Content knowledge	628	26.7
7	Group progress & self-regulation	499	21.1
1	Network	123	5.2
4	Database of primary sources	103	4.4

2	PBL model	66	2.8
5	Methodology in science	31	1.3
Total		2356	100.0

Table 2. Classification of Articles posted by Mentors

No.	Category	Frequency	Percentage
6	Content knowledge	136	32.9
2	PBL model	64	15.5
3	Social interaction	55	13.3
1	Network	53	12.8
5	Methodology in science	48	11.6
7	Reinforcement	39	9.4
4	Database of primary sources	18	4.4
Total		413	100.0

The statistics of the attributes of the articles posted by the learners and the mentors are shown in table 1 and 2. The categories 1 to 6 in the classification are the same in both groups, while the 7th category is 《Group progress & self-regulation》 for the learners and 《Reinforcement》 for the mentors. Apparently, social interaction is the most important discourse for high school students on the web. Articles on 《Content knowledge》 and 《Group progress & self-regulation》 ranked the second and the third, which implies that the learners are diligent and motivated and the problem assignments were challenging to domain knowledge. The low ranking of mentors' effort on 《Reinforcement》 also verifies this derivation because it did not seem necessary. The mentors were by no means parsimonious in offering encouragements.

In contrast, mentors spent more time in prompting on the 《PBL model》 in addition to content knowledge, whereas the learners didn't care too much about it. The issues on 《methodology in science》 were the least brought up actually revealed its unfamiliarity to the high school students. They were generally insensitive to the methodology issues. However, the low frequencies on 《Network》 and 《Database of primary sources》 seemed to reflect the learners' proficiency in accessing network and the CD database of the primary content knowledge sources. The GeoSchool user interface was friendly and the one-day workshop on the operational skills at the beginning was effective.

4.4.2 The Threads

Table 3. The Distribution of Elicited Discourse Threads

No.	Category	# of Threads	Percentage of Threads	Total posted articles
3	Social interaction	60	37.3	494
6	Content knowledge	59	36.6	573
7	Group progress & self-regulation	26	16.1	172
1	Network	9	5.6	52
2	PBL model	4	2.5	36
4	Database of primary sources	2	1.2	13
5	Methodology in science	1	0.6	6
Total		161	100.0	1346

In order to explore what kind of interactions the learners were interested in, we traced the part of discourse that are sustained more than 5 round of responses. The ranking of the categories of threads is almost the same as the classification of the learners' articles as shown in Table 1. These threads covered 1346 articles, which is 50.1 % of the total. An average of 8.3 posted articles per thread were categorized across the seven categories as shown in Table 3.

4.4.3 The Questions Raised

Table 4. The Distribution of the Questions Raised

No.	Category	Frequency	Percentage
6	Content knowledge	196	37.4
7	Group progress & self-regulation	141	26.9
3	Social interaction	114	21.8
1	Network	28	5.3
4	Database of primary sources	17	3.2
2	PBL model	15	2.9
5	Methodology in science	13	2.5
Total		524	100.0

The biggest category of the questions raised is 《content knowledge》. It appears that the learners were involved in the justification of their own responses or in the evaluation of other's responses while operate in a self-prompting dialogic mode. The second biggest category of the questions raised, 《Group progress & self-regulation》, is referred to plan, monitor, and evaluate progress, divide responsibilities, manage procedures and affect as well as task completion. It seems that the network-based environment provide a convenient channel for coordination. The third biggest category 《Social interaction》 reveals needs of interaction and entertainment on learning which were not allowed and encouraged in traditional classroom environment.

4.4.4 Strategies Mentors Applied with Effect

Table 5. The Strategies Applied by Mentors in Scaffolding 《Content Knowledge》

Item	Strategy	Frequency	Percentage
H	Answer directly	43	37.4
A	Ask back	25	21.7
E	Suggestions & hints	16	13.9
C	Remind their prior experience	10	8.7
G	Pretend to be a peer learner	6	5.2
D	Give examples & draw an analogy	6	5.2
B	Ask question back to create a conflicting situation	5	4.3
F	Illustrate terminology	4	3.5
Total		115	100.0

Among 342 articles posted by the mentors, 223 (65.2%) were justified to be helpful. Table 5 shows the strategies with effect applied by mentors in scaffolding discourse of category 《Content Knowledge》. Not surprisingly, the guided prompts that with significant effects were《Answer directly》, while《Give examples & Draw an analogy》 and 《Ask question back to create a conflicting situation》 were less worked.

5 DISCUSSION

Although there have been some insightful studies examining collaborative learning in science (Coleman, 1998; Edelson, Gordin, & Pea, 1999; Krajcik, et.al.,1998; Lin, et.al., 1999), few have attempted to investigate whether the formation of network-based learning community will promote learners' reflective practice or ability of inquiry. This study sought to document a rich description of the social discourse under the Geoschool environment in order to understand the impact of a network-based environment on social discourse in science learning. Following issues deserve further discussions on the interpretation of out results.

5.1 The interpretation of the percentage of the categories.

One of the purposes we classify learners' posted articles into categories is to discover the characteristics of the learner's interactive process and the behavior pattern of the inquiry based learning of high school students.

At the beginning of the study, we thought the percentage of each category represented the importance of it. We found that the three largest categories collectively accounted for almost 86% of all posted articles categorized. The rests were on 《Network》, the 《Database of primary sources》, the 《PBL model》, and the 《Methodology in science》. They were fairly evenly distributed over the remaining smaller categories.

However, cross-referenced by other artifacts, we realized that inquiry did pose many challenges for learners. Among the challenges, the use of the database of primary sources and the familiarity of inquiry skills are the most difficult ones. In short, being small does not mean that the smallest categories can be ignored. On the other hand, the smallest percentages should be interpreted as the reflection of learners' limited experience and inability to elicit discussions.

5.2 The effects of discourse with mentors

The effects of mentor's role in the social discourse of learning can be further elaborated in the following ways:

First, the existence of mentors has impacts on learners' motivation. One learner wrote: "We've got to think of some insightful questions to ask the mentor, otherwise our group would be looked down upon by her (group E #120)." Reflecting on and articulating explanations on the web, from one perspective, is much the same as that in front of others. That places the inquiry on the table and leaves it open to evaluation and criticism. This is a characteristic of the discourse in the network-based community.

Second, the mentors in the social discourse present a sense of certainty and authority for the learners. One learner wrote: "I just transformed data into a figure. I would like to share the finding with you. I'm afraid that you would think that I'm an idiot because my score on Earth Science is B at school. The finding might be just wrong. I'm looking forward to your comments (group E #551)."

Third, reinforcement is another effect the mentors can have on the learners. Different from the scaffolding provided by technology, mentors are sensitive to the quality of inquiry and can be more encouraging to the learners.

5.3 The unhelpful scaffolding Styles

Sustained inquiry should be a key element in science learning. There are several styles of scaffolds that proved to be ineffective.

First of all, the responses with scandal connotation would be of absolutely no help. One mentor wrote: "hello, hello, I don't think you are the kind of people who accepts others' opinion without reasons. ... Pick your brain, otherwise it will gather spider web.

Besides, some mentors are very enthusiastic in helping learners whenever they got stuck. One mentor wrote: "I am so impressed by you guys' sustained discussion. I can't help but prompting something. ... Try to think about ... Then how about ...Why not..." The pattern described above is to raise several questions continually. The effect of this kind of scaffold is usually followed up by no further response. The reason for such a failure can be seen from at least two aspects. On one hand, the learners usually doesn't like to answer so many questions at once; on the other hand, the mentor provides the prompt at a time when learners are not in need. Therefore no further discussion would emerge. Many threads were ended up with mentor's big talk, which didn't facilitate the inquiry process but in effect killed it.

Interestingly, in the category of 《Reinforcement》, we can also find some unhelpful scaffolds. For some aggressive mentors, affirmative comments quite often followed by mentor's expectation of higher-order inquiry skills on learners. For example, the learner might be asked to provide further justification or reconcile what they know and do not know. This kind of reinforcing style also threatens the learners.

5.4 When does the meaningful learning occur?

It is difficult for the mentors to realize when was it appropriate to offer a prompt. The answer can be found by examining what these learners were actually doing during their natural unguided discussions. We found that later intervention is better than earlier intervention. However, with no intervention at all, the peer

learners might encounter difficulties accepting one another's point of view and might not be able to overcome conflicts before giving up. The excerpts below are two learners' discourse in such a case (group D#342-347).

Learner A: Let's propose hypothesis#3 as "Both 'Spring-rain stationary front' and 'Mei-yu stationary front' cause weak upward convective motion.".

Learner B: I think this hypothesis should be modified as "'Spring-rain stationary front' causes strong upward convection; while 'Mei-yu stationary front' causes weak convection." What do you think?

Learner A: Why?

Learner B: It makes more sense from what I know.

Learner A: We can still stick to the original one and continue with the derivation. If the final result turns out to be wrong, we could just overthrow the hypothesis later on.

Learner B: No comments ... Shouldn't we make assumptions with as much sense as possible instead of groundless wild guesses?

6 CONCLUSIONS

As a tailpiece, it is worth commenting on the analysis of posted articles on the web. To explore the authentic interactive process of learners, we classified 2865 posted articles. It was a time-consuming task. However, it was this process of classification that uncovered the underlying interactive dynamics among the members of the network-based learning community.

Apparently, the influences of social discourse on science learning were multi-faceted. In the social discourse, the learners' were motivated, timely encouragements were provided; scaffolding was also facilitated for their understanding of content knowledge. However, inappropriate scaffolding styles could turn into just the opposite.

The percentages of the social discourse in the categories reflect the learners' initiation on aspects of learning activity, however, they do not imply the importance of the categories in the learning process. Low percentage of a category could be caused by the difficulties of inquiry skills and reflective practice encountered by the learners in the discourse. Therefore, a comparison of different group dynamics warrants further study.

ACKNOWLEDGEMENTS

This work has been supported by the National Science Counsel under the Grant NSC 88-2511-S-008-002 and NSC 88-2511-S-008-006. We owe our sincere acknowledgement to all the researchers, participating teachers, and research assistants in the GeoSchool Project for their crucial contributions. Finally, we owe a special thanks to Professor Tse-Liang Yeh, who continually and willingly gave his time to view the manuscript and provided us with his expertise, advice, questions, and support.

References

[1]Coleman, E.B. (1998).Using explanatory knowledge during collaborative problem solving in science. *Journal of the Learning Science*, 7(3&4), 387-427.

[2]Edelson, D.C., Gordin, D.N. & Pea, R.D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences*, 8(3&4), 391-450

[3]Kagan, S. (1994). *Cooperative Learning*. CA: Resources for Teachers, Inc.

[4]Krajcik, J.,Blumenfeld, P.C., Marx, R.W., Bass, K.M., Fredricks, J, & Soloway, E. (1998). Inquiry in project-based Science classrooms: initial attempts by middle school students. *Journal of the Learning Sciences*, 7(3&4), 313-350.

[5]Lin, X., Hmelo, C., Kinzer, C.K., & Secules, T.J. (1999). Designing technology to support reflection. *Educational Technology Research & Development*, 47(3), 1042-1629.

The Artistic Interface - A Transition from Perception to Screen

Peter D Duffy
Queensland University of Technology
66 Harts Rd, Indooroopilly, Brisbane, Qld 4068
p.duffy@kormilda.qld.edu.au

1 Introduction

At present a dichotomy of computer art instruction exists, where the computer as an art medium, presents the learner with almost limitless possibilities of image manipulation; yet instructional methodology and current art curriculum provide no coherent framework through which the learner can effectively access this information.

2 Research

Throughout the last five years the researcher has taught numerous art concepts and involved students in art tasks using the computer. The reality of the researcher's teaching situation is that the use of the computer within an art context is not debated, but accepted as a part of the everyday teaching process. After several years and testing different ways of approaching the teaching of computer programs several issues emerged which warranted further consideration:
1. Frustration exists due to the limited time that students had available to use the computer and the amount of information students were expected to utilize.
2. Many computer graphic programs are structured in similar ways (display a similar interface) and use similar symbols (icons) to represent functions within the program
3. Students seem unaware of these similarities and unable to transfer an understanding of one programs GUI (Graphic User Interface) to another computer graphic program.
4. Students appeared to have no mental map or problem solving strategies with regard to searching for answers to problems within a computer art environment.
These thoughts led to the intention within this research study which is to document the qualitatively different ways that students interact with the graphic user interface of computer graphic software in an art education context in order to create art.

It is hypothesized that students need to build some form of mental model regarding the software program they are interacting with in order to understand its application domain. That by examining the influence of different types of interface cues regarding navigation within a computer art context a greater understanding of students' conceptions regarding utilizing the computer as an artistic medium could be facilitated. Interface cues in this regard pertaining to the icons, layout and menus presented to the user. This is defined by the researcher as the Artistic Interface. This Artistic Interface is the interaction that occurs between the student's artistic intent and the graphic user interface of the computer.

The underlying art educational assumption here is that the clearer the mental model the student has, the more capable the student will be at understanding the program, at locating a specific function and achieving the desired artistic result. Within the context of this study it is postulated that students with a clearer mental model of the graphic user interface (GUI) will have a more effective art educational experience (a more effective Artistic Interface) when utilizing the computer as an artistic medium.

In order to develop this 'mental model' a phenomenographical mode of inquiry will be used. Roth and Anderson (1988) stated that they consider learning to be a change in one's view of some phenomenon. Also Marton (1992) suggested that: "In order to develop teaching methods that help students arrive at new understandings of a given phenomenon, we must first discover the finite ways individuals may understand that phenomenon. Then, through experimentation, we may discover the most effective ways to bring

students from a given conception to another, more advanced one, that is, from 'misunderstanding' to understanding." (p.253) Thus if students' conceptions of how they interact with the computer in an art educational context can be documented, then a learning framework could be developed which could enhance their understanding of the GUI of a particular program, and maybe other computer graphic programs.

3 Educational Considerations

Within a consideration of the influences of the GUI this study situates itself into the line of those devoted to the analysis of a possible correlation between the user's cognitive skills and his / her navigation abilities in an interactive, iconic, multimedia environment. This has been supported and further documented by Castelli, Colazzo, and Molinari, 1994; Elm and Woods, 1985; Osborne, 1990; Thuring, Hannemann, and Haake, 1995.

An effective analysis of students utilizing the computer in art education must begin with 'what is the student trying to do? Previous studies (Elm and Woods, 1985; Osborne, 1990) have demonstrated that getting lost is a consequence of the lack of a clear conception of the relationships within the system. In relation to this study this statement seems to imply that an effective use of the computer as an artistic medium depends upon the ability of the user to abstract from the system display discrete understandings relevant to the desired artistic result and that this may involve building a conceptual representation of a particular software programs GUI. It is further postulated within this study that if a learner can construct an effective mental map, or conceptual representation of a particular software programs GUI then this mental map maybe facilitate an easier and more effective understanding of another program due to the similarities in their GUI.

4 Conclusions

There is ongoing educational debate about the nature of the information society and the range of 'literacy's' needed to handle, understand, and communicate information in a variety of forms (Baker, Clay and Fox, 1996). The researcher has suggested that literacy in the information age requires not only the skills to operate the technology, but also the ability to identify and structure a line of inquiry in order to solve a particular problem. In this instance what is being analyzed is the range of 'literacy's' needed to form a line of inquiry into a computer art domain.

This research into the Artistic Interface is an attempt to document students' understanding of differing computer graphic arbitrary symbols (a software programs vocabulary) placed according to a systematic formula (a software programs grammar) to produce an understanding of various icons (pictograms used to represent a function of the computer). The researcher will seek to examine the qualitatively different ways that students understand the GUI in a particular computer graphic program and within a particular art educational context. This will involve a phenomenographical study that will lead to further understandings regarding students' perceptions of the Artistic Interface.

References

[1]. Baker, D.A., Clay, J., and Fox, C. (1996). "Challenging ways of knowing in English, maths and science". London: Falmer Press

[2]. Castelli, C., Colazzo, L., and Molinari, A. (1994). "Ht-Dedalus: Analysis of some models of hypertext performance". EC Newsletter, 6(1), 15 - 27.

[3]. Elm, W.C., and Woods, D.D. (1985). "Getting lost: A case study in interface design". Human Factor Society, 927 - 931.

[4]. Marton, F. (1992). "Phenomenography and "the art of teaching all things to all men"" Qualitative Studies in Education, 5(3), 253-267.

[5]. Osborne, D.J. (1990). "Browsing and navigation through hypertext documents: A review of the human-computer interface issues". Interactive Multimedia, 1, 3-32.

[6]. Roth, J.J., and Anderson C.W. (1988). "Promoting conceptual change and learning from science textbooks". In P.Ramsden (ed.) Improving learning: new perspectives. London: Kogan Page.

[7]. Thüring, M., Hannemann, J., and Haake, J. (1995). "Hypermedia and cognition: Designing for comprehension". Communications of the ACM, 38(8), 57-66.

The Design of CAI with Thinking Activity to Progress Constructive Teaching
- An Example of Division-concept in Mathematics of Elementary School

Pou-Yah Wu*, Mei-chueh Shao, Kai-Ren Chen, Ying-Xin Zhong, Ting-Wei Lin and Cheng-Wei pan.
Department of Mathematics Education, National Tainan Teachers' College, Taiwan
**Pou-Yah Wu's e-mail:pywu@ipx.ntntc.edu.tw*

This study aims at establishing a computer assisted learning system of division-concept of networked elementary school mathematics course based on constructivism and stress on students' thinking activities. It explores how students' thinking manifest on network, how the thoughts of the learner and those of the students on-line transfer, and how the thinking of the virtual students' solving problems reflect, so as to develop a set of CAI system about constructive pedagogy. In the system, we provide the learners with diverse tools for thinking activity, letting him/her choose what he/she needs to solve problems. We use network technology to simulate the real learning situation and to make the learner and the user on the line and the virtual students to communicate and discuss immediately. By setting up the CAI system that is compatible with the mathematics education of the elementary school in Taiwan now, we expect the learner to establish the right concepts positively so as to attain constructive pedagogic concept.

Keywords: **Constructive pedagogy; Division of Mathematics; Elementary School; Networked CAI; Thinking Activity.**

1 Introduction

The course design of pedagogy in Taiwan before 1993 is based on objective theory of knowledge. However, the pedagogic design ignores the complex and interactive phenomenon practically. Therefore, mathematics of elementary school in Taiwan in 1993 adopts pedagogic theory of constructivism [6]. Constructive pedagogy improve the shortcomings of the traditional pedagogy; but it also cause the deficiency of pedagogic duration owing to the orders of discussion and reflection in case it is put into practice in the real pedagogic environment. With the popularity of network, provided constructive concepts are applied to the learning environment of network, CAI effect would be promoted further. This study aims to design networked pedagogic environment matching "basic division-concept in mathematics of elementary school" by the learner's thought, using network technology, letting the learner have an environment to learn at home. The traditional CAI system neglects the positive learning and the interaction between the learners. So, we take into how to facilitate the interactive relationship between the system and the learner. Through the transmission of the networked thought, the learners can real-time communicate, making up a whole constructive learning environment, hoping to attain the constructive pedagogic concept.

2 Principles of system establishment

2.1 Basis of learning theory

The pedagogy of constructivism lies in stressing "knowledge is constructed positively by the learner", so that pedagogic design should arrange activities of learning-orientation. In the process of learning, the teacher serves as "problem poser" whereas the students acts as "problem solver"; the teacher plays the role of assistance, and the learner should construct knowledge positively through the interactive discussion between the learners [2]. Each learner utilizes his previous concepts to expound the phenomena around, and then comes up with adjustment or assimilation toward his acquired cognitive structure to establish new concepts. Besides, the learning situation is also an important part of the content, functioning to help the learner to comprehend the differences between the perspective on conceptual traits. Thus, the learning activities ought to provide learners with quasi-actual experimental situation to manipulate, explore. By means of the cognitive conflict brought about by the students in the process of the activity, challenging his original concepts, he/she constructs the right concepts via the discussion and coordination with one another.

2.2 Basis of course content-concept of division

Division is the anti-calculation of multiplication. Both multiplication and division are thought of as the transformation of unity quantity. The so-called "transformation of unity quantity" refers to that using unity quantity as that described by calculating unit, transforming to another description by calculating unit using another unity quantity [1,3]. The situational mode of division question is categorized into two basic principles of including division and even division. Seen from the viewpoints of "transformation of unity quantity" to look at the questions of multiplication- division, the questions of multiplication is to reduce the quantity suggested in the units of higher layers (units accumulated by several units of lower layers) to the activity of transformation from the quantity suggested by units of lower layers; whereas the questions of division "including division" is on the contrary, that is, the quantity suggested by the units of lower layers changed into the transformation activity by the quantity suggested by the units of higher layers. As to even division, it is an activity of new unity quantity of high layers and unknown unity quantity.

2.3 Foundation of system establishment

This system is a learning environment constructed on the network, adopting three-tier client/server system architecture, and meaning adding a layer of service server on the original client-server two-tier client/server system architecture. In the structure of three-tier client/server master-slaver, the part of management of learning data is in the charge of database server, web server takes charge of teaching jobs, while the users of client proceed all kinds of learning activities via browser.

3 Pedagogic design of networked construction

3.1 Pedagogic design of constructive division of new course

The two questions types of division (including division and even division) should be reckoned as different ones, then helping students combine these two types of questions gradually. And by the activity of consecutive subtractions solving questions to communicate with the relationship, then introducing the format of division calculation. Thus, in the design of pedagogy, place the two combined types of characters, letting children solve problems by tangible objects or emblems and try to record the activity of solving questions. After solving the questions including division and even division successfully, try further to grasp the times of distribution including viewpoints of division when confronted with them again [4,5]. The number of unity quantity can be decided by the times of distribution to help students realize and construct the relationship containing two types of questions as to including division and even division. Finally they can introduce the processes of solving questions concerning the methods of many-steps subtraction recording including division and even division and discuss and form the formulas using " ÷ "taking notes of the common sense about the activity of solving questions including division and even division, letting children construct the whole meaningful concept of division.

3.2 CAI pedagogic design of constructive pedagogy by thinking activity

This system emphasizes the spirit of construction to help students establish the concept of division, thereby, expecting the system to become more congenial to the real pedagogic environment. We let the computer become a virtual teacher, besides posing problems, he/she can judge the students' types of solving problems and mode of operation, and providing the dialectics and clarification and discussion undertaken between the users or between the user and the virtual students. Thus, the design of the problems by this system is introduced by the ordinary ones of daily situation to make sure if students have grasped the messages of the problems and communicate and clarify the messages with each other through asking (As in Figure 1). After posing the problems and clarifying the messages, let the students solve the problems. In order to make the system grasp the process of solving problems and thinking, we design "tool table of operation of thinking activity", which contain tangible objects, representation, digits and the symbol of calculations and so on. For example, as shown in Figure 2, if learner choose "to bakery", then the tangible objects can be used to solve the problems. If the learner choose "drawing circles", then representation can be used as the tools of solving the problems (As in Figure 3); if the learner choose "to digital factory", then digits can be used as the tool of operation (As in Figure 4). By the tool of operation chosen by the user, the computer can grasp what he thinks. If the user fails to solve the problems by themselves, they can discuss with others on the line, or discuss by the activity of solving the problems of the virtual students (As in Figure 6and 7) to attain the cooperation and learning. At last, after the user solve the problems successfully, the computer will play the role of the virtual teacher, raising questions to let the user to fortify the concepts, avoiding no continual between the user's order of thought and the concept (As in Figure 5). Then posing problems again to judge the students' learning state in order to proceed another activity dynamically. In doing so gradually, the system expects the learner construct an overall meaningful concept of division.

4 Architecture and implementation of system

4.1 Design environment and tools

This system uses Windows NT server as server platform. The developing languages include HTML, JavaScript, ActiveX, ASP (Active Server page) and so on. Using ASP as the main way of control, and exercising ASP and ODBC (Open Database Connectivity) to go with it, making the user's management of teaching material simplified. In the aspect of editing course software, Authorware5 is a chief developing tool.

4.2 System flowchart

The system flowchart we designs just as Figure 8 shows, the general elucidation is as follows:

1. Pedagogic situation of networked construction: In the beginning, the system would ask the user to register data to set up the database of students' basic data. At the outset of the course, the system will judge the user's competence by the pretest; then according to the basis, the system can pose the problems. After clarifying the messages of the problems, the system lets the user proceed to solve the problems. After solving the problems successfully, it lets the user carry on a series of on-line discussion and communication with the students or virtual students. Based on the acquired knowledge, the students construct the concepts, and fortify or revise the concepts through the experience of reflection. Again, the system poses the problems to judge the students' learning situation, then it proceeds the next teaching activity.

2. Database of "student model": It consists mainly of three databases:

(1) Database of students' basic data: It is used to record the students' basic data such as name, age, the experience of using the computer and so on.

(2) Database of learning: It is used to record the course units the students have learned, the learning state and duration of each unit, and the students' learning results and so forth.

(3) Database of learning achievement: It records the students' assessment about answering and the mode of students' operation.

3. Database of "posing problems of constructive pedagogy": It stores the material content of division pedagogy. The content contains two types of division problems (including division and even division) and various types of processes pedagogic activities.

4. Database of problems: It stores the problems for pretests and posttests.

4.3 Function of on-line communication

Because the system aims at establishing a more compatible with the learning environment of real pedagogy, so that this system design a series of communicative mechanism on the line to help students proceed the learning activities to produce the learning effect. The details will be narrated as follows:

1. Group of discussion: It is an open but not synchronized function on the line. Once the user encounters the learning difficulty, he/she can put the problems on the discussion place, and when other users see them, they can put forth the ways of solving these problems.

2. Room for discussion: It is an open and synchronization for communication. This on-line unction can improve the fact that the single CAI system fails to undertake the defects of communication and discussion immediately. Take Figure9 for example, the user in the room for discussion can carry on the mutual discussion, communication to solve the problems with other users on the line for their learning difficulty.

3. On-Line call: This is a one-to-one synchronous communication way, enabling the learners to proceed one-to-one discussion and forward the brief introduction to other users on the line.

4.4 Operation flowchart for User

When the user enter the system by using browser for the first time, the system would demand the user to register, thereby getting the user's data to set up student model basic data for database, and letting the user accept the pretest to judge the user's level of operation, and recording the user's answering situation. Utilizing the user's answer for reference, modifying the connection dynamically, letting the user connect the courses properly. Afterwards, whenever the user enters the system, he has to register user name and password as the recognition. The system then will proceed next activity according to the user's previous record. When the user undertakes the learning activity, the system will take down the learning state each time, so as to analyze if the user's learning state will attain the expected aim and will be used as learning analysis.

5 Conclusions

With the approach of eased network age, the network will definitely become the trend. Thus, establishing CAI system on the network cannot be delayed. In the light of these, we hope the constructive pedagogy combine with network to make up for the deficiency of pedagogy, letting the learners have more learning space, so as to acquire the real mathematics concepts. This study proceeds to test by the pedagogic content of "division-concept" of elementary school, presently testing all the functions provided by the system, hoping to reassess pedagogic content and system in many months, looking forward to reaching the learners' interaction, fulfilling the pedagogic concept indeed, letting children construct whole mathematics concept.

References

[1] 甯自強, "單位量的變換(一):正整數乘除法運思的啓蒙", 教師之友, Vol. 34, No 1, pp. 27-34, (1993).

[2] 甯自強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看—", 科學教育學刊, Vol. 1, No 1, pp. 101-108. (1993).

[3] 甯自強, "單位量的變換(二)", 教師之友, Vol. 36, No. 5, pp. 35-44, (1995).

[4] 楊瑞智, "國民小學數學新課程中年級除法教材的設計"八十二學年度數學教育研討會,嘉義,台灣,pp.119-136(1993).

[5] 楊瑞智, "國民小學實驗課程整數乘除算則的教材處理",八十六學年度數學教育研討會,嘉義,台灣 pp.98-113(1997).

[6] 蘇育任, "建構主義式教育的迷思與省思", 國民教育集刊, No. 5, pp. 121-139, (1997).

[7] 吳博雅, 王偉仲, 謝堅, 曾彥鈞, 陳詩茹, 牛晉媛, "網路建構式電腦輔助教學系統之研究—以國小數學科面積基本概念爲例", 1999 中華民國 CAI 研討會論文發表, pp. 159-165, (1999).

[7] Dalgarno, B. Constructivist Computer Assisted Learning: Theory and Techniques. WWW. 21Oct. 1997. Available: http://services.canberra.edu.au/~barney/articles/ascilitc96/paper.htm (1997)

[8] Hiltz, S. R. Teaching in a Virtual Classroom. 1995 *International Conference on Computer Assisted Instruction ICCAI'95* Hsincku, Taiwan http://it.njit.edu/njIT/Department/CCC/VC/Papers/Teaching.htm

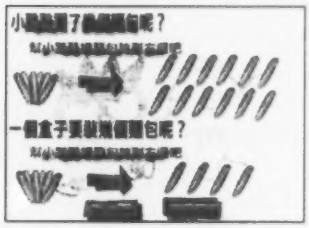


Figure 1:The Clarification of the problem

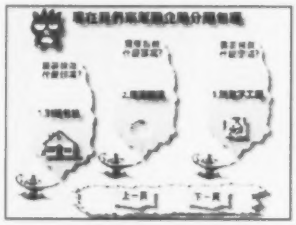


Figure 2:The choice of operation tool of problem solving

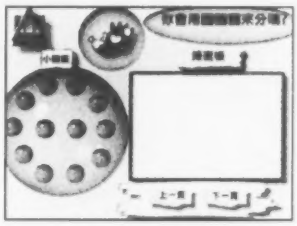


Figure 3:The presentation of thinking activity - representation

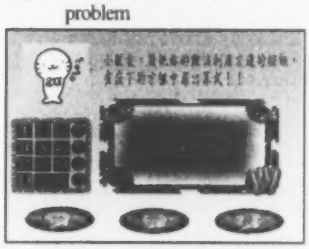


Figure 4:The presentation of thinking activity - digital and operator symbol

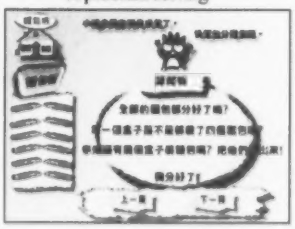


Figure 5:Reflection and discussion

Figure 6:The strategies of virtual students

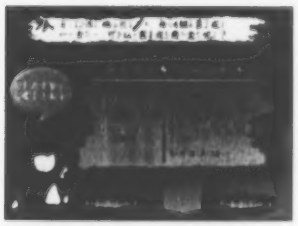


Figure 7: The communication of solving methods of virtual students

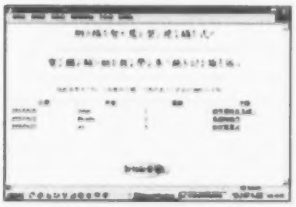
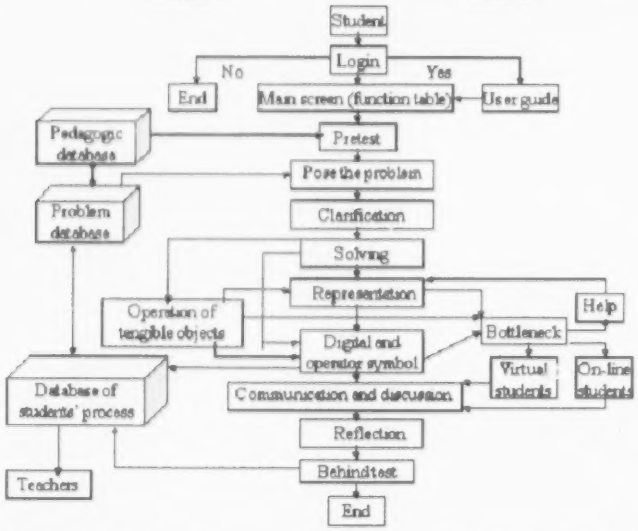


Figure 9: Group of discussion



Figurre8: The design of networked constructive pedagogy with thinking activity

BEST COPY AVAILABLE

The Discussion on the Dynamic Knowledge Generationand the Learning Potential Ability

Chao-Fu Hong, Chiu-e Chen*, Ming-Hua Hsieh, Cheng-Kai Huang and Shih-Hsiung Chang
*Aletheia University and Dah-Yuan Elementary School**
cfhong@email.au.edu.tw
No. 32 Chen-Li Str. Tamsui City Taiwan ROC
Tel: 02-26212121-5536

After we discussed with teachers to understand their instructional politics, we integrate the teachers' instructional politics, the process of knowledge generation, memorizing to construct the concept graph. Furthermore, we used the dynamic web pages to track the learner's learning and used the tracking data to reconstruct the learner how to construct his knowledge to understand the learner's thinking logic. In this paper we proposed the dynamic knowledge generation model and learning ability potential model. These were according to link the concepts to generate the knowledge. As following above idea we integrated the constructing materials and the dynamic knowledge generation to consist the expert system. The system would analyze his learning data to rebuild he how to build his knowledge, to understand his learning ability and he already built the whole knowledge or not. Rely on these results the system could supply the suitable materials to him for study. And the learning cycle would continue until the learner completely constructs the new knowledge into his ground knowledge. Finally, we could from proto type system to collect the experimental data and rebuilt the learner's learning steps, then followed the expert system to understand his learning ability potential. The system could supply a suitable material to him and help him to cross over the learning obstacle. These results also proofed that our model could really understand the learner's thinking logic and learning potential.

Keywords: **dynamic knowledge generation, learning potential ability, concept graph, expert system**

1 dynamic knowledge construct process of learners

A meaningful learning must accord with three main conditions: Accepting the learning material, having the knowledge of dealing with learning material, and firing this knowledge at the learning time, (Mayer, 1975,1984). Accordingly, learning behavior has originality, creation and activity. It's easy to make learners to find the meaning of learning. If we want learners to have meaningful learning, we must do: "if you want to teach active knowledge for learners, you have to understand how to get the knowledge first. It's the same as you want to teach learners to think, you have to understand how learners think first." Therefore, if want to know the learner how to learn the knowledge, it can use the information process theory to discuss the human how to process his information like Fig.1. we design a structural material like a story, attaching pictures, and animations that attract learners. At the last section we give an additional problem among the units, which give learners integrating the prior knowledge. Then, the blind spot in every learner is obtained by using the model of a learning barrier analysis. The reason of inspiring learning barrier is obtained by using learners' browse web pages order and frequency. (Note: 3D learning barrier analysis) Meanwhile, learners will dynamically update their constructional knowledge network by learning number, browsing process, and test frequency. (Note: all of attributions of cognition nodes are dynamical.) Because learners are not static learning, we developed a dynamical model as Fig.1..

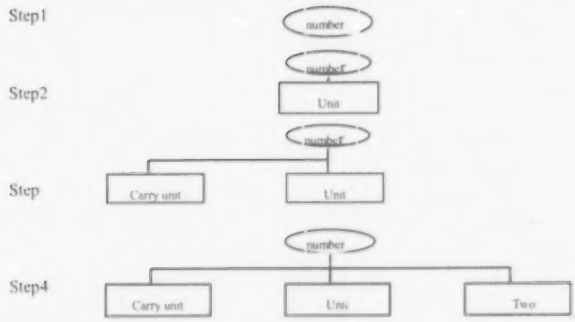


Fig.1 dynamic knowledge construct process of learners

2 the dynamical knowledge generation and learning ability analysis

In our model (**the model of dynamical knowledge generation and learning ability analysis**), using the teachers teaching experience, the system partition a judge learners' ability to achieve learning and the label of understanding course. And the Table1 is appropriate inference rule, what are the schools' teachers to classify the learners' learning ability.

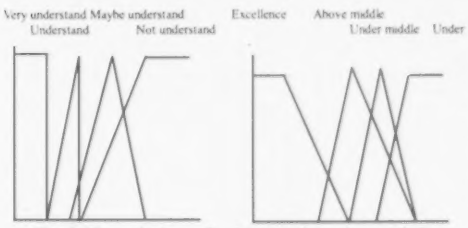


Fig.2 The relation of achieve a learning and the label of understanding course

Table 1. Inferring rule

TIMES / RESULT	UNDER	UNDER MIDDLE	ABOVE MIDDLE	EXCELLENCE
Cannot Understand	-2	-1	-1	0
Maybe Understand	-1	-1	0	+1
Understand	-1	0	+1	+2
Very Understand	0	+1	+1	+2

After the student had to go to the chapter's test. The testing results would according the learning obstacle analysis model to find his incompletely building knowledge and compared with the expert system to understand his learning ability. Finally, the system searched the suitable materials for him to study. The graph of learning cycle is shown in Fig. 3.

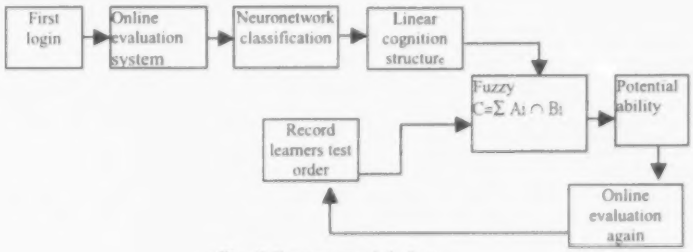


Fig. 3 System model chart

3 Conclusion

Although teacher can control his class ambiance and teaching trends, but he has many different individual

learners in the classroom. If teacher cannot understand the learners how to learn and how to integrate their knowledge on his teaching, the teaching does not only let learner have a stuff learning, but also increase his teaching load. Therefore, in our paper we proposed "dynamical knowledge-generation model and learning ability analysis", to integrate the conceptual knowledge generation into structuring material and connect with the dynamical estimating expert's system. This system can collect what material learner had learned and the result of online testing was transmitted to the system. These real data used our analyzing model to decide his learning ability and supplied a suitable material to him for study. Thus, we believe our system do not only can help the teacher to understand learner how to build his new knowledge, but also can reduce the learner's learning barrier.

Reference

[1] Chao-Fu Hong、Yueh-Mei Chen*、Yi-Chung Liu、Tsai-Hsia Wu :Discuss 3D cognitive graph and meaningful learning,ICCE99

[2] Chao-Fu Hong、Yi-Chung Liu、Yueh-Mei Chen*、En-Yi Jen :Apply OO and T cell Cognitive Structurein Discovery Teaching,ICCE99

A Distance Ecological Model to Support Self/Collaborative-Learning via Internet

Toshio Okamoto
University of Electro-Communications, Graduate School of Information Systems
Choufu, Choufugaoka 1-5-1, Tokyo 182-8585
Tel: +81-424-43-5620; Fax: +81-424-89-6070
E-mail:okamoto@ai.is.uec.ac.jp

With the rapid development of information technology, computer and information communication literacy has become the main new ability required from teachers everywhere. For enhancing teaching skills and Internet and multimedia information literacy, a new teachers' education framework is required. Here we propose a Distance Educational Model, as a School-Based Curriculum Development and Training-System (SCOUTS), where a teacher can learn subject contents, teaching knowledge, and evaluation methods of the students' learning activities (subject: "Information") via an Internet based self-training system. We describe the structure, function and mechanism of the model, and then show the educational meaning of this model in consideration of the new learning ecology, which is based on multi-modality and new learning situations and forms.

Keywords: **Distance Education, Teacher Training System, Learning Ecology, School Based Curriculum Development**

1 Introduction

Recently, with the development of information and communication technologies, various teaching methods using Internet, multimedia appeared. Most of them emphasize, in particular, the aspect of collaborative communication between students and teacher during interactive teaching/learning activities. Therefore, now-a-days it is extremely important for a teacher to acquire computer communication literacy [1]. So far, there were many studies concerning system development, which aim at fostering and expanding teachers' practical abilities and comprehensive teaching skills, by using new technologies, such as computers, Internet, multimedia. In Japan, systems using communication satellites such as SCS (Space Collaboration System) are developed and used as distance education systems between Japanese national universities. In the near future, a teacher's role will change from text based teaching, to facilitating, advising, consulting, and his/her role will be more that of a designer of the learning environment. Therefore, a teacher has to constantly acquire/learn new knowledge and methodologies. We have to build a free and flexible self-teaching environment for them under the concept of "continuous education". At the same time, we build a collaborative communication environment to support mutual deep and effective understanding among teachers. In this paper, we propose a Distance Educational Model, which is based on the concept of School Based Curriculum Development and Training System, advocated by UNESCO and OECD/CERI (Center for Educational Research and Innovation), and describe the structure, function, mechanism and finally the educational meaning of this model. Based on such a background, it is necessary to construct an individual, as well as a collaborative learning environment, that supports teachers' self-learning/training, by using Internet distributed environments and multimedia technologies. A teacher can choose the most convenient learning media (learning form) to learn the contents (subject units) that s/he desires.

2 Distance Educational Model based on SCOUTS

Until now, when a teacher wanted to take a class on "IT-education", s/he had to leave the office or school. Now it is possible to learn various kinds of subject contents by building a virtual school on the Internet environment.

2.1 Distance Educational Model

Our Distance Educational Model is built on 3 dimensions. The first one is the subject-contents, which represents what the teachers want to learn. The second one represents the teaching knowledge and skills as well as the evaluation methods of the students' learning activities. From the third axis, the favorite learning media (form) can be chosen, e.g., VOD, CBR, etc. By selecting a position on each of the 3 axes, a certain cell is determined. A cell stands for a "script", which describes the instruction guidelines of the learning contents, the self-learning procedure, and so on (Fig. 1). In the following, I will explain the meaning of each axis in more details.

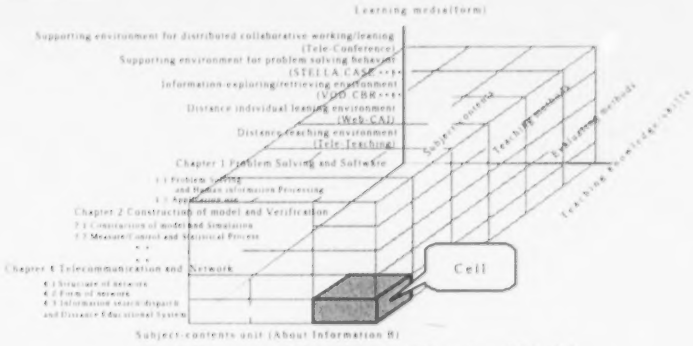


Fig.1 Structure of the Distance Educational Model

2.1.1 Subject –contents unit

In this study, we focus on the subject called "Information", which is due to be established as a new obligatory subject in the regular courses of the academic high school system in Japan. The subject "Information" is composed of three sub-subjects, "Information A", "Information B" and "Information C". The contents of each sub-subject are as follows.

Information A: *raising the fundamental skills and abilities to collect, process and transmit "information" using computers, the Internet and multimedia.*

Information B: *understanding the fundamental scientific aspects and the practical usage methods of "information".*

Information C: *fostering desirable and sound behavior of participation, involvement and contribution in an information society; understanding peoples roles, and the influence and impact of technology, in the new information society.*

2.1.2 Teaching knowledge/skills

On this dimension, we have represented sub-subject contents, teaching methods and evaluating methods for "information" classroom teaching. 'teaching methods' stands for how to use and apply IT, to enhance a student's problem solving ability, involving comprehensive learning activities, like problem recognition, investigation and analysis, planning and design, implementation and executing, evaluation, report and presentation. We aim at teachers acquiring the proper students' achievements evaluating skills, according to each of the above activities.

2.1.3 Learning media (form)

This dimension represents five different learning environments, as follows: 1) "Distance teaching environment (Tele-Teaching)" based on the one-to-multi-sites telecommunications 2) "Distance individual learning environment (Web-CAI)" based on CAI (Computer Assisted Instruction) using WWW facilities 3) "Information-exploring and retrieving environment" using VOD, CBR (Case Based Reasoning) 4) "Supporting environment for problem solving", by providing various effective learning tools 5) " Supporting environment for distributed collaborative working/learning" based on the multi-multi-sites telecommunications. Brief explanations for each environment are given in the following.

(1) ***Distance teaching environment (Tele-Teaching)****: This environment delivers the instructor's lecture image and voice information through the Internet, by using the real-time information dispatching function via VOD (Video On Demand).*

(2) ***Distance individual learning environment (Web-CAI)****: This environment provides CAI (Computer Assisted Instruction) courseware with WWW facilities on the Internet.*

(3) ***Information-exploring and retrieving environment****: This environment delivers, according to the teacher's demand, the instructor's lecture image and voice information, which was previously stored on the VOD server. For delivery, the function of dispatching information accumulated on the VOD server is used. In addition to it, this environment provides a CBR system with short movies about classroom teaching practices.*

BEST COPY AVAILABLE

*(4) **Supporting environment for problem solving**: This environment provides a tool library for performance support, based on CAD, Modeling tools, Spreadsheets, Authoring tools, and so on.*
*(5) **Supporting environment for distributed collaborative working and learning**: This environment provides a groupware with a shared memory window, using text, voice and image information for the trainees.*

2.2 • Cell" definition

The concept of a "cell" in the Distance Educational Model is quite important because it generates the training scenario, including the information to satisfy the teacher's needs, the subject materials learning-flow and the guidelines for self-learning navigation. The frame representation of the "cell" is shown in Table 1. These slots are used when the system guides the process of the teacher's self-learning.

Table 1 The frame representation of the "cell"

	Frame name	Slot-value
Slot-name	Learning objectives for a student	Subjects which should be understood Subjects which should be mastered
	Subject-contents	The unit topic
	Teaching method	The students' supervision method and instructional strategies
	Evaluating method	The students' evaluation method
	Useful tools	The software used for the training activity
	Operational manual of tools	The software operation method used for the training activity
	Prepared media	The learning media which can be selected
	Guide script	The file which specifies the dialog between the trainee and the system

3 Outline of the teacher training system

The system configuration of the teacher's training environment is composed of two subsystems based on the Distance Educational Model. One of the subsystems is the training system, where a trainee can select and learn the subject adequate for him/her guided by the script in the "cell". The other subsystem is an authoring system with creating and editing functions for "cell" description. The users of the second environment are, e.g., IT-coordinators or IT-consultants, who can design lecture-plans in this environment.

3.1 Training system

The training system aims to support teachers' self-training. The configuration of this system is shown in Fig.2. The role of this system is first to identify a "cell" in the model, according to the teachers' needs. Then, the system tries to set up an effective learning environment, by retrieving the proper materials for the teacher, along with the "guide script" defined in the corresponding "cell". Therefore, the system offers programs for both Retrieving and Interpreting. The training system works as shown in the following.

STEP 1: Record the teacher's needs.
STEP 2: Select a "cell" in the Distance Education Model according to the teacher's needs.
STEP 3: Interpret the "cell" in the guide WM (Working Memory).
STEP 4: Develop the interactive training with the teacher according to the "guide script" in the guide WM.
STEP 5: Store the log-data of the dialog (collect information on the learning histories and teachers' needs and behaviors).
STEP 6: Provide the needed applications for the user's learning activities and set up an effective training environment.
STEP 7: Give guidance-information, according to "cell" script guidelines, decide on the proper next learning step "cell".

The interpreter controls and develops the dialog process between user and machine according to the information defined in our "guide script" description language. This "guide script" description language (GSDL) consists of some tags and a simple grammar for interpreting a document, similar to the HTML (Hypertext Markup Language) on the WWW. The interpreter understands the meanings of the tags, and interprets the contents. An example of GSDL is shown below.

*(1)**<free>* *Definition: description of the text (instruction)*
*(2)**<slot (num.)>*** *Definition: a link to a slot value in the "cell"*
*(3)**<question>*** *Definition: questions to a trainee*
*(4)**<choice>*** *Definition: branching control according to a trainee's response*
*(5)**<exe>*** *Call: to relevant "cells"*
*(6)**<app>*** *Definition: applications used for training activities (e.g., Tele-Teaching, etc.)*

BEST COPY AVAILABLE

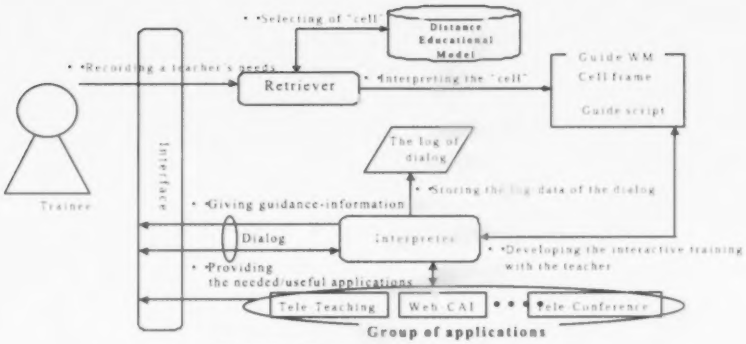


Fig.2 Configuration of Training system

3.2 Authoring system for creating and editing a "cell" description

The system provides an authoring module to create and edit the information in the "cell". This module also offers the function of adding new "cells", in order to allow supervisors (experienced teachers) to design the teachers' training program. The configuration of this system is shown in Fig.3. The tasks that can be performed by this system are: adding new "cells", editing the existing "cells", receiving calls for Tele-Teaching lectures, and managing the lectures schedule. This system is composed of the "cell" frame creating module, and the "guide script" creating module. A cell design can be performed as shown in the following.

STEP 1: Get the slot-values of "student's learning objectives", "subject-contents/teaching method/evaluating method", and "useful tools" from the "cell".
STEP 2: Substitute the return value of the slot of the prepared media with the training-contents corresponding to the user's needs.
STEP 3: Substitute the slot-value in the "cell" for the corresponding tag in the "guide script" template.
STEP 4: If "Tele-Teaching" as learning media is selected, then get some information about the lecture, by referring the lecture-DB and the VOD short movie-DB.
STEP 5: Add the new "cell" to the Distance Educational Model.

The lecture-database consists of "lesson managing files" containing user-profile data, lecture schedules, trainees learning records, lecture abstracts, and so on. The "guide script" template file contains tag-information, written in the "guide script" description language (GSDL), for all subject-contents items in the Distance Educational Model.

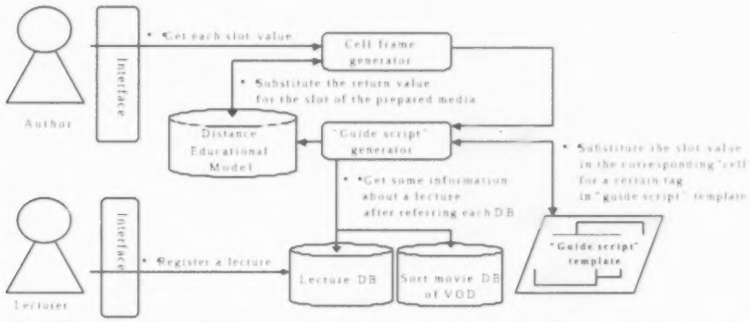


Fig.3 The procedure of "cell" description for creating/editing of the authoring system

4 Conclusions

This paper proposed the Distance Educational Model called the School Based Curriculum Development and Training System (SCOUTS). This model stands for the networked virtual leaning environment based on a three dimensional representation, which has on the axes 1) subject-contents, e.g., "information" for the training, 2) teaching knowledge, skills and evaluation methods and 3) learning and teaching media (forms). This represents a new framework for teachers' education in the coming networked age. We have mentioned the rationale of our system and explained the architecture of the training system via a 3D-representation model. Furthermore, we have described a "guide script" language. This system is superior to a simple rule-

based instructional plan, as it allows a better and more natural overview of the global structure, as well as a quick identification of missing parts. The aim of our system is to support teachers' self-learning, provided as in-service training. At the same time, we need to build rich databases by accumulating various kinds of teaching expertise. In such a way, the concept of " knowledge-sharing" and "knowledge-reusing" will be implemented. As a result, we trust that a new learning ecology scheme will emerge from our environment.With this system, we can construct various kinds of learning forms and design interactive and collaborative activities among learners. Such an interactive learning environment can provide a modality of externalized knowledge-acquisition and knowledge-sharing, via the communication process, and support learning methods such as "Learning by asking", "Learning by showing","Learning by Observing, "Learning by Exploring" and "Learning by Teaching/Explaining"'. Among the learning effects expected from this system, we also aim at meta-cognition and distributed cognition, such as reflective thinking, self-monitoring, and so on. Therefore, we expect to build a new learning ecology, as mentioned above, through this system. Finally, we will apply this system to the real world and try to evaluate its effectiveness and usability from experimental and practical point of view.

References

[1]. Nishinosono, H.: A Teacher Education System for Information Education Teachers at High School Level in the Information Society. Proc. of the conference JET, pp.523-524 (1998)

[2] Collis, B.: Design, Development and Implementation of a WWW-Based Course-Support System. ICCE99, pp.11-18, IOS Press (1999)

[3] Seki, K., Takaoka, R., Matsui, T., Okamoto, T.: A Teaching Model in Distance Education based on Teacher's Needs. IEICE Technical Report, ET98-12, pp.49-56(1998)

[4] UNESCO Report: World Declaration on Higher Education for the 21 Century Vision and Action, Paris (1998)

[5] Salvador, L. G.: Continuing Education Through Distance Training. ICCE99, pp.512-515, IOS Press (1999)

THE GOOD, THE BAD, THE UGLY
OR
INTERACTIVE LEARNING ENVIRONMENTS

*Bobbie T. Biggs, Ph.D. and **James Swartz, Ph.D.
**bbiggs @comp.uark.edu and **jswartz@comp.uark.edu*
**Professor and **Associate Professor*
**Vocational & Adult Education and **Educational Leadership, Counseling & Foundations*
**115 Graduate Education Building and **250 Graduate Education Building*
University of Arkansas, Fayetteville, Arkansas, U. S. A.

Qualitative research methods of interview, observation, and document collection were used to analyze a three-hour (48 contact hours) distance education course. The research team consisted of a professor who was the instructor, an Associate Professor who taught qualitative research and five doctoral students enrolled in an advanced qualitative research class.

There were a total of eight learners in four sites. The learners consisted of a specialized population of male adults who were instructors at two-year technical colleges taking the class in response to a state mandate which stipulated that no one would be allowed to teach at the newly-created two-year technical colleges without a baccalaureate degree. The instructor was a female professor with about thirty-five years teaching experience and eight years experience with interactive compressed video distance education. Nine visiting guest speakers of varying teaching experience and no experience with interactive compressed video also participated.

Initial analysis indicated that strong teaching skills and classroom management skills were necessary to conduct the course. Far-site independence of movement, talk, and turn taking required special give and take between learners and the professor. Modifications of ordinary class behavior on the part of learners and the professor were noted.

Keywords: **Distance Learning, Classroom Environment, Classroom Management, Connectivity**

1 Introduction

The presenter's interest is not in distance education as a whole, but in the interaction between the qualities of distance education and teaching strategies for the professor and a particular set of learners. One of the research projects the presenter has completed in this arena was qualitative and the presenter was the subject of the research. The learners in the study were two-year technical college teachers, who were working on a bachelor's degree in vocational education. Since qualitative research is time and context bound, it is difficult to make inferences that would apply across time and context to all teachers who deliver instruction through distance education . That is, these distance education classes occurred in a specific context, with specific groups of people, in specific places, in specific situations, and at a specific time within the current guidelines of distance education technology. The significance of the research lies in the notion of transfer [9]. Transfer is the type of inference qualitative research uses instead of the quantitative notion of generalizability. Consequently, it is up to the reader to draw inferences about how the research time and context fits his/her own time and context. This is in direct contrast to quantitative research which makes decisions about the inferences generated by rejecting null hypotheses. Qualitative research is an appropriate research methodology because all distance education is conducted at a specific time, with specific people, in a specific place, and under specific circumstances [19]. Distance education is a practice rather than a laboratory setting; therefore, professors need to know more about the practice in a practical context-bound environment.

After eight years of teaching in a distance education classroom, the subject had many questions about what strategies were truly facilitating learning. There was also the question of whether a professor with more than thirty years of teaching experience in a traditional classroom could be successful in a distance education classroom. What were the similarities and differences between the classrooms? What issues would an experienced professor need to become cognizant of if he/she wanted to be a successful distance education teacher?

In qualitative research designs, the role of the researcher should be clear. Researcher roles range from participant observer to detached observer [15]. In this particular investigation, the researchers (excluding the subject) did maintain a role usually associated with detached observers. Their position was off camera in the back of the originating site. Although the researchers did travel to each site to observe and interview learners, the majority of observations were conducted in the originating classroom.

The primary observer, interviewer, and document collector was an Associate Professor who taught an advanced qualitative research seminar; the other five researchers were doctoral students in an advanced qualitative research seminar. The observations were overt in nature. The Associate Professor who was teaching the qualitative research seminar appeared on camera at the subject's invitation to introduce the research and inform the participants that their identities would be protected. Informed consent forms were sent to and signed by each person who participated in this research project, which included not only the professor and learners, but also guest lecturers and technicians.

Methods of assuring trustworthiness of the data were prolonged engagement, persistent engagement, triangulation, member checks, and peer debriefing [13]. Prolonged engagement means establishing a long enough contact with the object of research for the purpose of locating patterns in the data. Prolonged engagement was achieved to reveal patterns in the data as opposed to a collection of anecdotes. The entire distance education class was observed by one or more observers. Standardized open-ended interviews were conducted throughout the entire class; for example, three interviews were conducted with professor/subject and one interview was conducted with each class member. Documents were collected throughout the course at the same time the professor/subject distributed them to learners. Persistent engagement was achieved by constant analysis of the data as it were collected to establish patterns in the data and to exclude discrepant information which was anecdotal in nature. For example, sometimes learners who were present in the classroom with the professor might move closer to the professor to gain her attention. This was anomalous because the behavior was controlled for and was eliminated. Therefore, it was not a behavior that was a pattern throughout the course. Although possibly significant, it was an anecdote rather than a pattern. Data triangulation and researcher triangulation were also utilized to enhance the trustworthiness of the data. Data triangulation included observation of each class session, interviews with the professor, each learner, guest lecturers, and technicians. The instruction was documented through 48 hours of observation and approximately 30 hours of interviews with the professor/subject, learners, guest speakers, and technicians. Researcher triangulation was achieved through step-wise replication, which was a technique used during data collection. Step-wise replication is the use of multiple observers for the same observations. This technique was used in order to reduce the biases that might be present in any one single observer. Member checks were conducted with the professor because she was the focus of the research. A member check is a review by the research informant of interviews, observations, or documents. In the case of this particular research, the professor thoroughly reviewed interviews conducted with her in her role as a co-researcher. Peer debriefing was conducted by the six observers and interviewers at seven different meetings during the course.

2 Setting

The primary setting of the class was a state of the art distance education classroom at the University of Arkansas, College of Education and Health Professions. The classroom was designed for distance education and featured appropriate technical characteristics. The professor usually was seated at the front of the classroom behind a large desk approximately eight feet by four feet (8' x 4'). She also could stand behind or in front of the desk or sit at any table with on-site learners. The professor had three different cameras: one was mounted on a monitor (resting on an approximately 4' cabinet toward the center back of the classroom) which follows the movement of the professor; the second camera was attached to a monitor (resting on the same kind of cabinet as the monitors in the rear) to the

professor's right as she looked at the classroom and pointed toward the class; and the third camera had the appearance of an overhead projector and conveyed printed materials much in the way an overhead projector would except through the compressed video system (ELMO). There was also a computer and a SmartBoard available. The professor used a wireless lavalier microphone. There were microphones shared between every two learners, which when turned on activated the learner camera. There were four monitors resting on the aforementioned cabinets; one 52 inch monitor which showed the professor the far-site learners and one 36 inch monitor which allowed the professor to view the near-site and two 52 inch monitors on one side of the professor for the learners to see near and far-site camera outputs. There was sound absorbing material on the wall, carpet on the floor, and neutral colored wall coverings around the room. Behind the instructor the wall was covered with a camera-blue paint for possible use of special effects. Seating for learners consisted of six-foot tables placed in rows to one side of the room with comfortable office chairs, as opposed to standard learner desks and chairs. Far-site classrooms had varying arrangements and color schemes.

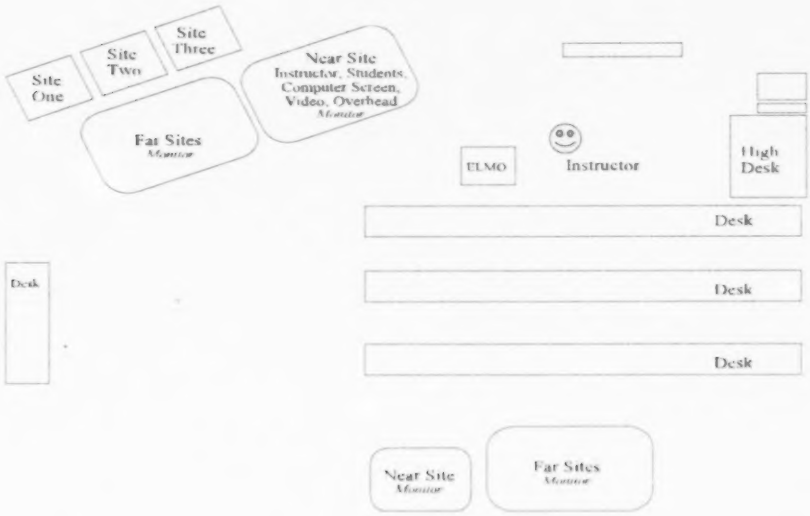


Figure 1. Distance Education Classroom

3 How the Technology Functions

There are four or five sites that combine to form the single distance education classroom. The professor was confined most of the time to the front desk in order to manipulate the controls for cameras and visuals. In her direct view were4 two large monitors, one side contained the camera feed for the near site while the other monitor showed the far sites. Only one far site could be viewed at a time. Selection of far-site location was voice activated; that is, if someone at a far site was speaking, the system automatically selected that site for viewing. Consequently, the professor could not select far-site locations for viewing at her discretion. Communication with learners was conducted through on-line compressed video imagery, world wide web, facsimile machine, electronic mail, standard U.S. mail service, and telephone. Of these options actual class time was centered around compressed video imagery. Guest speakers had been

invited to convey information to learners during the courses. Each of the guests was provided the opportunity to view the professor as she modeled utilization of the system before the guest presented. It has been interesting to note that most guests expressed discomfort with the system, but subsequently seemed to work well with the system. Guests were never required to manipulate the system; the professor performed that function for them. Technical difficulties have been noted as part of the functioning of the system. Technical difficulties included feedback, problems with playback of videos, and interruption of compressed video signal due to weather conditions. All sites had some local technical assistance, though it was minimal.

4 Activities

The professor used a variety of interactive activities, such as lecture and questioning, self assessment, in-class individual and group work, guest lectures, learner demonstrations, individual and group reports, and cross-site dialogue — teacher to learner and learner to learner. A typical class period featured an introduction by the professor, which included personal exchanges with learners. Other attributes of a typical class session were professor lectures with visuals, which consisted of projection of the content on the ELMO or on the monitor from the computer such as a slide show presentation, continual questioning and clarifying, and short video tapes. The professor might introduce a guest speaker. The class session would then proceed to engaging the learner in activities, such as group work, learner teaching demonstrations, and presentation of learner reports. The professor also traveled to each far-site two or three times during the semester, depending on the need.

5 INTERACTION OF DISTANCE EDUCATION CHARACTERISTICS WITH TEACHING STRATEGIES

This section is really the heart of the story. The following table lists the differences and similarities between traditional classroom instruction and distance education instruction for this particular professor and a particular group of learners [10]. Although the table describes both similarities and differences, the emphasis today will be on what teaching behaviors the professor had to modify because of distance education. Modifications include those associated with environment, presentation of knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

Table 1

Similarities and Differences Between Traditional and Distance Education Instruction

Similarities	Differences
• **Environment conducive to the teaching-learning process** ○ Become just as frustrated when cannot talk immediately ○ Learners want to be part of class ○ Diffuse anger or frustration ASAP ○ Face to face ○ Can establish rapport, but takes more effort ○ Make each learner feel welcome, at home, and glad they came ○ Nurturing positive attitude	• **Environment conducive to the teaching-learning process** ○ Difficult to read nonverbal cues ○ Situations may require explanations because all learners cannot see all that is happening in each classroom ○ Teacher and learners have narrow perception of the classroom itself, because all there is is the screen ○ Exhaustion of teacher and learners due to length of class period and number of previous hours in class ○ Rapport is more difficult because learners must be brought along at each meeting as if it is a new class, as you cannot see faces and cannot tell where they are, so you have to assume no one is with you ○ Informality is more difficult to maintain when teacher is confined to one spot ○ May be more stressful to professor than traditional classroom
• **Presentation of knowledge base** ○ Extensive preplanning ○ Transparencies for focus ○ Relevance of material ○ Setting up a learning activity ○ Teaching blocks of 15-20 minutes ○ Refer learners frequently to text	**Presentation of knowledge base** ○ Size of visual materials ○ Color of visual materials ○ Lectures need to be visible ○ Speak more slowly ○ Operating equipment without distracting from content
• **Classroom management** ○ Recreational stress management — joking, getting them ready to engage with me; an organization process ○ Have to manage learners the same — if they are not on target or if they are going things you do not want done — always a constant ○ Make assignment, which is introduction for next class	• **Classroom management** ○ Easier for the teacher to become isolated and self centered and be the fountain of knowledge because it is easier to handle class that way ○ Length of time it takes for class materials to reach learners and learner work to reach me (if the web and e-mail is not used) ○ May have to hold something that needs immediate discussion, because it is not in the hands of all learners — makes spontaneity difficulty ○ Timely feedback difficult ○ Encourage learners talk more and/or to work in groups if we are experiencing audio problems ○ Model for guests so they see what happens when camera jumps from site to site ○ Difficult to do group work across sites because of sound interruption to other learners ○ Have to make special arrangements for private conversations ○ Takes more direction for guests, especially to have appropriate visuals ready and class materials to learners ahead of time ○ Physical proximity cannot be used to control a disruption — all there is is verbal proximity
• **Nonverbal communication**	• **Nonverbal communication** ○ Observation difficult due to camera focus and lack of camera control in multiple sites ○ Limited movement unnatural

Similarities	Differences
• **Feeling of connectivity among class members and professor** ○ Connecting with learners personally through acquaintances or experiences ○ Be who you are and operate the same ○ Call each individual by name ○ Let learners know who you are ○ Introducing learners; establishing expectations; setting the stage for involvement	• **Feeling of connectivity among class members and professor** ○ Look regularly at the camera ○ Treat each site as if it were an individual in a larger class; call each person by name when they speak or when called upon ○ Learners may feel isolation, especially near-site learners, because camera is usually on teacher; the fewer the learners, the more the isolation ○ Professor had to make notes on learner needs, because in jumping from screen to screen (classroom to classroom), easy to lose site of needs ○ Learners usually have trouble speaking — breaking in and speaking up and out
• **Attention to physical appearance** ○ Clothing, makeup ○ Enthusiasm, humor ○ Voice tone/pitch ○ Pauses ○ Gestures	• **Attention to physical appearance**
	• **Methods of communication and or interaction** ○ Facsimile machine ○ Electronic mail ○ U. S. Mail ○ Telephone ○ World wide web
	• **Technical problems** ○ Manipulation of equipment distracts ○ Feedback in sound system ○ No on-site technician for problems ○ Exhausting for professor to have one screen moving them from site to site; split or multiple screen desirable ○ Limited professor movement due to microphone, camera and controls; otherwise, technician must be in room ○ Disconcerting to jump from classroom to classroom ○ Camera focus too distant for reading nonverbal communication ○ Having to look at another camera to see where professor is in relation to monitor may make teacher look distracted when checking it ○ Determining if system will be back up when it goes down and what to tell learners about staying or going home

Environmentally, the primary difference is a two-dimensional far-site communication that is limited to the focal length of the lens. This limitation excludes detail, relevant off-camera occurrences, and access to a great deal of nonverbal communication. For example, on numerous occasions learners requested that the professor move her camera closer to her face so they could see her facial expressions. This greatly restricted the professor's movement and eliminated hand gestures and body motion that she normally used to provide emphasis. Such a restrictive environment often causes stress to professors and learners and makes rapport problematic.

Presentation of the knowledge base required more time to deliver because lectures needed to become more visible and the professor needed to speak more slowly. On one occasion the professor was discussing an overhead transparency point by point and a learner remarked, "Please slow down; I can't hear you that well through the system." The combination of lack of screen resolution that is characteristic of a television image and the poor sound quality required more time to deliver instruction. One of the reasons that sound and picture quality can be poor is the need to reduce the band width in order to match the distributor's system which does not always match the originating signal. In addition, a distance education professor's attention must be devoted to operating equipment as well as to delivering content. Frequently it takes longer to deliver instruction via two-way compressed video; therefore, it may decrease the scope of the course.

The majority of the differences noted between traditional and distance education instruction appeared in the classroom management category. Normally physical proximity can be used to control classroom disruptions. That is not available to the distance educator. It is extremely difficult to take a learner aside for private conversations. The professor did this primarily through e-mail and telephone communications. Although it is beneficial to plan materials and instructional sequences ahead of time, the lack of physical proximity to learners and the inability to introduce new materials rapidly reduces spontaneity of instruction. For example, a far-site learner might request information about a regulation concerning affirmative action, which involved completion of certain forms. The professor would have to get the forms to the learner before he/she could discuss the specifics of the question. This is one example among many about how physical distance from learners reduces opportunities for the teachable moment. Physical isolation from learners means that organization and direction of the class can easily become centered on the professor which could cause the professor to utilize more controlling teaching strategies. It should be mentioned that guest speakers needed to be encouraged to prepare further in advance for their presentations and also had to be introduced to the technology. This sometimes produces a much more formal presentation than was appropriate for the particular teaching situation. The principle investigator's notes in the verification study included references to the stiffness of the guests as they presented. A member check with the professor revealed that the same guests were much more relaxed during traditional classroom presentations.

Nonverbal communication suffered significantly because the camera sees so little and with poor clarity. For example, with three or four remote sites and only one site visible on the monitor at a time and possibly only one learner on camera, the professor could not gain nonverbal feedback from the class as a whole. Even when as many as three learners were on camera at a single time, the camera was so distant that few nonverbal cues, except those involving the whole body, could be observed; for example, facial expression or hand gestures were not readily conveyed.

The feeling of connectivity among class members and the professor is different in the distance education setting. The system used in the College of Education and Health Professions is voice activated which causes learners problems with taking turns, because when they speak the picture jumps to their location; therefore, it is difficult for cross-site discussions to take place. The professor had to use special strategies to establish a classroom community from the four or five sites. The professor approached the task of creating one classroom by recognizing the personality of each site and then the personality of each learner at that site. These personalities were a product of the individuals and the technologies they had at their disposal. For example, there was one group that expressed a reluctance to use the ELMO at their location, while other learner sites would not speak in order to prevent the camera showing their location.

Methods of communication controlled methods of interaction. In a traditional classroom the professor can take a learner aside for a personal conversation while others are working on individual or group projects. However, in the distance education classroom what one learner hears, all learners hear. Of the means of communication utilized in the class, only e-mail or the telephone offered the possibility of a personal conversation.

Technical problems sometimes eliminated class or disrupted class. For example, line feedback made verbal communication very difficult on numerous occasions. On one occasion a storm at a distributing site caused the elimination of one class period. Other technical problems included picture quality, problems with showing videos in real time, and limits on my movements. In spite of these differences between the traditional classroom and the distance education classroom, it is still possible for a class to be conducted on a regular basis and with favorable results.

6 Conclusions

This discussion of similarities and differences between traditional and distance education instruction has centered on the differences rather than the similarities. The researchers have heard many speakers state that there is no difference in teaching in a traditional or distance classroom. The professor knows from eight years of experience there is a difference and is trying to understand the nuances about distance education. The differences cited were classroom environment, presentation of the knowledge base, classroom management, nonverbal communication, feeling of connectivity among learners and professor, methods of communication, and technical problems.

The cumulative effect of these differences resulted in a reduction of what is being called social abrasion. Social abrasion means being present which implies physical proximity and the social abrasion that such physical presence produces [14]. For this discussion social abrasion has been separated into the following categories: physical distance, emotional distance, simultaneous two-way verbal and visual access, private communication, and local knowledge.

Physical distance is an important part of social abrasion. In western civilization each person maintains approximately a three-foot distance between their body and the body of other people. This distance is either reduced or expanded based on interactions with others [6]. The expansion and contraction of this physical distance is an example of the abrasion between one person and another. Abrasion means contact and social exchange. This abrasion is done socially through verbal and nonverbal communications. If people are separated physically as they are in distance education, this sort of social abrasion is extremely reduced or nonexistent because there is no three-foot parameter to expand or contract. Physical distance also decreases interpretation of nonverbal communication. In a long camera shot facial gestures are lost, hand gestures become smaller, and a coherent sequence of body movements become unavailable to the viewer.

Emotional distance is increased through the possibility of physical presence. For example, the threat of being physically harmed or the pleasure of being physically touched are eliminated through distance education. Emotional identification with someone who is simply an image on screen may be more difficult [1]. This is one of the reasons why the professor visited the far sites. Trust in part may also be a function of physical distance. According to some researchers [5], credibility is a product of appearance and personal identification and is problematic when mediated. Authenticity can be achieved by the handling of real objects and the sharing of those objects in a common space [8]. Personal narratives delivered by professors or guest speakers may be less realistic when conveyed through a medium normally associated with fantasy [1]. Simultaneous two-way verbal and visual access are standard in a traditional classroom environment but are not guaranteed in distance education especially when visual access is limited to one site at a time in a multi-site communication. Social abrasion also means the possibility of one on one private oral and written conversations. This is extremely problematic with distance education because what one person says is heard by all. Also important to social abrasion is the honoring of local knowledge [7]. It is possible that knowledge like bread is best make locally [17]. For example, the classroom experience and interpretation of the meaning of course content can vary from site to site [2]. Meanings can vary from site to site because different sites may represent clusters of people with similar experiences that are unique to their areas. For example, professors sometimes have a site which will consist of persons who work at the same industry and may be at different levels of authority within the organization. It is probable that their experiences and knowledge and their meanings differed from other sites [4]. The inability to bring everyone together in one location to produce a common discussion seems impaired by distance education. The combination of these elements — physical distance, emotional distance, simultaneous two-way verbal and visual access, and private communication — and the maintenance of distinct knowledge bases (local knowledge) throughout the course may mean that distance instruction produces different outcomes than traditional classroom instruction. It is these outcomes upon which the research focused. It is the findings of that research the professor draws upon as she develops courses and teaches via two-way compressed video.

REFERENCES

[1] Altheide, D. L. (1976). Creating reality. Beverly Hills, CA: Sage Publications.
[2] Anyon, J. (1981). Social class and school knowledge. Curriculum Inquiry, 11(1), 3-41.

[3] Biggs, B. T., & Swartz, J. D. (1997) Evaluation of an interactive compressed video distance learning class: What we learned from the study. *The New Learning Environment: A Global Perspective* [18th International Council for Distance Education World Conference Papers, CD-ROM]. University Park, PA: The Pennsylvania State University.

[4] Breton, R. (1984). The production and allocation of symbolic resources: An analysis of the linguistic and ethnocultural fields in Canada. Review of Canadian Sociology and Anthropology, 21(1), 123-144.

[5] Fleming, M., & Levy, H. (1992). Instructional method design (2nd ed.). Englewood Cliffs, NJ: Educational Technology Publications.

[6] Goffman, I. (1974). Frame analysis. New York, NY: Harper Colophon Books.

[7] Greene, M. (1986). Reflection and passion in teaching. Journal of Curriculum and Supervision, 2(1), 68-81.

[8] Leiter, K. (1980). A primer on ethnomethodology. New York, NY: Oxford University Press.

[9] Lincoln, Y. S., & Guba, E. G. (1985). Naturalistic inquiry. Beverly Hills, CA: Sage Publications.

[10] Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis (2nd ed.). Newbury Park, CA: Sage Publications.

[11] Orr, B., & Biggs, B. T. (1998). Distance education and two-year institutions — a match? ATEA Journal, 16 (1), 16-19.

[12] Orr, B., & Biggs, B. (1998). Issues and barriers in teaching through two-way compressed video. Refereed poster presentation at the 6th International Conference on Computers in Education. Beijing, China, October 14-17, 1998. [published in proceedings]

[13] Patton, M. Q. (1990). Qualitative evaluation and research methods (2nd ed.). Newbury Park, CA: Sage Publications.

[14] Polanyi, M. (1966). The tacit dimension. Gloucester, MA: Doubleday and Company.

[15] Strauss, A., & Corbin, J. (1990). Basics of qualitative research. Newbury Park, CA: Sage Publications.

[16] Swartz, J. D., & Biggs, B. T. (1999). Technology, time, and space or what does it mean to be present? Journal of Educational Computing Research, 20 (1), 71-85.

[17] Taylor, W. D., & Swartz, J. D. (1988). The emerging knowledge crisis in instructional technology. In M. E. Shorey & A. D. Evans (Eds.), Preparing educators with essential media competencies (pp. 141-152). Columbus, OH: The Ohio State Educational Library/Media Association.

[18] Wolcott, H. F. (1995). The art of fieldwork. Walnut Creek, CA: Altamira Press.

[19] Yin, R. K. (1994). Case study research: Design and methods. Newbury Park, CA: Sage Publications.

The process of learning programming: a comparative study of students' reactions

Judy Sheard*, Angela Carbone* and Selby Markham*
**Faculty of Information Technology*
Monash University
900 Dandenong Road, Caulfield East, Victoria 3145, Australia
Tel: +61 3 9903 2701
Fax:+61 3 9903 1077
Judy.sheard@infotech.monash.edu.au, angela.carbonne@infotech.monash.edu.au
selby.markham@infotech.monash.edu.au

The study of programming is fundamental to any university computing degree course, although many students do not intend to become programmers. This raises an educational question about what students perceive are the benefits of studying programming languages. Added to this is the question of how students compare one language to another. A search of the literature indicates that there appears to have been no research into a comparison of the teaching and learning processes of programming languages by the students learning them. This study attempts to open up this area by reporting on the experiences of a group of students who learnt Visual Basic and COBOL in sequential semesters in the first year of their undergraduate computing course. It showed that there were differences in the way students experienced the subjects but that these were not linearly related to pedagogical models.

Keywords: **Teaching and learning programming, Visual Basic, COBOL**

1 Introduction

Programming languages have been around for half a century. There are a plethora of programming languages which have been developed during that time, ranging from assembler languages to the currently popular object-oriented and visual languages. It is very interesting that a literature search has revealed many references on learning programming, but no comparative studies on student reactions to the processes of the teaching and learning of particular programming languages.

The study of programming is fundamental to any university computing degree course. It is generally recognised that this is a basic skill which is important for all computing graduates to have acquired. Of course not all computing students intend to become programmers, however as professionals working in the computing industry they may expect, at some stage in their future careers, to need some knowledge of programming. The amount of programming taught in a course depends on the focus of the degree, with some courses teaching a minimum of programming and only to an introductory level. This paper reports on a study of first year student experiences learning two different programming languages, Visual Basic and COBOL, in a degree in which programming is often not central to the interests of students. The study aimed to establish if students had a preference for either language and to determine reasons for their preferences. Data was collected through a survey designed to gauge the students' reactions to the learning of each language by asking them to rate the difficulty of concepts and the usefulness of resources provided.

2 Background

2.1 Course

The research focused upon the Bachelor of Information Management & Systems which is a three-year computing degree. It aims to prepare students for careers in the development and management of information systems. The focus of the degree is the study of information flow, information management, computer-based management systems, and systems analysis and design. Students study two subjects of programming, (Computer programming for business A and Computer programming for business B) in the first year of the course. These are the only core (compulsory) programming subjects in the course and were included to provide students with "background" concepts and skills necessary to effectively manage an information technology project. There are six elective subjects in the course and students may choose to study more programming subjects.

2.2 Programming subjects

The two programming subjects are studied consecutively in the first year of the course. These subjects aim to introduce students to commercial business application development. Students learn Visual Basic in the first subject and then COBOL in the second subject. They are both taught as introductory programming subjects, but with necessarily different flavours. Both subjects are taught over a 13 week semester, with a two hour lecture and a one hour tutorial in a computer laboratory each week. The subject details are as follows:

2.2.1 Computer programming for business A

Students are introduced to Visual Basic, currently a popular language for developing Windows based applications. They learn the syntax of the Visual Basic language and the basic programming concepts of types, sequence, selection, iteration, functions, arrays, and files as applied in Visual Basic. They are also introduced to the concepts of object–orientation, event-driven and visual programming. The emphasis in this subject is on developing interactive graphical user interfaces using an integrated development environment.

Assessment in this subject consists of 30% for assignment work completed during the semester, and 70% for a final examination. Students must pass the examination in order to pass the subject.

2.2.2 Computer programming for business B

Students are introduced to the most widely used commercial programming language, COBOL. They learn the syntax of COBOL and the basic programming concepts of types, sequence, selection, iteration, functions, arrays, and files as applied in COBOL. They are also shown fundamental processing algorithms including file validation and updating, report generation and control break processing. The emphasis in this subject is on understanding, designing and developing batch and on-line commercial processing applications.

Assessment in this subject consists of 20% for assignment work during the semester and 80% for a final examination. Students must pass the examination in order to pass the subject.

2.3 Research Design

The research project was seen as an exploratory study which was aimed to help open up an area of research into computing education. As part of the exploratory exercise, a number of behavioural and response variables were formulated into a questionnaire in addition to the material which focussed upon the programming languages. We could have taken any number of approaches to the behavioural and response variables but we chose to use that derived from organisational approaches to motivation, in particular those which take seriously the relationship between expectations and outcomes [6][14].

The survey tools had five sections covering biographical data, behavioural information, language specific ratings, course delivery ratings and two open-ended questions. All ratings a 7-point Likert scale. The language specific questions differed for Visual basic and COBOL. The biographical questions were designed to help establish a profile of the students and enable comparisons to be made between responses on the basis of things such as gender, previous programming experience and time spent on each subject. The open-ended questions asked for students to add additional comments about what they liked and disliked about the language covered by the questionnaire.

Data collection was carried out during the last week of semester of each subject. At this stage of teaching,

every concept had been presented to them and they had completed, or were near completion of, their assignment work. All the students who attended classes during this week were given a questionnaire to complete. Participation in the survey was voluntary. Of the 92 students enrolled in Visual Basic 37 completed the questionnaire, and 43 questionnaires were completed the out of 84 students enrolled in the COBOL class.

3 Results

3.1 Student profiles

The students participating in the research were predominantly male (69%) which fits with the general profile for students doing programming subjects within the university.

For the Visual Basic subject, 57% of students had no prior experience with programming languages. The COBOL students (most of whom had completed the Visual Basic course) had 93% who had experience in at least one programming language. This can be seen as a low level validation of the student responses in that if there had been a low percentage of the COBOL students saying they had no experience with languages, the results would have been suspect.

The students doing these subjects are not in a computer science type of course and their access to a variety of technical software would be limited. It was of interest to the researchers to see how many students had the appropriate language compiler on their own computer. Of the students enrolled in the Visual Basic subject, 90% had access to the Visual Basic software at home. However, 74% of the students in the COBOL subject had access to a COBOL compiler at home and in most cases it was not the same one that was available at university. This may be seen as potential influence on their approach to the subject.

3.2 Subject content

There were no significant differences in student valuations of the amount of content or the difficulty of the content between both subjects. However the Visual Basic students claimed that they spent an average of 5.5 hours per week, including class time, on their subject. This is significantly higher than the COBOL students who claimed to have spent an average of 3.5 hours per week. This indicates that the Visual Basic students spent 2.5 hours outside class time each week whereas the COBOL students had only spent half an hour, an interesting result which will be discussed in Section 4 of this paper.

3.3 Subject pace

The mean and standard deviations of the student ratings of the pace of each subject are shown in Table 1. A t- test, which is a method of comparing the difference of means between two groups, showed that the pace of the Visual Basic subject was rated significantly slower than the pace of the COBOL subject. However, the students in the Visual Basic class with no prior programming experience found the pace significantly faster than their classmates who had previous experience with one or more other languages. This agrees with Liffick's [8] observation of novice programmers and Affleck's [1] study indicating the importance of prior knowledge of concepts and terminology when learning computer programming .

The mean and standard deviations of the student ratings of whether they had kept up with the subject are shown in Table 2. A t-test showed that the Visual Basic students felt that they had kept up with the work more than the COBOL students felt they had.

Table 1 Student ratings of the pace of each subject

	Visual Basic		COBOL		t
	Mean	SD	Mean	SD	
Pace of subject	4.7	1.1	5.3	1.0	-2.5/75*
* indicates t test results significant at p <=0.05					

Subject was very slow =1
Subject was very fast=1

Table 2 Student ratings of whether they had kept up with the work

	Visual Basic		COBOL		t
	Mean	SD	Mean	SD	
Kept up with work	5.0	1.3	3.7	1.6	3.9/78*
* indicates t test results significant at p <=0.05					

Fell very behind with the work =1
Kept up with the work completely=7

Table 3 Student ratings of the usefulness of subject resources

	Visual Basic		COBOL		t
	Mean	SD	Mean	SD	
Lectures	5.9	1.2	4.8	1.6	3.6/77*
Tutorials	5.4	1.5	5.1	1.3	ns#
Lecture notes	5.9	1.2	5.4	1.4	ns
Text book	5.0	1.7	4.7	1.6	ns
Tutorial exercises	5.8	1.1	5.1	1.3	2.7/77*
Assignment work	5.8	1.3	5.5	1.2	ns
Class mates	4.9	1.5	4.7	1.8	ns
Tutor	5.5	1.6	5.5	1.4	ns
Web site	5.8	1.2	4.7	1.4	3.7/76*
* indicates F test results significant at p <=0.05 # ns = difference not statistically significant					

Resource was not useful=1
Resource was very useful=7

3.4 Usefulness of resources

Table3 lists the means and standard deviations of the students' ratings of usefulness of resources provided for Visual Basic and COBOL. Both subjects provided similar types of teaching resources.

t-tests were used to determine any differences between the usefulness ratings between subjects. The results indicate that the Visual Basic lectures were rated significantly more useful than the COBOL lectures. From the standard deviations it can be seen that there was greater variation in the ratings of the value of lectures amongst the COBOL students. Both groups of students found the tutorials and their tutors useful however there was greater variation in the ratings amongst the Visual Basic students about this. The most frustrating finding was that both groups found their classmates the least useful resource. This is frustrating because both lecturers were trying to create collaborative learning cultures [7][11][12].

Each subject had a Web page that contained subject administration information, tutorial exercises, assignment work and access to a self-evaluation quiz of multiple choice questions [4]. The Web page for the Visual Basic subject also contained the lecture notes and a facility for students to monitor their progress in labs in comparison to other students [5]. The students found the Visual Basic Web site significantly more useful than the COBOL Web site.

A comparison of the ratings of tutorial exercises showed that Visual Basic Tutorials were seen as more useful than the COBOL exercises, and this may have been a consequence of the Visual Basic tutorial exercises having been designed to minimise poor learning tendencies within students [2] and to encourage good learning behaviours [5].

There were no significant differences between the subjects on the students' ratings of the usefulness of assignment work and lecture notes.

3.5 Difficulty of concepts

The survey questionnaire for both subjects asked students to rate the difficulty of various concepts in both the programming languages. These included things such as *variables and types*, *iteration*, *arrays* and *file access methods*. Some of these were common to the two languages so it was possible to compare student ratings. The only statistically significant difference found was for *sequential files* (t=2.021 ,df=75) where students found the concept easier in COBOL (mean of 3.7) than in Visual Basic (mean of 4.4) .

In COBOL the students found concepts progressively more difficult with the earliest topic having a mean rating of 3.9 and the others increasing up to 5.3. This pattern did not appear in the Visual Basic data. Related to this is the fact that the standard deviations for the ratings in COBOL were similar across all concepts while those for Visual Basic showed greater variation.

Table 5 Student ratings of satisfaction with subject and course

	Visual Basic		COBOL		t
	Mean	SD	Mean	SD	
Enjoyed the subject?	5.4	1.2	3.6	1.7	5.6/77*
Satisfied with subject?	5.0	1.1	3.9	1.2	4.6/77*
Satisfied with course?	5.1	1.3	5.0	1.0	ns#
Recommend the course?	5.1	1.4	4.2	1.8	2.4/77*

* indicates t-test results significant at $p <= 0.05$

\# ns = difference not statistically significant

Strong disagreement=1
Strong agreement=7

3.6 Behavioural Variables

Both groups of students were confident that they would complete the year successfully (mean of 5.2), although the Visual Basic students without previous programming experience were significantly less confident. Those with previous programming experience had a mean rating of 6.33 while those without such experience had a mean of 4.55 (t=2.5 df=26).

The means and standard deviations of the students' satisfaction ratings of Visual Basic and COBOL are shown in Table 5. Both groups of students were reasonably satisfied with the course. t-tests on the results show significant differences however between their enjoyment and satisfaction of the subjects. The Visual Basic students expressed greater satisfaction with their subject and rated it as more enjoyable. More Visual Basic than COBOL students indicated that they would recommend others to do their subject. There was greater variation amongst the COBOL students about this.

The behavioural variables were also explored using multiple regression analysis because there is a broad set of evidence which indicates that some of these variables are causally related [9] [14]

All of the items measuring reactions to the subjects were regressed on confidence and satisfaction. The model for confidence in completing the year was not significant but that for satisfaction was. The main contribution for the regression came from *enjoyed the subject* and, to a lesser extent, *kept up with the work*. *Pace*, *Content* and *difficulty* did not have statistically significant contributions.

3.7 Qualitative data

Students were asked indicate what the best and worst features of learning each language were. There were many more positive statements about Visual Basic with many students commenting that Visual Basic was easy, interesting and fun. Comments from Visual Basic students included:

- *Visual Basic is easy, not too difficult.*
- *Easy to create programs, easy to use the GUI.*
- *I liked its simplicity everything seems to be done for you,*
- *you can design screens before you start programming.*
- *Visual Basic is fairly simple compared to other languages, I liked the way the program was graphically based.*
- *debugging facility is easy to use*

Fewer students were as complementary about COBOL, stating that COBOL was hard, boring, and frustrating. Visual Basic with its GUI interface, lending itself to exciting interactive applications is a hard act for COBOL to follow!

Students indicated more motivation to learn Visual Basic. Visual Basic was seen as advanced and new. Typical comments from Visual Basic students included:

- *I can learn more things in Visual Basic, and it will be easy to find a job in the future because it is widely used.*
- *Good job prospects*

In contrast, COBOL was perceived as old. A student commented:

- *I'm skeptical about its future`*

Some of the Visual Basic students expressed concerns about the speed at which the language was taught. The students commented that they had to remember a lot of things, and they lacked the skills to use the debugging facilities, the editor, and the Visual Basic environment. These are typical anxieties of novice programmers (Winslow, 1996), highlighted by the following comments from Visual Basic students:

- *The speed that it was taught, especially to students with no programming background*
- *The windows based environment kept crashing*
- *The program not loading*
- *The auto debugger*

Many of the Visual Basic students (57%) were learning programming for the first time and these problems were not mentioned by the COBOL students, most (93%) of whom had previous programming experience.

4 Discussion

An overall impression from the qualitative data is that the students were more positive about learning Visual Basic in preference to COBOL. The students preferred programming in Visual Basic and using its graphical environment.

This was reflected in the quantitative data where there were statistically significant differences favouring some aspects the ratings of Visual Basic over COBOL.

The educational reasons for some of these differences are not easy to isolate (our aim was to open up the area rather than produce a definitive study) although there are some indicators. The pedagogical model being used for Visual Basic included the use of self-formed study groups in which students voluntarily participated. This could explain some of the difference in the time being spent in Visual Basic versus COBOL where the latter was using a more conventional pedagogy.

The study groups were formed as a direct result of applying the Reciprocal Feedback [11] in the lecture series. One outcome of this feedback was that students indicated that they wanted to talk to others about the subject and their particular programming concerns. Time in the lecture was devoted to forming study groups, and students then contacted each other outside of class time to collaborate on the lab exercises, assignments and exam. The study groups may have also helped students keep up with the pace of the subject highlighted from the data in Table 3. Against this there is the fact that Visual Basic students did not rate class mates as more useful than did the COBOL students. In fact class mates had the lowest mean rating for both groups.

What is also of interest is the fact that the students in the two subjects did not differ in the level of difficulty they gave to comparable content areas, except for file handling where COBOL came out as easier.

These factors raise questions about how the different pedagogical approaches do, in fact, impact on student learning. It is assumed, for instance, that by using student oriented teaching methods, students are better able to integrate their educational experience. There are only marginal differences in student outcomes from this study in spite of differences in teaching approach.

Although more students stated in their comments that Visual Basic was easy, surprisingly when the students' ratings of individual language concepts were compared the only significant difference in difficulty was that sequential files were seen as easier in COBOL. This topic was introduced much earlier in the semester in COBOL than in Visual Basic. All the other topics that have been compared were introduced in the same order in both subjects. The students generally found the topics presented were increasingly more difficult as the semesters progressed. This pattern was more apparent in COBOL. Learning programming is a very cumulative exercise with each new topic often building on knowledge from previous topics and therefore understanding of each topic depending on the understanding of previous topics [8]. However it would be a good idea, where possible, to vary the order of presentation by interspersing easier topics with the more difficult ones. This would reduce the pressure on students who fall behind in their work and give them a chance to catch up.

Both subjects provided similar types of resources for the students in printed format, however the Visual Basic Web site had additional resources in the form of program examples, and other computer assisted tools to support self-directed learning. The lecture notes were also available online. The students saw this as a more useful resource than the COBOL Web site. Perhaps the fact that the Visual Basic students had additional reasons to access the Web site encouraged them to make more use of it and also made them aware of other resources on the site. The data does not give any conclusive picture of the impact of resources on perceived performance and it was not possible to compare actual performance (approval to do this had not been sought from the University Ethics Committee).

5 Conclusion

This study was initiated to begin the exploration of student responses to programming languages within computing degrees. As might be expected, the results were mixed. There were differences between the student experience of COBOL and of Visual Basic but these differences were not necessarily consistent given the differences in the pedagogical models used by the two lecturers. The behavioural results indicated the importance of going beyond basic educational questions if we are to understand student behaviours within an educational environment.

The finding that students found Visual Basic more enjoyable was perhaps expected, however it was interesting that their enjoyment of the subject was significantly more important tin their satisfaction with the subject than whether they felt they were coping with the work and how difficult they found it. This research has highlighted aspects of teaching first year programming that influence student satisfaction and impact on learning outcomes.

This study has raised further issues which has or will be dealt with in further research. For instance, a research project has begun on student motivation and programming language choice, and their satisfaction with the language as an educational experience. Another project is looking at the more general question of student satisfaction. But areas which clearly need more research include the question of how programming software and environments influence students' valuations of, and satisfaction with, a programming language. Over and above this, our research has once more raised the general pedagogical questions about the specific qualitative and quantitative effects of one pedagogical model over another.

References

[1] Affleck, G. & Smith, T., "Identifying a need for Web-based course support", Proceedings of 16th ASCILITE conference, Brisbane, Australia, 5-8 December, pp 1-7 (1999).

[2] Baird, R.J., & Northfield R.J., "Learning from the Peel Experience", Melbourne: The Monash University

Printing Services (1995).
[3] Carbone, A. & Golshevsky, D.,"G-SPI: A Graphical Student Progress Indicator", Proceedings of the 2nd Asia-Pacific Forum on Engineering and Technology Education, Sydney, Australia, 4-7 July (1999).
[4] Carbone, A., Schendzielorz, P. & Zakis, J.D., "A Web-Based Quiz Generator for Use in Tutorials and Assessment", Global Journal of Engineering Education, Vol. 1, No. 3, pp. 341-346 (1997).
[5] Carbone, A., Mitchell, I., Gunstone, D. & Hurst, J., "The Student Learning Experience: Characteristics of Programming Tasks that Lead to the Poor Learning Behaviours", Proceedings of HERDSA'99, Melbourne, Australia, 12-15 July (1999).
[6] Gordon, J.R., Organisational Behavior NJ:Prentice Hall 5th Edn. (1995).
[7] Hagan, D. & Sheard, J., "The value of discussion classes for teaching introductory programming", Proceedings of ACM ITiCSE Conference on Integrating Technology into Computer Science Education, Dublin, Ireland (1998).
[8] Liffick, B.W., "A novice programmer's support environment", ACM SIGCSE Bulletin, Vol. 28, No. 1, (1996).
[9] Malley, J., The Measurement and Meaning of Student Satisfaction in the VET Sector: A Review, Melbourne:ACER. (1998).
[10] Mitchell, I., Macdonald, I., Gunn, F. & Carbone, A., "Turning Computer Science Demonstrators into Teachers", Proceedings of Australasian Science Education Research Association (ASERA), Canberra (1996).
[11] Rennie, P. & Carbone A., "Putting soul back into teaching: Building social capital to enhance student learning", Proceedings , HERDSA'99, Melbourne, Australia,12-15 July (1999).
[12] Sheard, J. & Hagan, D., "Designing and Developing a new learning environment for teaching introductory programming: change for effect.", Proceedings of World Multiconference on Systemics, Cybernetics and Informatics, Caracas, Venezuela, July (1997).
[13] Winslow, L. E., "Programming Pedagogy – A Psychological Overview", ACM SIGCSE Bulletin, Vol. 28, No. 3, (1996).
[14] Wittingslow, G. & Markham, S., "Customer-driven modelling of satisfaction Behaviour", Australasian Journal of Market Research Vol. 7, No. 2, pp29-38 (1999).

The Research on Difficulty of Asynchronous Learning Materials Based on Studying Time Distribution

Wu-Yuin Hwang and Rueng-Lueng Shiu
Information and Computer Education
National Kouhsiung Normal Univeristy
wyhwang@nknucc.nknu.edu.tw

The purpose of asynchronous distance learning systems is to enhance students' learning performance in the internet. In this paper, we investigate the characteristics of the asynchronous materials and propose the criteria to evaluate them. Employing the criteria, the materials could be adjusted to meet most students' learning pace. First, the TDC (time-distributed curve) which is a learning curve is derived from students' studying time distribution. By the TDC, it is obtained that the more difficult the materials of the chapter are the steeper the TDC becomes. Also the total learning time of each chapter indicates the quantity of the matter. Employing the total time of each chapter, we could evaluate whether the quantity of the matter is sufficient to match students' learning desire.

Keywords: **distance learning learning portfolio learning behavior learing time distribution**

1 Introcduction

1.1 The distribution of learning time with learning attitude

Teachers could interact with their students immediately at the classroom. Thus, they could get the learning behavior of their students by students' response. The learning behavior is regarded as a good measure to evaluate learning performance. But it is really hard to obtain every student's learning process and attitude because there are at least 30 students in each class. However, employing the database technology in asynchronous learning systems, it is possible to obtain all of the student's learning process and studying time.

1.2 Learning time distribution

In traditional education, students learning together in the classroom at the fixed time, and teachers control the course proceeding. But it is difficult to pay attention to all students. However, asynchronous learning systems not only provide a brand-new perspective to long-life learning but also keep track of learning time of all students. In accordance with the learning time of all students, teachers could modify the matter to match learning goals.

2 Experiment and analysis

The experimental course in our asynchronous learning system is "Basic computer concept", the materials of the course are divided into 12 chapters. The progress-control mechanism is that students need to finish the homework of the chapter in order to be promoted to the next chapter. Thirty participants engage in this experiment and they are all teachers.

The student's learning time and login time are recorded by technologies of ASP(Active Server Page) and Database. Therefore, we could get which chapter students read and how long they read the chapter. The important curve, Time-Distributed Curve (TDC), is generated by linear regression analysis. From the slope and the area of TDC, some characteristics and results are obtained.

2.1 TDC and DCA (Degree of Course Acceptance)

Student's reading time each chapter is recorded in our experiment. The recorded time begins from the date when the teaching materials are put in the internet for 15 days. In each chapter, all of the student's learning time everyday is summed up.

Employing the recorded data and derived chart, each chapter has a unique TDC (time-distributed curve) by linear regression analysis. According to the time-distributed curve, teachers may decide whether the materials should be improved.

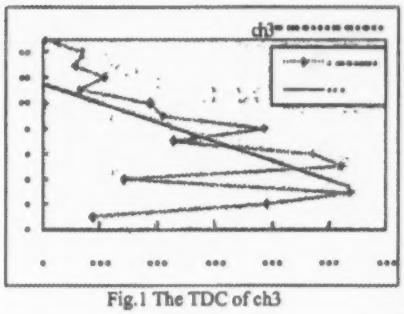


Fig.1 The TDC of ch3

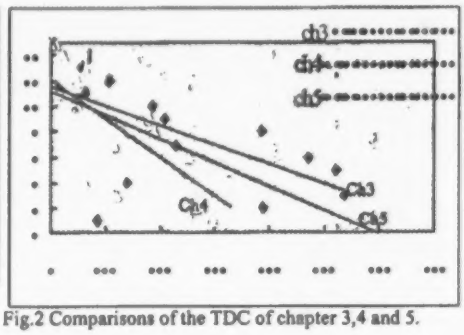


Fig.2 Comparisons of the TDC of chapter 3,4 and 5.

In Fig. 1, the X axle indicates time value and its time unit is one minute not an hour and The Y axle indicates days. For example, the total time on the 4th day is approximate 150 minutes. The slope of the TDC is minus because the total studying time would decrease while students proceed to study the matter.

The value of the slope is required to be concerned. The larger the value of the slope is, the smoother the TDC becomes. For example, figure 2 made comparisons of the TDC of chapter 3,4 and 5. Obviously, the TDC of chapter 4 has the smallest slope because it is the steepest one. And the TDC slope of chapter 3 is slightly larger than that of chapter 5. Thus, it is the most difficult to read chapter 4 and it is the easiest to read chapter 3. The reasons why the materials are hard to study may be either the materials are complicated or the user interface is not friendly to read. According to the above description, the slope of TDC could be termed as Degree of Course Acceptance (DCA, It means the harder the topic to read the smaller is the DCA.). Besides the TDC's slope is proposed to determine the degree of materials acceptance, there is another important characteristic, the area of the TDC, to influence the amount of learning time.

Based on the area and slope of TDC, the difficulty and quantity of the materials could be evaluated. According to the above description, it is shown that the quantity of materials would affect the amount of learner's studying time, also the difficulty of materials would affect the length of learning period. Due to these reasons, there are two margin lines, quantity and difficulty, in Fig. 3. The two margin lines are termed e are "Margin Line Of Quantity (MLOQ)" and "Margin Line Of Difficulty (MLOD)". There are plentiful materials on the right of MLOQ, but there are poor on the left side. The upper of MLOD the materials are located the harder they are read, but lower are easy.

Since the features of MLOQ,MLOD,DCA and the area of TDC are proposed, there are four kinds of situations that the TDC represents as follow:

1. It is easy to read the material, and the contents are plentiful.
2. It is easy to read the material, but the contents are poor.
3. It is hard to read the material, but the contents are poor.
4. It is hard to read the material, and the contents are plentiful.

BEST COPY AVAILABLE

The MLOQ and MLOD could be employed to enhance discriminating the difficulty of the materials if the DCA and the TDC's area of the chapters are different. Finally, how is the value of the MLOQ and MLOD obtained? The MLOQ is the average of all students' learning time of one chapter. The MLOD is the average of all students' learning days of one chapter.

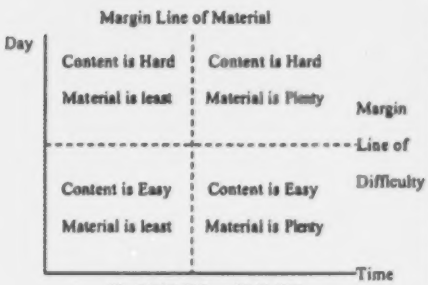


Fig.3 MLOQ and MLOD

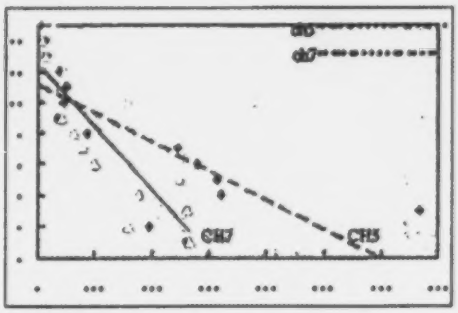


Fig.4 Compares the TDCs of the ch5 & 7

2.2 Time distribution of the interdependent course

What else may affect one's effort in the course? There are relationships between two topics. For example, there are relationships of dependency between chapter 5(Internet I) and 7(Internet II). Generally, the topic "Internet I" is dedicated to construct the fundamental concept and "Internet II" introduces the advanced ideas and practice. According to the normal teaching policy in both topics, the "Internet I" should have fewer and simpler materials than the "Internet II". Thus learners spent much less time to study "Internet I" than "Internet II".

Fig.4 compares the TDCs of the two chapters. As shown in Fig. 4, it is easy to find out chapter 7 has a smaller DCA (the slope of TDC), that is, chapter 7 is harder than chapter 5. Furthermore, the area of chapter 7 is less than that of chapter 5. The TDC of chapter 5 is located at approximately 11 on Y axle and 600 on X axle and the TDC of chapter 7 located at 12 on Y axle and 280 on X axle. According to MLOQ and MLOD as shown in fig.3, we concluded that "The chapter 7 is more difficult than chapter 5, but its quantities are much less". It is different from we described before, "Internet I" should have fewer matters than "Internet II". In our experiment, we provided much more contents in chapter 5 than chapter 7. Therefore the amount of materials in chapter 5 should be reduced.

3 Conclusions

The asynchronous learning service is an on-line collection of hypertext that provides us a new way to learn. Their students with different native intelligence come from any place and go to learn when they would like. It is very important to design and evaluate the asynchronous teaching matters so as to match teaching goals. This paper proposed some basic criteria to investigate the characteristics of teaching matters, then gave an advise to modify them to meet the learning desire. The basic criteria, the area and slope of TDC, are derived from learning time distribution. Through the basic criteria, instructors could modify the materials in accordance with mo. 'udents' learning pace and talent. Especially, our proposed mechanism is worth much attention to develop the adaptive learning system. Once the asynchronous learner's studying portfolio is available, the materials could be real-time adjusted to match the learner's state.

Reference

[1] • • •

Towards a model of using Information Technology in education for pre-service teacher education

Kai-ming LI, Yiu-sing LAM, Pak-hung LI and Kwok-leung WU
Department of Curriculum and Instruction,
Hong Kong Institute of Education, 10, Lo Ping Road, Tai Po, N.T. Hong Kong
kmli@ied.edu.hk, yslam@ied.edu.hk, phli@ied.edu.hk, klwu@ied.edu.hk

This paper reports the present scenario of using computer and traditional instructional media for primary class teaching in HKSAR. 323 primary teachers who have attended staff development seminars and refresher training workshops in the use of IT in education were invited to provide information for the study. The teaching time in a week and the teaching modes with 16 instructional media including computer technologies were examined. Results showed that textbook, blackboard and printed text materials remain the dominant instructional media in current practice of teaching in primary schools. The use of computer technology is rare despite the expectation that computer and computer-related technologies will make learning more effective and efficient and even to replace the traditional "educational technologies". The findings also indicated that technologies were used mostly as information delivery tools. Teaching strategies were limited to mass teaching and teacher-centered presentation. This phenomenon may have relationship with the ineffective training in the use of IT as indicated in many researches though courses in this area have been included in most teacher education programmes around the world. The last section of this paper will discuss on the contents of IT courses and to suggest a teaching model of using IT in education for pre-service teachers education programmes.

Keywords: **Methodologies, Teaching and Learning Process, Instructional Design**

1 Introduction

The Hong Kong Special Administration Region (HKSAR) government has already launched a five-year strategic plan of promoting the use of Information Technology (IT) in education aiming at enabling our students to be competitive and technological competent in the international arena since 1998 [1]. A total of about three billion dollars in capital cost and five hundred million dollars in annual recurrent cost will be used.

Computer and computer related technologies were expected to make teaching and learning more effective and efficient when it entered the classroom in 1980s [2]. Many teacher education programmes around the world have already started incorporating computer courses as basic requirement for teacher certification. In HKSAR, the previous colleges of education[1] have also started to include computers in education and computer applications courses in the Educational Technology subject which is compulsory to all the pre-service teachers in late 1980s. However, despite the provision of this training in many teacher education programmes, many researches report that the actual usage of new technologies in teaching was very limited. Teachers are not prepared to use new technology effectively in the classroom [3] [4]. Abdal-Haqq (1995) [5] even stated that "...few teachers routinely use computer-based technologies for instructional purposes" (p.1). In U.K., the HMI also commented that "new teachers make little use of Information Technology in the lessons"[6].

The purpose of this study is to find out the present scenario of the use of instructional technologies in primary

---

1 The previous colleges of education were amalgamated into the Hong Kong Institute of Education in 1994.

school teaching. The teaching time and the modes of using computer and traditional technologies are examined and compared. Such information will act as the base line for future investigation on the changes in teaching modes, strategies, and the use of new technologies in the 21st century classrooms. The last part of this paper will discuss on the contents and a teaching model that may be useful for preparing pre-service teachers to use computer more effectively in their future class teaching.

2 Method

2.1 Participants

The participants in this study were 323 primary teachers who attended staff development seminars and refresher training workshops in the use of IT in education offered by the Department of Curriculum and Instruction of the Hong Kong Institute of Education in 1999. 76% of them were female primary teacher. 95% of them possessed personal computers at home. 56% of them have received computer training in pre-service teacher education programme. This sample was further divided into three groups according to their teaching experiences: 27%, under 5 years; 25%, 6-10 years; 48% over 10 years.

2.2 Data Collection

The participants were asked to complete a survey at the beginning of the seminar and workshops. The first part of the survey was the demographic data of the participants while the second and third part required the participants to respond to the time spent in a week and the different modes of using 16 instructional media selected for this study respectively (see Table 1 and 2).

3 Results

3.1 The time of using instructional media in a week

Table 1 shows that board writing remains the most frequently used medium in the classroom. About 75% of the participants spend more than half of their teaching time with it. The second frequently used medium is board drawing (about 38%) while the third one is printed medium (about 30%). The table also reveals that 10 items have their using time less than half of the total teaching time in a week (item 6-11 and 13-16). It is also obvious to see that computer technologies were seldom used in class teaching at this stage. This phenomenon may be well explained by the un-readiness of computer facilities in most of the primary schools in the period of this study.

However, the figures revealed in the mean percentage of the use of traditional media in Table 1 show that about a quarter of the participants did not use any traditional instructional media and about 57% of them taught with these media less then half of the teaching time in a week. Only 17% of them used them for more than half of the teaching time in a week. This result shows that "text-book" teaching remains the dominant strategy in most primary school teaching despite those traditional instructional media have already placed in the schools as standard equipment.

Types of Media	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
Traditional Media					
1. Blackboard/Whiteboard Writing	1.5	2.9	20.4	33.8	41.4
2. Blackboard/Whiteboard Drawing	2.9	28	31.5	22.6	15
3. Realia/Model	1.9	51.3	33.2	10.6	3
4. Graphics	3.3	53.1	32	9.6	2
5. Printed Material	3.6	32.4	34	18.4	11.6
6. Photo	13.1	69.3	12.8	4.5	0.3
7. Slide	71.8	23.1	4.2	0.6	0.3
8. Overhead Transparency	40.8	38.7	17	1.9	1.6
9. Audio Tape	30.8	44.8	17.4	3.5	3.5
10. Video Tape	35.5	42.8	15.8	4.9	1

11.	Tape-Slide Programme	88.5	8.9	1.6	1	0
12.	Learning Package	13.1	49.4	25.6	9	2.9
Computer						
13.	Computer Generated Texts and Graphics	53.8	32	11.3	1.9	1
14.	Computer Presentation Programme	82.8	12.7	3.2	1.3	0
15.	Computer Assisted Learning Programme	86.4	9.1	3.9	0.6	0
16.	Internet	94.8	2.9	1.3	0.7	0.3
	Mean Percentage :	79.45	14.18	4.93	1.13	0.33

Table 1: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Primary Teachers of the Study (N=323)

3.2 The modes of using instructional media

Participants who have used the instructional media were asked to respond to the types of instructional modes of how these media were used. Table 2 shows that for the first three frequently used media as identified in last paragraph, they were used mostly for teacher's presentation (82%, item1; 79.2%, item2 and 66.7%, item4). The average percentages for group learning and individual learning activities for traditional media are 16.6% and 8.2% while those for computer are 8.6% and 4.5% respectively. These figures show that teacher's presentation is still the major mode of teaching among primary teachers at the present moment.

Types of Media		Teacher's Presentation (%)	Group Learning Activity (%)	Individual Learning Activity (%)
Traditional Media				
1.	Blackboard/Whiteboard Writing	82	-	-
2.	Blackboard/Whiteboard Drawing	79.2	-	-
3.	Realia/Model	66.4	30.6	9.5
4.	Graphics	66.7	23.5	7.6
5.	Printed Material	31.5	47.4	36.7
6.	Photo	48	24.5	9.8
7.	Slide	20.5	4.3	3.7
8.	Overhead Transparency	41.3	15	6.4
9.	Audio Tape	36.4	10.4	6.1
10.	Video Tape	35.5	8	4
11.	Tape-Slide Programme	11	3.1	1.5
12.	Learning Package	40.7	32.4	13.5
	Mean Percentage :	46.6	16.6	8.23
Computer				
13.	Computer Generated Texts and Graphics	26.3	17.1	9.5
14.	Computer Presentation Programme	9.2	7.3	3.7
15.	Computer Assisted Learning Programme	7.3	5.5	3.1
16.	Internet	4	4.6	1.5
	Mean Percentage :	11.7	8.63	4.45

Table 2: The Percentage of Responses to Teaching Modes Used with Instructional Technologies by Primary Teachers of the Study (Respondents can select more than one mode)

3.3 Effects of difference in gender and teaching experience on the use of instructional media

Since the sampling was not randomized, normal distribution of the sample could not be assured. A non-parametric analysis using the Mann Whitney U test was then used to compare the difference of the distribution of the responses between female and male primary teachers and the three groups of teachers with different teaching experiences.

Types of Media	Gender	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
3. Realia/Model*	Female	1.3	46.4	37	11.9	3.4
	Male	4.1	67.5	21.6	5.4	1.4
4. Graphics*	Female	3	48.1	35.1	11.7	2.2
	Male	4.2	70.4	21.1	2.8	1.4
5. Printed Material*	Female	3	31.8	30.5	20.3	14.4
	Male	5.6	34.7	44.4	12.5	2.8
6. Photo*	Female	11.8	66.8	15.1	5.9	0.4
	Male	17.8	76.7	5.5	0	0
7. Slide*	Female	74.8	19.7	4.3	0.9	0.4
	Male	61.6	34.2	4.1	0	0
11. Tape-Slide Programme*	Female	90.9	6.9	1.7	0.4	0
	Male	80.8	15.1	1.4	2.7	0
13. Computer Generated Texts and Graphics*	Female	58.7	30.6	8.1	1.3	1.3
	Male	37	37	21.9	4.1	0
14. Computer Presentation Programme*	Female	89.8	7.7	2.1	0.4	0
	Male	60.3	28.8	6.8	4.1	0
15. Computer Assisted Learning Programme*	Female	91.5	6.4	1.7	0.4	0
	Male	69.4	18.1	11.1	1.4	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Table 3: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week by Female and Male Primary Teachers of the Study

Significant differences were found in the distributions of 9 items between female and male teachers. In Table 3, referring to the "never use" column, it is interesting to see that female teachers used simple and traditional media (item 3,4,5 and 6) more than male teachers while male teachers used more complicated traditional media (item 7 and 11) and computer technologies (item 13,14 and 15) in this study. Similar analysis was conducted among the teachers with different teaching experiences. Only one item was found to be statistically different between the less experienced and more experienced teachers. Table 4 shows that experienced teachers used slide more than the less experienced teachers.

Types of Media	Teaching Experience	Never Use (%)	Less than 1/4 time (%)	Between 1/4 to 1/2 time (%)	Between 1/2 to 3/4 time (%)	More than 3/4 time (%)
7. Slide*	Group A	82.4	14.1	3.5	0	0
	Group B	66	29.1	4.3	0.7	0

** Statistically Significant Difference at $\alpha = 0.05$, Mann-Whitney U Test*

Group A: Teaching experience less than 5 years; Group B: Teaching Experience greater than 10 yearS

Table 4: The Percentage of Responses to Teaching Time Used with Instructional Technologies in A Week Between Two Groups of Primary Teachers with Different Teaching Experience of the Study

Analysis on the teaching modes of using these instructional media, however, showed that no significant differences were found between the female and male teachers and also among the three groups of teachers with different teaching experiences.

4 Discussion

From the above findings, it is obvious that the use of instructional media including computer technologies was limited. The teaching strategies employed by most primary teachers were still very teacher-centered although they have already completed instructional technology and related courses in the teacher education programme. Computer uses were rare even though more than 50 % of the participants have attended computer courses while receiving their pre-service teacher training and 95% of them possess home computers. It is evident that future teaching is influenced by the learning experiences that pre-service teachers gained in their tertiary education [7]. Researches also show that the provision of instructional models for classroom implementations

of technology is far more important than the training of the "know-how" skills [8]. The instructional strategy should act as the model and should be student-centred rather than terminology and hardware centred [9]. Task-based or problem based activities are more effective than skill drilling of certain hardware or computer software by direct demonstration. A course with well–designed contents and effective teaching model for the use of IT in education is believed to have positive influence on the actual implementation in school teaching.

4.1 The Contents

We suggest that for an IT in education course to be successful, the following areas should be included. We believe that such contents allow our pre-service teachers to have more comprehensive mastery of knowledge and skills of using IT in education and enable them to put theories and practical skills into real practice in primary school teaching.

1. Understanding the development, trends, advantages and limitations of using IT in education.
2. Understanding the roles and contributions of IT and teachers in the communication and learning process.
3. Designing and producing instructional materials with IT.
4. Operating computer hardware and application software while producing and using computerized instructional materials
5. Selecting and deriving learning activities with computerized instructional materials and resources
6. Evaluating the effectiveness of computerized instructional materials and programmes that involves the use of IT.

4.2 The Teaching model

Figure 1 is a proposed teaching model of using IT in education for teacher preparation programme. This model is informed by constructivist views of learning in which the learner is the center and the actor of learning. There are six major components in the model:

1. The teacher – is the one who build this model, creates a constructivist learning environment, acts as the resource, guide and the facilitator of the learning process and models the actual implementations and strategies of using IT in an authentic context.
2. The learner – is the master of this model, comes with different background and learning style, interacts with other components of this model and to construct the knowledge and skills actively.
3. Resources and support – assist the learner to complete his/her task throughout the learning process.
4. Integration – is the experience that the learner gains when applying IT in teaching and learning in an authentic situation.
5. Reflection – is the introspective thinking allowing the learner to have deeper understanding of the IT applications and be able to examine related issues critically.
6. Monitoring strategies – provide clear instructions and directions allowing the learner to have a complete picture of the objectives and significances of the learning, the tasks to be completed and the access to relevant resources and support.

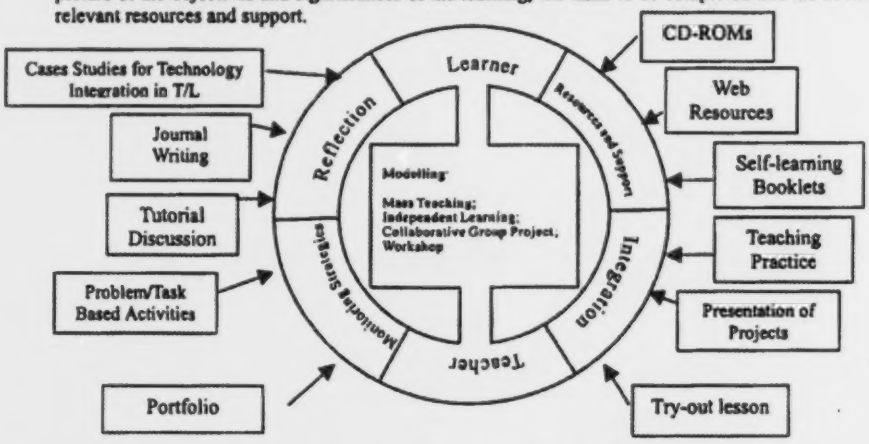


Figure 1: A teaching model of using IT in education for teacher education

5 Conclusion

The components of the teaching model guide the development of various strategies, learning activities and resources that can be found in Figure 1. Evaluation of the effectiveness of this model has been started and the results will be reported in due course. The findings of the survey in the first part of this study signal the ineffective use of instructional media both in terms of teaching time and strategies in primary school teaching. Change is expected if our students are to be really benefited by the five-year strategy of using IT in education. Teacher education, therefore, places an important role in this aspect.

References

[1] Education Manpower Bureau (1998). Information Technology for learning in a new era: 5-year strategy 1998/99 to 2002/03, November 1998, HKSAR.

[2] Goodlad, J.I. (1984). *A place called School*. New York: McGraw Hill.

[3] Bosch, K.A. and Cardinale, L. (1993). Preservice teachers' perceptions of computer use during a field experience. *Journal of computing in Teacher Education*, 10(1), 23-27.

[4] Office of Technology Assessment (OTA)(1995) Teachers and Technology: Making the Connection. US: OTA 1995 Report.

[5] Abdal-Haqq, I., "Infusing technology into pre-service teacher education", ERIC digest. (ERIC Document Reproduction Service #ED 389699). (1995)

[6] Her Majesty's Inspectors (1993). *The new teacher*. London: HMSO.

[7] Adams, P.E. and Krockover, G.H. (1997), Beginning science teacher cognition and its origins in the pre service secondary science teacher program. *Journal of Research in Science Teaching*, 34, 633-653.

[8] Novak, D. and Knowles, J. (1991). Beginning elementary teachers' use of computers in classroom instruction. *Action in Teacher Education*. 8(2), 43-51.

[9] Bigum, C. (1990). Situated computing in pre-service computer education. In A. McDougall and C. Dowling (Eds.). *Computers in Education*. North Holland: Elsevier Science.

TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP—COLLABORATION TYPE AND LOOSELY CONNECTED TYPE

Shoichi Kinosita* and Nobuyuki Arakawa**
*SEITOKU University, *550, Iwase, Matsudo, Chiba, Japan 271-8555,*
E-mail: kino@po.jah.ne.jp
**Kamishinmei Elementary School, *Futaba-4, Shinagawa-ku, Tokyo, Japan*
Email: arakawa.nobuyuki@nifty.ne.jp

1 Introduction

We construct a virtual school in INET since December 1997 about elementary and secondary education. This virtual school is collaboration type. About 10 teachers are the managers who control the open and close to the courses. This members also join to "Project Group for Learning Process" founded at 1984 in Matsushita Audio-Visual Research Foundation. The courses are consists of Japanese Language, Mathematics, Social Science, Natural Science, Arts, etc. The writer of each course is voluntary and often invited by the manager. The system of this school is controlled by CGI program that counts and classify the visitors.

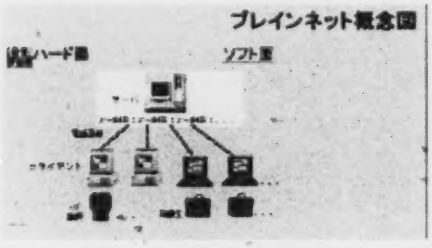


fig. 1 Structure of Type [A]

The other type -Loosely connected- virtual school will be appeared in several months. This type is the mirror image of writer's daily lesson. The writer is also the teacher at a classroom and the course is the same contents as the lesson at the class. The first purpose of this type is the help for absent student at lesson with inevitable reason.

The second purpose is the teacher's skill up the teaching methods and fill up his contents. Each course is gazed by the other writer and visitor by critical viewpoints and comments may send to him by E-mail or another way. These comments will effective for the writers. The writers are loosely connected by browsing and criticize for each other.

2 Comparison of Two Types of Virtual School

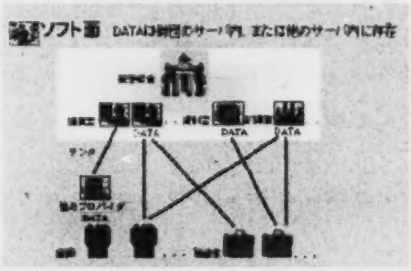


fig. 2 Software Structure of Type [A]

Let's call collaboration one is the type [A] and a loosely connected one is the type [B]. Type [A] may have fine course by fine teacher by the reason of solid watch and control and severe criticism. But the number of writers may be limited because of difficulties to make fine or excellent course. In fact, the number of writers of our school is about 20 teachers today. The increase of number of writers is very slow.

Type [B] may readily have many teachers because the reporting of own daily lesson wants little efforts except for some reviews and writing time.
On the other hand, the quality of course may not be

expected, and the learners to be supposed are very restricted.

Results

The two types [A] & [B] will be exist parallel to each other and exchange the writer, or perhaps invite the writer for type [B] at first and next to type [A] if the course will fine and universal.

The Language of both types is Japanese and every learner or visitor needs to read Japanese Language. This is an issue that is easily overcome by some Japanese to English interpretation software. Our two schools slightly gather the writers who want to spread their unique lesson and the effect appeared in the mutual discussion about order in lesson, resources, tools, and illustrations in both type.

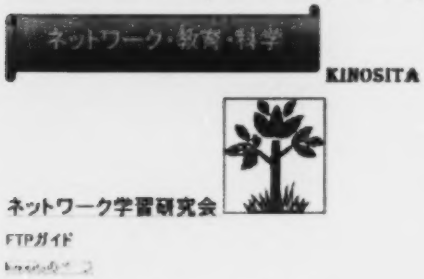


fig. 3 Front Page of Type [B]

There are many virtual schools in Japan and all over the world. These are almost supported by ministry of education, nation, or company who have many staffs working with development and editing. Our tiny two virtual schools will combine the teacher's skill and fine lessons from voluntary teachers in Japan or other country and serve the chances to learn for many learners who can't go to the school with willingness to learn.

References

[1] Our type [A] Home Page, http://www.mef.or.jp/bnm/(accessed on July 20,2000)
[2] Our type [B] Home Page, http://www.kinosita.itabashi.tokyo.jp/(accessed on July 20,2000)

Using Virtual Environments for Studying Water Phases and Phase Transitions

Jorge F. Trindade* and Carlos Fiolhais **
**Physics Department and High Education School for Technology and Management, Polytechnic Institute of Guarda, 6300 Guarda, Portugal*
E-mail: jtrindade@ipg.pt
*** Physics Department and Center for Computational Physics, University of Coimbra, 3000 Coimbra, Portugal*
E-mail: tcarlos@hydra.ci.uc.pt

In recent years, many studies have dealt with students' reasoning in science. Those studies suggested that pupils, in different degrees, have difficulties in understanding matter phases and phase transitions. To increase pupils understanding of phases and phase transitions, we are developing the "Virtual Water" project, a virtual environment centered on the learning of the structure and properties of water in its different phases. Within this environment, the molecular dynamics in the solid, liquid and gaseous phases of water and the corresponding phase transitions take place in three-dimensional space, with the possibility of haptic interaction with the molecules.

Keywords: **Virtual reality, virtual environment, water, phases and phase transitions**

1 Introduction

All substances undergo dramatic changes in their qualitative properties when certain parameters pass through particular values. Matter phases and phase transitions have received considerable attention in the framework of research on children's understandings in different ages and development stages [1-4], [10], [15].

Ice melting is an everyday example of a phase transition. When the temperature increases, keeping the pressure constant, the molecular vibrations become gradually more violent and thermal expansion occurs. Since this increase of vibration amplitude is gradual, one might expect that the macroscopic properties of water would also undergo a smooth change. While this is true for most temperatures, there is a well-defined temperature for which something dramatic happens: a sudden change in the properties of the substance and the appearance of a liquid. The liquid, in its turn and at a higher temperature, undergoes another phase transition going into a gas.

Few pupils use the corpuscular theoretical model taught in school to explain these processes. Indeed, their knowledge and understanding of the corpuscular theory of matter is sometimes very fragmentary. They apply it in some situations but not in others. For example, they may apply the corpuscular theory to explain gases but not to explain solids and liquids. There are also cases where pupils say that the shape and size of molecules changes when the state of matter changes: the shape of molecules depends on the shape of the vessel, molecules of solids are the biggest while gas molecules are the smallest for Portuguese children (13-15 years) [9], etc.

Other studies of students' conceptualization of phase transition from liquid or solid to gas have indicated that some children have difficulties conceiving gas as a substance [6] [12]. As students do not develop the general idea of gas prior to formal learning, the perceptual clues for detecting and identifying gases are weaker than for liquids and solids. Although pupils know some properties of air, they do not compare air with other gases, claiming that other gases do not have the same properties as air. A frequent explanation is that air is a big bulk system [11]. Gases are frequently linked by some invisible entity, something immaterial, for example energy in various forms. Kircher [5] also reports that high school pupils understand gases as a

continuous substance with no empty space between particles.

Since the use of images is a powerful tool for understanding complex and/or abstract information and since immersion in virtual environments is a recent technique which needs to be explored and evaluated, a virtual environment for studying phases and phases transitions is being developed by the Physics and Mathematics Departments of the University of Coimbra, Portugal, the Exploratory "Henry the Navigator", in Coimbra, and the High School for Technology and Management of the Polytechnic Institute of Guarda. We have named it "Virtual Water".

2 Overview of the Molecular Dynamics Virtual Environment

"Virtual Water" (VW) is a set of virtual environments designed to help in the instruction of high school students of Physics and Chemistry (it might also be useful for freshman university students). The main goals of this virtual reality application are:

a) To provide an educational environment for students to explore some microscopic concepts which they are taught in class.

b) To develop a practical knowledge concerning the application of virtual reality techniques to education, contributing with data on the usefulness of virtual reality [13-14].

The molecular dynamics component of VW is devoted to understanding some water properties and studying its phases and phase transitions by computer simulation. These simulations are based on the corpuscular theory of matter and use the equations of Newtonian Mechanics. We assume that the dynamics can be treated classically because more realistic simulations (incorporating quantum effects) are cumbersome and more computationally demanding. We also assume that the force between any pair of molecules depends only on the distance between them.

The interactions using *dataglove* allow the user to act and change the environment in order to distinguish the properties of solids, liquids and gases. The *cybertouch* system associated to the dataglove enables the user to experience some molecular behaviors that are impossible to feel in real world. For example, in the solid phase the user may fly through the ice structure and learn about it (Figure 1). Using the *dataglove* the user is able to break the ice and with the *cybertouch* system he can feel the increase of molecular vibrations with the temperature. While breaking ice may be a common macroscopic experience, watching the network of hydrogen bond and feeling molecular vibrations, for example, are quite uncommon experiences. On the other hand, in the liquid and gas phases, it is possible see and try to grab a molecule, understanding by direct experience that its speed is bigger than in the solid phase.

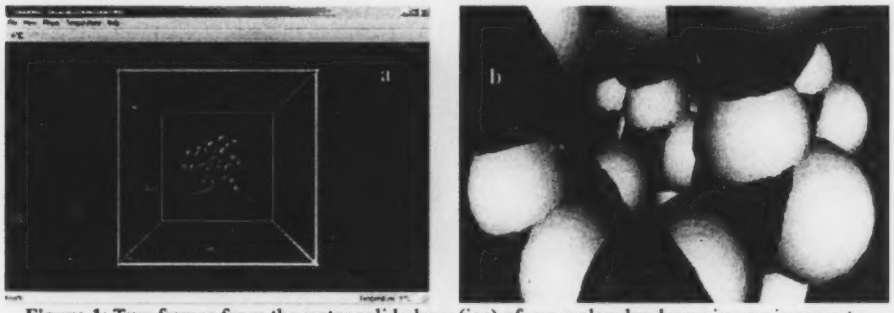


Figure 1: Two frames from the water solid phase (ice) of our molecular dynamics environment: a) balls model of a group of molecules; b) flying through the ice structure.

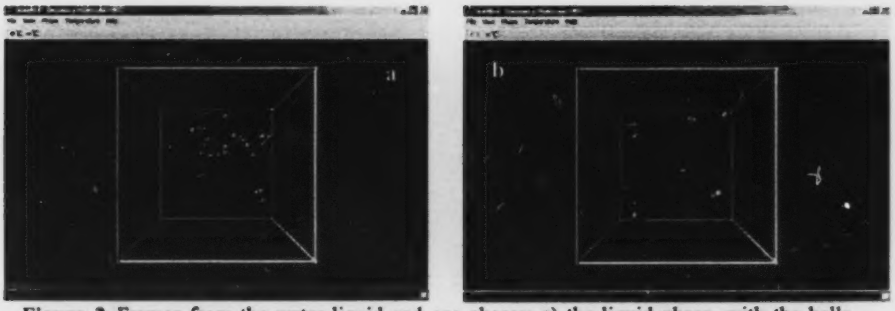


Figure 2: Frames from the water liquid and gas phases: a) the liquid phase, with the balls model of twelve molecules; b) The gas phase, showing the same molecules. These pictures, as well as those of Figure 1, were created with *PC Gamess*, *Molden*, *3D Studio Max*, being the dynamics implemented in *Visual C*$^{++}$on *WorldToolkit*.

Using balls models of water molecules the user may interiorize the corpuscular theory of matter. Since the molecular dynamics simulation takes place in a box (closed system) it is easy to understand that the molecules are the same in solid, liquid or gas phases. It is clear from our virtual environment that, in any phase of water, empty intermolecular spaces are present, these being smaller in the solid and liquid phases than in the gas phase (Figure 2). The density is different in the three phases.

For designing the VW models we used the free software *PC Gamess* [8], that performs the calculations on the water molecule, and *Molden* [7], for the molecular representations. For model development and optimization we used commercial software packages (*Mathcad* and *3D Studio Max*) and *Visual C*$^{++}$ for implementing the molecular dynamics algorithm. Concerning the definition and creation of the virtual scenarios we used *WorldToolkit* (from Sense8). For navigating in the virtual environment and interacting with our models we use a *dataglove* with *cybertouch* system (for haptic information) from Virtual Technologies.

3 Conclusions

Important strategies in teaching Physics and Chemistry are based on central the idea that matter consists of particles but the fact that these are invisible hinders sometimes the development by students of the right scientific concepts. However, the analysis and comparison of various results in the pedagogic literature show that some incorrect concepts and their relationships are simply transferred from the macroworld to the microworld. In fact, there is a firm link between the concepts on matter structure and empirical knowledge of macroscopic phenomena.

If students accept the corpuscular theory mainly for gases and not for solids and liquids, it is advisable to confront them with this contradiction and to treat specifically the processes of phase changes from gas to liquid, and *vice versa*, in terms of identity of substance, identity of particles and conservation of the number of particles. Similar procedure applies to students who accept better the corpuscular theory for solids.

The use of immersive virtual environments and haptic information, although recent, seems to be a powerful means for visualizing and understanding complex and/or abstract information. Actions like grabbing a molecule, breaking hydrogen bonds networks, feeling molecular vibrations, flying through channels in ice and through the empty spaces of molecules in liquid and gas phases (as in George Gamow's book "Adventures of Mr. Tompkins"), etc. are impossible in real world but possible in computer simulations.

"Virtual Water", our virtual environment for studying phases and phase transitions based on corpuscular theory of matter is promising to make progresses along the indicated directions. We are acquiring new means in learning and teaching the Physics and Chemistry of water and building knowledge on virtual reality techniques and tools, which can later be applied to other problems. In particular, our experiment with virtual reality should point out what are the most effective educational benefits and also to indicate the weaknesses of this new technology in an educational setting.

Feedback from pupils is being collected and analyzed in order to quantify the pedagogical usefulness of our

virtual environment. Of course, if these techniques prove to be successful, teacher's strategies should incorporate them. We hope that, with tools like the one we are developing, intangible experiments become more and more concrete and that this fact may facilitate the development of scientific models among science students.

Acknowledgements

The authors thank Prof. Dr. Victor Gil, from the Chemistry Department of the University of Coimbra, for his precious suggestions, and Prof. Dr. José Carlos Teixeira, from the Computer Graphics Center of the same University, for his technical advice. We also wish to acknowledge the assistance of the students Nuno Pereira and Eduardo Coutinho, who have developed the molecular dynamics component of "Virtual Water". This research was supported in part by the Portuguese Foundation for Science and Technology (project PRAXIS/FIS/14188/1998).

References

[1] Andersson, *B.*, "Pupils' conceptions of matter and its transformations (age 12-16)", Studies in Science Education, *18*, pp. 53-85 (1990).

[2] Driver, R. Squires, A., Rushworth, P. & Wood-Robinson, V., "Making Sense of Secondary Science - Research into Children's Ideas" (London: Routledge) (1994).

[3] Driver, R., Goesne, E. & Tiberghien, A. (ed.), "Children's Ideas in Science" (Milton Keynes: Open Universitv Press) (1985).

[4] Garnett, P., & Hackling, M., "Student's alternative conceptions in chemistry: a review of research and implications for teaching and learning", Studies in Science Education, 25, pp. 69-95 (1995).

[5] Kircher, E., "Research in the classroom about the particle nature of matter" in W. Jung, H. Pfundt and C. Rhoneck (ed.), in *Proceedings of the International Workshop on Problems Concerning Students' Representation of Physics and Chemistry Knowledge* (Ludwigsburg: Pedagogische Hochschule), 342-359 (1981).

[6] Lee, O., Eichinger, D. C., Andersson, C. W., Berkheimer, G. D. & Blakresle, T. D., "Changing middle school students' conceptions of matter and molecules", Journal of Research in Science Teaching, 30 (3), pp.249-270 (1993).

[7] Molden, a package for displaying MOLecular DENsity, written by G. Schaftenaar, CAOS/CAM Center Nijmegen, Toernooiveld, Nijmegen, The Netherlands.

[8] PC Gamess, a program for ab initio quantum chemistry, written by Alex. A. Granovski, Moscow State University.

[9] Pereira, M. P. & Pestana, M. E., "Pupils' representations of models of water", International Journal of Science Education, 13(3), pp.313-319 (1991).

[10] Pfundt, H. & Duit, R., "Bibliography: Student's Alternative Frameworks and Science Education", 4th ed. (Keil, Germany: Institute for Science Education) (1984).

[11] Sere, M. G., "Children's conceptions of the gaseous state prior to teaching", European Journal of Science Education, 8(4), pp.413-425 (1988).

[12] Stavy, R., "Children's conceptions of gases", International Journal of Science Education, 10(5), pp.553-560 (1988).

[13] Trindade, J., Fiolhais, C. & Gil, V., "Virtual Water, an application of virtual environments as an education tool for physics and chemistry". In *Advanced Research in Computers and Communication in Education*, Proceedings of ICCE' 99 – 7th International Conference on Computers in Education, Chiba, Japan, ed. G. Cumming, T. Okamoto, and L. Gomez, vol. 2, pg. 655-658, (IOS Press, Amsterdam) (1999).

[14] Trindade, J., Fiolhais, C., Gil, V. & Teixeira, J. C., "Virtual environment of water molecules for learning and teaching science", Computer Graphics Topics, 5 (11), pp.12-15 (1999).

[15] Wandersee, J. H., Mintzes, J. J. & Novak, J. D., "Research on alternative conceptions in science". In D. Gabel (ed.), *Handbook of Research on Science Teaching and Learning* (New York: Macmillan), pp.177-210 (1994).

Web-Based Subject-Oriented Learning Program on Geophysics For Senior High School

Rong-Kuan Yang* Yi-Ben Tsai and Shi-Jen Lin*****
** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
e-mail: rk@eqm.gep.ncu.edu.tw
*** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
E-mail: ybtsai@eqm.gep.ncu.edu.tw
**** Department of Management Information System, National Central University, Taiwan*
E-mail: sjlin@mgt.ncu.edu.tw

Homepages of contents on the topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been composed for the subject-oriented learning program for senior high school students. Learning test activities were performed to testify the teaching and learning effect via Internet. The homepage contents bear the characteristics of (1) scientific theory-based descriptions, (2) more local examples, (3) highly relating to common life, (4) more dynamic illustrations, and (5) providing interesting practicing works. The results of subject- oriented learning test activities in this study show that the learning style, learning procedures and the homepage contents are all highly accepted by the participants from senior high school. And the learning effect is obvious as judged by comparing the pre-learning and the after-learning concept diagrams drawn by each individual participant.

Keywords: **subject-oriented learning program, learning test activities, concept diagrams**

1 Introduction

Internet system supplies plenty of knowledge conveniently and quickly, the explorer can achieve the purpose of self-learning by collecting, reading, analyzing and combining different kinds of data via Internet. For the purposes of improving the learning environment, enhancing the teaching quality, and raising the learning effect on Earth Sciences education for senior high school, web-based course contents on topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been set up based on the idea of subject-oriented learning program [2]. Senior high school students can not only do the self-learning but also exchange their learning ideas with others through Internet learning system under different conditions of time periods and places. By joining the study results from fields of education, computer technology, geophysics and geology, subject-oriented learning test activities for each specific subject were performed respectively with the participation of volunteered teachers and students from different senior high schools so as to evaluate the learning effect of Internet learning system.

2 Objectives

By especially considering the educational idea of subject-oriented joint learning mode[1], homepage contents were set up. Internet learning test activities were performed by using joint learning software and concept diagram drawing software developed by the computer technologist' s [3]. The major objectives of the study are as follows:

1) Setting up basic web-based contents on Earth Sciences so as to enhance the teaching and learning interests for high school education, the contents may also serve to a better understanding of the earth environment for social people.

2) Setting up the effective searching catalog so as to assist in surveying and collecting related data.
3) Assisting in solving educational problems and improving learning effect through Internet communication system.

3 Subject-Oriented Joint Learning Test Activity

Subject-oriented learning strategy was the major concern in the study. Participants were advised to carry out the learning program by reviewing and collecting related contents through Internet. All the communications were put through BBS posts or e-mails, there were volunteer helpers, college students, to respond all proposed questions from time to time. Team works were important besides individual learning as well, each would share personal learning results with others and came out a group report, individual learning effect was evaluated by comparing the pre-learning and after-learning concept diagrams.

After entering the web site "gepedu.gep.ncu.edu.tw" (Fig. 1), participants would click the right icon to choose the specified subject for the activity. Each one should draw a pre-learning concept diagram by connecting the provided concept terms with proper words after watching the "Miss story" (a short documentary film) prepared for the subject. And then, the major stages for the learning test activity were:

1) Participants were separated into groups of different topics on the specified subject based on his own study interest.
2) Every group set up its study assumptions and strategy; certain assignments were distributed to each individual member of the group.
3) Group members started to survey and collect related data for the topic, and all the working records were kept by using joint learning software.
4) Participants bearing the original role of topic group were re-divided into different groups of experts to cover more study fields. Members discussed and shared personal study ideas and results with others.
5) Each participant returned to his original group of topic and made after-learning concept diagram a group report for the study was also made with the efforts of all the group members.

4 Results and Discussions

Three learning test activities were finished in the study [2]; detailed descriptions of the activities are in Tables 1 to 3. When first learning test activity on Earthquake was being held; related software was not well developed. Internet function was limited to content reviewing. By the time of second learning test activity on Plate Tectonics Theory software was more fully developed, all works were done under Internet environment; more working records were preserved in personal joint learning files for the second and the third activities. All discussions and questions among the students were put through BBS posts and e-mails; volunteer helpers joined the discussions and also answered the questions in time. There are 119 posts from the second activity and 552 posts from the third activity, most of the posts are highly related to the learning program. Each participant finished drawing two concept diagrams in pre-learning and after-learning stages respectively, there are 24 diagrams from the second activity and 46 diagrams from the second activity. And each group had also submitted the group report as required in the learning activity in time, there are 2 and 3 reports for the first and the second activities respectively. Plenty of discussions and notes have also been recorded in the joint learning software in Internet. However, the insufficiency of the Internet system and the learning pressure under traditional education system may interrupt the continuous progressing of the learning program, occasional oral communications seem to be necessary. Though the ability in data analyzing, reducing and deducing may not be well satisfied, students show obvious improvement in the knowledge of the subject as judged by comparing and analyzing the individual pre-learning and after-learning concept diagrams and from group reports.

5 Conclusion

Homepage contents for all the three subjects are highly acceptable to high school students and teachers, most of them confirm with the learning effect of the subject-oriented joint learning program. If the traditional learning pressure would be suitably released, students will be more willing and free to perform self-learning program through Internet learning system even though they are not very well familiar with the operation of the used software.

References

[1] Chen, F. C., "The study of a cooperative project-based learning design in network-based environment", NSC Study Report, NSC-88-2511-S-008-002, pp. 1-8(1999)

[2] Chin B. H., Yang, R. K. and Wang, C. Y., "Development of a learning environment for solid earth (geophysics) through Internet", NSC Study Report, NSC-88-2511-S-008-005, pp. 1-5(1999)

[3] Lin, S. J., Chou, S. C., Chen, Y. M., Chan, T. W., "A study of Internet-based collaborative project learning environment", NSC Study Report, NSC-88-2511-S-008-003, pp. 1-8(1999)

Table 1 Learning Test Activity on Earthquake

Time	1998.5.3, 1 day
Location	computer room in Wuling Senior High School
Participants	12 high school students, 3 high school teachers, 17 volunteer helpers(students and teachers from Department of Earth Sciences, National Central University)
Subject	Earthquake
Group of Topic	Occurrence and Distribution, Intensity and Magnitude
Working Pattern	content reading via internet, one to one oral communication, working processes recorded by volunteer helpers
Evaluation Materials	concept diagram, questionnaires, working records

Table 2 Learning Test Activity on Plate Tectonics Theory

Time	1999.2.27~1999.3.6, 8 days
Location	computer rooms in Wuling Senior High School, ChenSheng High School and National Central University, personal working environments
Participants	6 students and 1 teacher from ChenSheng High School, 6 students and 1 teacher from Wuing Senior High School, 7 volunteer helpers from National Central University
Subject	Plate Tectonics Theory
Group of Topic	Continental Drift, Sea Floor Spreading
Group of Expert	Dynamics, Mechanism, Effect
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software, three assignments

Table 3 Learning Test Activity on Chi-Chi Earthquake

Time	2000.2.2~2000.2.26, 25days
Location	computer room in National Central University, personal working environments
Participants	4 students and 1 teacher from ChenSheng High School, 2 students and 1 teacher from TaoYuan High School, 2 students and 1 teacher from Wuling Senior High School, 3 students and 1 teacher from HsinChu Experimental High School, 2 students from ChungLi High School, 5 students from HsinChu High School, 2 students from HsinChu Girls' High School, 2 students from ChenDer High School, 1 students from ChuTung High School, 7 volunteer helpers from National Central University
Subject	Chi-Chi Earthquake
Group of Topic	Mechanism, Analysis, Effect
Group of Expert	Focus, Magnitude, Focal Mechanism, Hazard
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software

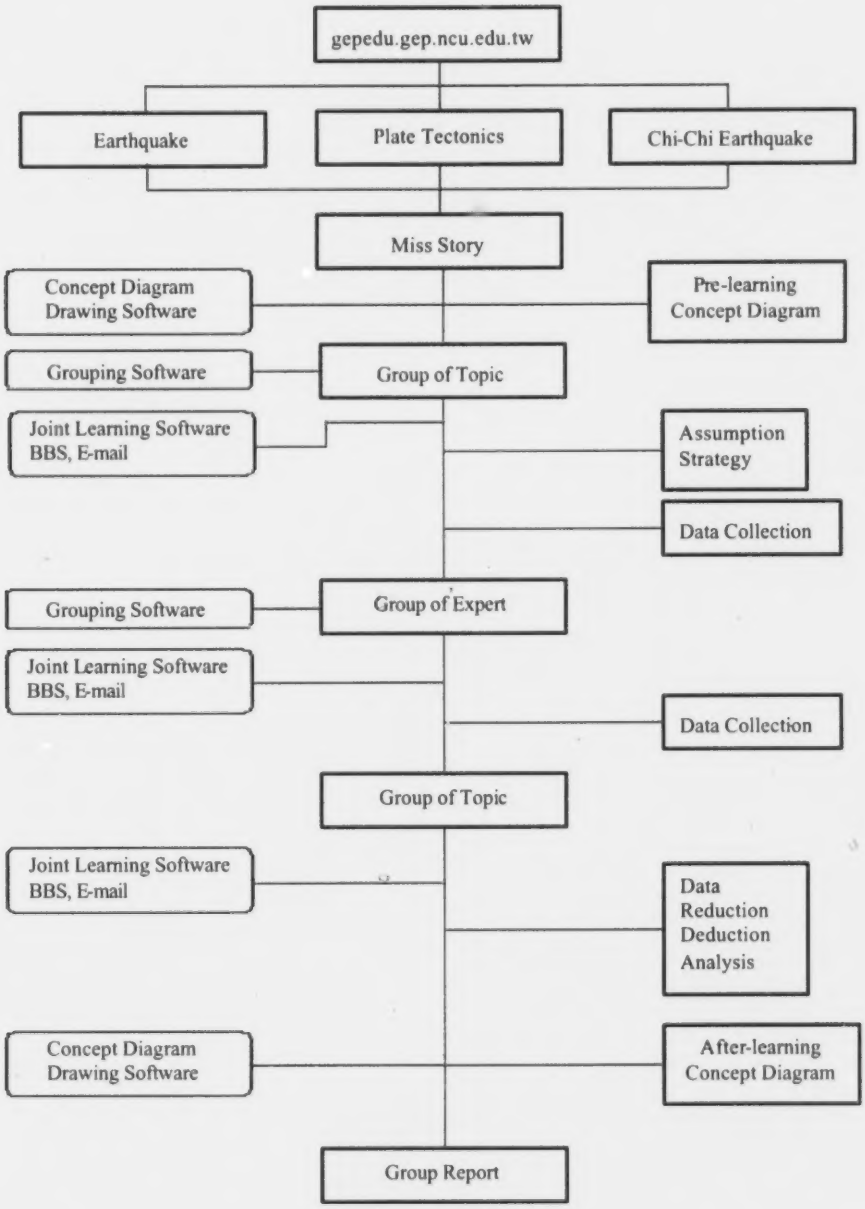


Figure 1 Flowchart for subject-based joint learning test activity

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

HOT NEWS
Background
Committees
Call for Papers
Deadlines
Registration
Program
Paper Acceptance
Reviewers
Venue & Travel Info.
Contact Info.
Host & Sponsor
Related Websites
Discussion Board
Proceedings
HOME

Proceedings

Content

▶Full & Short Papers (Telecommunication in Education)

A Flexible Transaction Model for Virtual School Environments
Design and Implementation of a WWW-Based School Official Memorandum System
DESIGN AND IMPLEMENTATION OF WEB-BASED LEARNING SYSTEM FOR TEACHER-TRAINING PROGRAMME
Development of Japanese-English,English-Japanese Conversation System with Voice Reading function and Machine translation
Educational Newspaper Information Gathering Agent for NIE
Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships
Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan
Online ESL Learning: An Authentic Contact
Relating telecommunication training objectives to SMEs' actual needs
Web Based Real plus Virtual Observatory Project

▲HOME

A Flexible Transaction Model for Virtual School Environments

Woochun Jun*, Sukki Hong**
**Dept. of Computer Education*
Seoul National University of Education
Seoul, Korea
E-mail: wocjun@ns.seoul-e.ac.kr
***Dept. of Business Administration*
Konkuk University
Chungju, Korea
E-mail: skhong01@kku.edu

Recent advances in Internet technologies have led to the advent of virtual schools. However, existing technologies have many limitations when applied to virtual school implementation. Especially, existing transaction models are not suitable for supporting virtual schools. In this paper, we present a new transaction model in order to support virtual school environments. First, we introduce the general characteristics of the virtual school environments. Then, we discuss transaction model requirements for virtual schools. Based on those requirements, we propose a new transaction model. We also show a locking-based concurrency control scheme for supporting collaboration works among students. Finally, we give conclusions and future research issues.

Keywords: **Collaborative Learning, Virtual School**

1 Introduction

Recently interests in virtual schools have been increasing due to advances in Internet technologies. The virtual school, which is based on distance learning, can overcome time and space limitations in the traditional schools. But, in order to complement lack of face-to-face communication in virtual schools, multimedia-based education is becoming popular. This multimedia-based education emphasizes the students' self-control. That is, multimedia- based education encourages interactions between teachers and students and also interactions among students. In the meanwhile, object-oriented databases become popular for supporting multimedia resources.

In the literature, many transaction models have been proposed for object-oriented database environments [5,7,8]. But, those transaction models have not reflected requirements in virtual schools. In this work, we propose a new transaction model that supports virtual school environments. The proposed model considers all those requirements.

This paper is organized as follows. In section 2, we discuss the transaction requirements in virtual school environments. Based on the discussion, we propose a new transaction model in Section 3. In Section 4, we present a locking-based concurrency control technique based on our model. Finally, we give conclusions and future research issues.

2 Transaction Requirements in Virtual School Environments

In this section we discuss transaction requirements in virtual school environments.

First of all, all transactions should maintain the correctness of database. One of the characteristics of database systems is manipulation of shared data. In this case, concurrency control technique is required to

synchronize accesses to the database so that the consistency of the database should be maintained. Concurrency control technique requires an application-dependent correctness criterion to maintain database consistency while transactions are running concurrently. Serializability is a widely used correctness criterion [1,6]. But, serializability is too harsh for most applications so that we need user-defined correctness criteria, which is less restrictive than serializability.

Second, the length of transactions must be flexible. Usually, transaction length in virtual school environment is long since transactions are navigating on various multimedia information in database systems [2]. For long transaction case, the following problems might occur. That is, if locking-based concurrency control is adopted, long transaction blocks other transactions to run concurrently due to conflicting access. This will, in turn, degrade overall performance. Also, if a long transaction is aborted during its execution, it may waste execution time and resources it used.

Third, in virtual school environments, students' behavior is unpredictable. That is, since they are working in on-line way, it is hard to predict what kinds of actions they might take. Thus, they must be given some kind of self-controls.

Fourth, the transaction model reflects interactivity. Especially, it must support collaborative works between students and teacher or among students. Those collaborative works require common data to be shared among users in order to achieve common goal. In some cases, unlike traditional transaction model, uncommitted result by one student may be open to other students.

Finally, transaction model may need to support parallelism in order to reduce overall transaction response time. Especially, the parallelism can be used in object-oriented databases as follows. In object-oriented database, objects are accessed by means of methods. A method is nothing but a procedure to read or update attributes in objects. Two methods can run concurrently if they access different attributes in an object. Thus, transaction response time can be reduced by adopting parallelism.

3 The Proposed Transaction Model

Our transaction model reflects all requirements of transaction in virtual school environments as discussed in Section 2.

Our model is based on both Split/Join transaction model [4,9] and nested transaction model [7]. But, none of them support all those requirements of transactions in virtual school environments. Our model is to combine these two models. Our model also extends the previous model [3] so that we achieve higher parallelism as below.

The Split/Join transaction is summarized as follows. The Split/Join transaction is to restructure in-progress transaction dynamically so that it supports efficient resource management as follows. The Split transaction can be divided into two serializable transactions during its execution. In this case, two divided transactions can proceed independently with their own resources. Thus, the Split transaction model provides flexibility in resource management so that it can overcome the disadvantage of long transaction. On the other hand, the Join transaction can merge two on-going serializable transactions into one transaction. In this case, the transaction model is used to combine collaborating works into one in virtual school environments.

The nested transaction model is summarized as follows. A nested transaction consists of concurrently executable top-level transactions. In turn, a top-level transaction consists of one or more steps. Each step is either atomic operation or subtransaction. This subtransaction can run concurrently with top-level transactions or other subtransactions. In the meanwhile, a subtransaction can invoke another subtransaction. Thus, unlike flat transaction model, nested transaction model can exploit internal parallelism.

The basic structure of the proposed transaction model is shown in Fig. 1.

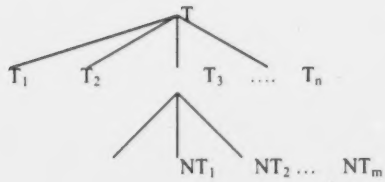


Fig. 1. The transaction model

T represents global transaction, which can be merged or split in various form during its execution. Also, depending on its nature, it can be committed without any restructuring. T_1, T_2, ...,T_n represent subtransaction or merged or split transaction. Also, NT_1, NT_2,..,NT_n represent subtransactions started by a nested transaction. In our model, we adopt open nested transaction [8]. In open nested environment, intermediate results of a subtransaction can be seen by other subtransaction as well as top-level transactions. This will increase parallelism further.

4 The Proposed Concurrency Control Technique

In this Section, we present a concurrency control technique based on our model. The proposed model is based on locking-based scheme. Our aim is to let two conflicting transactions go to negotiation stage if the lock requesting transaction requests a conflicting lock on a data item with a lock held by other transaction. In that case, the lock holding transaction and the lock requesting transaction can negotiate for conflicting lock types. If negotiation is successful by those two transactions, the lock requesting transaction can get a lock successfully and access the data. Otherwise, the lock request is blocked until the lock holding transaction release its locks. By doing so, the parallelism can be maximized among collaborating users. Assume that a transaction requests lock (L_R) on a data item already locked by other transaction with lock type (L_H), the following algorithm can be applied.

If L_R and L_H are compatible then grant L_R
    Else negotiate between lock requester and lock holder;
        If negotiation is successful then grant the lock
            Else block the lock request;

5 Conclusions and Future Works

In this paper, we first introduce the general characteristics for virtual schools. Then, we present all possible requirements for transactions in virtual school environments. Those requirements are user-defined correctness, flexible transaction length, the unpredictability, interactivity and internal parallelism. Based on those requirements, we propose a transaction model and a locking based concurrency control technique.

The immediate research issue is to apply real-time concept in transaction management. In that case, each transaction must have real-time deadline. Since all transactions are on-line based in virtual school environments, the transaction response time is very critical. Thus, we will develop the real-time priority assignment scheme and real-time transaction processing scheme for virtual school environments.

References

[1]Eswaran, K. P., et al, "The Notions of Consistency and Predicate Locks in a Database System", Communications of the ACM, Vol. 19, No. 11, pp. 255-265, (1976).

[2]Finkelstein, R., "The Jasmine Object- Oriented Database Solution for Online Interactive Transaction Processing (OLIP) and Electronic Commerce, Jasmine White paper , (1998).

[3]Jun, W. C. and Hong, S. K, "A Transaction model that Supports Virtual Universities", The Journal of Korean Association of Information Education, Vol. 2, No. 2, Nov. pp. 174 – 182, (1998).

[4]Kaiser, G. E. & Pu, C., "Dynamic Restructuring of Transactions", in Chapter 8, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California. pp. 265 - 295, (1992)

[5]Khoshafian, S., Dasananda, S. & Minassian, N., "The Jasmine Object Database", USA: Morgan Kaufmann Publishers, (1999).

[6]Korth, H. F. & Silberschartz, A., "Database System Concepts", Singapore: McGraw Hill, 2nd Edition, (1991).

[7] Moss, J. E. B., "Nested Transactions: An Approach to Reliable Distributed Computing", Cambridge, Mass.: MIT Press, (1985).

[8] Muth, P., et al., "A Transaction Model for an Open Publication Environment", in Chapter 6, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California., pp. 159 – 218, (1992).

[9]Pu, C., Kaiser, G. E., & Hutchinson, N., "Split-transaction for Open-ended Activities", Proceedings of the 14th Very Large Data Bases Conference, Los Angeles, California, USA, pp. 26- 37, (1988).

Design and Implementation of a WWW - Based School Official Memorandum System

Gi-Ping Lee, Yue-Shan Chang and Ching-Chuan Chou
Department of Electronic Engineering, Ming-Hsin Institute of Technology
1 Hsin Hsing Road, Hsin-Fong, Hsin-Chu, Taiwan 304 R.O.C.
louis@mheman.et.mhit.edu.tw, ysc@mhit.edu.tw, ruth@mhit.edu.tw

1 Introduction

The official memorandum is a very important document that offers a decision path of something in the most organizations. In general, the executed policy usually needs agreement of decision-maker through official memorandum. All the official memorandums are traditionally passed by one-by-one human delivery from faculties to managers in an organization. It may results in the lower performance of administrative. Even though some administrative operations are via e-mail or other approach. It have some limitations, such as the official documents usually need the signature of decision-maker, it is not ease to overcome via the e-mail.

In order to have a speedy the administrative operation environment, especially the official memorandum delivery, we design and implement a WWW-based Official Memorandum System in a school. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application.

Obviously, the system is based on the client-server model. Implementing the system has some existing techniques can be used, such as CGI, Java/Servlet [3], Java/CORBA [3]. Lotus' InterNotes [1] product uses CGI mechanisms to allow Web browser access to documents and forms managed by the Notes Server. Documents to be placed on the Web are translated by a program to HTML. These documents and forms are accessed through a standard HTTP server as though they were normal HTML documents. Java is a portable object-oriented language, and also a good platform for writing client/server web-based applications. Servlets are secure protocol and platform-independent server side web-enabled software components, written in Java. Java/CORBA has a clear advantage over CGI solution, such as flexibility, maintainability, and responsiveness etc.

Security issue in the system will be taken care by using traditional approaches. There are two secure mechanisms will be used: one is account/password, the other is the firewall. First one can prevent non-authority user log-in into system and disrupt the system. All the general users must apply for an account excepting the chief of department. And the system will force all users to change the password periodically. This mechanism can avoid internal hackers. Second one is to avoid external hackers who intrude into system for non-authority accessing. Few hackers, of course, can intrude into and disrupt the system. Some approaches can be used for enhancing the security of information, such as data compression/decompression before accessing to/from database and checking the data consistency of duplicated database periodically. All of them are the future works

Fault tolerance is in order to enhance the reliability of system. In fault-tolerance community, many approaches have been proposed to enhance the data reliability [4,5]. The approach in the system is database replication. We use warm stand-by primary/backup scheme to improve the system availability. Many issues in the data replication that have to be guaranteed are employed like the [5]. These issues are such as idempotent operation, data consistency, and recovery. Because the system is a three-tier scheme, all operations supporting fault-tolerance are implemented in the core of the system. This feature can also prevent the database crash during the formal execution phase.

A complex system has to be manageable in an easy way. In order to enhance the system flexibility, a web-based management tools should be implemented. System manager can add and remove user easily. In

addition, system manager can also maintain the database, such as record manipulation, in an easy way.

Many features are described previously. In addition, we will support some important functions shown as following: Official documents writing, Official documents progression tracking, Auto-delivery, Automatic signing, Urgent document notification.

2 Design and Implementation

According to the described above, we design the system architecture like as Figure 1. The architecture is simple and complete. The system includes an Official Memorandum System and a replicated database. The system will receive requests from clients. For security issue, we add a firewall in the front of web server. All the requests must be checked by the firewall for ensuring the request is an authority request. In addition, the Official Memorandum System is responsible for all the features described above, which include fault-tolerance. A replicated database is also included in the system. The database used in the system is the SQL database.

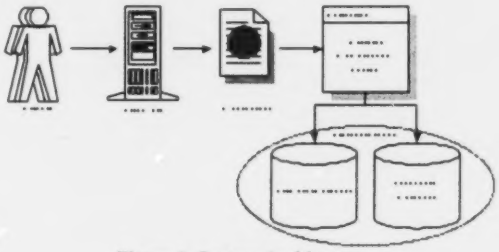


Figure 1. System Architecture

The whole system is implemented and run on the Windows NT 4.0 and SQL server 7.0. The programming paradigm is ASP that using VBscript. With the fault-tolerant, the system needs to access primary and standby database separately. To guarantee the consistency of two databases, we apply the traditional two-phase commit protocol on the replicated database transaction processing.

Figure 2 shows the GUI of document reviewing for those chiefs of department. When they login into the system, the system will show the urgent document on top of the reviewing page, which indicate these documents have to review first. The document reviewing process will sign the signature automatically when the process achieved.

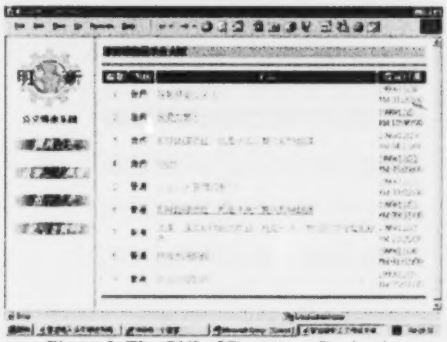


Figure 3. The GUI of Document Reviewing

3 Conclusions

In this paper, we have been stated the design and implementation of a web-based official memorandum system. This system can migrate the conventional official memorandum system to network. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application. In order to avoid the informal accessing to this system, the firewall is utilized at the front-end of the system. Besides, the duplicated databases are used in this system to prevent the database crash during the formal execution phase.

BEST COPY AVAILABLE

References

[1] Lotus Development Corp., "Lotus InterNotes Web Publisher", Setember 1995, http://www.lotus.com/corpcomm/334a.htm.

[2] Evans and D. Rogers, "Using Java Applets and CORBA for Multi-Users Distributed Applications", IEEE Internet Computing, Vol. 1, May-June 1997, pp.43-55.

[3] Guang-Way Sheu, Yue-Shan Chang, Deron Liang, Shyan-Ming Yuan, Wintson Lo, "A Fault-Tolerant object service on CORBA" in Proc. of the 17th International Conference on Distributed Computer Systems (ICDCS'97) Baltimore, USA, pp.393-400.

[4] Yue-Shan Chang, Jyh-Tzong Chiou, Shang-Rong Tsai, "Highly Reliable File Services on the DMINIX System, " The 11th Technological and Vocational Education Conference of R.O.C., Vol.3, Mar. 1996, pp. 30-39.

DESIGN AND IMPLEMENTATION OF WEB-BASED LEARNING SYSTEM FOR TEACHER-TRAINING PROGRAMME

YIP Wai-ming* and AU Wing Kee**
**The Hong Kong Institute of Education*
10 Lo Ping Road, Tai Po, N.T. HONG KONG
Tel: +852 29487709
Fax: +852 29487726
E-mail: wmyip@ied.edu.hk
***The Hong Kong Institute of Education*
10 Lo Ping Road, Tai Po, N.T. HONG KONG
Tel: +852 29487693
Fax: +852 29487726
E-mail: wkau@ied.edu.hk

The advancement of recent technologies has evoked great impact on education. The Information Technology (IT) revolution has changed the habits of human civilizations immensely. The application of distributed systems, Internet, telecommunications and so on, along with the rapid development and advancement of computer technology, has given profound change to our life style and significant impact to our philosophy of education. Various contemporary issues in the application of IT in education have aroused widespread concern. Nowadays, learning is not necessarily confined within spatial and temporal boundaries. Networked databases, online resources and Internet services provide new opportunities for teachers and students to be engaged in learning and teaching activities which are different from the traditional classroom setting. In this paper, we are going to discuss the initial phase in designing and implementing a Web-based learning system for use in teacher-training programme. The research in building a Web-based supportive learning system for teacher training has the following characteristics: (1) It is a support system that aims to help the enhancement of learning effectiveness with the aids of modern information technologies, particular in the area of course information dissemination, sharing of resources, and computer mediated communication. (2) Future teachers are immersed in the IT learning environment so that a positive attitude and perception can be formed towards the adoption of IT in classroom. (3) Student teachers are encouraged to participate actively in the IT-immersion environment. After the initial phase completed, extended future research will be focus on its effectiveness and its empirical contribution in enhancing learning effectiveness.

Keywords: **Web-based Instruction**

1 Introduction

The application of Information Technology (IT) in education has recently generated lots of interests. With the advancement of new technologies, something impossible in the past was found significantly advantageous nowadays. One distinct example would be the use of digital technology and the continuous improvement of computer networks. The integration of text, sounds, graphics, and even video segments has been found more and more efficiently be used than in the past [9]. Undoubtedly, the fast growing multimedia technologies play

a vital role in enhancing better learning and teaching effectiveness. Internet and the use of the World Wide Web (WWW) have been regarded as a powerful media since its development began in early 90's. Networked database and distributed systems make the "knowledge" and information dissemination more efficient and faster. As the Internet and the WWW remove the geographically boundaries, learning and teaching activities need not happen at the same time and at the same place. Furthermore, communications between teachers and students, and among the students, which traditionally relied on face-to-face interactions, can be supplemented by both synchronous and asynchronous modes of communication through recent development of telecommunication and network technologies. In order to meet the new learning needs in the new millenium the idea of learning network is established for promoting life-long learning. With the help of an immersion learning environment using IT, students can construct and refine their knowledge through interactions with other students and teachers at anytime and anywhere. In fact, the number of schools and Universities using the Web to deliver courses are increasing [6].

2 Rationale in using Web-based learning system for teacher training programme.

Khan [5] suggests that the Internet is fast emerging and the WWW is becoming an increasingly powerful, global, interactive, and dynamic medium for delivering instruction. More and more institutions are using the Web to provide instruction and training. Increasing number of these institutions offering Web-based courses are recognizing the fact the Web is a viable and important medium for learning and instruction. As the capabilities of the Web have become more widely known, students and faculty have been quick to utilize its potential [4]. Research on the use of Web-based system in the past decade often focused on its contribution to distance learning, flexible learning or open learning. Each of the above three terms has its own meaning and are different from each other, yet all of them are regarding learning happened at learners' own time, pace and schedule. Internet offers the potential for a classroom reconfiguration through the utilization of WWW as a tool. Teachers are no longer regarded as absolute authority and the fount of knowledge, but the students begin to take responsibility for their individual learning. They become active participants in acquisition of knowledge and need to be responsible for their own development. However, traditional learning system and Web-based system are not necessarily mutually exclusive of each other. On the contrary, they may be employed to support each other. This idea becomes the fundamental principle in establishing a flexible, learner-centred and effective Web-based supportive environment for learning.

To establish an IT-immersion environment for future teacher

Most of the universities in Australia, U.S. and U.K. require their graduates to be information literate. Education faculties within these universities would add stipulations that their pre-service teacher graduates would need to be competent with the application of IT in education.[1]. Another major reason in the development and implementation of Web-based learning system is to create an IT immersion environment, so that future teachers can be immersed in the situation that not only IT skills or literacy be taught, but provide opportunities for student teachers to build up confidence in using IT. As a result, their positive attitude and perception towards the application IT in the classroom can be developed. How IT is used will vary depending on teacher' s understanding of technology and how it may be used to support the learning and teaching process. The development of student teachers' positive, confident attitudes, self-efficacy, and perceptions toward Information Technology is essential. Bandura [2] stated that people who perform poorly might do so because they lack the skills or they have the skills but they lack the sense of efficacy to use them well. General self-efficacy beliefs reflect a sense of personal control, a sense of personal competence and goal-directed determination. The teacher' s beliefs in their personal efficacy, ability to motivate and promote student learning will affect the types of learning environments they create and the level of academic progress their students will achieve.

Practise what we preach

Student teachers need to be IT competent before they enter into the profession. Teacher educators also have a distinct role in preparing competent teachers to teach IT or can teach with IT in the classroom. It would be desirable to enable student teachers immersed in the IT learning environment so that they can experience the possibilities in using networked technology and telecommunication as one of the learning media. More importantly, they are provided a chance to venture out and form the habit of life long learning, which is an essential element in their future success. In view of learning strategies, throughout the use of new

communication tools, students also have chances to collaborative with other students, and most likely they will be benefit from this kind of learning and teaching activities [7].

Flexibility, learner-centred approach

It is generally agreed that the Internet has the potential to revolutionize learning. However Radford [8] pointed out that a flexible and location-independent education is certainly not a replacement for traditional human face-to-face interaction between teachers and students, but on the contrary, provides another means to facilitate better communication. He said not all learning activities should be technology mediated, but in some way some learning tasks may not require people to be in the same room and at the same time. Lai [6] said that many "Web-assisted" courses are designed with the intention to provide students with easier access to course-related materials. Lecture notes, examination scripts and other relevant materials are archived on course Web sites and allow flexible access by course participants. In addition, electronic mail and discussion lists are used to supplement face-to-face communication between students and teachers. In some cases, they are only needed to meet face-to-face once or twice in a course.

3 System design

A pilot scheme has been introduced to explore the possibilities in using Web-based learning system in the Hong Kong Institute of Education since September 1999. The main purpose of this project is to look for the best means to support learning and teaching, and in the long run, develop courses that can be offered to the students in a flexible manner. A number of essential design principles in designing a Web-based learning system can be identified:

- Interactivity: Major considerations to enhance interaction between the learners as well as the teacher, a wide range of synchronous or asynchronous tools are used to supplement and/or enhance face-to-face interactions.
- Collaboration, it is important to establish a supportive environment to encourage collaboration or forming online study groups.
- Social and interpersonal interaction: the cognitive dimension of learning environment, to build up a best environment for learning, and to promote social and interpersonal interaction.
- User control: it should be designed for students and teachers easy to manipulate and most importantly, sense of ownership by providing personal space such as virtual office.
- Structure and management of learning environment, a Web-based learning environment should be a flexible learning environment includes clear and explicit information and simple administrative task.

The pilot system design consists of three components and each one serves different purposes in supporting learning:

Instructional delivery system

The main function is for information dissemination where instructional materials, announcement, lecture notes, tutorials etc. can be delivered via the Web and the learners may access the information at any time at their own pace.

Database

For the purpose of resource sharing, it serves information exchange, link resources, web resources, shared project examples and a platform for collection of assignments and feedback etc.

Internet-mediated Communication

The communication channel between the teachers and the students forms an important part in the Web-based learning system. It aims to provide a platform for Internet-based communication. Although email is a "conventional" way extensively used, other software tools for discussion and collaboration among students are employed. For example, newsgroup, guest book and discussion forum are adopted. Instructors may create a general discussion forum or specific topics to be debated that makes the learning activities more fruitful through student-teacher interaction.

4 Phases of development

This project comprises four phases.

Development and planning

The initial phase focussed on hardware infrastructure, setting up of software configuration, network connection, traffic and loading testing, security control method such as user authorization etc., Existing Web-based learning system were also installed, tested, compared and evaluated, examples included Learning Space, WebCT, Blackboard, etc.

Designing and testing

Course content design and the adoption of appropriate instructional delivery approach are crucial elements to the success of Web-based learning system. In this phase, different subject specialists in the Department of Information and Applied technology were invited to participate in the content design. Subjects included Information Technology, Home Economics, Business Studies and Design & Technology. Overall testing was also carried out in this phase including log on procedures, security control, database maintenance, statistics, Web-survey and evaluation etc.

Implementation

The system is opened for use but limited to specific courses level, which have been developed at the design phase. Formative evaluation will also be carried out to record

- feedback from both teachers and students.
- System stability
- Continuous modification and improvement on the content courseware design

Evaluation

As the Web can be globally been assessed, the use of formative evaluation is very critical where a single error will distribute world widely. An empirical approach will be adopted aims to observe effects on students and teachers using both quantitative and qualitative methods. This is an on-going process from the beginning till the end of the project. A variety of instruments will be employed, some important areas to be concerned are:

- Background study - Students and Teachers perceptions towards web-base learning
- Structure and in-depth interview – to obtain opinions from user point of view on web-based learning
- System analysis – a formative evaluation on the whole system concerning
    - the learning effectiveness
    - effective instructional design strategy
    - effectiveness on computer-mediated communication

5 Conclusion and future research

Information Technology develops at a rapid rate. The advancement of technologies provides new opportunities that never be achieved in the past. In particular the integration of multimedia technology and a new mode of communication using network technology that are greatly differ from our tradition. Brown (1999) states that there will be no doubt that the Internet is a major force in reshaping the nature of school. As the nature of Web-based system is open and flexible, the Web technology still has lots of potentials that can be contributed to education, especially in course design and development. On the other hand, the application of Web-based learning systems are continually to grow, it suggests future directions for educator and researcher to investigate how this new learning technology can contribute to along with educational and learning theories.

The initial phase of this project is to build up a platform for web-based learning systems. Extended future research will mainly focus on evaluation of such systems in enhancing teaching and learning effectiveness and its contribution to instructional strategy.

Reference

[1] Au, W.K., Kong, S.C. Leung, K.P. Ng, M. W. E., Pun, S.W.. "Levels of Information Technology (IT) competency core course elements and assessment tools for teacher training in IT in education". Hong Kong: Hong Kong Government. (1999).

[2] Bandura, A."Perceived Self – efficacy in cognitive development and functioning", Educational Psychologist vol 28 No.2 pp 117-148 (1993).

[3] Brown M.E. "The wired curriculum, a choice of content, connectivity or community?" In Lai, K.W. (Ed.) Networking, teaching, learning and professional development with the Internet. New Zealand: University of Otago Press. (1999).

[4] Crossman, D.M."The evolution of the World Wide Web as an emerging instructional technology tool". In Khan, B.H. (Ed.). Web-based Instruction. New Jersey: Educational Technology Publications. (1997)

[5] Khan, B.H. "Web-based Instruction". New Jersey: Educational Technology Publications. (1997)

[6] Lai, K. W. "Net-Working : Teaching, Learning and Professional Development With the Internet". New Zealand: University of Otago Press.(1999)

[7] Ma, J. Huang, R & Shih, T.K. "The Concepts, Framework and Architecture of an Integrated Educational System for Virtual Universities". In Cumming G, Okamoto, T.,& Gomez, L. (Eds.) Advanced Research in computers and communications in Education. IOS Press. (1999).

[8] Radford, A.J. "The future of Multimedia in Education", First Monday, Issues 2 Volume 11 (1997)

[9] [illegible] (1999)

Development of Japanese-English, English-Japanese Conversation System with Voice Reading and Machine Translation

Yumemi MATSUZAKI* and Kanji AKAHORI**
**Graduate School of Decision Science and Technology, Human System Science, Tokyo Institute of Technology*
***The Center For Research and Development of Educational Technology, Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552,Japan
Tel: +81-3-5734-3233
Fax: +81-3-5734-2995
E-mail:{yumemi,kanji}@ak.cradle.titech.ac.jp

1 Research Background

In recent years, the internationalization of Japan has attracted many foreigners. But, in the present state we have seen mostly people are shy to speak to foreigners because they cannot speak foreign languages. Again, there are many attempts that enable one to communicate on the Internet. In a preceding research, there was an attempt to add word translation to word chatting function (refs.[1]). Besides in any communication plurality of media help in the understanding (refs.[2])(refs[3]). For examp le, there was another preceding research that showed that listening along with subtitling in the same language help understand the content in the foreign language education (refs.[4]).

2 Research Objectives

In this research, therefore, we have developed a conversation system, which uses machine translation and text reading in the networking environment. This system uses machine translation, which enable people to communicate between two different languages. And, it fulfills text-reading function of chatting to help understand conversation contents

3 Developmental Environment

This system is developed with "Microsoft VisualBasic 6.0". The Japanese-English translation engine of this system used "LogoVista E to J ver 5.0 "and the English-Japanese translation engine used "LogoVista J to E ver1.1". Japanese Voice synthesis engine is "IBM ProTalker 97", and English Voice synthesis engine is Microsoft Agent.

4 Outline of Developed System

In this system, when we input Japanese or English, we can get Japanese text or English one and its rendering text and voice synthesis of its rendering one.
The steps from the text input to the translation, and the voice output is shown as follows.
(1) Sentences, which the client inputs, are passed to the server.
(2) These sentences are then passed to the translation engine, and the server translates in English in case of

Japanese input and vice versa.

(3) The server sends translated sentences to both client and the other party.

(4) Translated sentences are indicated after input sentences on the receiver side, and translated sentences are displayed along with basic input on the other party side.

(5) If translated sentences are in Japanese, its voice output is given using "IBM ProTalker 97"(refs[5]) If it is English, then the output is given using "Microsoft Speech API"(refs[6])

5 Evaluation Experimentation

Three pairs consisting of one Japanese speaking person and one English speaking person were considered and experimented on the different setup. Type one is not using machine translation. Type two is using machine translation. We administered a free response type questionnaire for collecting data regarding the feeling of the participants during the different sessions. From the result the interest concerning learning of foreign language came up, and the participants' opinion of being able to take part in the conversation, not being aware of talking with foreigners using machine translation, were very positive. The pictures dawn by subjects with two different conditions are shown as the follwing.. The condition with word chatting not using the machine translation module. The left picture shows the picture which the sender want to send, and the left drawings shows the picture drawn by the receiver with the above condition.

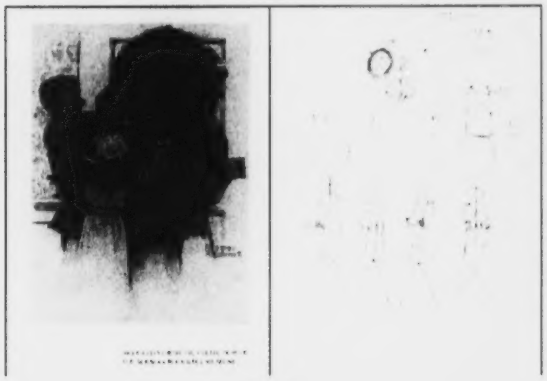


Fig.1

The condition with word chatting using the machine translation module. The left picture shows the picture which the sender want to send, and the left drawings shows the picture drawn by the receiver with the above condition. We can compare two pictures drawn by the receiver under the two conditions. As a result, we may roughly estimate that the picture using the machine translation module shows more precise information than the picture without the machine translation. As the above differences are based on a quite subjective judgment, it is not conclusive. Though the difference seems to be apparent from the view of quantities of sending information, we can't find the specific reasons caused the differences. The system developed with the chatting using the translation module will work effectively, especially to the persons who want to communicate each aother.

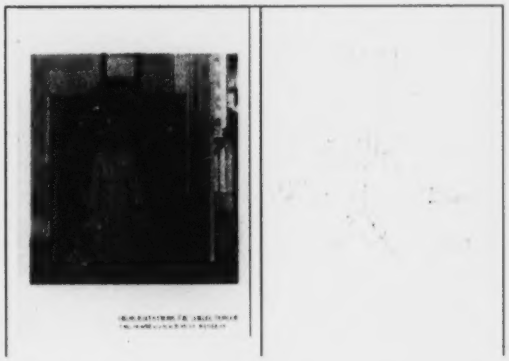


Fig.2

6 Future Works

We are now planning to expand the scope of speech recognition system as the future works. We have been introducing the speech recognition module to our system, and we are now evaluating the effectiveness of the speech recognition module to enhancing the communication.

Acknowledgement

The authors would like to thank Dr. Madhumita Bhattacharya in National Institute of Multimedia Education for her great assistance.

References

[1] Alexander BELOV, Masato HAYASAKA, Kanji AKAHORI, "Conversation learning by Japanese-Russian and Russian-Japanese chatting which uses machine translation." Japanese Journal of Information and System in Education. Vol.15. pp533-534. (1999)

[2] MARKHAM,P.L "The effects of captioned television videotapes on the listening comprehension of beginning, intermediate, and advanced ESL students." Educational Technology, 29(10). pp38-41. (1989)

[3] http://home.att.ne.jp/gold/PEROYON/Jikken1.htm

[4] Shiho YOSHINO, Kanji AKAHORI. "Effect of title addition in catching scene in English.", Japanese Journal of Educational Technology . Vo l.21. Suppl., pp29-32. (1997)

[5] http://www.jp.ibm.com/pspjinfo/pt20/intro.html

[6] http://www.microsoft.com/JAPAN/developer/library/tecnart/msdnnews/speak.htm

The Gathering and Filtering Agent of Education Newspaper for NIE

Chul-Hwan Lee, Sun-Gwan Han, Hee-Seop Han
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1284
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
chlee56@compedu.inue.ac.kr {fish,hansg}@compedu.inue.ac.kr

This paper presents the ENIG Agent to gather distributed information of educational newspaper in the web as well as student to provide the sound information for the NIE learning. The ENIG Agent gleans an appropriate newspaper headline of educational news portal site for real-time provision of the information. For gathering the optimized information, The ENIG agent performs the pre-process of educational news site, information noise filtering, pattern matching. The gathered educational newspaper information is removed a harmful data by using the pattern matching in the inference engine. The student can show the result of sound data through the web-browser as well as can use to learning with another application. For efficiency of this system, we evaluate the performance of the ENIG system by the experience of the NIE learning.

Keywords: **NIE, Newspaper Information gathering, Intelligent Agent, Supervised learning**

1 Introduction

These days, the web brings about a great change of education by a rapid growth of the Internet. It is not an easy work that a student finds the education information in the web. For searching the suitable information, a various search engines were developed and it provided a service for all. However, the general search engine is not fit that a student use at learning directly, because the information of search engine can contain a many data unconcerned learning. The learning requires the filtered information that can apply learning directly. Therefore, for efficient education, new type of search engine needs for the information retrieval and gathering [9].

Besides, the NIE means "Newspaper In Education", it is a method that student and teacher increases an efficiency of learning by using newspaper. The late web is used a good place for the NIE learning and a collaborative learning. However, when student and teacher study on the NIE learning through the web sites, they spend much time and repetitive efforts to find the newspaper contents. The student can lose a basic purpose of the NIE learning by the wasteful spending. The NIE learning needs an intelligent searching agent that searches automatically an important content about newspaper on the web. Moreover, because the gathered educational newspaper can contain harmful data, the data can remove by using the pattern matching in the inference engine [8].

Consequently, this paper describes about the ENIG Agent for the NIE learning. For providing the student just wants newspaper contents, we designed and implemented the intelligent agent system. In the following section, the NIE and the agent for information retrieval will be surveyed and the basic structure of the ENIG Agent will be designed. Furthermore, the next section will be discussed about implementation and experiment of ENIG Agent system. Finally the conclusion and future works will be described.

2 NIE and intelligent gathering agent

The NIE is the initials of 'Newspaper In Education'. It is the education method for individual who make friend with newspaper and improves the achievement of learning using the contents of newspaper. The newspaper, "a living text book", is applied with open education through the NIE learning.

Roles of newspaper for education are listed below [5].

- The newspaper is a bridge that can connect the disparity gap between school and society.
- The newspaper is the reflective of actual world.
- The newspaper reappears the scene of the history and is researching material of present society.
- The newspaper is the most suitable of clear text model and is used with subject matter of language learning.
- The newspaper is the unique textbook that everybody can read in ones lifetime continuously.

For the reasons stated above, we can expect a advantages that the NIE learning is originality, thinking power, ability to read and understanding and writing text, the establishment of sociality through ones sense of values, ability to practical use of information and so on[8].

When teacher will teach using NIE content on the web, we must consider below list.

- The newspaper is not be made data for the NIE. Because it is made for adult, it has a very difficult vocabulary. Therefore, teacher must supply to student a vocabulary database.
- The newspaper has an article about negative contents of society. Such contents must be edited or deleted by using an intelligent agent.
- Because the web is opened to everyone, the newspaper may have contents that student never see. In special, an article of obscene, crime, violence must be deleted.
- The contents of a newspaper are best the events of the day. But the NIE is used the contents of old newspaper. Such contents are good saving at scraping DB.

The method of information retrieval is variety. For information retrieval of educational homepage, intelligent agent used a very suitable tool [9]. The intelligent agents having the characteristics of autonomy, social ability, reactivity, pro-activeness and cooperative relationship can provide the searching results of a user demanded through machine learning [11].

An agent gathers information instead of the user. Because the agent system does not deal with basic data, instead it deals with knowledge information, can easily process the knowledge of education homepage. Moreover, an agent system is capable of using effectively gathering of information on the dynamic web environment. Therefore, the web based instruction using the NIE learning needs intelligent agent system [3].

3 ENIG System

Generally, the web document has many added tag information in contents. This added tag can represent efficiently information and data of HTML document. However, the user does not use the tag information but can use only the text or the multimedia information. The tag information treats only an unnecessary noise to users. If an unnecessary noise tag in a content is removed, the filtered document is translated a regular expression in the ENIG system. The pattern of information is extracted at transforming regular expression by the string matching method.

The extracting information of content is interpreted the accuracy of information by inference engine. Inference engine has the knowledge base augmented with a rule-based system, and it has function of learning and inference by a supervised learning.

3.1 Structure of the ENIG agent system

The structure of the ENIC Agent system is shown figure 1. This system consists of four parts. The document of homepage on web filters tags by the noise-filtering module in analyzer. The information of filtered document is translated from HTML document into regular expression. The regular document is matched with the string pattern provided by string matcher in an agent and it extracts the information of articles in educational newspaper. The information of an articles is removed harmful data by the knowledge base in an inference engine. The interface module consists of two screens. The rule and knowledge is edited and added, deleted through the knowledge manager and gathering information is supplied to student by using the result viewer. The learning environment is a learning space that studies the NIE learning through web browser and a learning application programs.

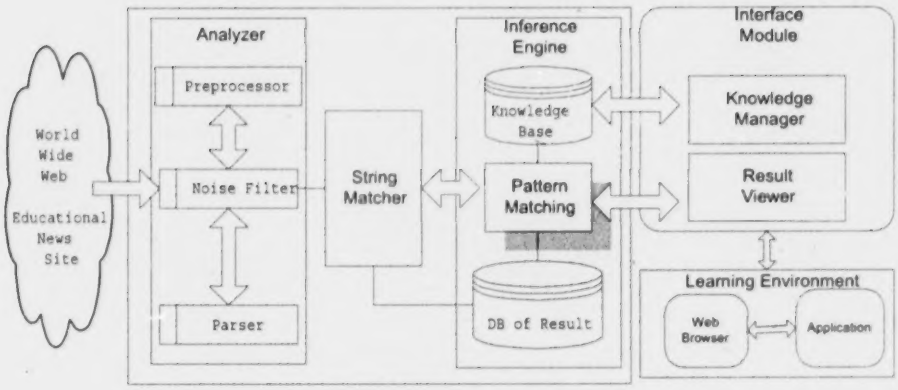


Figure 1. Structure of ENIG Agent

3.2 Noise filtering

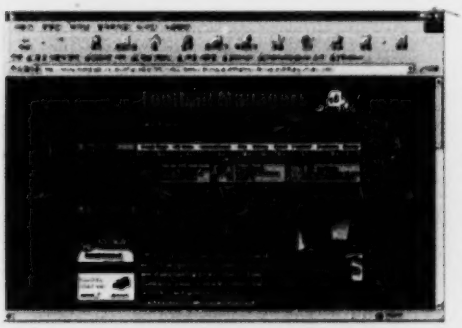


Figure 2. Homepage of educational newspaper

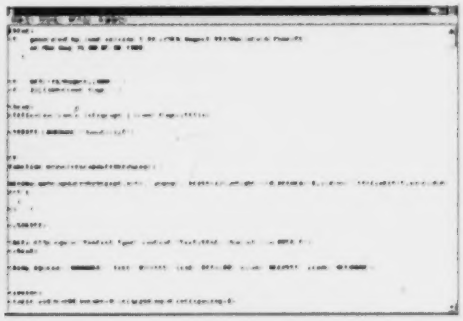


Figure 3. Source of homepage

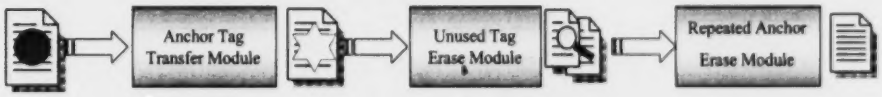


Figure 4. Steps of noise filtering

The example of educational newspaper site is shown figure 2. The tag information is not shown to user on the web-browser. While, the source of newspaper homepage is shown figure 3. The source is represented with a text and a complex tag information. Such tag information represents the arrangement of a document data and a multimedia information, a hyperlinked information.

The noise filtering is used to remove duplication data or an unnecessary data. For processing data called by HTTP, the noise filter processes work that removes a useless portion of the input data. The tags of HTML document have an irrelevant information to user, because tags only represent the formation of homepage and information of hypertext.

The noise filtering of the ENIG agent system removes an unnecessary tags in the document of an educational newspaper homepage except <A>...</A>tag, anchor tag of hyperlink and text data. The HTML sources are a difficult document to process noise filtering unconditionally, because the tag of document includes important information for the contents of document. Therefore, the noise filtering work must require a preprocessing module. Three steps of the noise filtering work is shown figure 4.

BEST COPY AVAILABLE

The preprocessing work for the noise filtering converts from basic <A>...</A> tag into suitable information and the works is listed below.

- Convert relative path for absolute path
- Change the URL of ASP form for the URL of HTML form
- Convert the path of CGI for general HTML form
- Change the path of script for absolute path
- Convert the hyperlink of image for absolute path

At the next step, the preprocessed documents are removed unnecessary tags by the noise filtering method except following items. <TABLE>,<TR>,<TD>,<LI>,<P>,
 tags are necessary the tags to keep the information of documents. The HTML document is composed one line of text or a record of table by such tags. Because most results of searching are represented with form of list or table, such tags is very an important information and may be not removed.

The final step of noise filtering is a work that gets rid of the duplicate from the URL of a document. The filtered document of educational newspaper homepage is show figure 5. We can know that the filtered document is ease for content analysis upon deletion of an unnecessary HTML tags. The advantage of noise filtering is that, it can process the same analysis about another newspaper homepages through removing tag.

```
Newspaper=Electronic Telegraph
URL=http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=3mmquqwM&atmo=3mmquqwM&pg=/
title=updatednews
date=2000.8.14
<table>
<tr>
<td>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
nhon14.html"
Honda to double British factory output
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
njake14.html"
Boy, 5, vanishes on trip to beach
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wiraq14.html"
West's raids spark Iraq fury
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
npaed14.html"
Labour welcomes Hague's paedophile plans
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wthai14.html"
Murder hostel was notorious for drugs
</a>
```

Figure 5 Result of a noise filtering

3.3 Pattern matching

The filtered document is translated from each information and data into regular expression. The pattern of regular documents is extracted with sequence of regular expression by the method of string matching. The hyperlink information of image may infer by using the pattern matching through regular expression, because the hyperlinked image do not contain the text information on hyperlink. The pattern matching is executed to extract text data and information of hyperlink in HTML documents. Specially, if image has been including hyperlink, the pattern matching is a very important work. The article information of the educational newspaper site has information of hyperlink as followed.

***< a href= .....> ..... text ..... ***

Generally, the hyperlinked text information exists between <a> tag and tag. If an image exists between the anchor tags as " <img src=...> ", then text information can exist at front or back of the anchor tags. In this case, each tag and the text information is changed the defined tokens previously. In addition, each data is created a string of a regular expression by the pattern matching.

The portion of tokens for creation of regular expression is shown table 1.

Table 1 Token for regular expression

<table>	</table>			<tr>	</tr>	<td>	</td>	<a>		href	text
T	T	P	p	R	r	D	d	A	a	H	M

If the filtered document is represented with regular expression by tokens of table 1, the content of figure 5 is converted a tag page into the sequence of the alphabet as "TRDAHMaAHMaAHMaAHMa...". And the string pattern of regular expression has the process of pattern matching. This study used the three types of pattern for pattern matching as followed.

- *"AHMa" : "< a href= ……> …… text …… "*
- *"MAHa" : "... text ... <img src=...> "*
- *"AHaM" :" <img src=...> ... text ..."*

The extracted string by pattern matching restores to the original tag and text information in HTML document. The extraction strings are reverted with source records. Figure 6 shows result that article is extracted through pattern matching of regular expression.

The translation of regular expression and the pattern matching have a many advantages. The advantage of pattern matching method is that the complex matching of string can extract only one time by matching of substring, and that agent can easily learn the rule of pattern.

Therefore ENIG system eases the addition of new educational newspaper site and pattern by the addition of URL and the type of pattern.

```
Electronic Telegraph|updatednews|2000.8.14|Honda to double British factory output|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/nhon14.html
Electronic Telegraph|updatednews|2000.8.14|Boy, 5, vanishes on trip to beach|http://http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/njake14.html
Electronic Telegraph|updatednews|2000.8.14|West's raids spark Iraq fury|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wiraq14.html
Electronic Telegraph|updatednews|2000.8.14|Labour welcomes Hague's paedophile plans|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/npaed14.html
Electronic Telegraph|updatednews|2000.8.14|Murder hostel was notorious for drugs|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wthai14.html
```

Figure 6 Example of string exchanging for regular expression

3.4 Inference and learning method

The extracted newspaper information is not provided all good information to student. In case of an inserted advertisement site, such site can become an obstacle of learning by the useless content. Moreover, a negative content or a harmful page too must be not suitable site to student. Such sites can be provided about a lustful content and a crime, an slang, a violence and so on. The harmful data can be removed in advance learning by inference engine and knowledge base. Reasoning rule uses the rule-based production system. The representation of knowledge is shown below

IF A THEN B

The production system has a merit that it is simple and easy the representation of rule as well as the addition of knowledge. The learning method of the ENIG Agent system uses the supervised learning learned by human teacher. If new rule is occurred, teacher input new rule and knowledge in knowledge base. For example, if the extracted information contains harmful text as a sex and a narcotic, a knife, then teacher input new rule and knowledge as "*IF sex AND narcotic AND knife THEN delete*".

The harmful site at gathering site reason a rule by the analysis of content and the rule are stored in knowledge base by teacher. The bad information of extracted document is removed by the vocabulary DB and the rule of knowledge base. For forbidding the access of the student, the addition and deletion of rule and fact in the knowledge base can be control only by a teacher.

4 Implementation and Experiment

The implemented ENIG Agent can extract only the important information of newspaper site. In addition, it can be had with only a text and URL information at various homepage. For implementation of the ENIG Agent, we used Visual C++ and the CLIPS DLL. The CLIPS is rule-based a production system shell and it is used as an inference engine.

The execution screen of the ENIG agent system is shown figure 7. The ENIG system is composed of three parts. The left side of the screen is a part that the directory manager manages and edits educational newspaper sites, and the mid-screen is a part to view the result of the gathering information, and the button of right above is part to add a rule for inference and machine learning. If 'gathering' button is clicked, the ENIG agent gathers and extracts an article from an educational newspaper site. If 'learning' button is clicked, a rule and knowledge is added and edited by teacher in the ENIG agent.

This ENIG agent system can be applied directly at the homepage of different domain without change of system. If site is constructed standard HTML document, an agent can search and gather even the document of a foreign site.

The applying example of NIE learning using the ENIG system is shown figure 9. This example is used the ENIG system and the Web Browser and word processor. The screen is the NIE learning about music using the ENIG agent system and the Window application. The information of newspaper on the web can be applied directly at a web-based instruction (WBI).

One of the advantages of this system is that the extracted information uses a mobile environment directly. Because the extracted information is very small data and hyperlinked information, such data can be inserted the mobile communication as a cellular phone, a PDA, a notebook computer, a portal computer, and so on. Furthermore, the information of this system can transmit the WML by WAP.

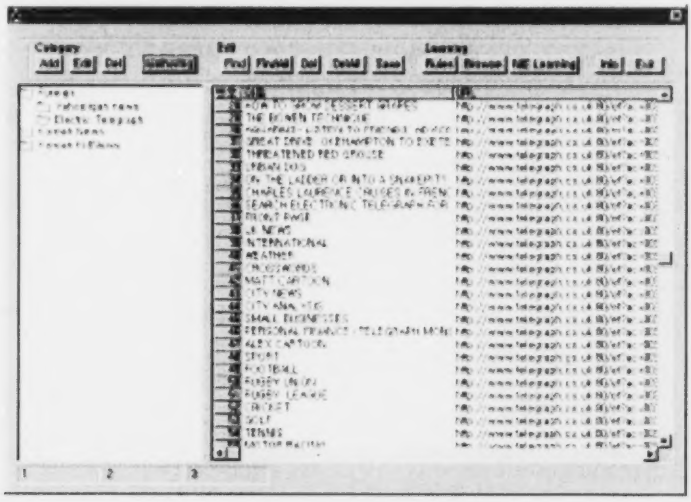


Figure 7 ENIG Agent system

BEST COPY AVAILABLE

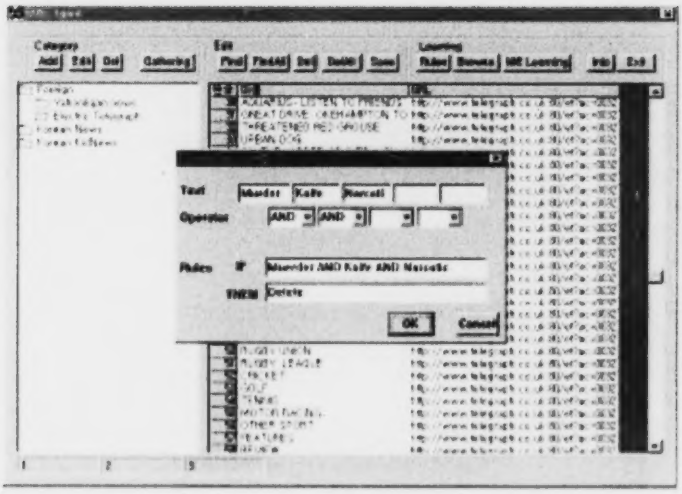


Figure 8 Addition of knowledge

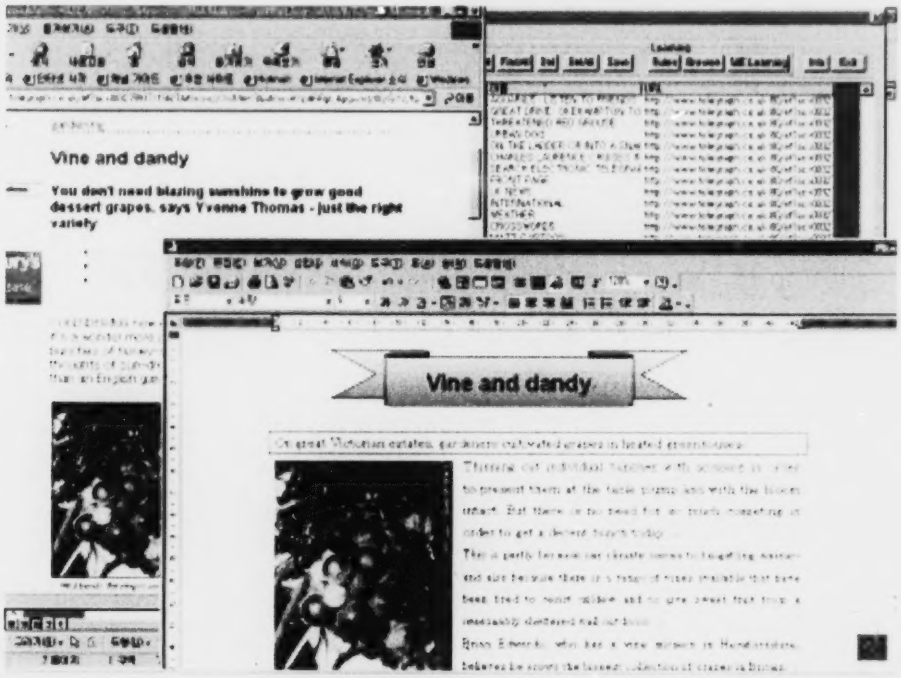


Figure 9 Example of NIE learning using ENIG agent

5 Conclusion and Future works

As mentioned above, we described about the ENIG agent system for the gathering information of educational newspaper homepage. In addition, we designed the method of noise filtering and pattern matching for suitable information. The method of noise filtering was used to remove unnecessary tags at source of HTML document and the method of pattern matching was used to extract necessary URL and text

BEST COPY AVAILABLE

information. The learning of agent was used to provide with good information to student by supervised learning. Most a web-based instruction was mainly learning about information retrieval. As student spent a lot of time to find learning information and data, so these lead deficiency of time for the essential learning.

Consequently, the ENIG agent system can provide not only to student for the learning of information retrieval but also can help them capturing the genuine NIE learning. And this system can execute the role of information treasury for the whole education through scraps of information.

The future works are that we improve the faculty of agent for information gathering of all sites; moreover, we need research about unsupervised learning of agent and not supervised learning. In addition, we need research to remove gathering information of header and footer through addition of heuristics and pattern type that requires the study about the method of keyword searching it. Finally, for providing a location of information to the agent, we will research the extension method of URL.

References

[1] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol. 72, pp.329-365, 1995.

[2] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[3] Erik Selberg, Oren Etzioni, "Multi-Service Search and Comparison using the Metacrawler", Proceedings of the 4th World Wide Web Cinference, Boston, MA, USA, pp 195-208, 1995

[4] Filippo Menczer, Alvaro E. Monge, "Scalable Web Search by Adaptive Online Agents: An InfoSpiders Case Study", Intelligent Information agents, Springer, USA, pp 323-347, 1998.

[5] Frances Anderson, "Classroom Newspaper Activities: A Resource for Teachers, Grades 1-8", Charles C Thomas Pub, 1985

[6] Henry Lieberman, "Personal Assistants for the Web: An MIT Perspective", Springer, USA, pp 279-292, 1998.

[7] Josheph Giarratano, Gary Riley, "Expert System, Principles and Programming", PWS Publishing Company, 1994.

[8] Paul Sanderson, "Using Newspapers in the Classroom: Cambridge Handbooks for Language Teachers", Cambridge Univ. Press, 1999.

[9] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[10] Sandip Sen and Gerhard Weiss, "Learning in Multiagent systems", The MIT Press, USA pp 259-298, 1999.

[11] Wooldridge, M., Jennings, N. R., "Intelligent Agents", Springer-Verlag, 1995.

Integrating Electronic Mail Systems in Computer Literacy Instruction: Its Impacts on Student Attitudes and Interpersonal Relationships[1]

Fu-Yun Yu
Graduate Institute of Education
National Cheng-Kung University
No. 1, Ta-Hseuh Rd., 701, Tainan, Taiwan, R. O. C.
Tel: +886-6-275-7575 ext. 66225
Fax: +886-6-276-6563
E-mail: fuyun@mail.ncku.edu.tw

The effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, was explored in this study. More specifically, the effects of e-mail utilization in classrooms on student attitudes toward the instructor, the class and interpersonal relationships were the focus of the study. In total, sixty-eight prospect teachers enrolled in "Computers in Education" course participated in the study for a whole semester. Results from the study provided substantial evidence supporting e-mail's facilitative effects on student attitudes toward the instructor, the class as a whole, and other classmates.

Keywords: **Attitudes toward the class, Computer literacy instruction, E-mail, Interpersonal-relationships.**

1 Introduction

With unique characteristics like faster and asynchronous communications, greater flexibility for participant time management, improved receiver control and use of the message, and cost savings, etc. electronic mail (hereinafter named e-mail) is becoming more and more common in contemporary organizations [8, 12, 22, 24, 31, 33, 36]. In views of many of its advantageous features over conventional communication modes, e-mail has presented itself as a promising instructional and learning tool since its advertent.

Despite its potential value in variant educational settings, substantial evidence has come mostly from studies done in the areas of communication, literature and language learning [1-6, 9-21, 23, 25-30, 32]. For instance, Marttunen & Laurinen (1998) using e-mail as a forum for argumentation and debate supported the idea of incorporating the media for critical thinking and argumentation skills [19]. Whipp (1999) integrating e-mail discussion activity in an undergraduate methods course found that e-mail activity promoted reflection and joint interpretations of field experiences among participants [32].

Studies focusing on intercultural communications further stressed the multicultural learning opportunities e-mail engendered. For example, Cohen & Miyake's 1986 study showed that joint participation in the e-mail interaction across cultures could encourage multilingualism and awareness to other cultures [4]. Results from Ma's study (1993) indicated that students participating in the international e-mail communication tended to be more open of sharing information that provided them with subject and cultural knowledge [18]. Ruhe's endeavor (1998) in creating classroom e-mail exchanges among college

[1] The study was partly supported by National Science Council of the Republic of China (NSC 89-2413-H-006-008)

preparatory English-as-a-Secondary students scattering around different continents again demonstrated that e-mail could be effective in teaching intercultural awareness [23]. Numerous scholars, on the other hand, focused on exploring and actualizing e-mail's educational potential for the teaching of writing and composition [1-3, 5-6, 10-11, 16, 25-30].

Though e-mail, as an instructional aid, has been claimed to provide students with greater access to faculty and peers, the impacts of e-mail systems on student attitudes toward the instructor, the class as a whole as well as interpersonal relationships severely fall short of empirical research basis at the present time. Thus, the present study focused on determining the value of e-mail communication in enhancing participant affect and social gains. The major purpose of the present study was to investigate the effectiveness of e-mail, one of the most accessible, convenient, and easy to use computer-mediated communications, on student learning outcomes. By incorporating e-mail into the instructional process, and inviting on-line communications both between and among instructors and students throughout the semester, the researcher expected to observe the differential effect e-mail has on student attitudes toward the instructor, the class and their classmates.

2 Methods

2.1 Participants and learning context

Two classes of students from "Computers in Education" course (N=68) participated in the study. The course was offered in 1999 semester year under a teacher preparation program in a National university in Southern Taiwan. The course was introductory and selective, aiming to strengthen prospect teachers' computer competency. Student self-introduction held at the first class session revealed that most students possessed only fundamental computer skills, had limited exposure to computer-mediated communication, and had not experienced e-mail utilization within class in the past. Additionally, as the course was offered during the Fall semester, most students were new to each other and had not taken the instructor's class before.

The study was conducted in a university computer laboratory with fifty computers designed for individual student learning. A Classroom Broadcast System was installed to network student workstations in the computer lab to further facilitate teaching and learning. During each class session, the instructor would give an overview of today's topics, explain and demonstrate the procedures involved in operating different computer applications and functions, which were interspersed with student hands-on practice. E-mail together with basic operation systems, word-processing, spreadsheet, computer-generated presentation using PowerPoint, and web-surfing techniques were taught by the same instructor in a one-semester two-credit course.

Two performance-type posttests were designed to assess student skills on operation systems, e-mail, word-processing and spreadsheet. A group-based final project of any topics of student choice was used for web-surfing and PowerPoint skills assessment.

2.2 Experimental design and treatment conditions

As most participants from both classes possessed fundamental computer skills and were acquainted to neither each other nor the instructor, a posttest-only experimental design was adopted in the study. To examine the potential effects of incorporating e-mail systems in a classroom setting, two participating classes were randomly assigned to different treatment conditions, namely, the e-mail utilization condition and the traditional condition. Prior to the commencement of the study, students were required to obtain a university e-mail account. A 2-hour class session was designated for e-mail instruction and practice. Procedures for sending, receiving, reading, responding, forwarding, printing, and deleting mails as well as e-mail features like address-book and attachment were explained, demonstrated and practiced in the class.

To examine the effectiveness of e-mail, as a supplementary instructional aid to computer literacy class and as a communication link between and among instructors and students, all instructional components and procedures were kept essentially the same except the way in which supplementary materials were disseminated to students and student assignments were handed in. In the e-mail utilization condition, instructors send out supplementary materials including weekly course outlines, additional reading materials, announcements, and computer-related news updates (e.g., newest computer virus) via e-mails at least two

days ahead of meeting time. Moreover, students were requested to hand in all their assignments/reports electronically and were encouraged to use it for future correspondence with the instructor, their teammates, and other classmates. As e-mail was treated as a supplementary channel to the class, no compulsory measures were taken to force students to use e-mail except those mentioned. Nevertheless, students were strongly encouraged by the instructor to log in the system at least once a week to check mails and print out any materials they deem useful. As mentioned previously, a group-based project gearing toward integrating Internet resources for any instructional topics of group choice was designed as the second evaluation component of the class, students were encouraged to take advantages of e-mail systems to communicate with their self-chosen teammates along the way. By opening up on-line communications both between and among instructors and students throughout the semester, the cultivation of elevated attitudes toward classmates, the instructor and the class was postulated.

In the traditional group, on the other hand, students would receive essentially the same supplementary materials in class and would hand in assignments directly to instructor, only that they were in hardcopy format. In other words, after the instruction on e-mail systems and functions, the instructor did not intentionally integrate e-mail utilization into the instructional process to further promote computer use. One last thing, performance-type posttests on e-mail ascertained that students in both treatment conditions mastered the skills.

2.3 Measures

A post-session self-report questionnaire administered individually at the last session of the class was used to collect data pertaining to the effects of integrating e-mail on student attitudes and interpersonal relationships. The 9-item "Class Evaluation" developed by the university was used for the measurement of student attitudes toward the instructor and the class as a whole. Sample items included, "the instructor was prepared and the instructional content was appropriate; the instructor was available to discuss academic matters with students both in and out of class and could explain things in a clear fashion; the instructor's attitude toward teaching was diligent, and the instructor was responsible and punctual." The 13-item "Perceptions Toward Teammates Scale," developed by Yu (1996-97), was used to test the hypothesis relevant to student perception toward their teammates [34]. Sample items included, "I am willing to work with my teammates again next time; I liked my teammates." Finally, the 11-item "Perceptions Toward Other Classmates Scale," developed by Yu (1996-97), was included to test the hypothesis relevant to student perceptual impressions of other classmates. Sample items included, "Other classmates helped me greatly with respect to my learning; other classmates were friendly." The internal consistency reliability (coefficient alpha) for student perceptions toward their teammates and other classmates was .92 and .86, respectively.

Each statement on the questionnaire was rated on a five-part discrete scale, with corresponding verbal descriptions ranging from "strongly disagree" through "disagree," "no-opinion/average," "agree," to "strongly agree." Each response received a weight of 1, 2, 3, 4, or 5, respectively. To counteract possible response-set tendencies, both positive and negative statements were included. Scoring on the negative statements was reversed so that negative and positive responses could be summed and averaged with higher scores reflecting more positive attitudes.

3 Results and discussion

Data were analyzed using the analysis of variance technique on student attitudes toward the instructor/class, their own teammates and other classmates. A .05 level of significance was adopted for use in this study. The means and standard deviation (SD) values for each of the dependent variables were listed in Table 1.

Results from t-tests showed significant differences between the two treatment conditions in student attitudes toward the instructor/class, $F(1, 66) = 2.898$, $p < .01$, and student attitudes toward other classmates, $F(1, 66) = 2.033$, $p < .05$. However, data analysis did not show significant differences between the two treatment conditions in student perception toward their own teammates, $F(1, 66) = 1.476$, $p > .05$. The results further showed that subjects in the e-mail utilization condition tended to rate the instructor/class and other classmates more positively than those in the traditional group.

Table 1: Descriptive Statistics of Different Treatment Conditions on Subject Attitudes Toward the Instructor/Class, Their Teammates, and Other Classmates

	Integrating E-mail Group (N=35) M (SD)	Traditional Group (N=33) M (SD)
Attitudes Toward the Instructor/Class	43.3605 (2.8042)	41.0303 (3.7800)
Perception Toward Their Teammates	57.7940 (6.2625)	55.3747 (7.3470)
Perception Toward Other Classmates	45.1944 (5.4867)	42.7273 (4.4880)

Data from after-session debriefings with participating students combined with sample e-mails both sent and received by students supported the idea of integrating e-mail systems into the learning process. While some students did take advantages of e-mail systems to ask academic-related questions (e.g., procedures for a specific application functions not covered in class, deadline for assignments, etc.) and/or send social greetings during holidays, the majority of e-mails transmitted were forwarding mails of variant topics ranging from health-related issues to jokes, novels and updated news in the technology world, etc. Many students pointed out that e-mail's distinct features like forwarding and address-book immensely facilitated interaction and information sharing among classmates and the instructor. Most students developed the habit of logging in the systems to retrieve e-mails along the way. Through increased interactions among the participants via receiving a wide array of articles and useful information forwarded from classmates and the instructor, mutual understanding, acceptance and bonding thus fostered. Thus, it was reasonably why students in e-mail conditions tended to view the instructor as better prepared, easier to locate, and other classmates as friendlier and more helpful.

Though the non-significant results in student attitude toward their own teammates was somewhat surprising at first, a closer look at e-mail use pattern among teammates shed some light onto the issue. E-mail was introduced into the learning environment in an attempt to facilitate group interaction within team-members; however, students in the e-mail treatment group rarely used this channel for online discussion and primarily as a last resort for scheduling purpose with their own teammates. As most group members sat closer to each other during the class and arranged meeting time for final project discussion right after class sessions, they didn't find e-mail especially useful in that aspect. As students did not use the technology for inner group communication except under very extreme situations, the fact that e-mail's integration into the learning environment did not significantly influence subjects' attitudes toward their teammates was understandable.

4 Conclusions

This study focused on examining whether incorporating e-mail into computer literacy classroom settings could positively influence student attitudes and interpersonal relationships. Results indicated that student attitudes toward the instructor/class and other classmates were positively influenced by this approach. The obtained results provided empirical evidence supporting the usefulness of e-mail as an aid for promoting out-of-classroom contacts of various types among faculty members and classmates, which, one way or the other, contributed to more positive attitudes.

Though e-mail might provide students with greater access to faculty and peers and seemed to enrich teacher/student interpersonal relationships in the present study, a word of suggestions for avant-courier was rendered. For e-mail to be effective as an alternative option for further two-way communication between teachers and students, all essential elements must be present. First, the important role "feedback" played during the process. Many students stressed that their willingness to continue having out-of-classroom contacts with instructors via e-mail was determined by the presence of the instructors' response in return. As Zaremba (1997) clearly pointed out "Without feedback, e-mail is likely to be less effective than it potentially could be. The quality of communication may be a function of the timeliness of feedback provided by the recipient." [35]. To create a bond of communication with students via e-mail, timeliness of feedback provided by the recipient would be an important task all participants need to attend to.

Secondly, for electronic communication to take effects, accessibility of essential hardware and software must be in place [22]. Some students mentioned specifically during the interview that limited access to computer hardware and network seriously prevented them from taking a full advantage of e-mail as a unique

communication tool. To ensure ongoing communications among participants electronically, interested implementers cannot ignore measures overcoming equipment and facility shortage.

Finally, opportunities for training and familiarization of the system for all parties would certainly facilitate the integration process. Extra time, care and possibly some incentives may be needed not only to get students accustomed to on-line message exchanges but also to have students appreciate e-mails' advantages especially during initial exchanges. Only when all the essential components as mentioned were in place, many of the potential impacts e-mail could have on the instructional settings like liberation of traditional roles associated with different parties, and humanitarian learning environments for all individuals would thus be actualized.

References

[1] Allen, M., "E-mail in the writing class: Promoting student communication", Paper Presented at the Annual Meeting of the Teachers of English to Speakers of Other Languages, ERIC No. 394 348, (1995).

[2] Bard, D., "Literacy practices in extra-academic conversations: Quilting bees via e-mail", ERIC NO: ED 422569, (1998).

[3] Chen, G. M., "The effect of e-mail debate as a teaching tool: a pilot study", Paper presented at the Annual Convention of Speech Communication Association, New Orleans, Louisiana, November, (1994).

[4] Cohen, M. & Miyake, N., "A worldwide intercultural network: Exploring electronic massaging for instruction", Instructional Science, Vol. 13, pp. 257-273, (1986).

[5] Coogan, D., "Tutoring, a new way to do new work", Computers and Composition,Vol. 2, No. 2, pp. 171-181, (1995).

[6] Dowden, R. & Humphries, S., "Using e-mail in computer assisted freshman composition and rhetoric", T.H.E Journal, Vol. 24, No. 10, pp. 74-75, (1997).

[7] Dreher, H. V., "Telecommunications for Learning", Englewood Cliffs, NJ: Prentice Hall, pp. 44-46, (1991).

[8] D'Souza, P. M., "Electronic mail in academic settings: a multipurpose communication tool", Educational Technology, Vol. 32, No. 3, pp. 22-25, (1992).

[9] Durost, D. D & Hutchinson, S. L., "Keypals--e-mail leads to new friends", Dimensions of Early Childhood, Vol. 25, No. 4, pp.17-22, (1997).

[10] Grosz-Gluckman, V., "A look at the use of electronic mail (e-mail) as a learning tool in the writing skills of adult LEP Female Students", ERIC NO.: 416720, (1997).

[11] Hawisher, G. E. & Selfe, C. L., "The rhetoric of technology and electronic writing class", College Composition and Communication, Vol. 42, pp. 55-65, (1991).

[12] Holliday, L., "Challenging questions about e-mail for language learning", ESL Magazine, Vol. 2, No. 2, pp. 14-15, (1999).

[13] Kroonenberg, N., "Developing communicative and thinking skills via electronic mail", TESOL Journal, Vol. 4, No. 2, pp. 24-27, (1994/1995).

[14] Leh, A. S., "Electronic mail in foreign language learning: communication and culture", Proceedings of Selected Research and Development Presentations at the 1997 National Convention of the Association for Educational Communications and Technology, ERIC No. 409 851, (1997).

[15] Liang, T., "Cooperative learning on the Internet: The intercultural E-mail connection", Proceedings of the Fifth International Symposium on English Teaching, pp. 233-242, The Crane Publishing Co., (1996).

[16] Liaw, M-L., "Communication strategies used by freshman English students in e-mail writing", Proceedings of the Fifth International Symposium on English Teaching, The Crane Publishing Co., pp. 211-222, (1996).

[17] Lunde, K. R., "Using electronic mail as a medium for foreign language study and instruction", CALICO Journal, Vol. 7, pp. 68-78, (1990).

[18] Ma, R., "Computer-mediated conversation as a new dimension of intercultural communication between college students in Taiwan and USA", Paper presented at the International Conference of Chinese Communication Research and Education, Taipei, Taiwan, June, (1993).

[19] Marttunen, M. & Laurinen, L., "Learning of argumentation in face-to-face and e-mail environments", ERIC NO.: 422791, (1996).

[20] Rankin, W., "Increasing the communicative competence of foreign language students through the LF

chatroom", Foreign Language Annuals, Vol. 30, No. 4, pp. 542-546, (1997a).
[21] Rankin, W., "The Cyberjournal: developing writing, researching, and editing skills through e-mail and the world wide web", Educational Technology, Vol. 37, No. 4, pp. 29-31, (1997b).
[22] Ruberg, L. F & Miller, M. G., "Moving from U.S. Mail to e-mail", ERIC No: ED363312, (1993).
[23] Ruhe, V., "E-mail exchanges: Teaching language, culture, and technology for the 21st Century", TESL Canada Journal, Vol. 16, No. 1, pp. 88-95, (1998).
[24] Russell, A. L. & Cohen, L. M., "The Reflective colleague in e-mail cyberspace: A means for improving university instruction", Computers & Education, Vol. 29, No. 4, pp. 137-145, (1997).
[25] Schwartz, H. J., "Cross-cultural team teaching: E-mail for literary analysis", ERIC NO: ED319060, (1990).
[26] Silva, P. U., Meagher, M. E. Valenzuela, M. & Crenshaw, S., "E-mail: Read-life classroom experiences with foreign language", Learning and Learning with Technology, Vol. 23, No. 5, pp. 10-12, (1996).
[27] Sinagra, M. D & Battle, J. & Nicholson, S. A.., "Booktalking: Engaging development readers with authors and others in the academic community", Journal of College Reading and Learning, Vol. 29, No. 1, pp. 30-40, (1998).
[28] Tompson, D. P., "Teaching writing on a local area network", T.H.E. Journal, Vol. 15, pp. 92-97, (1987).
[29] Tudini,V. & Rubino, A.., "Connecting language student through e-mail. A Pilot Projec", Babel: Australia, Vol. 33, No. 1, pp. 18-21, 32-33, 37, (1998).
[30] Wang, Y. M., "E-mail dialogue journaling in an ESL reading and writing classroom", ERIC NO: ED397845, (1996).
[31] Warschauer, M., "Comparing face-to-face and electronic communication in the second language classroom", CALICO Journal, Vol. 13, No. 2, pp. 7-26, (1996).
[32] Whipp, J. L., "Facilitating critical reflection about field experiences on e-mail: Emancipatory teaching in cyberspace", ERIC NO.: ED432308, (1999).
[33] Wilkinson, L. & Buboltz, W. C, Jr., "E-mail: Communication of the future?", ERIC NO: ED421170, (1998).
[34] Yu, F. Y., "Competition or non-competition: its impact in interpersonal relationships in a computer-assisted learning environmen", Journal of Educational Technology Systems, Vol. 25, No. 1, pp. 13-24, (1996-97).
[35] Zaremba, A. J., "Effects of e-mail availability on the informal network, and dissemination of upward and "human" message", ERIC NO: ED414946, (1997).
[36] Zolten, J., "E-mail bonding: Making the most of electronic communication between teacher and student", ERIC No: 416543, (1997).

Network Usage Survey and Its Analysis with Related Factors between University Students and Occupational Groups in Taiwan

Gin-Fon Nancy Ju, Soochow University
70 Lin-Shi Rd. , Taipei , Taiwan, R.O.C.
E-mail : gju@mail.scu.edu.tw

This research was to investigate the current situation of computer network usage, frequency and purposes between university students and occupational groups in Taiwan. The research also analyzed the influences of its related factors on computer network usage, such as computer experience background, the attitudes toward computers, personality, aptitudes, critical thinking ability, academic achievement and so on. The subjects of university students were sampled from the Soochow University. The subjects of occupational groups were sampled from various occupations. The Computer Experience Background Scale and the Computer Attitude Scale were conducted by author for this research. Lai' s Personality Scale, Differential Aptitude Tests and Critical Thinking Appraisal are three published tests selected appropriately by the author and used for the research purposes. Academic achievement in the research was based on the students GPA.

According to the computer network usage of university students, 150 students were sampled in 1997. The network usage was classified into three types of purposes: (1) information searching, (2) BBS, (3) e-mail. The findings were that the students used computer network for searching information the most frequently, then for BBS, for e-mail the least frequently. Besides, the male students significantly used computer network more frequently than the female students, especially for the usage of information searching and e-mail purposes. About computer experience background and the attitudes toward computers, the students who have more computer experience background and who have more positive attitudes toward computers significantly used computer network more frequently where the influences from computer experience background was larger than the influences from computer attitudes.

Since the subjects from the university students can be arranged and administered by the Lai' s Personality Scale, Differential Aptitude Tests and the Critical Thinking Appraisal, and their GPA can be retrieved from the university, therefore, the relationship between computer network usage and personality, aptitudes or critical thinking ability were analyzed. The findings of the Lai' s Personality Scale were that the students who were more objective, less depressed, and less nervous significantly used computer network for information searching purposes more frequently. The students who were

more social types of personality significantly used computer network for BBS purposes more frequently. The students who were more worry and distress significantly used computer network for e-mail purposes more frequently. The Differential Aptitude Tests was found that the aptitudes of arithmetic and abstract reasoning were significantly positively correlated with the frequency of computer network usage for BBS purposes. None of critical thinking abilities was significantly related to the computer network usage. The students' GPA was not found to be significantly related to the computer network usage either.

Since we sampled 110 university students for the same survey again in 2000, the changes of the computer network usage by time sequence were investigated in this research. It was found that no matter the usage of information searching, BBS, or e-mail purposes, the university students in 2000 have significantly more frequency in using computer network than the students in 1997. The university students in 2000 yielded significantly more computer experience background than did the students in 1997 too. However, for the attitudes towards computers, the university students in 2000 did not make significantly difference from the students in 1997. These results indicated that university students always respected the importance of computers in their lives. They significantly used computer network more and more by years. As a matter of fact, computer network will be the main tool to get survived in the future hi-tech world.

For surveying computer network usage of occupational groups, 115 adults were sampled in 1999. It was found that they significantly used computer network for information searching and e-mail more frequently than for BBS. No gender effect was found to be related to the usage of computer network. In addition, the more computer experience background the occupational groups have, the more significantly frequently they used computer network. However, their attitudes toward computers were not significantly related to the computer network usage. The results of age stages showed that the elder people significantly used computer network less frequently than the younger people.

General speaking, the occupational groups used computer network for e-mail purposes significantly more frequently but for BBS significantly less frequently than did the university students. The occupational groups significantly yielded more computer experiences than did the university students. It has to be mentioned here that since we sampled university students and occupational groups in different years, these results might confounded with the time effects. Further research and experimental design were suggested to verify these problems.

Reference

[1] Sternberg, R. J. "Diversifying Instruction and Assessment." Educational-Forum, 59, p47-52. 1994

[2] Watson, G. & Glaser, E. M. "Critical Thinking Appraisal." The Psychological Corporation, Harcourt Brace Jovanovich, Inc. 1980

Online ESL Learning: An Authentic Contact

Yu-Chih Doris Shih* and Lauren Cifuentes**
**Department of Educational Curriculum & Instruction, Texas A&M University*
4205 Boyett St., #C, College Station, TX 77801, USA
E-mail: dorisshih@hotmail.com
*** Department of Educational Psychology, Texas A&M University*
College Station, TX77843, USA
E-mail: laurenc@tamu.edu

As communication via telecommunications become easier, learning through online technologies is made possible. In a telecommunications project among US preservice teachers and Taiwanese English as a Second Language learners, Taiwanese students practiced English language and discussed cultural information with US partners who served as online tutors. Data revealed that Taiwanese ESL learners perceived online learning of English language and American culture to be valuable for its authenticity. Instructions on intercultural communication skills were found to be necessary prior to the connection in order to help eliminate misunderstandings between participants of two countries. The success of online learning depended on several factors such as participants' motivation, participants' attitudes, technology, preparation, and support services. Furthermore, Taiwanese learners who had successful experiences applied ten strategies to their ESL learning. These strategies were employed during a circular process of online learning.

Keywords: **ESL, Online Learning, Telecommunications, Intercultural Computer-Mediated Communications**

1 Introduction

The purpose of this research was to investigate a telecommunications project for Taiwanese students to learn the English language and acquire cultural information through online technologies. Preservice teachers (PSTs) at a state university in the United States worked with Taiwanese learners of English as a Second Language (ESL) at a Taiwanese university. The goal of the research was to study intercultural online learning.

In Taiwan, many scholars have been discussing the need for educational reform and change of instructional methods [7][36]. One change under consideration is increased use of online instruction. Taiwanese researchers suggested that the educational reform should include the adoption of methods proposed in the West (i.e., the United States, Great Britain, Australia, and other English-speaking countries), such as involving students in active learning, teaching critical thinking skills, and incorporating individualized instruction [4][25]. Harasim (1990) and Owston (1997) believed that instruction could be enhanced by online teaching. They have stated that online instruction allows for active learning, idea generating, idea linking, and idea structuring as well as helps the students to develop skills in critical thinking and problem solving. Individualized instruction is supported because both synchronous and asynchronous modes of instruction are workable through technologies.

When online teaching is used as a language instructional method, it remedies Taiwan's geographical isolation as an island and provides opportunities for ESL learners to communicate in an authentic English environment. Successful second language (L2) learning includes not only knowing the linguistic features of the language but also understanding the cultural concepts [14]. Sayers and Brown (1987) remarked, "foreign language students

need authentic contacts with native speakers and much practice in a range of language skills -- including reading and writing -- if they are to develop cultural awareness and communicative competence" (p. 23). L2 learners learn language and culture if instruction is facilitated by supportive individualized learning activities [13]. These activities must address the learner's current language level (Krashen's stage of i) and the level beyond the present language and literacy capacities (Krashen's stage of i + 1) [21]. Telecommunications can help overcome the limitations of Taiwanese isolation by providing for supportive and authentic language instruction.

2 Literature Review

Learning through telecommunications has evolved during the 1990s in the West and has proved to be successful [1][8]. To bring more applications into Taiwan, we need to first explore Taiwanese students' needs and attitudes in the use of such technology. Some scholars stated that Asian students employ different learning strategies than students in the West [17][32]. Cheng (1980) pointed out that the educational system in Taiwan has adopted many different educational methods developed in the West; however, utilization has been non-systematic and inappropriate for societal needs in Taiwan. Furthermore, Stewart (1985) and Dooley (1995) noted that the applications of educational technology in other countries besides the United States may be unsuitable because of cultural non-transferability. For instance, other cultures may value a different set of learning and teaching modes when compared to the United States, or they may have insufficient equipment for advanced technological applications. Taiwanese scholars have also urged that future investigations must be done specifically on distance-learning courses in Taiwan [6][37]. Therefore, close examination must be carried out prior to fully adopting new telecommunication technologies as learning tools in Taiwan.

As technology advances, communication over a distance and across cultures becomes easier and inevitable. However, very little can be found in the literature that addresses issues of online intercultural communication and the design considerations that would enhance such interaction. Lee (1999) urged designers and instructors of computer-based instruction to take cultural issues into consideration when developing learning environments and technology integration within curricula. Caution must be taken, especially when intercultural contacts occur in an online learning context, because communicators may not be who they seem to be online [28].

Collis and Remmers (1997) pointed out that to allow successful online cross-cultural contact, at least four issues have to be taken into consideration: communication and interaction, language, content, and representation form. First, communication and interaction are easily misinterpreted across cultures. According to the two researchers, more communication and interaction are not necessarily better than less, and well-structured communication may be preferable for wider audiences. Second, because language includes verbal and nonverbal cultural communication, those developing cross-cultural online instruction must be sensitive to cultural differences in communication styles. Third, designers must choose cross-cultural course content. Last, visuals can overcome problems associated with text-based language. However, one must be sensitive to cultural differences in the acceptability and interpretability of various aspects of visualization.

Research on online connections has been conducted in many areas during this decade. Projects connecting students with teachers or other students in multiple locations were implemented in many subject areas such as science [22], history [3], teaching [27], and language arts [35]. Similar projects in the area of foreign language learning are found in the teaching of Portuguese [20], Russian [30], Spanish [24], and ESL [19][33]. The results of these studies mainly stated how the participants at different sites benefited from the connection in increased technical competence, personal development, language improvement, and more meaningful cultural exchanges. No research has been found that explores the learning strategies used by students while learning a L2 online and the issues encountered during their online intercultural communications.

3 Purposes and Research Questions

There were three purposes of this study: first, understanding the Taiwanese ESL learners' perceptions of learning through distance technologies; second, exploring issues related to online intercultural communication; and third, identifying the learning strategies the Taiwanese learners employed during distance learning to accomplish the

acquisition of ESL and understanding of American culture. The three research questions guided the study were:

(1) How do ESL learners in Taiwan perceive language acquisition and cultural understanding via distance learning technologies after the experience?
(2) What intercultural phenomena can be observed in online learning for Taiwanese students?
(3) What online learning strategies do the Taiwanese use while learning the English language and learning about American culture?

4 Method

This study employed a qualitative research design. This design enabled the researcher to inquire, comprehend, and describe the experiencing world of the participants and the meaning of these experiences [2][26].

4.1 Participants

The project involved students in two different countries: US and Taiwan. There were 40 PSTs in the United States who took either *EDTC 305: Instructional Technology: Theory and Practice* or *INST 462: Language Acquisition and Development* at a state university. These were PSTs being prepared to teach English, ESL, political science, and history at the elementary or secondary level. The same number of participants in Taiwan were students who study in the Department of English Language and Literature at a university in Taipei, Taiwan. They were members of *English Composition and Conversation* classes at either sophomore or junior levels. The US and Taiwanese students participated in this research because their instructors included this online connection project as part of their course requirement. The participants in the United States ranged from the ages of 20 to 22, while the students in Taiwan ranged from the ages of 19 to 20.

In addition, the three professors in Taiwan whose students were project participants were also involved as research subjects. They were interviewed by the researcher in regard to their students' perceptions of online experiences, students' improvement in the English language as well as other types of knowledge through the connection.

4.2 Procedures

To carry out the study, US PSTs corresponded with Taiwanese university-level ESL learners for ten weeks. These PSTs served as tutors of the English language and American culture. The participants in both countries were matched one-on-one randomly prior to the connection. They were also given instructions and orientations on the utilization of e-mail systems and on online learning/teaching. The PSTs were provided with a lecture, discussion, supportive readings, example tutorial correspondences, and a web site of resources. The web site included a downloadable lecture about online learning, the expected online correspondence process guidelines, a midterm survey, sample correspondence, and previous participants' reflections (http://www.coe.tamu.edu/~lcifuent/classes/edtc305/online.htm). They also read on topics such as effective facilitation of computer conferencing [9], computer-mediated communication [18], interactivity in online environments [15], online teaching strategies [8], and cultural differences in teaching and learning [17].

Similarly, the students in Taiwan were supplied with an orientation where the project is introduced to them along with rules and regulations. Sample correspondence, results of previous connections, and suggestions for online learning and discussion topics were presented at their departmental website (http://www.eng.fju.edu.tw/cultural_connections.htm).

Every participant received a welcome letter to encourage them to open themselves up to this new experience. The PSTs were given a rubric with expected number grades to help them accomplish the requirements for their part of the connection. The Taiwanese students initiated the connection by sending out their first e-mail message to their US partners. The US PSTs analyzed their student's language level and started to instruct him or her according to that level through e-mail.

Mid-way during the ten-week connection, the PSTs were asked to fill out an online midterm survey. In Taiwan, the students submitted a brief report to their instructors every two weeks to keep track of their connection progresses.

At the end of the connection, the PSTs and their Taiwanese students filled out a post-connection survey. The PSTs also handed in all of their e-mail printouts and personal journals that reflected their online teaching and learning experiences. Similarly, the Taiwanese students handed in their final reports to their Taiwanese instructors. Two weeks after the end of the connection, the researcher traveled to Taiwan to conduct interviews with 12 Taiwanese students and the three Taiwanese professors. The interviews included open-ended questions.

4.3 Data Collection and Analysis

There were eight data sources: (a) printouts of correspondence; (b) the PSTs' midterm survey; (c) the PSTs' post-connection survey; (d) the Taiwanese students' post-connection survey; (e) the PSTs' reflective journal entries; (f) the Taiwanese students' final reports; (g) transcripts of the interview with the Taiwanese students; and (h) transcripts of the interview with the Taiwanese professors.

Data analysis in qualitative studies is an ongoing process during the research; it is best done simultaneously with the data collection [26]. Each time data are gathered, information was analyzed using procedures proposed by Emerson, Fretz, and Shaw (1995). The steps included close reading, open coding, writing memos, noting themes and patterns, and focused coding.

5 Results

Data analyses revealed remarkable information on the areas of (a) learner perception, (b) intercultural communication, (c) factors affecting online connection, (d) online learning strategies, and (e) online learning processes. First, this particular group of Taiwanese ESL learners was positive about L2 and cultural learning in an online setting. The results of a post-connection survey showed that participants more or less agreed that (a) E-mail connections have a positive place in ESL classrooms (mean of 3.71); (b) the Web-connection has a positive place in ESL classrooms (mean of 3.51); (c) they would participate in another online connection if given the opportunity (mean of 3.58); and (d) they would suggest their other friends or classmates participate in a similar project (mean of 3.85) (see Table 1). Even though the response to the question "Overall, my connection was successful" was not very high (mean of 3.26), learners who had an unsuccessful connection held positive attitudes toward the project. One student wrote in her final report, "My pal does not respond to me so often. I didn't learn much through this project this semester. But that doesn't mean this project is not good. I hope school brothers or sisters can still have the chance to get in this project."

Table 1. Taiwanese Students' Responses Toward the Online Connection

Questions	M	SD
The **E-mail connection** has a positive place in ESL classrooms.	3.71	0.67
The **Web-board connection** has a positive place in ESL classrooms.	3.51	1.50
I would participate in another online connection if given the opportunity.	3.58	1.13
I would suggest other friends or classmate participate in a similar project.	3.85	0.78
Overall, my connection was successful.	3.26	1.07

Note. Participants responded on a 5-point Likert scale (1= Strongly Disagree; 5 = Strongly Agree). The survey was complete by 37 participants.

Second, intercultural communication issues cannot be ignored. A lot of Taiwanese learners interpreted that their tutors were angry with them when they did not receive messages over a week. In addition, learners read what wasn't intended in the messages. They constantly apologized to the PSTs for being an inconvenience. Several learners ceased active interaction with the PSTs due to these personal interpretations. The Taiwanese professors suggested that acquainting learners with different thinking patterns and expression styles is necessary in future connections.

Third, factors that affected online connections included participants' motivation, attitudes toward each other, participants' fields of experience, frequency and quality of interactions, technology, preparation, and support

services (figure 1). Any missing component would hinder the success of the connection. Other resources such as teachers, peers, family members, libraries, and web resources provided extra assistance to the participants.
Fourth, during the correspondences, ten learning strategies were found to be used by the learners in their messages. These were paraphrasing, translation, Q&A from tutor to student, Q&A from student to tutor, explanation, elaboration, decision-making, self-reflection, metacognition, and transfer. The learners in the more successful pairs tended to use a variety of the ten strategies.

Finally, data indicated these ESL learners went through a series of processes for successful learning (figure 2). Motivated learners set learning goals for themselves with the PSTs' help. Those who prepared themselves well by finding topics of discussion or information in the libraries, the WWW, and traditional learning environment aimed for frequent and quality interactions via e-mail with the PSTs. After each interaction, a review period prompted learners for more interactions. Learners who went through these stages concluded that they had learnt new information and increased their confidence in using English reading and writing skills. Needless to say, this result increased their motivation to learn and thus encouraged the start of another learning cycle.

6 Discussions and Conclusion

This study is significant to both distance-learning educators and language-learning educators. There are at least three reasons for this significance. First, the study provides insights for distance educators, both for those in Taiwan and for those in other countries who have Taiwanese students enrolled in courses that are delivered via telecommunications. The results of the study help these instructors to further understand Taiwanese students' positive perceptions of L2 learning through online technologies, identify suitable conditions and environment for these learners, and decide the extent to which this mode of instruction is applicable to students from this cultural background.

Second, the online intercultural communications issues explored in this study assist telecommunications users with more effective communication. They help users become aware of and anticipate problems when coming into contact with people of other cultures via distance technologies. Even without using online technologies, intercultural communication is already complex. Therefore, interaction may be hindered further when technology is the transmission medium. Understanding the barriers and facilitators of online intercultural communication leads to better and more successful intercultural interactions.

Third, the identified ten online learning strategies and online learning processes will add to the literature on language learning and teaching. Such research is in demand because ESL programs in the United States are planning to deliver more ESL courses to foreign countries via distance learning technologies.

In summary, most Taiwanese ESL learners had a positive experience with the online connection. The few connections that failed were due to lack of participants' response, lack of participants' motivation, and technical failure. Nevertheless, providing L2 instruction to learners over cyberspace is a method that should not be ignored. Learners need to be prepared with adequate intercultural communication skills and online learning strategies.

Follow-up investigation of online ESL acquisition might include specific amount of improvement on learners' writings and learning via synchronous technologies such as chats, interactive videoconferences, and desktop videoconferences.

References

[1] Bates, A. W., "Technology, open learning and distance education", Routledge (1995)
[2] Bogdan, R. C., & Biklen, S. N., "Qualitative research in education: An introduction to theory and methods", Allyn & Bacon, 3rd ed (1998).
[3] Butler, W. M., "Writing to learn history on-line", The Clearing House, Vol. 69, No. 1, pp. 17-19 (1995)
[4] Chang, H-J., "Trends of instructional methods", Social Change and Educational Development, pp. 483-522, Taiwan Bookstore (1991)

[5] Cheng, S-H., "Chinese contemporary history of education", San-Ming bookstore (1980)
[6] Chou, C., Chou, J., & Tyan, N. N., "An exploratory study of Internet addiction, usage and communication pleasure - The Taiwan's case", International Journal of Educational Telecommunications, Vol. 5, No. 1, pp. 47-63 (1999)
[7] Chu, C-C., "Social change and current educational system", Social Change and Educational Development pp. 37-65, Taiwan Bookstore (1991)
[8] Cifuentes, L., & Shih, Y-C D., "Teaching and learning online: A collaboration between U.S. and Taiwanese students", Journal of Research on Computing in Education, Manuscript accepted for publication (2000)
[9] Cifuentes, L., Murphy, K.L., Segur, R., & Kodali, S., "Design considerations for computer conferences", Journal of Research on Computing in Education, Vol. 30, No. 2, pp.172-195 (1997)
[10] Collis, B. & Remmers, E., "The World Wide Web in education: Issues related to cross-cultural communication and interaction", Web-based instruction, pp. 85-92, Educational Technology Publications (1997)
[11] Dooley, L. M., "Problems and issues in distance learning using interactive video between the U.S. and selected African countries", International Journal of Educational Telecommunications, Vol. 1, No. 1, pp. 93-104 (1995)
[12] Emerson, R. M., Fretz, R. I., & Shaw, L. L., "Writing ethnographic fieldnotes", The University of Chicago Press (1995)
[13] Enright, D. S., "Supporting children's English language development in grade-level and language classrooms", Teaching English as a Second or Foreign Language, pp. 386-402, Heinle & Heinle (1991)
[14] Fantini, A. E., "Bilingualism: Exploring language and culture", Language, culture and cognition, pp. 110-119, Multilingual Matters (1981)
[15] Gunawardena, C. N., "Changing faculty roles for audiographics and on-line teaching", The American Journal of Distance Education, Vol. 6, No. 3, pp. 58-71 (1992)
[16] Harasim, L. M., "Online education: An environment for collaboration and intellectual amplification", On line Education Perspectives on a New Environment, pp. 39-64, Praeger (1990)
[17] Hofstede, G., "Cultural differences in teaching and learning", International Journal of Intercultural Relations, Vol. 10, pp. 301-320 (1986)
[18] Jonassen, D. H., Davidson, M., Collins, M., Campbell, J., & Haag, B. B., "Constructivism and computer-mediated communication in distance education", American Journal of Distance Education, Vol. 9, No. 2, pp. 7-25 (1995)
[19] Kamhi-Stein, L., "Promoting EFL teacher development through e-mail instruction", Computer-Assisted English Language Learning Journal, Vol 7, No. 4, pp. 14-19 (1997)
[20] Kelm, O. R., "The use of synchronous computer network in second language instruction: A preliminary report", Foreign Language Annals, Vol. 25, No. 5, pp. 441-454 (1992)
[21] Krashen, S. D., "The fundamental pedagogical principle in second language teaching", Studio Linguistica, Vol. 35, No. 1-2, pp. 51-70 (1981)
[22] LeBaron, J., & Teichmaun, V., "KITES: A middle school environmental science telelink to West Germany", Educational Technology, Vol. 29, No. 6, pp. 51-53 (1989)
[23] Lee, C. D., "Towards a framework for culturally responsive design in multimedia computer environments: Cultural modeling as a case", Paper presented at 1999 American Educational Research Association Convention at Montreal, Canada (1999)
[24] Leh, A. S., "Electronic mail in foreign language learning: Communication and culture", ERIC Document Reproduction Service No. ED409851, Association for Educational Communications and Technology (1997)
[25] Lin, S-C., "Current social change and instructional reformation in Taiwan", Social Change and Educational Development, pp. 459-482, Taiwan Bookstore (1991)
[26] Lincoln, Y. & Guba, E., "Naturalistic inquiry", Sage (1985)
[27] Lowry, M., Koneman, P., Osman-Jouchoux, R., & Wilson, B., "Electronic discussion groups: Using E-mail as an instructional strategy", Tech Trends, Vol. 39, No. 2, pp. 22-24 (1994)
[28] Newbold, W. W., "Transactional theory", http://www.bsu.edu/classes/newbold/htx/theory.htm (accessed on July 20, 1999).
[29] Owston, R. D., "The World Wide Web: A technology to enhance teaching and learning?" Educational Researcher, Vol. 26, No. 2, pp. 27-33 (1997)
[30] Samsonov, P., "Russian translation via e-mail", IALL Journal of Language Learning Technologies, Vol. 30, No. 3, pp. 39-42 (1998)

[31] Sayers, D., & Brown, K., "Bilingual education and telecommunications: A perfect fit", The Computing Teacher, Vol 15, No. 8, pp. 23-24 (1987)
[32] Smith, P. J. & Smith, S. N., "Differences between Chinese and Australian students: Some implications for distance educators", Distance Education, Vol. 20, No. 1, pp. 64-80 (1999)
[33] Soh, B-L, & Soon, Y-P., "English by e-mail: Creating a global classroom via the medium of computer technology", ELT Journal, Vol. 45, No. 4, pp. 187-292 (1991)
[34] Stewart, A., "Appropriate educational technology: Does 'appropriateness' have implications for the theoretical framework of educational technology?" Educational Communication and Technology, Vol. 33, No. 1, pp. 58-65 (1985)
[35] Traw, R., "School/university collaboration via e-mail: A unique approach to teaching reading and language arts", Tech Trends, Vol. 39, No. 2, pp. 28-31 (1994)
[36] Wang, C-Y., "Social science education in social change", Social Change and Educational Development, pp. 147-164, Taiwan Bookstore (1991)
[37] Young, S., "A field study of the implementation of a synchronous distance course with asynchronous Internet-supported telecommunications technologies in Taiwan, R. O. C.", International Journal of Educational Telecommunication, Vol. 5, No. 2, pp. 111-125 (1999)

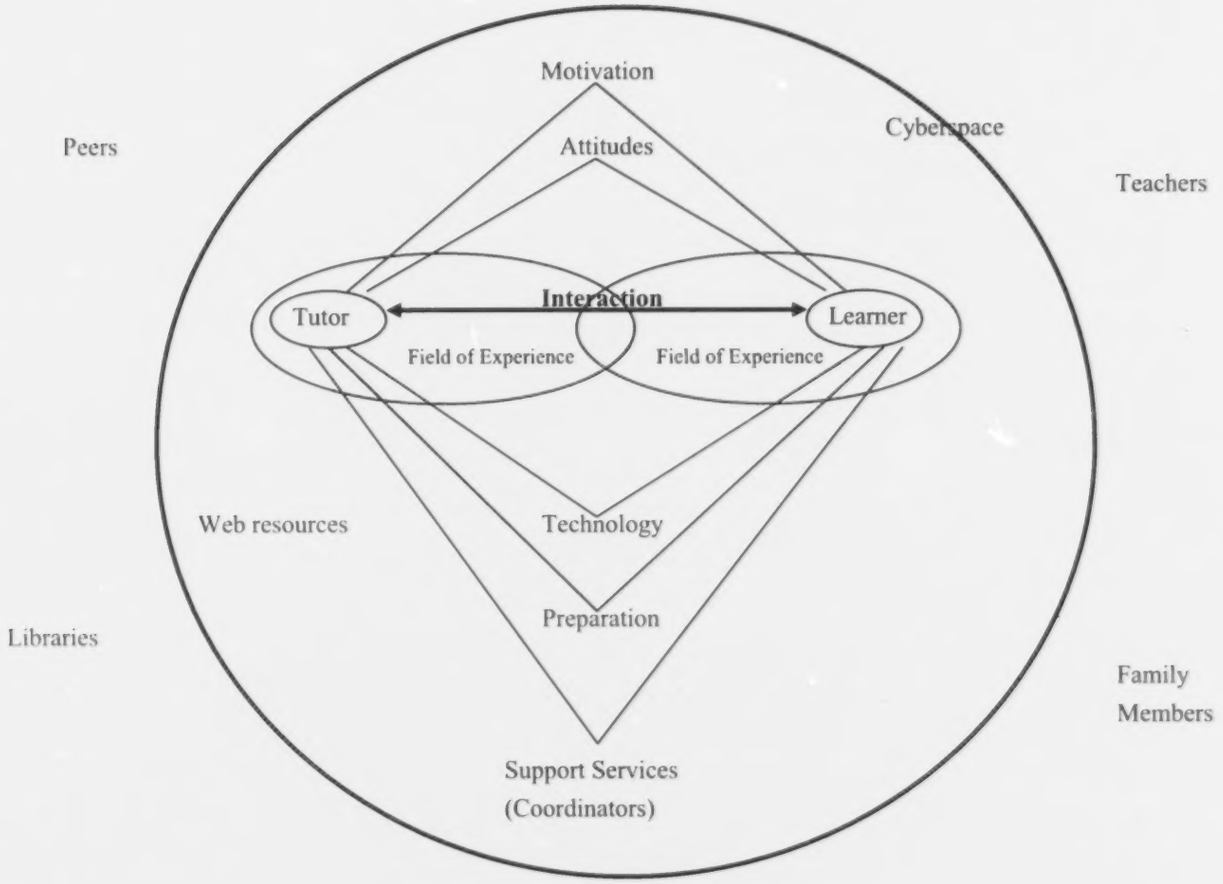


Figure 1. Factors Affecting Online Connections

2647

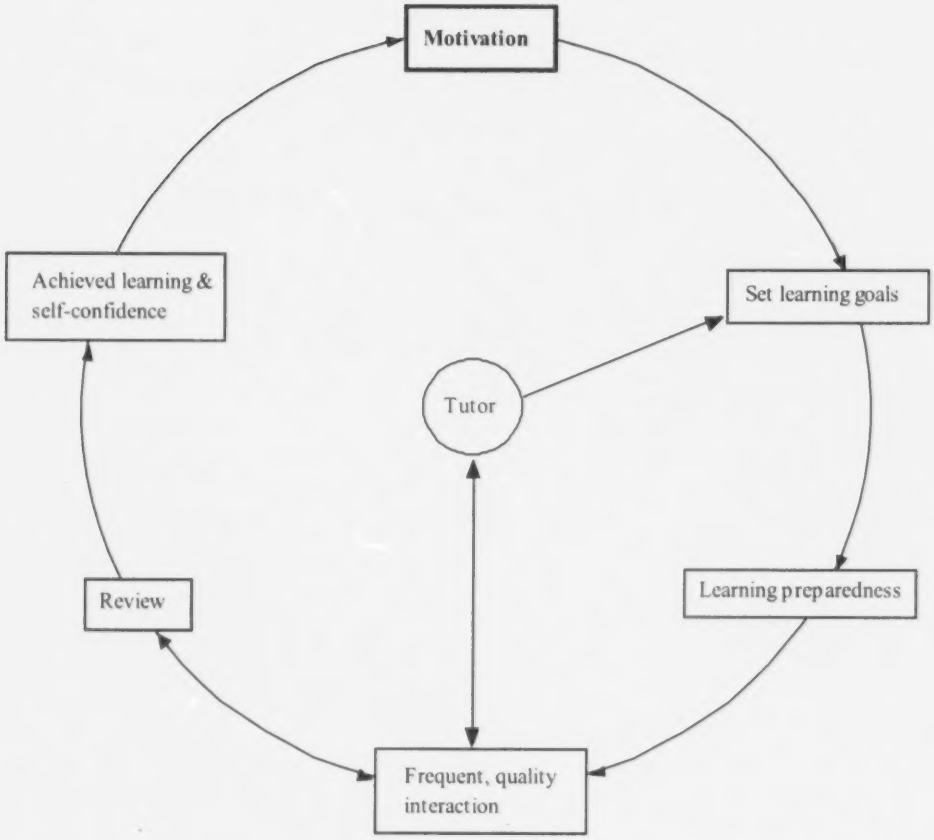


Figure 2. Online Learning Processes in the United States-Taiwan Connection.

Relating telecommunication training objectives to SMEs' actual needs

Paola Forcheri, Maria Teresa Molfino, Alfonso Quarati
Istituto per la Matematica Applicata del Consiglio Nazionale delle Ricerche, Genova -Italy
Via De Marini, 6 –16149 Genova, Italy
Tel: +39-010-6475673
Fax: +39-010-6475660
E-mail: {forcheri,molfino,quarati}@ima.ge.cnr.it

The need of studying training measures to help European Small and Medium Enterprises (SMEs) to avail themselves of new information communication technology is generally acknowledged. To be effective, however, these measures must be based on sound knowledge of the context in which they are to be implemented. This type of approach is particularly important for SMEs located in areas experiencing serious industrial decline, where the development of exchanges and co-operation is vital for opening up new opportunities. Accordingly, we carried out a survey to gauge companies' attitudes towards teleconferencing tools so that methodologies could be devised to exploit the potential for growth within SMEs. The survey was based on a series of interviews conducted from late 1998 to early 1999 with organisations reflecting the socio-economic make up of the economy of Liguria, a region in north-west Italy. The results of the survey, that are discussed in this paper, formed the basis for the design of training schemes about teleconferencing tools and applications devoted to SMEs. The activity is framed into the project called Teleconferencing, part of the European Community's ADAPT II initiative.

Keywords: **Telecommunication education, Training in enterprises, Teaching/learning strategies**

1 Introduction

Current socio-economic trends and the shift towards a global market are highlighting the need for companies to keep abreast of the new opportunities offered by Information and Communication Technologies (ICT), whose development has itself been a major factor in market globalisation. Doing so also means gaining awareness of the economic, organisational and company policy issues involved.

In this context, the mastery of teleconferencing tools assumes particular importance. By giving impulse to distance interaction, these tools increase companies' opportunities to control a share of distant markets and to draw on resources spread over a wide area. This is borne out by numerous theoretical and applied studies that analyse the effects of tele-collaboration on the development of new communication patterns and their influence on company organisation [2].

Let's take a look at some of these. [1] examines the pros and cons of desktop videoconferencing from the technological, economic, operational, psychological, and managerial viewpoints, as seen by both the company and the end user. Wiesenfeld, Raghuram & Garud [15] analyse the characteristics of communication means and the impact these have on the way remotely located employees identify with the company's central offices. Kraut, Steinfield, Chan, Butler & Hoag [11] examine how the use of computer networks influences inter-company collaboration (such as that created in a European project) and how the use of those networks for co-ordination alters production output.

Jarvenpaa and Leidner [8] examine problems linked to creating and maintaining a climate of confidence whenever communication is largely conducted via ICT, while Anderson and Kanula [3] study a virtual

forum attended by people engaged in lifelong learning, focusing on participation levels and attendees' perception of the forum's effectiveness and value. Email as a tool for supporting company policy is the theme explored by Romm and Pliskin [12], who draw on a set of case studies.

Rosen [13] provides numerous case studies on the use of videoconferencing in large corporations in an effort to stimulate discussion on the integration of collaboration and communication. This is done by analysing the competitive edge that those companies gained and the changes brought about in their way of doing business.

For their part, Schreiber and Berge [14] analyse the advantages and opportunities that teleconferencing systems offer to distance in-service training, reporting a number of cases where the goals pursued arise from a clear company need. Teleconferencing as a tool for lifelong learning is the topic focused on by Kaye [10], who examines in particular the possibilities that this instrument offers for learning in an informal context. Economic issues involved in the use of videoconferencing systems within the education sector is the area investigated by Jacobs and Rogers [7], who provide a detailed analysis of the cost/benefit ratio in a case of trans-European ISDN-based distance learning.

The above-mentioned studies generally refer to large, technologically-advanced corporations with considerable financial resources. However, in today's global market, it is also vital for Small and Medium Enterprises (SMEs) to harness ICT in order to maintain market share. The problem they often face is that they cannot afford the investment needed to cope with increased competition and to get a foothold in new markets. Distance interaction technology offers SMEs useful support in tackling this problem. On the one hand, it fosters collaboration between companies which operate in complementary sectors but are located at a distance from each other. On the other, it permits SMEs to offer their services to large companies both as suppliers and as mediators in local markets they know well. It is widely recognised that if SMEs are to harness the potential this technology offers, they not only require suitable and affordable infrastructure but also need training and technology transfer schemes to help them acquire the necessary competence and know-how ([6], http://europa.eu.int/comm/dg12/publ/globalisation.html).

These kinds of considerations form the basis of the numerous initiatives launched by the European Union and aimed to devise efficient training and orientation measures suitable to help SMEs to cope with innovation in communication.

To be effective, however, these measures must be based on sound knowledge of the context in which they are to be implemented. In this way, they can take account of the company's effective needs, economic situation, skills base, technological potential and cultural heritage. This type of approach is particularly important for SMEs located in areas experiencing serious industrial decline, where the development of exchanges and co-operation is vital for opening up new opportunities. For mainly economic reasons, these companies have little chance to develop competencies and to benefit from distance collaboration.

This is the background our work is set against. In particular, we carried out a survey to gauge companies' attitudes towards teleconferencing tools so that methodologies could be devised to exploit the potential for growth within SMEs. The survey was based on a series of interviews conducted from late 1998 to early 1999 with organisations reflecting the socio-economic make up of the economy of Liguria, a region in north-west Italy.

The activity is framed into the project called Teleconferencing, part of the European Community's ADAPT II initiative. The purpose of the project is to study the potential of network technology, especially teleconferencing tools, in response to the need for intra-company and cross-company collaboration. The project is run by IMA-CNR, who drew up the project guidelines in partnership with eight companies representing a cross-section of the local economy in Liguria.

We shall report here the findings of the survey, focusing in particular on cultural problems hindering the spread of teleconferencing in companies. In addition, we shall propose orientation and training methodologies that help overcome these barriers.

Henceforth, we shall use the term teleconferencing to refer to interpersonal communication systems based on the written word (e-mail, chatting, etc) or on sound and images (videoconferencing).

2 The Survey

2.1 Background

Liguria has been seriously hit by the general decline in industry; the reduction in heavy industry in particular has wrought serious consequences, including high unemployment, demographic decline and ageing of the population. The socio-economic transformation underway calls for considerable flexibility, the capacity to exploit innovation and the fostering of exchanges and co-operation in order to open up new opportunities. Thus the region of Liguria represents a good test-bed for studying opportunities and problems regarding the use of teleconferencing technology within companies.

Our survey involved a series of interviews conducted from late 1998 to early 1999 with 41 companies in Liguria that varied in size, both in terms of turnover and staff numbers (see Table 1). Of the total, 20% are from the public sector and 80% from the private sector, and they are spread throughout the four provinces of the region (32% Genoa, 32% La Spezia, 20% Imperia and 17% Savona).

Revenue 1997 (Millions of EURO)	Percentage	Staff members	Percentage
To 2.5	**37%**	To 10	**17%**
2.5 to 50	**49%**	10 to 100	**63%**
Over 50	**15%**	Over 100	**20%**

Table 1. Breakdown of the organisations interviewed according to turnover and staff numbers

2.2 Methodology

The survey was carried out through interviews based on a questionnaire. Staff members from companies involved in the project were consulted during the drafting of this questionnaire to ensure that the language used and the approach to problems adopted matched their way of thinking as closely as possible. The companies themselves carried out preliminary evaluation of the questionnaire.

2.3 The Questionnaire

The questionnaire is divided into four sections.
The first section is designed to identify the type of company in terms of economic structure (public or private, size, field of activity) and its organisation, with special attention to teamwork. In this way it is possible to investigate the relationship between these parameters and the attitude manifested towards teleconferencing tools.

The second section looks at the organisation's level of technological advancement and its attitude towards communication tools. The purpose here is to understand whether and how networking can modify the kind of relationships established within the organisation.

The aim of the third section is to analyse the type and quality of computer tools devoted to information exchange. Investigation centres on the use made of the Internet and on the organisation's attitude towards the Web, with an eye to determining whether the staff is familiar with this tool, the needs the Web may fulfil and possible training requirements (depending on the type of information usually exchanged).

The fourth section focuses on teleconferencing, assessing the degree of knowledge about tools of this kind and determining whether and when the organisation considers teleconferencing useful for its purposes. The point of this section is to study the types of support (methodological, technical, training, orientation, infrastructure, etc) that the organisation may need in order to use teleconferencing effectively.

3 Results

3.1 Type of organisation and group work

Type of organisation. The public-sector organisations interviewed were from the fields of public administration, public services, the health service and state-run industry.
The breakdown of private companies was as follows:

- industry (14%) – steel, photographic chemicals, electronic engineering, parts machining, plant building, construction, olive oil production, floriculture;
- companies involved in port-based activities (17%) – port authority, shipbuilding, container terminals, transport, brokerage;
- service and commercial companies (49%) – gas and water distribution, medical services, company support services, research and training, tourism, logistics, storage, consultancy, wholesaling and retailing. Sectors like port activities, olive oil production, floriculture and tourism are of vital importance to the Ligurian economy.

Teamwork. All of the companies interviewed engage in teamwork, and most (82%) do so on a regular basis; there are no notable differences here between the different types of companies. Teamwork mainly concerns organisation (90%), document and information sharing (63%) and brainstorming (63%). Other significant areas are internal documentation (61%), followed by external relations (59%) and internal messaging, while internal surveys play only a minor role (29%).

Interestingly, given that in nearly half the cases (46%) teamwork involves most of the staff, tools that make collaborative activities more efficient would be extremely valuable for the organisation. Hence it is worth studying the possibility of teleconferencing, at least for some specific situations such as electronic bulletin boards advising recipients about 'technical' events. These may include notification of a circular being received or a service being temporarily suspended. Another instance may be an in-house electronic bulletin briefing all the staff on the main events concerning the organisation. The application of teleconferencing to these situations does not curb interpersonal relationships and has the advantage (even in small companies with a staff of 10 to15) of reducing time wasting, the risk of misinformation and subsequent misunderstandings [1].

3.2 Office Automation

Level of office automation. Computers, in-house networks for management purposes and Internet connections are found in most of the organisations (see Table 1).

	Used	To be introduce	Not to be introduced
Mainframe	63%	5%	12%
Terminals	66%	0%	15%
Personal computers	100%	0%	0%
LAN	63%	5%	15%
Intranet	15%	22%	22%
Internet connection	85%	12%	2%

Table 1: Computer tools used in organisations

However, while PCs are used by the majority of staff members (either for individual work or management applications), the Internet is still only used by a minority (see Table 2).

We can therefore state that while computers have by now permeated corporate life, the same is not true of communication and information sharing tools, although awareness of their potential does exist.

	PC for individu work	Terminals o PC for database management	LAN or Intranet for shared applications	External connection/Internet
More than half	34%	37%	23%	9%
About half	13%	14%	15%	9%
Less than half	53%	49%	62%	82%

Table 2: Number of users by type of tool and kind of use

Use of networking. Networks are widely employed for exchanges between headquarters and branches (14

positive answers, two planning introduction in the short term). They are used mainly for handling administrative/accounting matters and sales orders, for organising production, as well as for structuring and maintaining the network itself.

Far less significant is the level of network use by travelling salesmen (two cases, for transmitting sales and exchanging messages), although the trend is growing (six planning to introduce it for this purpose).

Tele-working from home is equally uncommon, with only two of the organisations surveyed adopting it, and five cases where there has been talk of introducing it. In both of the affirmative cases, tele-working is used for remote network maintenance, and only one of the two companies conducts other activities in this way.

In our view, the answers indicate that network connection is seen as an advantage when it is capable of improving work efficiency without changing work organisation or modifying internal relationships. By contrast, when the introduction of new technology requires methodological innovation or the development of new types of interpersonal relationships, its appeal is not so strong. One fact supports this consideration: although many of the organisations hire external consultants (68% have at least one consultant, 46% more than one), only one currently uses tele-working for this purpose and three are considering it. Clearly, technological innovation demands a change in attitude and therefore requires gradual phasing in, together with training that makes people aware of the impact of new communication tools rather than just illustrating their technical features.

3.3 Networking and communication with the outside world

Typology of dedicated connections and connections to the Internet. Those interviewed appeared to be greatly perplexed by this set of questions, apart from a handful of cases where the interviewee was the head of EDP. To our way of thinking, this shows that the spread of the network has not been matched by a general grasp of network-related concepts. Consequently, training and orientation dedicated to network concepts and opportunities are called for, so that companies understand the kind of network services that might meet their needs.

Companies and the Web. The Web is used somewhat more for gathering information (86%) than for spreading it and for presenting the company on the market (80%). Nonetheless, the response to the question regarding the potential benefits of using the Web shows that companies recognise that the Web is a medium for addressing a wider market (49%) and improving their public image (37%).

In our view, the reason for this lies in cultural and economic factors. Coverage of the Web in the press and electronic media till recently mainly focused on the possibility to acquire information rather than provide it. What's more, while acquiring information is relatively straightforward, providing it entails more complex know-how. Company presentation in the Web's hypermedia format is culturally different from more conventional forms, thus requiring great investment in terms of conception, design and implementation. Finally, the investment and maintenance entailed in information acquisition is fairly low in cost, being limited to getting Web access and covering communication costs. By contrast, information providing is quite costly both in terms of site construction and maintenance.

In order to help companies use the Web as a tool for market presentation, it may well be worthwhile providing implementation methodologies that are in line with company goals. To make information hunting more efficient, it would be useful to give tips about the most interesting commercial sites and advice on search methods.

Advantages, disadvantages, information to include on the site. The main advantages that companies see in the Web are the possibilities for market expansion (49%), for improving public image (37%) and, obviously, for low-cost access to information (49%) (see Figure 1). This response shows that companies now view the Web as a standard means for widespread distribution of information, and the sort of information they envisage providing at their sites matches this vision.

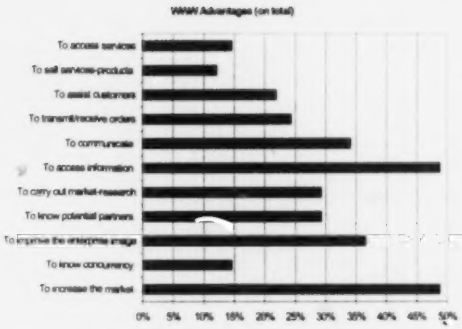


Figure 1 - Advantages of the We

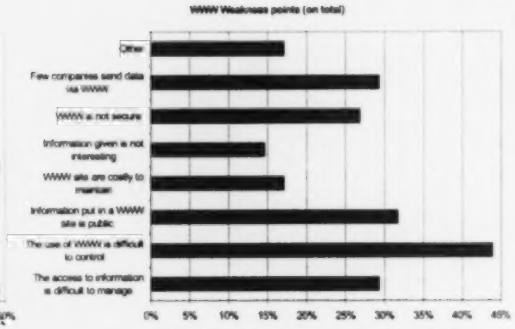


Figure 2 - Disadvantages of the Web

There is far less interest in using the Web for commercial purposes such as placing orders (24%), acquiring information about competitors (15%), product sales and services (12%), or customer support services (22%). This lack of confidence is confirmed by the answers regarding the Web's perceived weak points: lack of security (27%), competitors' access to information (32%), and unwillingness to transmit data over the Web (29%) (see Figure 2).

In our view, a further hurdle to commercial use of the Web is the lack of control over how the user accesses a site (29%). Technological mediation makes it particularly difficult to discern client needs and provide the right response. This, together with the fact that many of the companies interviewed see the Web as a means of serving clients and providing information on products, highlights the economic importance of building web sites that can also offer customer-care services.

An interesting perspective on this problem comes from research into adaptivity concepts, which seeks to construct Web sites that dynamically select the information to be displayed according to the user's behaviour during site navigation [4, 5]. We believe it would be useful to draw companies' attention to these studies, as application of such techniques might give their web sites a crucial edge in marketing and business.

To our way of thinking, there are many factors that contribute to the Web's image as an unreliable commercial tool, most notably: the lack of thoroughly tested sales methodologies; the need to invest both in technology and in the study of new models of sales organisation; the uncertainty of results; the market's suspicious attitude.

A further obstacle to widespread Web use within companies is the impossibility of controlling the use the staff makes of it (44%). This is a major hindrance to the spread of network-based distance communication. The problem is a realistic one, even if psychological restraints exist that allow general use of the Web under acceptable conditions.

3.4 Teleconferencing and interpersonal communication

Analysis of the answers reveals that while e-mail is widely employed, other teleconferencing systems are not so common; what's more, there is little interest in evaluating their adoption in the future and even a certain degree of reluctance to examine the possibility at all (see Table 3).

What lies behind this situation is poor knowledge of teleconferencing tools, as demonstrated by the small number of responses about related benefits and drawbacks. This is understandable, given that networks have only recently reached Liguria's small and medium-size enterprises [9].

	Used	To be introduced	Not to be introduc	No answer
Video-conference	7%	20%	44%	29%
E-mail	85%	12%	2%	0%
Computer conferencing	7%	15%	49%	29%
Desk-top video-conferencing	5%	10%	51%	34%
Chat	2%	2%	56%	39%

Table 3 – Attitude towards teleconference systems

Let's take a closer look at the answers about e-mail's benefits and drawbacks and compare them with those regarding other teleconferencing tools. It must be noted, however, that the comparison can only be qualitative because the number of responses varies depending on the tool in question.

E-mail is considered advantageous in terms of communication potential, lower communication costs, image and innovation. It is relatively straightforward for the staff to use, relies on fairly simple technology and is regarded as highly beneficial. It meets companies' basic need to communicate swiftly in writing, and calls for innovation only in the tool to be used for the task, not the underlying methodology. The technology required is simple and relatively cheap, and what's more in many cases it has already been tested by the company's decision-makers on a personal basis.

In addition, it must be noted that the introduction of e-mail within a company is in itself capable of enlarging the company's market both for reasons of prestige (as the answers reveal) and because e-mail is becoming a standard form of communication parallel to telephone and fax.

Conversely, other types of teleconferencing systems, and particularly those that involve computers, are look upon with suspicion; people are clearly concerned that the perceived drawbacks (complex technology, lack of know-how among the staff, and modest gains) may outweigh the advantages. In our opinion, the reason for this kind of response lies in technological and socio-economic factors.

In technological terms, it cannot be denied that these systems are fairly intricate, apart from chat-oriented ones. This is particularly true for those who are relative newcomers to computer-mediated communication. Employing these systems efficiently presupposes technical know-how within the company and well-trained staff.

From a socio-economic viewpoint, these tools contribute to modify work organisation and methodology, thus entailing a transformation in social relationships. For these systems to be fully exploited, considerable innovation effort is required: the organisation must have the need and the ability to carry through change, as well as the capacity to develop methodological skills. In addition, costs are incurred that cannot be offset either by greater prestige or by access to widely used forms of communication.

It must be added that advanced teleconferencing systems have not yet gained a high profile in popular culture; they have received far less media attention than e-mail and the Web, as their usership remains fairly small.

Despite all this, companies acknowledge that computer-based teleconferencing tools might offer valuable assistance in certain corporate areas (see Figure 3). Furthermore, the boom of outsourcing and the introduction of tele-working will probably have an impact on the development of computer-driven teleconferencing tools. These forms of collaboration have brought various problems to the fore: that of identifying oneself within the organisation, of conveying one's ideas to the interlocutor without misunderstandings, of conducting effective discussion about a written document, a graph, etc.

Considering these factors, we believe that orientation and training programmes are vital in order to help companies understand the potential of these tools, both in operational as well as theoretical terms.

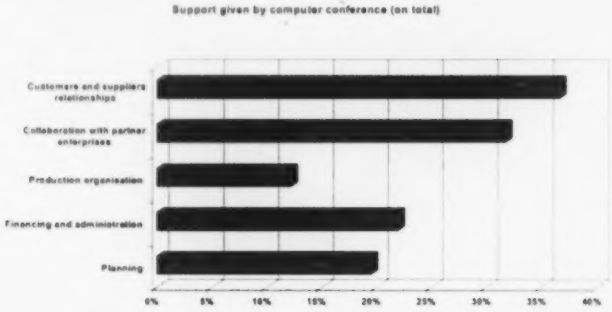


Figure 3 – Support given by computer conference

4 Conclusions

The survey shows that the spread of the network among Liguria's small and medium-sized enterprises has not been matched by a general grasp of network-related concepts. Consequently, training and orientation dedicated to network concepts and opportunities are called for, so that companies understand the kind of network services that might meet their needs.

Moreover, the survey reveals that these enterprises are aware of the potential of networking tools in expanding information sharing and communication possibilities. This awareness, however, is restricted to forms of use that do not modify work organisation and interpersonal relationships; one reason for this is that companies do not yet have the firm grasp of network concepts required to envisage applications in less immediate contexts. In fact, there is no perception at all of such applications because this would require awareness of the tools, an understanding of the actual possibility of achieving greater productivity, changes in organisational structure and internal relationships, and an investment in technology and know-how.

As these results reveal, there is a clear need to develop orientation and training projects addressed to SMEs. These should provide:

1. Network concepts and opportunities, so that companies understand the kind of network services that might meet their needs. In particular, enterprises should be helped to learn the following:
   - 1.1. Basic notions about network technology;
   - 1.2. Infrastructure and public services;
   - 1.3. Distance communication methods and techniques;
   - 1.4. Methods of sharing documents and applications.

2. General skills in teleconferencing tools as well as methodological and content-based knowledge of potential advantages in relation to specific needs. In particular, enterprises should receive training so that they are able to do the following:
   - 2.1. Explore typical working tasks and decide what type of teleconferencing tools, if any, can increase the quality of the job;
   - 2.2. Investigate if and how the use of teleconferencing tools can favour the introduction of organisation methods not adopted in the enterprises, but able to improve competitiveness;
   - 2.3. Critically analyse a communication technology to define how useful it can be in a specific work situation;
   - 2.4. Recognise specific tools as particular examples of communication models;
   - 2.5. Abstract the communication features of a software tool so as to be capable of comparing one tool with another of the same class without difficulties.

3. Awareness of the psychological and cognitive issues entailed in communication and collaboration through the computer. Specifically, enterprises should gain practical awareness that:
   - 3.1. Computer-mediated communication differs from direct communication, and calls for adjustment in the ways one interacts with others;
   - 3.2. All those involved in an activity requiring computer-mediated communication, especially those without a technological background, must be able to call on technical support. In this way they will be encouraged, psychologically as well as practically, to use the new tool;
   - 3.3. If an experiment in the use of distance interaction methods is to be successful, there first needs to be a well-established atmosphere of reciprocal trust between the participants;
   - 3.4. People must be aware of both the opportunities and technical limitations of the tools used;
   - 3.5. To encourage the use of these systems, the work needs to be organised in such a way that each person gets a turn at assuming responsibility for some task or other;
   - 3.6. The system must be made indispensable for getting access to information and joining in discussion.

It is no easy task to create training schemes, including experimental ones, that meet these conditions. There are a number of reasons for this. From the educational viewpoint, an approach to training is called for that combines conventional training with a situated approach to the learning of teleconferencing opportunities and problems. When it comes to choosing the topic on which the training initiative is to be based, it is necessary to ensure that it is one of common interest to all the companies involved. Then there is the matter of the required expertise, calling for the involvement of various actors: training experts, to select the best methodology for tailoring the programme to the context; company representatives, to spell out production and organisational requirements; experts in the subject area; and experts in the specific technology. In economic terms, a balance must be struck between the need to provide up-to-date technology and the

necessity for companies to contain costs.

European projects like *Teleconferencing* that are designed to help enterprises cope with innovation provide strong impulse in this direction. They create the conditions under which pilot projects of the kind described above can be introduced, provide tools for evaluating their effectiveness, and form the cultural background needed to built advanced technology training systems that meet the needs of enterprises.

Acknowledgements

The Teleconferencing Project is carried out by an international consortium comprising IMA-CNR (Italy), Thati Gmbh (Germany), AMT (U.K.) and OPCAREG (France). It is jointly funded by the European Commission's Social Fund and by Italy's Ministry for Employment and Social Security. The Italian partnership involved in the project comprises: IMA-CNR, Genoa (Italian promoter), CONSULTEAM (Savona), the Employment Agency of Liguria, Enaip Liguria, ERG Petroli S.p.A. (Genoa), Gruppo Imation (Ferrania, Province of Savona), ISOMAR (Savona), Nuova Magrini Galileo (Bragno, Province of Savona), Ricerca e Progetto S.a.s. (Genoa) and STEM - ISI Impianti S.p.A (Genoa).

References

[1] Angelides M.C., "A Framework for Examing Desktop Video Conferencing in the Organisatonal Context", CIT Journal Vol. 6, No. 3, pp.285-296, (1998).
[2] Ahuja M.K. & Carley K.M., "Network Structure in Virtual Organisations", JCMC Vol. 3, No.4, http://jcmc.huji.ac.il/vol3/issue4/ahuja.html, (1998).
[3] Anderson T., & Kanula K., "On-line Forums: New Plarforms for Professional Development and Group Collaboration", JCMC Vol. 3, No.3, http://jcmc.huji.ac.il/vol3/issue4/anderson.html, (1997).
[4] Eklund J., & Brusilosky P., "Individualising Interaction in Web-based Instructional Systems in Higher Education", http://www.uow.edu/auc/Conf98/papers/eklund.html, (1998).
[5] De Bra, P., & Calvi L., "AHA: a Generic Adaptive Hypermedia System", Proceedings of the 2nd Workshop on Adaptive Hypertext and Hypermedia, http://wwwis.win.tue.nl/ah98/DeBra.html, (1998).
[6] European Commission, "The green paper on innovation", December (1995).
[7] Jacobs G., & Rodgers C., "ISDN-based distance learning: tangible costs, intangible benefits", Computers & Education Vol.31, pp.41-53, (1998).
[8] Jarvenpaa S.L. & Leidner D.E, "Communication and trust in global teams", JCMC Vol. 3, No.4, http://jcmc.huji.ac.il/vol3/issue4/jarvenpaa.html, (1998).
[9] Forcheri, M.T. Molfino, & A. Quarati, "Design of learner-centered tools for continuous training in SMEs", Education & Information Technology, Vol. 3, pp.261-276, (1998).
[10] Kaye A.R. (Ed.), "Collaborative Learning through Computer Conferencing", Springer-Verlag, (1993).
[11] Kraut R., Steinfield C., Chan A., Butler B. & Hoag A., "Coordination and virtualization: the role of electronic networks and personal relationships", JCMC Vol.3 No.4, http://jcmc.huji.ac.il/vol3/issue4/kraut.html, (1998).
[12] Romm C.T., & Pliskin N., "Toward a Virtual Politicking Model", Communication of ACM, Vol.40, No. 11, pp. 95-100, (1997).
[13] Rosen E., "Personal videoconferencing", Manning, Greenwich, (1996).
[14] Schreiber D. A., & Berge Z. L. (Eds), "Distance Training", Jossey-Bass Publishers, San Francisco, (1999).
[15] Wiesenfeld B.M., Raghuram S., & Garud R, "Communication Patterns as Determinants of Organisational Identification in a Virtual Organisation", JCMC Vol.3, No.4, http://huji.ac.il/vol3/issue4/wiesenfeld.html, (1998).

Web Based Real plus Virtual Observatory Project

Masato SOGA, Takuma OKUNO, Hideaki KAWANISHI
Faculty of Systems Engineering, Wakayama University
930, Sakaedani, Wakayama, 640-8510, Japan
Tel: +81-73-457-8457
Fax: +81-73-457-8112
E-mail: soga@sys.wakayama-u.ac.jp

We have been developing remote telescope system, which can be used by remote site via Internet with web user interface. Student in remote site can control the telescope easily and can see live picture of celestial bodies. If there is time difference between student's site and telescope's site, the student can see live picture of celestial bodies in daytime in classroom. It will be strong tool to learn astronomy. Moreover we are also developing virtual observatory which shows the status of the real telescope in a virtual space. The virtual observatory supports virtual planetarium, so that student in remote site can know what can be seen in the sky of telescope's site. Moreover a learning environment to learn the structure, behavior and function of telescopes were developed in virtual world. The remote telescope system is easy to use, so that it neglects chance to learn how to use the telescope. In science education, it is also important to teach how to use equipments. The learning system compensate for it.

Keywords: **Remote Telescope, Virtual Observatory, Astronomical Educaion**

1 Introduction

We have developed a remote telescope system in a public observatory in Japan [1]. This first version has a web based user interface, and remote student can use the system from remote site via Internet. If the client site has certain time difference between Japan, the student can see live picture of the celestial bodies in daytime. Moreover the student can operate the telescope as he/she wishes by using slight motion buttons on the web based user interface. This first version was the world first interactive remote telescope which offers live picture on a web user interface in 1997, though a remote telescope offering still image was made before[2].

Although the first version of the remote telescope system were quite successful, it has some problems. The system does not have the function for exclusive control. The exclusive control is necessary in the multi-user environment, because more than two clients cannot use the system simultaneously. On the first version, the student must promise the date and time of the usage in advance.

Another problem of the first version is that the telescope is too huge (105cm reflector) to use as a remote telescope. Besides the dome of the observatory is not controlled from remote site. Therefore the staff of the observatory must always help the usage.

We are now developing second version of remote telescope system to solve the problems of the first version. The second version uses small telescope (Meade LX200 20cm reflector), so that it is easier to use as a remote telescope.

The second version has a scheduling system, which can work as the exclusive control. Clients can reserve the date and time of usage of the remote telescope on a web page for scheduling. The system has 3D planetarium as well as web user interface. The planetarium shows what can be seen in the real sky where the telescope is located. Moreover the second version supports vertual environment to learn structure, behavior and function of various types of telescope. These virtual planetarium and virtual environment for

learning are regarded as virtual observatory. Although today some other remote telescopes has been developed in the world [3-6], our remote telescope is unique which supports virtual observatory.

2 Scheduling system

The scheduling system was developed for multi-user usage (Fig.1). It has two important function. They are exclusive control system and reservation system. Exclusive control system enables to permit usage by only one client at every time. If a student tried accesses to the system during the usage by another student, the exclusive control system reject it, and make him/her wait until the superior student terminates the usage. Reservation system enables to reserve date and time of usage in advance. The reserved usage is superior to non reserved usage, so that non reserved usage is terminated by force when it is the time of reserved usage.

The scheduling system is made by using CGI(Common Gateway Interface), and the CGI program works by a scheduling web page on a public directory. Clients' information such as account information and reservation information, is preserved in a file in the scheduling system. Since the file includes very important contents, it must be protected from illegal access. The file is not on the public directory, but on a private directory to which cannot be had access. The security is kept by this method.

Fig.1 Scheduling system

3 Live picture

The live picture of celestial bodies enhances students' learning of astronomy (Fig.2). There are two methods to send live picture. One is by stream, the other is by still image series. We are currently using the latter way. SGI O2 Unix workstation is used as a camera server. O2 has a program which takes still image with CCD camera. Our system utilize the program, and automatically save JPEG picture in every three second into a same file in the camera server. We also developed Java applet which has access to the file, and read it, then display the still images continuously. Remote clients can see live picture as if it is animation.

4 Remote control of the telescope

A student can control the telescope from remote site. In the first version of the remote telescope system, we

BEST COPY AVAILABLE

used CGI to control the telescope. In the second version, we considered that we would use CGI on a HTTP server, however CGI has the following problems.

(1) When a client terminate usage of the telescope, it is impossible for the server to refuse connection.

(2) More than two clients can have access to the remote telescope system simultaneously at anytime. Therefore it is impossible to realize exclusive control.

Fig.2 Live picture (Example: Moon)

(3) In a collaborating learning, more than two clients have access to the system simultaneously. In this case, the same number of CGI process as the clients' number run in the server, so that the load of the server become heavy.

We used Java applet in order to solve the problems. The merit of communication by Java applet is as follows.

(1)When a client terminates usage of the telescope, it is possible for the server to disconnect the connection.

(2) It is possible to realize the exclusive control.

(3) It is possible for the server to send various information to Java applet at client machine.

By these reason, we developed a telescope control program by Java applet. The procedure of usage is as follows.

(1) A client set a target celestial body, and push the submit button. Then the command to control the telescope is sent to the server program.

(2) The server program receives the command and send it to serial port. Then the telescope receive the command, and it moves to get the target.

(3) The telescope send status to the server, after it finish moving.

(4) The server program send the status to applet at the client machine.

Figure 3 shows the procedure.

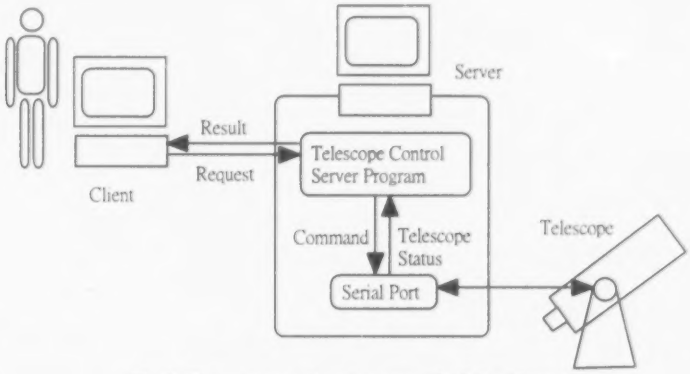


Fig.3 The process of remote control of the telescope

5 Graphical user interface

The GUI of remote telescope system is made by applet. The GUI by applet in second version has the following functions (Fig.4).
(1) To move telescope by setting target's coordinates
(2) To move telescope by selecting a target in a menu
(3) To move telescope by slight movement buttons
(4) To show local time where the telescope is located
(5) To show universal time
(6) To show the rest of the reserved time
(7) To show some information about the target

In the above, functions (1)-(3) are the same as the first version. A student can control the telescope easily by the GUI. The slight movement buttons enable the student to move the telescope slightly, so that the student can scan the celestial body. This function is especially useful when the student observes apparently large target such as the moon. The student can feel as if he/she is traveling over the moon by space ship.

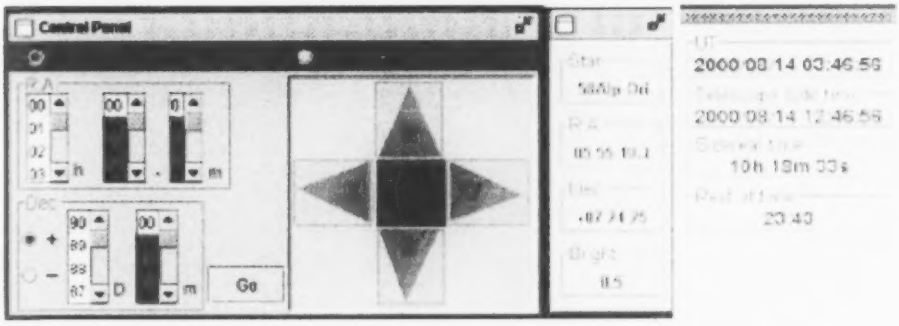


Fig.4 Graphical User Interface

6 Virtual Planetarium

The planetarium is made by Java3D (Fig.5). The planetarium reflects the real sky where the telescope is located by calculating sidereal time. Remote clients in all over the world can know what can be seen in the sky at that time at telescope site, such as stars, planets, nebulas, and galaxies. The planetarium also has a telescope model in the center of the planetarium. It is a kind of virtual telescope. The virtual telescope reflects the real telescope. The direction of the virtual telescope indicates that of real telescope. By this function, clients can know easily in which direction the telescope is. Since a beam line from virtual telescope to celestial sphere is shown in the planetarium, the user can easily recognize which star the telescope catches currently. Besides when the user click one of stars on the virtual planetarium, both virtual and real telescopes start to move, and catche the target star.

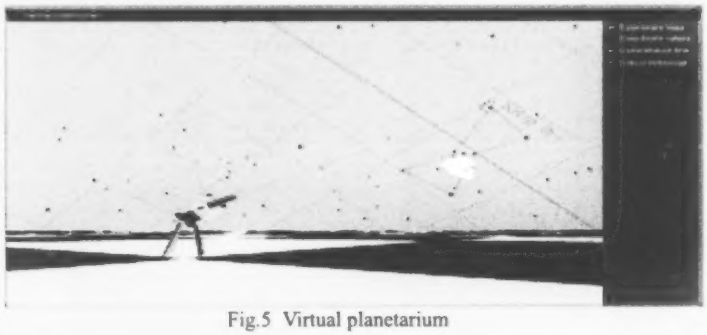


Fig.5 Virtual planetarium

BEST COPY AVAILABLE

7 Learning environment for learning telescopes in virtual world

In science education, it is important for students to observe target in real world as well as to learn how to use the equipments for the observation. The remote telescope system enables to observe real celestial bodies in the classroom. Nevertheless it neglects to learn how to use telescope. Because students can easily operate the remote telescope system without knowing the structure of the telescope and every function of each part.

We have been developing a system in virtual world, by which students can learn kinds of telescopes, every structure, every characteristics, and every function. The system is made by VRML, and the telescopes in the virtual world can be moved around two axes. The astronomical telescopes are classified optical structure and by mounting structure independently. Therefore the system has a table which shows the combination of optical structure and mounting structure (Fig.6). Some combinations exist and other combinations do not exist. If a combination exists, a circle is filled in the table. If it does not exist, a cross is filled. Triangle means seldom existence, dot means rare existence. This table guides students to every combination. If a student click a symbol (circle, triangle, dot), then the telescope is shown with the combination of optical and mounting structure.

Since the virtual telescopes can be rotated around two axes by mouse dragging, students can learn how to operate telescopes. Besides students can learn the function of every axis by rotating it. For instance, one axis of equatorial mounting is set in the direction to polar star (Fig.7). The telescope can track a celestial target by rotating around the axis, because the celestial target moves in the sky in accordance with earth's self rotation.

Moreover the virtual telescopes show optical structure of them, and show ray trace. When the a student rotates a virtual telescope, he/she can know how the focus point of the telescope moves. Students can learn the focus points do not move in some types of telescope. They can know such type of telescope is useful for attaching heavy equipment on the focus point.

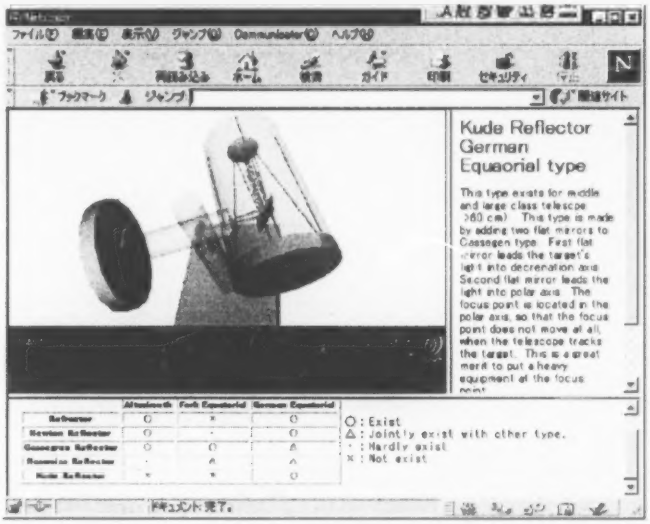


Fig.6 Virtual environment for learning structure and behaviour of various type of telescope

8 Conclusions

In this paper, we described the second version of remote telescope system. We explained scheduling system, telescope control, GUI, live picture, virtual planetarium and learning system. This total system can be regarded as synthesis of real observatory and virtual observatory. The real observatory offers live picture of celestial bodies. The virtual observatory offers planetarium and learning system. In the remote telescope

BEST COPY AVAILABLE

system, students can operate the telescope easily, so that it neglects the chance of learning how to use the telescope. In science education, it is also important to learn how to use the observation equipment. The virtual observatory compensates for it.

The student can observe real celestial objects by real observatory from remote site. If there is time difference between the client site and observatory site, the student can observe real celestial objects in daytime in classroom. It will be a strong tool to learn astronomy. This system brings experimental environment into classroom in astronomical domain.

Our future work is to make dome or sliding roof and to install the telescope in it.

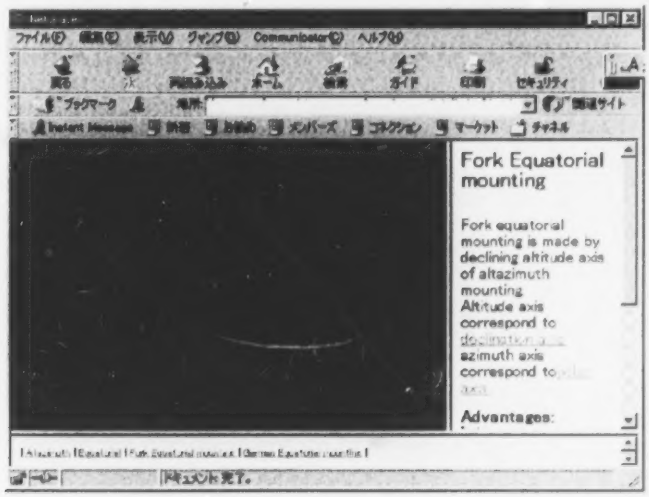


Fig.7 Virtual environment for learning function of parts of a telescope

References

[1]M.Soga, K.Watanabe, T.Tanaka, M.Sakamoto, H.Tanaka, S.Toyomasu, M.Okyudo, J.Arimoto, "A Remote Control System of a Telescope by WWW and Real Time Communication for Astronomical Education", Proc. of World Conference on Educational Multimedia/Hypermedia / World Conference on Educational Telecommunications (ED-MEDIA / ED-TELECOM'98), pp.1305-1310

[2] Mark J.Cox, John E.F.Baruch (1994). Robotic Telescopes: An Interactive Exhibit on the World-Wide Web. 2nd International Conference of the World-Wide Web, 1994

[3] Hands-On Universe, http://hou.lbl.gov/

[4] The CWRU Warner and Swasey Observatory Nassau Station, http://astrwww.cwru.edu/nassau/nassau.html

[5] Remote Access Astronomy Project Remotely Operated Telescope, http://www.deepspace.ucsb.edu/rot.htm

[6] Telescope In Education, http://www.mtwilson.edu/Science/TIE/

ICCE / ICCAI 2000

Learning Societies in the New Millennium: Creativity, Caring & Commitments

Proceedings

Content

Full & Short Papers (Virtual Lab/Classroom/School)

A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents
A Constructivist Virtual Physics Laboratory
A Distributed Backbone System for Community-Based Collaborative Virtual Universities
A Flexible Transaction Model for Virtual School Environments
A Virtual Classroom for Algorithms with Algorithmic Support
Agent-oriented Support Environment in Web-based Collaborative Learning
Buiding the Virtual Classroom for the New Mienniumn
Design and Implementation of A N-Tiered Heterogeneous Virtual School Adminstration System
Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology
Development of the Web-based classroom system which a teacher can apply
Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools
Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language
Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)
The Status of Cyber University in Korea and its Future Direction
TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP -COLLABORATION TYPE AND LOOSELY CONNECTED TYPE-
WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone
Web-Based Subject-Oriented Learning Program on Geophysics for Senior High School

▲HOME

A Collaborative Learning Support System Based on Virtual Environment Server for Multiple Agents

Takashi OHNO* Kenji SAITO* Hajime SAITOH and Takashi MAEDA***
**Graduate School of Hokkaido Information University*
Ebetsu 069-8585, JAPAN
Tel: +81-11-385-4416 Fax: +81-11-384-0134
***Graduate School of Engineering, Hokkaido University*
Sapporo 060-8628, JAPAN
Tel: +81-11-716-2111(ext.6498)
E-mail:{t-ohno, maeda, ksaito }@do-johodai.ac.jp, hajime@complex.eng.hokudai.ac.jp

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing a collaborative learning support system being developed on VESMA(Virtual Environment Server for Multiple Agents) system.

Keywords: **Collaborative Learning, Intelligent Agent, Virtual Environment**

1 Introduction

It is generally agreed that learning efficiency improves if the students find teaching/learning materials interesting. It is the same when we engage in collaborative learning with the use of computer networks. In other words, it is possible that the learner's interest and concern will be attracted if there is an intermediary who supports the learner with the idea of using the teaching/learning materials function as a learning object between the learner (user) and the learning object. And, it is very important to grasp the learner's mental state in collaboration with plural learners in a virtual environment like a computer networks. We take into consideration the collaborative learning environment that is suitable for each learner, the personality of the group and the knowledge levels of learners. We have been constructing such a learning support system as a part of our Virtual University project being built up on VESMA(Virtual Environment Server for Multiple Agents) system.

Fig. 1 Client of VESMA System

In the rest of the paper, we describe a general mechanism of VESMA system and its features in section 2. In section 3, we discuss on collaborative learning in such a virtual environment including some intelligent agents who support such learning. In section 4 and 5, we will discuss the supporting function of effective collaborative learning and the learning process in the collaborative learning support system. Concluding remarks and some future works are briefly described, in the last section,.

2 VESMA System

In this paper, we have been constructing a virtual environment using the VESMA system developed in the

Java language. This VESMA system provides the programming environment to simulate the virtual space which a lot of elements exchange the message and affect each other. This system has been used for an agent programming, the simulation of a physical/social phenomenon and a probabilistic network etc. by present.

2.1 Server-Client System The VESMA system is a system which consists of the server and the client, and contains user's avatar, the object and the agent that is in virtual environment in the server. The client displays an environment surrounding user(s), and interprets the inputs of the user, and let the avatar execute it. This system can be executable in all platforms, and translate an arbitrary object between server-client or server-server through a computer network, because this system uses the Java language.

The objects corresponding to the entrance can exist in a virtual space of the VESMA system, these objects are connected with another place of this server or other servers, and the user can move between the servers freely by accessing this entrance object.

2.2 Layered Structure A virtual space of the VESMA system can take the layered structure, as can be seen in the last paragraph of section 2.1. When a complex virtual space and a lot of rooms are made, it is very convenient to be able to make the layered structure for representing a spatial metaphor. For instance, layered structures such as the city, university, faculties, and laboratories can be represented.

2.3 Autonomous Object The object is static or passive in a usual educational virtual environment system, so it can answer to a user's request or reply to a messages, but it is difficult to realize an object which behaves actively. The object in VESMA system can behave with own thread by programming the object to send oneself the message. In other words, VESMA system supports making of an autonomous agent.

2.4 Simulation of Various Phenomenon The VESMA system is not only suitable as the educational virtual environment programming environment, but also suitable for the simulation of a physical phenomenon. Our collaborative learning support system on VESMA system can simulate a physical phenomenon as well. It is also possible that the user can experiment by operating the experiment tool in the virtual environment, and change the parameter and setting the experiment, and repeat the experiment trying and erring. These experiments are useful for voluntary environments.

Moreover, our system can simulate not only physical phenomenons but also social phenomenons or probabilistic process, and can display the results of the simulations by various graphical expressions such as a density graph or digraph.

3 Collaborative Learning in Virtual Environment

3.1 Virtual Environment and Learning Style

The virtual environment in this paper means a "communication environment in computer networks". Usually, a user can take only the service that he had already known the existence in the usual network. Though such information is useful, sometimes people get information that is of significant value by chance discovery. We think that positively building up and providing such an environment to increase the chance of this happening are important. The virtual environment in made by various information can be considered for the typical example. In this paper, we use VESMA system to realize the collaborative learning support system. Because of server-client architecture supported by VESMA system, our collaborative learning support system can be "distributed" in space and "synchronized or non-synchronized" in time. Generally, learning styles can be divided into the following three types : 1. *Individual learning*, 2. *group learning*, 3. ***Collaborative learning***.

(1)*Individual learning* : the problem solving whereby a learner does by himself. (2)*Group Learning* : the problem solving via task sharing. (3) *Collaborative learning* : the problem solving by use of result sharing. In other words, Each learner solves his own problem based on the information and data given to him by other learners. Thus Collaborative learning is group learning with more goal oriented communications. In the field of the education, it is considered that the latter learning style is especially effective because the quality of the answer improves on the whole by having learners with differing knowledge do an information exchange.

3.2 Collaborative Learning

The following are the strong points of collaborative learning in a virtual environment[2] : (1)There is no restriction of time and geographical space. (2)It can lead to solving problems by doing opinion exchange with other people. (3)It can obtain objective awareness of problems. On the other hand, it has several weak points : (1)Learners get behind if they don't participate voluntarily. (2)There is the possibility that learning may progress in different directions. (3)Differing abilities of learners (members) may be a problem for the progress of their learning. We think about the method of the learner support which a weak point 3 is changed to the strong point.

Good ideas in subject preparation, group formation support, communication support, and ideas such as an interface become necessary to get over these problems. We examine the interface using intelligent agents in consideration of such characteristics in this paper.

4 Supporting Collaborative Learning

4.1 Grasp of the learner's state

It is important to grasp learner's state in the learning system. When learning in a virtual environment on the computer network, it is especially important. Because, people's communications become indirect in a virtual environment.

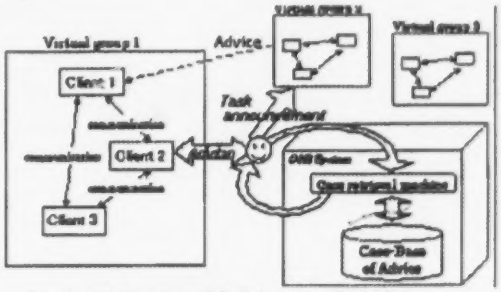


Fig. 3 Architecture of Collaborative Learning Support System

Generally, when students learn about certain topic, offering materials suitable to the learner's level of understanding is necessary. This research aims to check the learner's mental state, in broad sense, using agents to grasp it automatically. It is also important to promote collaborative learning smoothly by giving a kind of "role" to each learner in the group in consideration of the learner's personality. For example, the learner who is good at teaching others might become a leader, and give support to other learners in the group. The control that gives hints to make it refer to an exercise is necessary for cases when learners come to a deadlock in their learning.

4.2 Learner Modeling

Then, the following is necessary for the learner modeling from the viewpoint of collaborative learning,
The individual model : It has proper knowledge, the mistaken knowledge, the knowledge that it hasn't been studied, the interest or concerns, information such as a role, personal manipulation history.

$D_l = \{(T_1, U_1), \ldots, (T_n, U_n)\}$ D_l : learner model, T_l : learning topic, U_l : understanding of topic

4.3 Intelligent Agents

An agent works like a human beings, and supports teachers and learners. An agent communicates other agents or avatars, and behaves actively in various situation. Making a graphical representation of these agents, users can come in contact with an agent familiarity. In this paper, we will discuss the intelligent agents ("*learner modeling agent*", "*group agent*", "*advisor agent*", "*evaluation agent*") who support collaborative learning in virtual environment.

The *learner modeling agent* grasps the learner's degree of progress and the degree of his understanding. The *group agent* controls the information that a *learner modeling agent* has, and monitors the relationships of each learner in the group. An *advisor agent* carries out various supports directly for the learner. An *evaluation agent* judges whether or not the knowledge that a learner got by working at collaborative learning is useful. Fig. 2 illustrates the architecture of collaborative learning in virtual environment including *advisor agent*. These agents do various support while the learner advances collaborative learning.

As different autonomous object, some characteristic mascots may be included in our Virtual University based on a feature described in 2.3.

5 The method of some supporting in Collaborative Learning

5.1 Collaborative Learning Support

As an example of collaborative learning support, *pattern1* • •When you come to a deadlock. *pattern2* • • When you mistake the solution. *pattern. 3* • •When you can not understand what to do next .

How to solve the problem of the pattern 2 : First is support by the learner in the group(using *Contract Net*). Next is support by the learner in other group(using *Contract Net*). Finally is Support by the *CBR* system. *Contract Net* achieves the allocation of the task by the negotiation between the processing nodes. In this paper, the selection of the advisor was attempted by contract net. We think it might be easier to understand "By getting advice from the learner who is close to one's understanding degree".

5.2 CBR and Calculation of Similarity Degree

CBR(Case-Based Reasoning) is a kind of reasoning which solve the new problem by a case similar to current problem. A case is expressed as follows.

$$D_c = \{(T_1, U_1, W_1) \ldots\ldots (T_n, U_n, W_n)\}$$

D_c : case, T_i : learning topic, U_i : understanding of topic, W_i : importance degree of topic

The advisor agent selects a case that current condition and a case are the most similar.

$$Sim_l = \sqrt{\sum_{i=1}^{n} W_i (U_{ci} - U_{li})^2}$$

Sim :similarity degree, U_{ci} :understanding degree of topic of case base, U_{li} : understanding degree of topic of learner model, W_i : importance degree of the topic

•

6 Concluding Remarks and Future Works

We have constructed a virtual environment on a VESMA system, and examined communication processes on it. And, we have examined the function of the intelligent agents in the collaborative learning support system and the validity and support for the learning process.

In this paper, we have discussed that learners can obtain better methods for voluntary learning by the appropriate support of the intelligent agents. And various intelligent agents provide environments for the group learning which enables learners to do active collaborative learning.

And we have realized practical collaborative learning support system in which the following advantages are provided using VESMA system. The learners communicate each other and share the teaching/learning materials in the virtual environment by not only a text -based interface but also a graphical interface. A user of VESMA system can move among two or more servers which is distributed in the Internet. We can make a small creature, or can make physical experiments because of the function of VESMA which realize autonomous objects. And VESMA system has the layered structure of virtual environment, so many places can be constructed in one server corresponding to user's spatial metaphor, and the learner can easily access a place he/she wish.

References

[1] Hajime Saitoh, Azuma Ohuchi, Noriko Tanaka and Takashi Maeda, "On the Application of The Participants Assistance System in Collaborative Communication Environments to a Collaborative Learning", Communications and Networking in Education, Learning in a Networked Society, (June 13-18, 1999).

[2] Takashi Ohno, Noriko Tanaka, Hajime Saitoh and Takashi Maeda, "A study on Collaborative Learning Support System using Interface Agent" (in Japanese), THE INSTITUTE OF ELECTRONICS, INFORMATION AND COMMUNICATION ENGINEERS, TECHNICAL REPORT OF IEICE, OFS99-26, AI99-38 (1999).

[3] I. Tomek, "Virtual Environments in Education", Advanced Research in Computers and Communications in Education, (Eds. G. Cummings *et al*), IOS Press, (1999).

A Constructivist Virtual Physics Laboratory

Fu-Kwun Hwang
Dept. of Physics, National Taiwan Normal University
#88, Sec. 4, Ting-Chou Road, Taipei, Taiwan 116
Tel: +886-2-29346620
Fax: +886-2-29326408
E-mail:hwang@phy03.phy.ntnu.edu.tw

A virtual Physics Laboratory with 60+ physics java applets was established for student to play and enjoy learning physics (http://www.phy.ntnu.edu.tw/java/). Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher around the world already design worksheets incorporate with our java applets in their day-to-day instruction. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply their physics to everyday life. It can be operated as different kinds of modes, such as studying individually, study cooperatively and having lessons collectively etc. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

Keywords: **Java Animation, Virtual Laboratory, Computer Assisted Learning.**

1 Introduction

Many have predicted that the Internet, particularly the World Wide Web, will transform education. As more schools adopt the internet and more teachers and students become increasingly interested in the web-based activities, the need for easy-to-use and meaningful web learning environments has increased dramatically. At the same time, education research has shown that the learning style and student-centered learning are important to meaningful learning . Learning becomes an active process of discovery and participation base on self-motivation rather than on more passive acquaintance of facts and rules [8]. Current and emerging technological advances in information and communication technology make it possible to develop interactive learning environment to support new ways of learning. The most promising technologies are based on virtual machines, meta-languages, and open Internet standards. Although the Internet lowers the barriers to authoring and distribution of educational software, its ability to deliver active content may, in the long run, be more significant. Interactive learning environments are having an increasing role in teaching and learning, and are likely to play an important role in the future [10]. In particular, those tools that encourage/enhance discovery, creativity, and thinking are very much needed.

One of the most exciting developments is the integration of interactive software into web-based courses using the Java programming language. Many physics teachers and students recognized benefits of using the WWW to enhance teaching and learning, while they were using our Virtual Physics Laboratory (VPL). We have developed more than 60 physics related java applets, which become the core of VPL. Java animations developed at our site offer many advantages for the integration in our didactic concepts: All of our java animations visualize the effects and parameters of the related physics concepts or phenomena. It provides

user to manipulate all necessary parameters in a very intuitive and interactive way. Through modifying these parameters in java animation, students get a much better understanding of the underlying physics and mathematics aspects. Our tools are easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The most important implication of choosing a web-based technology is the way it facilitates sharing. We have received tremendous email feedbacks from physics teachers, parents and students all over the world. Many teachers developed their own worksheets in cooperated with our java applets, and used it in their classroom. Due to the slow connection over the Internet and many requests from educators, our VPL contents were distributed as mirror sites at more than 35 educational institutions around the world.

2 The Learning Process

Traditional approaches to education promote subject-based learning, which encourage teachers to focus on covering materials and students to adopt surface learning which fail to integrate knowledge [3]. When the television was invented half century ago, many had predicted that the television would transform the education. Some people thought if the best teacher were lectured on TV, all the students would be educated under the best environment. We have learned the lesson, teaching and learning is not delivery process between teacher and students. It appears that "learning consists of the growth of additional neural connections stimulated by the passage of electrical current along nerve cells (neurons) and enhanced by chemicals (neurotransmitters) discharged into the gaps (synapses) between neighboring cells" [11,12]. People learn differently and know things differently because they take different pathways on different occasions; which related to the context, their previous experiences, and their physical and emotional state. Not all pathways are accessed in the same way. However, as a particular pathway is re-used, additional connections are built which strengthen the linkages. Some of these mental pathways become so worn that the mind seeks to use these easy routes to arrive at an understanding. In many case, learning means making new pathways, adjusting pathways or removing pathways among memories that become "known" as incorrect. Learning is a personal activity and the function of a teacher is to help student create interaction between subject under studied and student's cognition structure.

The rapid advancement of the Internet, particularly the development and prolific expansion of the WWW, enable educators to create multimedia teaching resources and interactive instructional strategies which can be delivered to any students without regard to time, place, or computer platform. However, the medium of delivery is not the sufficient condition for learning. Education research informs us that technological advances do not necessarily lead to improve learning. Nothing happens until the learning is actively engaged. For today's technology to have a long lasting impact on science education, it will need to base more on successful pedagogy than on the latest compilers, hardware, or algorithms.

Interactive engagement (abbreviated IE) teaching methods take many different formats [2]. All of them, however, force the student to play a much more active role in the learning process, increase the amount of interaction with fellow students and instructors, and emphasize conceptual understanding as well as quantitative problem-solving. Hale's study [1] compared IE methods, with traditional lecture methods at variety institutions, and showed a significant, across the-board improvement in students' conceptual understanding in IE classes. The most dramatic differences are seen in the area of conceptual understanding. The interactive capabilities of WWW-based instructional strategies can be employed to better match how we teach with how we know students learn.

3 Virtual Physics Laboratory: Enjoyable place to play and learn physics

Game playing is a self-motivated and rewarding activity. An enjoyable computer game is found to be player centered, and it must enhance discovery. Learning should be a self-motivated and rewarding activity, too. Can we make learning as motivated and rewarding activity as computer game playing? This was the initial spark for the VPL project, to develop an enjoyable interactive learning environment helping learners to make sense of physics.

Research on animation can be organized according to the purpose of the animation. In general, instructional graphics satisfy five purposes: they are cosmetic, motivation, attention getting, presentation, and practice [7]. Cosmetic and motivation are in the affective domain, while the others are in the cognitive domain.

1. Graphics used for cosmetic purposes are used to "dress up" the text. Unfortunately, learning does not take place directly as a result of cosmetic graphics. Rieber notes, "At their best, cosmetic graphics help maintain student interest. At their worst, cosmetic graphics distract student attention from other important material."
2. Graphics used for motivational purposes, appealing to the viewer's attitudes. It's important for learner to see material as exciting and relevant. Although learners may be motivated by novel graphics, they may also become saturated as they are inundated with such visuals. As a result, motivating visuals can quickly lose their instructional impact.
3. Graphics used to gain attention. Their primary difference from motivational graphics is that they are not designed to influence the attitude of the viewer but rather to focus the viewer's attention. Attention-gaining graphics may directly influence students' learning, thus it is classified according to the cognition domain of learning. A good example is our "Thin Lens Animator"[13] that shows the images of an object in front of a lens as user click and drags the object across the screen.
4. Graphics used for presentation. For instance, our "Pendulum Animation"[14] is not only present a dynamic visual, but also present data. The data is observed to change as the animation is running. Therefore, the learner can make a connection between the state of the data and the state of the animation.
5. Graphics used for practice activities. This purpose is especially suited to interactive computer simulation where learner receives feedback based on his or her input. For example: Users can type in the base frequency and modify different components of higher order frequency with mouse to create new sound wave and hear it instantly in "Fourier Synthesis"[15].

Our Java applets can be used for all the aforementioned purposes. Most of all, we focus more on students' cognition development. The created java applets aim at invite students to develop deeper, more connected understanding of physics concepts. Seeking connections in contrast to the conventional model of learner as receiving information and of instruction as providing information, in short, to promote conceptual change. According to Rieber, there are two prerequisites for animation to have positive effect on learning outcomes: (1) there must be a need for external visualization (2) learning of the described phenomenon must require an understanding of how an object's properties change with time or position. Rieberb recommends, "Animation should be incorporated only when its attributes are congruent to the learning task". That is, the animation may not be an advantage over a static image in all case. We have designed our java applets according to the recommendation. Many physics concepts especially those involve spatial and time variance, such as stationary wave, Doppler effect[16], and so on, are difficult to express clearly in words or in pictures on the blackboard. By means of our animated java applets, drawing or demonstrations, teacher can cut down the lecture time in class and enable students to understand physics concepts more effectively.

Examples 1:Traffic light system (html page 6k, java class files 27k)[17]

Situation: "Would you like to engineer the traffic light system for a one-way street that consists of several lanes along which rush-hour traffic flows? How would you time the onset of green lights at the various intersections? How to apply what you have learned in kinematics to promote the traffic flow? This java applet let you play with it and find out your answer." All the relevant information is provided for students to find out the answer. This is an authentic situation; the underline principle was used in many cities to control the one-way traffic lights. Each moving square in Figure 1 represents a car, its color indicates whether the car is accelerating, moving with constant velocity, or stopped. The height of each blue circle gives information about the velocity of the corresponding vehicle. User can adjust the timing between green light, yellow light and red light, change time delay between successive intersections, ... etc. It is a kinematics problem for high school students related to topics in constant motion and motion under constant acceleration. Students can work in-group, discuss with each other, propose solutions, explain the reasons of their predictions, use physics concepts to analyze and synthesis the answer, and run the animation to compare and find out the answer. Many students find it is a fun game to play and they gain deeper understanding of related physics concepts at the same time.

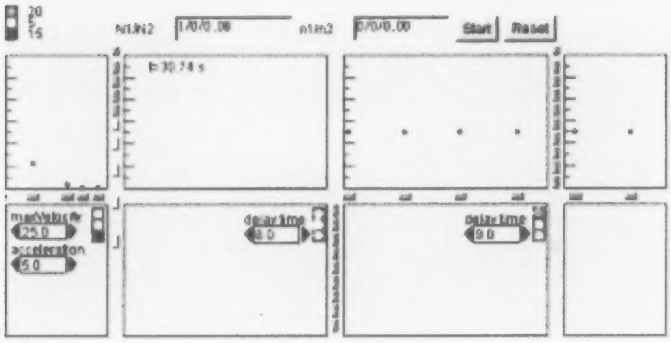


Figure 1: Screen shot of Traffic Light System java simulation

Example 2: Measure your Reaction time (html page 6k, java class files 20k)[18]

Situation: "You are driving on the high way and listening to the music you like most. Suddenly, you see the brake light of the car in front of you just turned on. You will try to hit the brake and slow down your car. But, there is a small time delay before you really do that--- your reaction time. During that period of time, your car is still moving at the same HIGH speed! If you do not want something VERY BAD happened, what is the minimum distance between your car and the one just before yours?" This is a very dangerous situation in real life. However, students can try out such experiments with our java animation safely.

Figure 2: Screen shot of Reaction Time Measurement java animation.

As shown in Figure 2, when the user clicks the button to start the animation, the car will move from left to right at preset constant velocity. The streetlight will turn from green to yellow, and then turn to red light at random selected time. User needs to click the "Brake" button when the red light is on. Those small dots were generated at run time; its height shows velocity of the car at the same horizontal position. Users can move the mouse within the area to find out corresponding value for each dot. Figure 2 indicates the vehicle is moving at 20m/s (72km/hr), arrives at the first red bar when the red light turn to red, and user click the "Brake" button after the car runs 12.2 meter more (the second red bar position). So the reaction time for the user is measured to be 0.61s for this case. It also shows car running at 20m/s need 25.51 m (or 2.55s) to fully stop after driver hit the brake. (Assuming the friction coefficient between the road and the tire of the vehicle is 0.8, which is a typical value for auto tires on dry concrete.) Users can measure their reaction time with this simple java applet, and find out the safe distance to keep when they are driving on the high way. This java applet also reminds users that the braking distance for the vehicle is proportional to the square of the velocity. When you change speed of your car from 80km/hr to 100km/hr, the braking distance increased by a factor of $(100/80)^2 = (1.25)^2 = 1.56$ (velocity increased by a factor of 1.25). Such requirement is a law governs by nature. May be you can miss the speed ticket if the police is not there; however, car accident will happen if not enough distance were reserved for the corresponding speed. This is a very important lesson need to be

learned; it can save people's life.

Most of the functions provided by our java applets are operated with mouse click and drag, ease to use and intuitive. Sound, colors and good animated drawings can attract learners' attention and sharpen their ability of thinking. Many more examples can be found at our VPL. Interaction between the student and the learning materials is essential. For different learning tasks different interactivities are appropriate. The design of java applets focused on promoting students' integrated understanding of physics concepts through the use of carefully designed curriculum. We want to generate sequences of stimuli that can be used either to activate a person's existing mental models or initiate the development of new ones. To enable student to connect new ideas to their existing knowledge, making bridge to connect their own piece of information. Our approach is remarkably different from typical novice strategies where students attempt to mathematically analyze a problem before qualitatively describing it (an approach often called "plug-and-chug" and characterized by the lack of conceptual though during the problem-solving process [9]). Requiring student to consider problems qualitatively has been shown to have a positive influence on students' problem solving skills and conceptual understanding [5,6].

In physics, information about a physics system were represented in many different ways: using words, equations, graphs, diagrams, table of numbers, contour maps, vector plots, and so on. Many students have considerable difficulty, not only with creating these representations but also in seeing how they express information about the system and how they are related to each other. Our VPL can help student conquer their learning difficulty. With so many feedbacks from teachers, parents and students all over the world, we found

1. Applets in VPL can help students make sense of translation among representation: Showing animations of a dynamic system and move the relevant information to a coordinated graph, diagram, or plot can, when used in conjunction with an appropriate lesson, significantly help students develop skills in using different representations to help them make sense of the physics. For examples: "Superposition principle of wave", "Simple harmonic motion" and "Transverse Wave and Longitudinal Wave" java applets.
2. Applets in VPL can help students understand equations and physical relations among measurements. Many students treat equations as if they were only a way to calculate a variable or determine a number as a solution. Physical equations represent relationships between various observations and measurements. We know how the nature operates from those relations. For examples: " Spring Force and Simple Harmonic Motion", "Thin Lens" and "Double Slit (interference) " java applets.
3. Applets in VPL can help students build mental model of physical systems: In some cases, students don't have the experience or imagination to put together what they are reading in the texts and hearing from the lectures into a coherent, sensible picture. They memorize bits and pieces, but because these pieces are not linked into consistent, self-supporting structure, they forget or confuse the parts. Visions of interacting objects having qualities and measurable properties. Producing visualizations that display these characteristics can help students create these mental models. For examples: "The location of an supersonic airplane", "Moving point source (Doppler effect/Shock wave)" and "Propagation of electromagnetic wave".
4. Applets in VPL can give students engaging, hand-on, active learning experiences. Students learn much more effectively when they have control on their own learning. Having animations that students can use to explore phenomenon on their own, can produce more effective learning experiences. For examples: "Reaction time and car accident ", "The electronic multimeter" and " Projectile/Satellite Orbits" java applets.
5. Applets in VPL can serve as a sketchpad on which students can explain and describe their understanding to each other. Educational research shows it is valuable to have students explain what they are thinking, both to themselves and to each other. Two or three students working together to answer questions with a simulation can produce a powerful learning environment. For examples: "Physics of rainbow", "Billiards and Physics" and "Mixing colored light beams/paint pigments" java applets.

4 Future work

When learners are novices in the content area, they may not know how to attend to relevant cues or details provided by animations. Teacher can provide hints or demonstrations in the classroom and find out how the learner operated with the java animation. However, VPL is designed for web access, which allows students' direct access without teacher's guidance. All of our java applets are client-based simulations. We see the needs to establish communication between client and server. We will extend their function to support client-

server communication: to control and synchronize animation running on several machines, to exchange data between distributed applets. Besides, it can be used to monitor how the remote user operated with our java applets, identify when they encounter difficulty for research purpose and provide assistance at the same time. Therefore, our java applets can be used as stand-alone learning tools or as shared animations to support cooperate learning over the net.

5 Conclusions

Many web sites are aimed at providing information while we focus on interactive animations to assist student construct his/her own physics concepts. The VPL offers possibilities to concentrate on student-centered approach for learning. Learners do not have to sit passively watching the java animation. They are allowed to interact with the animation themselves. It requires learners to constantly make decisions about which parameters to modified and evaluate progress, thus forcing students to apply higher order thinking skills. Our java applets are ready over the net, easy-to-use and meaningful for many physics teachers, whose primary concern is teaching instead of technology. The size of the java applets is small, usually less than 30k, which is suitable for the overcrowded Internet. Many physics teacher already design worksheets incorporate with our java applets in their day-to-day instruction. We welcome lectures to translate our web pages into their own languages and share with us. All the labels and texts used in the java applets can be easily changed to local characters with any web page editor. This provides many users at different countries to use our java applets for their teaching and learning. Our VPL can be used as a teaching tool during the lecture or as assignments for the students to play and enjoy learning physics. It can be used in different ways, such as studying individually, study cooperatively and having lessons collectively etc. Our goal is not only to help learners accomplish their physics learning faster or more effectively, but also to engage them in new ways of thinking, enjoy the funs of physics and apply physics to their everyday life. These attributes closely match those of modern educational theories where learning should be a self-motivated and rewarding activity.

References

[1] Hale, M. E., Oakey, J. R., Shaw, E. L., & Burns, J., "Using Computer Animation in Science Testing", Computer in the Schools, 2, 83-90. (1985)

[2] Heller, P., Keith, R., & Anderson, S. "Teaching problem solving through cooperative grouping. Part 1: Group versus individual problem solving," American Journal of Physics, 60, 627-636 (1992)

[3] Margetson, D. Current Educational Reform and the significance of problem-based Learning studies in Higher Education, 19, 1, 5-19 (1994)

[4] Novak 1999, G., Patterson, E., Gavrin, A., and Christian, W., Just-in-Tie Blending Active Learning with Web technology, (Prentice Hall, Upper Saddle River, NJ 1999)

[5] Larkin, J. H., McDermott, J., Simon, D. P., and Simon, H. A., "Expert and Novice Performance in solving Physics Problems" Science, 208, 1342-1355.

[6] Leonard, W. J., Dufresne, R. J., and Mestre, J. P., "Using Qualitative Problem Solving Strategies to Highlight the Role of Conceptual Knowledge in Solving Problesm" Amercian Journal of Physics, 64, 1495-1503 (1996)

[7] Rieber, L., Computer, Graphics, and Learning (Brown & Benchmark, Madison WI 1994)

[8] Sfard, A., On two metaphors for learning and dangers of choosing just one. Educational Research, 27 (2), 4-12 (1998)

[9] Titus, A., "Integrating Video and Animation with Physics Problem solving Exercises on the World Wide Web", Ph. D. dissertation. North Carolina State University: Raleigh, NC. (1998)

[10] Wasson, b., Advanced educational technologies: The learning environment. Computers in Human Behavior, 13 (4), 571-594 (1997)

[11] Creating the Future, http://www.newhorizons.org/crfut_perkins.html, David Perkins: Mindware and the Metacurriculum (Accessed on May 20, 2000).

[12] Turn on the Lights!, http://www.cefpi.com/issue/issue5.html,Using what we know about the brain and learning to design learning environments (Accessed on May 20, 2000).

[13] Thin Lens Animator, http://www.phy.ntnu.edu.tw/java/Lens/thinLens.html (Accessed on May 20, 2000).

[14] Pendulum java applet, http://www.phy.ntnu.edu.tw/java/Pendulum/Pendulum.html (Accessed on July 31, 2000).

[15] Fourier Synthesis, http://www.phy.ntnu.edu.tw/java/sound/sound.html (Accessed on July 31, 2000).

[16] Doppler Effect and Shock Wave, http://www.phy.ntnu.edu.tw/java/Doppler/Doppler.html (Accessed on July 31, 2000).
[17] Traffic Light System, http://www.phy.ntnu.edu.tw/java/trafficControl/trafficControl.html (Accessed on July 31, 2000).
[18] Reaction Time, http://www.phy.ntnu.edu.tw/Reaction/reactionTime.html (Accessed on July 31, 2000).

A Distributed Backbone System for Community-Based Collaborative Virtual Universities

Qun Jin *, Jingde Cheng **, Hiroaki Ogata * and Yoneo Yano *****
** School of Computer Science and Engineering, University of Aizu, Aizu-Wakamatsu City, 965-8580 Japan E-mail: jinqun@u-aizu.ac.jp*
*** Department of Information and Computer Sciences, Saitama University, Urawa, 338-8570 Japan E-mail: cheng@ics.saitama-u.ac.jp*
**** Department of Information Science and Intelligent Systems, Tokushima University, Tokushima, 770-8506 Japan E-mail: {ogata, yano}@is.tokushima-u.ac.jp*

In this paper, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We discuss designing and prototyping of a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system as well.

Keywords: **Distance learning, virtual university, virtual community, MOO, software agent.**

1 Introduction

Information and network technologies have been changing how people work, live and learn. The so-called Internet revolution has brought great impact on the global society, and is greatly changing the educational systems. In recent years, distance education/learning and virtual universities have been attracting more and more attentions, and play an important role in the educational system revolution for the new coming century.

Virtual universities cover a very broad field. Many research works have been conducted in the domain [1, 2]. However, experiments and experiences have demonstrated that electronic communication in the networked virtual environment has some different characteristics from face-to-face communication in the real world [3]. Many studies have also shown that learning in the networked virtual environments involves approaches that are not typical of general classrooms [4, 5]. It is necessary for a virtual university to have general functions, utilities and resources of a physical real world university available on the networks. However, it is not enough and efficient only trying to move a physical university to the virtual world without considering on the fact that there are great differences between physical and virtual universities.

In this study, we propose a new framework for community-based collaborative virtual universities, which not only support the delivery of knowledge from an expert to a group of learners, but also facilitate the exchange and distribution of knowledge between large and diverse groups of people. We design and develop a distributed backbone system for community-based collaborative virtual universities, in which computation is effectively used to provide organized proper support for communication, interaction and collaboration between human users and between a human user and the system (a networked computer and/or a software agent) as well.

2 Framework for Community-Based Collaborative Virtual Universities

The Internet provides a universal, free, and equal electronic communication environment for people of all ages with different education backgrounds, ability levels, and personal inclinations. It makes knowledge

delivery, sharing and building possible among large and diverse groups of people across the networks.

The central purpose of community-based collaborative virtual universities is to provide a learning environment that widely opens to large and diverse group of people who have the will to learn and to share their knowledge with others across the networks. They are a networked virtual workspace with the time-independent and place-independent access, in which computation is effectively utilized to actively and properly support human-human communication, interaction and collaboration in addition to human-computer communication, interaction and collaboration, towards effectively assisting and enhancing learning activities in the virtual environments [6].

Community-based collaborative virtual universities are participants-driven. That is, participants or learners share a common interest in a topic or area, share a way of knowing and a set of practices [7]. Knowledge is not just delivered from teachers or experts, but also constructed by participants' team works and/or discussions. Community-based collaborative virtual universities support different ways for novices and experts to work in the same environment to accomplish similar goals. They may be large, the task general, and the communication open. Alternatively, they can be small, the task specific, and the communication close.

3 Design and Implementation of the Distributed Backbone System

3.1 Overview

The backbone system for flexibly supporting community learning has been designed so that a learner can navigate through it, select relevant information, respond to questions using computer input devices such as a keyboard, mouse, or voice command system, solve problems, complete challenging tasks, create knowledge representations, collaborate with others, or otherwise engage in meaningful learning activities.

Figure 1 shows an overview of the distributed backbone system for community-based collaborative virtual universities, which have been implemented in MOO (Multi user dimension Object-Oriented), well known as a text-based social virtual reality [8]. Human users and software agents co-exist and interact in the MOO based virtual community. Social interaction between users is actively mediated and facilitated by cooperative agents who support their learning activities in the virtual environments as well.

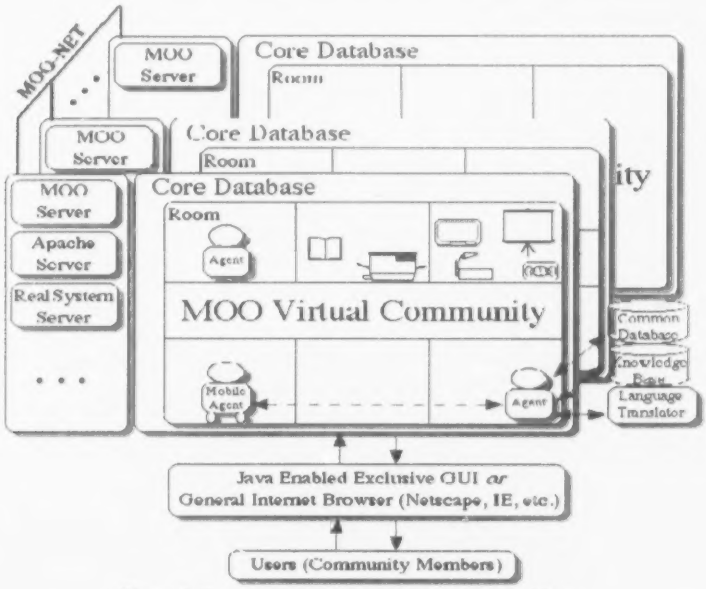


Figure 1 Overview of the MOO-Networked Backbone

3.1.1 Web and Multimedia Integration

To fully utilize multimedia such as graphic images, sounds, and/or movies, we have integrated the MOO Server with the web server (e.g., Apache Server) and other servers providing multimedia services (e.g., RealSystem Server). Since the seamless integration of the MOO Server with the web server, technically, it is possible to integrate MOO with any types of server services and incorporate any type of multimedia such as MPEG1, MPEG2, and/or MP3 data in the MOO virtual environment.

3.1.2 Graphical User Interface

Java enabled exclusive graphical user interface specially designed for accessing MOO virtual environments has been developed. Consequently, MOO commands and verbs could be transferred to a hyper link. For example, users can go in or out of a room by simply clicking a corresponding hyper link that represents the entrance or exit; they may read a note by clicking the hyper link representing the note. Since it is constructed with Java language, it could be run with a general Internet Browser (e.g., Netscape, Internet Explorer).

3.1.3 Software Agent Support

To further provide flexible and proper support for communication, interaction and collaboration in the networked virtual environments, a multi agent paradigm has been adopted in this study. We have proposed a kind of software agents that adapt well to users' behavior and incorporated them both within the MOO environment and on the interface which we call interface agents, and integrate one interface agent for each user that bridges the virtual environment and the user to aid his/her manipulations and various activities.

Interface agents provide different ways of supports. They may provide suggestions, answer questions to a user. They can search something from an outside database or knowledge base for their owners by ``*wireless*" communication with the DB/KB agent to transfer their owners' request and obtain the search results. Interface agents may accompany a user to move around the virtual environment if the user requests so. They can also provide actively supports to a user once a problem occurs.

In addition to interface agents, there are also various types of software agents inside or outside the virtual community, which are called task agents. Task agents provide specific functions or resources available in the local environment or outside over the Internet to interface agents directly or indirectly. In the latter case, they are mediated by a so-called mediator agent.

3.1.4 Multilingual Environment with Language Translator Agents

Due to the diversity of the users in the community-based collaborative virtual universities, it has to encompass the needs of people of all ages, races, and nationalities with different education backgrounds, and ability levels. Consequently, this causes a language problem in knowledge representation and communication.

As described in the previous sections, integration of MOO environment with the web and multimedia service servers make it possible to play sounds and movies in any language, and display information and knowledge on the Java enabled graphical user interface or a general Internet browser in a language that the client program and browsers may support. However, the language has to be selected and specified by the users themselves. Moreover, it is impossible to conduct real time communication in different languages.

In this study, we have created a new kind of task agents (translator agent) that serves for each users and automatically select one suitable language for the user to communicate with others and browse the information and knowledge in the virtual environment according to the information given in a pre-defined property. The translator agent can also translate for the users from a non-native language to their tongue, even though they understand the non-native language. The agent may also display the original languages that other users speak in addition to the translated language.

3.1.5 Distributed Virtual Environments with MOO-net

To effectively provide general university functions, utilities and resources over the networks, we have designed the backbone system as a distributed one based on the MOO-net mechanism, which is a low-bandwidth information network for the MOO family and operates using a packet-switched model [9]. As a result, distributed virtual lecture could be delivered across the MOO-networked virtual environments using a

special virtual lecture hall. Real time communication could be conducted between users in different MOO virtual environments. Further, agents may communicate with other agents in different virtual environments, and even search objects from there for users.

3.2 Prototyping Implementation of the Distributed Backbone System

The prototype system has been implemented in the three test-beds isMOO (available at URL telnet://n132.is.tokushima-u.ac.jp:6666 or http://n132.is.tokushima-u.ac.jp:6868), izMOO (available at URL telnet://pross50.u-aizu.ac.jp:8888 or http://pross50.u-aizu.ac.jp:7000) and vu21MOO (available at URL telnet://vu21.u-aizu.ac.jp:6666 or http://vu21.u-aizu.ac.jp:6868) which are running under the LambdaMOO Server with the Japanese patch and the JHCore and enCore Databases with MOO-net (http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/), the RealSystem Server (http://www.realnetworks.com/ products/servers/index.html), and the Apache Web Server (http://www.apache.org/httpd.html).

The LambdaMOO embedded object-oriented script language has been used to construct programs for software agents within the MOO virtual environment, although it is possible and might be more *powerful* to create task agents outside the MOO virtual environment using a standard programming language. Our prototype translator agents support three languages: English, Chinese and Japanese.

4 Conclusion

This study aims at proposing and building an innovative educational system for the coming new century. In this paper, we have proposed community solution as an alternative for virtual universities, and described a new conceptual framework for community-based collaborative virtual universities. We have further introduced design and prototype implementation of the distributed backbone system for community-based collaborative virtual universities.

For future direction, we plan to improve the functions of proper communication support based on studies of natural human communication processes, and design and develop an educational information resource base with high quality multimedia. We will further develop mechanisms that facilitate mutual understanding beyond differences in place, time, language and culture, and make the virtual environments flexibly responsive to users' behavior.

Acknowledgments

This work has been partly supported by 1998--1999 and 2000-2002 Japanese Ministry of Education Grant-in-Aid for Scientific Research Contract Nos. 10780195 and 12558012, 1999 HITOCC Research Grant No. 99-12, 1999 University of Aizu Research Grants Nos. R-9-1, P-17 and P-22, and 2000 University of Aizu Research Grants Nos. R-9-2, P-9 and G-25. The authors wish to express their gratitude.

References

[1] R. Chellappa, A. Barua and A.B. Whinston, "An Electronic Infrastructure for a Virtual University," Commun. ACM, Vol.40, No.9, 1997, pp.56-58, (1997).

[2] L. Harasim, "A Framework for Online Learning: The Virtual-U," IEEE Computer, Vol.32, No.9, pp.44-49, (1999).

[3] P. Wallace, The Psychology of the Internet, Cambridge University Press, (1999).

[4] L. Lau, Distance Learning Technologies: Issues, Trends and Opportunities, Idea Group Publishing, (2000).

[5] Q. Jin and Y. Yano, "Design Issues and Experiences from Having Lessons in Text-Based Social Virtual Environments," Proc. IEEE/SMC'97, pp.1418-1423, (1997).

[6] Q. Jin, "A Framework for Community-Based Collaborative Virtual Universities," Proc. ICCE'99 Tutorial and Workshop, pp.70-74, (1999).

[7] Q. Jin, "Collaborative Virtual Environments for Information Exchange and Knowledge Organization," Journal of Three Dimensional Images, Vol.13, No.3, pp.54-58, (1999).

[8] P. Curtis, LambdaMOO Programmer's Manual, Version 1.8.0p5, 1996.

[9] A. Wilson, MOO-net Overview, available at URL http://www.cs.cf.ac.uk/User/Andrew.Wilson/MOO-net/overview.html (accessed on August 15, 2000).

A Flexible Transaction Model for Virtual School Environments

Woochun Jun*, Sukki Hong**
**Dept. of Computer Education*
Seoul National University of Education
Seoul, Korea
E-mail: wocjun@ns.seoul-e.ac.kr
***Dept. of Business Administration*
Konkuk University
Chungju, Korea
E-mail: skhong01@kku.edu

Recent advances in Internet technologies have led to the advent of virtual schools. However, existing technologies have many limitations when applied to virtual school implementation. Especially, existing transaction models are not suitable for supporting virtual schools. In this paper, we present a new transaction model in order to support virtual school environments. First, we introduce the general characteristics of the virtual school environments. Then, we discuss transaction model requirements for virtual schools. Based on those requirements, we propose a new transaction model. We also show a locking-based concurrency control scheme for supporting collaboration works among students. Finally, we give conclusions and future research issues.

Keywords: **Collaborative Learning, Virtual School**

1 Introduction

Recently interests in virtual schools have been increasing due to advances in Internet technologies. The virtual school, which is based on distance learning, can overcome time and space limitations in the traditional schools. But, in order to complement lack of face-to-face communication in virtual schools, multimedia-based education is becoming popular. This multimedia-based education emphasizes the students' self-control. That is, multimedia- based education encourages interactions between teachers and students and also interactions among students. In the meanwhile, object-oriented databases become popular for supporting multimedia resources.

In the literature, many transaction models have been proposed for object-oriented database environments [5,7,8]. But, those transaction models have not reflected requirements in virtual schools. In this work, we propose a new transaction model that supports virtual school environments. The proposed model considers all those requirements.

This paper is organized as follows. In section 2, we discuss the transaction requirements in virtual school environments. Based on the discussion, we propose a new transaction model in Section 3. In Section 4, we present a locking-based concurrency control technique based on our model. Finally, we give conclusions and future research issues.

2 Transaction Requirements in Virtual School Environments

In this section we discuss transaction requirements in virtual school environments.

First of all, all transactions should maintain the correctness of database. One of the characteristics of database systems is manipulation of shared data. In this case, concurrency control technique is required to

synchronize accesses to the database so that the consistency of the database should be maintained. Concurrency control technique requires an application-dependent correctness criterion to maintain database consistency while transactions are running concurrently. Serializability is a widely used correctness criterion [1,6]. But, serializability is too harsh for most applications so that we need user-defined correctness criteria, which is less restrictive than serializability.

Second, the length of transactions must be flexible. Usually, transaction length in virtual school environment is long since transactions are navigating on various multimedia information in database systems [2]. For long transaction case, the following problems might occur. That is, if locking-based concurrency control is adopted, long transaction blocks other transactions to run concurrently due to conflicting access. This will, in turn, degrade overall performance. Also, if a long transaction is aborted during its execution, it may waste execution time and resources it used.

Third, in virtual school environments, students' behavior is unpredictable. That is, since they are working in on-line way, it is hard to predict what kinds of actions they might take. Thus, they must be given some kind of self-controls.

Fourth, the transaction model reflects interactivity. Especially, it must support collaborative works between students and teacher or among students. Those collaborative works require common data to be shared among users in order to achieve common goal. In some cases, unlike traditional transaction model, uncommitted result by one student may be open to other students.

Finally, transaction model may need to support parallelism in order to reduce overall transaction response time. Especially, the parallelism can be used in object-oriented databases as follows. In object-oriented database, objects are accessed by means of methods. A method is nothing but a procedure to read or update attributes in objects. Two methods can run concurrently if they access different attributes in an object. Thus, transaction response time can be reduced by adopting parallelism.

3 The Proposed Transaction Model

Our transaction model reflects all requirements of transaction in virtual school environments as discussed in Section 2.

Our model is based on both Split/Join transaction model [4,9] and nested transaction model [7]. But, none of them support all those requirements of transactions in virtual school environments. Our model is to combine these two models. Our model also extends the previous model [3] so that we achieve higher parallelism as below.

The Split/Join transaction is summarized as follows. The Split/Join transaction is to restructure in-progress transaction dynamically so that it supports efficient resource management as follows. The Split transaction can be divided into two serializable transactions during its execution. In this case, two divided transactions can proceed independently with their own resources. Thus, the Split transaction model provides flexibility in resource management so that it can overcome the disadvantage of long transaction. On the other hand, the Join transaction can merge two on-going serializable transactions into one transaction. In this case, the transaction model is used to combine collaborating works into one in virtual school environments.

The nested transaction model is summarized as follows. A nested transaction consists of concurrently executable top-level transactions. In turn, a top-level transaction consists of one or more steps. Each step is either atomic operation or subtransaction. This subtransaction can run concurrently with top-level transactions or other subtransactions. In the meanwhile, a subtransaction can invoke another subtransaction. Thus, unlike flat transaction model, nested transaction model can exploit internal parallelism.

The basic structure of the proposed transaction model is shown in Fig. 1.

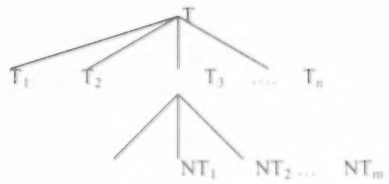


Fig. 1. The transaction model

T represents global transaction, which can be merged or split in various form during its execution. Also, depending on its nature, it can be committed without any restructuring. T_1, T_2, ...,T_n represent subtransaction or merged or split transaction. Also, NT_1, NT_2,..,NT_n represent subtransactions started by a nested transaction. In our model, we adopt open nested transaction [8]. In open nested environment, intermediate results of a subtransaction can be seen by other subtransaction as well as top-level transactions. This will increase parallelism further.

4 The Proposed Concurrency Control Technique

In this Section, we present a concurrency control technique based on our model. The proposed model is based on locking-based scheme. Our aim is to let two conflicting transactions go to negotiation stage if the lock requesting transaction requests a conflicting lock on a data item with a lock held by other transaction. In that case, the lock holding transaction and the lock requesting transaction can negotiate for conflicting lock types. If negotiation is successful by those two transactions, the lock requesting transaction can get a lock successfully and access the data. Otherwise, the lock request is blocked until the lock holding transaction release its locks. By doing so, the parallelism can be maximized among collaborating users. Assume that a transaction requests lock (L_R) on a data item already locked by other transaction with lock type (L_H), the following algorithm can be applied.

If L_R and L_H are compatible then grant L_R
    Else negotiate between lock requester and lock holder;
        If negotiation is successful then grant the lock
            Else block the lock request;

5 Conclusions and Future Works

In this paper, we first introduce the general characteristics for virtual schools. Then, we present all possible requirements for transactions in virtual school environments. Those requirements are user-defined correctness, flexible transaction length, the unpredictability, interactivity and internal parallelism. Based on those requirements, we propose a transaction model and a locking based concurrency control technique.

The immediate research issue is to apply real-time concept in transaction management. In that case, each transaction must have real-time deadline. Since all transactions are on-line based in virtual school environments, the transaction response time is very critical. Thus, we will develop the real-time priority assignment scheme and real-time transaction processing scheme for virtual school environments.

References

[1]Eswaran, K. P., et al, "The Notions of Consistency and Predicate Locks in a Database System", Communications of the ACM, Vol. 19, No. 11, pp. 255-265, (1976).

[2]Finkelstein, R., "The Jasmine Object- Oriented Database Solution for Online Interactive Transaction Processing (OLIP) and Electronic Commerce, Jasmine White paper , (1998).

[3]Jun, W. C. and Hong, S. K, "A Transaction model that Supports Virtual Universities", The Journal of Kor ean Association of Information Education, Vol. 2, No. 2, Nov. pp. 174 – 182, (1998).

[4]Kaiser, G. E. & Pu, C., "Dynamic Restructuring of Transactions", in Chapter 8, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California. pp. 265 - 295, (1992)

[5]Khoshafian, S., Dasananda, S. & Minassian, N., "The Jasmine Object Database", USA: Morgan Kaufmann Publishers, (1999).

[6]Korth, H. F. & Silberschartz, A., "Database System Concepts", Singapore: McGraw Hill, 2nd Edition, (1991).

[7] Moss, J. E. B., "Nested Transactions: An Approach to Reliable Distributed Computing", Cambridge, Mass.: MIT Press, (1985).

[8] Muth, P., et al., "A Transaction Model for an Open Publication Environment", in Chapter 6, Database Transaction Models for Advanced Applications, edited by A. K. Elmagarmid, Morgan-Kaufmann Publishers, San Mateo, California., pp. 159 – 218, (1992).

[9]Pu, C., Kaiser, G. E., & Hutchinson, N., "Split-transaction for Open-ended Activities", Proceedings of the 14th Very Large Data Bases Conference, Los Angeles, California, USA, pp. 26- 37, (1988).

A Virtual Classroom for Algorithms with Algorithmic Animation Support[1]

Shyong Jian Shyu*, Yin Te Tsai and R. C. T. Lee*****

** Department of Information Management*
Ming Chuan University
Gwei Shan, Taiwan
Email: sjshyu@mcu.edu.tw

*** Department of Computer Science and Information Management*
Providence University
Shalu, Taiwan
Email: yttsai@pu.edu.tw

**** Department of Computer Science and Information Engineering*
National Chi Nan University
Puli, Taiwan
Email: rctlee@ncnu.edu.tw

A virtual classroom on algorithms with algorithmic animation and reference database supports is presented. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. The hypermedia courseware is designed to ease the navigation. A maintenance program is devised to automatically update the hyperlinks whenever the courseware is updated. Interactive algorithm animations are applied as knowledge construction assistance. It is expected that with visualization aids learners could demonstrate their comprehension of abstract algorithms. A reference database on algorithms is built up for both educational and research purposes. Studying communications such as self-testing, bulletin board, related web links, ..., etc., are also provided.

Keywords: **Multimedia and Hypermedia in Education (15), Virtual Classroom(19), Web-Based Learning(21), Algorithm Animations**

1 Introduction

The technologies of multimedia and networking on personal computers lead the research of computer-assisted learning into a new era in the last decade. Researches on the design issues of the hypermedia courseware recently please refer [17, 3, 4, 19]. Many evaluation studies also reveal positive results on learning via hypermedia courseware [7, 10, 12, 18]. With the popularity and maturity of hypermedia and web technologies, distant learning with a synchronous style via the web attracts many researchers' attention in both of the theoretical and practical points of view. The characteristics of such a web-based virtual classroom encourage the students to actively participate the construction of knowledge with their own pace and without the limitations of time and space. It is our aim in this paper to propose our design and implementation of a virtual classroom for studying algorithms with supports of interactive animations and a research paper database.

Material about algorithms is a core component for undergraduate degrees in computing. A major problem in teaching algorithms is the difficulty of capturing the dynamic movement of data and complicated data structures in static materials such as books and lecture notes [16]. Because different students learn at

[1] This work was supported in part by National Science Council of Republic of China under grant NSC 89-2511-S-126-003

different rates, whatever pace the lecturer chooses will be wrong for some students. A virtual algorithmic classroom would be very crucial to assist students constructing their understanding with their own pace. Further, since the abstraction of algorithms might be challenging to learn and understand, it is hoped with graphical depictions the students' comprehension could be more effective and concrete. Thus we develop animations interactively by Java in our virtual classroom.

An algorithm animation is a dynamic graphical depiction of the data and operations of an algorithm. The animation purpose is to illustrate how the algorithm functions to someone seeking to learn the algorithm [15]. Researches concerning with the studies of algorithm animation or software visualization can be found on [9, 5, 13, 15, 14, 11]. A number of practical algorithm animation systems have been built over the last ten years. Some well-known systems include
BALSA [1], Tango [13], Zeus [2], AACE [6], Zeus (http://www.research.digital.com/SRC/home.htm0),
PAVANE and Opsis (http://swarm.cs.wustl.edu/pavane.html),
ZADA (http://ls4-www.informatik.uni-dortmund.de/RVS/zada.html), ...etc.
These systems typically have been used to create animations to accompany a lecture in an electronic classroom, or to prepare animations for students to observe and interact with outside the classroom. The updated technologies of multimedia tools and web programming and a complete hypermedia courseware helping students' comprehension make our algorithmic animations differ from theirs.

Besides the animations, in order to ease the tracing of the newest research results or referencing the related papers on algorithms, we built up a paper reference database to store research papers of algorithms, which can be queried and appended for educational or research purposes at the remote sites. We also provide some studying communication aids in a asynchronous mode such as self-testing, bulletin board, related web links, ..., etc., to improve the social communication among students in this virtual classroom.

The rest of this paper is organized as follows. The content of our algorithmic virtual classroom and the implementation result of our hypertextbook are presented in Section 2. The implemention of algorithm animations is illustrated in Section 3. The facility of the paper reference database is discussed in Section 4. Section 5 gives concluding remarks and future studying.

2 The Content of Our Algorithmic Virtual Classroom

There are four main themes in our algorithmic virtual classroom: (1) The Fundamentals of Algorithms, (2) Algorithmic Strategies, (3) Algorithmic Reference Database and (4) Studying Communications. Our design focuses on undergraduate students in science or management departments, while the database might have benefits for various kinds of users. The material is mainly based upon [8].

We re-organized the course material on algorithms as the hypermedia courseware (or hypertextbook) which helps the learners' actively exploring the knowledge. Each keyword (term or concept) on the web-courseware is linked onto its explanation page where the meaning is explained and all the links to the other occurrences in our courseware are also listed. A query facility for these keywords also provided. Consider that the course materials might be updated and the linkage relationships among keywords and their positions of occurrences on the web pages might also be changed. We developed a courseware maintenance program in C to automatically re-construct the linkage relation of all hyperlinks into its newest version whenever the courseware is updated. Figure 1 shows our hypertextbook on web. As the left frame shown in Figure 1, a tree-view browser is applied for learners to locate where he is in the courseware space. Figure 2 is the query result page of the keyword "insertion sort" which can also be reached by clicking "insertion sort" on the web content in Figure 1.

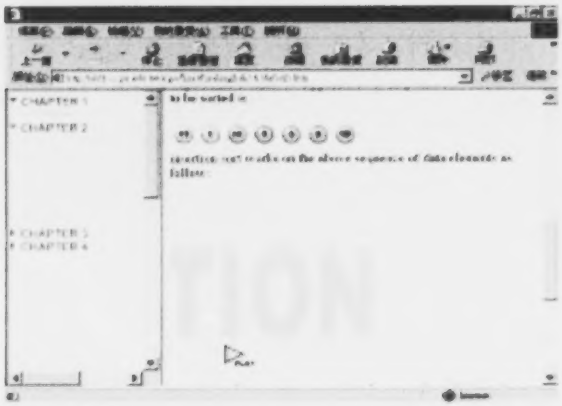


Figure 1 The web page format of our hypertextbook

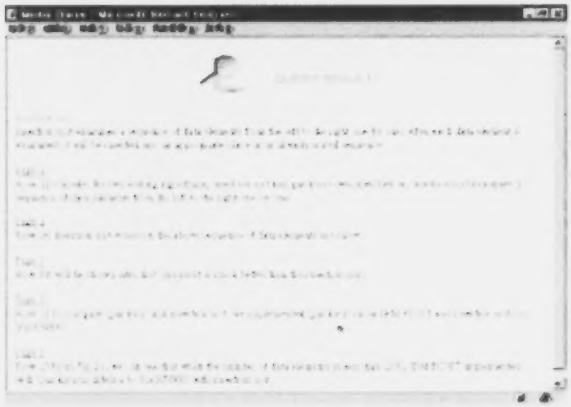


Figure 2 The query result of the keyword "insertion sort"

The content of the four main themes is described more in detail in the following sub-sections.

2.1 The Fundamentals of Algorithms

The content in this subject includes:

(a) Celebrity Hall: The contribution of some well-known computer scientists for algorithmic study such as D. E. Knuth, R. E. Tarjan, R. M. Karp, S. A. Cook, … etc, are introduced here.

(b)The Introduction of Complexity: The concept of complexity such as order, upper bound, lower bound, … etc, are explain.

(c)The analysis of computer algorithms: The analytic models of computer algorithms are explained. Proper examples are presented also.

All of the above materials are prepared as a web hypertextbook to ease the navigation.

2.2 Algorithmic Strategies

In current stage, three strategies are ready in our web classroom: greedy, divide-and-conquer and tree searching strategies. We not only construct the hypermedia courseware but also apply interactive animations as our learning assistants. Three interactively animated examples, i.e., solving the stamp problem, the minimum spanning tree via Kruskal's and Prim's algorithms respectively, are prepared for exploring the spirit of the Greedy method, while three, i.e., finding the maximum, quick-sort and merge-sort, interactive

animations are for Divide-and-Conquer and three, i.e., breadth-first-search, depth-first-search and hill-climbing, for tree searching. The implementation result is illustrated in Section 3.

2.3 Algorithmic Reference Database

It is most critical in almost every research areas, including of course the research of algorithms, to maintain a mostly updated reference database. We construct a web-based database via CGI technology to maintain those important references related to algorithms. Section 4 shows the implementation result in detail.

2.4 Study Communications

To increase the content of our courseware, we collect links of some important related web sites in our external-resource pages which enlarge the learners' view on the studying of algorithms. Meanwhile, to help students to self-evaluate the learning effect, self-tests are provided for learners to answer yes-no question sheets on the web. The system will score the result and give explanations automatically.

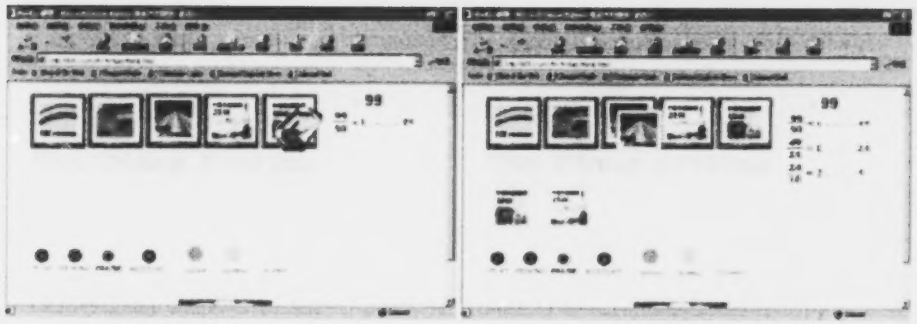
In order to improve the social communications for students in this asynchronous learning environment, we provide some interactive facilities:

(a)Bulletin board: This is an area for learners and teachers to post their idea, suggestions, questions, ...etc., on the web pages remotely. They could share the learning experience or learn from peers without the limitation of time or space.
(b)Paper up-loading: A web interface is provided for users to up-load their finding of new research papers on algorithms.

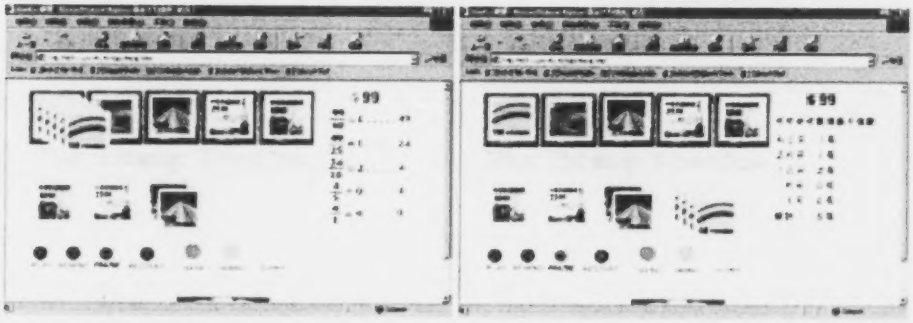
3 Interactive Algorithm Animations

Algorithm animations might be an effective tool for understanding the behavior and abstraction of algorithms. However, most approaches mentioned in Section 2 have focused on much sophisticated graphical depictions and not on the process of how learners construct their comprehensions via animations. As a way, two categories, static animation and dynamic animation, are considered in our virtual classroom. The former cannot be changed once built, while the latter might be changed according to some predefined parameters. We call the dynamic animation as interactive animation if the learners can assign values to those parameters in an on-line manner. The learners can choose either one to observe the actual data moving and to demonstrate their abstract concept. A control panel is provided for learners to control the running speed.

The static animations by Director offer multimedia presentations. Figure 3 illustrates an animated example of solving the stamp problem, which is to explain the greedy method. The interactive animations by Java allow the learners to change the animated results by assigning input variables with different values. Through observing the various running situations in terms to the given variables, learners can realize how those algorithmic steps are actually executed. It is expected that the conceptual cognition of these abstract strategies can be enhanced via the visualized running examples and the learners' comprehension could be more concrete. Figure 4 shows an example of merge-sort where the number of input instance can be assigned in an on-line manner.



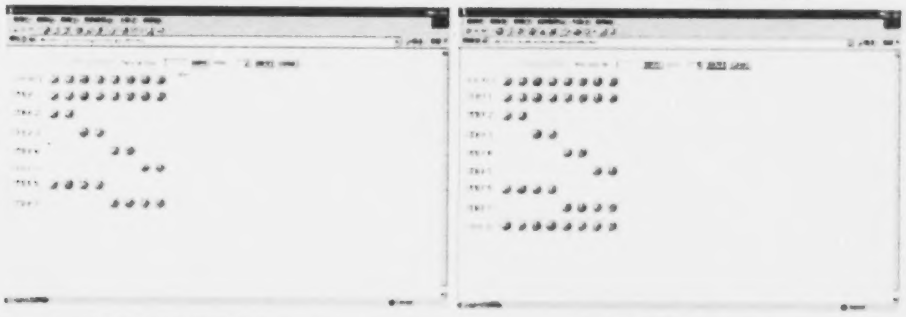
(a) the stamp with largest value is chosed (b) running with greedy



(c) running with greedy (cont.) (d) the final result

Figure 3 The static animation for the stamp problem

(a) input instance is assigned as 8 (b) the left half balls are sorted

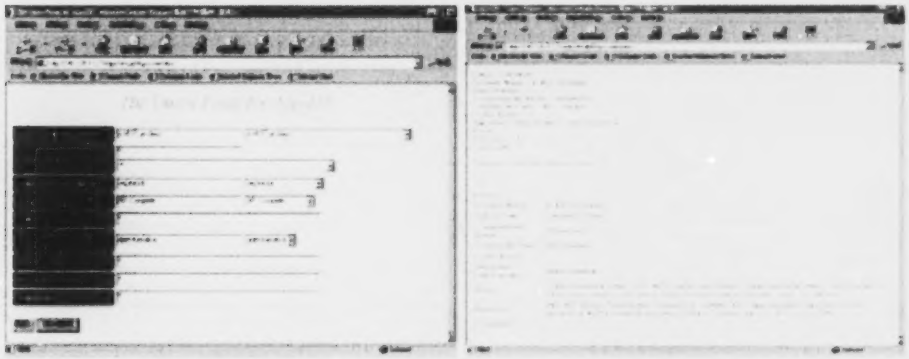


(c) the right half balls are sorted (d) the final result

Figure 4 The interactive animation for the merge-sort problem

4 Reference Database Support

To meet general researchers' requirements, it is designed to supporting query by using various fields such as: problem name, data domain, computational model, complexity class, lower bound, algorithm characteristics, result, reference and comments. It also supports the up-load functionality for interested researchers to up-load their new findings all over the world. This database is valuable not only for the researchers but also for students who could access the newest or related results at their interests. Figure 5 illustrates the query form, where k-MST problem with NP-complete complexity and other constraints are given, and the queried result of our reference database. This service would like to attract interested users' participation to our virtual classroom where discussions via the bulletin board are welcomed.



(a) a query form (b) the quried result

Figure 5 The query and result reference database on algorithms

5 Concluding Remarks and Future Studies

We propose the design and implementation our virtual classroom for algorithms in this paper. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. It is expected that such a learning environment could help students to learn algorithms more effectively at their own pace. The hypermedia courseware will be increased and updated as a long-term project.

The activities in the traditional classroom are simulated to a great extent in our virtual classroom. However, we are not intending to give up the face-to-face interactions. The authors applied this hypermedia courseware on web as a learning assistant in a part of this semester. Students showed interests on constructing their knowledge via the hypermedia courseware and animations. Some students expressed that they supposed to understand the recursion in quick-sort before feeding data to the interactive animation, however they found their misleading after the visualization of data movement in the animation. This is one of the benefits what we intend to give in this virtual classroom. The construction of the knowledge tree is underway to help tracing the learning pattern of learners. Also an empirical evaluation of the learning effect will be studied in the near future.

The reference database gradually gathers interested researchers' attention. The authors would express their special thanks to those who up-loaded their findings of new papers and those who gave valuable suggestions.

References

[1] Brown, M. H., Exploring algorithms using Balsa-II, Computer, Vol.21, No.5, 1988, pp.14-36.
[2] Brown, M. H., ZEUS: A system for algorithm animation and multi-view editing, Proceedings of the 1991 IEEE Workshop on Visual Languages, Robe Japan, Oct. 1991, pp. 4-9.

[3] Carver, Jr., Curtis A., Howard, Richard A. and Lane, William D., Enhancing student learning through hypermedia courseware and incorporation of student learning styles, IEEE Transactions on Education, Vol. 42, No. 1, February 1999, pp.33-38.

[4] Chou, Chien, Developing hypertext-based learning courseware for computer networks: the macro and micro stages, IEEE Transactions on Education, Vol.42, No.1, February 1999, pp.39-44.

[5] Glassman, Steven, Turbo Environment for Producing Algorithm Animations, IEEE Symposium on Visual Languages, 1993, pp. 32-36.

[6] Gloor, P. A., AACE—Algorithm animation for computer science education, Proceedings of the 1992 IEEE Workshop on Visual Languages, Seattle, WA, Sept. 1992, pp. 25-31.

[7] Goodman, J. and Blake, J., Multimedia Courseware transforming the classroom, Computers in Nursing, Vol.14, No.5, 1996, pp.287-296.

[8] Lee, R. C. T., Tseng, S. S., Chang, R. C. and Tsai, Y. T., Introduction to the Design and Analysis of Algorithms, UNALIS, Taipei, 1999.

[9] Najork, M. and Brown, M. H., A Library for Visualizing Combinatorial Structures, IEEE Visualization, October, 1994.

[10] Marchionini, G. and Crane, G., (1994). Evaluating hypermedia and learning: methods and results from the Perseus project, ACM Transactions on Information Systems, Vol.12, No.1, pp.5-34.

[11] Mukherjea, Sougata and Stasko, John T., Toward Visual Debugging: Integrating Algorithm Animation Capabilities within a Source Level Debugger, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 3, 1994, pp. 215-244.

[12] Novick, D. G. and Fickas, S., Collaborative Networked hypermedia education: lessons from the Nero project, International Journal of Computers and Education, Vol.24, No.3, 1995, pp.157-162.

[13] Stasko, J. T. TANGO: A framework and system for algorithm animation. Computer , Vol.23, No.9, Sept. 1990, 27-39.

[14] Stasko, et al, Software Visualization: Programming as a Multimedia Experience, MIT Press, 1998.

[15] Stasko, J. T, Using Student-Built Algorithm Animations as Learning Aids, Proceedings of the ACM Technical Symposium on Computer Science Education (SIGCSE '97), San Jose, CA, 1997, pp.25-29.

[16] Stern, Linda, Sandergaard, Harald and Naish, Lee, A Strategy for Managing Content Complexity in Algorithm Animation, ITiCSE'99, Cracow, Poland, June 1999. pp.127-130.

[17] Sun, Chuen-Tsai Chou, Chien and Lin, Bing-Kuen, Structural and navigational analysis of hypermedia courseware, *IEEE Transactions on Education*, Vol. 41, No. 4, November 1998, pp.347-357.

[18] Thuring, M. Hannemann, J. and Haake, J. M. (1995). Hypermedia and cognition - designing for comprehension. *Communications of the ACM*, Vol.38, No.8, pp.57-66.

[19] Valdes, D., Moure, M. J. and Mandado, E., Hypermedia: A Tool for Teaching Complex Technologies, *IEEE Transactions on Education*, Vol. 42, No. 4, November 1999, pp.361-376.

Agent-oriented Support Environment in Web-based Collaborative Learning

Tomoko Kojiri and Toyohide Watanabe

Department of Information Engineering,
Graduate School of Engineering, Nagoya University
Furo-cho, Chikusa-ku, Nagoya 464-8603, JAPAN

Phone: +81-52-789-2764, Fax: +81-52-789-3808
E-mail: {kojiri,watanabe}@watanabe.nuie.nagoya-u.ac.jp

Currently, the web-based learning support systems are one of interesting and hot topics in points of the utilization of Internet and the application of computers to education. In particular, the web-based collaboration is very applicable means to make unfamiliar students, who are unknown with each other, discuss together in the same virtual interaction space. However, there are some problems derived from the gap between the real world and virtual environment: coordination for discussions, cooperative reactions, comprehension of learning progress, etc. These problems may be dependent on the fact that the actions of students cannot be influenced from the behaviors of others directly.

In this paper, we address a coordination mechanism to promote cooperative actions/reactions for progressive discussions. Our idea is to apply an agent-oriented framework to this coordination mechanism and introduce two different types of agents. One is a coordinator and the other is a learner. The coordinator monitors the learning progress of group and promotes the discussion, if necessary, so as to reach their common goal successfully. The learners are assigned to individual students, and act as interaction mediators among students in place of the corresponding students. Of course, the coordinator is a passive entity and learners are active entities in our collaborative learning space.

Keywords: **Collaborative learning environment, coordinator, learning situation, learner, personal learning history**

1 Introduction

The fast and world-wide enlargement of Internet/Intranet has made it possible that every person can interact instantly without depending on their physical locations. Also, various applications, which are available on the web environment, have been developed with respect to the content-based resource sharing, in addition to the traditional message exchanges. The web-based collaborative learning is one of applications, based on such a hot topic, and has been applied as computer-support for virtual learning space. If their computers were connected mutually through the web-based learning environment, students can discuss their common solving process successively and exchange various solving methods/ideas cooperatively. However, there are some problems to encourage activated discussions among students and make it possible that individual students should understand the correct answer and solving process effectively:

1) students may not participate into the discussion interactively because of their hesitation, derived from the fact that they are unknown with each other;

2) students cannot grasp the behaviors of others directly or indirectly because only the direct actions and reactions are observable through the interactive interface.

These problems are radical drawbacks for collaborative learning.

In order to solve these drawbacks effectively, we propose an agent-oriented support environment for collaborative learning. Of course, the agent-oriented frameworks for the construction of collaborative

learning mechanism/environment have been already investigated until today. Florea[1] proposed a multi-agent collaborative learning environment in the web world. In this environment, three kinds of agents were introduced: personal agent which gets the information according to the requests of each student, tutor agent which generates advices when personal agents asked for the help, and information agent which acquires more information from Internet. Agents are activated by students' requests so that this system environment does not benefit passive students. Ogata, et al.[2] proposed mediator agents in the collaborative learning environment which assist students to find suitable collaborators. The mediator agent for each student holds the corresponding students' profile which indicates the understanding and interesting degrees about knowledge. When a student has problems, his/her mediator agent asks other mediator agents for the learning situations of their corresponding students and specifies appropriate students who may be able to help solving the problems. This research copes with the above problem 1) indirectly because this functionality supports to arrange appropriate learning group, but does not manage the progress of collaborative learning. Nakamura, et al.[3] and Liming, et al.[4] introduced respectively pseudo students which correspond to individual human students. These pseudo students have the same knowledge as the corresponding students and participate in the discussion in their ways if the corresponding students do not join in the discussion positively or cannot understand the discussion stage. These research viewpoints focus on passive students such as problem 1), but do not solve the problem 2). So, in spite of these various agent-based investigations, the previous drawbacks are not always overtaken.

In this paper, we address a collaboration learning environment, organized systematically under two different types of agents: coordinator and learner. The coordinator takes roles to monitor the discussion situation among students, grasp the learning progress and guide the learning process if necessary. The learners are virtual students corresponded possibly to individual students in our web-based collaborative learning environment. The coordinator and learner are complementary entities in the learning environment: the coordinator is a passive entity; and the learner is an active entity as the autonomy for practically participated student. In our investigation, we expect the collaborative learning of high school students who study mathematical exercises together, especially computation for the roots of equations. First of all, we show an overall framework of our collaborative learning environment in the web-world in Section 2. The functionalities about two different types of agents are stated in Sections 3 and 4, and then our prototype system is shown in Section 5. Finally, we conclude our paper in Section 6.

2 Collaborative Learning Environment

In the web-based collaboration learning environment, the actions/reactions of participated students are inherently different from their behaviors to be performed in the real world. Students in the physically constrained learning space can speak with each other by means of face-to-face, feel/recognize activities, occurred from the discussions of students, directly by various sensitive receptors and find out some new events/facts indirectly. Although these are not always implemented adaptively in the web-based virtual learning space, it is necessary to organize a collaborative learning environment in which the logical activities for support of interaction, discussion and comprehension can be implemented successfully and effectively.

Figure 1 shows our collaborative learning environment conceptually, which is characterized by two different types of agents: coordinator and learner. The coordinator places on the center of our virtual classroom (as a network server), monitors the interaction among students and generates advices if necessary according to the learning situation. This interaction is supported on the conversation means through the public communication line. The learner is a pseudo student in our virtual classroom and is assigned to the corresponding student one by one. The learner takes roles of the personal management of interaction interface for the corresponding student, the handshaking control of public communication line, the management of its own private learning history, and so on. In addition, the learner can communicate with other learners directly through the private talking line in order to exchange their personal learning histories.

Since students are studying with limited learning tools in the virtual web-based learning space, they sometimes do not able to communicate naturally. Furthermore, various students participate in the learning group and the learning process is not always completed successfully: i.e. some students are not able to solve the problem, some students are not able to understand the derived answering process after all, and so on. The coordinator solves such drawbacks in the virtual web-based learning space by managing the learning situation globally: the coordinator takes a place of teacher in our classroom activity. For the purpose of resolving inappropriate learning situation stepwisely and guiding

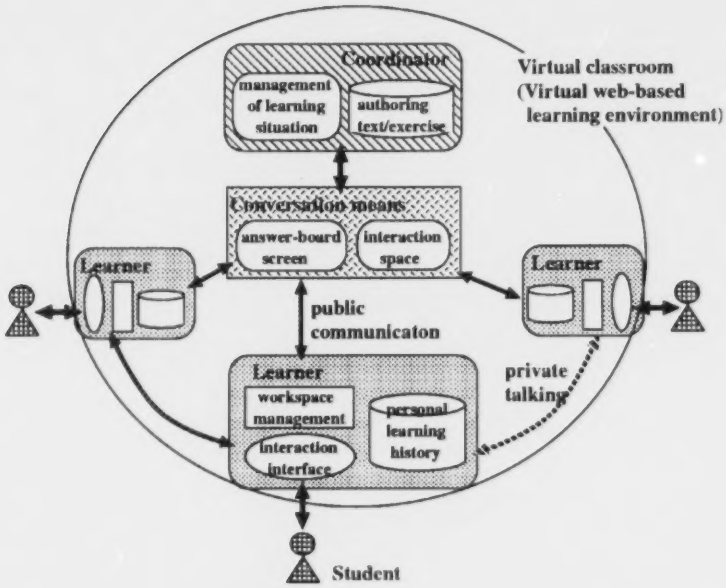


Figure 1: Collaborative learning environment

the learning group effectively, how to model and control learning situation is an important subject. If the coordinator grasps the learning situation appropriately, the advices which were generated from it may give appropriate hints in order for the learning group to proceed to the next phase of learning process. However, it is not always necessary to model the learning situation in detail precisely. This is, we think, because among the learning group students are able to help each other by discussion, so that the coordinator only has to detect the situation which the learning group cannot proceed the learning by itself.

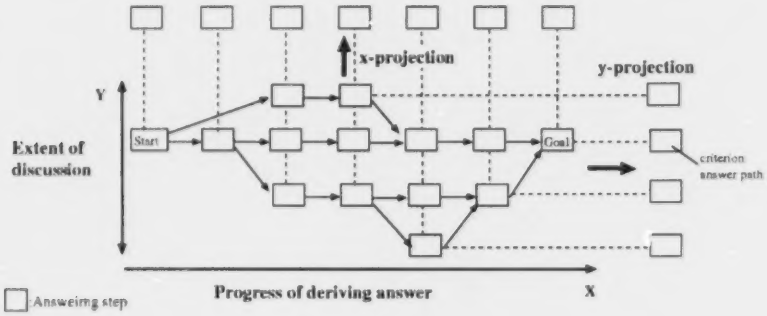


Figure 2: Answer space

The coordinator holds the right answer and the answering paths for an exercise as a knowledge to grasp the current learning situation. When the exercise has several answering paths for the goal, the answer space of exercise is expanded as 2-dimensional network structure, in Figure 2. In this figure, the learning progress along x-axis means the stepwise progress of deriving answer, whereas that along y-axis shows the extent of discussion. If the coordinator grasps the learning situation on the basis of the answering process of network structure as it were, it is very troublesome to manage the eventually

changeable conversation stages successively. Therefore, our coordinator manages the learning situation with respect to the following two viewpoints separately: ratio of derived step for a whole answering process and extent of discussion. By monitoring the learning situation under these points of view, the coordinator is able to grasp the learning situation easier and generate advices timely. In particular, it is necessary and sufficient to manage the learning situation of group globally, but not individually do that of each student.

The learner acts as a network client in place of the corresponding human student in the virtual web-based learning space. This provides not only the interaction interface for virtual learning space attached to the corresponding student, but also the function of indirect interaction among students, so as to judge the understanding levels or personalities of them, which we call the focus function. According to the focus function, students select the opinions of particular students whom they evaluate as key students. In order to realize the focus function, the learner needs to have the knowledge about the corresponding student and exchange it with other learners. Therefore, the personal learning history is prepared for learner, which represents understanding level and personality of corresponding student. The learner constructs and maintains the personal learning history according to the current situation. Exchange of personal learning history is one-to-one interaction so that public communication is not necessary for the focus function. Therefore, we introduce mobile agents called mediators as children of the learner, that take responsibilities for the exchange of personal learning histories among learners. The mediator moves among learners by requesting/carrying the personal learning history on the private talking line.

3 Coordinator

The coordinator grasps the learning situation from two viewpoints: ratio of derived step for a whole answering process and extent of discussion. For the ratio of derived step, which corresponds to the x-axis of answer space in Figure 2, we have already proposed the resolution derivation scenario which represents the phases of deriving answer stepwisely [5, 6, 7]. The scenario is generated by means of projecting the answer space onto x-axis and consists of ordered states which correspond to individual phases of deriving answer. Grasping an approximate learning situation makes it possible that the coordinator generates advices timely and effectively because each state corresponds to the individual ratio of derived step. On our scenario structure, the current learning state is pointed by the indicator *current*, which points out the currently discussing stage. The coordinator infers the current state from student inputs and moves the indicator to the corresponding state. However, the utilization of only one current discussion indicator is not enough to manage the learning state of group sufficiently. In addition to *current*, indicators *upper* and *lower* are prepared for the representation of current understanding levels of learning group. *Upper* points out the state of understanding level which is estimated that best understanding student reached to and *lower* points out the state of worst understanding student did. The coordinator is able to grasp the learning situation on the basis of the relationship among these 3 indicators (Figure 3).

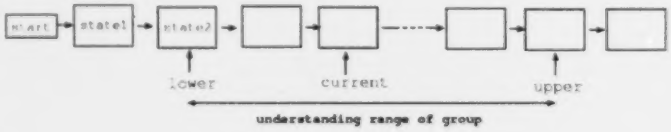
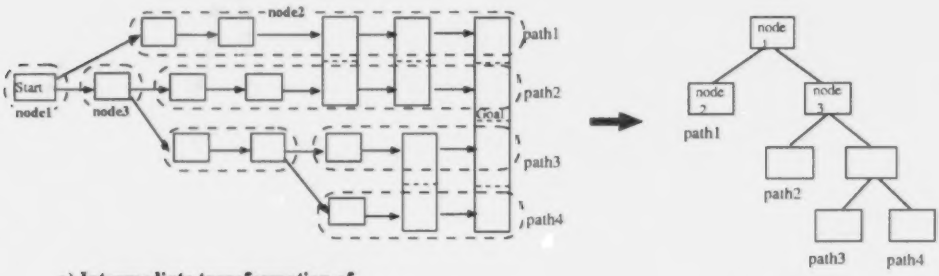


Figure 3: Resolution derivation scenario and indicators

On the other hand, the extent of discussion is estimated by the number of derived answering paths with different discussion viewpoints. The difference of discussion viewpoints among answering paths is defined as the ratio between common and uncommon answering steps. That is, if two answering paths contain large number of answering steps as common part, they are regarded as more similar paths; but if they have many different answering steps, they are judged as different paths. Common answering steps means that the answering methods which are used to derive those steps are the same. Once two answering paths were diverged, the following answering steps may be derived based on different answering methods so that they are regarded to be uncommon. From such viewpoint, the coordinator holds an answer tree which was transformed from whole answering paths as a tree structure. Figure 4

shows the construction of answer tree, derived from the answer space in Figure 2. The answering steps after the divergence are regarded as uncommon steps so that they are copied as different objects(Figure 4a). Then, the answer tree is transformed by means of collecting common answering steps for the purpose of grasping the difference among answering paths. The nodes in the tree are generated as a collection of answering steps that are common to particular answering paths and the path from root node to particular leaf node corresponds to each answering path. When the answer has been derived, the coordinator specifies derived/underived answering paths, calculates the differences between the derived answering path and other answering paths based on the answer tree, and estimates the extent of discussion.



a) Intermediate transformation of answer space corresnponds to Figure 2

b) Answer tree

Figure 4: Construction of answer tree

By grasping the learning situation from these aspects, the coordinator is able to handle the changeable learning situation and generate appropriate advices at the right time.

4 Learner

The learner is situated on each student's computer and acts as a pseudo student in the virtual web-based learning environment. The learner provides the interface to the human student and controls the private talking among students such as focus function. Since the learner connects the private talking line according to only corresponding student's request, it behaves independently with the coordinator that manages the public communication.

A personal learning history is the model of corresponding student which is held by the learner. The personal learning history represents the understanding level and the characteristic of corresponding student. Some data of personal learning history are prepared by the human student beforehand and others are gathered by the learner occasionally through the learning. Currently, the picture and utterances of students are collected as a personal learning history. The feature of student does not change through the learning, so the picture is set by each student before the learning starts. Utterances indicate the understanding level of student and also attitude toward the learning; i.e. active or passive, understanding or not-understanding, and so on. They are gathered and added to the personal learning history by the learner when corresponding student send their opinions to the public communication line.

In order to exchange the personal learning history through private talking line, the learner generates mediators for each communication. The mediator is constructed as a mobile agent which processes its tasks while moving through the network autonomously[8]. Figure 5 shows the movement of mediator for acquiring the personal learning history of other students. When the corresponding student requests to get the personal learning history of particular students, the mediators are generated by the learner respectively. Once generated, the mediators move to the target learners through the network and ask for the personal learning history, attended inherently to the target learners. After the acquisition of personal learning history of target learner, the mediators move back to their original learner and disappear autonomously, since their roles are to acquire the personal learning history from target learners. Under such mechanism, students are able to know other students' characteristics even in our virtual web-based learning environment without any direct interaction.

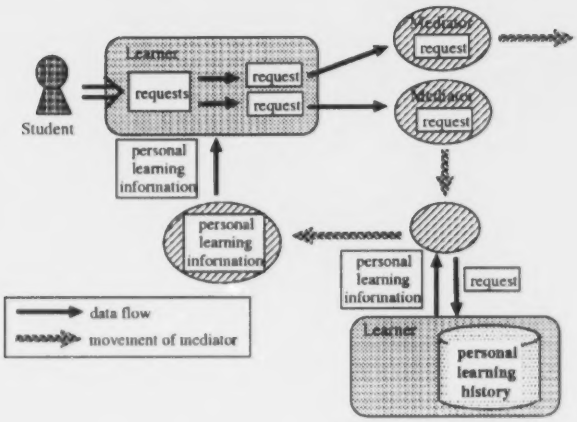


Figure 5: Mechanism for acquiring personal learning information

5 Implementation

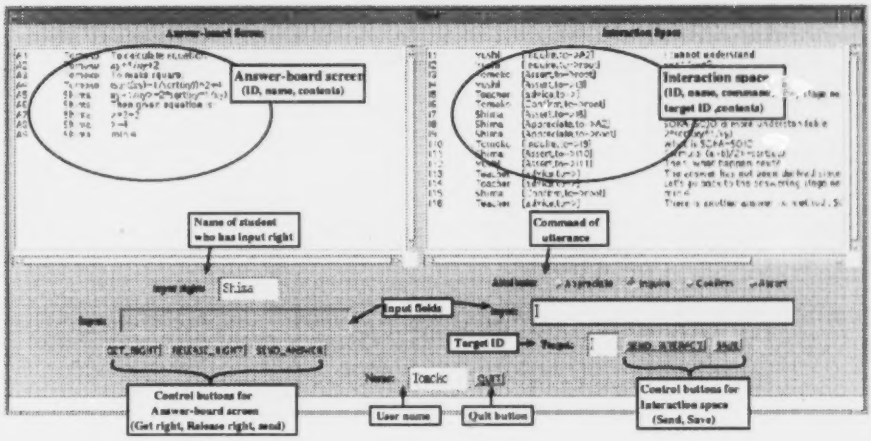


Figure 6: Interaction interface on student operation

We have implemented our prototype system on Internet using UDP protocol, since UDP protocol is suitable to control the frequent interaction of short messages. Figure 6 shows the interaction interface in our system. Two communication tools are prepared: answer-board screen and interaction space. The answer-board screen is a public communication tool which is used to arrange the group's answering process. Only one student is permitted to input on the answer-board screen at a time so that the input right is set. On the answer-board screen, ID, student' name, and contents of input is shown. The answer-board screen functions as a blackboard in our real world. On the other hand, the interaction space is prepared for free conversation so that all students are able to input freely. In order for the coordinator of our system to grasp the learning situation easily, commands that classify the opinions are introduced: Appreciate, Inquire, Confirm, and Assert. Students choose the commands when they input their opinions. In addition to the commands, students specify the target inputs which trigger off their opinions for the purpose of grasping the flow of conversation smoothly. Thus, in addition to the ID, student's name, and contents of input, command and ID of target input are also displayed on

interaction space.

As for the coordinator, we prepared several advices which indicate the states of learning situation when the learning is proceeded inappropriately. Currently, the coordinator generates advices when it detects the following learning situation:

- learning situation has not been changed for a long time,
- some students cannot understand currently discussing stage, and
- students have not derived all viewpoints of solving the exercise.

The coordinator's objective is to activate the discussion, so the advices are generated on the interaction space as the same style as all other students' utterances. Figure 7 shows an example of advices generated by the coordinator. As for the advice, the speaker name is set as "Teacher", the command of advice is "advice", and the ID of target input is nothing because the advice is generated for the learning group but not for individual students.

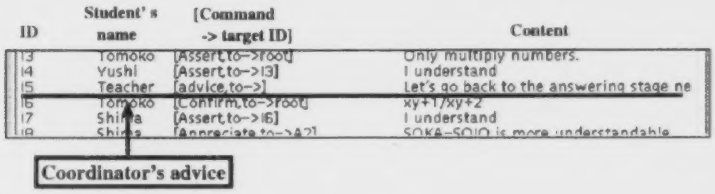


Figure 7: Advice example of coordinator on interaction space

The learners was implemented using AgentSpace[9] as a middle-ware to control the behavior of mediator. Figure 8(a) is an interface for generating requests. On the upper window, the causality of utterances on interaction space is arranged based on corresponding student's utterances. The arrangement of utterances on the upper window helps to decide the focusing students for generating requests. Once a student decides focusing students, he/she inputs IP addresses of focusing students, because mediators need IP addresses where they will work on beforehand in our current version. Then, he/she specifies the file name of focusing student's personal learning history. If a student wants to know only the particular utterances of focusing students, he/she sets the ID's of corresponding utterances shown on the upper window. Figure 8(b) is the result windows of requests for personal learning history. When requests have been completed successfully, the result windows are generated and the personal learning histories of focusing students are shown individually. Currently, the picture of focusing student is shown on the upper window and his/her utterances are shown on the lower window.

6 Conclusion

In this paper, we proposed a collaborative learning environment which contains two different agents: the coordinator and the learner. The coordinator monitors the public communication among learning group and generates advices so as to lead them to their learning goal. For this purpose, the coordinator grasps the learning situation globally from two viewpoints: the ratio of derived step for a whole answering process and the extent of discussion. Although the management structure of learning situation is simple, the coordinator may be able to find the most cases that students are not able to cope with inappropriate learning situation by themselves. On the other hand, the learner controls the private talking such as focus function. The learner holds the personal learning history of corresponding student as his/her characteristics and acquires other students' personal learning histories by generating the mobile agents called mediators. Currently, these agents function independently. However, for our future work, the interactions among coordinator and learners are necessary for the coordinator to generate more effective advices. In addition, the evaluation for the interaction interface of our prototype system and the preparation of more factors for personal learning history based on the result of the evaluation are also our future works.

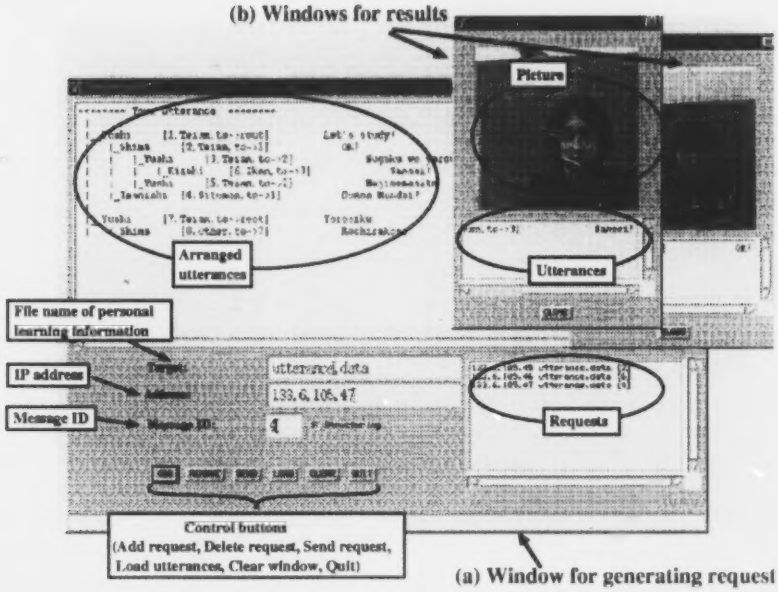


Figure 8: Interface for handling requests

Acknowledgments

The authors are very grateful to Prof.T.Fukumura of Chukyo University, and Prof.Y.Inagaki and Prof.J.Toriwaki of Nagoya University for their perspective remarks, and also wish to thank our research members for their many discussions and cooperations.

References

[1] A. M. Florea: "An Agent-based Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 161–164 (1999).

[2] H. Ogata, K. Imai, K. Matsuura and Y. Yano: "Knowledge Awareness Map for Open-ended and Collaborative Learning on World Wide Web", *Proc. of ICCE'99*, Vol. 1, pp. 319–326 (1999).

[3] M. Nakamura and S. Otsuki: "Group Learning Environment Based on Hypothesis Generation and Inference Externalization", *Proc. of ICCE'98*, Vol. 2, pp. 535–538 (1998).

[4] G. Liming, H. Minghua and Q. Yuhui: "A Web-based Multi-Agent Collaboration Learning System", *Proc. of ICCE'98*, Vol. 1, pp. 205–210 (1998).

[5] T. Kojiri and T. Watanabe: "Cooperative Learning Support Mechanism, Based on Scenario of Specifying Solving Process", *Proc. of ICCE'98*, Vol. 2, pp. 532–534 (1998).

[6] T. Kojiri and T. Watanabe: "Adaptable Learning Environment for Supporting a Group of Unspecified Participants in Web", *Proc. of SITE'99*, pp. 1937–1942 (1999).

[7] T. Kojiri and T. Watanabe: "A Management Method of Leaning Situation in Collaborative Learning", *Proc. of ICCE'99*, Vol. 1, pp. 386–393 (1999).

[8] J. E. White: "Telescript Technology: Mobile Agents", *Software Agents (J. Bradshaw (ed.)), MIT Press*, pp. 437–472 (1997).

[9] I. Sato: "AgentSpace", *http://islab.is.ocha.ac.jp/agent/* (1999).

Building the Virtual Classroom for the New Millennium

Chien-chih (James) Lee, Doctoral Candidate
Technology and Education, Mississippi State University
30 H Wallace Circle, Starkville, MS 39759
cl2@ra.msstate.edu

The virtual classroom has the potential to enhance the educational productivity with a multimedia visual learning environment, broaden capability for global connectivity without the limit of time and space, and reduce costs of distribution while expanding academic territories. The main goals of this article are to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies for the future virtual classroom.

Keywords: **Virtual Classroom, XML, VRML, On-line Conferencing**

1 Introduction

What is a "virtual" classroom? Can the interpersonal dynamics that occur in a face-to-face classroom be replicated in "cyberspace"? Does technology provide ways to broaden the scope and availability of training opportunities to the courts? The Federal Judicial Center (FJC) began exploring these questions in the spring of 1994 (Orlando-Morningstar & Buchanan, 1996). Web-based conferencing uses software, modems, and computers to bring geographically dispersed individuals into a "virtual" classroom for instruction, discussion, and collaboration. Use of on-line conferencing is expanding at all levels of education, particularly in higher education. This was very evident in the number of sessions devoted to on-line conferencing at the most recent EduCause Conference, "The Networked Academy," held in Seattle, Washington, December 8-11, 1998 (Charp, 1999). The virtual classroom is the concept that the world is our classroom, that distance learning serves students wherever they may be (Hawes, 1998). The main goals of this article are to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies for the future virtual classroom.

2 Identifying the Benefits and Limitations

First of all, let us identify the benefits and limitations of on-line conferencing of implementing a virtual classroom in education. This is a supply and demand age. In the early 1980s, institutions of higher education began using on-line conferencing applications to deliver distance education programs. Around the same time, federal agencies, such as the Federal Aviation Administration, used on-line conferences to facilitate group discussions about process improvements and total quality service initiatives (Orlando-Morningstar & Buchanan, 1996). Today, many businesses use on-line conferencing to foster collaboration among employees worldwide. Academic institutions, such as the University of Maryland and Indiana University, offer students virtual university programs that let them attend class without stepping foot on campus. This is the future in education. The point is that we must not only need to understand society's needs, but we also have to know how to meet them. Therefore, we have to analyze and investigate the strengths and weaknesses of this system.

The virtual classroom has the potential to enhance the educational productivity with a multimedia visual learning environment, broaden capability for global connectivity without the limit of time and space, and reduce costs of

distribution while expanding academic territories. T H E Journal (1994) points out that there are other benefits of the virtual classroom. First, students can communicate with instructors without leaving their rooms. On-line conferencing eliminates travel expenses and time normally associated with off-site training. Second, instructors can be more responsive and accessible to students with questions that will create a better learning and teaching environment. Third, the virtual classroom allows personal discussions with instructors from various locations and time zones. Fourth, the virtual classroom can complete group homework without having to meet and can also share graphical information. Fifth, students will be encouraged to ask more questions because of the reduced likelihood of embarrassment or intimidation. Finally, there will be no discrimination against race, gender, age or nationality.

The World Wide Web offers a wealth of information and flexibility to college faculty members trying to improve their courses. However, many teachers/professors do not have the time or technical expertise necessary to put their courses on the Web (Gordon, 1999). In addition, as distance learning becomes more widespread, so do sticky copyright issues (Harney, & Riichards, 1996). Most colleges and universities adhere to the same copyright guidelines in distance learning as they follow in the regular classroom. But a simple copyright infringement that may have gone unnoticed in a traditional classroom may be easily detected in distance learning programs, which, by their nature, have more exposure than regular class work. In addition, showing a copyrighted picture in a class without permission is not a copyright violation, but transmitting the same image to remote sites using technologies such as the satellite or microwave may well be an offense. And if a professor offers a class via distance learning, how can he be sure his lecture notes and class design are not being pirated by someone at a remote location (Harney, 1996). The third problem is that since on-line technology is a new teaching tool, some faculty members and learners are still using the traditional "think" style. They have felt frustrated when trying to use the on-line learning tool. Their frustration could be related to their learning styles and/or to their conservative possible personality.

3 Creating An Interactive Virtual Classroom

Another issue, we must deal with concerns plans for creating a virtual classroom on the Web. Creating the virtual classroom has a lot to offer to anyone interested in designing distance learning (Clemens, Starke-meyerring & Duin, 1999). The more careful the plan, the more efficient the outcome will be. There are three key factors that we need to understand in order to establish a virtual classroom, including dealing with audio-visual equipment, exploring some different characteristics between the virtual classroom and a traditional classroom and conducting instruction for the virtual classroom.

Audio-visual equipment must be set up in the virtual classroom. In a physical classroom there is the standard set of audio-visual equipment, and tools that are available to the instructor. These might include a chalkboard, overhead projector, video cassette player, possibly a sound system, and even a textbook. Professional instructors know how to make the best use of these tools. The virtual classroom will need equivalent equipment and tools in the form of network-based software applications. Some of these virtual tools have a relatively long history on the Internet and provide obvious applications. Others are still emerging and their potential use in a virtual classroom is not yet understood. With the appropriate design, the students should be able to take advantage of these tools without leaving the comfort of their favorite Web browser interface. Dwyer, Dan, and Doerr, (1995) assert that some of those considered for our classroom are as follows. The first is the electronic textbook. In the area of high performance computing an example of a useful electronic textbook is the Computational Science Education Project (ORNL, 1994) sponsored by the U.S. Department of Energy. The growth of electronic publishing on the Internet should ensure a good supply of electronic textbooks over the coming years. The second is the electronic chalkboard. In an electronic course, the instructor might make use of the shared whiteboard offered by a tool like NCSA Collage (NCSA, 1994) to answer a question from a student. Such tools allow images to be displayed, manipulated, annotated, and shared between two people or among a whole group. The third is a video cassette recorder and a sound system. Use of mpeg movies and audio clips can be effective additions to textual materials. Dwyer, Barbieri and Doerr (1994) point out that we might create a "cartoon" to illustrate how messages are passed between processors in a distributed system or record the animated output of a parallel trace tool. The fourth is use of a listserv to redistribute e-mail questions or an usenet newsgroup are simple methods for sharing this interaction. A more dynamic question and answer period could be created using a chat session. For some

types of courses a multi-user, text-based virtual reality, also known as a MUD (Multi-User Domain) or MOO (Multi-user domain Object Oriented), might be effective. An example of an experiment in this area is the Diversity University (Dinsdale, 1994). The fifth is video teleconference.The ability to use video teleconferencing could enhance electronic courses not only by transferring these more subtle forms of communication, but also by providing additional visual and audio cues which help the instructor and students to form an informal rapport. Work on the MBONE (Kumar, 1994) and with CUSeeMe (Cogger, 1994) have much potential in this area.

Different characteristics between the virtual classroom and a traditional classroom must be explored. Orlando-Morningstar and Buchanan (1996) list six rules that govern the on-line virtual classroom. First, an on-line conference is more an appropriate training medium for delivering new knowledge and creating attitudinal change than a medium for building skills. Second, rich content makes for successful training. Participants will continue to log on to an on-line conference if they perceive that they are gaining some benefit from the experience. If they do not perceive a benefit, they will not come back. Third, although the heart of the program will be the on-line presentations and discussions, participants will still need note-taking guides and supporting print-based material. A schedule of program activities should also be provided to serve as virtual beacons for participants as they move from one lesson to another. Next, on-line conferences require more reinforcement than face-to-face participants. Rich content, although critical, is often not enough. To correct this, the authors assert that on-line moderators have learned to remind participants that they need to include the conference in their daily work routine. Telephone calls to non active participants are often the most effective means of reconnecting individuals to the conference. Moderators print a hard copy of the on-line group discussion and fax or mail it to all participants to help them get back into the discussion loop. These and other reinforcing activities are necessary to successful conferences. Fifth, on-line conferences need as much facilitation as do face-to-face meetings. Imagine attending a seminar where the moderator asks a question, group discussion will ensue but dies down after only a few minutes. The moderator, instead of acknowledging participant comments and summarizing the discussion, moves to another question. The participants would either find the program not very interesting or would be quite confused. Finally, some groups just do better than others. Conference moderators will always need to employ their best facilitation skills to bring a group back on track. Sometimes a group conference call will be all that is needed to do the trick.

Instruction for the virtual classroom must be conducted. Getting started may not be easy. How to use the virtual technologies in the curriculum in order to raise academic success is the point. According to Hawes (1998), the following skills are the ones that must be taught in the virtual classroom are the main things to prepare teaching in the virtual classroom. First, teach the students to use the computer. Students suffer from information overload when they first learn about computer programs. They may be learning about operating systems, software, e-mail, and the Internet all at the same time. Consequently, they need lists of steps to follow. An excellent method of computer instruction is to treat it as an independent activity. Give the students a list of steps and let them progress at their own pace. A list of practice application steps that guides them through a simple project will help reinforce the skills. Second, teach the students to search the Internet. Internet search day is even more exciting. The colors and pictures are so enticing that it is hard to get students through the lesson in the allotted hour or so, but they must learn how to use the search engines and how to type in location addresses if they are going to conduct their own searches. Third, teach the students to read the sources. In the reading/study skills classroom or lab, instructors show students how to analyze the information they find on the Internet. Selections they read on the Internet extend and reinforce textbook lessons and issues. Next, teach the students to communicate. Encourage the students to communicate with the instructor about once a week through an office/lab visit or through e-mail to share concerns, questions, or amazing discoveries. Finally, teach students to enhance functional knowledge. An excellent introduction to the Internet for instructors is Randall Ryder and Michael Graves's "Using the Internet to Enhance Students' Reading, Writing, and Information-Gathering Skills" in the Journal of Adolescent and Adult Literacy (December 1996/January 1997). These authors continue to contribute so much to the enhancement of the reading classroom.

4 Integrating New Technologies

New technologies in the future virtual classroom must be integrated. Porter (1997) offers a philosophy of distance learning, one that emphasizes the value of using technology to enhance the delivery of quality education

and training but also suggests that educators and trainers think critically about how, when, and where that technology can best be used. As Porter explains, distance learning "requires us carefully to evaluate our instructional methods and the technologies to establish communication among learners and educators/trainers" (xvii). There are several new technologies which will be used more frequently in the future classroom.

First, XML, short for "extensible markup language", standards are too much of a good thing and are the next revolution. XML – the long awaited big brother to HTML – is becoming a reality. On June 22, Oracle announced XML interfaces for major programming languages. Jesse Berst, Editorial Director, ZDNet AnchorDesk (1999), wrote in his article " Four Reasons You're Gonna Love XML" points out the following advantages of using XML. First, a better way to search. Today a keyword search can return thousands of possibilities. Second, a better way to distribute and track information. Today it is difficult to republish content across many sites, and more difficult to track who is reading it. Tomorrow XML will make both a snap. Third, a better way to do business. Today you can browse catalogs online. Tomorrow XML tags will allow data to be customized just for you. Finally, a better way to do business...on the road. Today Web graphics bog down and slow Internet connections. Tomorrow your notebook will download only material tagged as text.

XML is based on the same basic principles as HTML, short for Hypertext Markup Language, the lingua franca of the Web. But HTML is like a generic first-grade reader: simplistic and imprecise. In contrast, XML tags information with precise descriptions that open up new worlds of possibility. After being hyped heavily as a makeover for the Web, XML is starting to measure up. The consortiums and their giant backers are weighing in. Berst J. (1999) states that there are three main events influencing impact of XML. First, Oracle's announcement XML components that interface to development languages including Java, C and C++ on June 22, 1999. Second, Microsoft is supporting XML broadly in Office 2000. Third, IBM recently announced it would deliver an XML toolkit as part of its Web Sphere Studio.

Second, Virtual Reality (VR) is more powerful in the virtual classroom than in the traditional classroom. Web pages will make alive with VRML, short for virtual reality markup language and other media technologies. VR is the love of kids even including teenage students and adult learners. Across the nation, researchers and faculty are exploring ways to turn virtual reality into a tool to enhance student learning. VR is accomplished through advanced computers that manipulate complex graphic images with sounds and other sensory information to recreate a high-sensory, three-dimensional experience for the user (Roach, 1997). Its technology can take many forms. The most advanced form, referred to as full immersion virtual reality, gives the user a full-blown experience of a unique space or location by using sensory clothing, goggles with head-mounted display, motion pads, and other special equipment. Full immersion virtual reality is used in complex training situations for flight and other advance machinery. The U.S. military has made extensive use of virtual reality technology to teach flight and combat training.

Roach (1997) points out that project ScienceSpace, a joint venture among George Mason University, the University of Houston and NASA's Johnson Space Center, is using virtual reality technology to introduce students to Newtonian physics, electrostatics, and molecular biology. The project's objective is to help students succeed at parts of the science curriculum that often discourage them from considering or completing undergraduate science and engineering majors, according to Dede. Students are taught complex subjects by being immersed in virtual reality environments that let them see and feel the dynamics of a particular subject. The environments consist of a high-performance graphics workstation, a head-mounted display for sight and sound, a magnetic tracking system for the head and both hands, a 3-D mouse, and a vest. Dede believes Project ScienceSpace can have a major impact because it's directed at students who, if they master the most abstract science subjects, could go on to become highly productive scientists, engineers, and researchers. In "NewtonWorld", the virtual reality environment for exploring Newton's Laws of Motion, students are made to see objects and feel pressure that allows them to experience the concepts of mass, velocity and energy. Institutions must devote considerable resources and funds to engage in virtual reality research. Like other advanced computer technology applications in higher education, virtual reality programs will have to undergo rigorous evaluation if they are to receive funding and support. "VR is always going to be kind of an exotic technology. It's always more expensive," Dede says (Roach, 1997).

Third, build a powerful and adaptable telecommunications system in order to build speed and volume. Hophins (1997) states that the design of a data must incorporate speed and volume. Determine how many users need to

connect, how many to exchange information, and the projected volume of use. The traditional copper-based network often functions below today's standards for speed, and troubleshooting is difficult, which results in high system maintenance and low reliability. The most challenging information aspect is implementing a local-area network (LAN) that will function effectively into the future (Hopkins, 1997). Select the best technology the institution can afford that meets current and projected needs, keeping in mind that there will always be a new technology just around the corner. Hopkins (1997) points out that one of the current state-of the-art technologies is a LAN backbone based on asynchronous transfer mode (ATM) technology, which offers the many benefits. First, fiber-optic equipment increases system reliability. Second, a topology capable of operation uses redundant fiber paths and is capable of supporting exponentially growing data requirements. Third, a network management station monitors the network and provides warnings and alarms to alert network administrators to imminent problems with the system. Finally, a fiber -based ATM data network will support more users than the copper-based network and offer greater speed and performance.

Fourth, conferencing software plays a key role in the innovative university project. Due to an increasing number of off-campus students it was more difficult to coordinate appointments and physically meet with teaching assistants and other students. Hectic schedules the night before an exam make it hard for teaching assistants to accommodate all students and their questions. Finally, both students and teaching assistants are looking for more efficient ways to use their time. The University of Illinois at Urbana-Champaign (UIUC) states that the Oakley's conferencing program allows students to send color text, graphics, digitized voice recordings and hand-drawn equations or circuit diagrams over the network to a central bulletin board (T H E Journal 1994). A faculty member or another student can use the network to respond to a student's posting or inquiry for help, or join in an on-line discussion--all using data files, pictures and sounds. Structured on a bulletin board model, PacerForum allows many users to collaborate on various projects in different locations at different times. Students post messages that can include texts in various fonts, sizes and colors, screen shots, pen-based graphics and digitized voice recordings. The multimedia format helps facilitate clear and precise communication, especially useful in this technical discipline. The University of Cincinnati solved the problem by developing a model "virtual classroom", that can be used by anyone teaching a course at its main campus or at any of its branch campuses.

The system, known as "Classware," was developed jointly by Academic Information Technology Services and the Center for Academic Technologies (Gordon, J. 1999). That is an advantage for the students as well as the faculty. Even a faculty member who knows nothing about HTML coding can take advantage of Classware. Classware requires very little knowledge about HTML. Now publishing on the Internet is as simple as filling out a form and making a few choices. It takes about 10 minutes to set up an electronic classroom. There's no paper, no waiting in line. Other similar programs are WebCT and Bllackboard. WebCT is shorted for "Web Course Tools", which is a networked system designed to aid in the delivery and facilitation of online instruction and learning. It was developed by the University of British Columbia and is presently being used at varying levels by a variety of educational institutions worldwide. WebCT is a powerful tool that includes course design, question post, live chat, and student data management. It is charged by using a license. Blackboard can be downloaded free on the Internet.

5 Conclusion

In conclusion, the purpose of the virtual classroom is no different than that of the traditional classroom. However, life-long learning and off-campus students are increasing. Many advancement in education technologies are involved in the virtual classroom of the future. Those improvements will reinforce the education system. Curriculum Review (1998) reported that U.S. kids lead the computer technology revolution. Most American children feel quite comfortable in front of the computer screen, a recent Roper Reports Worldwide study reveals. Some 67 percent of U.S teens had used a computer in the past month. About 54 percent reported using computers at home, while 78 percent had used them at school. The virtual classroom is essential for the 21st century in education. To prepare for the next generation, we need to identify the benefits and limitations of on-line conferencing, create a virtual classroom for interactive education on the Web, and integrate new technologies in the future virtual classroom.

References

[1] Barker, B., Frisble, A., & Patrick, K., Broadening the definition of distance education in light of the new telecommunications technologies. The American Journal of Distance Education, 3(1), 20-29, (1989).

[2] Berst, J., Four reasons you're gonna love XML. ZDNet Anchordesk, http://www.zdnet.com/anchordesk/story_3533.html.. (accessed on July 1, 1999).

[3] Clemens, L., Starke-Meyerring, D., & Duin, A. H. Book review., Journal of Business & Technical Communication, 13(1), 101-102. (1999).

[4] Curriculum Review, 38(1), 1. (1998).

[6] Dwyer, Dan, Barbieri K. and Doerr, H. M). Creating a virtual classroom for interactive educationon the Web, http://www.igd.fhg.de/www95/proceedings/papers/62/ctc.virtual.html, (accessed on June 23, 1995).

[7] England's Journal of Higher education & Economic development, 11 (3), 47-48. (1996).

[8] Gordon J,. Getting faculty and classes on the web. Community College Week, 11(18), 7, (1999).

[9] Harney, O. J., & Richards, J., Copyrights and the virtual classroom Connection: New England's Journal of Higher Education & Economic development, 11 (3), 47-48. (1996).

[10] Hawes, K. S. (1998). Reading the internet: Conducting research for the virtual classroom. Journal of Adolescent & Adult Literacy, 41(7), 563-565.

[11] Hopkins, C., Entering the digital age. American school & University, 69(3), 3. (1997).

[12] NCSA., NCSA Collage. (1994). http://www.ncsa.uiuc.edu/SDG/Software/Brochure/UNIXSoftDesc.html#XCollageNCSA. (accessed on March 2, 2000)

[13] Ronald, R.,The virtual Classroom. Black Issues in Higher Education, 14(18), 20-23. (1997).

[14] T H E Journal, 22, 79-80. (1994).

[15] ORNLCUSeeMe. Cornell University. ftp://gated.cornell.edu/pub/video/. (1994). (accessed on March 12, 2000)

[16] Orlando-Morningstar, D. & Buchanan M. J., The virtual classroom: using on-line conferencing to deliver training and education. Federal probation, 60(4), p11. (1996).

[17] Porter, L., Creating the Virtual Classroom: Distance learning with the internet. New York: John Wiley. (1997).

Design and Implementation of A N-Tiered Heterogeneous Virtual School Administration System

Huang Gooshyon
Tamkang University Information Center
151 Ying-chuan Road, Tamshui, Taiwan 251
Tel: +886-2-2621-5656-2681
E-mail:georgehw@mail.tku.edu.tw

There are two types virtual school administration systems, web-based or voice-based, which are currently used by students. They are systems with different access mechanisms but same business logic, and require two times of resources for development and maintenance. Whenever the business logic of the systems changes, both of the systems need to be implemented. As the wireless communication grows more popular, the school has been considering adding a wireless interface to the system. However, with current architecture, the only way to add a wireless application protocol (WAP)-based system is to implement an additional system from scratch. Since the voice-based system and the web-based system have the same business logic, they can be integrated into one. We can dedicate an application server for the business logic, which interacts with the web-based interface and the voice-activated interface with a set of application programming interface (API). With the extraction of the business logic and the business logic API, developers for the voice-activated interface and the web-based interface can implement the interfaces without specific knowledge of the business logic of the system. With this design and architecture, the system can be further expanded to support a WAP-based interface and other interfaces easily.

Keywords: **Internet, wireless, virtual school, heterogeneous**

1 Introduction

The Internet is widely used for school education, especially virtual school education [2][3][4]. The advantage of the Internet is its capability of supporting multimedia and its attractiveness to the user. For the virtual school education, the students study via the Internet. They do not have to be in the classrooms of a school and can learn at anywhere at anytime. However computers and communication networks are needed to support virtual education through the Internet. The cost of the computers and setting up the communication networks is very expensive. Thus, the systems are not available everywhere. Furthermore, system interfaces must be developed in order to allow the users to access the computers and the networks. The purpose of these system interfaces is to provide an easier way for the students to access the systems and to allow the students to interact with the instructors real-time. Those systems interface do not need to be attractive and colorful since its main goal is to provide a mechanism for the students to access information real-time. For a web-based system, the homepage can be design in a way to reduce the network traffic and system load. However, not every student can access the computers and the networks due to his financial situation or the load of the system. For the students who cannot access the computers and the networks, the telephone (the voice activated based interface) provides another popular access media. Therefore there are needs for systems to support both telephone (voice- based) and web browser (web-based) interfaces [1]. The web-based system is more visual and more user friendly, however, the voice-based system is more convenient, more affordable, and requires no hardware investment from the students. As the technology evolves, the wireless communication is gradually taking over the traditional wire line communication. To support the wireless communication the system will need to be expanded to support the wireless application protocol (WAP)-based interface [10].

Originally, a couple of the school administration systems we had can be accessed via a regular telephone or via a web browser but not both. They were basically two different systems, though they support the same business logic. Both of them have their own user interface and system logic and were designed, implemented, and maintained separately. To support them two sets of resources are needed. The original system architecture is shown in Figure 1. Developers for both of the systems handle both the business logic's and the user interface's design and implementation. Whenever the business rule changes, both of the systems need to be modified and updated. It is very costly and difficult to keep both of the system consistent.

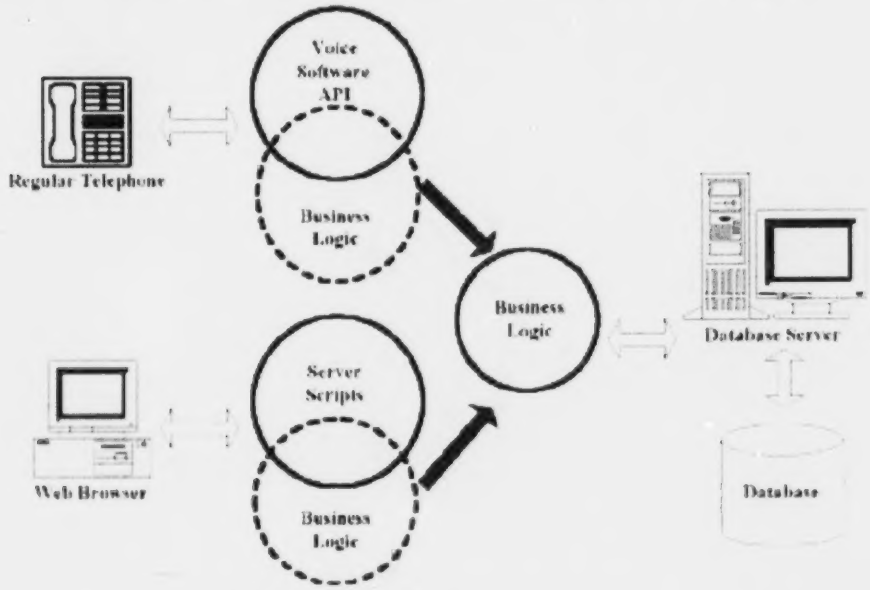


Figure 1. Logic view of voice system and web system

To reduce the maintenance cost of the two systems and to make them easier to be upgraded and expanded, we have proposed to integrate the two systems by extracting the business logic module out of them and migrate it into an application server. The remaining of the systems is migrated into a web server and a voice server respectively. By doing this, we dramatically reduced the cost of maintaining the system. After the architecture change, whenever there is a business change, only the application server is affected. We reduced the maintenance cost by 50%. No more concerns about the consistency of the systems. With the modification of the system architecture, we make it more scalable and expandable. The system can be easily expanded to support other access media without making changes to the application server. For example, to support a WAP-based interface, a WAP server can be easily introduced and integrated into the modified system architecture.

2 System Architecture and Implementation

2.1 Architecture

The administration system is an N-tiered system.

- Data Services Tier: The database services and implementations.
- Business Logic Tier: The business rule of the system.
- Translation Tier: Translate the I/O between application server and gateway server. For the voice-based system, the gateway server is the voice server. The purpose of the voice server is to translate PSTN and HTTP between application server and usual telephone. For the web-based system, the translation tier is transparent; it does not do anything. For the WAP-based system, the WAP Gateway is the gateway server. The purpose of WAP Gateway is to translate the WSP/WTP and HTTP between WAP telephone and web server.

- Presentation (UI) Tier: The input and output of the web-based system is HTML. The input and output of the voice system is the key press and voice of usual telephone. The input and output of the WAP-based system is WML [10].

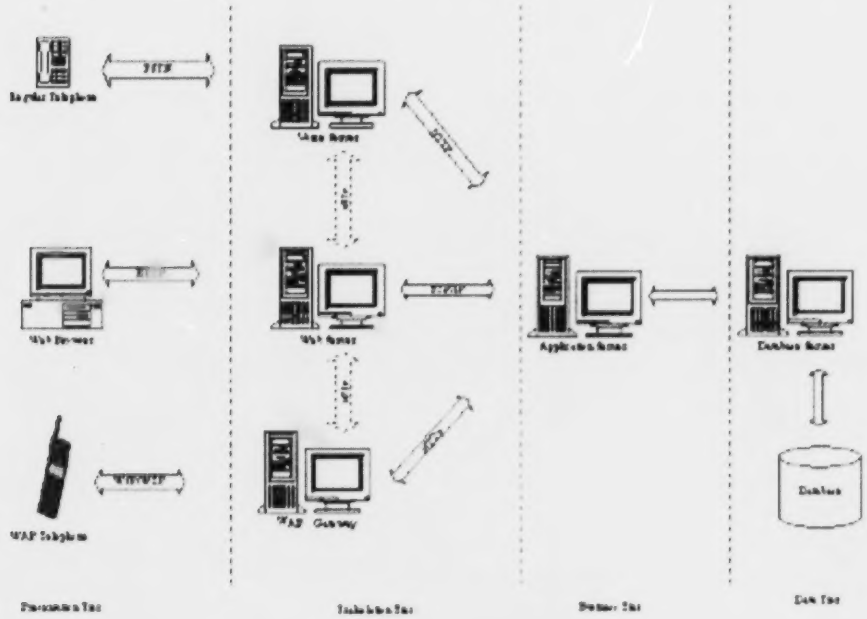


Figure 2. System Architecture

In the Architecture, the application server is the most important part. The application server needs to process business logic and interact with voice server, web server, and WAP Gateway. Because the protocol between the application server and the voice server and the WAP Gateway is HTTP protocol, we can set the application server and the web server in the same machine. The developers of the application server are more responsible, because they must handle business rule, HTML and WML. The developers of the other systems implement User Interface and do not have the knowledge of business rule of the system, because the developers of the application server handle the business rule. The application server sends different output format to different systems by parameters. Under the Architecture, after building the web system, the other systems are easily to build.

2.2 Architecture of the Voice System

Because taking business logic out of the voice system, the function of voice system is coherent. It translates the output of web server to telephone. The output format of web server is HTML. So the voice server has to simulate to web browser, shown as in Figure 3.

Figure 3. The communication methods are between voice server and web server.

3 Case Study

The Enrollment System of the Tamkang University [7] is designed and implemented following the architecture of this paper, shown as in figure 4. The system has been deployed and used by thousands of concurrent users [8].

3.1 Hardware Structure

We used thirteen Pentium based servers to implement the system. Six of them are used as the web servers. One machine is used as the UNIX Gateway. One server is used as the alert and automating email server. Four voice servers are used to support the voice activation. Finally, all student enrolment information is stored in one database server. The network hardware are two 100 MB/sec switch hub.

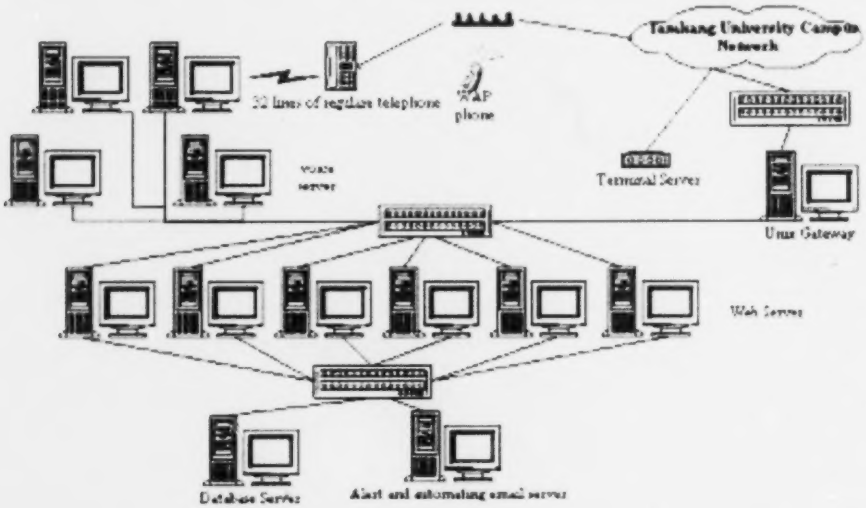


Figure 4. System Hardware Structure

3.2 System Software

OS: Microsoft NT4.0 is used for the web servers, voice servers, and the alert and automating email server. Free BSD 3.0 is used for the UNIX Gateway [8].
Web server: Microsoft IIS 4.0.
Database: Microsoft SQL Server 6.5.

3.3 Load Balancing and Scalability

To make the system suitable for all schools, we also took into considerations of the cost of hardware and the scalability of the system. A set of low-end servers can be grouped together to replace a high-end server[6]. To achieve this, a DNS server is needed for the load balancing work. The simple round robin methodology is used for the load balancing. With the current flexible four-tiered architecture, servers can be added into the system to share the performance load whenever the system load is heavy[9].

3.4. Security

Two security strategies are used to increase security:

1. Packet filter: It only allows IP packets through port 80 to access the web server, the packets of the other ports can not pass through. The web system can avoid being attacked by the other machines.
2. Supports multi-protocol: TCP/IP protocol is used between the web server and outside systems. IPX protocol is used between the web server and the database server. The web server should be hacked, the database server is kept away Internet and the database is still safe.

3.5. Network Management and Monitoring

The alert system has the following features:

1. Monitoring the system: It sends to keep-alive message to web servers, voice servers, and database servers in every period.
2. Network management system: Checks network traffic between web servers, voice servers and database server.
3. Auto Backup the data of database server.

3.6. User Interface Design

One of the most important criteria of the virtual school administration system is to let students access and retrieve correct information real-time. The user interface must be simple to reduce network traffic and system download time. The homepages for the web system and WAP are simple and straightforward to improve system performance. The look and feel of the WAP homepage depends on the WAP telephone the user users. An Ericsson r320 model WAP homepage is shown here as a sample WAP homepage. We can compare the home pages for the web system and WAP system.

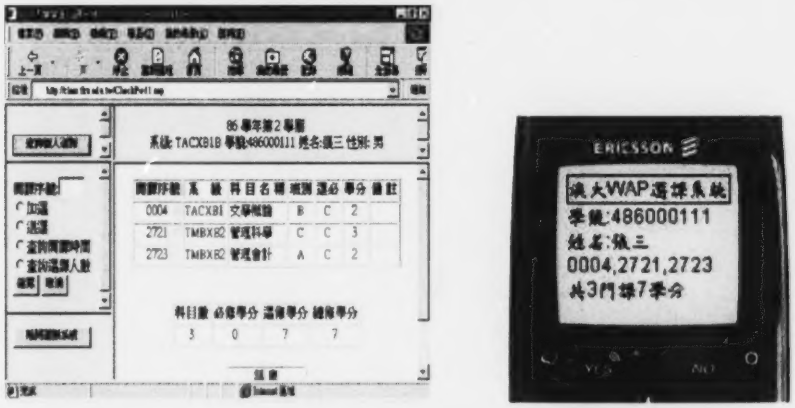


Figure 5. The display of the homepage of WAP-based system

3.7 Log statistics and analysis

Duration of enrollment period, the system generates the log automatically everyday for statistics and analysis, as shown in Table 1.

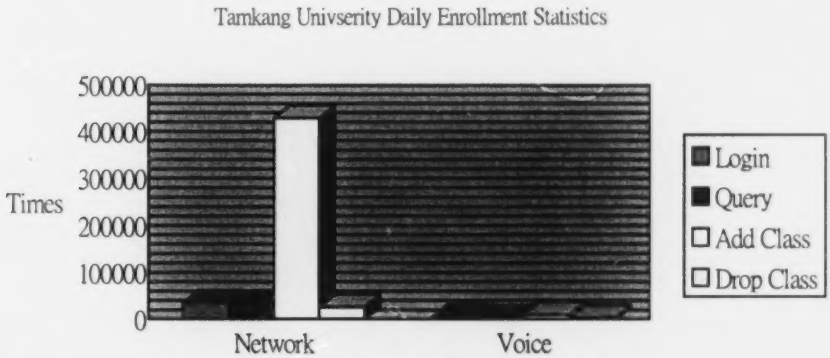


Table 1. Tamkang University Daily Enrollment Statistics

By comparison, the load of the web system is much heavier than the load of voice system. Since the voice system has 32 telephone lines, it can only support 32 concurrent users. In the peak hour of the enrollment (the first hour of each grade enrollment), the load of the web server is high.

We expect the voice system and the WAP system to be fully loaded during the peak hour. A dedicated business logic-processing server is used for the voice system and the WAP system. Since the telephone lines of the voice system and the WAP system are limited (up to 32 lines), a dedicated web server for the business logic processing of the voice system and the WAP system is sufficient.

4 Conclusions and future development

The development and maintenance resource of the heterogeneous systems depends on how many access media. The more access media, the more resource it needs. My proposal has the following advantages:

- Resource Reducing: Because the business logic is centered, heterogeneous systems need one business-logic process only, the resource of development and maintenance is less than usual systems.
- Expandability: With the N-tiered system architecture design, the business logic system was designed and implemented to support different UI systems. Different UI access method can be easily added into the system.

In the system, the application server interacts with voice server and WAP Gateway on HTTP protocol., so the application server must have functions of the web server. We can develop a new structure of the application server for voice-based system and WAP-based system, and the application server interacts with the voice server and WAP Gateway on TCP/IP.

References

[1] C. Chou and C. T. Sun, "A Computer Network-Supported Cooperative Distance Learning System for Professional Communication Education", IEEE Transactions on Professional Communication, Vol. 39, No. 4, pp. 205-214, (1996).

[2] Colin McCormack & David Jones, "Building a Web-Based Education system", John Wiley & Sons, (1998).

[3] Dwyer, D., Barbieri, K.& Doerr, H. M., "Creating virtual classroom for interactive education on the Web", Computer Networks and ISDN Systems 27, pp. 897-904, (1995).

[4] Nian-Shing Chen, "Web-based Learning Environment", Information and Education, Vol. 64, April, pp. 2-13, (1998).

[5] C. T. Sun, C. Chou & B.K. Lin, "Structural and Navigational Analysis of Hypermedia Courseware", IEEE Transactions on Education, Vol. 41, No. 4, CD-ROM, November, (1998).

[6] Chen-Chung Liu, Gwo-Dong Chen, Kuo-Liang Ou, Baw-Jhiune Liu & Jorng-Tzong Horng, "Managing Activity Dynamics of Web Based Collaborative Applications", International Journal of Artificial Intelligence Tools, Vol. 8, No. 2, (1999).

[7] Gooshyon Hwang & Chao-Tsong Fangtsou, "Introduction of Tamkang University Enrollment System", Ministry of Education Computer Center Newsletter, Vol.8802, (1999)

[8] Jack Chou, "NT Dynamic Web Server Design", Unalis Company, (1997)

[9] J.J.P. Tsai, S.J. Yang & A. Liu, "An Integrated Architecture for Distributed Real-Time Systems Analysis", in IEEE Second World Conference on Integrated Design and Process Technology, Austin TX., pp. 152-159, (1996) Dec. 1996

[10] WAP Forum, http://www.wapforum.org/what/whitepapers.htm (accessed on July 1, 2000)

Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology

LO Ting Kau*, AU Wing Kee, and YIP Wai Ming*****
The Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T., Hong Kong
*E-mail: * tklo@ied.edu.hk, ** wkau@ied.edu.hk, *** wmyip@ied.edu.hk*

Design and Technology (D&T) as a school subject aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society. Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. This article discusses the ways that IT can be made relevant to the learning and teaching of D&T and in teacher education. It then describes the development of an ongoing project[#] which aims at developing an IT-immersion environment to enhance learning and teaching of D&T at a teacher education institution in Hong Kong. The setting up of this information-rich, collaborative learning environment is to complement "traditional" lab-based approach to learning and teaching of Computer Aided Design (CAD) and Computer Aided Manufacture (CAM).

Keywords: **IT-immersion, Learning Environment, Design and Technology, Teacher Education**

1 Introduction

Design and Technology (D&T) as a school subject "aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society." [3] Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. [5] IT is also being regarded as an effective tool for learning and teaching D&T in two main areas, namely:

- ***IT as a tool.*** IT can support many aspects of designing and making in D&T. For example, information processing and presentation, modelling, computer-aided design and manufacturing, control and communication.
- ***IT as a source of knowledge.*** Here, IT is being regarded as a source of knowledge to learn about materials, equipment, designing and manufacturing. This encompasses CD-ROM information systems, and the use of local or online databases accessible over the Internet. [2] [6]

2 IT in Education Policy in Hong Kong

The Hong Kong Special Administrative Region (HKSAR) Government launched its IT in Education Policy in 1998. [1] [5] According to this policy, Hong Kong teachers will be required to reach different levels of IT Competency in Education over the next few years; and IT-supported instruction will become one of the essential instructional strategies in future. Consequently, teacher education institutions in Hong Kong will be

[#] The project entitled "Development of an IT-immersion Environment to Enhance the Teaching and Learning of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)" is supported by the Teaching Development Grant (TDG) administrated by the HKIEd, which is granted by the University Grants Committee (UGC), Hong Kong.

required to integrate in their pre-service programmes IT competency elements such as producing courseware, applying the skills of computer-aided instruction, and using various electronic networks for peer support and collaborative learning.

3 The Project

The following sections describes an ongoing project which aims at developing an IT-immersion environment to enhance learning and teaching in D&T at the Hong Kong Institute of Education (HKIEd), the major provider of D&T teacher education in the territory. This project is a response to the HKSAR Government's urge for the integration of IT to enhance the effectiveness of learning and teaching in teacher education institutions. [1][5] The initial target group of the project is student teachers undertaking D&T at the Institute. This target group will continually widen and might eventually include practising teachers in D&T and other technology-related subjects in Hong Kong secondary schools.
The project aims to:

- develop an IT-immersion learning environment for student teachers majoring in D&T, especially focused on areas of CAD and CAM;
- develop appropriate courseware for the enhancement of learning and teaching of basic and selected topics on CAD and CAM;
- develop an appropriate web-interface for students and staff to enhance face-to-face classroom interactions;
- enable students to appreciate modern techniques of product design and prototype making through the use of CAD and CAM technologies.

4 IT-immersion Learning Environment for D&T

Davies [4] suggests that an ideal learning environment for D&T is one where the learners have maximum autonomy and are working on self-directed projects and teachers are constantly assessing with pupils where they are and where they need to go. The IT-immersion learning environment under discussion utilises some of the attributes and resources of Web-based learning and adopts a constructivist approach to create a meaningful learning environment where learning is fostered and supported. This IT-immersion environment, we believe, would facilitates greater interaction between the teacher and students, and students and students; assist D&T student teachers transit to the new mode of learning and teaching, and enable them to develop habits of life-long learning. To effect the paradigm shift from a largely teacher-centred approach to a more interactive and learner-centred approach, it is important that D&T student teachers appreciate the need for the change and are receptive to the challenge of taking up their new role as a learning facilitator in future.

Key features of the IT-immersion environment include:

- ***Learner-centred, time and space independent learning***. With the use of Web-based instructional materials, students are allowed to progress at their own pace and at any time and space.
- ***Changing Roles of Teachers and Students***. In the IT-immersion environment, the role of the teacher changes from knowledge provider to that of facilitator and guide. Conversely, students are no longer passive learners. They become participants, collaborators in the creation of knowledge and meaning.
- ***Self-directed Learning***. One increasingly important competency in the future society will be "self-directed learning". In the IT-immersion environment, students continually learn to use IT tools for the accessing, processing, and transformation of information into new knowledge.
- ***Just-in-time Learning***. "Just-in-time learning" [7] implies a high level of individualisation and self-direction in the learning process. Each student learns just what he/she needs at the time when he/she needs it. This is a radical diversion in the instructional delivery system from place-based and time-fixed group instruction to one that is fully under learner-control.
- ***Individual differences accommodated***. Learning is a complex process that takes place as an interaction between learners and their environment. The interactive multimedia and hypermedia capabilities of Web-based and CD-ROM based instructional materials would enable student control over timing and pacing and provide interactivity and active learning.
- ***Collaborative / Cooperative Learning***. Collaborative learning in this IT-immersion environment regards that both teachers and students be active participants in the learning process. The Web, for

instance, presents an especially good environment for asynchronous collaboration in which students work together but not necessarily at the same time. This IT-rich environment also provides ground for cooperative learning that students and teachers interact together in order to accomplish a specific goal or develop an end product which is content specific. For instance, an ad-hoc group of students, teachers, and perhaps outside experts, can come together for a particular task or design project. The group splits into distributed design teams to tackle design challenges. The design teams interact over the computer network, working cooperatively and drawing on different expertise. The design is shared over the network, evaluated, and combined into an integrated artefact or system.

It is perhaps worthwhile pointing out that in an IT-immersion learning environment, IT is still considered as a supportive tool. Its introduction supplements, and indeed may change the "traditional" learning and teaching approaches in D&T. However, it is not intended to and will not replace traditional teaching altogether. For one reason, D&T is intrinsically an action-based subject. Engagement with designing and making requires students to be active cognitively and physically. Besides, lab-based activities serve a variety of different purposes that would be unlikely replaced by other means [8], for example: (a) first hand experience of using a variety of materials, equipment and processes safely; (b) actually realise high quality products, test them and evaluate them in use; and (c) face-to-face interaction among peers and the tutor.

5 Basic Components

The IT-immersion environment comprises two major components, namely: (a) the physical component, and (b) the virtual component (Figure 1).

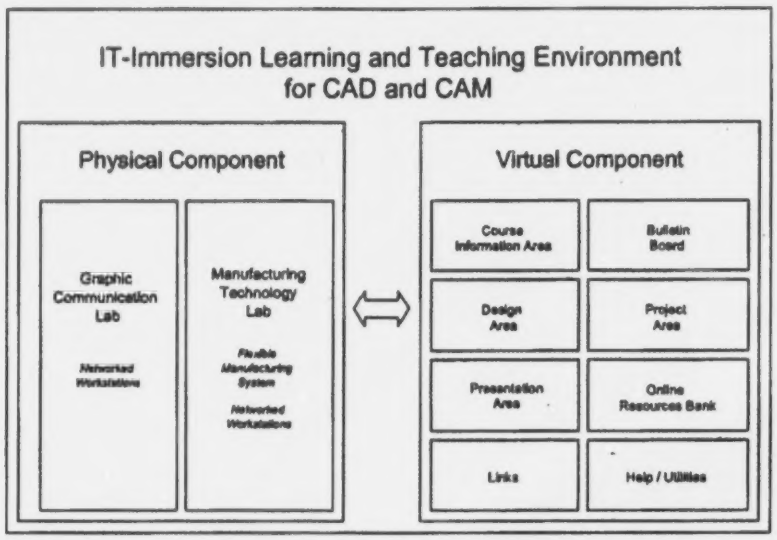


Figure 1. Major Components in the IT-immersion Learning and Teaching Environment.

The ***Physical Component*** includes facilities installed in the two labs at the HKIEd for CAD and CAM:

- ***Manufacturing Technology Lab***: A Flexible Manufacturing System (CNC Lathe, CNC Mill, and Robot), a CNC micro-router, 15 networked PC workstations, video-conferencing systems, appropriate software and peripherals, etc.
- ***Graphic Communication Lab***: 21 networked PC workstations, video-conferencing systems, digital camera, appropriate software and peripherals, etc.

The ***Virtual Component*** of the IT-immersion environment include:

- ***Course Information Area*** - for students to gain access to course-specific information such as course outlines, schedules, course materials, assignments and other course-related information.
- ***Bulletin Board*** - for teachers and students to post up announcements.
- ***Design Area*** - for supporting both synchronous communication (e.g. real-time interactive chat, used to brainstorm with teachers or peers) and asynchronous communication (e.g. e-mails) to facilitate design activities. For example, students can "talk" online and discuss their design ideas via video-conferencing and/or Internet technologies with peers, teachers or experts outside the campus who can provide them with suggestion for improvement on the design. Digital cameras can be used to record the development of models/products and to present design ideas.
- ***Project Area*** that houses students' individual and collaborative design projects. A Data Bank will be set up for students to store their design works. The Data Bank will become a central design database, accessible by all members of each of the design and manufacturing teams to ensure that all team members are working with identical information.
- ***Presentation Area*** - for students to present their projects and showcase their design work beyond the classroom and to a wider audience.
- ***Online Resource Bank*** - for teachers to upload and retrieve interactive instructional and reference materials.
- ***Internet links*** - to support teachers and students using the Internet to locate professional materials and content resources in D&T and other related disciplines.
- ***Help / Utilities.***

6 IT-enhanced Activities and Learning Experiences

In the IT-immersion environment, student teachers are provided with the opportunities to use IT to explore, develop, model, communicate and realise their design ideas in a variety of ways. As such, IT becomes an integrated and natural part of their study in D&T. More specifically, to take as an example, video conferencing technology can be used as an effective medium for developing new ways of learning and teaching D&T and introducing teachers and students to various aspects of information, communications and design technologies. Using the latest information and communications technology provides the opportunity for expertise and resources to be made available to pre-service and practising D&T teachers off-campus from the HKIEd. Via video conferencing systems or the Internet, they can work collaboratively together on concurrent design projects, discuss problems and jointly solve them, and exchange ideas and information.

In brief, working in an IT-immersion environment would help D&T student teachers to understand how to become discerning users of available hardware and software. This in turn, would help them to understand what IT can and will do to enhance their future pupils' learning in D&T.

7 Conclusion

This paper discussed the potential of an IT-immersion approach to provide D&T student teachers with a richer, more meaningful education relevant for the future workplace and learning environments. It is also suggested that this IT-immersion approach can be used in a mixed-mode manner to support traditional lab-based approach to learning and teaching CAD and CAM. This adjunct or mixed-mode seems appropriate for a wide range of learning and teaching activities in D&T where real world experience and face-to-face interaction are essential. By using a mixture of traditional and IT-immersion instructional methods and tools, the learner can experience recent technology development and its impacts on learning. The point is to find out the right balance.

The project is still at its developmental stage, the effectiveness of the IT-immersion approach to learning and teaching D&T has yet to stand the test of time. However, the experience so far suggests that the project will be a success and will bring substantial benefits to both teaching staff and students.

References

[5] Au, W. K., Kong, S. C., Leung, K. P., Ng, M.W. & Pun, S. W., "Level of Information Technology Competency, Core Course Elements and Assessment Tool for Teacher Training in IT in Education: The Final Report", Hong Kong: Education Department, HKSAR, (1999).

[4] Barlow, J., "Computers in Technology Education", in J. Williams & A. Williams (Eds.), "Technology Education for Teachers", pp. 136-179, South Melbourne: Macmillan Education Australia, (1996).

[1] Curriculum Development Council (CDC), "Syllabus for Secondary Schools: Design & Technology (Secondary 1-3)", Hong Kong: CDC, (1999).

[6] Davies, L., "Virtually There! The Millennium", The Journal of Design and Technology Education, Vol. 4, No.1, pp. 61-64, (1999).

[2] Education and Manpower Bureau (EMB), "Information Technology for Learning in a New Era: Five-Year Strategy 1998/99 to 2002/03", Hong Kong: Education and Manpower Bureau, (1998).

[3] National Association of Advisers & Inspectors in Design and Technology (NAAIDT), "Enhancing Design and Technology through the Use of IT", Wellesbourne: The Design and Technology Association (DATA), (1995).

[7] Romiszowski, A., "Web-Based Distance Learning and Teaching: Revolutionary Invention or Reaction to Necessity? ", in B. Khan. (Ed.), Web-based instruction, pp. 25-37, Englewood Cliffs, NJ: Educational Technology Publications, (1997).

[8] Wankat, P. & Oreovicz, F., "Teaching Engineering", New York: McGraw-Hill, (1993).

Development of the Web-based classroom system to be implemented by the teachers

Go Ota* and Kanji Akahori*
**Cooperative Research Center Saitama University*
***Tokyo Institute of Technology*
*E-mail: *gohome@jona.or.jp **akahori@cradle.titech.ac.jp*

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan from the year 2002. Accordingly, all the schools have been rushing to deploy the personal computers and prepared to connect to the Internet through 2001. While the scope of this project aims at covering 40000 or more schools, there exists the two major problems:1) The number of teachers who have expertise in handle the PC and the Internet, are too far short in proportion to the number required. 2) Dial-up networking prevents the students from having access to the Internet any time when they want. With a view to overcoming these problems, we have designed and developed the Intranet system or "micro Internet for classroom: mIc". The "mIc" is developed and designed to incorporate the various functions such as web-mail, electronic bulletin board "BBS", mailing list, search engine, web video conference and etc. Since "mls" consist of Microsoft Active Server Pages (ASP), it can be used from Web browsers and custom-tailored at ease.

Keywords: **Intranet, Collaboration, Video-conference, BBS**

1 Introduction

The Japanese ministry of Education made an announcement that a new curriculum "Information and Computer" will be introduced nation-wide in Japan at both the elementary school and the junior high school in 2003 and at the high school in 2002 respectively. Accordingly, all the schools have been rushing to deploy the personal computers and are prepared to connect to the Internet through 2001. While the PC have been gradually and extensively, it seems quite obvious that far small number of the teachers can handle the PC and the Internet to the contrary.

The Minister of Education has been sending the computer engineers or other computer technical personnel to school since 1994 with a view to training the teachers about the computer and the Internet. They are also required to see to it that both the teachers and the students can implement the PC and the Internet smoothly without any problems. Additionally, The Ministry has been initiating their own training programs for the teachers as well. While the project is supposed to cover 40000 schools or more, it has been experiencing the extreme difficulties of the shortage in the engineers and the technical staffs to reach out all the teachers in 4000 schools or more. It has been experiencing the difficulties as well as that Dial-up networking prevents the students from having access to the Internet any time when they want.

Despite these difficulties, it seems quite viable that all the students will get accustomed to the computer and the Internet at the earliest convenience. We, therefore, have designed and developed the Intranet System(micro Internet for classroom: mIc)

2 Design of mIc

This system "mIc" is developed and designed for both the teachers with least knowledge about the PC and the Internet, and the students as well to learn the various functions.

(a) Simulation of the Internet.
We are of an opinion that the E-mail and Electronic Bulleting Board shall be viable tools for "collaboration" among the students. Should the students require any information from the Internet, the search engine shall be inevitable to learn as well. We, therefore, have designed to incorporate these functions in the system. The teachers simply use the system without any other programs and the students can experience those functions as if they were connected to the Internet.

(b) Web-based easy operation.
The teachers can use "mIc" from Web browser. Therefore, should the teachers use the system, they can create new BBS, mailing list and registration of the students on Web based. As far as the teachers will use solely "mIc", the profound knowledge about the Internet server and the program of CGI is not necessary.

(c) Customization.
The curriculum of "Information and Computers" varies depending on the computers deployed ,the network system applied, and the objective of the education for PC & the internet in each school respectively. The system "mIc" can be customized by merely changing the text-files.

3 Structure of mIc

Considering the Standardizing the server of the average school environment, "mIc" will be installed in WindowsNT server or Window98. Please take note that less than 10 people can work with Window98 simultaneously.

3.1 ASP and COM

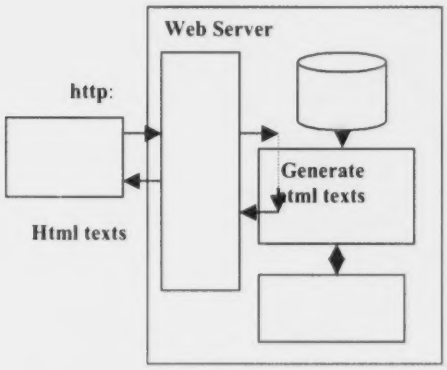


Figure 1: The Action of ASP

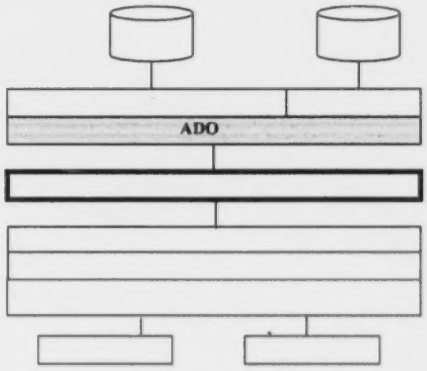


Figure 2: The structure of mIc

The system "mIc" consists of Microsoft Active Server Pages(ASP) which is the server-side execution environment. The ASP can run scripts and Component Object Model(COM) on the server . It can also easily create the dynamic contents and the powerful Web-based applications. The COM is the Microsoft software architecture that allows application to be built from binary software components. Windows itself and many other applications such as WORD, EXCEL and etc. are consisted of the COM.

Figure 1 shows the process of "mIc". ASP files appears to be the same as the HTML files but it includes additionally VBscripts or Javascripts, which call COM. At first, a browser makes a request to the server to send an ASP file in such a manner as to the HTML file. Secondly, the server executes ASP file and Bvscripts or Javascripts At last, the server send these to a browser. By using ASP, a browser only interprets common HTML without executing scripts in the client environment. Figure 2 shows the structure of "mIc". We have applied to some COM, which have access to a database, a browser, files, and a mail server. ADO is the database access COM and the system uses Microsoft Access or SQL Server.

3.2 Setup of mlc

The system "mlc" can be easily installed by simply copying the ASP files in such a manner as for HTLM files .The teacher will be required to edit the "mlc"' configuration file which contains such information as URL, the install path and etc. Should a teacher wish to display some comments enabling the students to take note for their reference, he simply input the comments in the text-file corresponding to the exact page. The "mlc" can build more than one system in one server by creating more than one data base file.

4 System function

The functions of "mlc" will be detailed as follows;

4.1 Registration

The teachers can register the students with the use of browser. They can register even many number of students at once with the use of EXCEL or ACCESS. If the teachers will use BBS and E-mail via other programs than "mlc", they will be required to register newly each time they change the application.

4.2 System Menu

Three different user modes are available in the menu , one for a teacher , one for students and one for a guest respectively. The teacher can customize the menu for each mode. Should the teacher not use the mailing list, he can simply edit the configuration file to turn off the flag of the mailing list and the menu eventually will not display the button of the mailing list.

4.3 Web mail

The system "mlc" has two different Web mail modes whose user interface are the same , the one simulation mode and the other SMTP/POP3 mode. While the simulation mode will not actually allow to send or receive mails via the Internet, it will allow to simulate the mail functions without the mail server. Should you have the mail server and use the SMTP/POP3 mode, it will allow to send or receive mails via the Internet as the regular web mail.

4.4 Electronic bulletin board (BBS)

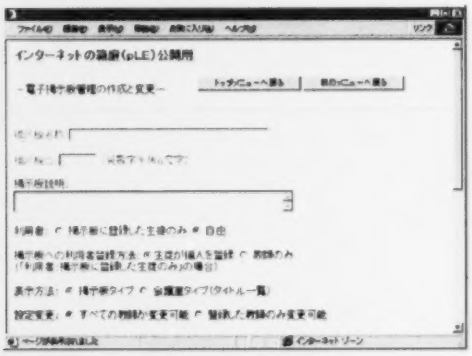


Figure 3: Screen image of Defining BBS

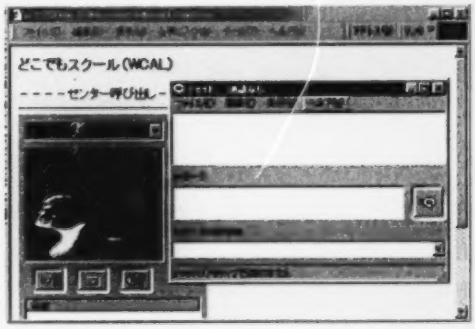


Figure 4: Screen image of Video conference

The system "mlc" allows to set up more than one bulletin board. Should the teacher wish to create a new BBS, he will be required to simply define the BBS on the browser and no new program will be necessary(Figure 3). "mlc" allows to set up the users' list covering the users who can have the access only in the BBS. The users' list can be selected in accordance with the student attribution such as Class , Group and etc.

4.5 Mailing list

The operation of the mailing list will follow the same manners as mentioned above for BBS.

4.6 Search engine

Since "mIc" has a directory service like "YAHOO" , the teachers and the students can add any new URL to the directory for their reference. If "mIc" is installed in WindowsNT server with Microsoft Index Server, the text-matching search engine can be used. The attention is drawn that "build-up of HP" has become one of the most important curriculum in Japan . The student can register their own HP's in the directory of "mls" and can subsequently search them in the classroom.

4.7 Web Video conference

Since the Video conference is very efficient and effective tool in term of the international communication, we have designed to incorporate the function "Web Video conference" in the system so as to suffice in this respect(Figure 4). A student can communicate with other students and visualize them via web video conference and refer to the data interactively via web data conference. Data conference allow the students to collaborate on "chat", "whiteboard" and "program sharing" without Video and Audio. Since the web videoconference is based on Microsoft Netmeeting 3.0 Active X, the multipoint data conference is possible and thus more than one student can participate the meeting simultaneously.

4.8 Generator of the questionnaire

Understanding strongly the importance of the questionnaire so as collect of the opinion from the students for various topics, "mIc" is designed to generate automatically the questionnaire in the form of HTML and ASP files. The teacher can easily make these files by filling in to the points raised as question on the web pages . The form filled in by the students can be saved to the text file in the form of the spreadsheet such as Excel.

5 Further development(future work)

We have already started to introduce the system"mIc" at schools ranging from the junior high school through the university . Having learnt from the experience, it seems very obvious that the teachers can make BBS and use search engines at ease. Through the continued experiments, we are prepared to improve the system further.

mIc Web Site (In Japanese)
URL www.jona.or.jp/~gohome

References

[1] Michael,G., Greg Merley, Distance Education A System View, Wadsworth Publishing Company, (1996)
[3] Go,O.,Kanji ,"Development of integrated Collaboration System with BBS and mailing list"(1999)
[2] Go,O.,Kanji, A.,"Development of School intranet system baeed on COM and ASP", (1999)

Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

Jia-Rong Jerome Wen * Chia Chin Li and Jian Jie Dung***
**jerome@nknucc.nknu.edu.tw djj@icemail.nknu.edu.tw*
116,Ho-Pin 1st Road,Kaohsiung,Taiwan,R.O.C
***april@ficnet.net*

The information education in Taiwan has been progressing rapidly since the Network Technology was adopted on a large scale.Under the Nine-Year Consistent Courses policy the by Ministry of Education, the information education will be integrated into other subjects and all teachers need to use computer and Internet resources to assist teaching .The plentiful education web sites on Internet also provide the student with materials for assisting learning .The essay presents the development process of information Education in Taiwan ;through it, we point out the obstacles we meet when promoting information education in primary schools and high schools.Meanwhile ,through introducing two education web sites :Gas Station for Learning and Schoolfellows' English Adventure Land, which were constructed in different models ,we offer the workable models and strategies for promotiing distance education in primary schools and high schools.

Keywords: **Distance Learning, Nine-Year Consistent Coures ,Teaching Material Resources Center, Schoolfellows' English Adventure Land**

1 Introduction

1.1 Analysis of Current Situation

"Nine-Year Consistent Syllabus" implemented in 2001, all schools will no longer especially establish the subject of Information Education, but enlist it in the learning area of "Nature and Technology." Nevertheless, in order to train students to have the basic abilities to make use of technology and information, teachers have to emphasize the application of information in the teaching of different subjects. And all teachers of different subjects are expected to take computer as a tool of instruction, integrate via network the traditional teaching materials and the teaching materials on Internet, and provide students with broader and more diversified learning resources.[2][3]

1.2 Problems Faced by Distance Learning:

To apply information education to the teaching of various subjects will really be a consistent trend in the education of Taiwan in the future. However, when confronted with the important educational reform, the actual implementation encounters difficulties because of Taiwan's restricted environment for information education.

The ratio of the number of class computers to the number of the students of a class is such a wide gap.If teachers are requested to use the limited computer classrooms to apply information to the teaching of various subjects, obviously, it is not an easy job to promote this at the current stage.[5][7]

2 Distance Instruction and Distance Learning

After the Ministry of Education implemented "Foundation Establishment Plan of Information Education," the computer and network equipment of various schools are increased. Besides, it also promotes the establishment of "Information Education Software and Teaching Materials Resources Center" at primary schools, junior high schools, senior high schools and vocational schools, in order to enrich the network teaching materials for subjects of primary schools and high schools.[1][8]

Besides, the famous distance instruction network of primary schools and high schools in Taiwan is illustrated as follows (Table1):

Web Site Name	Address	Institute	Object
Gas Station of Learning	http://content.edu.tw	Ministry of Education	Grade 1 to 12 student
Schoolfellows' English Adventure Land	http://192.192.186.8/seal/	San Hsin Institute of Housework and Commerce	Grade 1 to 12 student
Pathfinder	http://pathfinder.ntntc.edu.tw/	National Tainan Teachers College	Grade 1 to 9 student
Computer Assisted Instruction	http://www.wcjs.tcc.edu.tw/	Wu Chi Junior High School	Grade 7 to 9 student
Teaching Resource	http://www.ctjh.tpc.edu.tw/ctjh/resource.htm	Chiang Tsui Junior High School	Grade 7 to 9 student

Table1: Virtual Classroom Web Site for Grade 1 to 12 student

3 Teaching Materials Resources Center Focusing on Systematic Subjects

3.1 Concept and Idea:

The Ministry of Education in Taiwan starts "Foundation Establishment Plan of Information Education" not only to establish hardware environment, train teachers, carry out promotion activities, etc., but also to establish Information Education Software and Teaching Materials Resources Center, simply called "Education Resources Center" or "Gas Station of Learning."(http://content.edu.tw)

3.2 Outline of Resources Center:

The Ministry of Education advises various school to develop the on-line teaching materials of different subjects. The center can effectively integrate the resources of all primary schools and high schools and develop a series of network instruction resources with its own characteristics. "Teaching Materials of Subjects" are divided into four divisions: primary school, junior high school, senior high school and vocational school. In each group there are: 14 subjects in primary school, 19 subjects in junior high school, 17 subjects in senior high school, and 21 subjects of 4 categories in vocational school (the divisions of senior high school and vocational school was established in January 2000). The information integrated and collected by web sites cover the education resources of the Chinese's Five Education: virtue, wisdom, physical, group and aesthetics.

Through a united interface of users, it decreases the learners' load in adaptation to learning environment. The establishment of "Education Resources Center" is expected to achieve the following objectives: [6]

- Strengthen the applied network resources for teachers and students, and make the educational environment more diversified .
- Lay a foundation for a lifelong learning environment.
- Strengthen the quality and quantity of the resources of information learning so as to reach the aims of sharing of resources
- Shorten the distance between city and village [1]

4 Schoolfellows' English Adventure Land Focusing on Self-Learning

4.1 Concept and Idea

Teaching Materials Resources Center mainly edits the teaching materials according to the contents of the systematic teaching materials of various subjects. Therefore, they are suitable for teachers to adopt in class and for students to review after class. However, in the age of information explosion, the knowledge in books can no longer satisfy most of the students' thirst for knowledge. Therefore, with network being the media, distance education must have more diversified contents. It also has to create an interacting relationship between school and students. It can hold various kinds of activities and offer substantial awards to encourage all the students to participate. Then an activated distance learning environment can be created beyond system. Kaohsiung municipal government is positively involved in the activity. The "Schoolfellows' English Adventure Land , SEAL "(http://192.192.186.8/seal/) established by the municipal government at San Hsin Vocational School is based on this idea. It has the following characteristics :(1)Diversified Contents and Scope.(2)Individualistic Learning Environment.(3)Internet Learning without Limitation of Time and Space. (4)Flexibility of Time, Holding of Activities.(5)On-Line Contest,Internet Pen Pal Society.(6)Teacher Mechanism--Student Groups Management and Inquiry of Students' Learning Process:,Self-Made Test Paper Management:

4.2 Evalutaion on SEAL

The working group of Seal held an investigation in December 1999, towards the junior and elementary school teachers that used this website to assist their teaching. The questionnaire adapted Likert's five point scale from extremely disagree(1) to highly agree(5). In the 73 effectively retrieved questionnaires, there're 67 English teachers and 6 are not English teachers.

The statistics results of the questionnaire, in the curriculum arrangement and management session, show that sample teachers think the arrangement of the curriculum in SEAL is appropriate and the related activities that go with the curriculum is successful. (M=4.10 ,SD=0.82) ◦ Sample teachers think that the recording of learning profile on the website of each student helps teachers to understand the student's learning style and problems. (M=4.26,SD=0.83) ◦ Sample teachers think that the idea of designing language games and holding on-line composition contest is appropriate. (M=4.16,SD=0.83 ;M=4.03 ,SD=0.93) ◦ About the learning interaction, most teachers thinks that English pen pal club will help to enhance the interaction between students, M=4.18 SD=0.93) . Most teachers think that SEAL is worth popularizing in assisting traditional learning. (M=4.59,SD=0.66) ◦

5 Workable Model and Strategy

In the implementation of distance education in primary schools and high schools, besides the consideration of the contents of teaching materials, how to make use of the characteristics of Internet appropriately to activate instruction is an important topic that cannot be neglected for discussion. Focusing on the above-mentioned analysis, we propose a model and strategies for distance learning be carried out in primary schools and high schools:

5.1 Four Elements for Activating Web Site:

According to the discussion above,there are four elements to activate the web site teaching materials :the content, interactivity, learning profile and activity. We have to take these four elements into consideration when designing the learning web site. The detailed function of the four elements is as follow:

5.1.1 Content

Text, image, sound , photo , animation chip and other mutimedia components should be included in an excellent education web site.Through multiple information styles supplied , the student can obsorb knowledge easily

5.1.2 Interactivity

With more interactivity function the education web site is more attractive and effective .The interactivity machanism encourages the student to use higher -level cognition skil[1]..

5.1.3 Learning Profile

The learning profile lets the student know what he has learned and what to learn .The porfile also provides the teacher information about the student.

5.1.4 Activity

Not only in classroom but also in virtual classroom, well-designed activities are very important to improve the effectiveness of learning . Besides, through holding an activity , the student can cooperate and compete with others .

5.2 Strategy for Promoting Distance Learning

From this point of view, we will suggest applicable strategies for school administrators,teachers and students.

5.2.1 As for school adminstrator:

∗ Establishment of Web Site by Full-time Professionals:
The school administrator should know there should be full-time professionals to put teaching materials on Internet, hold Internet activities and carry out the maintenance work of systems.

∗ Strengthening of Propaganda:
The education departments or general affairs units of schools should positively introduce such an environment in the learning of students, and positively hold activities of relevant kind.

5.2.2 As for teacher and related professional:

∗ Development of Excellently Activated Web Site:
A web site must have substantial contents , diversified activities as well as interactivity machnism and learning profile to make the web site become a dynamic and lively learning environment.

∗ Material Making:
Teachers need not learn the establishment of web site. Teachers' job should be an all-effort studying of suitable contents of teaching materials for the learning of students.

∗ Resource Assisted Teaching:
All the related teaching web sites need the teacher to use them .Many web sites are well constructed ; however,few teachers use it to assist teaching . The teacher can provide the web site constructor with feedback for promoting the funciton or the rescources of the web.

5.2.3 As for Students:

∗ Participate in activities :
Only students' participation can make web sites activated and meaningful; otherwise, web site is merely an empty shell in a waste of information development.

∗ Resource Assisted Learning:
The student can make good use of on-line material to assist learning after class ; meanwhile , the student's feedback also helps the web constructor refine the web .

6 Conclusion

After the implementation of "9-year consistent" new syllabus in primary schools and junior high schools, information will be applied to various subjects and the application of network resources will become broader. The information-application-oriented network learning functions can be facilitated more effectively. The "Plan of Teaching Materials Resources Center" undertaken by Ministry of Education integrates various schools' resource to establish a garden that provides teachers with instruction resources and students with learning resources.The Plan not only can reach the purpose of resources sharing, but also decrease the load of learning through united interface environment. Besides, the distance learning environment beyond system, as provided in "SEAL," is also a good example for primary school students and high school students to involve in distance learning.

In term of positive implementation of information education, it is important to cooperate with the existing instruction environment and choose a workable model. For the government, based on the principle of effective utility of resources, it is necessary for her to integrate the establishment and the sharing of instruction resources. For schools, they have to encourage teachers and students to use Internet positively to assist in their teaching and learning. For teachers, they might not be required to allocate teaching materials on Internet, but they have to use the existing Internet resources and teaching materials positively, adopt suitable instruction methods, and correctly use Internet to communicate with students or parents. For students, they should meet the instruction of schools, use the teaching materials on Internet to assist in their learning, and learn new knowledge themselves.

References

[1]Bates A.W.,"Technology, Open Learning and Distance Education",Routledge. (1995)

[2]Chin Nian-Shing , "The World Wide Web Integrated Learning Environment", Information & Education ,vol 64, Taichiung Home Economical and Commercial Vocational School . (1998)

[3]David H. Jonassen:,"Computers in the Classroom: Mindtools for Critical Thinking", Prentice-Hall. (1996)

[4]Hung Ming-Jou,"Teaching On Internet", Hua-chai Software. (1999)

[5]J. Mark Pullen (1999):Synchronous Distance Education and the Internet. George Mason University.

[6]The Preface of "Gas Station of Learning,http://content.edu.tw/new/intro1.htm(2000)

[7]Wang Chuan-Shi: "Experimental Research on Adoption of Information Technology in Subject of Chinese Language at Primary School.",Research Plan of Graduate School of Information Education of National Kaohsiung Normal University, unpublished.

[8]Wang Wen-Ke,"Research Approach of Education (new ed.)", Taipei City: Wu Nan. (1999)

Monitoring and Verifying Mathematical Proofs Formulated in a Restricted Natural Language

Peter Schmidt
Department of Computer Science, University of Bonn
Römerstr. 164, 53117 Bonn, Germany
E-mail: peter@uran.informatik.uni-bonn.de

A restricted natural language is presented which is suitable for formulating mathematical proofs in the domain of calculus. A line of a proof according to the language consists of three parts: A marking, a proof statement, and a foundation of the statement. Foundations include among others the name of a theorem, the name of a concept, or a formula manipulation operation. It is demonstrated how mathematical proofs worded in that language may be automatically monitored and checked for correctness and completeness by a computer program. For that, techniques of the fields of theorem proving and of formula manipulation are applied; the lines of the original proof are transformed into a quantifier free form and checked line by line; an internal knowledge base of concepts and theorems allows for verifying proof statements which are founded by concept definitions or theorem applications. The described methods may be used in virtual or face-to-face universities for the purpose of proof exercises by students or for the purpose of automatically checking and scoring student proofs. The approach together with a medium-grained XML representation of concepts, theorems, and proofs may form the core of a learning environment which gives students the opportunity of an intensive interactive occupation with mathematical proofs.

Keywords: **Calculus Proofs, Verifying, Restricted Natural Language**

1 Introduction

Finding and constructing mathematical proofs are standard activities of persons who study mathematics or disciplines of science. For learning purposes, it would be desirable to have an interactive software system into which students could enter a mathematical proof in the usual way utilizing the natural language and the software system would monitor and verify the student's proof or provide help if needed.

From the side of the field of mechanical theorem proving, techniques and procedures are available to automatically prove theorems or check a given proof, if the theorem or the proof are worded in a formal language like first order logic or the quantifier free clause form (see e.g. [1], [5]). The main bottleneck to reach the above mentioned goal is the difficulty of processing and correctly understanding natural language input. As a solution to the problem or as a compromise we here suggest a restricted natural language to formulate proofs. The language results from an inquiry into mathematical proofs which occur in mathematical textbooks of the domain of calculus (see e.g. [8]). We chose the domain of calculus because of the importance of calculus for the edifice of mathematics and for many practical applications and because calculus belongs to the first fields which are studied at the universities.

Secondly, we discuss how proofs utilizing that restricted language may be automatically monitored and checked for correctness and completeness by a computer program. To monitor a proof, the proof is transformed into an internal form which includes the quantifier free notations of the occurring logical expressions. A proof is checked line after line like a human would do who tries to verify a given proof. The checking for correctness of the single statements relies on the techniques of the fields of theorem proving and of formula manipulation and of their combinations. Regarding the theorem proving techniques we utilize methods which are similar to the methods of Bledsoe, Boyer and Henneman to automatically prove limit theorems ([2],[3]).

Apart from providing opportunities of doing proof exercises, the described methods may be used in virtual or face-to-face universities for the purpose of automatically checking and scoring proofs of students.

Thirdly, we shortly discuss the extension of the approach to an extensive learning environment.

2 Mathematical Theorems and Proofs in the Domain of Calculus

The *subjects of calculus* include among others limits of sequences and functions, derivations of functions, determination of properties of functions, integrals, the study of special classes of functions, and many practical applications of theoretical results.

Proof methods used in calculus are multifarious and include direct proofs using the analytical definitions of concepts like limit, continuous or differentiable (epsilon-delta notation), inductive proofs, indirect proofs or proofs by counter-examples, or direct proofs utilizing chains of inferences of already proven theorems.

A large set of proofs in the domain of calculus follows a recurrent pattern. One characteristic of those proofs is the use of analytical definitions of the main concepts to establish the proof. A further characteristic of many proofs is that they employ formula manipulation methods as a central technique to establish the proof. Proofs often consist of a construction process. Those characteristics allow for monitoring proofs without a long chain of logical deductions.

3 A Restricted Natural Language to Formulate Proofs

The restricted language to word proofs is here informally described mostly by examples so that persons who are familiar with proofs of the domain of calculus can understand the scope of the various allowable statements. The language is not supposed to be exhaustive, but the current version of the language covers a large set of calculus theorems and proofs in textbooks and in collections of exercises.

The usual structure of a natural language proof in a textbook consists of a series of statements which are substantiated by one or more foundations. The statements may have a reference to other statements of the proof. The restricted language reflects that structure by dividing a proof into proof lines. Each proof line consists of up to three parts: a marking, a proof statement, and a foundation of the proof statement. By clearly separating the three parts of a proof line from each other, the variety of natural language wording reduces to a simple and easily comprehensible structure.

3.1 The wording of a proof

Basic elements of the language. There are a series of basic elements which may occur in a proof including numbers, variable names, function names, the universal quantifier (ALL), the existential quantifier (SOME), and the logical operators of negation (NOT) and of conjunction (AND). R denotes the real numbers. *Keywords* of the language generally consist of capital letters. *Intervals* play a central role in proofs and may be designated in the usual way, e.g. [a,b] for a closed interval of the real numbers, (a,b) for an open interval, or ALL x WITH |x-a|< delta for an interval with the point a in the middle of it. *Partitions of intervals* are often used in various contexts. They usually define end points and a list of intermediate points and fix the length or a maximum length of the resulting part intervals (see an example below). *Iterations* may be used in the usual way, e.g. i=0,...,n or j=1,2, ... to denote a finite or infinite sequence.

Proof statements. The current version of the language comprises the following proof statements which are described in the next paragraphs:

(1) Assignment statements. Assignment statements allow for defining new variables or functions. An assignment statement starts with the keyword LET. Examples are

LET delta = min(delta1,delta2),

where min denotes the minimum function and delta1 and delta2 are earlier defined variables, or

LET h(x) = f(x)+g(x) ALL x IN [a,b] , where the new function h(x) is defined, or

LET f : [a,b] -> R , where a function and its domains are defined.

(2) Choice statements. Choice statements describe a choice of an entity from a set of possibilities. A choice may e.g. refer to a number chosen from an interval or to a partition of an interval. A choice statement starts with the keyword CHOOSE. The format of such a statement depends on the choice situation. Simple examples are

CHOOSE eps > 0 or CHOOSE x IN [a,b].

An example which covers the choice of a partition of an interval is

CHOOSE PARTITION p OF [a,b] WITH $a=x_0 < x_1 < ... < x_n=b$ AND ($|x_i-x_{i-1}| <$ delta , i=1,...,n) ,

where [a,b] is an interval, x_i are points in the interval, and the mentioned restriction of the lengths of the intervals $[x_{i-1},x_i]$ holds.

(3) Relational statements. Relational statements, i.e. equations and inequalities, frequently occur in calculus proofs. The statements often include constraints on the appearing variables. Typical recurrent examples relate to analytical definitions of concepts and formula manipulation operations. An example which states the definition of continuity is: ALL eps > SOME delta >0 ALL x WITH |x-a| < delta: |f(x)-f(a)| < eps. Often a chain of equations and inequalities appears like ALL x IN [a,b]: |f(x)+g(x)| <= |f(x)| + |g(x)| <= M+N < INFINITY . Another simple example of a relational statement is eps/2 + eps/2 = eps , where eps is a given variable.

(4) Property statements. Property statements describe a property of an entity, e.g. the property of a function to be continuous in an interval. An example is: f IS continuous IN [a,b]. Other properties which often occur in calculus proofs are e.g. uniformly continuous, monotonously growing, or differentiable.

A series of **further statements** which often appear in a proof more or less drive or structure the proof.

(5) Proof type statements. A *proof type statement* characterizes how the proof is done, e.g. by finding a contradiction. The statement starts with the keyword PROOF TYPE and is followed by the name of a proof method from a list of proof methods, e.g.
by DIRECT, DIRECT_BY_DEFINITION, DIRECT_BY_A_CHAIN_OF_THEOREMS, INDIRECT, COUNTEREXAMPLE, SPECIALIZATION, COMPLETE_INDUCTION. The classification of the proof may be relevant regarding several aspects which are mentioned below. An example of a proof type statement is: PROOF TYPE INDIRECT.

(6) To prove statements. *To prove statements* are used to specify what must be or will be proven. There are two variants which may precede a statement: *to prove* or *sufficient to prove*. Here are examples: Let us assume that the conclusion of a theorem is: 'The function f(x) is bounded in an interval [a,b]'. Then the first line of a proof may be e.g. TO PROVE SOME m > 0 ALL x IN [a,b]: |f(x)| < m or the first line of the proof may be e.g.

SUFFICIENT TO PROVE ALL x IN [a,b]: |f(x)| < 1 . In the first case the keywords are followed by a statement which is equivalent to the conclusion of the theorem. And in the second case the keywords are followed by a statement from which the conclusion of the theorem may be inferred.

(7) Assume statements. *Assume statements* are mostly found in indirect proofs. They then state the negation of the statement of the theorem. The statement starts with the keyword ASSUME and there follows another statement. An example is ASSUME NOT [c] , where [c] denotes the marking of the conclusion of the theorem (see an example in Theorem 2 below).

(8) Contradiction statement. A *contradiction statement* states the contradiction of statements occurring in the proof. The statement starts with the keyword CONTRADICTION and its foundation contains the contradicting statements in one or the other way. An example is CONTRADICTION {[4],[6]}. The statement says that the statements marked by [4] and [6], respectively, are contradictory (see an example in Theorem 2 below).

(9) Anchor statements and **induction step statements.** *Anchor statements* and *induction step statements* serve the purpose to structure induction proofs. The statements start with the keywords ANCHOR and INDUCTION STEP, respectively. Examples are ANCHOR n = 1 and INDUCTION STEP n TO n+1.

(10) Proof finishing statement. The *proof finishing statement* consists of the keyword QED and states that the proof is assumed to be complete.

Markings. *Markings* serve the purpose to mark statements so that other parts of the proof may refer to the marked statement. The markings consist of letters and digits embraced by brackets, e.g. [A].

Foundations. A *foundation*, possibly together with other foundations, substantiates a proof statement. There are a couple of possibilities of denoting a foundation: A foundation may consist of the name of a theorem, of a formula manipulation operation, of a property of an object, or of a line number which denotes a logical line of the current proof or of the theorem. The foundation of a logical proof line is enclosed in curled brackets whereby the single foundations are enclosed in brackets and separated by commas, e.g. {[4], [5]}.

3.2 Examples of user proofs

The following examples illustrate the use of the language to formulate proofs. Note the more often occurring *double points*, e.g. one in the proof line which is marked by [2]. That double point is necessary for reasons of uniqueness to separate the prefix containing the quantified expressions from the inequality. An alternative would be to use an IF ... THEN ... statement. The foundations starting with the letters *fm* refer to formula manipulation operations, e.g. {[fm: rewriting]} in line [7]. The theorems are here not worded according to the language. A corresponding wording is necessary when the theorems and the proofs are automatically processed by a monitoring program.

Theorem 1 (Sum of continuous functions)
Let
[p1] f: R->R, g: R->R, a in R,
[p2] f is continuous at the point a
[p3] f is continuous at the point a
Then
[c] f+g is continuous at the point a

Proof:
[1] PROOF METHOD DIRECT_BY_DEFINITION
[2] TO PROVE
ALL eps > 0 SOME delta > 0 ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a) + g(a))|< eps {[c]}
[3] CHOOSE eps > 0
[4] SOME delta1 > 0 ALL x with |x-a| < delta1 : |f(x) - f(a)| < eps/2 {[p2]}
[5] SOME delta2 > 0 ALL x with |x-a| < delta2 : |g(x) - g(a)| < eps/2 {[p3]}
[6] LET delta = min(delta1,delta2)
[7] ALL x IN R : |(f(x)+g(x)) - (f(a) + g(a))| = |(f(x) - f(a)) + (g(x) - g(a))| {[fm: rewriting]}
<= |(f(x) - f(a)| + |g(x) - g(a)| {[fm: triangle inequality]}
[8] ALL x with |x-a| < delta : |(f(x)+g(x)) - (f(a)+g(a))| <= |(f(x)-f(a)| + |g(x)-g(a)| {[7]}
< eps/2 + eps/2 {[4], [5]}
= eps {[fm: simplification]}
[9] QED {[2],[8]}

Theorem 2 (Global Monotony)
Let
[p1] f: [a,b]->R is continuous
[p2] f is differentiable in (a,b)
[p3] for all x in (a,b): f'(x) > 0
Then
[c] f is strictly monotonously growing in [a,b].

Proof:
[A] PROOF METHOD INDIRECT
[B] ASSUME NOT [c] {[A]}
[C] SOME x1 IN [a,b], SOME x2 IN [a,b] : x1 < x2 AND f(x1) >= f(x2) {[B]}
[D] (f(x2) - f(x1)) / (x2 - x1) <= 0 {[C]}
[E] SOME x0 IN (a,b) : f'(x0) = (f(x2) - f(x1)) / (x2 - x1) {[Mean-value theorem]}
> 0 {[p3]}
[F] CONTRADICTION {[D], [E]}
[G] QED

4 Monitoring and Checking User Proofs

A user may enter a proof of a given theorem utilizing the above described language. The natural language proof is then transformed into a quantifier free version. That version is suitable for applying techniques of theorem proving and of formula manipulation. Each step of the user proof is checked by one of several special procedures (see below). We will first discuss the quantifier free version of the above mentioned theorems. Then we will describe the special procedures in the context of checking the proof statements of Theorem 1 and of Theorem 2.

4.1 Quantifier Free Version of a Theorem and a Proof

To check a user proof the natural language proof is transformed into a quantifier free form. Generally, the known methods of the field of mechanical theorem proving apply to get a quantifier free version (see e.g. [1], [5]), but one has to take into account some particularities which result from the fact that the proof representation exceeds first order logic:
(i) The *choice statement* corresponds to a quantification. The identifier succeeding the element CHOOSE has to be treated as a universally quantified variable, if the constraint attached to the variable represents an interval. If the constraint represents an assignment, the variable corresponds to an existentially quantified variable. An example is: A statement "CHOOSE eps > 0" has to be treated as "ALL eps > 0".
(ii) The ranges (scopes) of the quantifiers are not explicitly given in the proof. They have to be determined according to the following rule: The range ends when another quantifier with the same variable name appears or with the last appearance of the variable name.

After having dealt with those exceptions one can apply the usual transformation procedures to the proof lines which contain quantifiers. The statements of the example proofs which contain quantifiers take the following forms (an 'a' or an apostrophe is here added to the markings of the original proof lines):

The quantifier free form of Theorem 1. Figure 1 essentially shows the quantifier free form of the proof of Theorem 1 according to the transformation procedure. We assume that the reader is in general familiar with that procedure and we only mention some modifications and specific aspects which relate to the example proof.

(i) According to the transformation procedure the quantified variable names must be replaced by unique names and the existentially quantified variables are replaced by Skolem functions. In the example, the variable *eps* of line [3] is renamed into *eps0*; *delta1* and *delta2* are replaced by the Skolem functions *d1(eps0)* and *d2(eps0)* which depend on *eps0*; *delta* of line [6] is renamed into *delta0* and defined as *min(d1(eps0),d2(eps0))*; the various variables *x* are not renamed here in the example because of readability.

(ii) The equations and inequalities are assigned a corresponding interval of validity. With that we follow the proceeding of Bledsoe et al. [2].

In addition to the quantifier free version, the monitoring program utilizes a table of the occurring objects, i.e. the functions, variables, constants, and their characteristic properties. We do not here mention further details.

```
[2a] |(f(x)+g(x)) -(f(a)+g(a))|< eps                          ; x IN ( a-delta , a+delta ),
[4a] |f(x) - f(a)| < eps0/2                                   ; x IN ( a-d1(eps0) , a+d1(eps0) ) ,
[5a] |g(x) - g(a)| < eps0/2                                   ; x IN ( a-d2(eps0) , a+d2(eps0) ) ,
[7a] |(f(x)+g(x)) -(f(a)+g(a)) |= |(f(x)-f(a))+(g(x)) -g(a)) | ; x IN R
     |(f(x)-f(a))+(g(x)) -g(a)) |<= |f(x)-f(a)|+|g(x) - g(a)|  ; x IN R
[8a] |(f(x)+g(x)) -(f(a)+g(a)) |<= |f(x)-f(a)|+|g(x)-g(a)|     ; x IN ( a-delta0 , a+delta0 )
     |f(x)-f(a)|+|g(x)-g(a)| < eps0/2 +eps0/2                  ; x IN ( a-delta0 , a+delta0 )
     eps0/2 +eps0/2 = eps0
```

Figure 1: Quantifier free version of the proof of Theorem 1

The quantifier free form of theorem 2. Figure 2 essentially shows the quantifier free form of the proof of Theorem 2. The quantities x0, x1, and x2 are existentially quantified.

```
[C'] f(x1) >= f(x2)  AND  x1 < x2
[D'] ( f(x2) - f(x1) ) / ( x2 - x1 ) <= 0
[E'] f'(x0) = ( f(x2) - f(x1) ) / ( x2 - x1 )
     (f(x2) - f(x1) ) / ( x2 - x1 ) > 0
```

Figure 2: Quantifier free version of the proof of Theorem 2

4.2 Checking a proof for correctness and completeness

The monitoring procedure of the user proof consists of checking one line of the proof after the other. The whole procedure of checking a proof falls into several special subprocedures which process the different kinds of proof statements. There are the following subprocedures which generally utilize the quantifier free versions of the original statements to process the original user statement:

PROCdef: checks the correspondence between a concept and its analytical definition
PROCfm: checks formula manipulation operations
PROClogic: checks logical manipulations
PROCassume: checks the different kinds of assume statements
PROCtoprove: checks whether the succeeding statement corresponds to the statement of the theorem
PROCtheorem: checks whether a theorem may be employed in a special situation
PROCcontradiction: checks contradicting statements
PROCqed: checks whether the theorem is in fact proven

We will describe some features of the procedures in the context of checking the example proofs and mention some more details which are not immediately related to the examples. It should be obvious that the subprocedures also apply to analogous proof steps of other theorems. With the description, we use the line markings of the original proofs (like [2] or [C]), and we do not additionally mention the corresponding line markings of the quantifier free versions (like [2a] or [C']), although the procedures actually utilize the transformed statements.

Checking Theorem 1.

Line [1] states the proof method as 'DIRECT_BY_DEFINITION'. That information will be used later when the 'QED' statement of line [9] occurs (see below).

Line [2] consists of a 'TO PROVE' statement and mentions the analytical definition of the continuity of the function f(x) + g(x) at the point a and as the foundation the conclusion *[c]* of the theorem. The subprocedure *PROCtoprove* uses the subprocedure *PROCdef* to verify that the user statement and the analytical definition of continuity correspond to each other. To check that statement, *PROCdef* uses an internally provided analytic definition of the concept of continuity. The user statement and the analytical definition are compared in the quantifier free form by a unification process. The user statement is regarded as correct when a unification is possible. *PROCtoprove* utilizes the foundation of the line [2] to establish the connection between the concept of continuity and the user definition. Line [2] is internally marked and used later when the 'QED' statement is processed (see below).

A 'TO PROVE' statement may also appear in a proof e.g. to state a lemma which will be used later in the proof. In that case no foundation would be needed and a connection to the conclusion of the theorem would not be established.

Statements which explicitly state the analytical definition of a concept or vice versa infer the concept from an analytical definition are frequently found in calculus proofs. They are all treated by the subprocedure *PROCdef* in a similar way.

Line [3] mentions the choice of an *eps* > 0. That statement corresponds to a universally quantified variable *ALL eps > 0*. The statement results in an entry into the table of the entities of the proof. No further operation happens.

The lines [4] and [5] reflect the analytical definitions of continuity of the functions f and g, respectively. The foundations {[p2]} and {[p3]} trigger the comparison with the definitions of the continuity of f and of g, respectively. The subprocedure *PROCdef* establishes the correctness of the user statements as in the case of line [2]. In order to deal with the *eps/2*, in contrast to the usual *eps* without any factor, a generalized version of continuity is used: *SOME M >0 ALL eps>0 SOME delta>0 ALL x WITH |x-a|<delta: |f(x)-f(a)| < M* eps*. A suitable factor of *eps* in the middle of the proof is often the key with continuity proofs to assure a neat < *eps* without a factor when the proof is finished. The reader will know that.

Line [6] defines the variable *delta* and its value by an expression. The statement results in an entry into the table of the entities of the proof. No further operation happens.

Line [7] gives rise to an equation and an inequality. According to the mentioned foundations, the subroutine *PROCfm* uses a simplification process to check the first equation and a *triangle inequality* subprocedure to check the second relation. Formula manipulation operations play a central role with proofs in the domain of calculus, so corresponding methods need to be available.

Line [8] divides into three relations. The first inequality is an immediate consequence of [7]. *PROCfm* checks their correspondence by standardizing the inequalities and by establishing that the interval mentioned in the line [8] is contained in the interval R of [7].

The second statement resulting from [8] establishes the statements of [4] and of [5] as foundations. *PROCfm* uses *evaluation heuristics* to handle the check of the correctness.

The third relation resulting from [8] only needs simplification which is also done by *PROCfm*.

Line [9] states that the theorem is proven. In the case of a *direct proof* one expects that the conclusion of the theorem will explicitly or implicitly occur as an inference within the proof, usually at the end of the proof. The subprocedure *PROCqed* processes the proof type of the line [1] and uses the preceding 'TO PROVE' statement which was already recognized as equivalent to the statement of the theorem to check whether the relation of the line [2] is fulfilled by the statement of line [8]. Therefore *PROCqed* uses *PROCfm* and a unification process is again employed. *PROCqed* recognizes that the proof is complete.

Checking Theorem 2.
Line [A] states the proof method as 'INDIRECT'. That information will be used later when the 'QED' statement of line [G] occurs (see below).

Line [B] mentions an 'ASSUME' statement which contains a negation of the conclusion of the theorem. The subprocedure *PROCassume* recognizes that one part of the contradiction, i.e. the part referring to the conclusion of the theorem, is established.

An 'ASSUME' statement may also be used to state something which will be proven later. That corresponds to an alternative use of the 'TO PROVE' statement.

The statement of line [C] is an immediate inference of the mentioned foundation [B]. The subprocedure *PROClogic* verifies that the statement of line [C] logically follows from the logical formula NOT [c] .

The statement of line [D] is an immediate consequence of its foundation [C]. *PROCfm* uses *evaluation heuristics* to handle the check for correctness.

Line [E] divides into two relations. The first relation consists of an application of the Mean-Value Theorem. The subprocedure *PROCtheorem* proves the correctness of the line by checking whether the premises of the mentioned theorem are fulfilled. *PROCtheorem* uses an internally provided version of the theorem. The second relation is an immediate consequence of the premise [p3] and checked by *PROCfm*.

Line [F] is founded by the statements of the lines [D] and [E]. The subprocedure *PROCcontradiction* uses *PROCfm* to check the contradiction.

Line [G] states that the proof is complete. In the case of an indirect proof one expects that a contradiction occurs and that one part of the contradiction is an inference of the negated conclusion of the theorem and the other part is a valid statement which was inferred. *PROCqed* processes the proof type of the line [A] and uses the preceding 'ASSUME' and 'CONTRADICTION' statements to verify that the proof is complete.

Error handling. In a *positive* case, a user proof can be recognized as correct and complete, that means that the occurring statements can be inferred using the corresponding foundations and that the sequence of statements actually proves the conclusion of the theorem. In a *negative* case, several types of light or severe errors may occur. From the perspective of a monitoring system which checks the various proof lines there may happen three cases in connection with each proof line:
(i) *The correct case*: The monitoring program can recognize that a statement can be inferred by using the given foundations. That positive case includes the possibility that a minor error occurred which can be clarified by a dialogue between the system and the user. The list of minor errors includes syntactical errors (e.g. regarding the language or any mathematical formula) or a lacking foundation which can be completed by the system. The completion may be possible e.g. in the case that the foundation of an obvious formula manipulation operation is missing or a reference to a preceding proof line is missing.

(ii) *The error case*: The monitoring program detects e.g. a logical error, an incorrect formula manipulation transformation, an unallowed application of a theorem, a premature 'QED' statement or no 'QED' statement. In that case the system can supply a hint to the user and the user gets the opportunity to correct the error.

The feedback in the case of multiple errors in a single statement depends on the way in which the errors are interconnected. Generally, the error possibilities are multifarious. Some multiple errors can be handled one after the other, e.g. when there are two errors in a formula. The hint that the formula is not correct may make the user rectify one error, so that only one is left.

Let us consider another example: A user enters the wrong name of the theorem which he applies and the application of the theorem is also wrong. The system would try to apply the mentioned theorem and two outcomes are possible: (a) The theorem cannot be applied or (b) the theorem can be applied. In the case of (a), a hint that the theorem is not applicable could help the user to recognize that he entered a wrong theorem name. In the case of (b), the system would state the conclusion of the theorem application. The user might then also recognize that the theorem name is wrong. In those cases the double error is reduced to one error.

(iii) *The unclear case*: The monitoring program cannot decide the correctness of a proof line. Various reasons may be responsible for that. One reason is that an important foundation is missing, e.g. a reference to the theorem which was used , so that the monitoring program cannot infer the user statement. Other reasons refer to the performance of the mentioned subprocedures: They may not be able to verify a correct statement or falsify a wrong statements in certain situations. Such a case suggests to expand the monitoring program.

5 Applications and Extensions and Pragmatics

The above described approach may be utilized for different purposes by different groups in educational institutions. Students have the opportunity to occupy themselves with mathematical proofs and do exercises which may be immediately checked for correctness and completeness.

On the other hand virtual or face-to-face universities may employ such methods in automatic on-line test systems. Proofs delivered by students could be automatically checked and scored. While students construct a proof the system might give hints in the case that foundations are missing, that there are syntactical errors, that the sequence of inferences is not complete, that a statement is just wrong, or that the student is lacking an idea how to prove the theorem. Dependent upon the amount of hints or help provided the software system might decrease the score gained.

The language as it was described above does not contain a set of symbols which are frequently used in theorems and proofs, as e.g the notation for limits, sequences, sums, integrals, or the faculty function. To integrate them one may use the notations of MathML [9]. A closer look at the proofs which are found in the text books of calculus suggests that a large set of the proofs can be worded using the above outlined language when one assumes that the usual mathematical symbols are available and some more extensions are done.

The described approach of verifying proofs demands an internal knowledge base of the concepts and theorems of calculus when proof statements are founded by concept definitions or theorem applications. Such a collection will sensibly use XML as a representation language (see e.g. [6]). See an XML representation of a theorem and of a proof on the website [7]. By utilizing that knowledge base an extensive learning environment which deals with mathematical proofs may be developed. Some aspects related to getting support with finding and constructing proofs are: One may retrieve theorems having the premises which may be used with the proof. One may retrieve a list of proof ideas of the domain and discover the one which may be useful in the current context. The roughly outlined approach to a learning environment stresses the personal proof finding and proof construction activity. A different approach to a learning environment in the field of mathematical proving relies on a general, interactive theorem prover [4].

It is obvious that one has to get used to entering a proof in the restricted natural language. An adequate interface may help to reduce the cognitive overload. Another option is to further develop the language, so that the proofs may be entered in a less restricted way and look more like textbook proofs. Such proofs might then be transformed into the restricted natural language. It is clear that the students would use such a verifying system only when the advantages outweigh the disadvantages. Some advantages are the confirmation of correctness and completeness or the detection of errors and the option of getting help.

6 Conclusions

A restricted natural language to formulate mathematical proofs in the domain of calculus was presented. It was demonstrated how mathematical proofs worded in that language can be transformed into an internal representation and checked for correctness and completeness. Some educational applications were mentioned. The extension to a learning environment was roughly outlined.

Our current prototype of verifying proofs includes an interface to enter natural language proofs, some procedures of theorem proving and an own formula manipulation system. The prototype will be further developed with respect to the methods and the knowledge bases.

References

[1] Bibel, W., "Automated Theorem Proving", Vieweg, Braunschweig, Germany, (1987).

[2] Bledsoe, W.W., Boyer, R.S., Henneman, W.H., "Computer proofs of limit theorems", Artificial Intelligence 3, pp. 27-60, (1972).

[3] Bledsoe, W.W., "Non-resolution Theorem proving", Artificial Intelligence 9, pp. 1-35, (1977).

[4] Buchberger, B., Jebelean, T., Vasaru, D., "Theorema: A System for Formal Scientific Training in Natural Language Presentation", Proceedings of the Tenth World Conference on Educational Multimedia and Hypermedia (ED-MEDIA/ ED-TELECOM 98), Freiburg, Germany, June 20-25, pp. 174-179, (1998).

[5] Chang, C.-L., Lee, R.C., "Symbolic Logic and Mechanical Theorem Proving", Academic Press, NY, (1973).

[6] Goldfarb, C.F., Prescod, P., "The XML Handbook", Prentice Hall PTR, Upper Saddle River,NJ, USA, (1998).

[7] XML representation of a theorem and of a proof, http://www.cs.uni-bonn.de/~peter/ICCE2000example.html

[8] Smith, K.T., "Primer of Modern Analysis", Springer Verlag, New York, (1983).

[9] Mathematical Markup Language (MathML) 1.01 Specification, http://www.w3.org/TR/REC-MathML.

Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Robert M. Corderoy[*] and Paul Cooper[**]
[*]*Centre for Educational Development and Interactive Resources*
E-mail: bob_corderoy@uow.edu.au
[**]*Department of Mechanical Engineering, Faculty of Engineering*
E-mail: paul_cooper@uow.edu.au
University of Wollongong. Australia

A well designed PBL environment can assist and support students in building heuristics that will enhance their ability to solve problems in the real world. Problem based learning is situated in the context of a meaningful 'real world' based environment which draws on 'real variables' without the 'risk factor' normally associated with everyday practice. It poses an ill-structured, 'real world' based problem which drives the learning. Posing the problem before learning takes place provides relevance, challenge and interest, and is a powerful motivational strategy. This paper reports on the development of an on-line, problem based learning (PBL) environment (the VECC) in which students develop and practice engineering consultancy skills. Evaluation of the pilot implementation with 3rd year Engineering students at the University of Wollongong is briefly outlined. The VECC models the skills and processes of an 'expert consultant' "a professional engineer" in the field of Heat Transfer within a supported learning environment so that 'novice' student's develop appropriate problem solving skills vital for their later engineering practice. The power of a web-based environment to provide platform which supports both synchronous and asynchronous computer mediated communication enables students to interact with a virtual client in an environment which is "safe" and highly flexible.

Key Words: **Problem based learning, virtual environments, problem solving, consultancy, virtual client.**

1 Introduction

Traditionally, students graduating from engineering courses have had limited if any exposure to the wide range of practical skills centred on 'real world' contextualized problem solving and client contact which engineers must have 'in the filed' to be successful. There are many reasons for this, often based in the pedagogical approach characteristic of the institution in which they are trained. Providing a 'risk free' and cost effective environment in which students may develop and practice such skills is perhaps the other major influencing factor. A possible solution to this impasse is to provide a means of developing and practicing these skills using simulated environments.

Universities and other tertiary institutions throughout the world are rushing to embrace alternative delivery methods, particularly those that utilise the versatility and power of the World Wide Web. This is in response to the globalisation of education, the recognition of the need to provide mechanisms which will maximise opportunities for and support life long learning and the need to expand the boundaries to encompass educational experiences which are set in 'real world' contexts. The scope and boundaries for what is possible in such environments is limited only by the imagination of developers and the limitations of the web in its

present form. The web is a dynamic medium whose boundaries are being extended almost daily.

Further, suggests Burnett (1997) [3], the use of the Web will continue to expand as it becomes more stable, easier to use and more accessible to everyone. What we are learning from using the Web today will provide the confidence and expertise to take advantage of the advances in its technology. Now is the time according to Alexander (1995) [1] to stop focussing on the technology itself and to start focussing on what students are to learn, and the best way for them to achieve these learning objectives. This indeed was one of the key issues of "Secrets of On-line Teaching".

In recent times many of these institutions have experimented with the use of on-line delivery with the purpose in mind of extending access to educational experiences to a wider audience on a any time, any place basis. In many cases, the results have been less than satisfactory and have fallen short of student expectations for a number of reasons. The problem is exacerbated by a number of factors. These include: time and funding restraints; the often unjustified self perception of expertise in the field and the mistaken belief by many that, putting a subject or teaching resource on-line involves little more than providing content as a web based document. Given that this situation will probably not change in the foreseeable future, how can we as teachers/designers/developers ensure that our web-based resources are effective, efficient and supportive life long learning?

"An understanding of the techniques and protocols of on-line teaching and learning and the processes of both the design of new and the conversion of pre-existing resources has become essential for academics, as universities throughout the world embrace alternative delivery methods in response to the globalisation of education." Corderoy & Lefoe (1997) [5]

2 Design Issues for On-line learning Environments

An integrated online environment such as the VEEC provides a set of tools, systems, procedures and documentation that facilitates the occurrence of any or all parts of the learning experience using some form of computer mediated communication. Moving to web based delivery of a subject or any aspect of that subject will carry with it the need for both the designers and the teachers to recognize and act on the many issues associated with such environments.

The logistics of setting up and running this type learning experience mirrors the issues that are addressed in setting up any on-line course. In general the issues can be identified as belonging to three basic categories identified in any on-line learning environment, namely technical support, pedagogical and equity issues.

Some of the more important issues include:

- Interface easy to use and navigate
- Bandwidth limitations
- Security and submission of work
- Equity of access to the technology
- Unfamiliar format for some - provide time to adjust
- Lecturer's participation - make regular contact - ensure all have accessed by a certain time
- Lecturer's willingness to moderate/facilitate collaboration
- Consider cultural differences
- Work load changes for lecturer
- Perceived inequality of experience

Of these, the authors single out technology problems including access, interaction and communication and workload as being crucial to successful learning outcomes for students working in on-line environments

2.1 Technology

The students need to be 'trained' in the basic use and operation of the technology before they start and this is often best achieved by 'face to face' instruction at the start of session. As a good rule of thumb, problems are minimised by designing to the 'lowest common denominator' in terms of available technology. Related to this aspect is the equity issue of student access.

2.2 Interaction/Student Participation and Enthusiasm

One of the most significant challenges for those using on-line teaching environments is the 'silent student'. Ensuring that the students engage in the learning is closely related to the degree of interactivity fostered between students and their peers as well as between the students and the instructor. Success in the latter is dependent upon an instructors commitment to providing 'rapid feedback' to submitted tasks and posed questions as well as regular personal 'checking in' on-line. Such commitment provides an incentive for all students to be active and enthusiastic.

2.3 Resources/Time and Workload

There is a need to consider carefully the design and structuring of on-line environments, particularly those which already exist in a traditional format. Content cannot be simply 'placed on the web'. Time and effort must be spent in considering the resources and structure needed to best present the materials in the 'new environment'. Developing materials for on-line delivery is not an easy or short process. Both the teacher and the students must be committed to accepting a greater workload as a trade-off for the value of working in an environments which mirrors 'real life' situations and skills application.

3 Developing the VECC

The VEEC has been developed on a sound pedagogical basis using a team approach, utilising the specific skills of each team member. The Faculty of Engineering and the design/development team at the Centre for Educational Development and Resources at the University of Wollongong, Australia, have been involved in the development of a prototype over the past 18 months. The VECC is a highly interactive and innovative web based simulated consulting environment, based in the 'real world' problems and processes usually associated with the task of a professional consulting engineer in the area of Heat Transfer. It provides an environment which models the 'experts' heuristic's for solving the problem, facilitating the development of an appreciation and understanding of the application of the skills and processes needed in a real world consultancy in the 'novice' student. The result will be a graduate engineer who is better prepared for the 'real world' engineering practice.

This flexible, web delivered, student-centred resource provides not only training in specific technical area, but also orientation and experience in professional practice. This type of advanced training has been demonstrated to have significant benefits to students entering the workforce. Ryan *et al.*, (1996) [8]

The framework of the VECC package is modelled on the resources that one finds in a real engineering consultancy office. The consultant in such an office will have developed an expertise in their chosen field - in this case Heat Transfer - and will also undertake continual professional development. This CAL learning environment will therefore foster a positive attitude in students towards lifelong learning. Candy *et al.*, (1994) [4]

The Industrial Problem Solving Assignments are the main educational vehicle for building students' confidence in tackling real world situations and complex tasks. This feature differentiates the VECC from other engineering CAL packages. To quote Laurillard (1993) [6], "we cannot separate knowledge to be learned from the situations in which it is used". In the VECC, students will immediately see the relevance of the engineering theory to be used, since they must actively search for the appropriate theoretical model. That search is the same process the student will eventually use as a practicing professional engineer.

When using this resource the student role-plays a consultant who carries out all the managerial and technical tasks required to expedite a number of high-level Industrial Problem Solving Assignments. This problem-based learning approach "confronts the students" Boud *et al.*, (1991) [2] with 'real world' based ill-structured problems and scenarios which provide a stimulus for learning and in so doing "encourages the students to take a deeper approach to learning". Ramsden (1992) [7]. The PBL approach enriches the learning outcomes by simultaneously developing higher order thinking skills and disciplinary specific knowledge bases and skills. It promotes the student to the active 'practitioners' role in the process.

The consultant's activities include:

- negotiating with the client on cost and timetabling of the consultant's services
- obtaining the client's technical brief and tendering for the project
- sourcing technical information such as plant dimensions
- making on-site measurements of temperatures or other parameters
- student-centred learning through the Computer Aided Learning (CAL) module integral to the Virtual Engineering Consultancy Company
- simulation of real-life problems using a toolbox of simulation resources.

4 Expected Outcomes

The most significant expected outcomes for students using this web-based package include:

- A PBL based CAL resource that provides Engineering students with training in professional practice as consultants in Heat Transfer Engineering through 'virtual access' to 'virtual clients'.
- The simulated 'real world' environment that the web provides will provide them with a better understanding not only of the processes involved in professional Engineering practice but also the relationship between the Engineers and client.
- Improved effectiveness of delivery to a diverse student population of full-time, part-time and off-campus students.
- Improved skills in collaborative working and negotiation.
- Improved attractiveness of University of Wollongong Engineering graduates to potential employers.
- Flexibility in terms of meeting the course requirements with regard to time and place and individual learning styles.
- Improved opportunity for students to be active members of the cohort in all facets of the course.

5 The Pilot Virtual Engineering Consultancy Company (VECC)

To date the fundamental structure of the VECC and a substantial number of software resources (including interactive Heat Transfer simulations) have been developed. The complete package will eventually contain in excess of 30 simulations which will support and develop the students understanding and proficiency in aspects of Heat Transfer including: furnace insulation; steel quenching; conduction and boiling heat transfer.

Extensive work has also been carried out on the structuring of the 'theory section' of the package. Consideration has been given the 'chunking' of this considerable resource so as to provide a meaningful resource for the students while at the same time being 'easily accessible' within a web based environment.

The centre of the VECC resource is the consultant's office (Fig 1) that models a typical engineering office in the real world and has facilities including:

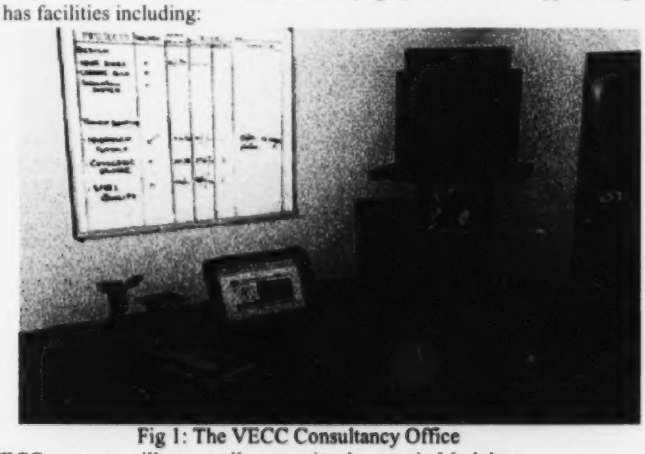


Fig 1: The VECC Consultancy Office

In summary, the VECC resource will eventually comprise three main Modules;

- **Training (CAL) Module** - the student uses resources such as simulations, text-based material, videos, animations, etc to learn the fundamentals of Heat Transfer theory.

- **Trouble-shooting Module** - here the student has to solve challenging real-life problems that are far more in-depth than conventional engineering assignments. In an example already developed, the student's client is a corporation that has just built and commissioned a large hydrogen production furnace. The furnace is overheating and the student must find out why, suggest remedial measures and act as an expert witness in a court case.

- **Design Module** - Students design a number of pieces of thermal equipment to satisfy a specification from their client. Examples will include a transistor heat sink and car radiator. The detailed design of thermal equipment is not a topic normally covered in an undergraduate course on Heat Transfer perhaps because it requires a problem-based learning approach and yet it can be one of the most rewarding aspects of an engineering student's study.

- A **project management whiteboard** that will be automatically updated as a student progresses through the study programme.

- A **laptop computer** which is the virtual gateway to the web and provides contact with the clients (the lecturer) for each project, resources external to the VECC and the brief containing full technical details. (Appendix 1)

- A **video monitor** for access to video clips of site visits, illustrative fluid visualisation experiments, lecture presentations, etc.

- A **desktop computer** which represents a powerful computing resource where the heat transfer simulations are located. These already include four unique simulations of important conduction heat transfer situations. Each simulation deals with a real world problem and will be used as part of the consultant's exploration of the case studies.

- A **telephone** for initial contact with the consultant's clients achieved using an audio track.Hello, Chris Garbutt here. I'm the Engineering Manager of Heat Treat TM. Our company deals with a large variety of construction projects involving thermal and chemical processing. We struck some heat transfer problems with one of our projects involving a furnace that is not operating as was planned and we're asking your consultancy firm, along with others, to tender for a trouble shooting role in fixing the problem.

  If you are interested in taking on this challenging consultancy, a brief containing full technical details of the project at our company's web site can be accessed through your laptop computer. I hope you can help us out. Please E-mail me if you have any queries. Bye for now.

- A **virtual library** of books which is the link into the CAL module where the student explores the topic of Heat Transfer through the problem-based learning approach of the VECC.

6 Pilot Evaluation

Students who took part in the pilot implementation had access to a limited prototype version of the 'complete' site. At this stage of its development, some of the segments of the VECC exist as discrete units that are independent of the overall structure. It was expected that this may cause some navigational/continuity problems for some students, however early anecdotal evidence collected from the students seems to suggest that this was not the case. Approximately 80 3rd year engineering students (20 groups comprising 3 or 4 students each) used the VECC to complete a major assignment during semester 1. Each group consulted in various degrees with the client using the E-mail link, used the various resources available within the consultancy office to support their investigations and develop their 'solutions' to the 'posed problem'.

Data collected during this pilot includes: student interviews and comments including a special forum where technical issues and the learning processes were discussed; lecturer's observations; archived E-mail communication between the lecturer and students and; individual marks awarded to students together with the lecturer's 'quality of answer' evaluation.

6.1 The Students' perceptions

Comments made by students to the lecturer include:

- convenient and easy to use;
- provides for flexibility in their study schedules;
- provides access to a greater richness of resources;
- helped them develop an understanding of the issues critical to client management;
- motivating;
- provides time to consider actions and issues
- allowed them to develop collaborative networks
- use of a real world problem put the theoretical concepts learned and the analytical skills developed into the context of their future activities as professional engineers and;
- comfortable working in this delivery mode.

6.2 The Lecturers' perceptions

Although at this early stage in development there is no longitudinal data for comparison, the lecturer is confident that data to be collected during the continued development and use of the VECC will support and re-enforce observations made so far including:

- overall performance of the majority of groups is better than past years, not just in terms of the overall mark but in the quality of the answers;
- role play appears to have contributed to a deeper understanding of the problem and possible solutions and enriched the learning experience;
- there has been no change in the completion rate, the number of students 'opting out' is about the same as usual;
- students who took full advantage of this support by contacting the 'client' (lecturer) performed better than those who did not;
- seems to be a time efficient way of presenting both the technical information and the processes involved in consultancy in a richer environment;
- flexibility for both students and lecturer is a 'real plus' and;
- the students seemed to be more motivated and this is reflected in their willingness to explore the resource base fully, developing better quality answers.

7 Future directions

There are several issues unique to technology based delivery which need to be investigated with respect to the VECC. The student groups had minimal exposure to the 'structure' and process of the VECC in lectures. Did this add to the cognitive load placed on them so that unnecessary effort was expended on learning about the system, rather than from it? Experience shows that with poor design, there can be an enormous increase in the cognitive load for students and the result is a poorer outcome than expected. To address this, it is envisaged that an extensive help system will be provided within the package. Specific lab sessions prior to using the system will also be run to allow students time to become familiar with the package. Such 'user support' mechanisms are an essential part of complex learning systems and it is essential that all students avail themselves of it. Ensuring that they do is one of the keys to facilitating useful student interaction with the learning environment. The issue of preferred learning styles and the 'students' fit' to the delivery mode needs to be explored.

8 Conclusion

Flexible modes of delivery such as Web based instruction can provide an effective means of addressing the problems of increasing student demands, decreasing funds, the need to establish a presence in the

international market place and rapid technological change. The rapid rise in the development of sophisticated and improved technologies has been the driving force behind the widespread embracing of the concept of flexible delivery and the application of the many and varied tools upon which it is based in the field of education and life long learning. The VECC is a web based flexible learning tool which provides students with 'real world' based experiences in professional practice. Early indications suggest that students are benefiting from this virtual consultancy learning environment which uses a problem based learning approach to develop the skills which are vital to engineering practice in the real world.

References

[1] Alexander, S. (1995) Teaching and learning on the World Wide Web. *Proceedings of AUSWEB95 The First Australian World Wide Web Conference*, Southern Cross University, Lismore. Australia.

[2] Boud, D. & Faletti, G. (1991) (eds) The Challenge of Problem-Based Learning. Kogan Page, London.

[3] Burnett, D. (1997) TiLT Seminar Series – Confessions of an Online Teacher. http://www.scu.edu.au/services/tilt/tsf/on/dale/bsemsummary.html

[4] Candy, P. Crebert, G. & O'Leary, J. (1994) Developing Lifelong Learners through Undergraduate Education. *NBEET Report No 28*, Canberra.

[5] Corderoy, R. M. & Lefoe, G. (1997) Tips and Secrets for Online Teaching and Learning: An inside View. *Proceedings of ASCILITE 97*. Perth.

[6] Laurillard. D (1993) Rethinking University Teaching: A framework for the effective use of educational technology. Routledge. New York

[7] Ramsden. P. (1992) Learning to Teach in Higher Education. Routledge, London.

[8] Ryan G, Toohey, S. & Hughes, C. (1996) The purpose, value and structure of the practicum in higher education: A literature review. *Higher Education 31*, 355-377.

Appendix 1

YOUR BRIEF

Heat Loss Calculations

If you choose to accept this assignment HeatTreat requires you to:

- to calculate the total heat loss from the furnace walls and roof (as a first approximation assume a outside surface heat transfer coefficient to be $20W/m^2$ including both convection and radiation heat transfer)
- to calculate the interface temperature between the Zirconia Blanket and the Mineral Wool to ensure that the latter does not overheat.

Surface Temperatures

The client has measured outside temperatures on the outside of the furnace to be in the range of 105 to 170°C. These are potentially very hazardous. You must perform the following tasks. A map of some of the surface temperature measurements is shown below.

Outside Wall Temperatures

Furnace level	1	2	3	4	5	Floor
Mean outside surface temp (°C)	75	64	68	70	68	52

a) Carry out a sensitivity analysis of one of the wall the surface temperatures to the outside heat transfer coefficient (calculate the expected radiation heat transfer coefficient assuming emissivity, $\varepsilon = 1$, and then vary the convection heat transfer coefficient in a range that would be expected under normal weather conditions ie between 5 and $20W/m^2K$, say).

b) Determine whether the firebrick insulation shown in the design drawings is likely to have been put in place correctly (if the insulation has not been properly installed legal action may be taken against the insulation installation sub-contractors). Assume the flue duct wall temperature is equal to the gas temperature of Section 6 of the furnace.

c) Recommend a solution to these high surface temperatures problems. Some possibilities include:
Add extra insulation to outside of furnace (you must calculate how much must be added and whether the resulting temperature of the structural steel is within acceptable limits).
Shut down furnace and replace internal insulation in problem areas (very much a last resort represents a very high cost option).?

Summarise your recommendations.

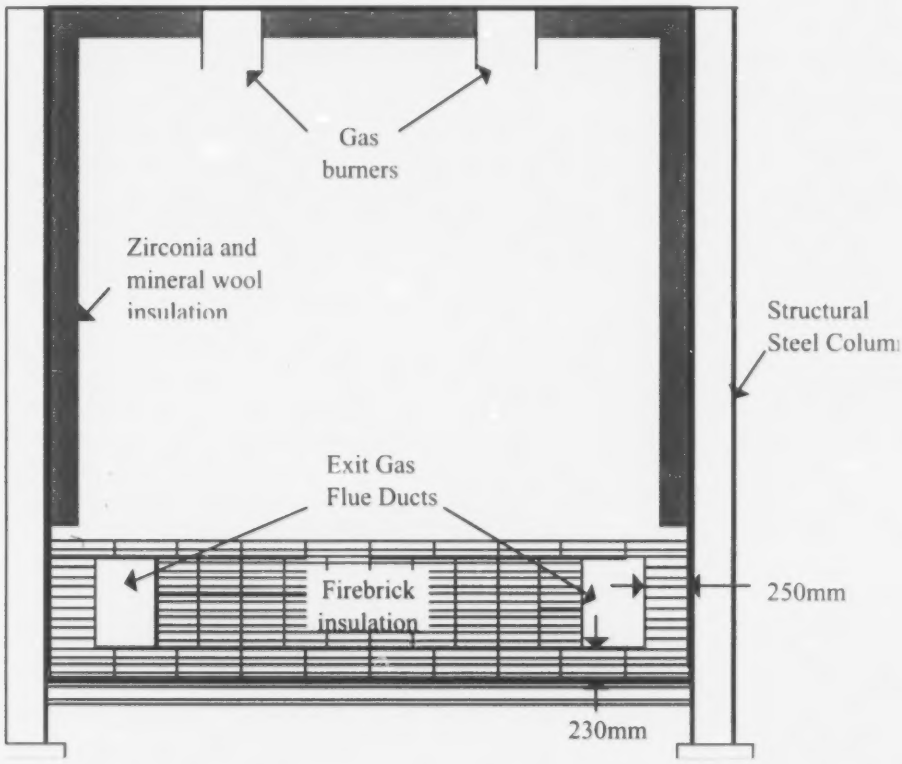
Further information

It is up to you to source any further information that is required. Local sources of information include:

- the training module "Conduction Heat Transfer" on your desk
- thermophysical data of various materials in the appendix of "Conduction Heat Transfer"
- simulations and video footage available on the desktop computer and video screen.

Remember that obtaining relevant information is often a critical task in high level engineering work and decision making.

If you require specific information on this Brief please contact your client at the following E-mail address. Paul_Cooper@uow.edu.au.



Layout of furnace insulation and structural steel.

The Status of Cyber University in Korea and its Future Direction

Wang, Sukhee *, Kim, Youngsil**
Bisan Dong, Dongan-gu, Anyang-Si, Kyungki, Korea
Daelim College of Technolog, Computer Science Dept.
*Tel.: * 82-31- 467- 4882, ** 82-31-467-4884, Fax . : * 82-31-467- 4888*
** e-mail: shwang@daelim.ac.kr, ** e-mail: YSKIM@daelim.ac.kr*

Cyber universities create innovative and more effective approaches to teaching and learning. In Korea, cyber universities are running in many different ways: universities established as an example case designated by Education Ministry, universities opened for life-long education, and cyber graduate school for educating professionals in many fields. Also, cyber campus for college level has started in many technical colleges. In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

Key Words: **cyber school, cyber university, Interactive learning, Web-based learning**

1 Introduction

Cyber student population is dramatically increasing since the development of information communication technology. Evolution of information technology allows us to learn anywhere, anytime. Since 1988, five universities including Seoul National University have been selected as model case cyber universities, and ten universities including Sogang University as experimental case. According to this policy, Seoul National Cyber University opened four courses in March, 1998. In the first semester of 2000 school year, total of 24 courses were opened.

Some of the model case cyber universities are Bool Cyber University, Open Cyber University, and Seoul Cyber Design University. Also, experimental case universities are Korea Cyber University (KCU) and Information Technology Cyber University, a consortium of 14 universities including Kangwon, Kyunghee, Korea National Open University sponsored by Education Ministry.

Cyber universities for life-long education are Unitel Cyber Campus and Campus 21. Campus 21 was established by Netist, Internet Contents Development Company, in 1998. Now courses in Information Technology field, Foreign Language field, and Programming field are available. [1,3,8]

So far, these cyber universities were not allowed to confer degrees on students. However, since March 2000, cyber universities, permitted from Education Ministry, confer degrees on students by Life-Long Education Law. Education Ministry received application for establishment of cyber university until June 2000. Sixteen cyber universities and one In-company cyber university are now registered.

In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

2 Present Status

Cyber universities program delivers unparalleled convenience and flexibility in the pursuit of their bachelor's, master's and professional bachelor's degree. They also offer customized training programs and reeducation programs for employees to many of the corporations. In Korea, the cyber universities and the courses they offer are increasing, and many of the students are willing to attend cyber universities due to their cost and time reduction, higher retention rates and self-paced training and performance support. Now, we would like to introduce some desirable cases.

2.1 KCU (Korea Cyber University)

KCU is the first cyber university consortium of 37 universities including Hanyang, and Younsei University, sponsored by Chosun Daily News, and Digital Chosun. In the first semester of 1999 school year, there were 507 classes, 25,389 students enrolled in, in the following semester, 706 classes, and 41,293 students. Korea Cyber Universities are planning to open classes to the public so that the students can pursue their degrees online. [3]

2.2 OCU (Open Cyber University)

OCU, selected as the designated institution from the Education Ministry in February 1998, is composed of 14 participated universities five cooperating universities, and 3 organizations. The 444 courses have been offered until first semester 2000. In fall semester 2000, 244 courses will be opened. [10]

2.3 Information Technology Cyber University

Consortium of 15 universities is take part in IT Cyber University. Total 26 multimedia lecture contents are completed including 12 internet technology courses, 2 IT general courses, 6 web based multimedia courses, and 4 IT venture classes. [4]

2.4 Namhae College

Inside NAMHAE Cyber Academy, there are cyber lecture room, broadcasting room, discussion room, chatting room, on-line evaluation room. And also, graphic file and audio lecture files are available. 345 classes have been offered so far, 1st semester in 2000, 84 courses were opened. [5]

2.5 Present Status

The Education Ministry has received 16 applications to launch degree-offering cyber universities, which are set to open March 2001, for the first time in Korea. By the June, 2000 deadline, four consortia of universities, eight individual universities and four private groups submitted applications to operate institutions offering courses on the Internet. Thirteen of them applied to provide bachelor's degrees, while the remaining three wanted to open courses for junior college diplomas. According to their submitted plans, the 16 applicants would recruit a combined total of 15,800 students in 81 departments. Samsung Electronics applied to set up an in-house college program for its employees. Samsung's plan envisages establishing a "Samsung Semiconductor Institute of Technology" that would offer a four-year bachelor's degree program and a two-year diploma course on digital and display engineering. It would be the nation's first accredited institution of higher learning set up exclusively for employees of a specific company. Education Ministry is planning to finish screening the applications by November, 2000.

3 Critical Issues

Cyber university hold great promise for enriching educational opportunity, especially for the homebound, or geographically isolated students. However, these advantages are overshadowed by many concerns.

3.1 General Aspects

* For cyber universities are at the point of beginning, law, technology, management system and marketing strategies are not yet fully established. Therefore, students don't have confidence in getting degrees.
* In cyber universities, there is lack of opportunities meeting professors face-to-face.
* Many of the students who have low-speed modem, spend lots of time to downloading lecture materials. When the lecture is transferring, time delaying is the most critical problem for real-time question and answer.
* For the cyber students don't have opportunities to meet other classmates or professors, the students don't have a chance to have social relationships, and get personality and ethics education.
* Due to the expanding of cyber universities, the traditional education system, which have played a great role in our history, is threatened. So, it is important to maintain balance of both education system.
* Lack of fund for developing high-quality multimedia contents and running cost is the biggest problem. In 1999, for example, the Information Technology Cyber university spent $2million for developing 26 multimedia lecture contents (about $50,000 per course).

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught. [6,7]

3.2 Faculty and Student Aspects

* For faculty in Korea, developing courseware and teaching takes too much time. So, they feel over-burdened on developing courseware and preparing lectures. In Korea, professors are obliged to teach for at least nine hours a week. However, in the case of Information Technology Graduate Cyber School, the professors are obliged to teach for three hours(one course) a week.
* It is hard for faculties to teach due to the diversity of student level. Also, it takes too much time to grade student's reports and quizzes. So, many teaching assistants should be available.
* Students have difficulties in course registration, dropping, adding and changing. [12,13]. In addition, it is hard for students to adapt due to the differences of platforms.
* Lack of interactiveness for intellectual motivation, and debating opportunities might result in passive participation for students. Moreover, flexibility of lecture schedules for employed students are not usually available.

4 Future Direction

Cyber campus must create an academic milieu that empowers the professional growth of faculty. The Cyber school must also create innovative and more effective approaches to teaching and learning. To implement the above objectives, the Cyber school will accomplish the followings.

* Testing: Exams should be available for each course.
* Feedback: immediate feedback provides each student with the topics they need.
* Security: Cyber university delivers all this safely and securely.
* Academic faculty must maintain control of shaping, approving and evaluating distance- education courses.
* Faculty should be compensated and given time, training and technical support to develop and conduct classes, and they should retain intellectual property rights over online materials.
* Students must be given advance information about course requirements, equipment needs, technical training and support throughout the course.
* Students should have opportunities to meet professors face-to-face whenever feasible.
* Full undergraduate degree programs should include classroom-based coursework.
* Quality of graphic resolution for multimedia files.
* Chattingroom in which professors and students are involved should be offered.
* Proper feedback for reports and projects should be offered.

* Online evaluation room and discussion room should be made.
* Shortening the time used for downloading the lectures should be considered.
* In classes offered by consortium, it should include high quality of contents, and the video will at least include 30% of the lecture. Also, in-class teaching (face to face) should be required at least twice a semester.
* Especially for college level, there are two ways of getting involved in cyber campus. First, students can take 80% of their credit at school and other 20% at any other cyber college. Second is allowing the students to take certain amount of cyber classes. This is for the students who have jobs during the day, for there are many difficulties attending the classes for them. Eventually, it will not only benefit in time reduction but also in higher retention rates.
* For developments of these high-quality cyber class contents and efficient operation, supporting of funds, technologies, software, and hardware is urgently needed.
* Cost and time reduction to develop multimedia lecture contents. New courses should be added regularly to give users access to the most current application and topics.
* Higher retention rates: Cyber university offers content in the form of interactive multimedia, users learn faster and retain more information.

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught.

5 Conclusion

The possibilities of cyber universities are endless as educators and students alike enthusiastically tout the convenience and advantages. But many professors worry about the accelerated pace and are trying to place some brakes on the race.

One-million member American Federation of Teachers, which includes about 110,000 college and university professors, approved at its Philadelphia convention a resolution calling for a set of quality standards for college-based distance-education programs. [2] Of course, it is critical that we hold this kind of programs to a high standard of academic rigor. However, We need to keep basic requirements to maintain high quality cyber lectures and student level. And also, government funding, technical equipment's, hardware/software supporting from the company, and tele communication infrastructure should be maintained.

References

Most of the internet site accessed on at the end of June to the beginning of July, 2000).

[1] Radford University http://www.runet.edu/~cyberu/intro.html

[2] Applied Technology Partners http://www.atpcorp.com/exam/university.html

[3] Korea Cyber University http://www.chosun.com/class/koreauni1.html

[4] Information & Communication University http://cyber.icu.ac.kr

[5] Namhae College http://www.namhae.ac.kr/infomanager1/main2.htm

[6] Kwak, Dukhoon (2000), "Management of Cyber university -Case Study: Information Technology Cyber University", Schoolnet 2000, Proceedings, PP.276-284

[7] Lee, Dongman, "Information and Communications University: Cyber Lecture", Schoolnet 2000, PP.400-408

[8] Campus 21 http://www.campus21.co.kr/home/default.asp

[9] Internet Library http://www.peacenet.net/english/internet/trend/1.htm

[10] Open Cyber University http://www.ocu.ac.kr/open_menu/introduction/default.htm

[11] Dongui Cyber University http://www.dit.ac.kr:82/menu6.htm

[12]"Integrated Information Services for 21st Century Education", June, 2000, Choongchung College

[13]"The Direction of Development for Integrated University Information System", Invited Seminar Proceedings, June 2000, Korea Info-Tech Co.

TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP—COLLABORATION TYPE AND LOOSELY CONNECTED TYPE

Shoichi Kinosita* and Nobuyuki Arakawa**
*SEITOKU University, *550, Iwase, Matsudo, Chiba, Japan 271-8555,*
E-mail: kino@po.jah.ne.jp
**Kamishinmei Elementary School, *Futaba-4, Shinagawa-ku, Tokyo, Japan*
Email: arakawa.nobuyuki@nifty.ne.jp

1 Introduction

We construct a virtual school in INET since December 1997 about elementary and secondary education. This virtual school is collaboration type. About 10 teachers are the managers who control the open and close to the courses. This members also join to "Project Group for Learning Process" founded at 1984 in Matsushita Audio-Visual Research Foundation. The courses are consists of Japanese Language, Mathematics, Social Science, Natural Science, Arts, etc. The writer of each course is voluntary and often invited by the manager. The system of this school is controlled by CGI program that counts and classify the visitors.

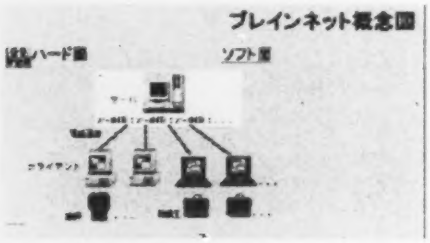


fig. 1 Structure of Type [A]

The other type -Loosely connected- virtual school will be appeared in several months. This type is the mirror image of writer's daily lesson. The writer is also the teacher at a classroom and the course is the same contents as the lesson at the class. The first purpose of this type is the help for absent student at lesson with inevitable reason.

The second purpose is the teacher's skill up the teaching methods and fill up his contents. Each course is gazed by the other writer and visitor by critical viewpoints and comments may send to him by E-mail or another way. These comments will effective for the writers. The writers are loosely connected by browsing and criticize for each other.

2 Comparison of Two Types of Virtual School

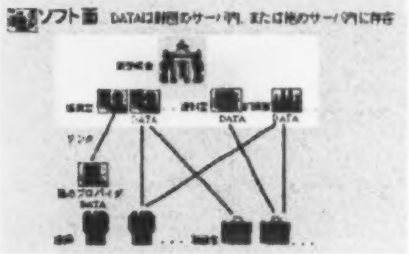


fig. 2 Software Structure of Type [A]

Let's call collaboration one is the type [A] and a loosely connected one is the type [B]. Type [A] may have fine course by fine teacher by the reason of solid watch and control and severe criticism. But the number of writers may be limited because of difficulties to make fine or excellent course. In fact, the number of writers of our school is about 20 teachers today. The increase of number of writers is very slow.

Type [B] may readily have many teachers because the reporting of own daily lesson wants little efforts except for some reviews and writing time.
On the other hand, the quality of course may not be

expected, and the learners to be supposed are very restricted.

Results

The two types [A] & [B] will be exist parallel to each other and exchange the writer, or perhaps invite the writer for type [B] at first and next to type [A] if the course will fine and universal.

The Language of both types is Japanese and every learner or visitor needs to read Japanese Language. This is an issue that is easily overcome by some Japanese to English interpretation software. Our two schools slightly gather the writers who want to spread their unique lesson and the effect appeared in the mutual discussion about order in lesson, resources, tools, and illustrations in both type.

fig. 3 Front Page of Type [B]

There are many virtual schools in Japan and all over the world. These are almost supported by ministry of education, nation, or company who have many staffs working with development and editing. Our tiny two virtual schools will combine the teacher's skill and fine lessons from voluntary teachers in Japan or other country and serve the chances to learn for many learners who can't go to the school with willingness to learn.

References

[1] Our type [A] Home Page, http://www.mef.or.jp/bnm/(accessed on July 20,2000)
[2] Our type [B] Home Page, http://www.kinosita.itabashi.tokyo.jp/(accessed on July 20,2000)

WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

Long-Chyr Chang, Heien-Kun Chiang, and Pi-Shin Wey
Da-Yeh University
112, Shan-Jiau Rd., Da-Tsuen, Changhua 51505
Tel: +886-4-8528469~3138
E-mail: long@aries.dyu.edu.tw

Web-based 3D life-like learning environment is becoming a major research topic. WALTZ supports dynamic, collaborative, and synchronous/asynchronous learning activity in 2D/3D virtual environments. In this paper, an overview of WALTZ's architecture and design philosophy is presented. Then, a WALTZ-style Pythagorean theorem learning space is shown to illustrate the powerfulness of the WALTZ environment. The ultimate goal of WALTZ is to provide an active and pleasant social learning environment for learners to study collaboratively and waltz happily in shared virtual, dynamic and yet exciting learning spaces.

Keywords: **Web learning, Virtual Reality, Collaborative Learning, CAI**

1 Introduction

The World Wide Web (WWW) opens a new learning space that learners can communicate and share their idea in this wonderful virtual world. The new learning space provides versatile ways of communication and interaction that would make learning more fun and entertaining than ever before. It has captured great attentions from CAI (Computer Assisted Instruction) researchers since its debut as it has great potential to surmount the difficulties and weakness of traditional CAI systems [5,7,8]. Up to date, most web-based CAI systems only support asynchronous learning and still use 2D hypermedia style to showcase their learning materials and instructions [13]. Some systems [3] might support collaborative learning additionally, however, they are still far away from success as the new way of learning also brings new problems that are even more challenging for educators. There is no simple way of knowing what the best web-based learning environment would be and how to utilize this environment effectively for teaching as well as learning. It is a research area that needs to be seriously explored through the cooperation of experts from different disciplines such as subject content experts, instruction developers, CAI researchers, and web engineers etc. Despite such problems, most educators would agree that discovering leaning, collaborative learning, learning by doing, and learning with fun are among those of effective learning methods according to Constructivism [2,9,12]. Fortunately, recent rapid progress of web technologies such as JAVA, VRML, and network technologies bring a new opportunity for implementing the learning methods described above. Before VRML was created in 1994, web spaces are flat. Most web systems are hypermedia style, which do not have enough expressive power of modeling real world entities. The living world specification [11,14] in 1997 illustrates emerging needs of dynamic and interactive 3D shared virtual worlds. Today there are many popular 3D avatar (virtual human) based virtual society (mainly for social meeting and chatting) websites [1]. The trend of web windowing systems is moving from 2D multimedia representation to 3D shared virtual space. WALTZ foresees the integration of the two media will become a popular form of presenting learning materials as well as a virtual fun place to play, learn and exchange idea. Many studies have also indicated that a successful web-based learning system not only has to be content-rich but also highly interactive as well as highly adaptive to meet the needs of learners [5,8]. Transforming 2D virtual classrooms into life-like 3D learning space is certainly one of the research directions that deserve special attention.

WALTZ, a research project under active development, is a web-based adaptive/interactive learning and teaching zone, which supports dynamic, collaborative, and synchronous/asynchronous learning in 2D/3D

virtual environment. WALTZ envisions that the CIA (Content, Interaction and Adaptivity) learning model will be an essential ingredient of future successful web-based CAI (Computer-Aided Instruction) systems. The CIA learning model is developed based on the Interaction Model of Gilbert [5] and Instruction Design Model of Moallem [15]. The CIA learning model has three corner stones: Content, Interaction and Adaptivity. The overlay areas of each neighboring corner stones are versatile representation, adaptive instruction and adaptive interaction. Figure 1 illustrates the CIA model in detail.

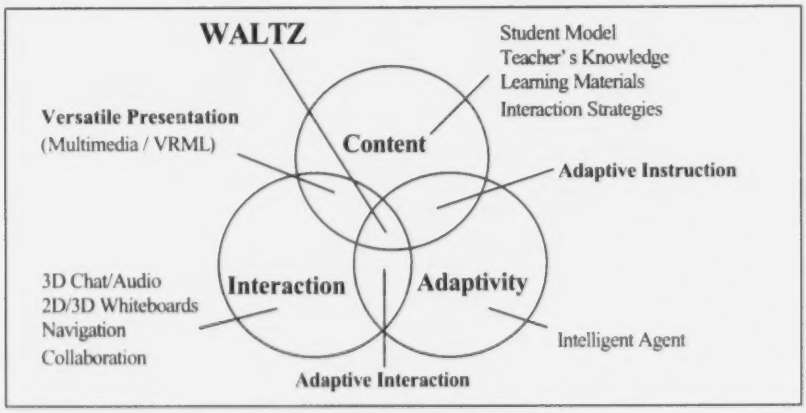


Figure 1. WALTZ's CIA Learning Model

2 An Overview of WALTZ

The main goal of WALTZ is to develop a web-based interactive and adaptive environment based on the CIA learning model so that it can be easily adapted to any instructional and learning subjects according to the theory of constructivism. WALTZ is capable of supporting discovering learning, project-based learning and collaborative learning in 2D/3D shared virtual learning space. WALTZ supports the following features:

(1) Dynamic interaction and flexible communication

WALTZ supports two types of interaction: Human-Computer Interaction and Social Interaction. The former supports instructional interaction and emphasizes individual and adaptive learning. Learners can browse information, navigate virtual worlds, and respond to problems that are dynamically generated from the WALTZ's system according to student's learning status. The latter supports collaborative mechanism and emphasizes collaborative learning among students, student and teacher, groups of students, and the whole class. In addition to support asynchronous communication in traditional 2D virtual classroom setting, WALTZ also supports synchronous communication in both 2D shared and 3D shared learning space as well.

(2) Versatile presentation of multimedia and virtual reality

Both multimedia and virtual reality have their advantages and disadvantages. Multimedia learning has great success in instruction and learning in recent years. Virtual reality is the best technology to provide 3D life environment. Web-based multi-user environment are even envisioned as one of the popular user interface in the future [9]. However, it is still hard to construct a high quality VR system in terms of cost and technology. Furthermore, virtual reality might not be suitable for all types of instruction. Thus, the use of both multimedia and virtual reality technologies in alearning system will be able to support a rich and effective learning environment that attracts students.

(3) Agent-based learning environment

Based on Constructivism, an ideal learning system should provide adaptive learning scenarios, where teaching materials and learning activity would be individualized according to students' mental model and learning needs. WALTZ supports helper-agents, which would interact with learners in several ways. For

example, an instruction agent would present an easier course material to a learner if it found the current content is too difficult for him/her. An interaction agent would suggest a group of learners to use a 3D whiteboard instead of a 2D whiteboard if they were trying to understand the three dimensional structure of molecules. WALTZ's virtual classroom could be populated with shared objects and active agents, such as user agents (represented by virtual human) and helper-agents so that users can enjoy and learn effectively in the social learning environment.

(4) Collaborative mechanism for activity management

Recently, group learning has been found to have a positive effect during learners' learning process [6,17]. In order to effectively support WALTZ's virtual, shared, and interactive social world, a set of collaborative mechanisms has been developed to manage interactions among students, teachers, and instructional content. These mechanisms [4] include object association, automatic object notification and change management, object delegation, object negotiation, object constraint, and object history tracking. Built on top of these collaborative mechanisms; WALTZ constructs an agent-based group activity model, where each participant is modeled as a user agent to manages the dynamic behaviors of all participants in an activity.

(5) Standard VRML authoring language for shared multimedia contents

Content development plays an important role of a successful web-based learning system. WALTZ supports authoring tools for shard virtual worlds based on multi-user VRML living world specification. This feature will make developments of shared 3D contents almost as easy as non-shared static 3D contents. Message passing between shared objects on different computers will be through new prototyped VRML nodes and WALTZ communication subsystem will update the states of each shared object once they are changed.

(6) Open architecture and platform independent web-based learning environment

The enchantment of web-based learning environment in WALTZ is due to its global network connectivity, simplicity and yet friendly user interface, and extensible architecture. The implementation of WALTZ is based on JAVA , VRML and standard network technologies so that it can be easily applied to other systems or platforms. A client can use current popular web browsers, such as Microsoft Internet Explorer or Netscape Navigator (with VRML plug-ins, such as Cosmo player or Cortna player) to browse information, navigate, and communicate with other clients in the WALTZ.

WALTZ is expected to be able to

- represent different media information effectively,
- construct various learning scenarios by integrating the technologies of virtual reality, multimedia, and World Wide Web, and
- to provide activity management facilities and collaborative mechanisms to enable highly interactive collaboration among all students, teachers, and instructional material in collaborative learning activity.

3 The Architecture of WALTZ

WALTZ is basically a client/server distributed virtual reality system. The client side provides human-machine interface that uses the technologies of audio, image, HTML, VRML, and the Java Internet capabilities to provide a web-based multimedia/virtual classroom according to the theory of Constructivism. Its environment contains JAVA control applet, multimedia, virtual world interface and collaborative tools such as text chat tool and shared whiteboard. Figure 2 illustrates the architecture in detail. Each client (user) can join one to multiple sessions to collaborate with other participants in 2D/3D shared virtual classrooms (or learning spaces). The server side is composed of five main components: (1) collaborative mechanisms subsystem, (2) VRML world server, (3) intelligent agent-based server, (4) Web server, and (5) communication subsystem for supporting real-time synchronous or asynchronous message interchange. The collaborative mechanisms subsystem ensures that the inter-dependency/intra-dependency of all activities/participants will be maintained and validated during their interaction. In addition, notification, delegation or negotiation protocols will be executed once some events of interest are triggered. The VRML world server will handle all VRML events coming from the event manager and updates the states of each shared VRML objects. The agent-based helpers communicate with the activity manager in inferencing and discovering potentially new learning patterns of students based on the diagnosis and feedback of students'

learning history. A communication subsystem supporting TCP/UDP/RTP protocols is used by all components of WALTZ to facilitate the real-time synchronous or asynchronous communication of interacting objects (or entities). The web server is responsible for downloading multimedia and VRML representation of instructional materials or virtual learning space.

4 Pythagorean Theorem Learning Space

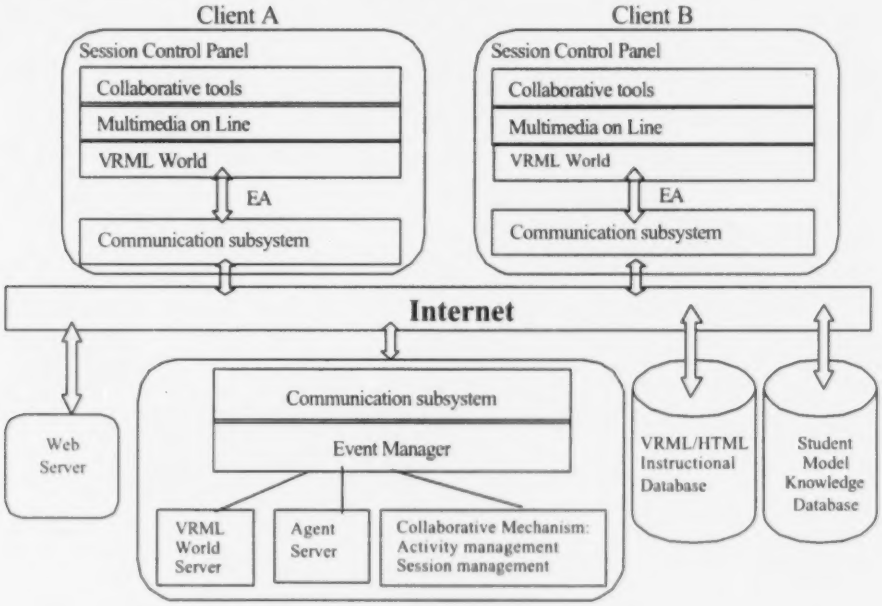


Figure 2. The Architecture of WALTZ

Pythagorean theorem is an interesting mathematical subject of the eighth grade students in Taiwan. It has rich heritage in mathematical history. Based on our survey, most current web-based systems teaching Pythagorean theorem only focus on the 2D interactive theorem proving process. WALTZ, in contrast, not only offers 2D interactive theorem proving process but also provides several key learning components to help students better understand the fundamentals of Pythagorean theorem. Figure 3 is an entry to the Pythagorean theorem learning space, where users can meet and navigate the virtual world dynamically or enter into any one of the learning components described below. The user interface contains two parts: VRML virtual world and JAVA applet control panel. The VRML virtual world is the learning space, provided by the WALTZ web server, where learners can navigate the virtual world, enter into a learning session, and meet other learners in the same session. The control applet provides chat tools so that a learner can talk to other learners for collaborative work.

The design of WALTZ-style Pythagorean Theorem learning space intends to support the features that are listed in Section 2. Current implementation of the WALTZ-style Pythagorean Theorem learning space consists of the following five learning components:

(1) Multimedia instructions

In WALTZ, instructional design of Pythagorean theorem covered three on-line learning sections: history of Pythagorean theorem, prerequisite knowledge and skills of Pythagorean theorem, and all the concepts about Pythagorean theorem. Since Pythagorean theorem is related to the mathematical concepts in both algebra and geometry and each concept need different multimedia features for presentation. Thus, different multimedia components such as text, graphic, animation, sound etc. were carefully designed and arranged in the interface to present the subject domain.

(2) Collaborative and interactive Pythagorean theorem proof/verification

One of the major features of WALTZ is the collaborative learning environment for Pythagorean theorem proof/verification. The activity manager in WALTZ provides facilities for instructors/learners to create/modify/delete/join an activity/session, to assign permission, to set constraints, to record the history of learners' Pythagorean practices, and to support group awareness during their collaborative learning. Figure 4 is an interactive program that allows users to learn Pythagorean theorem by experimental method. Students can drag each vertex of the triangle. If it is a right triangle then one can visually verify if it satisfies the Pythagorean equation: a^2+b^2=c^2. If it is an acute (or obtuse) triangle then the Pythagorean equation is not valid and a^2+b^2 >(<) c^2. Figure 5(a) shows a collaborative Pythagorean theorem proving program in action which not only support collaboration but also group awareness (i.e. can visually see who is making the move). All participants in a collaborative application is managed under the control of activity (or session) manager, as shown in figure 5(b).

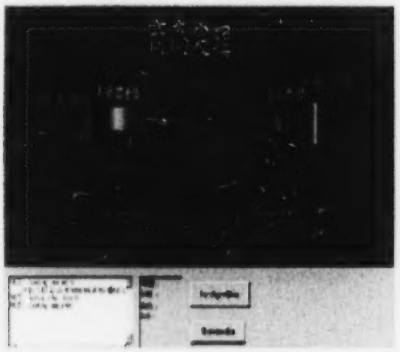


Figure 3. Pythagorean theory learning space

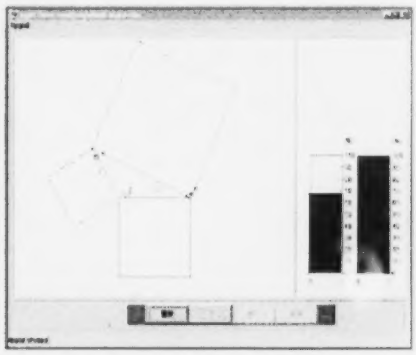


Figure 4. An obtuse triangle: a^2+b^2< c^2

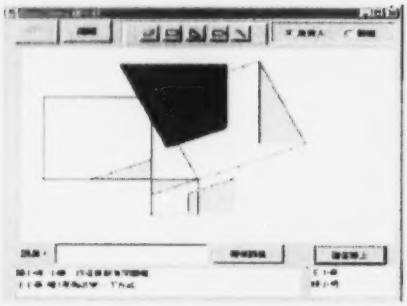


Figure 5(a). Collaborative Pythagorean application

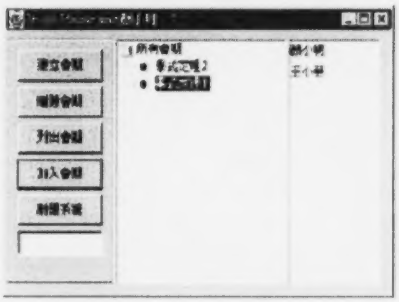


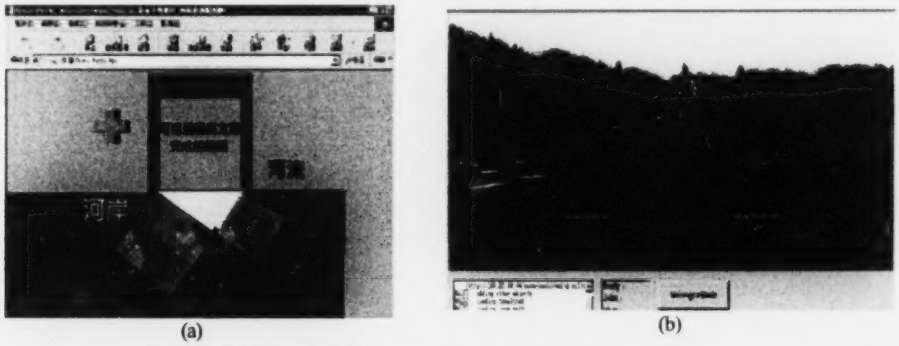
Figure 5(b). Session management

(3) Adaptive multimedia on-line testing

Traditional drill and practice CAI was criticized too boring to be used for young students. A web-based on line test without multimedia will have the same problem. A precompiled multimedia CAI program using Shockwave or Flash authoring technologies provides a better solution, however, it is not easy to change or add new contents adaptively into the program without recompiling the whole program. WALTZ is a dynamic virtual environment which can add/delete objects during users' learning journey. WALTZ intends to support an adaptive multimedia testing mechanism. Students will be given multimedia style test questions based on their current learning status. The multimedia test problems are generated on the fly by converting text -based questions stored in the database into multimedia representation. WALTZ will classify questions and suggest appropriate multimedia templates to make the conversion almost as easy as a PowerPoint presentation.

(4) Multi-user Project-based Pythagorean theorem virtual environment

To support project-based collaborative learning, a virtual environment is constructed. Team members can join the same session to solve the mathematical puzzles generated from the WALTZ system by interactively moving pieces of puzzle into the right place according to Pythagorean theory. Since WALTZ is a shared virtual environment that supports collaborative learning, each member of the team can see actions from other team members and they can communicate with each other to discuss how to solve the puzzle before they can go on to their next journey. Figure 6(a) & (b) illustrates a situation that a team must solve the puzzle of bridge using Pythagorean theorem before they can pass through the river and enter into the forest to continue their next journey.



(a) (b)

Figure 6 (a) & (b). Project-based multi-user collaborative learning space

(5) Pythagorean resource

Besides the aforementioned components, WATLZ also provide useful utility tools, such as online notepad and calculator that users can use conveniently. In addition, many different web sites relate to Pythagorean theorem were linked in WALTZ for learners to acquire various information easily.

5 Conclusion and Future Research

Due to progressively advanced development of 3D graphics and open network technologies, a web-based learning system that provides asynchronous and hyperlink-style environment might not attract young students in the feature. In addition, such systems will have great difficulty in constructing a situated, dynamic, and collaborative learning environment according to Constructivism. Therefore, This research proposed a CAI learning model from which a new architect of a web-based 3D life-like learning space, WALTZ, is created. By using Pythagorean theory as a case study, the study has demonstrated that WALTZ has a great potential to provide an improved learning environment over traditional virtual classroom setting.

Though WALTZ is still far from perfect, this research indicates that it deserves special attention among CAI research community. Next generation of WALTZ will focus on dynamic behaviors of agents via current state of the art MPEG-4 technology.

Acknowledgement

This research is founded by National Science Council (grant#: NSC 88-2520-S-212-004) in Taiwan.

References

[1] Blaxxun Interactive, http://www.blaxxun.com/ (accessed on June 2, 1998).

[2] Brooks, M. & Brooks, J., "In Search of Understanding: The Case for Constructivist Classrooms", Alexandra, VA:ASCD, (1995).

[3] Carlson, S. & Hawkins, R., "Linking Students Around the World: The World Bank's New Educational

Technology Program", Educational Technology (September-October), pp. 57-60, (1998).
[4] Chiang, H. K. & Lin, C. H., "A Study of Collaborative Mechanisms for Web Teaching and Learning", Journal of Da-Yeh University, Vol 8, No 2, pp. 63-79, (1999).
[5] Gilbert, L. & Moore, D. R., "Building Interactivity into Web Courses: Tools for Social and Instructional Interaction", Educational Technology (May-June), pp. 29-35, (1998).
[6] Harasim, L., "A Framework for Online Learning: The Virtual-U", Computer, pp. 44-49, (1999).
[7] Henin, I. & Droctor, L., "Incorporating the Web as Teaching Tool: Introduction", http://web.uvic.ca/~esg9/emo/emomain.html/ (accessed on May 1, 1999).
[8] Hughes, C. & Hewson, L., "Online Interactions: Developing a Neglected Aspect of the Virtual Classroom", Educational Technology (July-August), pp.14-55, (1998).
[9] Jung, B. & Milde, J., "An Open Virtual Environment for Autonomous Agents using VRML and Java", VRML 99 Proceeding, (1999).
[10] Kearsley, G. & Shneiderman, B. "Engagement Theory: A Framework for Technology -Based Teaching and Learning", Educational Technology (September-October), pp. 20-23, (1998).
[11] LW, "Living Worlds Specification, Draft 2", http://www.livingworlds.com/draft_2/index.htm (accessed on April 12, 1998).
[12] Merrill, M. D., "Constructivism and Instructional Design", Educational Technology, Vol 31, No 5, pp. 45-33, (1991).
[13] Merrill, P. F., Hammons, etc., "Computers in Education", NY: Simon & Schuster Company, (1996).
[14] Mitra, K., "Living Worlds", http://www.livingworlds.com/draft_1/lw_ideas.html (accessed on November 21, 1997).
[15] Moallem, M., "Instructional Design Model and Teacher Thinking: Toward a New Conceptual Model for Research and Development", Educational Technology (March-April), pp. 5-18, (1998).
[16] Pesce, M., "VRML: Browsing and Building Cyberspace", New Riders, (1995).
[17] Sherry, L. & Myers, K. M., "The Dynamics of Collaborative Design", IEEE Transactions on Professional Communication, Vol 41, No 2, pp. 123-139, (1998).

Web-Based Subject-Oriented Learning Program on Geophysics For Senior High School

Rong-Kuan Yang* Yi-Ben Tsai and Shi-Jen Lin*****
** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
e-mail: rk@eqm.gep.ncu.edu.tw
*** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
E-mail: ybtsai@eqm.gep.ncu.edu.tw
**** Department of Management Information System, National Central University, Taiwan*
E-mail: sjlin@mgt.ncu.edu.tw

Homepages of contents on the topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been composed for the subject-oriented learning program for senior high school students. Learning test activities were performed to testify the teaching and learning effect via Internet. The homepage contents bear the characteristics of (1) scientific theory-based descriptions, (2) more local examples, (3) highly relating to common life, (4) more dynamic illustrations, and (5) providing interesting practicing works. The results of subject- oriented learning test activities in this study show that the learning style, learning procedures and the homepage contents are all highly accepted by the participants from senior high school. And the learning effect is obvious as judged by comparing the pre-learning and the after-learning concept diagrams drawn by each individual participant.

Keywords: **subject-oriented learning program, learning test activities, concept diagrams**

1 Introduction

Internet system supplies plenty of knowledge conveniently and quickly, the explorer can achieve the purpose of self-learning by collecting, reading, analyzing and combining different kinds of data via Internet. For the purposes of improving the learning environment, enhancing the teaching quality, and raising the learning effect on Earth Sciences education for senior high school, web-based course contents on topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been set up based on the idea of subject-oriented learning program [2]. Senior high school students can not only do the self-learning but also exchange their learning ideas with others through Internet learning system under different conditions of time periods and places. By joining the study results from fields of education, computer technology, geophysics and geology, subject-oriented learning test activities for each specific subject were performed respectively with the participation of volunteered teachers and students from different senior high schools so as to evaluate the learning effect of Internet learning system.

2 Objectives

By especially considering the educational idea of subject-oriented joint learning mode[1], homepage contents were set up. Internet learning test activities were performed by using joint learning software and concept diagram drawing software developed by the computer technologist' s [3]. The major objectives of the study are as follows:

1) Setting up basic web-based contents on Earth Sciences so as to enhance the teaching and learning interests for high school education, the contents may also serve to a better understanding of the earth environment for social people.

2) Setting up the effective searching catalog so as to assist in surveying and collecting related data.
3) Assisting in solving educational problems and improving learning effect through Internet communication system.

3 Subject-Oriented Joint Learning Test Activity

Subject-oriented learning strategy was the major concern in the study. Participants were advised to carry out the learning program by reviewing and collecting related contents through Internet. All the communications were put through BBS posts or e-mails, there were volunteer helpers, college students, to respond all proposed questions from time to time. Team works were important besides individual learning as well, each would share personal learning results with others and came out a group report, individual learning effect was evaluated by comparing the pre-learning and after-learning concept diagrams.

After entering the web site "gepedu.gep.ncu.edu.tw" (Fig. 1), participants would click the right icon to choose the specified subject for the activity. Each one should draw a pre-learning concept diagram by connecting the provided concept terms with proper words after watching the "Miss story" (a short documentary film) prepared for the subject. And then, the major stages for the learning test activity were:

1) Participants were separated into groups of different topics on the specified subject based on his own study interest.
2) Every group set up its study assumptions and strategy; certain assignments were distributed to each individual member of the group.
3) Group members started to survey and collect related data for the topic, and all the working records were kept by using joint learning software.
4) Participants bearing the original role of topic group were re-divided into different groups of experts to cover more study fields. Members discussed and shared personal study ideas and results with others.
5) Each participant returned to his original group of topic and made after-learning concept diagram a group report for the study was also made with the efforts of all the group members.

4 Results and Discussions

Three learning test activities were finished in the study [2]; detailed descriptions of the activities are in Tables 1 to 3. When first learning test activity on Earthquake was being held; related software was not well developed. Internet function was limited to content reviewing. By the time of second learning test activity on Plate Tectonics Theory software was more fully developed, all works were done under Internet environment; more working records were preserved in personal joint learning files for the second and the third activities. All discussions and questions among the students were put through BBS posts and e-mails; volunteer helpers joined the discussions and also answered the questions in time. There are 119 posts from the second activity and 552 posts from the third activity, most of the posts are highly related to the learning program. Each participant finished drawing two concept diagrams in pre-learning and after-learning stages respectively, there are 24 diagrams from the second activity and 46 diagrams from the second activity. And each group had also submitted the group report as required in the learning activity in time, there are 2 and 3 reports for the first and the second activities respectively. Plenty of discussions and notes have also been recorded in the joint learning software in Internet. However, the insufficiency of the Internet system and the learning pressure under traditional education system may interrupt the continuous progressing of the learning program, occasional oral communications seem to be necessary. Though the ability in data analyzing, reducing and deducing may not be well satisfied, students show obvious improvement in the knowledge of the subject as judged by comparing and analyzing the individual pre-learning and after-learning concept diagrams and from group reports.

5 Conclusion

Homepage contents for all the three subjects are highly acceptable to high school students and teachers, most of them confirm with the learning effect of the subject-oriented joint learning program. If the traditional learning pressure would be suitably released, students will be more willing and free to perform self-learning program through Internet learning system even though they are not very well familiar with the operation of the used software.

References

[1] Chen, F. C., "The study of a cooperative project-based learning design in network-based environment", NSC Study Report, NSC-88-2511-S-008-002, pp. 1-8(1999)

[2] Chin B. H., Yang, R. K. and Wang, C. Y., "Development of a learning environment for solid earth (geophysics) through Internet", NSC Study Report, NSC-88-2511-S-008-005, pp. 1-5(1999)

[3] Lin, S. J., Chou, S. C., Chen, Y. M., Chan, T. W., "A study of Internet-based collaborative project learning environment", NSC Study Report, NSC-88-2511-S-008-003, pp. 1-8(1999)

Table 1 Learning Test Activity on Earthquake

Time	1998.5.3, 1 day
Location	computer room in Wuling Senior High School
Participants	12 high school students, 3 high school teachers, 17 volunteer helpers(students and teachers from Department of Earth Sciences, National Central University)
Subject	Earthquake
Group of Topic	Occurrence and Distribution, Intensity and Magnitude
Working Pattern	content reading via internet, one to one oral communication, working processes recorded by volunteer helpers
Evaluation Materials	concept diagram, questionnaires, working records

Table 2 Learning Test Activity on Plate Tectonics Theory

Time	1999.2.27~1999.3.6, 8 days
Location	computer rooms in Wuling Senior High School, ChenSheng High School and National Central University, personal working environments
Participants	6 students and 1 teacher from ChenSheng High School, 6 students and 1 teacher from Wuing Senior High School, 7 volunteer helpers from National Central University
Subject	Plate Tectonics Theory
Group of Topic	Continental Drift, Sea Floor Spreading
Group of Expert	Dynamics, Mechanism, Effect
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software, three assignments

Table 3 Learning Test Activity on Chi-Chi Earthquake

Time	2000.2.2~2000.2.26, 25days
Location	computer room in National Central University, personal working environments
Participants	4 students and 1 teacher from ChenSheng High School, 2 students and 1 teacher from TaoYuan High School, 2 students and 1 teacher from Wuling Senior High School, 3 students and 1 teacher from HsinChu Experimental High School, 2 students from ChungLi High School, 5 students from HsinChu High School, 2 students from HsinChu Girls' High School, 2 students from ChenDer High School, 1 students from ChuTung High School, 7 volunteer helpers from National Central University
Subject	Chi-Chi Earthquake
Group of Topic	Mechanism, Analysis, Effect
Group of Expert	Focus, Magnitude, Focal Mechanism, Hazard
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software

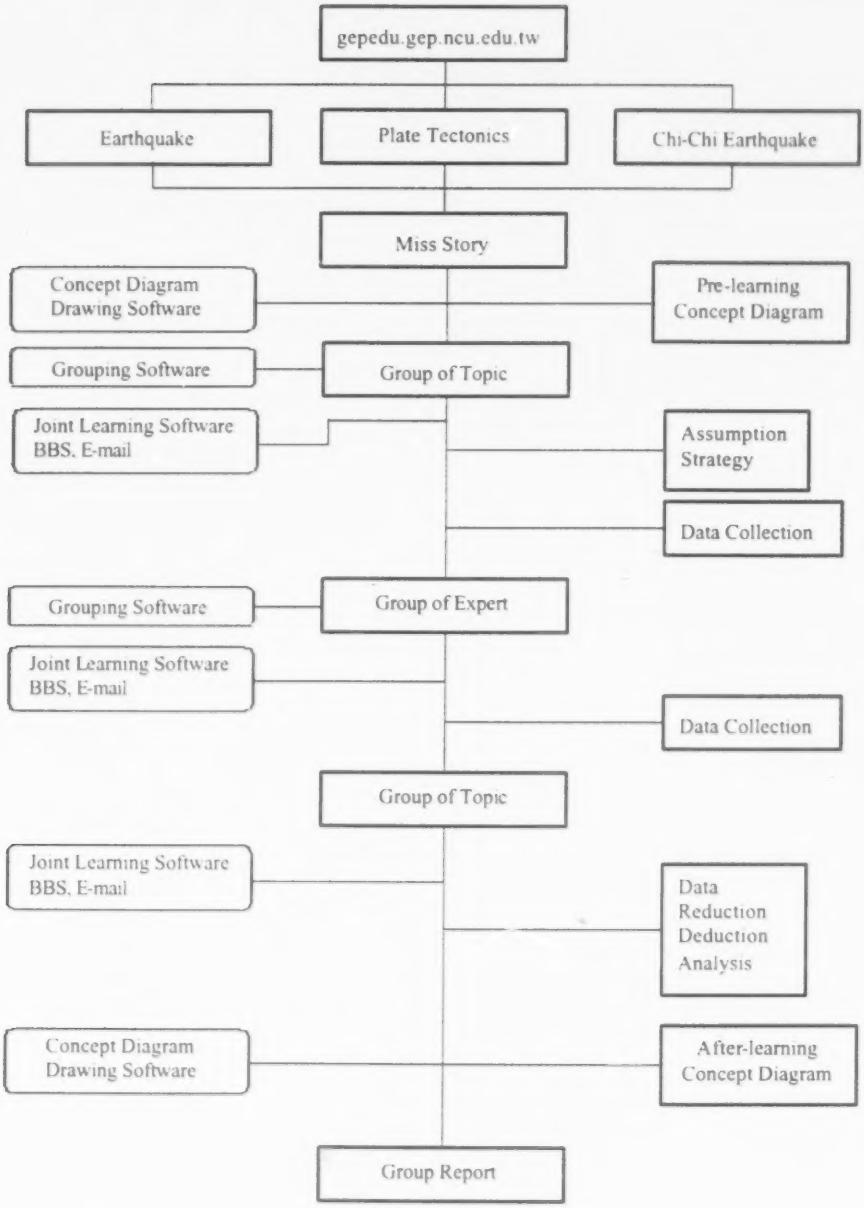


Figure 1 Flowchart for subject-based joint learning test activity

Proceedings

Content

▶Full & Short Papers (Virtual Reality in Education)

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)
A Case Study of Creating Geochemistry Lab of Virtual Reality in Education
A Virtual Reality Application for Middle School Geometry Class
Constructing a real-time CAD learning system based on OpenGL in Web-based environment
Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments
Strange Creatures in Virtual Inhabited 3D Worlds
The Effect of Virtual Reality Learning with Different Cognitive Style
Using Virtual Environments for Studying Water Phases and Phase Transitions
Using virtual reality courseware to enhance secondary school student learning in geosciences
Virtual Inhabited 3D Worlds and Internet Based Learning Environments
WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

▲HOME

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)

Stephen C F Chan*, Andy Wai, Jean Chow & Vincent T Y Ng
Dept. of Computing, Hong Kong Polytechnic Univ., Hong Kong
*csschan@comp.polyu.edu.hk

A web-based Computer-aided learning system for 3D - Surface Development Module (C3D-SD) has been developed for teaching the appreciation of 3D geometric shapes by unfolding the surface boundary of a solid object into a planar 2D pattern. The problem is similar to the problem of surface development in technical drawing and highly related to the reverse problem of folding a 2D shape into a 3D object, with practical applications in sheet metal work, pattern making, and packaging design. C3D-SD makes extensive use of animation, interactive control by the student, and quizzes to present the material and to engage the students. It makes use of the solid modeling library SML to create 3D solid shapes by Boolean combinations (union, intersection and difference) of primitive shapes, and Java3D for rendering and animation. It includes a Packaging Design Module which builds on the Surface Development module by automatically adding flippers and minimizing the rectangle enclosing the unfolded pattern. This system is the second installment of a series of CAL systems for Three-dimensional Geometry that the authors have been developing.

Keywords: **3D geometry, surface development, animation**

1 Introduction

Surface development is an important technique in design. Generally it involves unrolling a curved surface into a planar 2D pattern. Theoretically speaking only certain classes of surfaces are "developable" [Carmo 1976]. If, however (as is the case in many computer graphics systems), curved surfaces are approximated by sets of planar facets, then all curved surfaces can be unfolded into 2D planar shapes, although they may appear to be "unnatural" or "ugly". A related problem is the unfolding of the planar faces bounding a facetted solid object into a planar 2D shape. The inverse of the problem is folding a planar 2D shape into a 3D object, e.g., folded the card-board boxes for hamburgers in fast-food restaurants. These techniques have practical applications in sheet metal work, pattern making, packaging and package design, etc. [Giesecke et al 1997] This paper describes the development of a Web-based computer-aided learning system for teaching the appreciation of surface development/unfolding based on a polygonal representation of solid objects. It is a part of a series of Web-based tools for teaching 3D geometry that our group has been developing. A previous project focussed on sectioning and interactions between some primitive solid shapes was reported in [Chan et al 1999].

Traditional teaching materials on these topics were mainly text based. Better materials have graphics or charts in addition to plain texts. In presenting descriptive topics, this approach is adequate. However, in teaching three-dimension geometry, the two-dimensional and static presentation style is obviously not enough. The use of videos can be effective to some extend but it is still one-way communication and not interactive. A more effective alternative is to use real solid objects to help students visualize 3D shapes. But some objects are difficult to be made, and it is impossible for teachers and students to change the size, scale, shape or appearance of the object quickly.

In contrast to the limitation of 2D materials, videos and real 3D objects, a virtual environment can be a better approach in presenting certain 3D geometry problems. A virtual environment is a computer-generated environment in which 3D or even the forth dimension (time) can be presented through animation. Within the virtual environment, one can change the size, scale, shape or appearance of the virtual object interactively. To have a clearer look, one can zoom into the object. To see the inner structure, one can set part of the object

to be transparent. And geometry can be animated by transforming the object over time. And of course, an interactive teaching approach is much better than one way communication in enhancing student understanding. Finally, for purposes of accessibility and distribution, the Web is the ideal environment. These considerations drove the development of this project.

2 Overview of C3D-SD

The main problem tackled by C3D-SD is surface development, as illustrated below in Figure 1. In (a) is shown a solid cone shaped object with the top cut off at an oblique angle. In (b) the surface of the cone is in the middle of being unfolded. In (c) the unfolding is complete. Note that we had tried to keep the unfolded 2D shape connected. As a result, the curved conical surface itself became disconnected (actually connected through a single vertex). It is not difficult to see that it is possible to unfold the surface while keeping the curved conical surface connected.

(a) (b) (c)

Figure 1. Surface development in action.

C3D-SD is organized into three types of activities:

1. Tutorials - Students are guided through demonstrations, including: matching 3D solids to unfolded shapes, animations of unfolding (e.g., of the conical object in Figure 1), animations of folding 2D patterns into 3D solids, adding flippers to unfolded 2D patterns for fastening, reducing the size of the rectangle bounding the unfolded pattern, etc.
2. Free-form exercises - Students are allowed to explore the teaching material on their own. They are provided with numerous opportunities to interact with the teaching material, e.g., creating complex 3D solids by combining primitive shapes, selecting view points, putting different textures on objects, controlling the animation process, etc. The problems are similar to those presented in tutorials. But many more shapes are available for students to experiment with, for self-guided exploration and exercise.
3. Tests - Students can test their understanding of the material through multiple -choice tests. They are asked, e.g., to match an unfolded 2D shape with the solid object, such as illustrated below in Figure 2. If so desired, they can turn to the free-form exercises to explore the test shapes that they have problems with.

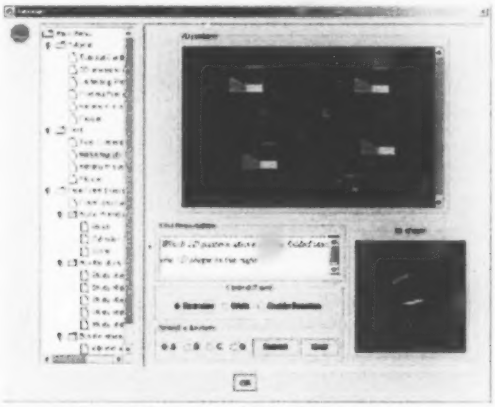


Figure 2. Sample multiple choice question.

The three types of activities are chosen for the following reasons. The tutorials provide core contents to be imparted to the students. The free form exercises allow the students to explore the subject on their own.

Different students with different backgrounds and learning styles benefit from different learning activities, hence both guided and sef-guided types of activities are provided. Finally, tests are developed to gauge the students' grasp of the material. It is expected that C3D-SD can be integrated with an intelligent tutoring system to provide a learning experience more tailored-made for the individual students.

C3D-SD focuses on five types of problems:

1. Matching 3D solid shapes with the corresponding unfolded 2D patterns.
2. Unfolding the surface boundary of a facetted solid and developing curved surfaces.
3. Folding 2D patterns into 3D solid shapes.
4. Simple packaging design: Adding flippers to the unfolded 2D pattern for fastening.
5. Simple packaging design: minimizing the rectangle bounding the unfolded 2D pattern.

3 The 3D Solid Design Module

Java was chosen to develop this system as it is a web-oriented development language and only a Java-enabled Web browser (e.g. Netscape, Microsoft Internet Explorer) is needed to access the Web pages without installing other plug-ins. However, it is difficult to build 3D applications using only the core Java classes. A Java-based high-level programming library, Solid Modeling Library (SML) [Chan et al 1998] is used in C3D-SD for designing 3D solid objects. SML supports the building of 3D solid objects through a set of atomic functions called Euler operators. These functions allow the incremental manipulation of Boundary Representation (B-rep) models, while processing the underlying well-formed data structure. It also supports the creation of solid primitives (block, cylinder, cone, sphere, torus) and Boolean operations (union, intersection, and difference) on solids and transformations (translation, rotation) of solid objects for easy creation of complex 3D solid shapes. For example, a hollow pipe can be created by the differencing (subtracting) a smaller cylinder from a larger cylinder. SML uses a hierarchical half-edge data structure that stores rich information about a solid model [Mantyla 1988], including solid-to-face, face-to-face, face-to-edge, edge-to-edge, edge-to-vertex, and vertex-to-vertex information. The data structure used in SML to represent the surface boundary of solid objects is illustrated in Figure 3.

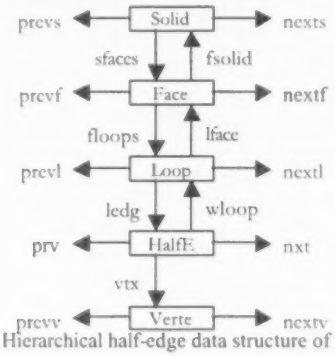


Figure 3. Hierarchical half-edge data structure of SML.

4 Surface Development

The process of surface development or unfolding is illustrated in Figure 4 using a cube as an example. Each face of the cube is coloured differently for easy identification. One might imagine that the unfolding starts by holding the bottom (red) face of the cube fixed to the horizontal plane, and rotating the rest of the cube about the edge linking the red face with the green face until the green face is in the same plane as the red face. This is followed by the blue face, then the yellow, then the light blue, ..., and finally the purple, until all faces lie in the horizontal plane.

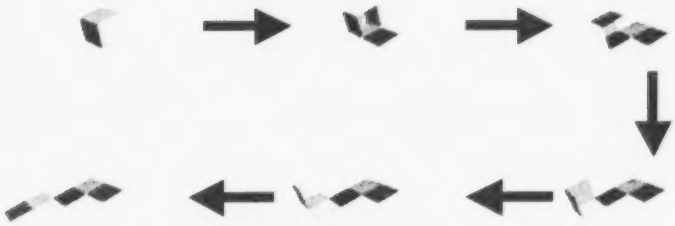


Figure 4. Unfolding a cube.

Sun Microsystems provides the Java3D application programming interface (API) which can be used to develop three-dimensional graphics applications and applets. It gives developers high-level constructs for creating and manipulating polygon-based 3D geometry and for constructing the structures used in rendering that geometry [Sowizral et al 1998, Sun 2000, Brown & Peterson 1999]. It is an object-oriented API, which can be used to construct individual graphics elements as separate objects and connect them together into a tree-like structure called the scene graph. It contains a complete description of the entire scene including the geometric data, attribute information and viewing information needed to render the scene from a particular point of view. Java3D provides a simple and flexible mechanism for representing and rendering scenes with lighting effect but it does not provide high-level construct for creating complicated solid object models. Hence SML was used to create the 3D solids which are subsequently converted into Java3D for rendering and animation.

4.1 Conversion from Solid (in SML) to Surface (in Java3D)

Each face object in SML is converted into a Java3D geometry object by using the information on the vertices of the face. As a result a SML solid object is converted into a group of Java3D geometry objects, each representing a face as illustrated in Figure 5. However, the data structures used to represent objects in Java3D and SML are different, and a conversion process is required to integrate the two systems to take advantage of their respective strengths to produce a more complete solution.

The displayable object in Java 3D is implemented by the Shape3D class. The Geometry and Appearance objects make up a Shape3D object. The Appearance objects controls the outlook of an object, e.g. color, material, etc. The Geometry object contains the vertexes information. We choose triangle as the basic shape in forming a geometry object because it contains the minimum number of vertexes that can form a plane. So that any face shape can be formed by the combination of triangles.

The conversion of an object represented in SML to one represented in Java3D involves 4 steps. Recall that each face in a SML Solid is converted into a Geometry object in Java3D.

1. Find the number of faces in the SML Solid object.
2. For each face, find the number of vertexes and the coordinates of each vertex.
3. Group three vertexes into a triangular strip.
4. Combine all triangular strips to form a Geometry object in Java3D.
5. Each Geometry object will result in a Shape3D object.
6. Group all Shape3D objects to form the representation of the solid in Java3D.

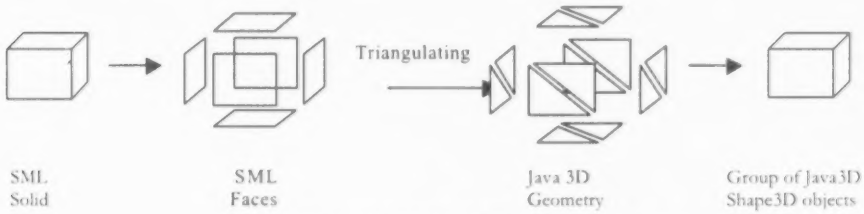


Figure 5. Converting an object from SML into Java3D.

4.2 Unfolding Path

In order to "develop" a surface approximated by a set of polygons, or to unfold the boundary of a solid, one needs to determine a connected path traversing all the faces one at a time. The path for unfolding can be

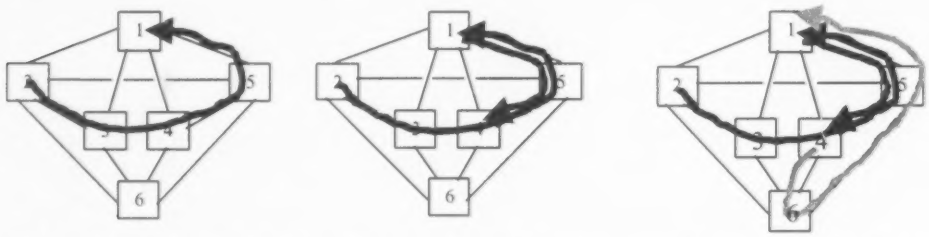
1. specified manually by the student,
2. pre-set in CAL-SD manually by the teacher, or
3. determined automatically by CAD-SD.

Automatic determination of the path for unfolding involves two steps:

- Determine the connectivity between the faces, e.g., in the form of a **graph** whose nodes are the faces, and an edge links a pair of neighbouring faces, and
- Traverse the graph to find the desired connected **path**(s) that visits each face one at a time and each face only once.

As the data structure of SML stores rich information of the complete solid, the connectivity relationships between faces can be easily derived. To derive the path(s) of traversing all faces one and only one at a time is a version of the traveling salesperson problem [Johnsonbaugh 1996]. It is a problem that is known to be hard (computationally expensive) for arbitrary graphs. In our system prototype, we chose to use exhaustive search because of its simple implementation. In future versions we may try to find a more efficient algorithm. In the default version of the algorithm, we simply try to find a solution (any solution) using the well-known **backtrack** algorithm. Firstly, pick up a face arbitrarily. Then, traverse to one of its neighbors. Repeat this process until all the faces have been visited. When a dead-end occurs, it will back track one or more steps to find another possible way (Figure 6). Dead-end means arriving at a face with no un-visited neighbours, while there are still un-visited faces remaining in the graph.

The algorithms implemented in C3D-SD so far traverse the faces of an object in a linear sequence, i.e., the unfolded faces form a linear chain of planar polygons. There are other alternatives, e.g., unfolding in two directions at the same time, resulting a Y shaped chain of polygons, etc. In future versions of the system, we will implement other unfolding algorithms.



(a) Dead-end occurs when traversing 2 ⇨ 3 ⇨ 4 ⇨ 5 ⇨ 1

(b) Backtracking from dead-end to face 4 to find another possible path

(c) Path 2 ⇨ 3 ⇨ 4 ⇨ 6 ⇨ 5 ⇨ 1 is one of the possible paths traversing all the faces one and only one time

Figure 6. Finding a possible path for unfolding the faces of a solid.

4.3 Heuristics for Developing Smooth Surfaces

In SML and in Java3D, as in many computer graphics systems, a curved surface (e.g. conical, cylindrical, etc.) is approximated by a set of planar polygons. If we choose a face' s neighbor in an arbitrary way, a solid may be unfolded into an "ugly" or "unnatural" shape because the set of polygons used to approximate a smooth surface my or may not be unfolded (smoothly) in an appropriate sequence. The left side of Figure 7 shows a cylinder approximated by a total of 22 plane faces (20 for the curved surface and 2 for the top and bottom faces). If we unfold the cylinder arbitrarily, for example, following the path 1-2-3- ..-21-22, may result in the patter in the middle. One of the polygons in the set used to approximate the curved cylindrical surface is disconnected from the other polygons in the set.

We observe, however, that in the set of polygons approximating a smooth curved surface, each polygon shares at least one edge with another polygon in the set, and the included angle between the two polygons is very close to, but just slightly less than, 180 degrees. Taking account of the Smooth Surface Heuristics discussed above, we can try to select the neighbor making the largest angle with the current face, instead of selecting an arbitrary one. Applying this heuristic to the unfolding of the cylindrical solid will result in the developed surface to the right.

Figure 7. Arbitrarily unfolding the cylinder to the left may result in the pattern in the middle, and applying smooth surface heuristics will result in the pattern to the right.

5 Partially Automated Packaging Design

The design of packaging such as the rectangular boxes used to hold hamburgers at fast food restaurants involves the design of the 2D patterns that can be folded into such boxes. Similar problems exist in sheet metal work and other areas. The surface development/unfolding algorithm discussed above can be used to partially automate such designs.

5.1 Addition of "Flippers"

In addition, one also need to add "flippers" to some of the faces. Flippers are extended faces for putting glue or stickers in order to fasten two faces together when folding the planar 2D shape into a 3D solid shape. We have developed a simple algorithm to determine which edges of the faces of a solid model need to have flippers added. As flippers are used in connecting neighbouring faces, basically, all edges around a face need flippers except:

1. Edges that have been used as axes of rotation during the process of unfolding, i.e., edges between consecutive faces in the connected path for unfolding. (in Figure 8)
2. Edges for which flippers have already created on the opposite face. (in Figure 8)

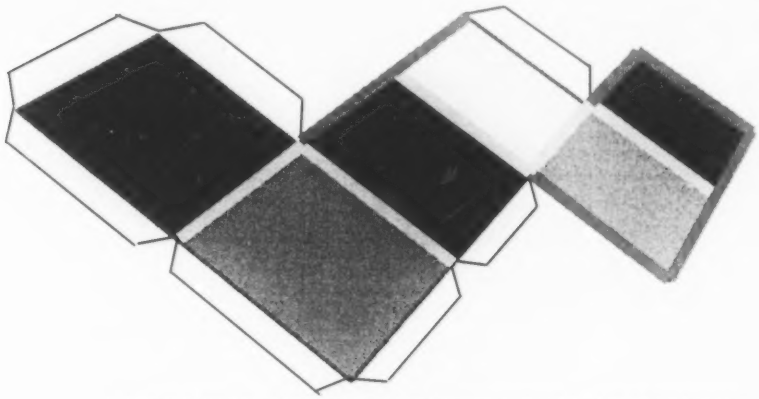


Figure 8. Creation of "flippers" in partially-automated design of packaging.

5.2 Minimizing Bounding Rectangle

The unfolding of 3D shapes are often constrained by certain requirements. For example, in the design of

packaging or sheet metal work, the unfolded shape may be the pattern to be cut out of a rectangular sheet, to be folded into the solid shape. In such cases it is desirable to reduce the amount of wastage by making the rectangular sheet required as small as possible. This translates into a requirement to minimize the area of the smallest rectangle enclosing the unfolded planar shape, as illustrated in Figure 9. Smallest rectangle enclosing the unfolded 2D shape. Such constraints may not be easy to satisfy absolutely. However, it is often enough to find a reasonable but not necessarily the perfect solution. In the case of determining a minimum bounding rectangle, it may be sufficient to find a local but not the absolute minimum. A local minimum can be determined by backtracking a few steps from the solution found to determine the set of related solutions and choose the one with the smallest bounding rectangle.

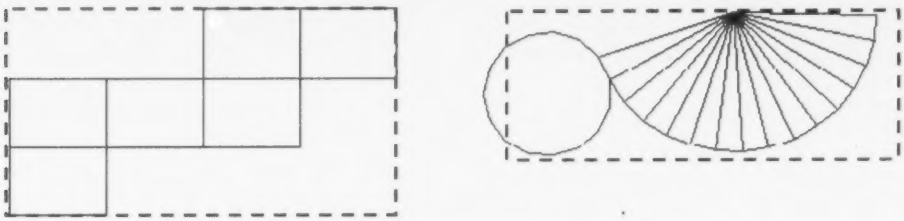


Figure 9. Smallest rectangle enclosing the unfolded 2D shape.

5.3 Some Examples Used in CAD-SD

Many examples of realistic solid shapes have been built into CAD-SD for illustrating and teaching surface development. Figure 10, Figure 11, and Figure 12 show the results of unfolding some common solid shapes, with "flippers" added automatically. For simple solid shapes it is fairly easy to deduce from the unfolded 2D patterns what the original 3D solid shapes are. Some of these are given to the students as exercises.

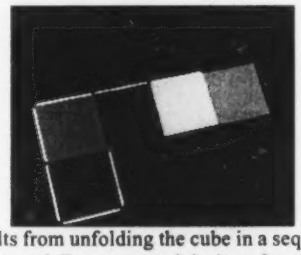


Figure 10. The 2D shape that results from unfolding the cube in a sequence different from that shown in Figure 8. Creation of "flippers" in partially-automated design of packaging., also with flippers added.

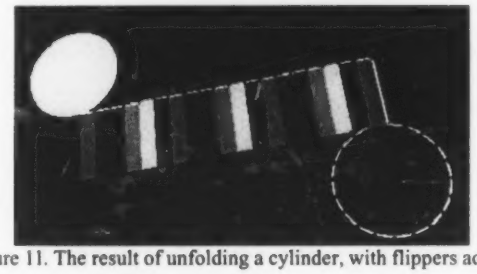


Figure 11. The result of unfolding a cylinder, with flippers added.

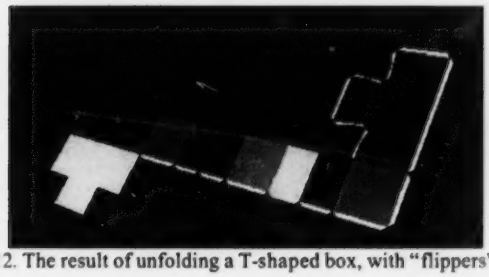


Figure 12. **The result of unfolding a T-shaped box, with "flippers"** added.

6 Conslusion

Using the SML solid modeling system and Java3D surface modeling and rendering system, we have successfully developed the basic structures of a CAL system that makes use of 3D modeling, animation, and interactivity to teach the appreciation of certain class of 3D shapes through surface development and unfolding. We have also shown how the unfolding algorithm can be used to partially automate the design of the 2D patterns used in certain sheet metal work and packaging design problems, by also automating the addition of flippers for attaching neighbouring faces, and reducing the rectangular sheet from which the planar (unfolded) patterns are to be cut out. Based on these basic functions, a comprehensive set of teaching materials can be developed to greatly enhance the degree and interactivity and effectiveness in the teaching of the appreciation of 3D geometry.

Acknowledgement

The work reported in this paper was partially supported by Hong Kong UGC/RGC/CERG grant PolyU 5102/97E.

References

[Brown & Peterson 1999] Brown, Kirk & Peterson, Daniel. *Ready-to-Run Java 3D*, Wiley, 1999.

[Carmo 1976] M P do Carmo. *Differential Geometry of Curves and Surfaces*. Prentice-Hall, 1976.

[Chan et al 1998] Chan, S., Ng, V., and Au, A.. "A Solid Modeling Library for the World-Wide Web", *Computer Networks and ISDN Systems*, Vol. 30, Issue 20-21, Nov. 1998, pp. 1853 – 1863.

[Chan et al 1999] Chan, Stephen, Lui, Kin Ming, Ng, Vincent & Chui, Raymond. "A Java-based Computer-Aided Learning System for 3D Geometry", *Proceedings, The 7th International Conference on Computers in Education*, Volume 1, November 4 – 7, 1999, Chiba, Japan, pp. 1010 - 1017.

[Giesecke et al 1997] Frederick E. Giesecke, Alva Mitchell / Henry Cecil Spencer, Ivan Leroy Hill / John Thomas Dygdon /James E. Novak with Shawna Lockhart. Technical Drawing, Tenth edition (p.626 - 640): Prentice Hall 1997.

[Johnsonbaugh 1996] Richard Johnsonbaugh. Discrete Mathematics, fourth edition (p.304 – 309, p.331 – 336): Prentice Hall

[Mantyla 1988] Martti Mantyla. An Introduction to Solid Modeling (p.161 – 174): Computer Science Press 1988

[Sowizralet al 1998] Henry Sowizral, Kevin Rushforth & Michael Deering. The *Java 3D API Specification*, Addison Wesley, 1998.

[Sun 2000] Sun Microsystems, Inc. *Java 3D 1.1 API Specification*, http://java.sun.com/products/java-media/3D/index.html, 14 April, 2000.

A Case Study of Creating Geochemistry Lab of Virtual Reality in Education

LI Fung-Chun, Jer-Yann Lin, Liu Shyh-Jiung, Hsu Shih-Hua, Tarng Chau-Rong, Yieng Chau-Fu and Wu Tzong-Yüng

Department of Nature Science Education, National Tainan Teachers College, Tainan, Taiwan, R.O.C.

Tel 886-6-2133111 ext66 or 669

Fax 886-6-2144409, E-mail li@ipx.ntntc.edu.tw,

Thanks to the financial supports of "Ministry of Education, Taiwan" and "National Science Council, Taiwan", we are building a preliminary geochemistry lab in education of virtual reality (VR). The mission of the Geochemistry Lab is to analyze and interpret the erosion history of upper Stream from the key elements (^{10}Be and ^{36}Cl) in the environment of Taiwan. Our lab's primary service is to the students of National Tainan Teachers College (NTTC). The lab is dedicated to the development of VR techniques for education. This study has tried to integrate the different domains of earth science, geochemistry, scientific education and information education. We have succeeded to make an integrated study in our Virtual Laboratory of Natural Science Education, NTTC, Tainan, R.O.C. We have made field investigations and collected 30 samples of rock from upper Tseng-wen Chi last summer. J-Y Lin, Liu S-J, Wu P-C and Chen H-P made Laboratory experiments. Li F-C, Yieng C-F, Wu H-T, and Tarng C-R created the lab of virtual reality in education. Yieng Chau-Fu has created six dynamic modules by himself for the VR experiments. Those modules of wrl files have simulated VR experiments and use AMS techniques to estimate the Beryllium-10 and Chlorine-26 in upper Tseng-wen Chi of Taiwan. This case study worked very well by means of virtual lab, experiment design, pretest and posttest. Let us understand that geochemistry lab of VR in education may assist students to learning with greater devotion and efficiency.

Keywords: **Virtual Reality, Virtual lab, geochemistry laboratory, Virtual Reality in Education, Accelerator Mass Spectrometry(AMS)**

1 Introduction and questions

Today, it is very popular and very important to reform education in Taiwan. It is a thousand pities that many education reformers neglect tools of learning and VR technology of teaching. All the earth-science professors of National Teachers College in Taiwan have the similar challenges that they must face every day. Problem is, they' re facing them without adequate tools. We cannot talk about Taiwan Education Reforms (TEF) without talking about tools and technology. That' s exactly what we' re here to talk about in this special issue of virtual reality (VR): how VR technology will and can help us to reach our some goal of TER. Tools and technology in and of themselves are not a solution to TER. Although VR technology is only a tools and only a very small part of the TER. It' s still a very interesting, very impressing and very efficient in future.

2 Plans and reasons for using virtual reality

We try to develop short, two-week, single unit courses on VR geochemistry lab. The VR sub-subject is called "Cosmogenic Nuclides Tell Erosion History of upper Stream in Taiwan". This strategy will introduce teachers and students to VR technology, allow them to get used to the VR equipment, begin to develop a feel for what works and what doesn' t, and make both teachers and students aware of the limitation of VR. Let them understand that geochemistry lab of VR is very interesting.

Our long-range plan is to utilize the geochemistry lab of VR to provide enrichment and advanced courses to the students of NTTC, Taiwan.

What' s so special about Virtual reality (VR) in education? It' s their interactivity: You do something and the VR does something back (Thomas C.O' Brien 1994). Can VR play an increasing role in school? Can different students react to it in different ways? If there are different ways and reactions then understand the diverse reaction can help teachers tailor the instruction to individual students (Kathryn A.A Ivestad 1994). We suspected that differences in student' s attitudes toward VR geochemistry experiment learning might underlie their different responses to using VR – and that their performance in the lab would be strongly influenced by the different learning ways each student approaches different learning tasks.

Is a Geochemistry Lab. of VR in Education a special kind of learning environment? Students work individually and intensively over a long period, doing the best they can with little or no assistance from teachers.

3 Main Tools of VR

VR equipment including World UP for Windows NT, VR Expert800 (Pentium • ••••••• •••••••••••MB DRAM, Graphic accelerator (64MB Texture Memory, 3000 MFLOPS Geometry Accelerator), PCI Bus System, Support OpenGL• HEDIA• Direct 3D Direct Draw), head mounted displays (HMDs), positional 3D trackers, data gloves, eyeglasses and VR software toolkits (home PC virtual reality software). Yieng Chau-Fu has created six dynamic modules.

•

4 Experiment in education (K.E.Chang, S.F.Chen, and T.C.Sung 1999)

Six dynamic modules have been created for the virtual lab. The virtual lab concept reflects an approach to designing educational activities. This experiment design allows learners to choose a particular module that interests them, and then provides links and makes a test or learning.

To test our hypotheses, we worked with 60 students who were randomly selected and had taken part in the geochemistry program of VR for at least two seminars.

- Subjects "Cosmogenic Nuclides Tell Erosion History of upper Stream in Taiwan "
- Experiment design: Our experiment employed a pretest-posttest control group design. Each class of earth science in NTTC was randomly assigned to one of the "VR" groups or "paper-and-pencil" group. Since subjects of the three groups might have different prerequisite abilities, their earth science achievement scores of last semester were used as covariates. The posttest scores were collected after the experiment and submitted to an analysis of covariance (ANCOVA).
- Materials and Techniques: 30 samples of rock was randomly collected by LI Fung-Chun, Tarng Chau-Rong and assistants from the upper stream of Tseng-Wen Chi. The Experimental Techniques of Laboratory can be divided 3 steps (unfinished). Step1, Chemical separation. Step2, Solid source mass spectrometry. Step3, Isochronal regression line fitting.
- Procedures:
  1. Use two methods of simple random sampling and stratified sampling to collect 30 samples of rock from the upper stream of Tseng-wen Chi.
  2. Make analyses in chemical laboratory.
  3. Create this geochemistry experiment of VR.
- Formal experiment: The next day after the subjects finished their formal earth science lessons, they worked individually with geochemistry laboratory of VR or with paper-and-pencil to construct the earth science concept about "Cosmogenic Nuclides Tell Erosion History of upper Stream in Taiwan", one dynamic module each time. Approximately an hour are needed to complete each experiment of module. Since there were six modules in the experiment materials, the formal experiment phase lasted for one week.
- Posttest: Immediately after the last formal experiment completed, the subjects were administered to take the earth science achievement test and answer the questionnaires for the posttest.

5 Result

Pretest scores were used as covariates to understand the potential differences of students' knowledge. The test of homogeneity of regression showed that the homogeneity of regression of the two groups were not different ($F=0.01$, $P>.05$). The posttest scores of one experimental group (geochemistry experiment of VR) and one control group (paper-and-pencil group without VR) were significantly different ($F=4.01$, $P<.05$). The posttest scores of two groups were different. Why so? We think that the geochemistry experiment of VR can see visions of 3D and can revolutionize our approach to the central aspect of education: student's learning. Some of our students clearly were more comfortable in the geochemistry lab of VR than others. From this study, we understand that VR in education may assist students become more self-reliant and more willing to accept challenging material and work out of curiosity and interest. Using VR to bring out these qualities will go a long way toward fostering a new generation of students who are very interesting to learn.

Thanks to those supports of "Ministry of Education, Taiwan" and "National Science Council (NSC), Taiwan", this case study is very expensive. Ministry of Education gives us all the financial supports of software and hardware. NSC gives also us financial support and six assistants for those studies from 1997 to 2002 (NSC 86-2511-S-024-003-CL, NSC 87-2511-S-024-009, NSC 88-2520-S-024-002, NSC 89-2511-S-024-008, NSC 89-2515-S-024-002, NSC 90-2520-S-024-001 & NSC 90-2520-S-024-001). Their supports let this work with greater devotion and efficiency. Thanks a lot.

Reference

[1] • • • • • • • • • • • • •(1999) ASP • •ACP •103• •SIM655• • • • • • •

[2] K.E.Chang, S.F.Chen, and T.C.Sung (1999) Concept Mapping System with Scaffolding and Guided Learning, Computer-Assisted Learning Forum '99

[3] LI Yuan-Hui. (1976). Denudation of Taiwan Island since the Pliocene Epoch: Geology. 4, number 2, p.105-107.

[4] Steven A. Ackerman. (2000). University of Wisconsin, "Developing a Virtual Lab Using the World Wide Web" --http://www.geo.nsf.gov/ear/ehr_test/GEOEDU_Awards.html

A Virtual Reality Application for Middle School Geometry Class

Ki-Sang Song*, ByungRae Han* and Woo Yul Lee**

**Dept. of Computer Education*

Korea National University of Education, Korea; {kssong, raehan@comedu.knue.ac.kr}

***Kasan Middle School, Seoul, Korea*

The traditional mathematics teaching method which mainly depends on verbal explanation with pen and paper sketches has severe limitations teaching abstract concepts of formal and axiomatic geometry concepts such as points, lines, planes, and solids. In communicating information regarding geometric figures, one drawing may be worth many hundreds of words, and therefore visualization aids for complicated three-dimensional (3-D) solid objects are greatly helpful for both teacher and students. In this paper, we describe the utilization of Virtual Reality Markup Language (VRML) to visualize 3-D objects in middle school geometric class via WWW in a networked environment and show its usefulness for both teacher and students. In class, teacher uses VRML objects and students have been allowed to explore these objects with the teacher's explanation using their computer. The test results between a class with VRML based teaching and a class that solely depends on verbal explanation show that the application of VRML based 3-D objects has a positive effect on students' learning.

Keywords: **Virtual Reality; VRML; Mathematics; Geometry; WWW**

1 Introduction

Among Euclidean geometry subjects, Euclidean plane geometry is the study of properties of various figures, and the relationship between the figures in a plane irrespective of the location of the figures [1]. In Korea, the middle school mathematics curriculum includes definitions of plane, identifying plane and solid figures, and learning about some of their properties. In geometry class, teachers present these subjects mainly depending upon pen and pencil through verbal explanations. However, most teachers experience difficulties to describe or illustrate some solid figures that lie in three-dimensional (3-D) space. Sometimes teachers try to use notes, books and anything that may be helpful for visualizing abstract concepts of plane, intersections, etc. This kind of approach may work in some cases, but, most of the time they experience the limitations to illustrate these concepts and thus, they appeal better class aid materials.

In communicating information regarding geometrical figures, one drawing may be worth several hundred words. And thus, if real objects or figures such as polyhedra and polygons are provided, and students are allowed to explore them in class, the physical reality of geometry figures may be greatly helpful for students to grasp the 3-D geometric concepts in detail. Unfortunately, providing objects with physical reality is not easy due to the difficulties in making such complex objects. Therefore, it is necessary to devise alternatives to provide these materials, and we believe that the computer and information technology can be used for this purpose.

As the document from the National Council for Educational Technology [2] suggests, information technology can be a very helpful means [3] of providing 'observing patterns' and 'working with dynamic images' [2]. To provide interactive and dynamic figures as a thinking aid for students [4], we need networked computing facilities and appropriately designed class materials.

With these in mind, we have applied the World Wide Web and the VRML based 3-D illustration technique to provide 'virtual reality figures and solids' for geometric subjects. In this paper, we use VRML as a document authoring language and computer networks as a tool for providing distribution of multimedia to the classroom environment to allow students to explore these figures using their computer connected with a

working server equipped with class materials.

2 VRML and its implication to mathematics learning

2.1 VRML and its characteristics

The Virtual Reality Modeling Language (VRML) is the file format standard for 3-D multimedia [5] and shared virtual worlds on the Internet [6, 7]. Just as HyperText Markup Language (HTML) led to a population explosion on the Internet by implementing a graphical interface, VRML adds the next level of interaction, structured graphics, and extra dimensions (z and time) to the online experience.

The applications of VRML are broad, ranging from prosaic business graphics to entertaining web page graphics, to manufacturing, scientific, entertainment, and educational applications, and, of course, to 3-D shared virtual worlds and communities. Also, the VRML can be used for textual description of a 3-D world in its basic form. A VRML world can be simple or complex, and it may range from a single object, such as a cube or sphere, to a large environment of many objects representing a city or even a solar system. Once loaded into a VRML viewer, users have the ability to interactively navigate or fly through this 3-D world and view it from any perspective with a few clicks of a mouse.

VRML models are easy to create, and just as one can import a table of numbers into a spreadsheet application to perform calculations or create graphics, the same can be done with a series of 3-D coordinates that can be converted into a 3-D environment with VRML. Therefore, some middle school geometry subjects such as plane, polyhedra, etc., can be modeled in VRML and can be browsed on popular Web browsers with plug-in software.

We need to use a plug-in for the Web browser to navigate the VRML documents. In this paper, we use the Cosmo Player that is a high-performance, cross-platform VRML 2.0 client designed for fast and efficient viewing of virtual worlds. With this plug-in, a student is able to navigate and manipulate 3-D scenes of class material and bring experience to ' real objects' with virtual objects. Since Cosmo Player is a viewing client for VRML with support for the latest standards, if the teacher provides this software in a server, students download and install it in their computer.

2.2 VRML and its implication to geometry class

The aforementioned VRML characteristics can be applied to geometry classes by implementing solids, and figures that do not lie in one plane, in cyberspace of computer. In this paper, the *figure* means a picture or drawing that represents a geometric figure. Most geometry texts use plenty of figures to explain geometric figures; those drawings are described in 2-dimensional space. That means the teacher needs to prepare some materials that can be easily shown in 3-D space. Also, students cannot explore 2-D texts or drawings in a manner of flipping the figures or looking inside of an object.

Fortunately, if figures or objects are modeled and implemented with the VRML format, these drawbacks can be easily overcome. For instance, the VRML allows the document to be linked with any type of multimedia such as text, sound, movie and graphic images (in static or dynamic state) in 3-D space. After figures or objects are authored in VRML format, users are able to access easily to these objects using VRML browsers. If drawings in texts are integrated into Web courseware using VRML, the student is able to access specific figures and is able to observe that figure in many ways. For example, if a class learns about the concept of perpendicular, students can observe the figure at the point of under, top, and in front of the figure by simply controlling the browser control boxes.

Thus, they can vividly observe and "feel" figures taught in class as if these figures are real objects. Even though the VRML figures may not provide "object in reality, " but it can show the "object in virtual reality." Therefore, we are sure that the application of virtual reality based class aids is a challenging approach to improve the learning effectiveness in geometry class.

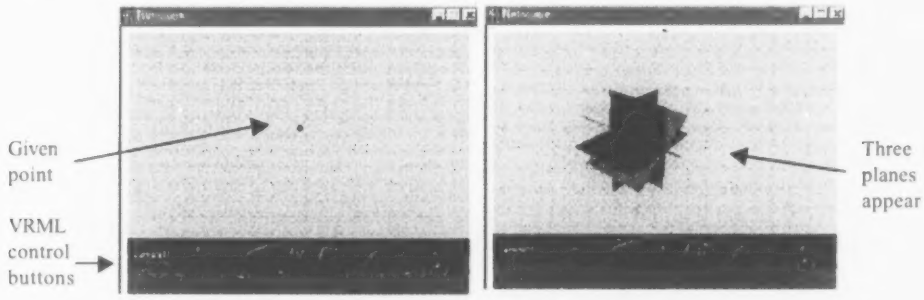
3 Modeling geometry figures into VRML format

When one designs courseware or computer assistant class aids, it is necessary to analyze not only learners, but also teaching subjects [8, 9]. It is hard to say that a specific method is the only unique way to teach a certain subject, and thus, the teacher needs thoughtful consideration for his/her class. With this in mind, we have designed geometric figures by fully utilizing VRML characteristics and interesting human computer interaction capability.

One example is as follows. To show "*a point is not sufficient to define a plane*," we used the VRML animation capability as shown in Figure 1. Fig. 1(a) shows a point in a Web browser. If a student clicks the point with the mouse, several planes appear and cross that point as shown in Fig. 1(b). Teacher then explains that "when any plane crosses a point in any directions, it is not sufficient to compose a plane with a point."

Since cross planes appear when the student touches the point with the mouse, the dynamic images allow the student to participate actively in the class. Also, teacher can show these figures as an example to deliver axiomatic ideas with dynamic visual aids, in which case the class can be changed into a more vivid learning environment.

Modeling geometric figures and drawings with the VRML needs several steps. First, basic drawing is described with the VRML code. Then, shape transformation is done for complicated object drawing. This step is required for various solids that are not possible using only basic drawings. Finally, covering a figure with certain colors and patterns finishes texture mapping.



(a) (b)

Figure 1. VRML drawings for showing "a point is not sufficient to make a plane"

We chose solid subjects in middle school mathematics class and, some of the examples of the courseware contents were "relationship between lines," "planes in 3-D space," "polyhedral objects," and "bodies of rotations." We drew these objects in VRML format and students explore these objects using several functions of VRML control buttons such as zooming, turning, and searching capabilities.

We used VRML drawings to describe these subjects as virtual reality including several polyhedra. It is known that the best way to learn to visualize 3-D is to make objects that demonstrate the spatial concepts [10]. Students can observe and use many spatial relationships while they construct polyhedra. Attractive visual aids also stimulate creative thinking. We are sure that objects displayed by the virtual reality technique are helpful for students. Current VRML technology allows students to navigate these objects as if they were handling real objects.

It is not easy to make polyhedron objects that have more than 8 faces. But, if we use VRML, it is quite easy to make such polyhedrons. Figure 2 shows a polyhedron that has 20 faces. If students observe these objects at several different angles using browser controller, they may easily grasp the principles of polyhedrons.

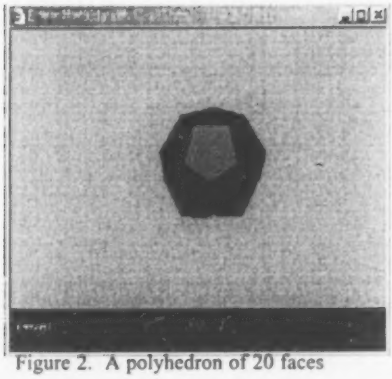


Figure 2. A polyhedron of 20 faces

4 Evaluation of a VRML based geometry class

The VRML based class materials were designed as a support for both teacher and students aids for the teaching and learning process of abstract concepts with physical reality. The designed materials are basically based on textbook contents that are drawn in 2-D.

4. 1 Method

To evaluate the effectiveness of VRML based geometry class, we designed two groups of classes; one applying networked VRML materials, and the other taught in conventional approach. Each class had 34 students and they did not show significant difference in their average score in the 1st semester of school.

For the VRML based class, the teacher used VRML materials in class and the students were encouraged to explorer these materials using their computer. The class was equipped with multimedia computers hooked into the network. The other class was taught in verbal explanations as in conventional classes. One teacher taught two groups at different times. The class schedules for each group were as follows.

Table 1. Class schedule for each group

Class	VRML group (classroom/ subject)	Non-VRML group (classroom/ subject)
1st class	Audio-visual class The relationship of line and plane	Blackboard classroom The relationship of line and plane
2nd class	Audio-visual class (Multimedia equipments are used) Polyhedra and rotational objects	Blackboard classroom Polyhedra and rotational objects
3rd class	Computer room Self exploration with VMRL materials	Blackboard classroom Problem practice
4th class	Test	Test

As Table 1 shows, we scheduled 4 classes and evaluation test was taken at the last class. Selected teaching subjects were included in the first year middle school mathematics class in Korea. The VRML group classroom was equipped with computers and audio-visual facilities. The teacher utilized VRML for his teaching and students were allowed to explore VRML objects with their computers. On the other hand, the blackboard classroom students did problem solving in the 3rd class.

After tutoring the subjects, both groups were tested with the same questions. The chosen method was student knowledge of taught geometry subjects. We designed 25 questions, and half of them required visual imaginations to answer correctly. We showed the characteristics of each question as relevant to visual imagination critical with symbol 'v' in Table 2, and each group's right answer rate. Examples of the given questions are shown in the appendix. Using a 5% level of significance that indicates the risk of incorrectly

chosen two groups were not equal, a *t*-test analysis [11] was conducted assuming equal variances and a null hypothesis of equal means.

Table 2. Test questions and relevant to visual imagination

Questions	Relevance	Correct answer rate (%)	
		VRML group	Traditional group
1	V	97.2	89.2
2	V	88.9	67.6
3		55.6	56.8
4		69.4	83.8
5		16.7	10.8
6	V	52.8	35.1
7	V	61.1	27.0
8	V	83.3	45.9
9	V	58.3	48.6
10		27.8	27.0
11	V	52.8	40.5
12		91.7	89.2
13		63.9	64.9
14		41.7	54.1
15		72.2	83.8
16		58.3	54.1
17	V	83.3	78.4
18		47.2	45.9
19		50.0	59.5
20	V	80.6	62.2
21	V	75.0	64.9
22	V	47.2	37.8
23	V	80.6	59.5
24	V	38.9	27.0
25	V	72.2	64.9

As shown in Table 3, the calculated *t*-statistics of −0.32 was less than the *t*-critical value of 1.99, indicating that the expected interval of plausible values of the average score of the spring semester could be constructed. That plausible interval values could be constructed implied that there was no difference in the two groups. Also, a *P*-value of 0.748 was calculated to indicate the level of significance in the breaking point of rejecting or accepting the null hypothesis. We used a 5% level of significance, and the null hypothesis of equal means must be accepted since it is less than the P-value of 74.8%.

Table 3. Two groups' average exam scores in Spring 1998

	Average	SD	*t*-Statistics	*t*-Critical	*P*-Value
VRML group	62.33	400.22	-0.32	1.99	0.74
Traditional class	63.83	382.65			

Table 4. Test results of visualization aid critical and non-critical questions

Questions		Average	SD	*t*-Statistics	*t*-Critical	*P*-Value
Visualization critical	VRML class	69.44	307.37	2.36	2.05	0.02
	Traditional class	53.47	380.38			
Visualization non-critical	VRML class	54.04	439.00	-0.33	2.08	0.74
	Traditional class	57.26	571.57			

Using the same method as used for the null hypothesis of two selected groups, we analyzed the effectiveness of the VRML based class by applying statistical differences of correcting answer rates for given questions between two groups. The test problem set was organized as 14 problems that were critical for visual experience and 11 questions that were normal questions that may be not dependent on visual aids.

The analysis of test data revealed that there is a statistical difference between the VRML based class and the traditional method class. Students of the VRML based class showed a 29.7% more correct answer rate to these questions than those in the traditional classroom in overall. To show the statistical meaning of this result, we applied the null hypothesis that "applying VRML based materials do not affect the two groups in statistical significance difference." As shown in Table 4, for visual experience critical problems, the *t*-statistics value is 2.36 and *t*-critical value is 2.05 and this means this hypothesis should be rejected. Also, the P-Value is 0.02 and we used the significance level of 5% and this result shows that applying VRML based materials affects the two groups' answering rate for given questions. Therefore, we can emphasize that the VRML based teaching is a very effective way for the geometry class.

Also, the hypothesis that "VRML based materials may not affect the two groups for non-visual critical questions" was analyzed in statistical significance difference. To decide to accept or reject this hypothesis, we used the same aforementioned method. As shown in Table 4, for visualization non-critical questions answer rates of between two groups, the *t*-statistics value is –0.33 and *t*-critical value is 2.08. This result shows that this hypothesis should be accepted. Furthermore, the P-value of 74% is much greater than the level of significance of 5% showing that this hypothesis is true. Therefore, we may conclude that VRML based teaching and conventional teaching method does not show significant differences in students' understanding for visualization non-critical questions. This implies that VRML drawings may not be quite as useful for a geometry class where visual aids are not so crucial.

5 Conclusions

Learning abstract geometric concepts in middle school class needs visualization of figures in 3-D space. The relationship between lines, planes, and figures cannot be easily described simply by using the verbal explanation approach. To visualize geometric objects for middle school class, we have designed and implemented VRML drawings for visual aids and the test results show that the VRML based visual aids are very effective in the geometry class.

The advantages of the VRML based geometry class can be summarized as follows. First, it provides a virtual reality of figures and objects that cannot be easily described verbally. Secondly, the WWW application of VRML materials can be effectively used for teaching or learning purposes in class. Finally, any shape of geometry figure can be easily modeled into VRML drawings; thus, it is a good visual aid tool for the geometry class. Therefore, we are recommending using VRML based visualization techniques as a visual aid tool for not only mathematics class, but also any class that requires detailed description of physical reality beyond the verbal approach.

References

[1] Bell, F. H., "Teaching Elementary School Mathematics: Methods and Content for Grades K-8", Wm. C. Brown Company Publishers, (1980).

[2] NCET, "Mathematics and IT – a Pupil's Entitlement", NCET, Coventry, NY, (1995).

[3] Masks, W. J., "How to use the spreadsheet as a tool in the secondary school mathematics classroom", National Council of Teachers of Mathematics, (1990).

[4] Abidin, A. and Hartley, J. R., "Developing mathematical problem solving skills", Journal of Computer Assisted Learning , Vol **14**, 278-291, (1998).
[5] Matsuba, S. N. and Roehl, B., "Special Edition Using VRML", (1997) .
[6] Adnanes, M., and Ronning, W, M., "Computer-networks in education - a better way to learn?", Journal of Computer Assisted Learning , Vol **14**, 148-157, (1998).
[7] Antechev, K. et al., "A WWW Learning Environment for Mathematics", http://www.w3.org/Conferences/WWW4/papers/89, (accessed on December 1999).
[8] Kahn, B.H. , "Web-Based Instruction", (1997).
[9] Heinle, N., "Designing Dynamic Web Pages with JavaScript", (1998).
[10] Pohl, V., "Visualizing Three Dimensions by Constructing Polyhedra", in 1987 Year Book of National Council of Teachers of Mathematics, Learning and Teaching Geometry, K-12, (1987).
[11] Cryler, J. and Miller, R., "Data Analysis and Modeling", Duxbury Press, California, (1994).

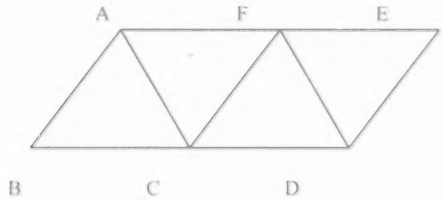
Appendix

Some of the test questions used for evaluating the effectiveness of the VRML based class are as follows.

Q1. Which one does not define a plane:
(1) Two lines in crossed position (2) Two lines that meet (3) Two parallel lines (4) A line and a point outside of the line (5) Three points out of a line

Q2. Choose which shows the condition for perpendicularity between line and plane:
(1) The line and plane are in parallel (2) The plane contains the line (3) The plane and line meet at same point and the line is perpendicular to a line which lies in the plane (4) The plane and line are in twisted position

Q3. If we want to make a regular tetrahedron with following development figure, which edge is in twisted position with edge AB?



(1) Edge BC (2) Edge CD (3) Edge AF (4) Edge DF (5) Edge ED

Constructing a Real-Time CAD Learning System Based on OpenGL in Web-Based Environment

Wen-Chai Song*, Shih-Ching Ou*,Song-Rong Shiau**
**Department of Electrical Engineering, National Central University, Taiwan*
***Department of Electrical Engineering, National Taipei University of Technology, Taiwan*
4F,NO.184-1,Kee-Kin 1st Road,An Lo District, 204, Keelung ,Taiwan
Tel:+886-2-24325455
Fax:+886-2-24324075
E-mail:songchen@ms10.hinet.net

The purpose of this paper is to apply network technology to make the design of Web-based learning graphics systems for user. Several issues will be addressed in this paper such as the development of an Integrated Interactive Graphics System (IIGS) for a better design environment. In this paper, we attempted to develop a web-based graphics learning system by Bézier, B-spline and NURBS algorithms. The purpose of the research was to increase the effect of Computer-Aided Design (CAD) in network .The other advantages is that network browser is the common platform in internet and intranet, the graphics system can be portable cross different operating system, as like windows 98,linux..etc. In fact, the graphics learning system have attempted to be shared the resource each other.

Keyword: **OpenGL, VRML, NURBS, CAD/CAM, CAI, Curves, Surfaces**

1 Introduction

As the Internet has improved in the last ten years, web-based graphics learning has become very important in Internet. In recent year, the distance learning by Internet has been established and developed in Computer-Assisted Instruction (CAI) system. In this paper, the user can design and learning sculpture curves and surfaces on a personal computer by the interactive way. The graphics system has friendly interface in operating process.

OpenGL is a software interface that allows the programmer to create 2D and 3D graphics images. OpenGL are both a standard API and the implementation of API. In other words, OpenGL is a set of functions which have the same syntax and which act the same way on every platform, even though different vendors have written the actual subroutines, which implemented the API standard.

Graphics programming concepts underlie the function of OpenGL. These concepts are easy for the average application programmer to understand and use. OpenGL is independent of the hardware, operating, and windowing systems in use. Using OpenGL to make a program is easier than using API to do. API is integrated into a windowing system, since learning how to program a windowing system is often quite complicated.

2 Curve Modeling

Curve methods are usually included in different courses such as geometric modeling, CAD/CAM, computer-aided geometric design (CAGD), computer graphics, etc. In teaching this material, it is essential that students have an access to computer graphics facilities. Practical experiences help them to understand the dry theory. There are many books concerning curve and surface modeling and each of them considers

this subject in a different way (with some modifications). Users are confused, especially beginners. The next weakness of method representations is in lack of comparative means. Learning can be more effective if different methods are studied simultaneously on the same data by changing control parameters.

This field is developing very quickly and therefore researchers need also an effective comparative tool for their new improved approaches or methods. For these reasons, a program package for modeling and analysis of parametric curve methods called CM ("Curves Modeling") has been constructed. It is written in OpenGL. Not only 2D but also 3D curves are considered. Three various methods are incorporated in CM in the first menu level. Including all menu levels, there are ten methods or their modifications. In the interpolation methods, a curve passes through all control points, in the approximation methods, however, a curve passes only near to control points.

Figure 1. The Curve modeling interface

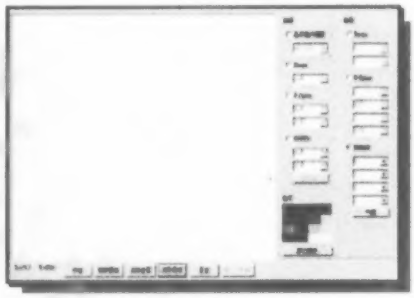


Figure 2. The Surface-modeling interface

A curve is compounded of small curves called curve segments and is determined by an equation in parametrical form (parameter u). In the knot vector for u (Uknot), there are parameter values for segment boundaries.

3 The Bézier, B-spline and NURBS Curves Algorithms.(extract)

NURBS curves:

A pth-degree NURBS curve is defined by

$$C(u) = \frac{\sum_{i=0}^{n} N_{i,p}(u) w_i P_i}{\sum_{i=0}^{n} N_{i,p}(u) w_i} \quad a \le u \le b \tag{12}$$

Where the {Pi} are the control points (forming a control polygon), the {Wi} are the weights, and the {Ni,p(u)}are the pth-degree B-spline basis functions defined on the non-periodic (and non-uniform) knot vector.

$$U = \left\{ \underbrace{a,\ldots,a}_{p+1}, u_{p+1},\ldots,u_{m-p-1}, \underbrace{b,\ldots,b}_{p+1} \right\} \tag{13}$$

4 Surfaces Modeling

In the computer graphics, a surface is usually generated by a surface representation method on a control net (linked control points in a 3D space). Methods for surface representation are divided in two major groups: approximation and interpolation methods. At the interpolation methods, a surface passes through all control points, at the approximation methods , however, a surface passes only near to control points. A surface is compounded of small surfaces, called patches, presented by two families of isoparametric curves.

A program package for modeling and analysis of parametric surface methods called SM ("Surfaces

Modeling") has been constructed .A surface is determined by an equation in parametrical form (parameters u and v). We speak about u and v directions (parametrical view) or about direction X and direction Y respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parameter values u and v for patch boundaries.

5 The Bézier, B-spline and NURBS Surfaces Algorithms.(extract)

NURBS surfaces:

A NURBS surface of degree p in the u direction and degree q in the v direction is a bivariate vector-valued piecewise rational function of the form

$$S(u,v)=\frac{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}p_{i,j}}{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}} \quad 0\le u,v\le 1 \tag{14}$$

The $\{P_{i,j}\}$ from a bi-directional control net ,the $\{W_{i,j}\}$ are the weights ,and the $\{N_{i,p}(u)\}$ and $\{N_{j,q}(v)\}$ are the non-rational B-spline basis functions defined on the knot vectors

6 The structure of the graphics learning system:

(1)System operating process and interface:
(2) Graphics algorithms:

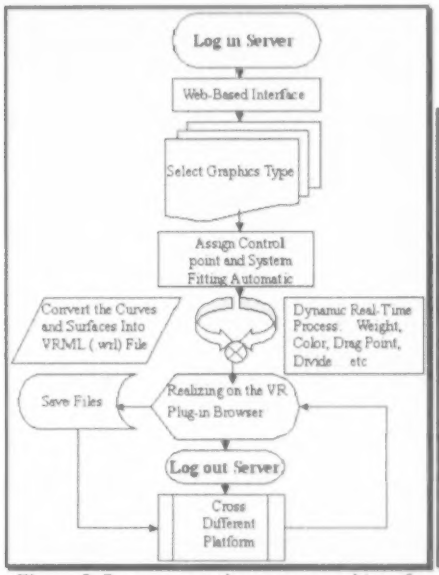


Figure 3. System operating process and interface.

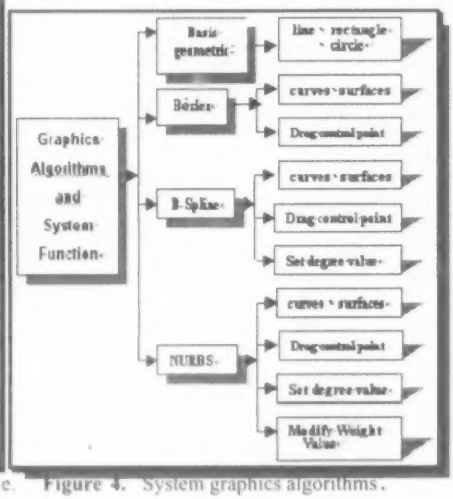


Figure 4. System graphics algorithms.

7 Brief Overview of OpenGL

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. OpenGL have the following obvious benefits:

(1) Reliable and portable
(2) Scalable

BEST COPY AVAILABLE

(3) Easy to use

VR as a Training Tool

Virtual Reality training can dramatically reduce the cost of delivering training by decreasing learning time for student and instructors.

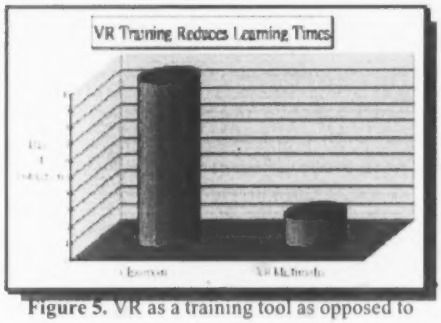


Figure 5. VR as a training tool as opposed to Classroom techniques (RTI)

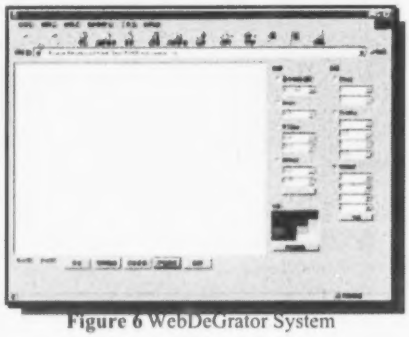


Figure 6 WebDeGrator System

8 Implementation and Example:

(1)The Integrated graphics Learning real-time system:
(2)Drawing NURBS curves and Covert Curves into VRML 3D Type:

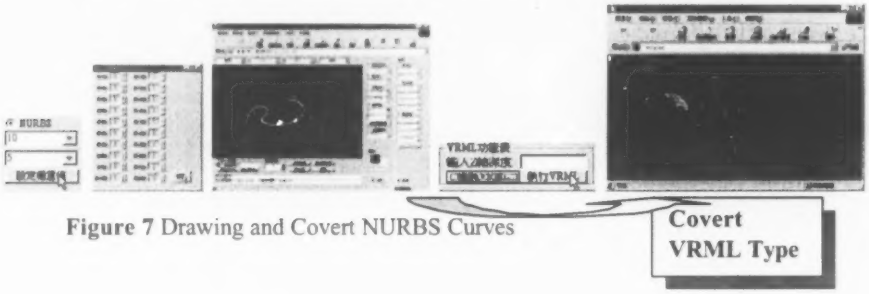


Figure 7 Drawing and Covert NURBS Curves

9 Experiment results:

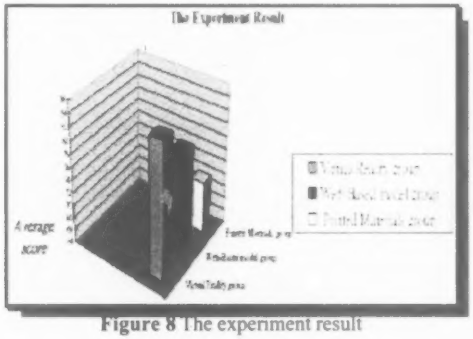


Figure 8 The experiment result

While the differences between the groups were significantly different, the virtual reality group performed is best; the Web-based model group is better than the printed materials group.

10 Conclusion:

The paper describes a new technology that we have established a VR-Based real-time graphics system. In summary, the system offers the following contributions:

1. To accomplish an Integrated Graphics Learning Real-time System
2. To share the resources in network.
3. To establish a computer network assisted learning system.
4. To explore and compare these algorithms of the sculpture curves and surfaces.
5. To integrate VRML with web–based learning system and realize 3D graphics on VR environment

11 Acknowledgments:

We would like to thank the anonymous reviewers for their invaluable and constructive comments that help to improve this paper. This research is working by the Automatic & CAD laboratory under Department of Electrical Engineering National Central University, Taiwan.

12 References:

[1] Ainge D. J., "Upper primary students constructing and exploring three dimensional shapes: a comparison of virtual reality with card nets", J. Educational Computing Research, 14(4), pp 45-369.1996.

[2] Bricken, M. A, "Description of the Human Interface Technology Laboratoryí s Virtual Worlds". Technical Report, Human Interface Technology Laboratory, U. of Washington, Seattle: 1990

[3] Christine Youngblut.."Educational Uses of Virtual Reality Technology". Institute for Defense Analyses. 1998

[4] Clark, R.E. "Reconsidering Research on Learning from Media". Review of Educational Research, winter, Vol. 53, No. 4, pp. 445-459, 1983

[5] Flanagan, D.: "Java in Nutshell, A desktop quick reference - Java 1.1", Second edition, O'Reilly, 1997.

[6] GERALD, "NURBS from Projective Geometry to Practical Use". FARIN,1999.

[7] Les Piegl & Wayne Tiller." The NURBS Book". .Springer, 1997

[8] Manetta and R. Blade in "Glossary of Virtual Reality Terminology" in the International Journal of Virtual, 1998

Designing Extensible Simulation-Oriented Collaborative Virtual Learning Environments

Yam San Chee* and Yong Bing Khoo**
School of Computing, National University of Singapore
3 Science Drive 2, Singapore 117543
** E-mail: cheesy@comp.nus.edu.sg*
*** E-mail: khooyb@comp.nus.edu.sg*

Theoretical understanding that learners acquire is concretized through exploration and collaboration with other learners as they articulate their understanding and knowledge of the learning domain. Recognizing that knowledge building is a dynamic process that requires learners' active participation, there has been a shift from traditional teacher-centered instruction towards interactive, peer tutoring, as well as simulation-oriented collaborative group learning. Systems that allow users to engage in such activities are increasingly interesting to scientific communities and learning organizations.This paper shows how our system's design leverages off the Model-View-Controller (MVC) architecture to allow developers to share the behaviors and interactions of virtual objects. We also present our approach to partitioning different parts of our system's virtual environment as well as storing and synchronizing virtual worlds such that our system can support unlimited interactivity with virtual objects and encourage user interactions in quasi-immersive online learning communities.

Keywords: **Collaborative learning, virtual reality in education, simulation, experiential learning**

1 Introduction

Constructivist theory, based in part on the results of Piaget's research, is the most widely accepted pedagogical standpoint adopted among teachers today. Constructivism emphasizes the careful study of the learning processes and leverages learners' active participation in problem solving as well as in learning activities that promote creative and critical thinking. Rather than memorizing concepts through iterative rote learning, learners internalize new concepts through exploratory learning and develop their own understanding by integrating newly acquired knowledge with prior knowledge and experience. Peer tutoring among learners and interactions with experts facilitate such learning processes where "knowledge [is] directly experienced, constructed, acted upon, tested, or revised by the learner" [10].

The pedagogical consequence is that learning environments should support and stimulate further growth and development of learners' minds while encouraging learners' autonomy and initiative. This constructivist orientation requires a fresh perspective on the roles of technology in learning. Instead of viewing computers solely as a knowledge presentation device, we can also view them as tools for supporting a pedagogical focus on communications in collaborative learning ventures [4]. Suppose we are able to bring a group of people together to interact in a model of a real environment, then we also have a tool for constructivist learning. Imagine students steering ancient battleships and firing cannon balls at one another in order to explore the concepts of relative velocities and projectile paths. Or perhaps a chemistry class where students can mix and test chemical reactions in the safety of a virtual chemistry laboratory.

A successful Constructivist Learning Design (CLD) should provide familiar environments that reflect the

thinking processes of the participants; in such environments there must be trust and public sharing of knowledge in this environment [14]. Moreover, the Across-Schools Pedagogy Issues group [4] endorses the "necessity of large-area networks for particular contexts, instructional goals, and learner characteristics." Injecting constructivism into the educational system culminates in a revolution, from planning for teaching to designing for learning [14] and the "key to reinventing our educational system . . . lies in what our teachers believe about the nature of knowing" [1].

Increasing interest in virtual environments coupled with a recognition of their potential benefits from the use of simulation, experientially-grounded learning, and socialized learning have led to the development of many virtual reality (VR) systems. Working within the constructivist paradigm, we have developed a system that creates virtual collaborative learning environments. Our system supports user interactions that facilitate mutual tutoring and knowledge sharing. The system can be used by academic institutions that offer courses through distance learning, or it may be used as a complementary form of on-line collaborative learning. In particular, these institutions can conduct laboratory classes with visual demonstrations, simulations, and presentations. The system can also be used to create virtual towns where users can interact with one another and coordinate online meetings.

In subsequent sections of this paper, we critically evaluate related applications, present our research focus, and describe one of the virtual worlds in our system to demonstrate how users collaborate and interact in virtual environments. After the virtual world description, we discuss our approach to system design such that it is easily extensible by future developers. Next, we present the basic mechanisms used to implement our virtual environment system. The discussion on system architecture is followed by the conclusion and intended further work for our system.

2 Critique of Related Applications

There have been several attempts to create similar VR environments. *VR for Learning* [6] is based on Couch's multi-user virtual reality system. It is limited in that it does not store its data in a database. Moreover, avatars in the virtual environments are static. They do not adhere to any common structure, and they *float* in the virtual worlds rather than *walk*.

Active Worlds is a proprietary-standard virtual world browser that provides game-like 3D rendering of the world with user-selectable (first-person or third-person) views. In addition to the browser window, *Active Worlds* also comes with a chat window that supports user communications. Mouse- and keyboard-based navigation through virtual worlds is remarkably smooth. However, the joints of *Active Worlds* avatars have far fewer degrees of freedom than that possessed by humans. Hence, the avatars are capable of a smaller repertoire of actions compared to avatars that model humans more accurately.

Community Place, developed by Sony Corporation, is designed to be scalable and to support many "geographically dispersed users, interconnected through low bandwidth, high latency communication links" [5]. However, the chat and whiteboard windows are separated from the navigation window. This increases the semantic distance between the different components of the system.

blaxxun, by blaxxun interactive, has the advantage of using Humanoid Animation 1.0 (HANIM) [13] compliant avatars. However, *blaxxun* lets avatars float instead of walk. Avatars move very quickly, but realism is compromised.

3 Research Focus

In order for our system to benefit as many users as possible, our work is implemented using non-proprietary technology. We developed the system's virtual world browser using Java3D and implemented the other components in Java. Hence, our system is portable to hardware platforms that support Java3D and Java Virtual Machine (JVM). Moreover, the system is designed to support a large number of users while maintaining reasonable performance.

Considerable effort was devoted to designing an engaging interface so that the system is pleasurable to use. This is pertinent because the objective of our system is to help users actively participate in learning

environments and not in learning how to use the system. This will encourage users to engage in experiential learning and increase their familiarity with the learning context.

In order to support collaborative learning and to enhance learning experiences, interactions between users and virtual world objects must be supported. Moreover, each object should have unique behaviors and properties, or they should be able to share behaviors and properties with other similar objects in an Object Oriented (OO) fashion. In our system, virtual object states are modified by manipulating components of these virtual models directly. The system processes new object states and updates virtual worlds as well as a database of virtual world states. By storing virtual world states, users can collaborate in discussions that span several login sessions. Similar to most virtual environments, avatars are pertinent for promoting user interactions because they allow users to establish their presence in virtual worlds by creating sensations of "being there."

4 BattleShips World Description

One of the virtual worlds in our system is the *BattleShips* world (Figure 1). This world allows users to explore three physics concepts:

- the time taken for free-falling objects to reach level ground is independent of the objects' masses
- the relative velocity between two moving objects creates the illusion that the objects are moving at different individual speeds
- the trajectories of projectiles are parabolic

Figure 1 A screen capture of the *BattleShips World* with two cannon balls of different masses falling down towards the cannons

This world contains two battleships equipped with cannons on both sides of each ship. By default, cannon balls from each cannon have different mass. Users can change the mass of a ball by selecting the *Examine*

mode on the floating toolbar palette followed by the ball of interest. The system will pop up an *Inspector* window (where users can enter a new mass for the ball) at the position of the mouse click.

One of the battleships has two user-selectable objects in the crow's nest on top of the mast. When users activate the trapdoor at the bottom of the crow's nest by clicking on the remote control button provided, the selected objects will start to fall to the deck of the ship. Users are asked to find the object that will reach the ground in the shortest time given that each object has a different mass. (The heaviest object will reach the ground fastest due to air resistance. This is contrasted with the *VacuumChamber* virtual world where the time taken to reach the ground is independent of the mass of free-falling objects due to the absence of air resistance.)

Users can collaborate in controlling a ship. For example, one user may be navigating the ship to place it in a more strategic firing position (with respect to the other ship) while trying to stay out of the other ship's line of fire. Another user (on the same ship) may control the firing of cannons and the angles of elevation of the cannons. Users can engage in mutual tutoring and knowledge construction by communicating with one another using our system's text-chat facility.

Because both ships are moving, it is necessary to consider the relative velocity between the two ships when navigating and firing the cannons. In addition, trajectories of cannon balls in this virtual world illustrate that projectiles trace a parabolic path in contrast to the early intuitive (but mistaken) belief held by many novices that cannon balls drop vertically near the end of trajectories [7].

5 System Design

Our system is designed to be easily extensible by developers so that virtual worlds supporting new learning activities can be created more efficiently through reuse of existing implementation. Its design adheres to the MVC architecture, hence providing minimally coupled yet cohesive subsystems. In this section, we describe the Model, View, and Controller portions of the system. Following that, we discuss how we use a database to store virtual world states persistently and how events are propagated to other clients in order to maintain virtual world consistency (across different clients).

5.1 Model

In our system, the Model is represented by the *vtalk* package. *vtalk* models virtual objects (*VObject*), virtual worlds (*VWorld*), and laws that can be applied to each *VObject* and *VWorld*.

5.2 Virtual Object

Every virtual object (*VObject*) in our system is modeled as an OO class. This design allows virtual objects to inherit and share properties as well as behaviors easily. In this manner, objects can be placed in new virtual worlds and behave according to the conditions of the new worlds. For example, consider a virtual world where users are placed on a planet with lower gravity (compared to the Earth). Users can choose to insert a cannon into the virtual world (even though there are initially no cannons in this virtual world) and fire the cannon to observe the trajectory of the cannon ball. The main challenge, however, is to classify a potentially infinite number of objects into an extensible taxonomy. Our approach to the taxonomy is to categorize objects into *Living* and *NonLiving* things. The taxonomy for *Living* things is well defined by Parker [8].

On the other hand, the taxonomy for *NonLiving* things depends on the context in which the objects are placed. As such, *NonLiving* objects are classified according to generic behaviors (such as moving when a force is applied to it) and properties. For example, billiard balls, golf balls, bowling balls are placed as subclasses of the *Ball* class. This classification of *NonLiving* things is developed in the context of the scope of our intended experiments and is not meant to encompass all possible scenarios.

In order to minimize coupling, the Model communicates with the other parts of the system via messages encapsulated into events. Consequently, behaviors of each object generate events (such as velocity changed) that are propagated to the virtual world that contains the object and other Views (typically represented by a virtual world browser) rendering the object.

Virtual worlds (*VWorld*) are managers of *VObjects*. A virtual world delegates events generated by objects that the world contains, responds to events using implemented laws (such as Newton's Laws of Motion), and routes events to affected *VObjects* as well as the network component of the system. Each *VWorld* presents a rich set of cohesive simulations where users can modify attributes of virtual objects and observe the effects. For example, when users change the texture of a billiard table, a billiard ball on the table will be observed to roll at a different speed (compared to the speed before the change) when the users hit the ball with a cue stick.

5.3 Laws

Laws are implemented separately from *VObjects* and *VWorlds* because different laws are applicable to *VObjects* depending on the learning objectives (determined by *VWorld*). The consequence of incorporating laws in virtual worlds is that laws cannot be shared across virtual worlds. On the other hand, embedding laws within *VObjects* may result in ambiguity of applicable laws as well as prohibit sharing of laws. Hence, the separation of laws from *VObjects* and *VWorlds* allows *VWorlds* to determine applicable laws and the priority of laws to resolve conflicts.

5.4 View

A View denotes the portion of the system that listens for events. This approach allows the system to present different representations of the same model, for example a 3D virtual environment and a 2D plan view of the 3D environment. Currently, our system has one View component, *VBrowser*. Consider a cannon ball fired from a cannon, the ball will generate high-level events that inform *VBrowser* that its velocity and acceleration have changed. Subsequently, the view will apply Newton's Laws of Linear Motion at every uniform interval to compute the new location, velocity, and acceleration of the ball. The laws can be applied independently of the world containing the virtual objects.

Collision detection is necessary for most virtual environments especially in simulation-oriented systems. Ideally, collision detection should be implemented in the Model. However, only *VBrowser* has access to geometric data of all virtual objects necessary to compute collision accurately. For these reasons, our system detects collisions by leveraging off collision detection mechanisms available through the graphics engine of *VBrowser* [12]. When *VBrowser* detects collisions, it generates events of the collisions and routes them to the virtual world where the collisions occurred. Virtual worlds would then handle the collisions according to the implemented laws of each world.

5.5 Controller

Users generally interact with the Model using a Controller. Because users interact with virtual objects through direct manipulations, the Controller's interface is part of *VBrowser*'s interface. For example, users navigate through virtual environments by dragging the mouse across *VBrowser* (representing the View). However, the engine that handles the mouse movements is part of the Controller. In this case, the Controller updates the Model, and the Model, in turn, generates events that are received by *VBrowser*. *VBrowser* would then update the View presented to users.

Our system supports direct manipulation of objects such that users interact with the objects they see in virtual worlds directly. Because the types of possible (and logical) object interactions depend on the virtual world containing the object, introducing the allowed interaction types into the Controller or View would couple these two components undesirably to the Model.

In view of this, Controllers convey user intentions of manipulating objects to the Model which then decides the appropriate interaction types and pops up a toolbar containing valid actions that can be taken next to the object of interest. Users can then select the desired action (from the toolbar) to perform.

5.6 Network

The network component of our system propagates events from virtual worlds in order to synchronize worlds on different clients and to update the database storing virtual world states. However, if all virtual world events are propagated to other clients, the events will be "bounced" from client to client indefinitely. For example, when client A sends an event denoting that the location of object 1 is changed, this event will be

sent to client B. Client B updates its copy of object 1, thus triggering off another location changed event. This event would then be propagated back to client A, and so on.

Although this event looping situation can be circumvented by tagging every event with the originating client, a better design is to send only high-level events that result directly from user interaction. For example, a user moves a stick to strike a ball. The location changes of the stick (as the user manipulates it) are sent to all clients in the same world. However, events of collision between the stick and ball as well as subsequent location changes of the ball due to this collision are *not* propagated. It is not necessary to propagate such events because every client is able to detect the collision and handle the subsequent ball movements locally. This is similar to the dead-reckoning technique. As a result, bandwidth requirements are reduced because "update packets can be transmitted at lower-than-frame-rate frequencies" [9].

5.7 Database

The relational database in our system is used to store virtual world states and other data necessary to facilitate restoration of virtual worlds. Using the Java Reflection API and object serialization [11], we designed the database to handle objects of new virtual object classes without requiring any modification in the database code. As a result, other developers can create new virtual objects, by extending available virtual objects, without implementing ways to store the new objects.

In interactive collaborative virtual environments, two or more users may attempt to grab the same virtual object at the same time. By leveraging off concurrency control mechanisms of the relational database, our system prevents concurrent attempts by multiple users to grab the same virtual object through the use of "ownership" data in every virtual object's database tuple. A user who holds an object is considered to be the "owner" of the object until the user releases the object [9].

On the other hand, a user may attempt to grab an object that is already held (virtually) by another user. However, this scenario is unlikely to occur with the exception of virtual worlds where such actions are appropriate because socially acceptable norms discourage users from "snatching" other users' objects.

5.8 Flow of Events

Figure 2 illustrates a typical scenario representing the flow of control and events when the system is running.

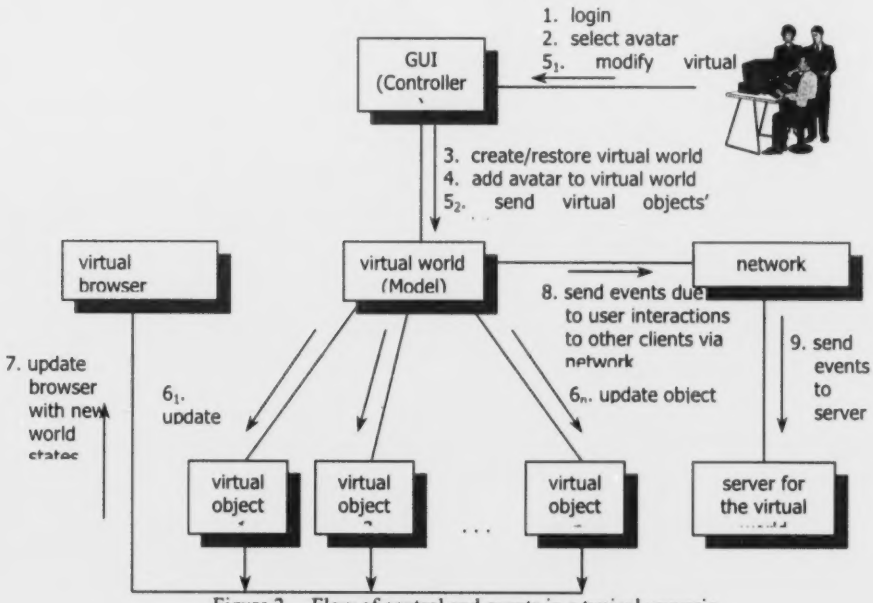


Figure 2 Flow of control and events in a typical scenario

When users interact with the objects in virtual worlds (Model), the Controller sends events to notify the associated virtual world of attribute changes. At the same time, the Controller also sends these events to other client machines via the network in order to synchronize virtual worlds on all clients. Every event is tagged with the time that the event occurred so that the order of events is preserved and consistent across all client machines. Because each client may have a different local time (such as in the case of client machines in different time zones), our system synchronizes the time of an event with the server's time.

The virtual world on every client machine will propagate the events encapsulating the changes to the virtual objects concerned. Upon receiving such events, the virtual objects will process these events representing the necessary updates and route the events to event listeners; that is objects that indicate interest in receiving virtual object events.

Finally, the View will interpret the events it receives from the Model and render the necessary changes by updating the geometric representations of all affected virtual objects.

6 System Architecture

In this section, we describe the basic mechanisms that we used to implement our system. We adopt a client-server architecture where there are multiple servers, with each server catering to several client machines (Figure 3). Although the system's server programs currently execute on one Sun workstation only, these programs can potentially reside on different physical workstations to support scaling beyond the processing power of one workstation.

Our system architecture is similar to the RING system [2]. Unlike the RING system, however, the servers in our system do not communicate directly with one another (although they share the same repository for virtual world states) because each server in our system handles only events from client machines in the same virtual world. Moreover, server programs may be hosted on different machines to distribute workload. When a user logs on to the system, the Controller retrieves the current states of the virtual world where the user is located from the database using JDBC. Using these states, the Controller instantiates the Model to represent the virtual world and all objects within the world. The Model then generates events to the listeners. One instance of a listener is the View (or *VBrowser*) that renders the virtual world as an interactive 3D environment on the monitor.

If the current states of the virtual world into which a user has entered are not available either due to a disconnected network or the fact that the world is newly created, then the virtual world is built locally according to the default layout of the world. If the world is new, then the Model will update the database with the default states of the virtual world. On the other hand, if the network is unavailable, the system is still functional because *vtalk* package's virtual network (*VNetwork*) is able to simulate the existence of a network connection. Hence, users can still engage in learning activities in virtual worlds in single-user mode. Changes made to objects in this mode are, however, not saved.

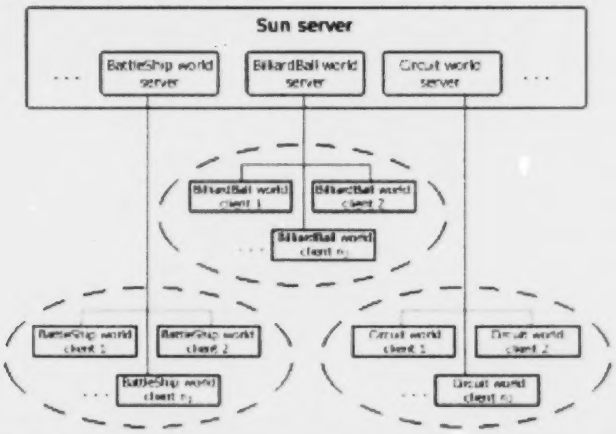


Figure 3 System architecture showing connections between virtual world servers and clients

The View of our system's virtual environment is generated using Java3D while the interfaces are created using Java Swing. The View is driven by events that are generated by virtual worlds and objects. Typically, these events are generic attribute changes (such as change in velocity) that affect the rendered view directly.

A possible event generation implementation is to use the Java Observer/Observable classes. Although these classes resemble the example code written by Gamma et al. [3], the Observer/Observable approach has the following disadvantages [15]:

- In order for event listeners to make use of the Observer/Observable classes, the classes modeling the event listeners have to be subclasses of the Observable class. However, it is usually difficult to meet this requirement because Java does not support multiple inheritance and the listeners may be subclasses of other classes already.
- Programmers need to understand details of how the update handler methods work.

Hence, the event generation mechanism of our system is based on the MVC architecture instead. Using this mechanism, each object that generates events stores its own list of event listeners [15]. When the attribute of an object changes, the object generates an event and routes it to every event listener in its list of listeners. Event listeners can be added and removed dynamically at run-time. As such, our system can create multiple views of the same model simultaneously. For example, it is useful to represent virtual worlds as 3D environments and also as a 2D plan view to aid navigation through large virtual worlds.

7 Conclusions

In this paper, we have explained the design of our simulation-oriented collaborative virtual environment based on the MVC architecture. We presented a description of our system's *BattleShips* virtual world where learners can explore physics-related concepts in an engaging and immersive fashion through interaction with objects in the world. Moreover, learners can participate in constructive online discussions as part of a learning community using our text-based chat facility. We further showed how different behaviors and laws can be shared and extended among virtual worlds and objects in an OO fashion. We also explained how our system is designed to support the addition of new virtual objects with minimal changes to the network and database. Finally, we presented the underlying system architecture of our current system to support collaborative learning distributed over geographic locations.

Our future work will include letting users see the actions and gestures of other users so that less time and effort is spent on prefatory remarks in online discussion (using text-chat). We will explore network topologies that afford greater scalability. We also intend to implement automatic distribution of load among several workstations and conduct formative and summative user evaluations.

References

[1] Fosnot, C., "Constructivism: Theory, Perspectives, and Practice", New York: Teachers College Press (1996).

[2] Funkhouser, T. A., "RING: A Client-Server System for Multi-user Virtual Environments", Proceedings of the 1995 SIGGRAPH Symposium on Interactive 3D Graphics. Monterey, CA: ACM SIGGRAPH, pp. 85-92, (1995).

[3] Gamma, E., Helm, R., Johnson, R., & Vlissides, J., "Design Patterns: Elements of reusable object-oriented software", MA, Addison-Wesley, (1994).

[4] Koschmann, T., Newman, D., Woodruff, E., Pea, R., & Rowley, P., "Technology and Pedagogy for Collaborative Problem Solving as a Context for Learning: Report on a CSCW '92 Workshop", ACM SIGCHI Bulletin, Vol 25, No. 4, October 1993, pp. 57-60, (1993).

[5] Lea, R., Honda Y., & Matsuda K., "Virtual Society: Collaboration in 3D Spaces on the Internet", Computer Supported Cooperative Work: The Journal of Collaborative Computing, Vol 6, pp. 227-250, (1997).

[6] Lim, K. P. E., "VR for Learning", National University of Singapore, Department of Information Systems and Computer Science, (1997).

[7] McCloskey, M., "Intuitive Physics", Scientific American, Vol 248, No. 4, pp. 122-130, (1983).

[8] Parker, S. P. (ed.), Synopsis and classification of living organisms, NY: McGraw-Hill, (1982).

[9] Singhal, S. & Zyda, M., "Networked Virtual Environments", ACM Press, pp. 119 & 142, (1999).

[10] Thompson, J.G. & Jorgensen, S., "How Interactive is Instructional Technology? Alternative Models for Looking at Interactions between Learners and Media", Educational Technology, Vol 24, (1989).

[11] Build an object database, http://www.javaworld.com/javaworld/jw-01-2000/jw-01-step.html (accessed on July 26, 2000).

[12] Extended Collision Detection for Java 3D, http://www.burrows.u-net.com/collisiondetectionJ3D.html (accessed on July 26, 2000).

[13] Specification for a Standard VRML Humanoid Version 1.0, http://ece.uwaterloo.ca:80/~h-anim/spec.html (accessed on July 26, 2000).

[14] Teachers' Perspectives on a Constructivist Learning Design, http://www.prainbow.com/cld/clds.html (accessed on July 26, 2000).

[15] The 'event generator' idiom, http://www.javaworld.com/javaworld/jw-09-1998/jw-09-techniques_p.html (accessed on July 26, 2000).

Strange Creatures in Virtual Inhabited 3D Worlds

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jerners Vej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +4598156279 Fax: +4598142444
E-mail: jensf@hum.auc.dk

This paper discusses the strange creatures that currently populate 3D cyberspace and3D Internet. First, the concept of Virtual Inhabited 3D worlds are discussed and defined. Next, some of the key elements or basic entities that can be found within the horizon of Virtual, Inhabited 3D Worlds are identified and denned. Among these basic elements are objects and agents, differentiated by whether or not their primary function is to carry out an action. Agents (denned as entities, which primary function is to carry out actions) have two main forms, which have been described as relatively sharply differentiable polar opposites. This is done based on questions such as: who is controlling the agents? 'who is doing the driving?' On the one hand there are agents that react independently of the user, but which are controlled by software or AL, the so-called 'autonomous agents' or 'bots'. On the other hand, there are agents, which directly represent and are controlled by users, the so-called 'avatars. Although there is then, in principle, a differentiation, in terms of definition, between bots and avatars, the paper argues that both concepts cover a relatively wide spectrum of very different types of phenomena with differing degrees of control. There also seems to be a tendency toward the appearance of more and more hybrids- in the present context termed 'cyber-hybrids' - combining avatars and bots. Furthermore, these hybrid forms are in many ways the most interesting and most promising in the virtual worlds at the moment. Rather than considering avatars and bots as polar opposites, it may therefore be more productive to consider them as the outer points along a continuum, between which can be found all sorts of combinations or hybrids. Following this line of argument, the paper outlines a new typology of hybrid creatures, which currently populate the continuum between (objects) bots and avatars in Virtual worlds.

*The paper was not available by the date of printing.

The Effect of Virtual Reality Learning Transfer with Different Cognitive Style

Wen, Jia-Rong* and Hsu, Li-Ling**
Industrial Technology Education, National Kaohsiung Normal University
** jerome@nknucc.nknu.edu.tw*
*** lingohsu@venus.seed.net.tw*

The virtual reality has great potential capacity in distance learning. There are three characteristics of virtual reality learning, simulation, interaction, and involvement of multiple users. The purpose of this study is to discuss the effect of virtual reality learning transfer with different cognitive style, and recognize the relationship between cognitive style and relatively different form. Cluster sampling was used in this study. Two schools, Kwan Hwa Junior High school and Youth Junior High school, were selected for sampling. Two classes of each school were recruited. Four research instruments such as "Cognitive Style Profile", "The Need for Cognitive Scale", "Computer Attitude Profile" and "The learning classroom of virtual reality" were used for evaluation. The main finding after analyzing the score statistically are as followed:(1).The cognitive style of students is generally good and above medium level, however, it seems not very good at discrimination skill.(2).The verbal spatial preference skill of students leans toward the spatial learning.(3).The computer attitude of students is good generally and has positive attitude.(4).The social position and owning computer have a remarkable influence on the VR learning transfer; yet sex, learning computer experience and family education mode do not have a distinguished influence on learning.(5).Increasing the opportunity for students to use computers helps VR learning transfer by computers.(6).The VR learning transfer differed by the difference of cognitive need.(7).The number of computer attitude will influence VR learning transfer, that one having positive (computer) attitude is much more efficient than the negative.(8).Discrimination skill and spatial skill will influence the VR learning transfer.(9).The number of different personal factor have a remarkable influence on cognitive style, cognitive need and computer attitude; yet family education mode does not have a distinguished influence on them.(10).The discrimination skill, spatial skill, cognitive need and computer attitude have a remarkable positive correlation with the VR learning transfer.(11).By means of predictive analysis, attitudes in computer, cognitive need and cognitive style have distinguished prediction.

Keyword: **cognitive style, virtual reality, learning transfer**

1 Introduction

A highly concerned subject to educators is how to enhance the outcome of education. In nearly a century, the researchers of educational technology are trying to find out the best educational media to assist their teaching. Educators expect the learner can learn effectively in short time. Because of individual difference, several factors could affect final achievement, including physiology, psychology, cognition, the attitude of educator, and the learning environment. As a result, the relationship between educational technology and the learning effect always being questioned.

Under the trend of "global life-time learning", distance learning has become a new learning model. It is excited that the technology shorten the distance between teaching and learning. Moreover, the interaction among virtual reality makes the communication possible between the real world. The researchers are aware of the potential of virtual reality. They believe the functions of simulation, interaction, and involvement of multi user leads the virtual space towards the model of virtual community. However, the reality and the virtual world have to coexist. The problems in real world have to be solved. It is important to consider how to make good use of the characteristics of virtual reality learning while trying to set up a virtual learning environment. We can not put every learner under virtual learning world(Chu,1998). Lin(1997) believed a

well-designed hypermedia helps learning. Furthermore, it has positive impact on the attitude of the learner using hypermedia.

The characteristics of the learning media and the learning attitude of the media are both variables of the cognitive style used to predict learning effects. Therefore, the objective of this study was to assist junior high school student study drawing in living technology education by using virtual reality. In addition, the impacts of the different cognitive styles on the learning using virtual reality are investigated. Student's adaptation of cognitive styles to the new media was discussed.

2 purpose

The purpose of this study is to discuss the transition of virtual reality learning transfer with different personal variable, cognitive need, cognitive style, and computer attitude. To summarize, the purpose of this study is follow: (1). To inquiry the influence compared with different personal variable, cognitive need, cognitive style, computer attitude and VR learning transition. (2) To explore the influence between personal variable and cognitive style. (3). Beside on the result and finding , to provide the concrete suggestions for teachers and people who design the environment of web virtual reality .

3 Method

3.1 Subject

Cluster sampling was used in this study. Two schools, Kwan Hwa Junior High school and Youth Junior High school, were selected for sampling. After the rejection the invalid samples 133 students are analyzed.

3.2 Materials

3.2.1 Cognitive Style Profile

To explore whether student with different cognitive styles react differently to the same material, this research adapted the Cognitive Style Profile that was developed by Keefe and Monk (1979) and translated by Liu (1992). The result of this profile is to investigate students' cognitive style in several dimensions. Scales between poor to excellent were measured to separate students into several groups. Factors as sequential processing skill (SQP); discrimination skill (DS); categorization skill (CS); analytic skill (AS); spatial skill (SS); memory skill (MM); and verbal spatial preference skill (VSP) are discussed.

3.2.2 The Need for Cognitive Scale, NCS

The NCS scale developed by Cacippo and Petty(1984) and translated by Cheng-Ren Zhan (1997) was used here. Research showed NCS had high positive correlation with IQ and low positive correlation with cognitive style.

3.2.3 Computer Attitude Profile

Ming-Long Wu (1997) developed the "Computer Attitude Profile" to investigate the computer attitude tendency of students. This profile includes four dimensions: computer affection, computer application, confidence attitude, and gender differences.

3.2.4 The learning classroom of virtual reality

This study adapted the " The learning classroom of virtual reality " which designed by Jia-Rong Wen (1999) (NSC 88-2520-s-017-001). Contents cover "Technology education--show visions". "The learning classroom of virtual reality" is divided into four areas: direction, disappeared-point, three visions and heap. The relationship between teaching materials and cognitive style is as the right side.

Figure 1 The relationship between teaching materials and cognitive style

3.3 Experimental design and procedures

The learning process of virtual reality in this research was divided into five steps: (1) The input of basic personal data; (2) Profiles Test; (3) pretest; (4) Virtual reality learning; (5)Posttest.

About the path of this framework , describe as follow:

A. To explore the relationship between personal various and VR learning transfer.
B. To inquiry the relationship between cognitive need and VR learning transfer.
C. To investigate the relationship between computer attitude and VR learning transfer.
D. To study the correlation between cognitive style and VR learning transfer.
E. To understand the effect of between personal various and cognitive need, computer attitude, and cognitive style.
F. To investigate the distinguished predictive force with cognitive style, cognitive need and computer attitude toward VR learning transfer.

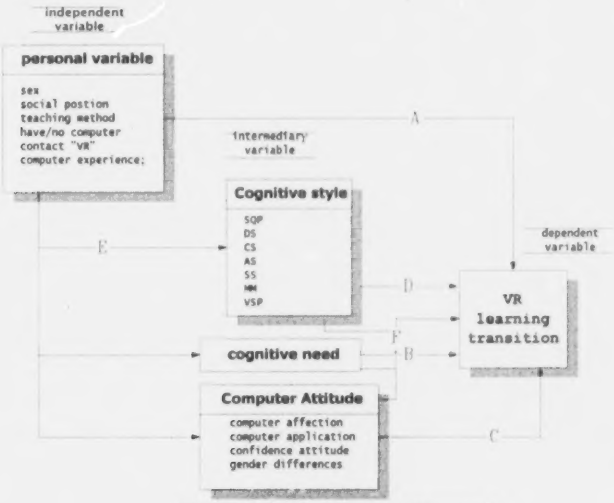


Figure 2 The framework of research

4 Results and Discussion

After the test, the collected data was analyzed in statistical methods such as T-test, one-way ANOVA, correlation, MANOVA,regression and the Scheffe test; the report, based on the results and discussion, is as follow.

4.1 descriptive illustration

4.1.1 The present situation description of cognitive style

Table 1. The present situation description of cognitive style

Cognitive Style	Mean	SD	TSTANDARD SCORE RANGES				
			weak	Lower than mean	mean	High than mean	strong
SQP	52.12	8.28	12	13	27	81	0
DS	44.72	12.24	33	22	30	40	8
CS	59.7	7.67	0	11	8	50	64
AS	51.28	9.71	30	35	0	24	44
SS	53.15	9.26	21	33	0	31	48
MM	53.98	10.29	10	29	17	36	41
			Space	Neutrality toward space	neutra lity	Neutrality toward language	language
VSP	45.39	7.29	21	68	30	10	4

As the Table 1, show the situation of junior high school students about cognitive style. Students have excellent skills in SQP, CS and MM. Students are short of DS skill. The mean of DS skill is lower than 50 and the SD is higher score, to display students have large different in DS skill. Both AS and SS have twin-peak distribution patters. VSP indicates the habit and perference of personal learning styles. From Table 1, the result shows that most of the subjects are used to or prefer spatial skill rather than verbal skill.

4.1.2 The present situation description of computer attitude

Table 2. The abstract description of computer attitude

	mean	SD	number	Mean of number
Computer affection	31.06	6.06	8	3.88
Computer application	54.71	8.61	13	4.21
Gender differences	23.86	4.78	8	2.98
Confidence attitude	19.05	5.86	7	2.72

According to Table 2. ,the mean of number approximate 3 to confirm the information spreading effect in these years. "Computer application" is higher and "confidence attitude" is lower than others. Study displays Junior High School students have bad confidence toward computer attitude.

4.2 The relationship of VR learning transfer with personal variable, cognitive need, and cognitive style

4.2.1 Test of significance of different personal variable for VR learning transfer

Table 3. The abstract of T-test of significance about personal variable in VR learning

Basic personal variable	classification				T_test	Scheffe
	Mean	SD	Mean	SD		
sex	male (67)		female (66)			
	6.57	11.05	6.36	11.32	0.105	
Have computer at home	have(86)		no(47)			
	9.07	10.42	1.70	10.95	3.829***	have > no
Have contact with 3D VR	have(45 □)		no(88 □)			
	7.78	10.47	5.8	11.47	0.807	

*P<.05 **p<.01 ***P<.001

Table 4. The abstract of ANOVA of significance about personal variable in VR learning

	Mean	SD	Mean	SD	Mean	SD	Mean	SD	F	Scheffe
socio-economic level	2(33)		3(42)		4(58)				4.017*	2 > 4
	10.30	9.27	7.26	11.80	3.71	11.06				
train	authority(3)		freedom(3)		assistance(3)		Other(4)		2.382	
	1.76	11.58	8.29	10.56	6.25	11.37	0.00	11.40		
Computer experience	Less 1 year(1)		1-1.9 year(2)		2-2.9 year(3)		More 3 year(4)		1.318	
	5.17	11.77	8.52	9.49	6.68	12.52	10.83	7.93		

Ps: 2:high socio-economic level ; 2:middle socioeconomic level; 4:low socio-economic level

According to Table 3 and Table 4, to show the basic personal variable influence VR learning transfer. "Have computer at home" and "socio-economic level" influence VR learning transfer directly. Those students whose families are at higher social or economic levels perform better in VR learning transfer. Their parents usually pay more attention to their environment of education and afford computers in their own homes.

4.2.2 Test of significance of different personal variable to cognitive style and computer attitude

Table 5. are the results of MANOVA comparing with different socio-economic level and computer experience. It shows that higher socio-economic level students get high score on DS.

In Cognitive Style Profile, students from families of different social or economic levels have significant difference ($p<0.05$) in DS. Moreover, after having applied Scheffe Mathod, those who are from higher social or economic levels ahve better DS than those who are from middle levels.

Table 5. The abstract of significance of MANOVA about socio-economic level

socio-economic level	1 (38)		2 (75)		3 (10)		Wilk's	F	Post compare
	Mean	SD	Mean	SD	Mean	SD			
SQP	3.36	0.86	3.29	1.02	3.34	1.04		0.068	
DS	3.03	1.29	2.31	1.24	2.93	1.25		3.992*	2>3
CD	4.36	0.90	4.21	0.95	4.22	0.88		0.313	
AS	2.88	1.73	3.50	1.57	3.00	1.61	0.845	1.665	
SS	3.73	1.57	3.52	1.49	3.10	1.57		1.941	
MM	3.70	1.24	3.50	1.31	3.43	1.40		0.423	
VSP	2.48	0.97	2.40	0.91	2.14	0.91		1.813	
								1.556	
computer affection	32.06	5.23	32.14	6.31	29.71	6.13	0.896	2.633	
computer application	55.73	7.35	55.81	9.54	53.33	8.52		1.326	
gender differences	16.36	5.81	19.48	5.77	20.28	5.55		5.150* *	4>2
confidence attitude	24.33	3.93	24.45	5.63	23.17	4.54		10.84	
								1.786	

In Computer Attitude Profile, students from families of different social and economic levels also ahve different profermance in the dimension of "gender differences".On the Contrary, those who are from lower social or economic levels have greater differeces between genders.This suggests that the male from lower social or economic levels have stronger stereotype about "computers are particularly for the male".

4.3 The relationship between cognitive style, cognitive need, computer attitude and learning translation

Table 6. The abstract of significance of ANOVA about cognitive need and computer attitude toward learning translation

	Mean	SD	Mean	SD	Mean	SD	F	Scheffe test
Cognitive need	1--lower(37)		2--middle(62)		3--higher(34)		3.247*	3>1
	3.78	10.50	5.97	12.51	10.29	7.97		
Computer attitude(3 in 1)	1--lower(31)		2--middle(72)		3--higher(30)		6.759*	3>2;3>1
	2.58	10.64	5.69	10.82	12.33	10.40		
computer affection	1--lower(40)		2--middle(54)		3--higher(39)		2.542	
	3.25	11.80	7.41	9.94	8.46	11.59		
computer application	1--lower(34)		2--middle(60)		3--higher(39)		3.535*	3>1
	2.79	9.86	6.5	11.80	9.62	10.41		
confidence attitude	1--lower(34)		2--middle(63)		3--higher(36)		2.049	
	3.68	10.89	6.51	10.42	9.03	12.24		
gender differences	1--lower(34)		2--middle(53)		3--higher(46)		0.449	
	7.35	13.10	6.98	10.02	5.22	10.95		

Table 6 shows that personal cognitive need affects VR learning transfer ($F=3.247$; $p<0.05$).After having applied with Scheffe, those with more cognition need have better VR learning transfer than those with less Need(3>1).

Table 7 shows the effect upon several dimensions in cognitive style toward VR learning transfer. From the result, those with "Strong" and "Higher Than Mean" DS have better in VR learning transfer than those with "Lower Than Mean" DS. In other words, DS and VR learning transfer are somehow associated. SS and learning transfer are also associated since they show significant differences. After having applied with Scheffe, those with "Strong" SS ahve better in learning transfer than those with "weak" SS.

Table 7. The abstract of significance of ANOVA about cognitive style toward learning translation

level	1 Weak		2 lower than mean		3 Mean		4 higher than mean		5 Strong		F	Post compare
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
SQP	6.67	10.30	1.15	11.02	8.33	11.27	6.67	11.18			1.255	
DS	4.24	12.26	-0.45	11.84	8.00	9.79	9.25	8.44	15.0	11.34	4.91***	5>2;4>2
CS			10.0	14.49	8.13	8.43	4.50	12.34	7.19	9.71	1.037	
AS	5.50	10.28	8.14	10.99			6.04	13.02	6.02	10.97	0.369	
SS	0.95	11.69	6.67	11.57	7.67	12.13	7.22	10.31	5.24	12.04	2.804*	5>1
MM	7.50	5.89	6.21	12.08	7.65	12.13	7.22	10.31	5.24	12.04	0.232	
VSP	4.76	12.60	7.21	10.01	5.33	11.37	8.50	15.47	6.25	11.81	0.352	

Table 8. The relationship of cognitive style, cognitive need, computer attitude with VR learning translation

	SQP	DS	CS	AS	SS	MM	VSP	Cognitive
Learning transfer	.056	.226*	.073	-.024	.221*	.009	.068	.051
	Cognitive need	computer affection	computer application	confidence attitude	gender differences	Computer attitude(3 in 1)		
Learning transfer	.245**	.188*	.186*	-.058	.218*	.244**		

In Cognitive Style Profile, DS and SS are highly associated with VR learning transfer ($p<0.05$). The correlation coefficient are 0.226 and 0.221 respectively. In the VR learning transfer of the subjects, the variances accounted by DS and SS are 0.5 and 0.48 respectively.

The Need for Cognitive Scale and VR learning transfer are significantly associated ($r=0.245, p<0.01$) with a variance at 0.06.This indicates that those with higher Cognitive Need tend to perform better in VR learning transfer. In the Computer Attitude Profile, only the dimension "gender differences" is staticstically independent from VR learning transfer. The rest dimensions of the profile are significantly positively associated with VR learning transfer.

This shows that it is easier for those with positive attitide toward computers to have more VR learning transfer.

4.4 Stepwise Multiple Regression

In the analysis of Distinguished Predictive Force of variables, Stepwise Multiple Regression was used with VR learning transfer as the dependent variable. And the independent variables included seven dimensions of Cognitive Style Profile (which are SQP, DS, CS, AS, SS, MM, and VSP), four dimensions of Computer Attitude Profile and NCS. The result shows on table 9.

Table 9. The Stepwise Multiple Regression table

order	R	R^2	ΔR^2	β	F
1.cognitive need	.245	.060	.060	.110	8.386**
2.DS	.328	.108	.048	.267	7.842***
3. Computer attitude(3 in 1)	.387	.150	.042	.219	7.569***
4.SS	.430	.185	.035	.198	7.247***

Within the thirteen independent variables, four of them show significance in Distinguished Predictive Force. They are NCS, DS, CA, and SS. They altogether can explain 18.5% variance in VR LEARNING TRANSFER. When only one single independent variable is effective, the distinguished predictive force of NCS is the best, which reaches 6%; DS accounts 4.8%; Computer attitude(3 in 1) predicts 4.2%; and SS only score 3.5%.

4.5 Synthetic analysis about VR learning transfer

After analysis,table 10 shows the result of comparison. As follow:

Table 10. The synthetic analysis about VR learning transfer

	Cognitive need	Computer attitude				
		Computer attitude(3 in 1)	computer affection	computer application	confidence attitude	gender differences
VR learning transfer	3 > 1	3 > 2 3 > 1		3 > 1		

	Cognitive Style						
	SQP	DS	CS	AS	SS	MM	VSP
VR learning transfer		5 > 2 4 >2			5 > 1		

Table 10 shows the facts which effect VR learning transfer. Those are "cognitive need"□" Computer attitude(3 in 1)"□" computer application" and cognitive style (DS and SS).

5 Conclusion and Suggestions

5.1 Conclusion

Distance education offers a new chance applying to review learning conviction and learning tactic for developing learning environment. Virtual Reality is an important style for distance education. In this study, the relationship of learning translation with cognitive style, cognitive need and computer attitude is concerned. The main results of this study are as follow :

(1).The cognitive style of students is generally good and above medium level, however, it seems not very good at discrimination skill.

(2).The verbal spatial preference skill of students leans toward the spatial learning.

(3).The computer attitude of students is good generally and has positive attitude.

(4).The social position and owning computer have a remarkable influence on the VR learning transfer; yet sex, learning computer experience and family education mode do not have a distinguished influence on learning.

(5).Increasing the opportunity for students to use computers helps VR learning transfer by computers.

(6).The VR learning transfer differed by the difference of cognitive need.

(7).The number of computer attitude will influence VR learning transfer, that one having positive (computer) attitude is much more efficient than the negative.

(8).Discrimination skill and spatial skill will influence the VR learning transfer.

(9).The number of different personal factor have a remarkable influence on cognitive style, cognitive need and computer attitude; yet family education mode does not have a distinguished influence on them.

(10).The discrimination skill, spatial skill, cognitive need and computer attitude have a remarkable positive correlation with the VR learning transfer.

(11).By means of predictive analysis, attitudes in computer, cognitive need and cognitive style have distinguished prediction.

5.2 Suggestions

According to the result of the research, we request the following suggestions to the related authorities in educating long distance of virtual reality reference:

(1) Among the seven items of Cognitive Style, students in domestic have better skills in sequential processing, categorization and memory; while in discrimination skill, the average is lower, and there are more differences inside. According to the explanation of the scale which evaluates the students whether they can focus on some level. The ones will high grades have better special quality on the focusing in cognitive styles, sharply watch the proper details and grasp the key points at work. The grades of students become lower is possibly due to fewer focusing on learning.

(2) The combinded resources of communities and schools can contribute to the education of the students from families of lower social or economic levels. In addition, the bond between the communities and the schools can provide various opportunities for students to operate computers.

(3) To increase students' oppertunities of active observation and to enhance their abilities in science and technology.

(4) To progress students' DS and SS, to benefit their VR learning transfer.

(5) To promote students' confidence in operating computers, to develop positive attitude toward computers, to enhance learning, to increase VR learning transfer the stereotype of gender differences should prevented

(6) To accommodate Spatial Learning, to escalate VR learning transfer.

(7) To let students establish the positive cognitive demand is more helpful to VR learning transfer.

(8) The computer attitude is also the important factor of VR learning trandfer. Students with positive confidence in believing computer is a kind of assit-tool have better learning effect.

References

[1]Cartwight,G.F.(1994).Virtual or Real?The mind in cyberspace. The futurist,18(2),22-26.

[2]Hong Jon-Chao (1994). A Study of Discovery Learning with Different Learning Styles in a CAI Environment, National Science Council, Vol. 4(2) 70-80.

[3]Keffe, I. W.(1979). Learning style: An overview .In O. B. Kierman (ed),Student Learning Styles. Virginin: NASSP Reston.

[4]Keefe,J.W.(1987).Learning style theory & practice. Reston,Virginia: National Association of Secondary School Principals.

[5]Liu Xin-Xiong (1992). A study of relationship of primary students between cognitive style, learning method, and achievements.

[6]MacNal, W. et al. (1991). Cognitive style and analytic ability and their relationship to competence in the biological science. Journal of Biological Education, 25(2),135-140.

[7]Messick, S. (1994) . The matter of style:Manifestations of personality in cognition, learning, and teaching. Educational Psychologist, 29 (3), 121-136.

[8]Moore, J. L., Lin X., Schwartz, D. T., Campbell, O., Hmelo, C., & Cognitive and Technology Group at Vanderbilt (1994). The relationship between situated cognition and anchored instruction: A response to Tripp. Educational Technology, 34(10), 28-32.

[9]Qiu gui-fa (1998). The learning of network: belief and development. Educational Research & Information. Vol. 6(1) 20-27.

[10]Rollins, H. A. & Genser, L. (1977). Role of cognitive style in a cognitive task: A case favoring the impulsive approach to problem solving . Journal of Educational Psychology, 69(3),81-287.

[11]Woodrow, J. The development of computer-related attitudes of secondary students. Journal of Educational Computing Research, 11(4), 307 – 338

[12]Wu Ming-long (1998). A Study of The Relationship Between Math Learning Behavior of Primary Students and Their Anxiety, Attitude toward Computer. The thesis of National Kaohsiung Normal University, not published.

Using Virtual Environments for Studying Water Phases and Phase Transitions

Jorge F. Trindade* and Carlos Fiolhais **
**Physics Department and High Education School for Technology and Management, Polytechnic Institute of Guarda, 6300 Guarda, Portugal*
E-mail: jtrindade@ipg.pt
*** Physics Department and Center for Computational Physics, University of Coimbra, 3000 Coimbra, Portugal*
E-mail: tcarlos@hydra.ci.uc.pt

In recent years, many studies have dealt with students' reasoning in science. Those studies suggested that pupils, in different degrees, have difficulties in understanding matter phases and phase transitions. To increase pupils understanding of phases and phase transitions, we are developing the "Virtual Water" project, a virtual environment centered on the learning of the structure and properties of water in its different phases. Within this environment, the molecular dynamics in the solid, liquid and gaseous phases of water and the corresponding phase transitions take place in three-dimensional space, with the possibility of haptic interaction with the molecules.

Keywords: **Virtual reality, virtual environment, water, phases and phase transitions**

1 Introduction

All substances undergo dramatic changes in their qualitative properties when certain parameters pass through particular values. Matter phases and phase transitions have received considerable attention in the framework of research on children's understandings in different ages and development stages [1-4], [10], [15].

Ice melting is an everyday example of a phase transition. When the temperature increases, keeping the pressure constant, the molecular vibrations become gradually more violent and thermal expansion occurs. Since this increase of vibration amplitude is gradual, one might expect that the macroscopic properties of water would also undergo a smooth change. While this is true for most temperatures, there is a well-defined temperature for which something dramatic happens: a sudden change in the properties of the substance and the appearance of a liquid. The liquid, in its turn and at a higher temperature, undergoes another phase transition going into a gas.

Few pupils use the corpuscular theoretical model taught in school to explain these processes. Indeed, their knowledge and understanding of the corpuscular theory of matter is sometimes very fragmentary. They apply it in some situations but not in others. For example, they may apply the corpuscular theory to explain gases but not to explain solids and liquids. There are also cases where pupils say that the shape and size of molecules changes when the state of matter changes: the shape of molecules depends on the shape of the vessel, molecules of solids are the biggest while gas molecules are the smallest for Portuguese children (13-15 years) [9], etc.

Other studies of students' conceptualization of phase transition from liquid or solid to gas have indicated that some children have difficulties conceiving gas as a substance [6] [12]. As students do not develop the general idea of gas prior to formal learning, the perceptual clues for detecting and identifying gases are weaker than for liquids and solids. Although pupils know some properties of air, they do not compare air with other gases, claiming that other gases do not have the same properties as air. A frequent explanation is that air is a big bulk system [11]. Gases are frequently linked by some invisible entity, something immaterial, for example energy in various forms. Kircher [5] also reports that high school pupils understand gases as a

continuous substance with no empty space between particles.

Since the use of images is a powerful tool for understanding complex and/or abstract information and since immersion in virtual environments is a recent technique which needs to be explored and evaluated, a virtual environment for studying phases and phases transitions is being developed by the Physics and Mathematics Departments of the University of Coimbra, Portugal, the Exploratory "Henry the Navigator", in Coimbra, and the High School for Technology and Management of the Polytechnic Institute of Guarda. We have named it "Virtual Water".

2 Overview of the Molecular Dynamics Virtual Environment

"Virtual Water" (VW) is a set of virtual environments designed to help in the instruction of high school students of Physics and Chemistry (it might also be useful for freshman university students). The main goals of this virtual reality application are:

a) To provide an educational environment for students to explore some microscopic concepts which they are taught in class.

b) To develop a practical knowledge concerning the application of virtual reality techniques to education, contributing with data on the usefulness of virtual reality [13-14].

The molecular dynamics component of VW is devoted to understanding some water properties and studying its phases and phase transitions by computer simulation. These simulations are based on the corpuscular theory of matter and use the equations of Newtonian Mechanics. We assume that the dynamics can be treated classically because more realistic simulations (incorporating quantum effects) are cumbersome and more computationally demanding. We also assume that the force between any pair of molecules depends only on the distance between them.

The interactions using *dataglove* allow the user to act and change the environment in order to distinguish the properties of solids, liquids and gases. The *cybertouch* system associated to the dataglove enables the user to experience some molecular behaviors that are impossible to feel in real world. For example, in the solid phase the user may fly through the ice structure and learn about it (Figure 1). Using the *dataglove* the user is able to break the ice and with the *cybertouch* system he can feel the increase of molecular vibrations with the temperature. While breaking ice may be a common macroscopic experience, watching the network of hydrogen bond and feeling molecular vibrations, for example, are quite uncommon experiences. On the other hand, in the liquid and gas phases, it is possible see and try to grab a molecule, understanding by direct experience that its speed is bigger than in the solid phase.

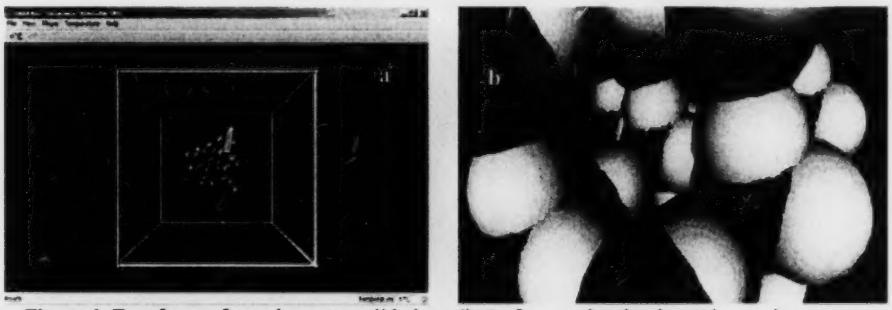


Figure 1: Two frames fro m the water solid phase (ice) of our molecular dynamics environment: a) balls model of a group of molecules; b) flying through the ice structure.

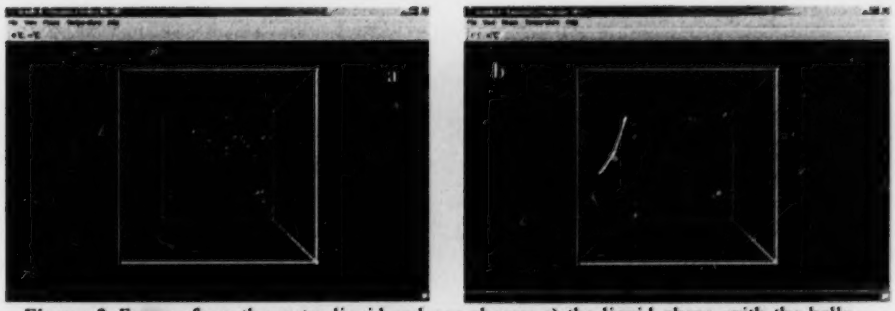


Figure 2: Frames from the water liquid and gas phases: a) the liquid phase, with the balls model of twelve molecules; b) The gas phase, showing the same molecules. These pictures, as well as those of Figure 1, were created with *PC Gamess*, *Molden*, *3D Studio Max*, being the dynamics implemented in *Visual C++* on *WorldToolkit*.

Using balls models of water molecules the user may interiorize the corpuscular theory of matter. Since the molecular dynamics simulation takes place in a box (closed system) it is easy to understand that the molecules are the same in solid, liquid or gas phases. It is clear from our virtual environment that, in any phase of water, empty intermolecular spaces are present, these being smaller in the solid and liquid phases than in the gas phase (Figure 2). The density is different in the three phases.

For designing the VW models we used the free software *PC Gamess* [8], that performs the calculations on the water molecule, and *Molden* [7], for the molecular representations. For model development and optimization we used commercial software packages (*Mathcad* and *3D Studio Max*) and *Visual C++* for implementing the molecular dynamics algorithm. Concerning the definition and creation of the virtual scenarios we used *WorldToolkit* (from Sense8). For navigating in the virtual environment and interacting with our models we use a *dataglove* with *cybertouch* system (for haptic information) from Virtual Technologies.

3 Conclusions

Important strategies in teaching Physics and Chemistry are based on central the idea that matter consists of particles but the fact that these are invisible hinders sometimes the development by students of the right scientific concepts. However, the analysis and comparison of various results in the pedagogic literature show that some incorrect concepts and their relationships are simply transferred from the macroworld to the microworld. In fact, there is a firm link between the concepts on matter structure and empirical knowledge of macroscopic phenomena.

If students accept the corpuscular theory mainly for gases and not for solids and liquids, it is advisable to confront them with this contradiction and to treat specifically the processes of phase changes from gas to liquid, and *vice versa*, in terms of identity of substance, identity of particles and conservation of the number of particles. Similar procedure applies to students who accept better the corpuscular theory for solids.

The use of immersive virtual environments and haptic information, although recent, seems to be a powerful means for visualizing and understanding complex and/or abstract information. Actions like grabbing a molecule, breaking hydrogen bonds networks, feeling molecular vibrations, flying through channels in ice and through the empty spaces of molecules in liquid and gas phases (as in George Gamow's book "Adventures of Mr. Tompkins"), etc. are impossible in real world but possible in computer simulations.

"Virtual Water", our virtual environment for studying phases and phase transitions based on corpuscular theory of matter is promising to make progresses along the indicated directions. We are acquiring new means in learning and teaching the Physics and Chemistry of water and building knowledge on virtual reality techniques and tools, which can later be applied to other problems. In particular, our experiment with virtual reality should point out what are the most effective educational benefits and also to indicate the weaknesses of this new technology in an educational setting.

Feedback from pupils is being collected and analyzed in order to quantify the pedagogical usefulness of our

virtual environment. Of course, if these techniques prove to be successful, teacher's strategies should incorporate them. We hope that, with tools like the one we are developing, intangible experiments become more and more concrete and that this fact may facilitate the development of scientific models among science students.

Acknowledgements

The authors thank Prof. Dr. Victor Gil, from the Chemistry Department of the University of Coimbra, for his precious suggestions, and Prof. Dr. José Carlos Teixeira, from the Computer Graphics Center of the same University, for his technical advice. We also wish to acknowledge the assistance of the students Nuno Pereira and Eduardo Coutinho, who have developed the molecular dynamics component of "Virtual Water". This research was supported in part by the Portuguese Foundation for Science and Technology (project PRAXIS/FIS/14188/1998).

References

[1] Andersson, *B.*, "Pupils' conceptions of matter and its transformations (age 12-16)", Studies in Science Education, *18*, pp. 53-85 (1990).

[2] Driver, R. Squires, A., Rushworth, P. & Wood-Robinson, V., "Making Sense of Secondary Science - Research into Children's Ideas" (London: Routledge) (1994).

[3] Driver, R., Goesne, E. & Tiberghien, A. (ed.), "Children's Ideas in Science" (Milton Keynes: Open Universitv Press) (1985).

[4] Garnett, P., & Hackling, M., "Student's alternative conceptions in chemistry: a review of research and implications for teaching and learning", Studies in Science Education, 25, pp. 69-95 (1995).

[5] Kircher, E., "Research in the classroom about the particle nature of matter" in W. Jung, H. Pfundt and C. Rhoneck (ed.), in *Proceedings of the International Workshop on Problems Concerning Students' Representation of Physics and Chemistry Knowledge* (Ludwigsburg: Pedagogische Hochschule), 342-359 (1981).

[6] Lee, O., Eichinger, D. C., Andersson, C. W., Berkheimer, G. D. & Blakresle, T. D., "Changing middle school students' conceptions of matter and molecules", Journal of Research in Science Teaching, 30 (3), pp.249-270 (1993).

[7] Molden, a package for displaying MOLecular DENsity, written by G. Schaftenaar, CAOS/CAM Center Nijmegen, Toernooiveld, Nijmegen, The Netherlands.

[8] PC Gamess, a program for ab initio quantum chemistry, written by Alex. A. Granovski, Moscow State University.

[9] Pereira, M. P. & Pestana, M. E., "Pupils' representations of models of water", International Journal of Science Education, 13(3), pp.313-319 (1991).

[10] Pfundt, H. & Duit, R., "Bibliography: Student's Alternative Frameworks and Science Education", 4th ed. (Keil, Germany: Institute for Science Education) (1984).

[11] Sere, M. G., "Children's conceptions of the gaseous state prior to teaching", European Journal of Science Education, 8(4), pp.413-425 (1988).

[12] Stavy, R., "Children's conceptions of gases", International Journal of Science Education, 10(5), pp.553-560 (1988).

[13] Trindade, J., Fiolhais, C. & Gil, V., "Virtual Water, an application of virtual environments as an education tool for physics and chemistry". In *Advanced Research in Computers and Communication in Education*, Proceedings of ICCE'99 – 7th International Conference on Computers in Education, Chiba, Japan, ed. G. Cumming, T. Okamoto, and L. Gomez, vol. 2, pg. 655-658, (IOS Press, Amsterdam) (1999).

[14] Trindade, J., Fiolhais, C., Gil, V. & Teixeira, J. C., "Virtual environment of water molecules for learning and teaching science", Computer Graphics Topics, 5 (11), pp.12-15 (1999).

[15] Wandersee, J. H., Mintzes, J. J. & Novak, J. D., "Research on alternative conceptions in science". In D. Gabel (ed.), *Handbook of Research on Science Teaching and Learning* (New York: Macmillan), pp.177-210 (1994).

Using virtual reality courseware to enhance secondary school student learning in geosciences

Hsiao-shen Wang* and Jyr-Ching Hu**
The Institute for Secondary School Teachers in Taiwan
67, Tsui-Feng St. Feng-Yuang, Taichung County, Taiwan, ROC
** hswang@ultra.isst.edu.tw*
*** jchu@ultra.isst.edu.tw*

Based on the rapid development of the technology of virtual reality, the project was to integrate the contents of the geosciences with virtual reality courseware (VRGeo) to enhance student learning in secondary level. Three subject-oriented course themes were included in the VRGeo. The first theme is Active Faulting in Chihshang. In this theme, a 3-D topography around Chihshang area was designed to demonstrate the surface faulting along the Longitudinal Valley. The 3-D demonstration enhances the comprehension of basic geologic information in studied area. The second theme focuses on the arc-continent collision process, which was divided to five consecutive scenarios from late Miocene to present day. The mountain building process in Taiwan was demonstrated clearly the growth of mountain in Taiwan and the relationship of the collision process due to arc-continent collision. Finally, the third theme shows the mechanism of the foehn due to geographic effects. In a pilot study, eighty percent of 120 in-service teachers agreed that the use of the courseware facilitated secondary school student learning in Geosciences. The VRGeo is now on-line to be used through the Internet (http://www.isst.edu.tw) and will be collected the experiment data for the future research.

Keywords: **Virtual reality courseware, CAL, CAI, Geoscience,**

1 Introduction

Wang (1999) indicated that when teaching courses in secondary level, it was important to identify student learning difficulties and to adopt the suitable teaching and learning strategies in subjects for the best learning effect. Based on the discussion with teachers in geoscience (ISST, 1997), it is found that secondary school students had the difficulties to understand the process of geographic effects for climate, aseismic surface faulting and orogenic process in Taiwan through traditional instruction. Traditional instruction usually used textbooks, maps, and videotapes in geoscience and had the learning effect in static geology concept but not dynamic processes. Thus, the purpose of the project focused upon how to provide a learning environment to enhance secondary school student learning in the dynamic processes of geographic effects.

2 General background

The Taiwan orogeny is young and presently very active (Tsai, 1986).. It provides an excellent environment for studying ongoing orogenic processes, especially since the region is monitored intensively with dense seismologic and geodetic networks for natural hazards. The Longitudinal Valley Fault zone of eastern Taiwan is the present-day plate boundary between the Philippine Sea plate and Eurasia. Repeated surveys of active deformation were carried out along its most active segment, the Chihshang Fault (Angelier et al., 2000). Creep on the Chihshang Fault started after of the "Taitung Earthquake sequence" in November 1951. Annual records of displacement from 1990 to 1998 revealed concentration of shear on a single fault. However, large earthquakes occurred in the past. Continuous motion took place in the absence of large

earthquakes for several tens of years along the Chihshang Fault. Along the Longitudinal Valley, earthquakes with magnitudes larger than 5 occurred in 1951 (Meilun magnitude Ms=7.1; Yuli, Ms=5.3), in 1972 (Juisui, Ms=6.9) and 1986 (Hualien, Ms=6.4 and 7.8).

The problem of a better description of the historical seismicity is still crucial in considering the need to better define the so-called earthquake cycle: the destructive Chichi earthquake (September 21th, 1999) highlights this importance (Ma et al., 1999). Thus a dynamic learning environment is needed to help student to construct the geographic concept in geoscience. Several 3D simulation and virtual reality applications had the learning effects in different subjects, such as special education, chemistry, music, Electrical Engineering, Computer, etc (DE SOUZA, et al. 1999; Cass & Roblyer, 1998; ALLPORT et al., 1998; Cox, L.1998). Based on the rapid development of cybernetic and virtual reality technologies, the learning environment would be developed by virtual reality technology in cyberspace.

3 Lessons learned from the development of VRGeo

Our work in the study first focused upon identifying the student learning difficulties in the process of geographic effects for climate, aseismic surface faulting and orogenic process in Taiwan. The next was to create the virtual reality courseware (VRGeo) to emphasize the dynamic processes of geographic effects, the natural hazards and earthquake risk mitigation along the Chihshang Fault. Finally, we expect to learn new and better ways to integrate the VRGeo in a classroom activities in order to enhance student learning.

Three subject-oriented course themes were developed in the VRGeo. The first theme is Active Faulting in Chihshang(Fig.1-1, Fig.1-2, Fig.1-3). In this theme, a 3-D topography around Chihshang area was designed to demonstrate the surface faulting along the Longitudinal Valley. The 3-D demonstration enhances the comprehension of basic geologic information in studied area.

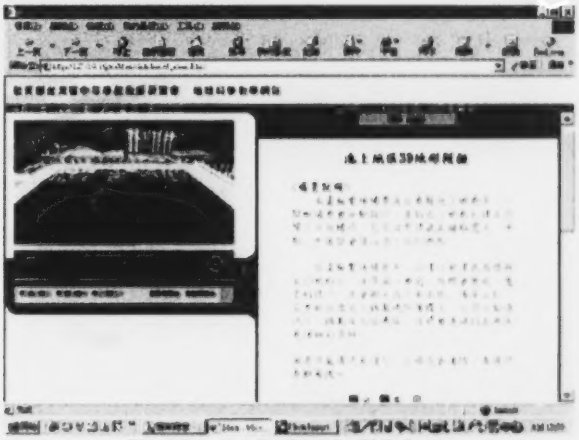


Fig. 1-1 Active Faulting in Chihshang

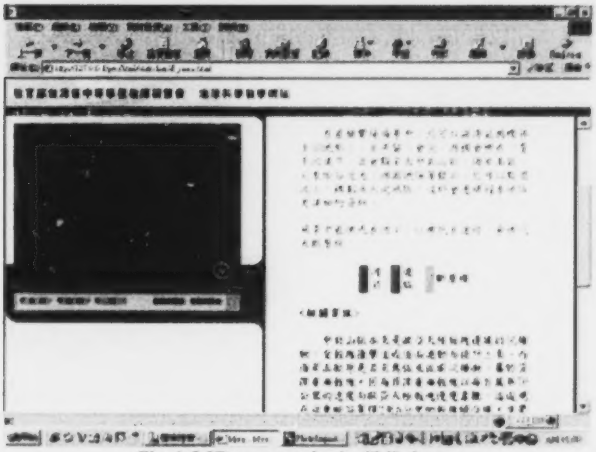


Fig. 1-2 3D topography in Chihshang

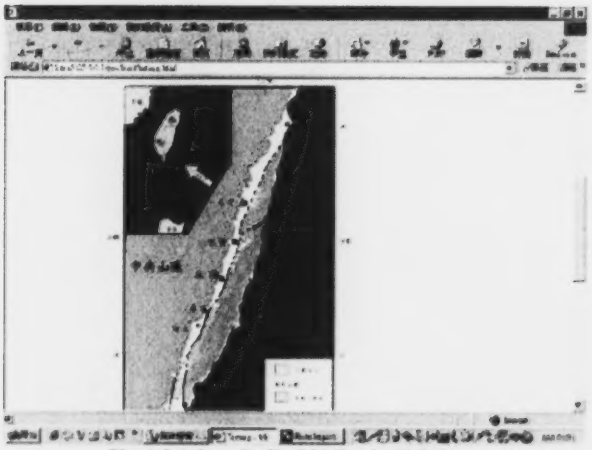


Fig. 1-3 A Longitudinal Valley in Chihshang

The second theme focuses on the arc-continent collision process(Fig.2-1, Fig.2-2, Fig.2-3), which was divided to five consecutive scenarios from late Miocene to present day. The mountain building process in Taiwan was demonstrated clearly the growth of mountain in Taiwan and the relationship of the collision process due to arc-continent collision. This demonstration will facilitate the teachers and students to well understand the plate movement and interaction during the collision process.

BEST COPY AVAILABLE

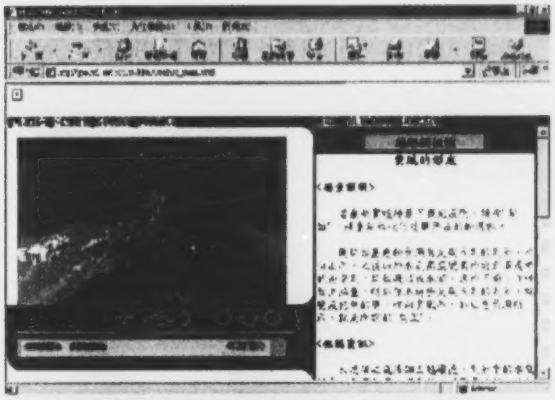


Fig. 2-1 the arc-continent collision process

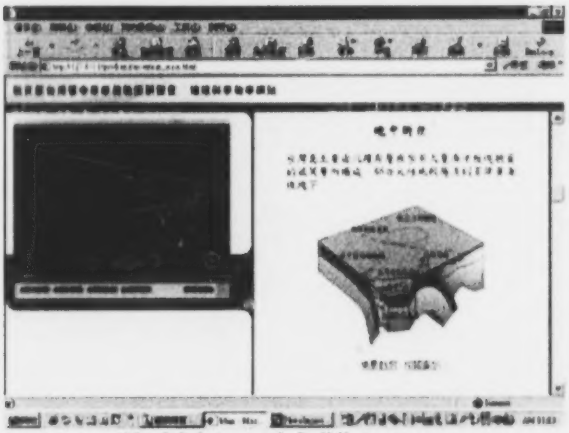


Fig. 2-2 the moutain building process

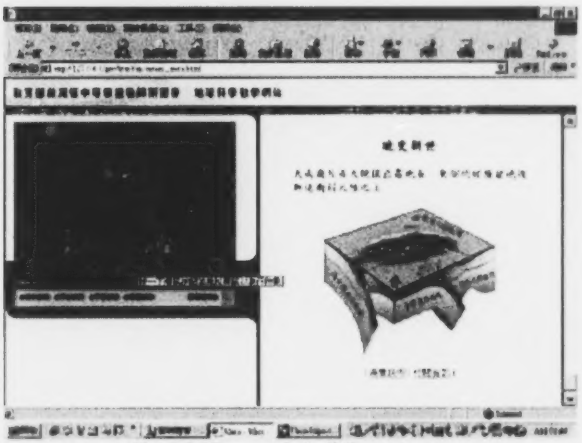


Fig. 2-3 3D moutain building process

Finally, the third theme shows the mechanism of the foehn due to geographic effects (Fig. 3-1, Fig.3-2,

Fig.3-3). The difference of rainfalls is deeply influence by the locality of windward slope or leeward slope. This VR scenario begins with the movement of the air stream and clouds from the windward slope. This scenario enhance the comprehension of the foehn in the leeward slope.

Fig. 3-1 the mechanism of the foehn

Fig. 3-2 the movement of the air stream and clouds from the windward slope

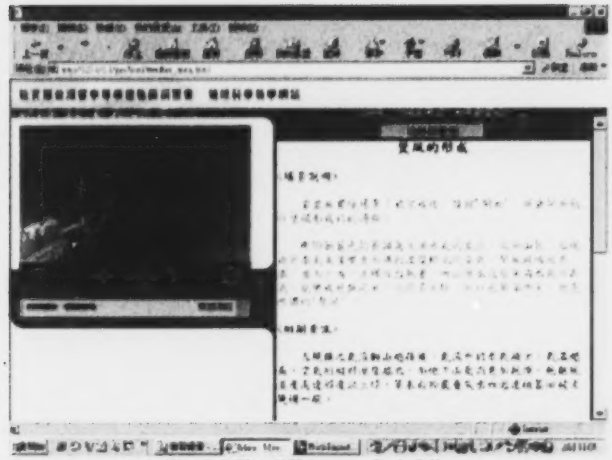


Fig. 3-3 The difference of rainfalls

In a pilot study, 120 secondary school geoscience teachers enrolled in 3 a-week workshops to use the VRGeo at The Institute for Secondary School teaches in Taiwan. Eighty percent of the teachers agreed that the use of the courseware facilitated secondary school student learning in Geosciences. The VRGeo project underlying theoretical framework combines constructionist educational theory with ideas that emphasize the importance of collaborative learning and narrative development. In the future research, we expect to integrate the VRGeo in a classroom activities with collaborative learning. The VRGeo is now on-line to be used through the Internet (http://www.isst.edu.tw) and will be collected the experiment data for the future research.

4 Conclusions

Offering a flexible learning environment and facilitating student learning with their own path will be the important issues to enhance the student learning effects in education. Virtual reality technology has the potential to support those issues and facilitate students better able to master, retain, and generalize new knowledge when they are actively involved in constructing that knowledge in a learning-by-doing situation (Youngblut, 1997).

This paper addresses the application of virtual reality as a facilitating educational tool in geoscience, designed to get students more deeply and flexible immersed in the VR environment, and to present educational experiences not possible using other methods. An important goal of VRGeo is to study the effectiveness of a virtual environment as a conceptual learning and evaluation medium.
Virtual reality has the potential to change the way we help students learn. For this to happen, we need to know how and when this new instructional tool with instructional concepts can be effectively to use, and it will be the main concern in the future research.

References

[1] Angelier, J., Chu, H.-T., Lee, J.-C. and Hu, J.-C. Active faulting and earthquake risk: the Chihshang Fault case, Taiwan, J. Geodynamics, 29, 151-185 (2000).

[2] Cass, M., Roblyer, M. D. A Review of Experimental Research on Virtual Reality in Special Education: The Status of the Dream. http://soe.eastnet.ecu.edu/vr/vrits/4-2cass.htm (1998).

[3] Cox, L. Introduction to Virtual Reality Through Music. http://soe.eastnet.ecu.edu/vr/vrits/2-4Cox.htm (1998).

[4] DE SOUZA, Antonio Lopes 1, SALGADO, Luiz Antonio 2, SOLLERO, Maria Karla V.3, & SUEMITSU, Walter Issamu4. An Internet-Based Environment for Support Teaching and Learning of Electrical Engineering. http://www.otc.kyit.edu.tw/ICEE1999/papers/291/291.htm (1999).

[5] ALLPORT, Christopher, SINES, Paul, SCHREINER, Brandon & DAS, Biswajit. Education in Three Dimensions: Using Virtual Reality in Education for Illustrating Spatial Relationships. http://www.otc.kyit.edu.tw/ICEE1999/papers/334/334.htm (1998).

[6] Ma, k.-F., Lee, C.-T., Tsai, Y.-B. and Shin, T.-C. The ChiChi, Taiwan earthquake: large surface displacements on an island thrust fault. EOS, 80, 605-611,(1999).

[7] The Institute for Secondary School teachers in Taiwan. The workshop of secondary school teachers in geoscience (1997).

[8] Tsai, Y.-B. Seismotectonics of Taiwan, Tectonophysics, 125, 17-37, (1986).

[9] Wang, H. S., Hargrave, C. P., Hsu, Y. S.(1999). The research of using different teaching and learning strategies in computer courses for inservice education. SITE99, Feb. 28-Mar. 4

[10] Youngblut, C. Educational Uses of Virtual Reality Technology. http://www.soe.ecu.edu/vr/vrits/3-1Young.htm(1997).

Virtual Inhabited 3D worlds and Internet Based Learning Environments

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper addresses some of the central questions currently related to 3-dimensional Inhabited Virtual worlds (3D-IVWs) and their virtual interactions and communication in Internet Based Learning Environments. First, 3D-IVWs-seen as a new and unique form of multimedia-are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVW s is denned and commented upon. Third, modes of interactivity and (virtual) interactions between users, avatar, bots, etc. in the new Virtual Worlds are briefly presented and typologized. Finally, two Internet based virtual inhabited 3D learning environments -one US-based and one based in Denmark- will be described and analysed.

*The paper was not available by the date of printing.

WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

Long-Chyr Chang, Heien-Kun Chiang, and Pi-Shin Wey
Da-Yeh University
112, Shan-Jiau Rd., Da-Tsuen, Changhua 51505
Tel: +886-4-8528469~3138
E-mail: long@aries.dyu.edu.tw

Web-based 3D life-like learning environment is becoming a major research topic. WALTZ supports dynamic, collaborative, and synchronous/asynchronous learning activity in 2D/3D virtual environments. In this paper, an overview of WALTZ's architecture and design philosophy is presented. Then, a WALTZ-style Pythagorean theorem learning space is shown to illustrate the powerfulness of the WALTZ environment. The ultimate goal of WALTZ is to provide an active and pleasant social learning environment for learners to study collaboratively and waltz happily in shared virtual, dynamic and yet exciting learning spaces.

Keywords: **Web learning, Virtual Reality, Collaborative Learning, CAI**

1 Introduction

The World Wide Web (WWW) opens a new learning space that learners can communicate and share their idea in this wonderful virtual world. The new learning space provides versatile ways of communication and interaction that would make learning more fun and entertaining than ever before. It has captured great attentions from CAI (Computer Assisted Instruction) researchers since its debut as it has great potential to surmount the difficulties and weakness of traditional CAI systems [5,7,8]. Up to date, most web-based CAI systems only support asynchronous learning and still use 2D hypermedia style to showcase their learning materials and instructions [13]. Some systems [3] might support collaborative learning additionally, however, they are still far away from success as the new way of learning also brings new problems that are even more challenging for educators. There is no simple way of knowing what the best web-based learning environment would be and how to utilize this environment effectively for teaching as well as learning. It is a research area that needs to be seriously explored through the cooperation of experts from different disciplines such as subject content experts, instruction developers, CAI researchers, and web engineers etc. Despite such problems, most educators would agree that discovering leaning, collaborative learning, learning by doing, and learning with fun are among those of effective learning methods according to Constructivism [2,9,12]. Fortunately, recent rapid progress of web technologies such as JAVA, VRML, and network technologies bring a new opportunity for implementing the learning methods described above. Before VRML was created in 1994, web spaces are flat. Most web systems are hypermedia style, which do not have enough expressive power of modeling real world entities. The living world specification [11,14] in 1997 illustrates emerging needs of dynamic and interactive 3D shared virtual worlds. Today there are many popular 3D avatar (virtual human) based virtual society (mainly for social meeting and chatting) websites [1]. The trend of web windowing systems is moving from 2D multimedia representation to 3D shared virtual space. WALTZ foresees the integration of the two media will become a popular form of presenting learning materials as well as a virtual fun place to play, learn and exchange idea. Many studies have also indicated that a successful web-based learning system not only has to be content-rich but also highly interactive as well as highly adaptive to meet the needs of learners [5,8]. Transforming 2D virtual classrooms into life-like 3D learning space is certainly one of the research directions that deserve special attention.

WALTZ, a research project under active development, is a web-based adaptive/interactive learning and teaching zone, which supports dynamic, collaborative, and synchronous/asynchronous learning in 2D/3D

virtual environment. WALTZ envisions that the CIA (Content, Interaction and Adaptivity) learning model will be an essential ingredient of future successful web-based CAI (Computer-Aided Instruction) systems. The CIA learning model is developed based on the Interaction Model of Gilbert [5] and Instruction Design Model of Moallem [15]. The CIA learning model has three corner stones: Content, Interaction and Adaptivity. The overlay areas of each neighboring corner stones are versatile representation, adaptive instruction and adaptive interaction. Figure 1 illustrates the CIA model in detail.

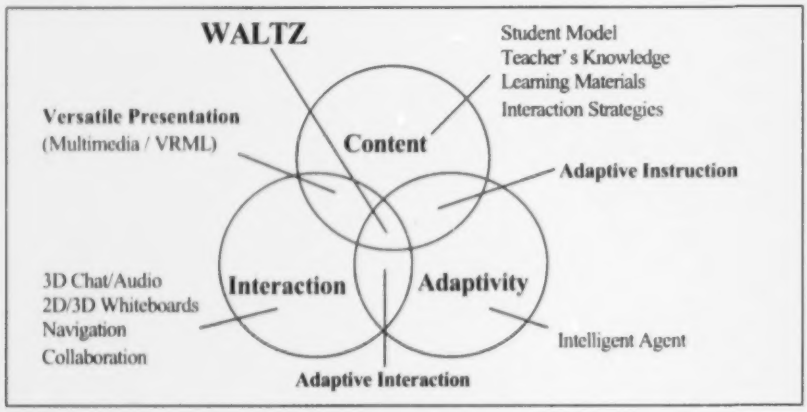


Figure 1. WALTZ's CIA Learning Model

2 An Overview of WALTZ

The main goal of WALTZ is to develop a web-based interactive and adaptive environment based on the CIA learning model so that it can be easily adapted to any instructional and learning subjects according to the theory of constructivism. WALTZ is capable of supporting discovering learning, project-based learning and collaborative learning in 2D/3D shared virtual learning space. WALTZ supports the following features:

(1) Dynamic interaction and flexible communication

WALTZ supports two types of interaction: Human-Computer Interaction and Social Interaction. The former supports instructional interaction and emphasizes individual and adaptive learning. Learners can browse information, navigate virtual worlds, and respond to problems that are dynamically generated from the WALTZ's system according to student's learning status. The latter supports collaborative mechanism and emphasizes collaborative learning among students, student and teacher, groups of students, and the whole class. In addition to support asynchronous communication in traditional 2D virtual classroom setting, WALTZ also supports synchronous communication in both 2D shared and 3D shared learning space as well.

(2) Versatile presentation of multimedia and virtual reality

Both multimedia and virtual reality have their advantages and disadvantages. Multimedia learning has great success in instruction and learning in recent years. Virtual reality is the best technology to provide 3D life environment. Web-based multi-user environment are even envisioned as one of the popular user interface in the future [9]. However, it is still hard to construct a high quality VR system in terms of cost and technology. Furthermore, virtual reality might not be suitable for all types of instruction. Thus, the use of both multimedia and virtual reality technologies in alearning system will be able to support a rich and effective learning environment that attracts students.

(3) Agent-based learning environment

Based on Constructivism, an ideal learning system should provide adaptive learning scenarios, where teaching materials and learning activity would be individualized according to students' mental model and learning needs. WALTZ supports helper-agents, which would interact with learners in several ways. For

example, an instruction agent would present an easier course material to a learner if it found the current content is too difficult for him/her. An interaction agent would suggest a group of learners to use a 3D whiteboard instead of a 2D whiteboard if they were trying to understand the three dimensional structure of molecules. WALTZ's virtual classroom could be populated with shared objects and active agents, such as user agents (represented by virtual human) and helper-agents so that users can enjoy and learn effectively in the social learning environment.

(4) Collaborative mechanism for activity management

Recently, group learning has been found to have a positive effect during learners' learning process [6,17]. In order to effectively support WALTZ's virtual, shared, and interactive social world, a set of collaborative mechanisms has been developed to manage interactions among students, teachers, and instructional content. These mechanisms [4] include object association, automatic object notification and change management, object delegation, object negotiation, object constraint, and object history tracking. Built on top of these collaborative mechanisms; WALTZ constructs an agent-based group activity model, where each participant is modeled as a user agent to manages the dynamic behaviors of all participants in an activity.

(5) Standard VRML authoring language for shared multimedia contents

Content development plays an important role of a successful web-based learning system. WALTZ supports authoring tools for shard virtual worlds based on multi-user VRML living world specification. This feature will make developments of shared 3D contents almost as easy as non-shared static 3D contents. Message passing between shared objects on different computers will be through new prototyped VRML nodes and WALTZ communication subsystem will update the states of each shared object once they are changed.

(6) Open architecture and platform independent web-based learning environment

The enchantment of web-based learning environment in WALTZ is due to its global network connectivity, simplicity and yet friendly user interface, and extensible architecture. The implementation of WALTZ is based on JAVA , VRML and standard network technologies so that it can be easily applied to other systems or platforms. A client can use current popular web browsers, such as Microsoft Internet Explorer or Netscape Navigator (with VRML plug-ins, such as Cosmo player or Cortna player) to browse information, navigate, and communicate with other clients in the WALTZ.

WALTZ is expected to be able to

- represent different media information effectively,
- construct various learning scenarios by integrating the technologies of virtual reality, multimedia, and World Wide Web, and
- to provide activity management facilities and collaborative mechanisms to enable highly interactive collaboration among all students, teachers, and instructional material in collaborative learning activity.

3 The Architecture of WALTZ

WALTZ is basically a client/server distributed virtual reality system. The client side provides human-machine interface that uses the technologies of audio, image, HTML, VRML, and the Java Internet capabilities to provide a web-based multimedia/virtual classroom according to the theory of Constructivism. Its environment contains JAVA control applet, multimedia, virtual world interface and collaborative tools such as text chat tool and shared whiteboard. Figure 2 illustrates the architecture in detail. Each client (user) can join one to multiple sessions to collaborate with other participants in 2D/3D shared virtual classrooms (or learning spaces). The server side is composed of five main components: (1) collaborative mechanisms subsystem, (2) VRML world server, (3) intelligent agent-based server, (4) Web server, and (5) communication subsystem for supporting real-time synchronous or asynchronous message interchange. The collaborative mechanisms subsystem ensures that the inter-dependency/intra-dependency of all activities/participants will be maintained and validated during their interaction. In addition, notification, delegation or negotiation protocols will be executed once some events of interest are triggered. The VRML world server will handle all VRML events coming from the event manager and updates the states of each shared VRML objects. The agent-based helpers communicate with the activity manager in inferencing and discovering potentially new learning patterns of students based on the diagnosis and feedback of students'

learning history. A communication subsystem supporting TCP/UDP/RTP protocols is used by all components of WALTZ to facilitate the real-time synchronous or asynchronous communication of interacting objects (or entities). The web server is responsible for downloading multimedia and VRML representation of instructional materials or virtual learning space.

4 Pythagorean Theorem Learning Space

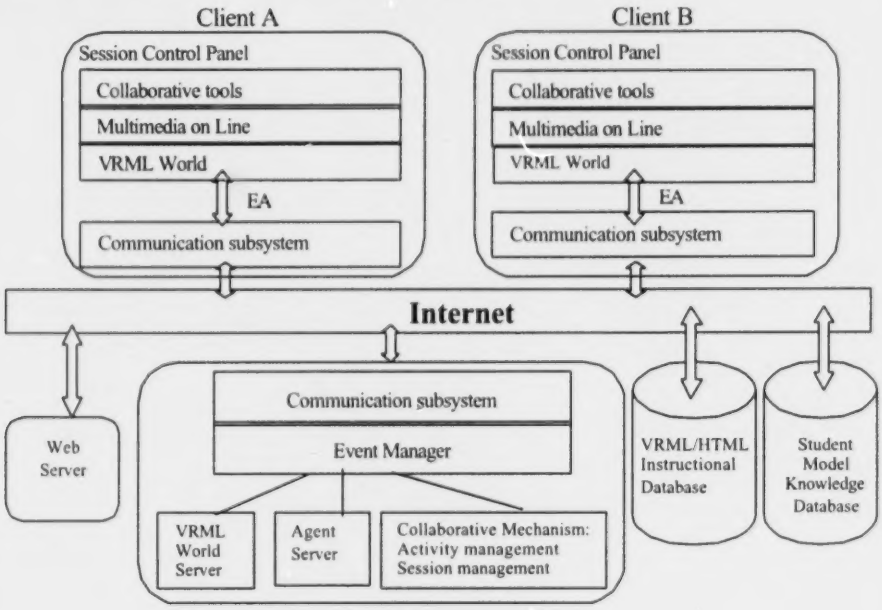


Figure 2. The Architecture of WALTZ

Pythagorean theorem is an interesting mathematical subject of the eighth grade students in Taiwan. It has rich heritage in mathematical history. Based on our survey, most current web-based systems teaching Pythagorean theorem only focus on the 2D interactive theorem proving process. WALTZ, in contrast, not only offers 2D interactive theorem proving process but also provides several key learning components to help students better understand the fundamentals of Pythagorean theorem. Figure 3 is an entry to the Pythagorean theorem learning space, where users can meet and navigate the virtual world dynamically or enter into any one of the learning components described below. The user interface contains two parts: VRML virtual world and JAVA applet control panel. The VRML virtual world is the learning space, provided by the WALTZ web server, where learners can navigate the virtual world, enter into a learning session, and meet other learners in the same session. The control applet provides chat tools so that a learner can talk to other learners for collaborative work.

The design of WALTZ-style Pythagorean Theorem learning space intends to support the features that are listed in Section 2. Current implementation of the WALTZ-style Pythagorean Theorem learning space consists of the following five learning components:

(1) Multimedia instructions

In WALTZ, instructional design of Pythagorean theorem covered three on-line learning sections: history of Pythagorean theorem, prerequisite knowledge and skills of Pythagorean theorem, and all the concepts about Pythagorean theorem. Since Pythagorean theorem is related to the mathematical concepts in both algebra and geometry and each concept need different multimedia features for presentation. Thus, different multimedia components such as text, graphic, animation, sound etc. were carefully designed and arranged in the interface to present the subject domain.

(2) Collaborative and interactive Pythagorean theorem proof/verification

One of the major features of WALTZ is the collaborative learning environment for Pythagorean theorem proof/verification. The activity manager in WALTZ provides facilities for instructors/learners to create/modify/delete/join an activity/session, to assign permission, to set constraints, to record the history of learners' Pythagorean practices, and to support group awareness during their collaborative learning. Figure 4 is an interactive program that allows users to learn Pythagorean theorem by experimental method. Students can drag each vertex of the triangle. If it is a right triangle then one can visually verify if it satisfies the Pythagorean equation: a^2+b^2=c^2. If it is an acute (or obtuse) triangle then the Pythagorean equation is not valid and a^2+b^2 >(<) c^2. Figure 5(a) shows a collaborative Pythagorean theorem proving program in action which not only support collaboration but also group awareness (i.e. can visually see who is making the move). All participants in a collaborative application is managed under the control of activity (or session) manager, as shown in figure 5(b).

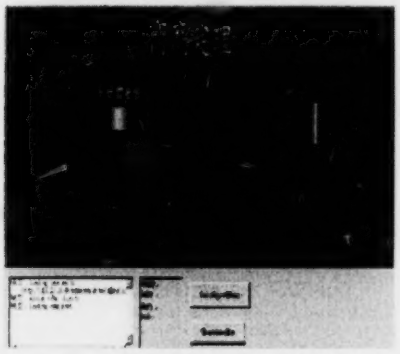


Figure 3. Pythagorean theory learning space

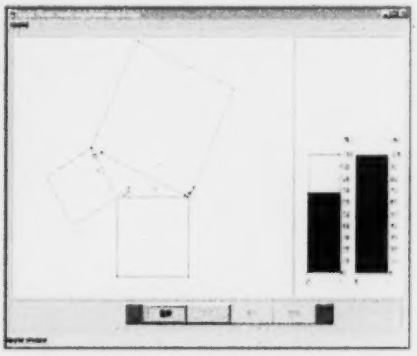


Figure 4. An obtuse triangle: a^2+b^2< c^2

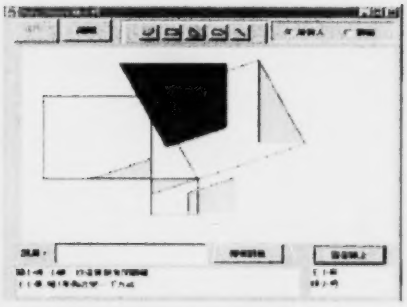


Figure 5(a). Collaborative Pythagorean application

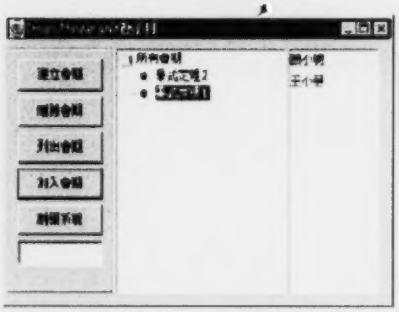


Figure 5(b). Session management

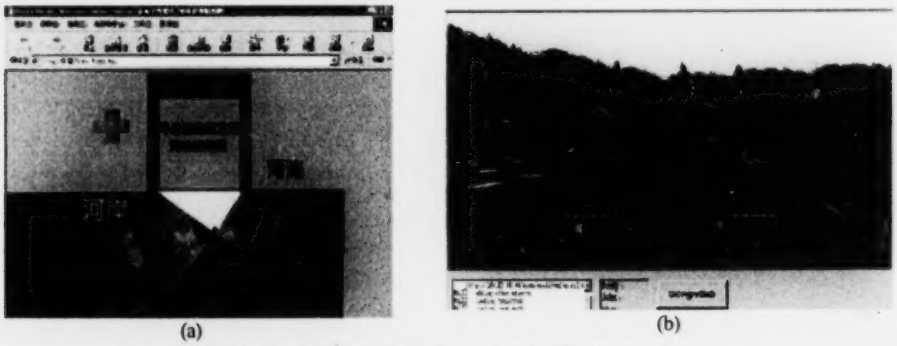
(3) Adaptive multimedia on-line testing

Traditional drill and practice CAI was criticized too boring to be used for young students. A web-based on line test without multimedia will have the same problem. A precompiled multimedia CAI program using Shockwave or Flash authoring technologies provides a better solution, however, it is not easy to change or add new contents adaptively into the program without recompiling the whole program. WALTZ is a dynamic virtual environment which can add/delete objects during users' learning journey. WALTZ intends to support an adaptive multimedia testing mechanism. Students will be given multimedia style test questions based on their current learning status. The multimedia test problems are generated on the fly by converting text -based questions stored in the database into multimedia representation. WALTZ will classify questions and suggest appropriate multimedia templates to make the conversion almost as easy as a PowerPoint presentation.

BEST COPY AVAILABLE

(4) Multi-user Project-based Pythagorean theorem virtual environment

To support project-based collaborative learning, a virtual environment is constructed. Team members can join the same session to solve the mathematical puzzles generated from the WALTZ system by interactively moving pieces of puzzle into the right place according to Pythagorean theory. Since WALTZ is a shared virtual environment that supports collaborative learning, each member of the team can see actions from other team members and they can communicate with each other to discuss how to solve the puzzle before they can go on to their next journey. Figure 6(a) & (b) illustrates a situation that a team must solve the puzzle of bridge using Pythagorean theorem before they can pass through the river and enter into the forest to continue their next journey.



(a) (b)

Figure 6 (a) & (b). Project-based multi-user collaborative learning space

(5) Pythagorean resource

Besides the aforementioned components, WATLZ also provide useful utility tools, such as online notepad and calculator that users can use conveniently. In addition, many different web sites relate to Pythagorean theorem were linked in WALTZ for learners to acquire various information easily.

5 Conclusion and Future Research

Due to progressively advanced development of 3D graphics and open network technologies, a web-based learning system that provides asynchronous and hyperlink-style environment might not attract young students in the feature. In addition, such systems will have great difficulty in constructing a situated, dynamic, and collaborative learning environment according to Constructivism. Therefore, This research proposed a CAI learning model from which a new architect of a web-based 3D life-like learning space, WALTZ, is created. By using Pythagorean theory as a case study, the study has demonstrated that WALTZ has a great potential to provide an improved learning environment over traditional virtual classroom setting.

Though WALTZ is still far from perfect, this research indicates that it deserves special attention among CAI research community. Next generation of WALTZ will focus on dynamic behaviors of agents via current state of the art MPEG-4 technology.

Acknowledgement

This research is founded by National Science Council (grant#: NSC 88-2520-S-212-004) in Taiwan.

References

[1] Blaxxun Interactive, http://www.blaxxun.com/ (accessed on June 2, 1998).

[2] Brooks, M. & Brooks, J., "In Search of Understanding: The Case for Constructivist Classrooms", Alexandra, VA:ASCD, (1995).

[3] Carlson, S. & Hawkins, R., "Linking Students Around the World: The World Bank's New Educational

Technology Program", Educational Technology (September-October), pp. 57-60, (1998).
[4] Chiang, H. K. & Lin, C. H., "A Study of Collaborative Mechanisms for Web Teaching and Learning", Journal of Da-Yeh University, Vol 8, No 2, pp. 63-79, (1999).
[5] Gilbert, L. & Moore, D. R., "Building Interactivity into Web Courses: Tools for Social and Instructional Interaction", Educational Technology (May-June), pp. 29-35, (1998).
[6] Harasim, L., "A Framework for Online Learning: The Virtual-U", Computer, pp. 44-49, (1999).
[7] Henin, I. & Droctor, L., "Incorporating the Web as Teaching Tool: Introduction", http://web.uvic.ca/~esg9/emo/emomain.html/ (accessed on May 1, 1999).
[8] Hughes, C. & Hewson, L., "Online Interactions: Developing a Neglected Aspect of the Virtual Classroom", Educational Technology (July-August), pp.14-55, (1998).
[9] Jung, B. & Milde, J., "An Open Virtual Environment for Autonomous Agents using VRML and Java", VRML 99 Proceeding, (1999).
[10] Kearsley, G. & Shneiderman, B. "Engagement Theory: A Framework for Technology -Based Teaching and Learning", Educational Technology (September-October), pp. 20-23, (1998).
[11] LW, "Living Worlds Specification, Draft 2", http://www.livingworlds.com/draft_2/index.htm (accessed on April 12, 1998).
[12] Merrill, M. D., "Constructivism and Instructional Design", Educational Technology, Vol 31, No 5, pp. 45-33, (1991).
[13] Merrill, P. F., Hammons, etc., "Computers in Education", NY: Simon & Schuster Company, (1996).
[14] Mitra, K., "Living Worlds", http://www.livingworlds.com/draft_1/lw_ideas.html (accessed on November 21, 1997).
[15] Moallem, M., "Instructional Design Model and Teacher Thinking: Toward a New Conceptual Model for Research and Development", Educational Technology (March-April), pp. 5-18, (1998).
[16] Pesce, M., "VRML: Browsing and Building Cyberspace", New Riders, (1995).
[17] Sherry, L. & Myers, K. M., "The Dynamics of Collaborative Design", IEEE Transactions on Professional Communication, Vol 41, No 2, pp. 123-139, (1998).

Proceedings

Content

▸Full & Short Papers (Web-Based Learning)

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)
A Comparative Study of Applying Internet on Cooperative and Traditional Learning
A Dynamic WBI System supporting Individual Learning Styles
A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community
A Framework for Internet Based Distributed Learning
A Java-based Interactive Learning System of Junior High School Level Geometry
A Learner-Centered Navigation Path Planning in Web-based Learning
A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents
A study of collaborative teaching for creative learning in an engineering class
A Study of Networked Constructive CAI System Using Multiplication-Concept of
A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics : Through a Practice of Three Junior High Schools
A Survey Study on Corporate Trainers' Experiences, Attitudes, and Perceptions towards Intranet-Based Training
A Virtual Classroom for Algorithms with Algorithmic Support
A Web-based Interactive Exercise System for Learning Mathematical Functions
Adaptive Programming Language Tutoring System on the Web
An Adaptive Navigation Support with Reorganized Learning Resources for Web-based Learning
An Analysis of the Practice of Web-Based Learning in Elementary Schools in Tiwan
An Effectiveness Study of Web-based Application for Mailing List Summary and Review
An Intelligent On-Line Learning System by Combining Assessment and Adaptive Learning
An on-line ITS for elementary algebra
Anatomy on the Cutting Edge: Pre-dissection Lecture-on-Demand at the National University of Singapore
Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space
AWETS: An Automatic Web-Based English Testing System

Building Mathematics Collaborative Learning Web Sites
Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet
CAI system generator on web -- using automatic trace recording
CALL with a Web-based Instructional System in Cooperative Learning Environments
CBR-Tutor: A Case-Based Reasoning Approach to an Internet Agent-Based Tutoring System
CedarLearning: The Development of Learner-Centred Environments
Computer-Mediated Language Learning
Construct in-service Training Web Site for School Teachers
Constructing a real-time CAD learning system based on OpenGL in Web-based environment
Design and Evaluation of Constructivist Web-based Instructional Systems
Design and Implementation of Teaching Models in Web-based Teacher Training
DESIGN AND IMPLEMENTATION OF WEB-BASED LEARNING SYSTEM FOR TEACHER-TRAINING PROGRAMME
Designing a Web-Based Action Learning Environment - Integrating Learning and Working in One Environment
Developing a research instrument for measuring the effectiveness of Web-based learning materials
Developing a Web Concordancer for English as Foreign Language Learners
Developing an Effective Web-Based Learning Environment for Overseas Chinese Education
Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology
Developing Web Courses Systematically
Developing Web-Based Language Learning Environment
Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW
Development of a Web System to Support Computer Exercises and its Operation
Development of CAI System with Character Code Discrimination on WWW Environment
Development of Cross-cultural Communication System and Web-based Japanese Education
Domain Specific Information Clearinghouses - A Resource Sharing Framework for Learners
Educational Newspaper Information Gathering Agent for NIE
Empowering Secondary School Teachers to Effectively Exploit Internet Resource for the Enhancement of Teaching and Learning
Examining problems of student teachers to build a web-supported environment
Factors in Web-based learning: student learning styles, motivation, learning strategies, and achievement
Gold Peach Web Community 2000: A Research on Developing Web Based Interactive Learning Environment
Group Composition Methods for Cooperative Learning in Web-based Instructional Systems

Integrating Information Technology with Language Pedagogy for a Second Language Online Writing System

Integrating Web-based Materials into Course Design

Is Everyone On Board: Learning Styles and the Internet

KnowDisLC: A Knowledge Distributed Web-Based Learning Community for University Students

Learner Control in Technology-mediated Learning within a Constructivist Model

LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES

Learning Digital Logic Design by Concept Mapping

Learning with Computer Mediated Communication in Remote Offcampus Cross-Cultural Contexts:Bridging the Information Gap

Making Exploration History Interactive for Web-based Learning

Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

Multimedia Whiteboard Design in WWW-Based Remote Cooperative Education System

Navigation Script for the World Wide Web

Networked Constructive CAI System Putting Emphasis on Communication and Discussion - An Example of Proportion-concept in Mathematics of Elementary School

Online Education: A Learner-Centered Model with Constructivism

Schema theory-based Instructional Design of Asynchronous Web-based Language Courses

SimPCS: A Web-based PCS Learning Tool

Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Student use of learning strategies in Web-based courses

Students' Attitude toward WPSS in Supporting Classroom Learning

The analysis of social discourse in a network-based learning community----The GeoSchool Experience

The Application of Scaffording Theory on the Elemental School Acid -Basic Chemistry Web

The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS

The Design of CAI with Thinking Activity to Progress Constructive Teaching - An Example of Division-concept in Mathematics of Elementary School

The Development and Evaluation of a Learning Support System for Converting Web Pages

The Impact of Web-Based Interactive Multimedia on Conceptual Development

THE INTERNET-BASED EDUCATIONAL RESOURCES OF THE U.S. FEDERAL GOVERNMENT

The network learning supported by constructivism

The Production of Web-based Interactive Video From Structured Script

The Rhetoric of the Web. A semiotic approach to the design and analysis of Web-documents

The Status of Cyber University in Korea and its Future Direction

Tracking and Guiding Tools for learning Groups in a Web Collaborative Learning System

TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP -COLLABORATION TYPE AND LOOSELY CONNECTED TYPE-

Virtual Inhabited 3D Worlds and Internet Based Learning Environments

WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

Web Based Real plus Virtual Observatory Project

Web Speaking: A Language Learning System in the Web

Web-Based Learning Portfolio(WBLP): An Electronic Authentic Assessment Tool on Web

Web-Based Subject-Oriented Learning Program on Geophysics for Senior High School

WWW-Supported Environments for Learning and Teaching Statistics

▲ HOME

A CAL System for Appreciation of 3D Shapes by Surface Development (C3D-SD)

Stephen C F Chan*, Andy Wai, Jean Chow & Vincent T Y Ng
Dept. of Computing, Hong Kong Polytechnic Univ., Hong Kong
*csschan@comp.polyu.edu.hk

A web-based Computer-aided learning system for 3D - Surface Development Module (C3D-SD) has been developed for teaching the appreciation of 3D geometric shapes by unfolding the surface boundary of a solid object into a planar 2D pattern. The problem is similar to the problem of surface development in technical drawing and highly related to the reverse problem of folding a 2D shape into a 3D object, with practical applications in sheet metal work, pattern making, and packaging design. C3D-SD makes extensive use of animation, interactive control by the student, and quizzes to present the material and to engage the students. It makes use of the solid modeling library SML to create 3D solid shapes by Boolean combinations (union, intersection and difference) of primitive shapes, and Java3D for rendering and animation. It includes a Packaging Design Module which builds on the Surface Development module by automatically adding flippers and minimizing the rectangle enclosing the unfolded pattern. This system is the second installment of a series of CAL systems for Three-dimensional Geometry that the authors have been developing.

Keywords: **3D geometry, surface development, animation**

1 Introduction

Surface development is an important technique in design. Generally it involves unrolling a curved surface into a planar 2D pattern. Theoretically speaking only certain classes of surfaces are "developable" [Carmo 1976]. If, however (as is the case in many computer graphics systems), curved surfaces are approximated by sets of planar facets, then all curved surfaces can be unfolded into 2D planar shapes, although they may appear to be "unnatural" or "ugly". A related problem is the unfolding of the planar faces bounding a facetted solid object into a planar 2D shape. The inverse of the problem is folding a planar 2D shape into a 3D object, e.g., folded the card-board boxes for hamburgers in fast-food restaurants. These techniques have practical applications in sheet metal work, pattern making, packaging and package design, etc. [Giesecke et al 1997] This paper describes the development of a Web-based computer-aided learning system for teaching the appreciation of surface development/unfolding based on a polygonal representation of solid objects. It is a part of a series of Web-based tools for teaching 3D geometry that our group has been developing. A previous project focussed on sectioning and interactions between some primitive solid shapes was reported in [Chan et al 1999].

Traditional teaching materials on these topics were mainly text based. Better materials have graphics or charts in addition to plain texts. In presenting descriptive topics, this approach is adequate. However, in teaching three-dimension geometry, the two-dimensional and static presentation style is obviously not enough. The use of videos can be effective to some extend but it is still one-way communication and not interactive. A more effective alternative is to use real solid objects to help students visualize 3D shapes. But some objects are difficult to be made, and it is impossible for teachers and students to change the size, scale, shape or appearance of the object quickly.

In contrast to the limitation of 2D materials, videos and real 3D objects, a virtual environment can be a better approach in presenting certain 3D geometry problems. A virtual environment is a computer-generated environment in which 3D or even the forth dimension (time) can be presented through animation. Within the virtual environment, one can change the size, scale, shape or appearance of the virtual object interactively. To have a clearer look, one can zoom into the object. To see the inner structure, one can set part of the object

to be transparent. And geometry can be animated by transforming the object over time. And of course, an interactive teaching approach is much better than one way communication in enhancing student understanding. Finally, for purposes of accessibility and distribution, the Web is the ideal environment. These considerations drove the development of this project.

2 Overview of C3D-SD

The main problem tackled by C3D-SD is surface development, as illustrated below in Figure 1. In (a) is shown a solid cone shaped object with the top cut off at an oblique angle. In (b) the surface of the cone is in the middle of being unfolded. In (c) the unfolding is complete. Note that we had tried to keep the unfolded 2D shape connected. As a result, the curved conical surface itself became disconnected (actually connected through a single vertex). It is not difficult to see that it is possible to unfold the surface while keeping the curved conical surface connected.

(a) (b) (c)

Figure 1. Surface development in action.

C3D-SD is organized into three types of activities:

1. Tutorials - Students are guided through demonstrations, including: matching 3D solids to unfolded shapes, animations of unfolding (e.g., of the conical object in Figure 1), animations of folding 2D patterns into 3D solids, adding flippers to unfolded 2D patterns for fastening, reducing the size of the rectangle bounding the unfolded pattern, etc.
2. Free-form exercises - Students are allowed to explore the teaching material on their own. They are provided with numerous opportunities to interact with the teaching material, e.g., creating complex 3D solids by combining primitive shapes, selecting view points, putting different textures on objects, controlling the animation process, etc. The problems are similar to those presented in tutorials. But many more shapes are available for students to experiment with, for self-guided exploration and exercise.
3. Tests - Students can test their understanding of the material through multiple-choice tests. They are asked, e.g., to match an unfolded 2D shape with the solid object, such as illustrated below in Figure 2. If so desired, they can turn to the free-form exercises to explore the test shapes that they have problems with.

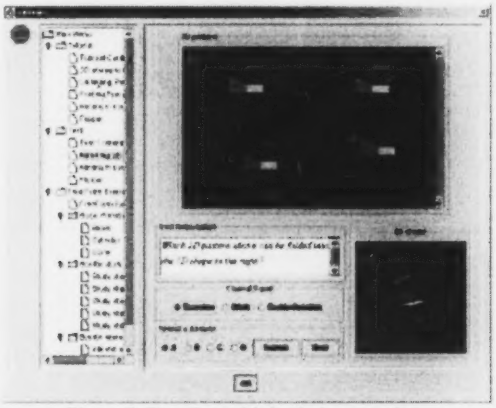


Figure 2. Sample multiple choice question.

The three types of activities are chosen for the following reasons. The tutorials provide core contents to be imparted to the students. The free form exercises allow the students to explore the subject on their own.

Different students with different backgrounds and learning styles benefit from different learning activities, hence both guided and sef-guided types of activities are provided. Finally, tests are developed to gauge the students' grasp of the material. It is expected that C3D-SD can be integrated with an intelligent tutoring system to provide a learning experience more tailored-made for the individual students.
C3D-SD focuses on five types of problems:

1. Matching 3D solid shapes with the corresponding unfolded 2D patterns.
2. Unfolding the surface boundary of a facetted solid and developing curved surfaces.
3. Folding 2D patterns into 3D solid shapes.
4. Simple packaging design: Adding flippers to the unfolded 2D pattern for fastening.
5. Simple packaging design: minimizing the rectangle bounding the unfolded 2D pattern.

3 The 3D Solid Design Module

Java was chosen to develop this system as it is a web-oriented development language and only a Java-enabled Web browser (e.g. Netscape, Microsoft Internet Explorer) is needed to access the Web pages without installing other plug-ins. However, it is difficult to build 3D applications using only the core Java classes. A Java-based high-level programming library, Solid Modeling Library (SML) [Chan et al 1998] is used in C3D-SD for designing 3D solid objects. SML supports the building of 3D solid objects through a set of atomic functions called Euler operators. These functions allow the incremental manipulation of Boundary Representation (B-rep) models, while processing the underlying well-formed data structure. It also supports the creation of solid primitives (block, cylinder, cone, sphere, torus) and Boolean operations (union, intersection, and difference) on solids and transformations (translation, rotation) of solid objects for easy creation of complex 3D solid shapes. For example, a hollow pipe can be created by the differencing (subtracting) a smaller cylinder from a larger cylinder. SML uses a hierarchical half-edge data structure that stores rich information about a solid model [Mantyla 1988], including solid-to-face, face-to-face, face-to-edge, edge-to-edge, edge-to-vertex, and vertex-to-vertex information. The data structure used in SML to represent the surface boundary of solid objects is illustrated in Figure 3.

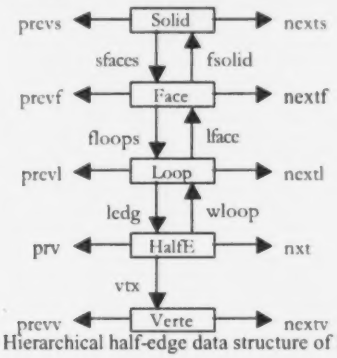


Figure 3. Hierarchical half-edge data structure of SML.

4 Surface Development

The process of surface development or unfolding is illustrated in Figure 4 using a cube as an example. Each face of the cube is coloured differently for easy identification. One might imagine that the unfolding starts by holding the bottom (red) face of the cube fixed to the horizontal plane, and rotating the rest of the cube about the edge linking the red face with the green face until the green face is in the same plane as the red face. This is followed by the blue face, then the yellow, then the light blue, ..., and finally the purple, until all faces lie in the horizontal plane.

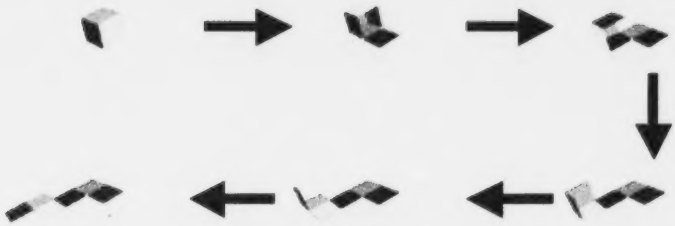


Figure 4. Unfolding a cube.

Sun Microsystems provides the Java3D application programming interface (API) which can be used to develop three-dimensional graphics applications and applets. It gives developers high-level constructs for creating and manipulating polygon-based 3D geometry and for constructing the structures used in rendering that geometry [Sowizral et al 1998, Sun 2000, Brown & Peterson 1999]. It is an object-oriented API, which can be used to construct individual graphics elements as separate objects and connect them together into a tree-like structure called the scene graph. It contains a complete description of the entire scene including the geometric data, attribute information and viewing information needed to render the scene from a particular point of view. Java3D provides a simple and flexible mechanism for representing and rendering scenes with lighting effect but it does not provide high-level construct for creating complicated solid object models. Hence SML was used to create the 3D solids which are subsequently converted into Java3D for rendering and animation.

4.1 Conversion from Solid (in SML) to Surface (in Java3D)

Each face object in SML is converted into a Java3D geometry object by using the information on the vertices of the face. As a result a SML solid object is converted into a group of Java3D geometry objects, each representing a face as illustrated in Figure 5. However, the data structures used to represent objects in Java3D and SML are different, and a conversion process is required to integrate the two systems to take advantage of their respective strengths to produce a more complete solution.

The displayable object in Java 3D is implemented by the Shape3D class. The Geometry and Appearance objects make up a Shape3D object. The Appearance objects controls the outlook of an object, e.g. color, material, etc. The Geometry object contains the vertexes information. We choose triangle as the basic shape in forming a geometry object because it contains the minimum number of vertexes that can form a plane. So that any face shape can be formed by the combination of triangles.

The conversion of an object represented in SML to one represented in Java3D involves 4 steps. Recall that each face in a SML Solid is converted into a Geometry object in Java3D.

1. Find the number of faces in the SML Solid object.
2. For each face, find the number of vertexes and the coordinates of each vertex.
3. Group three vertexes into a triangular strip.
4. Combine all triangular strips to form a Geometry object in Java3D.
5. Each Geometry object will result in a Shape3D object.
6. Group all Shape3D objects to form the representation of the solid in Java3D.

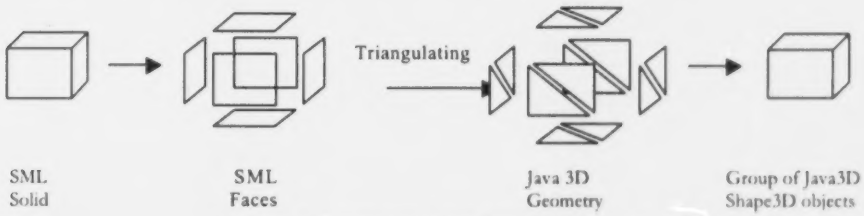


Figure 5. Converting an object from SML into Java3D.

4.2 Unfolding Path

In order to "develop" a surface approximated by a set of polygons, or to unfold the boundary of a solid, one needs to determine a connected path traversing all the faces one at a time. The path for unfolding can be

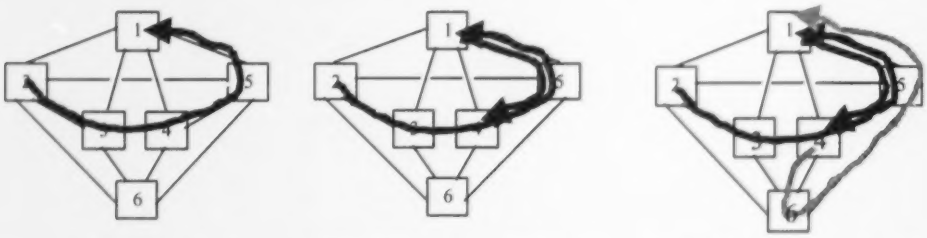
1. specified manually by the student,
2. pre-set in CAL-SD manually by the teacher, or
3. determined automatically by CAD-SD.

Automatic determination of the path for unfolding involves two steps:

- Determine the connectivity between the faces, e.g., in the form of a **graph** whose nodes are the faces, and an edge links a pair of neighbouring faces, and
- Traverse the graph to find the desired connected **path**(s) that visits each face one at a time and each face only once.

As the data structure of SML stores rich information of the complete solid, the connectivity relationships between faces can be easily derived. To derive the path(s) of traversing all faces one and only one at a time is a version of the traveling salesperson problem [Johnsonbaugh 1996]. It is a problem that is known to be hard (computationally expensive) for arbitrary graphs. In our system prototype, we chose to use exhaustive search because of its simple implementation. In future versions we may try to find a more efficient algorithm. In the default version of the algorithm, we simply try to find a solution (any solution) using the well-known **backtrack** algorithm. Firstly, pick up a face arbitrarily. Then, traverse to one of its neighbors. Repeat this process until all the faces have been visited. When a dead-end occurs, it will back track one or more steps to find another possible way (Figure 6). Dead-end means arriving at a face with no un-visited neighbours, while there are still un-visited faces remaining in the graph.

The algorithms implemented in C3D-SD so far traverse the faces of an object in a linear sequence, i.e., the unfolded faces form a linear chain of planar polygons. There are other alternatives, e.g., unfolding in two directions at the same time, resulting a Y shaped chain of polygons, etc. In future versions of the system, we will implement other unfolding algorithms.



(a) Dead-end occurs when traversing 2 ⇨ 3 ⇨ 4 ⇨ 5 ⇨ 1

(b) Backtracking from dead-end to face 4 to find another possible path

(c) Path 2 ⇨ 3 ⇨ 4 ⇨ 6 ⇨ 5 ⇨ 1 is one of the possible paths traversing all the faces one and only one time

Figure 6. Finding a possible path for unfolding the faces of a solid.

4.3 Heuristics for Developing Smooth Surfaces

In SML and in Java3D, as in many computer graphics systems, a curved surface (e.g. conical, cylindrical, etc.) is approximated by a set of planar polygons. If we choose a face' s neighbor in an arbitrary way, a solid may be unfolded into an "ugly" or "unnatural" shape because the set of polygons used to approximate a smooth surface my or may not be unfolded (smoothly) in an appropriate sequence. The left side of Figure 7 shows a cylinder approximated by a total of 22 plane faces (20 for the curved surface and 2 for the top and bottom faces). If we unfold the cylinder arbitrarily, for example, following the path 1-2-3- ..-21-22, may result in the patter in the middle. One of the polygons in the set used to approximate the curved cylindrical surface is disconnected from the other polygons in the set.

We observe, however, that in the set of polygons approximating a smooth curved surface, each polygon shares at least one edge with another polygon in the set, and the included angle between the two polygons is very close to, but just slightly less than, 180 degrees. Taking account of the Smooth Surface Heuristics discussed above, we can try to select the neighbor making the largest angle with the current face, instead of selecting an arbitrary one. Applying this heuristic to the unfolding of the cylindrical solid will result in the developed surface to the right.

Figure 7. Arbitrarily unfolding the cylinder to the left may result in the pattern in the middle, and applying smooth surface heuristics will result in the pattern to the right.

5 Partially Automated Packaging Design

The design of packaging such as the rectangular boxes used to hold hamburgers at fast food restaurants involves the design of the 2D patterns that can be folded into such boxes. Similar problems exist in sheet metal work and other areas. The surface development/unfolding algorithm discussed above can be used to partially automate such designs.

5.1 Addition of "Flippers"

In addition, one also need to add "flippers" to some of the faces. Flippers are extended faces for putting glue or stickers in order to fasten two faces together when folding the planar 2D shape into a 3D solid shape. We have developed a simple algorithm to determine which edges of the faces of a solid model need to have flippers added. As flippers are used in connecting neighbouring faces, basically, all edges around a face need flippers except:

1. Edges that have been used as axes of rotation during the process of unfolding, i.e., edges between consecutive faces in the connected path for unfolding. (in Figure 8)
2. Edges for which flippers have already created on the opposite face (in Figure 8)

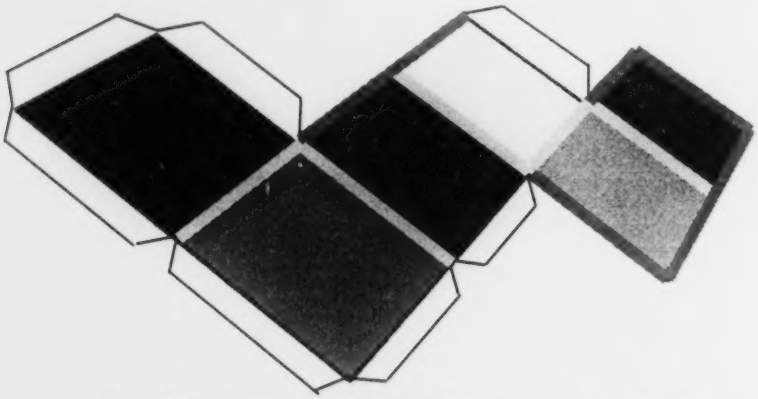


Figure 8. Creation of "flippers" in partially-automated design of packaging.

5.2 Minimizing Bounding Rectangle

The unfolding of 3D shapes are often constrained by certain requirements. For example, in the design of

packaging or sheet metal work, the unfolded shape may be the pattern to be cut out of a rectangular sheet, to be folded into the solid shape. In such cases it is desirable to reduce the amount of wastage by making the rectangular sheet required as small as possible. This translates into a requirement to minimize the area of the smallest rectangle enclosing the unfolded planar shape, as illustrated in Figure 9. Smallest rectangle enclosing the unfolded 2D shape. Such constraints may not be easy to satisfy absolutely. However, it is often enough to find a reasonable but not necessarily the perfect solution. In the case of determining a minimum bounding rectangle, it may be sufficient to find a local but not the absolute minimum. A local minimum can be determined by backtracking a few steps from the solution found to determine the set of related solutions and choose the one with the smallest bounding rectangle.

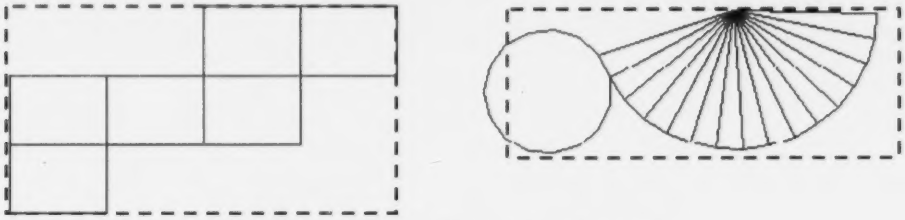


Figure 9. Smallest rectangle enclosing the unfolded 2D shape.

5.3 Some Examples Used in CAD-SD

Many examples of realistic solid shapes have been built into CAD-SD for illustrating and teaching surface development. Figure 10, Figure 11, and Figure 12 show the results of unfolding some common solid shapes, with "flippers" added automatically. For simple solid shapes it is fairly easy to deduce from the unfolded 2D patterns what the original 3D solid shapes are. Some of these are given to the students as exercises.

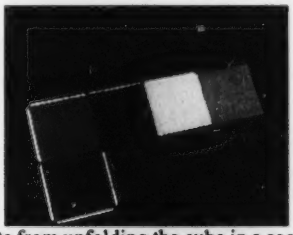


Figure 10. The 2D shape that results from unfolding the cube in a sequence different from that shown in Figure 8. Creation of "flippers" in partially-automated design of packaging., also with flippers added.

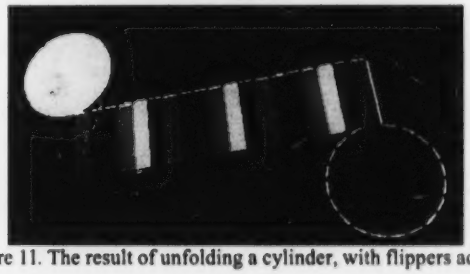


Figure 11. The result of unfolding a cylinder, with flippers added.

Figure 12. **The result of unfolding a T-shaped box, with "flippers"** added.

6 Conslusion

Using the SML solid modeling system and Java3D surface modeling and rendering system, we have successfully developed the basic structures of a CAL system that makes use of 3D modeling, animation, and interactivity to teach the appreciation of certain class of 3D shapes through surface development and unfolding. We have also shown how the unfolding algorithm can be used to partially automate the design of the 2D patterns used in certain sheet metal work and packaging design problems, by also automating the addition of flippers for attaching neighbouring faces, and reducing the rectangular sheet from which the planar (unfolded) patterns are to be cut out. Based on these basic functions, a comprehensive set of teaching materials can be developed to greatly enhance the degree and interactivity and effectiveness in the teaching of the appreciation of 3D geometry.

Acknowledgement

The work reported in this paper was partially supported by Hong Kong UGC/RGC/CERG grant PolyU 5102/97E.

References

[Brown & Peterson 1999] Brown, Kirk & Peterson, Daniel. *Ready-to-Run Java 3D*. Wiley, 1999.

[Carmo 1976] M P do Carmo. *Differential Geometry of Curves and Surfaces*. Prentice-Hall, 1976.

[Chan et al 1998] Chan, S., Ng, V., and Au, A.. "A Solid Modeling Library for the World-Wide Web", *Computer Networks and ISDN Systems*, Vol. 30, Issue 20-21, Nov. 1998, pp. 1853 – 1863.

[Chan et al 1999] Chan, Stephen, Lui, Kin Ming, Ng, Vincent & Chui, Raymond. "A Java-based Computer-Aided Learning System for 3D Geometry", *Proceedings, The 7th International Conference on Computers in Education*, Volume 1, November 4 – 7, 1999, Chiba, Japan, pp. 1010 - 1017.

[Giesecke et al 1997] Frederick E. Giesecke, Alva Mitchell / Henry Cecil Spencer, Ivan Leroy Hill / John Thomas Dygdon /James E. Novak with Shawna Lockhart. Technical Drawing, Tenth edition (p.626 - 640): Prentice Hall 1997.

[Johnsonbaugh 1996] Richard Johnsonbaugh. Discrete Mathematics, fourth edition (p.304 – 309, p.331 – 336): Prentice Hall

[Mantyla 1988] Martti Mantyla. An Introduction to Solid Modeling (p.161 – 174): Computer Science Press 1988

[Sowizralet al 1998] Henry Sowizral, Kevin Rushforth & Michael Deering. The *Java 3D API Specification*, Addison Wesley, 1998.

[Sun 2000] Sun Microsystems, Inc. *Java 3D 1.1 API Specification*, http://java.sun.com/products/java-media/3D/index.html, 14 April, 2000.

A Comparative Study of Applying Internet on Cooperative and Traditional Learning

Weichung Wang*, Yannjiun Tzeng and Yuan Chen
Department of Mathematics Education, National Tainan Teachers College
Tainan 700, Taiwan
**E-mail: wwang@ipx.ntntc.edu.tw*

The Internet-based cooperative learning has become a new trend in education, thanks to the rapid development of the technologies. This study evaluates the effects of utilizing the Internet on cooperative and traditional learning. Aiming on an elementary school natural science topic, this study compares learning performance of two pupil groups that contains 36 twelve-year-old pupils for each group. We found the learners who adopting Internet-based cooperative learning outperform the other group on Memory-demanding, integration, and deduction type problems. Furthermore, the Internet-based cooperative learning group has uniform performance on the three types problems and is generally more aggressive. In contrast, the Internet-based traditional learning group tends to perform better only on Memory-demanding type problems and has relatively passive learning attitude. Based on the experience, we encourage using the Internet in cooperative learning for nature science. Teachers also need to compose a complete plan and familiarize learners with an Internet browser before conducting the course.

Keywords: **cooperative learning; traditional learning; Internet-based cooperative learning; difference of significance**

1 Introduction

Rapid progress of the Internet has greatly changed the way of teaching and learning. The Internet not only overcomes the space and time limitation of a closed environment such as a classroom, the Internet also contains many useful educational resources that motivate and attract students. This new environment demands teachers to adapt new teaching methods by using applications like World Wide Webs (WWW) and E-mail. Therefore, the means by which teachers efficiently take advantage the new technology is an essential education subject.

While many teachers have started integrating the Internet into their classrooms, little systematical researches has focused on using the Internet in cooperative learning. Aiming to combine the Internet with cooperative learning concept, we conducted this study to (1) evaluate feasibility and efficiency of Internet-based cooperative learning, (2) develop strategies that can help students to learn actively and independently by Internet-based cooperative leaning, and (3) compare students' performance while applying the Internet on cooperative and traditional learning methods.

This study designed a way merging the Internet into a cooperative learning environment. The designed course focused on Sixth grade Natural Science (for twelve-year-old pupils) in Taiwan. Our study demonstrated the feasibility of Internet-based cooperative learning. We showed that pupils leaning in an Internet-based cooperative learning environment can outperform those who learn in an Internet-based traditional learning environment. Pupils' performances were evaluated by questions requiring their problem solving capability in memory demanding, integration, and deduction. All the findings are supported by statistical quantitative analysis results with significant difference.

In other words, this study focuses on the following questions:

(1) What kind of role does the Internet play in Internet-based cooperative learning and Internet-based traditional learning?
(2) Do pupils have enough computer literacy for Internet-based learning?
(3) Is there any learning efficiency difference between Internet-based cooperative learning and Internet-based traditional learning?
(4) If such difference really exists, which one is better?
(5) Do these two teaching methods have significant difference in student's problem solving capability? Especially in the aspect of memory demanding, integral, and deductive ability.

1.1 Literature review

We now survey literatures related to our study.

1.1.1 Using the Internet in learning environment

With the popularity of the WWW, a great deal of interest and enthusiasm has being expressed among teachers concerning the use of the WWW as a learning tool.[2,7] The main reasons are that the Internet offers a new learning environment that is quite different from the traditional classroom, and teachers can utilize Internet resources to enrich their teaching.

The Internet offers a learning environment that can be characterized by the following [6]:
(1) It has no limitation on place or time. That is, students can learn all kinds of knowledge at any place and any time.
(2) It is interactive and flexible. Students can choose different contents based on their learning conditions.
(3) The Internet integrates global educational resources.
(4) Students can communicate and discuss subjects with each other on the Internet. They also benefit from cooperative learning
(5) Multimedia effects of the Internet enhance students' motivation in learning.

In addition, Donald and LeuDeborah [3] suggested instructional strategies including Internet Workshop, Internet Activity, Internet Project, and Internet Inquiry.

1.1.2 Roles of teachers and students in cooperative learning

In order to achieve a better result in the cooperative learning process, teachers and students need to be fully aware of the role they play. Wang [13] claimed that, in most cases, cooperative learning should be practiced by a small group of students. The students' ability to cooperate are emphasized in the learning process. By group discussion, students can learn actively and build their own knowledge. Cooperative learning stresses that students play a major role in all learning activities and learn independently. According to the mission, students do their own literature search and then read, analyze, organize, and experiment with their material. Students establish learning concepts and share what they have learned via discussion with group members. Cooperative learning also emphasizes heterogeneous group learning. Teachers need to understand the profiles, difficulties, and expertise of learning of each student in order to group student in the best way. Therefore, teachers need to be well prepared and have a good plan on course work before performing cooperative learning.[9]

Some authors also pointed out that cooperative learning is more than just having a group of students solve problems in a cooperative way. Most importantly the following factors need to be included in the process of achieving a common goal [14]:
(1) Group members need to understand that they are a part of a team sharing a common goal.
(2) Group members need to realize that the problem is for the whole group and they share the success or failure with the whole group.
(3) Students need to talk to each other and join the discussion after accomplishing the common goal.
(4) Every group member needs to be fully aware of the fact that his or her contribution has a direct effect on the success of this group.

1.1.3 Comparison between cooperative learning and traditional learning

Colonel Paker first introduced the concept of cooperative learning in late nineteenth century. The concept has further become an active research subject in the last three decades. [1] One main topic of this research

field is to compare the efficiency of cooperative learning to that of traditional learning. Many experimental results showed that cooperative learning is superior to tradition learning.[4,5,8,10,11] Actually, Slavin [10] further pointed that:
(1) 63% of studies had showed that cooperative learning is superior to traditional learning,
(2) 33% of studies had showed no significant difference between these two methods, and
(3) 4% of studies had showed that traditional learning is superior to cooperative learning.

1.1.4 The way of communication of traditional learning and Internet-based learning

Advantage of computer network mediated communications can further enhance the advantage of using the Internet in cooperative learning. Traditional learning allows only one-way communication between student and teacher. Tyan and Hong [12] mentioned in their recent study: "The way of communication in traditional learning has many limitations. It has to be simultaneous in space and time; it is only a one-way broadcast communication from teacher to whole students as a group; its messages are is by oral in most cases; special arrangement, such as tape recording, note taking, and etc., are needed to record the teaching material."

In contrast, computer network mediated communications are more versatile. It can be simultaneous or non-simultaneous in space and time. It allows multilateral communications between a teacher and students and between students. In addition to broadcast from a teacher to the whole class, it also allows private dialogue. Finally its messages are textual and graphic information displayed by a computer, which can be automatically stored in a computer.

1.2 Organization of the paper

We state the methodology and the process of the study in the next section. Experimental results are demonstrated and analyzed in Section 3. Findings and inducing suggestions are elaborated upon in Section 4. We conclude the paper and provide further direction in Section 5.

2 Methodology

2.1 The presumptions of this study

We assume that students are capable of using the Internet while engaging in Internet-based learning, and the Internet-based cooperative learning group is trained to have skills for cooperative learning. In addition, a suitable site is designed by teachers based on the learning goal. Teachers needs to be prepared before perform the Internet-based learning.

2.2 Flow chart of this study

Figure1 shows the flow chart designed for this study.

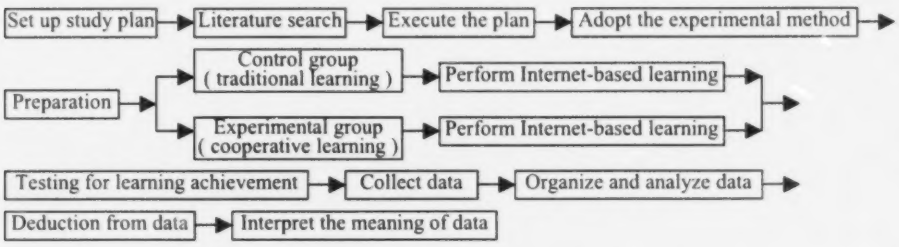


Figure 1. The flow chart for the process in this study.

2.3 The process of this study

2.3.1 The subject of this study

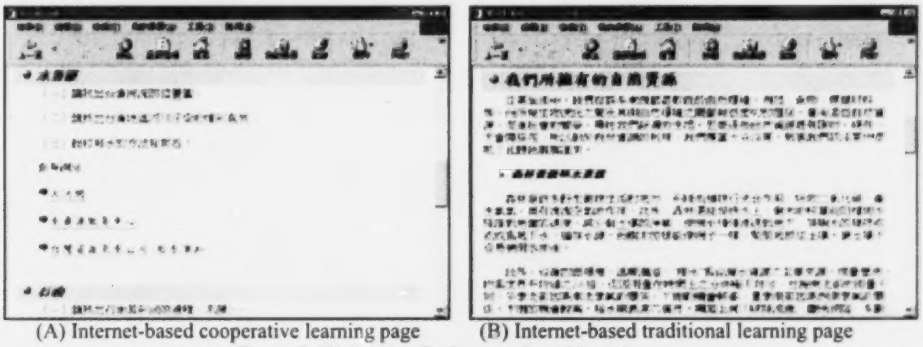
Two Sixth-grade "Computer Experimental Classes" of Hai-Tung Elementary School (Tainan, Taiwan) are the subjects of this study. Both classes have a normal distribution in students' learning capabilities. Each of these two classes has 36 student subjects.

We group the students by the following mean. All 72 students are listed sequentially according to their learning capability. Students with odd numbers are assigned to the experimental group; those with even numbers are assigned to control group. Students in each group are further divided into subgroups. Each subgroup has 3 members who have low, average, and high learning capability respectively.

2.3.2 The tool of this study

In this study, computers are the basic tool for both two groups. For the purpose of this study, a web site has been designed based on the twelfth volume of the nature science textbook for elementary school. Figure 2 shows some snapshot examples of the web. The Internet-based cooperative learning page contains only topics and possible URL links, but the Internet-based traditional learning page describes whole the knowledge for this course. The Internet-based cooperative learning group get knowledge about the topics from relative URLs and discuss with their members. However, the Internet-based traditional learning group only get knowledge from Internet-based traditional learning page. While the learning is proceeding, teachers need to help students to cooperate and make them more aggressive.

The experimental group receives Internet-based cooperative learning; on the other hand, the control group receives Internet-based traditional learning. An "Activity Page" (See Figure 3) is used to evaluate the achievement of these two groups and it contains memory-demanding, integration, and deduction problems that is designed based on the learning goal. For example, we design an integration problem about natural resource recycle to test students' ability to integrate the fractional knowledge thsy learned. The idea of letting student groups browse the Internet according to the "Activity Page" and then discuss and present the findings in a workshop is also suggested by Donald and Deborah.[3]



(A) Internet-based cooperative learning page (B) Internet-based traditional learning page

Figure 2. Web pages for Internet-based learning.

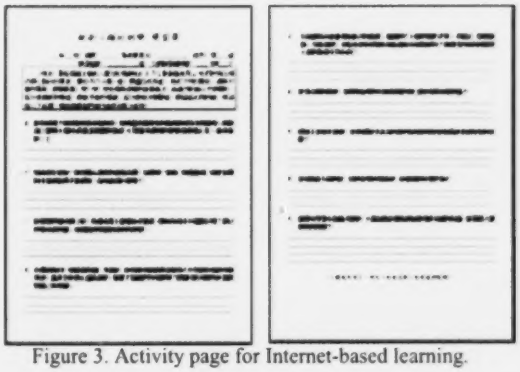


Figure 3. Activity page for Internet-based learning.

2.3.3 Data analysis

Figure 4 shows the flow chart for the data analysis. The data was obtained from the examination given after the learning experiment. The data was analyzed for statistically significant difference of 0.05 and 0.01. In order to investigate students' problem solving capabilities for different types of problems, the examination contains memory-demanding, integration, and deduction problems. We defined these three types of problems as follows:

(a) Memory-demanding type: this kind of problem is given to test students' ability to memorize the fractional knowledge they learned;

(b) Integration type: this kind of problem is given to test the students' ability to integrate the fractional knowledge they learned;

(c) Deduction type: this kind of problem is mainly to test the students' ingenuity and creativity after comprehending the knowledge th~y learned.

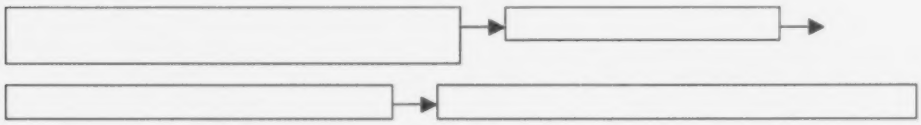
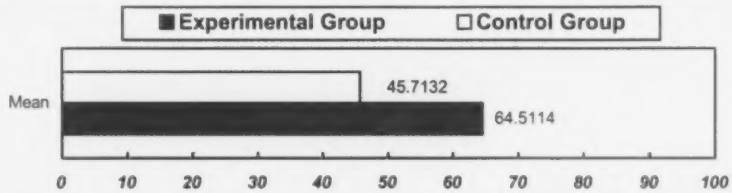


Figure 4. Data analysis flow chart.

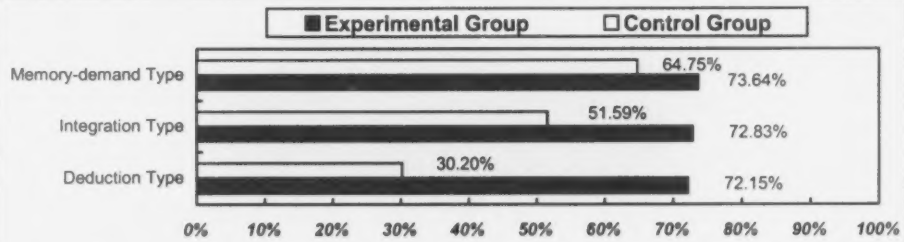
3 Experiment results

Both the experimental group(Internet-based cooperative learning group) and control group(Internet-based traditional learning group) are subjected to have a same examination for evaluation. Figure 5 shows total test scores for experimental group and control group, and Figure 6 shows a comparison on scores of memory-demanding, integration and deduction problems.



item / group	Samples (N)	Mean ($\overline{X}$)	Standard deviation (SD)	t-value	p-value
Experimental Group	36	64.5114	14.6882	4.5540	< 0.01
Control Group	36	45.7132	19.7863		

Figure 5. Total test scores for experimental group and control group.



Problem Type \ Item		Mean	Standard deviation (SD)	t-value	p-value	Ratio of correct answers
Memory-demand	Experimental Group	24.3007	4.0356	1.8285	< 0.05	73.64 %
	Control Group	21.3678	8.7102		> 0.01	64.75 %
Integration	Experimental Group	40.0590	7.4270	5.6315	< 0.01	72.83 %
	Control Group	28.3768	9.9087			51.59 %
Deduction	Experimental Group	7.9370	4.4192	4.589	< 0.01	72.15 %
	Control Group	3.3216	3.6473			30.20 %

Figure 6. Scores on various types of problems for experimental group and control group.

4 Findings and suggestions

4.1 Findings

Based on the data obtained and the observation made during the experimental process, the following conclusions can be drawn. Besides, due to the restriction on experimental samples, the excessive inference should not be draw from these conclusions.

(1) Internet-based learning is feasible in an elementary school nature science course.

This study shows that either Internet-based learning method can fulfill the learning goal after the analysis of examination according to "Activity Page". Most sixth grade students can easily adapted themselves to Internet-based learning environment. Hardware equipment is not an issue in Taiwan, on the other hand. Since the Taiwanese government has greatly prompted information education in recent years, all levels of schools are equipped with personal computers.

(2) There is a significant difference in students' total examination scores for Internet-based cooperative learning and Internet-based traditional learning.

The t-value of this difference is 4.554 that can be regarded as statistically significant at the level of 0.01. Therefore, Internet-based cooperative learning is greatly superior to Internet-based traditional learning.

(3) The Internet-based cooperative learning group has better learning results on Memory-demanding type of problems.

Students in the Internet-based cooperative learning group performed better in this type of problem than those in the Internet-based traditional learning group. The different is considered as level of significance of 0.05, but less than the level of significance 0.01. It means that the learning efficiency of Internet-based cooperative learning is superior to Internet-based traditional learning, but not in a large significance.

(4) On integration type of problems, the Internet-base cooperative learning group significantly outperforms the Internet-based traditional learning group.

Students in the Internet-base cooperative learning group need to piece together information from various Internet resources. During the process of integration, they build new models and images in their minds. By

merging new models and images with old knowledge, they can form new knowledge. New and old knowledge is then integrated into a full concept. This is the reason why the Internet-based cooperative group had better learning efficiency on integration type of problems than the Internet-based traditional learning group.

(5) Students in the Internet-based cooperative learning group have higher scores in deduction type of problems.

In deduction type problems, students in the Internet-based cooperative learning group outperformed those in the Internet-based traditional learning group by 72.15% versus 30.20% in the ratio of correct answers. This reflects that students in the Internet-based traditional learning group lack logical inference capability. On the other hand, the Internet-based cooperative learning group had better logical inference ability and more creative ability.

(6) The Internet-based traditional learning group performed best in the memory-demanding problems.

In traditional learning, the teacher delivers teaching material and its highlights directly to students. Since the teacher has organized his material before class, the teaching method is more suitable for Memory-demanding type of problem. This is why students in the Internet-based traditional learning group score higher in memory-demanding problems than other types of problems.

(7) Students in the Internet-based cooperative learning group scored evenly in all kinds of problems.

Students in the Internet-based cooperative learning group score 73.64%, 72.83%, and 72.15% on memory-demanding, integration, and deduction problems. Thus, this teaching method is suitable to all kinds of evaluation methods.

(8) Students in the Internet-based cooperative learning group are more aggressive in learning than those in the Internet-based traditional learning group.

In dealing with problems, students in the Internet-based cooperative learning group acted cooperatively and aggressively in searching for answers using Internet resources. On the other hand, those in the Internet-based traditional learning group are less aggressive in overcoming difficulties, and give up at an early stage.

4.2 Suggestions

(1) Elementary school natural science courses can better utilize Internet resources to perform cooperative learning.

The massive resources on the Internet are an important and attractive factor motivating students to learn actively. Thus, teachers need to better utilize such resources to improve learning efficiency.

(2) During the process of Internet-based cooperative learning, a teacher needs to develop students' capability in cooperative learning.

The success of cooperative learning depends heavily on students' capability in cooperative learning. Teachers thus need to develop students' capability to learn cooperatively during their regular teaching. They should also make students understand the spirit and meaning of cooperative learning which is that each group member is willing to share their knowledge with others.

(3) Before performing Internet-based cooperative learning, teachers need to have a complete plan regarding the learning environment.

An effective cooperative learning relies on teachers' full preparation before the class, which includes: students properly divided into groups; teaching related material, such as web sites; increase initiation factor for cooperation; improve group members' contribution; develop students' ability to browse the Internet; and so on. These entire things require teachers to communicate with their students to reach a consensus before the class.

(4) Both teachers and students need to be aware of the roles they play in Internet-based cooperative learning process.

Though students learn by using Internet resources in Internet-based cooperative learning, the teacher still plays a crucial role. Like a navigator in a voyage, the teacher prevents students from being overwhelmed by the massive information on the Internet and guides them to reach their learning goal according to a series of stages. Students need to have the spirit of a trail-blazer in daring to make all kinds of trial effects. They also need to share the learning experience with others.

(5) During Internet-based cooperative learning, a teacher needs to increase students' consciousness on cooperation.

In cooperative learning, knowledge is obtained through cooperation between group members. Hence, group members should realize that the goal of the group is their own learning goal. Group power can be used to overcome learning difficulties, and develop a learning method that is suitable to the whole group. This allows each group member to experience the joy of learning.

5 Conclusions

This paper describes that cooperative learning and traditional learning can be combined with the Internet in an elementary school nature science course, and the learning efficiency will not be reduced. In addition, Internet-based cooperative learning is greatly superior to Internet-based traditional learning in learning efficiency. Since this paper is the plot study of Internet-based learning, we only focus on the learning efficiency of applying Internet on cooperative and traditional learning. It is likely that future replications of the study will in turn lead to discovery of comparison between other learning methods, such as cooperative learning, traditional learning, Internet-based cooperative learning and Internet-based traditional learning. Furthermore, we intend to develop different teaching strategic to lead students' interaction in the future.

References

[1] Chen, S. J., "The Effects of Pairing Learning Methods and Cooperative Training on Concept Learning", Journal of Pingtung Teachers College, Vol. 11, pp. 25-54, (1998).

[2] Chu, Y. M., "The integration of Internet cooperative learning and traditional instruction", The 7th International Conference on Computer-Assisted Instruction (ICCAI 1998), Kaohsiung, Taiwan, pp. 551-557, (1998).

[3] Donald J. Leu, Jr. & Deborah Diadiun Leu., "Teaching with the Internet: Lessons from the Classroom", Norwood, Massachusetts, 1999 Edition, (1999).

[4] Hooper, S., "Cooperative learning and computer-based instruction", Education Technology Research and Development, Vol. 40, No. 3, pp. 21-38, (1992).

[5] Johnson, D. W., & Johnson, R. T., "Cooperative learning and achievement", In Sharan, S. (Ed.) Cooperative learning: Theory and research, pp. 23-38, (1990).

[6] Lin, C. S., "Computer Network and Education Reform", Friends of Elementary Education, Vol. 49, No. 1, pp. 5-12, (1998)

[7] Oliver, R., Omari. A. & Herrington. J, "Exploring Student Interactions in Collaborative World Wide Web Computer-Based Learning Environment", Journal of Educational Multimedia and Hypermedia, Vol. 7, No. 2/3, pp. 263-287, (1998).

[8] Sharan, S, "Cooperative learning in small groups: Recent methods and effects on achievement, attitude, and ethnic relations", Review of Education Research, (1980).

[9] Slavin, R., "Research in cooperative learning and achievement: What we know, what we need to know", Contemporary Educational Psychology, Vol. 21, pp. 43-69, (1996).

[10] Slavin, R. E., "Cooperative learning", NY: Longman, (1983).

[11] Slavin, R. E., "Cooperative learning: Theory, research, and practice", NJ: Prentice Hall. (1990).

[12] Tyan, N. N. & Hong, M. F., "Computer-Mediated Communication and Collaborative Learning in Higher Education", Journal of National Taipei Teachers College, Vol. 11, pp.1-22. (1998).

[13] Wang, C. H., "Cooperative learning", The Educator, Vol. 364, pp.34-38, (1997).

[14] Wang, W. C., "Cooperative learning in Mathematics", Friends of Elementary Education, Vol. 49, No. 4, pp.17-23, (1998).

A Dynamic WBI System supporting Individual Learning Styles

Jae-Mu Lee and Du-Gyu Kim
Department of Computer Education, Pusan National University of Education
263, KoJeDong, YounJeGu, PUSAN, 611-736 KOREA
Tel:+82-51-5007322
Fax:+82-51-5007174
E-mail: jmlee@ns.pusan-e.ac.kr

Being based on the hypertext structure, existing WBI provides various instruction paths. However, learners are provided with the same instruction content with little consideration of each learner's learning style. Therefore, WBI is lacking as a system that encourages individual learning, by failing to provide for different instruction methods for each learner. This prototype system can find the most effective approach to learning for each learner by analyzing a learner's achievement and learning history. It also provides instruction content based on the most effective instruction method for the learner taking into consideration learning style.

Keywords: **Web Based Instruction, Adaptive Learning, Individual Learning**

1 Introduction

The World Wide Web provides all learners with materials for instruction, and those materials have a hypertext structure similar to the way human beings perceive information, to effectively help learners understand them[3]. The Web enables us to communicate with anyone, anywhere, and at any time by a wide variety of materials irrespective of time and place[2].

While the Web has these advantages and educational effects, there are some problems. WBI does not consider an effective instruction program to present the materials for each individual. That is, all learners are provided with the same instruction content with little consideration of each learner's learning style. Therefore, it is worthwhile to develop an instruction program wherein is provided a more efficient instruction method for learners.
T
his study focuses on presenting the instruction content more individually, subject to the learners' process and achievement level of learning. An appropriate content is presented after analyzing each learner's individual needs. The aim is then to design and implement a system that can supply the most effective method for each learner after consideration of preferred learning styles, though the ultimate goal may be the same.

2 Related Works

Norihito Toyota classifies a learner's study type into HLT (Horizontal Learning Type) and VLT (Vertical Learning Type). In HLT, a learner studies broadly, gaining wide knowledge. However, they lack a deeper understanding. On the other hand, in VLT, a learner studies more deeply, gaining some specific knowledge and understanding it logically; however, they lack that wider understanding gained only by studying across a broader base and viewing the whole from various angles of vision. They also cannot proceed independently, so long as something is not understandable. The learners of this type can increase their knowledge reliably, step by step, to recognize the whole scope. It has the other advantage of supplying the content for instruction after considering the learning style in each step[5].

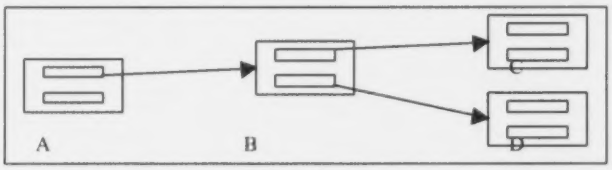
Referring to an individualized instruction in Mathematics education, G. Lenchner proposed that all learners

differ in the preference method to solve the questions. That is, each learner shows a different solution to the same question[6].

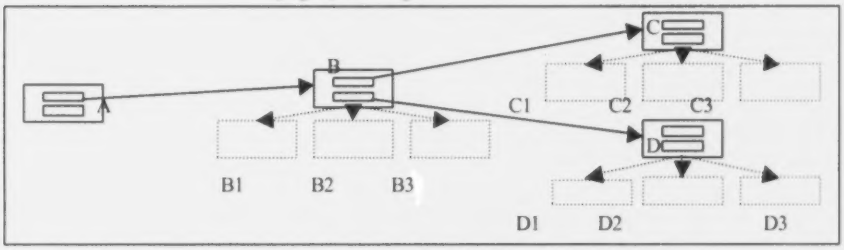
Paying attention to Norihito Toyota and G. Lenchner's proposal, this study focuses on providing learners with instruction content through effective methods, by analyzing the instruction process of learners of Mathematics at elementary school.

3 Design and Implementation of the System

As a system for this study, Windows NT Server 4.0 is set up as the Operating System, IIS 3.0(Microsoft) as the Web Server, and MS-SQL 7.0 as the Database. Interface with clients is made through the MS Explorer 4.0 or Netscape Communicator 4.0 (or higher version) Web browser.



[Fig 1] Existing WBI



[Fig 2] Dynamic WBI System Considering Learning Style

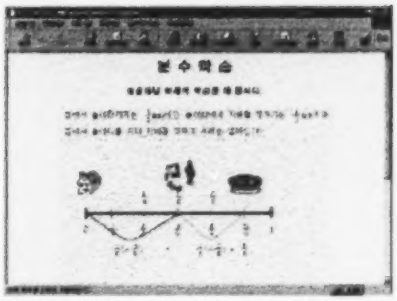
Our system has a distinctive feature compared with the existing WBI system. As shown in [Fig 1], existing WBI presents paths of instruction for learners, nodes A, B, C, and D. But, this system finds the most effective one among B1, B2, and B3 to provide a learner with, instead of node B as shown in [Fig 2] Dynamic WBI System Considering Learning Style. (BI, B2, and B3 contain the same content but different method of instruction). Additionally, one out of C1, C2, and C3 is presented instead of node C. That is, while the existing WBI system has provided learners with learning paths A-B-C or A-B-D without considering learning styles, this system can present a wide variety of learning paths like A-B1-C1, A-B2-C2, A-B3-C3, A-B1-D1, A-B2-D2, A-B3-D3, etc. according to learning styles.

When a learner chooses the next step for learning after completing one learning step, results of the completed learning is stored in the Database. This stored data is analyzed in the Learning Style Analysis Module. Through this analysis, learners can be provided with the most effective instruction method from styles A, B, and C.

Instruction methods are classified into type A, B, and C in the whole process of learning. Type A is an instruction method using concrete materials, B is one using vertical lines, and C is one using explanatory sentences and numerical formulae.

On the other hand, the analysis module analyzes the course that a learner has followed, and their level of achievement. And with a learner's understanding of the instruction content dependent in part on which type of instruction method is employed, a learner's achievement level is imposed on the variables of type A, B, and C respectively. Imposed scores are accumulated, and after a fixed instruction step, the most effective instruction content among the instruction method types A, B, and C (the content of which are the same) are presented according to accumulated scores.

[Fig 3]Addition of two fractions differing in denominators. (An Instruction Method expressed in explanatory sentences and numerical formulas)



[Fig 4]Addition of two fractions differing in denominators (An Instruction Method expressed in vertical lines)

[Fig 5] Addition of two fractions differing in denominators (An Instruction Method expressed in concrete materials)

In other words, learners can be provided with the most effective content different from one another in accordance with which instruction method is most effective for them, although they choose the same level of instruction content through the analysis of their learning process. Therefore, learners can take a more advanced individualized instruction.

For instance, when instruction content named "Addition of two fractions differing in denominators" are chosen, the most effective instruction [Fig 5] among methods [Fig 3], [Fig 4] and [Fig 5] is presented as follows:

4 Conclusion

This thesis focuses on development of a system, which can find the most effective method with which to provide instruction to learners, by analyzing their learning process and results.

Expected effects in application of this system are as follows.

First, if this system is applied to Virtual Education, learners are no longer provided with the same instruction content regardless of personal level; they are instead offered an instructional content and approach that takes into consideration their learning style. Additionally, even if they are of the same content, individualized instruction is possible because the most effective instruction method considers the learner's cognitive processes.

Secondly, it is almost impossible to provide each student with a proper instruction method for him in class lessons under the existing educational system. However, this system can maximize the educational effect by presenting the individualized content in accordance with which instruction method is the most effective for each learner. A problem yet to be addressed is that of verification of the benefits to be gained and the overall educational effect of this system.

References

[1] Corning.M. (1997), "Working with Active Server Pages". Queco

[2] Ibrahim.B, Franklin.S.D (1995), "Advanced Educational Uses of the World Wide Web", Proceedings of the
3rd International Conference on the WWW

[3] Kim D.H (1998), "Making and Using Web Documents for Elementary Education", Korean Association of Information Education Proceedings of the 3th KAIE Summer Conference, pp.72-89

[4] Kim.S.S, Hwang.D.J , Jeong.C.G (1997), "A Multimedia Collaboration Home Study System"
Proceeding of High Performance Computing ASIA'97 Conference and Exhibition sponsored by IEEE Computer Society, Seoul Korea, Apr, pp135-152

[5] Norihito.T(1997), "Fundamental Models on Individual-Type Learning Support System with Dynamic Strategy", The Institute of Electronics Information And Communication Engineers, ET 97-5, pp33-40

[6] Park S.T (1998), "Strategy of Instruction and Learning for Mathematics" , Kyomoonsa, pp116-124

[7] Tilton.E (1996), Composing Good HTML. http://www.cs.cmu.edu.~tilt/cgh

A European Learning Environment: Reflections on Teaching and Learning in a Multinational Virtual Learning Community

Brian Hudson*, Ahmed El-Gamal, Amal Gouda**, Eric Knutsen***, Merja Ruotsalainen****, Antti Peltonen****, Minna Pesonen**** and Tarja Te rvola******

**Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria*

***Pedagogy and New Technologies Research Group, School of Education, Sheffield Hallam University, Sheffield S10 2BP, United Kingdom*

B.G.Hudson@shu.ac.uk

a.e.gamal@shu.ac.uk

a.gouda@shu.ac.uk

****Hope Valley Community College, Hope Valley, Derbyshire S33 6SD, United Kingdom*

knutsen@dircon.co.uk

*****Research Unit for Educational Technology, P.O.Box 2000 90014 University of Oulu, Finland*

Merja.ruotsalainen@oulu.fi

antti.peltonen@oulu.fi

mpesonen@oulu.fi

ttervola@ktk.oulu.fi

This paper outlines the background to the development of a European Masters programme in *Multimedia Education and Consultancy*. The development arises from an Advanced Curriculum Development (CDA) Project supported by the European Commission under the SOCRATES programme, which involves nine institutions in seven different European countries. The aims and outline of the Masters programme are described together with the pedagogical approach adopted. A key feature of the latter is a virtual learning environment that is underpinned by the use of the concept of "metaphor". This is intended to convey how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users. A pilot unit/module on *ICT in Open Learning Environments* is outlined together with some of the key features of the learning environment. This was trialled by a group of students based at locations in Finland, Austria, the Netherlands and the UK during the second semester of the academic year 1999-00. Evaluations are provided by a participating tutor, an observer and from two participating students. Finally some reflections are outlined which focus on the innovative aspects of this learning environment and of our experiences as teachers and learners in a multinational virtual learning community.

Keywords: **Collaborative Learning - Web-Based Learning - Networked Social Learning - Teaching and Learning Processes**

1 Introduction

This paper reports on experiences as teachers and learners in a multinational virtual learning community, which have resulted from our involvement in a pilot unit as part of the development of a European Masters

course. The pilot unit is entitled *ICT in Open Learning Environments* and our involvement has taken place between February and May 2000.

2 Background to the development

The background to the development is the Advanced Curriculum Development (CDA) Project *TRIPLE M: Masters in MultiMedia Education and Consulting* that is supported by the European Commission under the SOCRATES programme (29268-IC-2-97-1-AT-ERASMUS-CDA-1) over the period 1998 to 2001. The *TRIPLE M* project is co-ordinated by Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria and involves a number of departments and research units with experience and expertise in teacher education and the use of Information and Communication Technology (ICT). The current participating institutions in the *TRIPLE M* project are:

- Pädagogische Akademie des Bundes in Oberösterreich, Linz, Austria (Co-ordinating institution)
- Charles University, Prague, Czech Republic
- Hogeschool Arnhem and Nijmegen, Netherlands
- Liverpool Hope University College, United Kingdom
- Pädagogische Akademie Vienna, Austria
- Sheffield Hallam University, United Kingdom
- Umeå University, Sweden
- University of Oulu, Finland
- University of Santiago de Compostela, Spain

A sub-group of the TRIPLE M Consortium has formed the *European Association for Multimedia Education and Consultancy*™ (*EAMEC*™) with the intention of offering a validated Masters programme in for *Multimedia Education and Consultancy* from September 2000. Initially this will be offered as a part-time route with a plan to run the programme on a full-time basis from September 2001.

3 Programme aims and outline

The academic aims of the programme have been developed in response to the needs of the 'Information Society' phenomenon related to the rapid development of high technology use in all sectors of society. The programme aims to meet the needs of teachers in schools and further and higher education especially. Specifically the programme seeks to develop the profile of the 'problem solver'/team co-ordinator at the interface of pedagogical, technological and organisational/cultural dimensions of development. In summary the programme aims to support the development of individuals who are able to:

- demonstrate and communicate knowledge and critical understanding of pedagogical issues as applied to the use of multimedia in new learning environments
- critically understand the social, organisational and cross-cultural phenomena related to new learning environments in trans-national and cross-cultural contexts
- appreciate and be responsive to the social and cultural impact of the Information Society in relation to values and working practices
- act as effective mediators and facilitators at the interface between the needs of users and providers
- co-ordinate the efforts of multi-disciplinary teams in terms of problem analysis, design and implementation issues
- be aware of the staff development needs of new users and appreciate the support structures and strategies for continuing development
- demonstrate a critical understanding of (educational) research and its role in a context of rapid change
- remain open to critiques of the Information Society with particular regard to the social and cultural implications

The programme is made up of six units/modules that together make up 90 European Credits (ECTS). These are as follows:

- Open Learning Environments (*OLE* - 10 ECTS)
- Digital Media Applications (*DMA* - 10 ECTS)
- Communication and Consultancy (*CC* - 10 ECTS)
- Research Methodolgies (*RM* - 10 ECTS)

- Project Studies (*PS* - 20 ECTS)
- Dissertation (*DS* - 30 ECTS)

The four more structured units (OLE, DMA, CC and RM) all follow a common pattern of:

- Telematic-based Studies (50%) e.g. Web-based work and discussions, multi-point videoconferencing sessions, and
- Local and Independent Studies (50%) in national groups e.g. day workshops and tutorials plus independent study.

4 Pedagogical approach

The pedagogical approach involves Telematic-based Studies in Web-based work, discussions and multi-point videoconferencing sessions in multinational learning communities. It is seen as crucial that these studies are supported by Local Studies - in national groups e.g. day workshops, practical activity, project work, research activity and tutorials and Independent Studies including literature reviews, independent project work, research activity, writing etc.

The use of ICT as a medium for learning and communication is fundamental to the underpinning philosophy of the programme and is an integrated and all pervasive aspect of the pedagogical approach, both in terms of learning about it and as an essential part of the learning process. Students need to use the Internet as an essential part of the learning and communication process.

The platform for the net-based learning environment is *LC Profiler – Learning Community Profiler*. This is the product of *LCProf Oy*, which is a Learning Service Provider (LSP) and a 'spin-off' company of the University of Oulu. The services are based on the methodology and system developed at the University of Oulu in a range of domestic and EU R&D and education projects during the last 5 years (e.g. Telematics projects T3: Telematics for Teacher Training, SCHEMA: Social Cohesion through Higher Education in Marginal Areas). The implementation of the system is based on the principle of creating a distributed community of learners and supporting the tutors to enable them to create their own learning communities. This means that the tutors also belong to a unique learning community of their own, which aims to support ongoing professional development.

5 The role of metaphor

The concept of metaphor plays a fundamental part in the underlying design of the *LC Profiler* environment and also in signifying key functions to the user. In their paper Pulkinnen and Peltonen [1] use the concept of "metaphor" to "explain how the technical construction of the pedagogical functions communicates the background theories of the learning environment to the users". This paper is also one of the Core Readings for all students on the OLE unit/module. Their analysis combines ideas about knowledge, the structure of knowledge and learning with social aspects to do with the organisation of learning such as practical arrangements connected with "time, place and repetitive rituals". Their overall metaphor which captures the nature of the *LC Profiler* environment is of "a place of studying (virtual space) created with the help of ICT". The three "cornerstones" of their analysis of the learning environment are the individual whether as teacher or learner, the technology and the culture as fully outlined in Pulkkinen and Ruotsalainen [2]. They describe these as providing the "cross-disciplinary basis for the elements that are necessary for learning" and identify these elements as pedagogical functions, appropriate technologies, and the social organisation of education

6 The pilot unit/module

As part of the curriculum development process, two units have been piloted during the period from February to May 2000. These are *ICT in Open Learning Environments* (February to May) and *Digital Media Applications* (March to May). The former is based on an existing unit/module at the University of Oulu and forms the model for the development of the Masters programme as a whole. The full unit/module is worth 10 ECTS M Level credits for which 5 ECTS is available for successful completion of the telematics-based component. This was trialled as part of the TRIPLE M project with a group of about 25 Finnish, 9 Austrian, 4 Dutch and 2 UK students

The course outline is seen as one of the most important navigation tools, referred to as an "orientation metaphor". The introductory screen is shown below in Fig 1.

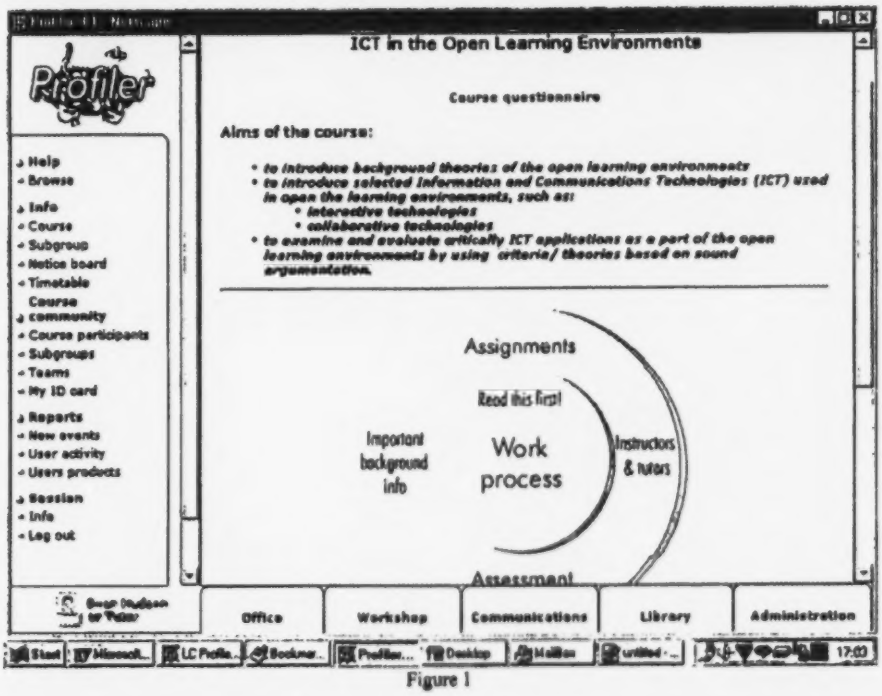


Figure 1

This screen includes a statement of the aims of the course and also conveys some of the metaphors that underpin the design of the system. (NB The use of the term "course" here is equivalent to the terms "unit/module" used previously and is a reflection of the diversity of the use of these descriptors across and within different systems) The most apparent metaphors are those which are to do with orientation to place or virtual working place. The Project Office, Workshop, Communications Centre, Library and Administration Centre refer to "working" and not to the technology and tools being used e.g. e-mail, chat, documents etc. This aspect is seen to be a particularly important issue in relation to signifying metaphors to users that refer to pedagogical practices. The metaphor of "project" is used to convey "the basic essence of learning" and the course flow orientates the user to time. This includes phases on the work process e.g. orientation, planning etc and also milestones, which are outlined in part in Figure 2.

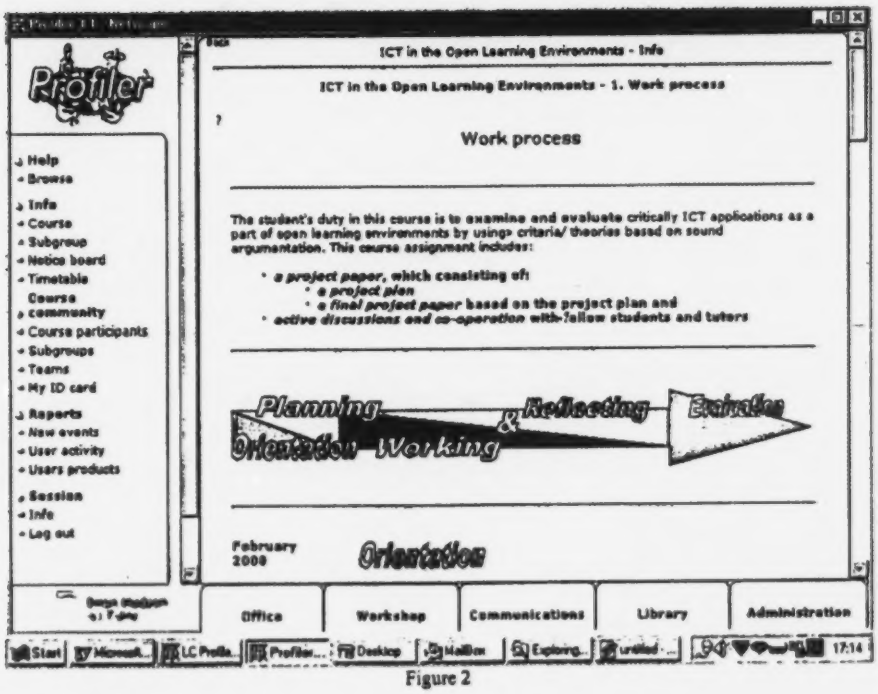


Figure 2

7 Experiences as teachers and learners

This section includes accounts and evaluations from a participating tutor (Brian Hudson), an observer (Ahmed El-Gamal) and from two participating students (Eric Knutsen and Amal Gouda).

As a particpating tutor I was immediately struck by the very clear sense of purpose that the course outline engendered with a very clear sense of the different phases, milestones and overall timescale. The active participation in discussions was not an option but a necessary requirement with comments being expected within fixed timescales and core readings, project plans of peers etc. As a result the level of communication on the course was very high - an analogy might be made with lighting a wood and coal fire - a little slow at the start but then bursting into flames from all sides!

Another key observation was of the role of the two main moderating tutors. Both could be characterised as being "on task" throughout the course of the unit/module. In general their responses to questions were very swift and they dealt with technical, pedagogical and social issues. The two tutors also interacted with each other in a very effective way by following up on each others comments, questions and prompts - so engendering a relaxed yet lively ambience around the discussions.

An example of the extent of the student discussions can be gleaned from the screen in Figure 3 below:

BEST COPY AVAILABLE

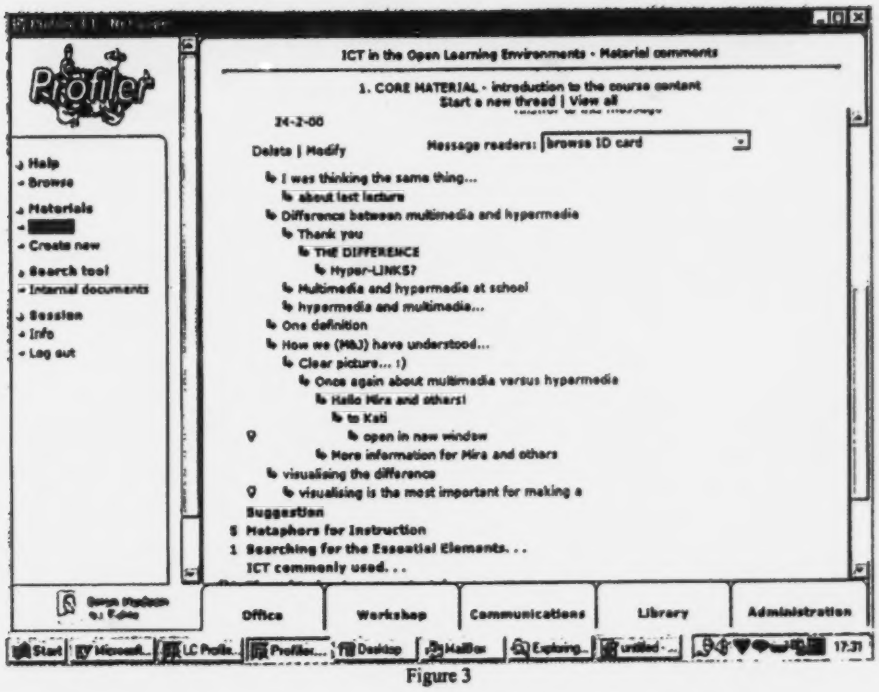


Figure 3

The particular thread started outlined above was started by student H on 24-02-00 with the comment:

Could some of you tell me what is the difference between multi- and hypermedia? Is there any difference, do they mean the same thing? The difference between these "words" was explained in the first core text but I just couldn't find the basic idea which might help to separate them.

These questions resulted in a rich, intense and well-informed discussion with around twenty contributions over a ten-day period, which seemed to conclude in an agreed consensus. Overall discussions were by no means restricted to technical matters but this particular thread was notable for its richness and intensity. A notable feature of this environment is the very clear way in which the threads are laid out and also the way in which the links are revealed when a thread such as the one above is opened.

Ahmed El-Gamal had the role of being a Local Tutor and was given access to *LC Profiler* as an observer. He is a staff member of Menofia University in Egypt on a PhD scholarship supported by the Egyptian Ministry of Education and Culture. He has chosen to cluster his comments around characteristics that he noticed about the learning environment in overall terms. This is a summary of his comments on these charactersitics:

Organization: The whole unit is well organized e.g. timetable, assignments, activities..etc. If there is any misunderstanding the student can post a question to the others.

Adaptability:Most of students adapted easily with this learning environment. Sometimes they have some technical problems e.g. the speed and the difficulty in using some tools, but they soon found assistace from the tutors and their peers.
Flexibility:It is a very flexible learning environment - students worked at different times in different countries, yet they have the opportunity to discuss the same topics.
Some students from different countries were able to create teams to conduct the same project.

Collaboration: Students collaborated with each other in solving some technical problems, clarifying some aspects in the references, developing teams and developing their project plans.

Conversation and discussion: Students were discussing different issues that were relevant to the course. All the participants have the opportunity to contribute to the discussion. They wouldn't end the discussion until they reached an agreement about the topic e.g. the discussion about the difference between Multimedia and Hypermedia was about 20 comments.

Social interactivity: Most of students have some social interactivity, by talking to the other students in the on-line café and by posting messages. Some friendships have been developed during the course.

Amal Gouda has studied to Diploma level in Educational Technology at Cairo University and is continuing her Masters studies at this time. She has chosen to group her evaluation around features of the studying process:

The studying process in OLE could be defined as an integrated process, which integrates the different resources and the different parts of the OLE to achieve the desired goals. The studying process in OLE is accomplished through the following parts:

Office: Every student can manage almost all his/her study through using the office and all the information about the course and other students are available on the office, in addition to the timetable and the framework of the course.

Workshop: Every student has developed his/her project plan and he/she has published it to the other course participants. This gave his/her opportunity to have the other students comments on it.

Communications: It gave the international students the opportunity to freely discuss different topics related to the course. It also allows them to discuss their project plans and the other students' project plans. Moreover, there are different categories for discussion e.g. questions and urgent message, general discussion about the study process..etc. In online café, the students can have a social chat with their peers.

Library: It has most of references that are related to the course, also it has a hyperlinks to enable students from browsing more materials. It was advised to write comments on these materials, in order to encourage the students to read them carefully.

Local studies: Every student met with his/her tutor many times to discuss the different topics and activities that seem to be unclear and to guide him/her through the course. The most important feature in the studying process in OLE is that it gave the opportunity to study and discuss different topics at any time during the day.

Eric Knutsen works in a secondary school and is in his first year of teaching as a teacher of ICT. He has chosen to respond to the aims of the course and to evaluate the extent to which these were met for him as a student:

- to introduce background theories of the open learning environments

This was done in a straightforward manner utilising the OLE of LC Profiler. It was useable as one would use a library in the traditional environment of a physical learning environment. The added value here was the amount of material referenced via the web. Using the expertise of the instructors on the course, I was able to make use of the varied written material and discuss other students' and my own opinions on the content. Being done in an asynchronous way, there was no need to be present physically or virtually for such discussion. Yet, I had the advantage of dozens of other opinions from which to draw my own conclusions. This took my learning beyond that previously possible via ..traditional learning ...

- to introduce selected (ICT) Information and Communications Technologies used in open learning environments, such as interactive technologies and collaborative technologies

One aspect of having been introduced to the background theory in the way it was done is the ability to review tens of project proposals and final project papers in light of the theory examined. This made the theoretical come to life, especially when undertaking my own individual work. This meant looking critically at the variety of components comprised with-in the environment being examined ...What made this a more lively introduction to the ICT was the regular use of LC Profiler and the success of the discussions taking place.

- to examine and evaluate critically ICT applications as a part of the open learning environments

by using criteria/ theories based on sound argumentation

Given the foundation above ... it was straightforward to see the relevance of the theory when examining the OLE at hand. Especially of interest was the use made of LC Profiler as an OLE by all members of the course and the social interaction made possible by all areas of LC Profiler, not isolated to the on-line cafe. This even fed the theoretical side to my thoughts about my assignment.

8 Conclusions

The experience of participating in this pilot unit has provided a real example of the transformative potential of the use of ICT. This is in spite of several years experience of using the *First Class* conferencing software which seems quite limited by comparison with *LC Profiler*. In McConnell's [3] terms *First Class* can be seen to be simply an example of "unstructured groupware" or an "electronic space". Some experiences result in real and lasting changes - for myself this experience has transformed my own pedagogical thinking and practice. Whilst being a vital component, the learning environment of itself is not the main ingredient for experiencing this transformation, although many people at this time are looking for the "quick fix" and simple solutions. However it has been the experience as a participant in a community of practice (Hudson [4]; Lave, [5] and Lave and Wenger, [6]) that has been fundamental. This process takes time and is about changes within (the person) and developing new ways of relating to other people. In general terms such high levels of on-line communication also necessitate the need to develop a more relaxed attitude towards committing ideas into print, for seeing such comments as transient and not permanent and being accepting of the need for "repairs" to communication as one would in more traditional forms of communication.

References

[1] Pulkkinen, J. and Peltonen, A. (1998) Searching for the essential elements of Web based learning environments, *3rd International Open Learning Conference*, 2-4 December 1998, Brisbane, Queensland, Australia.

[2] Pulkkinen, J. and Ruotsalainen, M. (1998) Evaluation study of a telematic course for technology teachers (T3 Project). Paper to the *Teleteaching' 98 Conference of the 15th IFIP World Computer Congress*, 31 August - 4 September 1998, Vienna and Budapest.

[3] McConnell, D.: 1994, *Implementing Computer Supported Co-operative Learning*, Kogan Page, p37.

[4] Hudson, B. (1999) A social perspective on teaching and learning in the context of Computer Mediated Communication in teacher education, *Journal of Information Technology in Teacher Education*, 8, 2 (In press)

[5] Lave, J.:1996, Teaching, as learning, in practice, *Mind, Culture and Activity*, 3, 3, 149-164.

[6] Lave, J. and Wenger, E.: 1991, *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press.

A Framework for Internet-Based Distributed Learning

Andreas Braun* and Andreas G. Harrer**

**Andersen Consulting, Maximilianstr. 35, D-80539 München,* andreas.braun@ac.com

***Technische Universität München, Orleanstr. 34, D-81667 München,* harrer@in.tum.de

Communication technology as well as the communication infrastructure are both changing rapidly. As a consequence, systems that support web-based learning need to be adapted due to changes in technology. This paper describes a model for web-based learning with intelligent tutoring systems (ITS) that allows separation of the concrete communication from the ITSs' implementation. The resulting framework provides a technical solution to distribute any ITS over a network. The ITS SYPROS is used to illustrate how a classical ITS can be extended to a web-based tutoring system with a maximum of code-reuse. The framework may be used freely with any ITS. To accommodate the needs of various ITSs, our model supports several architectures for distributed adaptive tutoring, including the three different models described in [3]: Master-Slave, Communicating Peers and Centralized Architectures. Our main goals are: • •Make the ITS usable for a wide range of users by supporting any web browser on any operating system. • •Offer a simple, extendable and platform independent framework to ease web-based tutoring. • • Provide a solution without royalties.• •Separate the communication technology from the client and server implementation. • •Enable method invocation and parameter passing semantics over the HTTP protocol to virtually support any web browser and users behind firewalls. • •Offer an simple user accounting and user communication functionality.• •Provide a wrapper to connect to an existing ITS. The Java source code is freely available: http://www.in.tum.de/~herzog/sypros.

Keywords: **Web-Based Learning, System Design and Development, Intelligent Tutoring Systems**

1 Introduction

Classical intelligent tutoring systems (ITS) are often platform dependant and not distributed. Modern, distributed intelligent tutoring systems (DITS) provide a more attractive solution with respect to usability and platform independence. Therefore, a modern distributed infrastructure like the internet with communication techniques like CORBA or RMI is suitable. A stable, safe and extendable basis for communication and cooperative work is needed. However, technology in this area is rapidly changing on the one hand. On the other hand communication technologies like CORBA or RMI are (still) not usable with every client, browser or platform and still have several drawbacks which prevent their usability at least for some users: Macintosh users and users with old browsers or behind firewalls/proxies who also want to use secure socket factories, only to name some.

This paper discribes a model and the resulting framework to overcome such problems. We propose to address these problems by providing an API with the semantics of object oriented remote method calls over HTTP and Servlets. Further functionality that is most likely in common for any DITS (such as user accounting and identification, security and administrative functionality) is implemented and encapsulated for ease of use.

In the current version, SYPROS is an ITS in the domain of the synchronization of parallel processes with semaphores [4], a domain of programming problems.

All the typical modules of an ITS [15] like the expert module with different types of cooperating domain experts [13], the instructional module with different tutoring strategies, the student model with cognitive and motivational traits [12], and the interface module with several support facilities, are fully implemented in SYPROS.

The current version system is a classical ITS for single-user mode and is written in C for UNIX systems. The user interface is based on the X Windows system and therefore the ITS is platform dependent. There is no direct support for multiple clients and no accounting, access control or WWW support as it would be needed for a web-based group learning system, which is our ultimate goal [11]. In the current implementation the user interface is divided at function level from the 'intelligence' and database functionality, but is linked to one single executable. The proposed model will provide an application interface (API) for the client and server side. The API will encapsulate various ways of communication over a network using an abstract factory pattern [2,10]. Concrete implementations for Java RMI and servlets are provided. This model is designed to be easily extendable by other means of network transportation (e.g., CORBA or even Sockets). It will include conceptional security at an eligible level. Further, various ways of interfacing to an existing ITS on the server side are given (Java native calls to C/C++ and the connectivity to shell scripts). This factory can also be easily extended. Figure 1 shows the distribution of SYPROS. The servlet proxy Server enables connection for old webbrowsers, running not necessarily on the same machine as the `SyprosServer` implementation. Two clients are connected: "**Old Webbrowser**" connects using the servlet proxy, "**New Webbrowser**" can either use servlet communication or RMI[17]/ CORBA[22] (or anything else).

This work covers two more aspects: a security discussion for the provided model with a special focus on security issues for an ITS and a usability discussion for various platforms and webbrowsers.

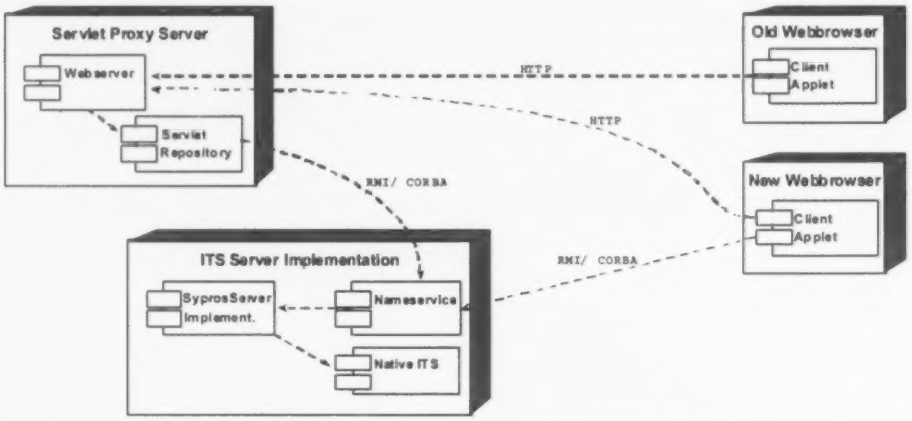


Figure 1. Distribution of client, server and servlet proxy in SYPROS (UML[19]).

Figure 2 shows the different layers for communication and levels of abstraction for a client initiated request. The dotted line between the implementation (application) level and the abstraction denotes that both the client and server implementation are separated from the underlying concrete communication. This model provides transparency in terms of process transparency. (That is, the machine on which the function or method is executed isn't known to the client's application level.) This can be compared to remote procedure calls (RPC) where the client stub and the server skeleton provide a similar transparency. In addition to that, our framework separates the concrete communication (the lowest layer in figure 2) from the application layer using the abstract communication layer. This provides transparency regarding the concrete communication technology used and therefore unburdens the application programmer from changing the application to support new technologies.

For some concrete communication implementations our framework supports language transparency as far as the client's implementation language may differ from the server's (e.g., for CORBA or Servlets).

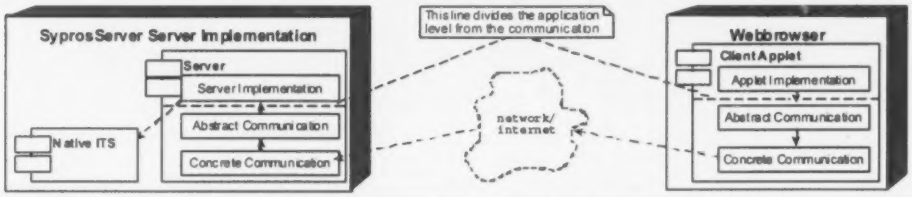


Figure 2. Levels of abstraction and layers for a request initiated by the client (UML deployment diagram).

2 Requirements

All base functionality for a distributed system is implemented. Remote method invocations are implemented independently from the Java RMI package over a `ComObject` which is JDK 1.1[9] compliant. User accounting, login procedures and access control as well as connection state information is supported directly in the framework.

A wrapper is provided to connect to an existing ITS over Java Native Interface (JNI[14]) or shell script invocation.

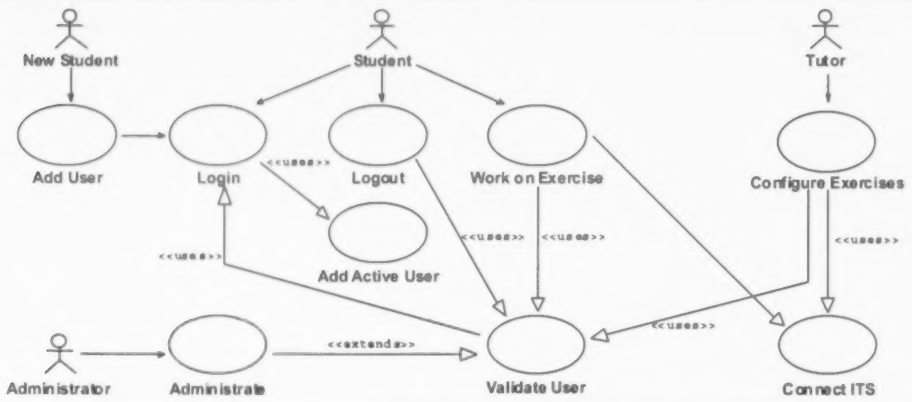


Figure 3. Some interactions among actors and use cases in SYPROS (UML use case diagram).

The use case diagram in figure 3 shows some of the use cases for SYPROS. Four types of human actors are shown in their interaction with the use cases. "**Student**" denotes an actor who is already known to the system. Therefore, "**Student**" logs into the server by passing the "**Login**" use case. "**Login**" performs authentification for which it `<<uses>>` the "**Validate User**" use case, which has knowledge of all valid user entries and so on. After accepting the user's login request some state information for that connection will be stored "**Add Active User**" and a `UserTicket` object is returned to allow stateful and secure client interaction. (`UserTicket` might be encrypted.)

"**New Student**" is an actor who is not known to the system. (Guests are handled identically.) Therefore, she can create a new user database entry herself ("**Add User**"). Later, the gathered information will be used to log into the system as described before.

An active user ("**Student**") might also use other services on the ITS server side. For example, the "**Work on Exercise**" use case first validates the call against the active users database and then uses "**Connect ITS**" (which interfaces the ITS using the wrapper) to work with the tutoring system.

"**Tutor**" is a human actor who might use the "**Configure Exercise**" use case to set up some exercises or check the student's results. The differing permissions (compared to a student) are handled by the "**Validate User**" use case.

An "**Administrator**" user will not use the client interface to connect to the server in this model. The administrator configures the databases and configuration files. Therefore, "**Administrate**" extends "**Validate User**".

Resulting from the requirements given before our model and the framework should further satisfy the following nonfunctional requirements, pseudo requirements and design goals: The server-side installation should be simple and conceptionally platform independent. It should not be addicted to any specific web server and should work with freely available products such as Apache.

The framework is designed to be fully platform independent using the Java programming language. However, some platform dependencies exist from possible webbrowser incompatibilities and the existing ITS. In order to support old webbrowsers or users behind a firewall or proxy, a servlet repository which acts as a proxy and a servlet based client communication is provided. The communication implementation may be switched online in the client implementation[1].

The SYPROS system can be used by four groups of people: students, guests (users who are not known to the system by now), tutors and administrators (tutors who fulfill administrative functions). Therefore, the framework supports users at different level of permissions (similar to e.g., UNIX or WindowsNT).

The client applet should be small so that it is suitable even for slow modem connections. The classes needed for communication on the client side are less than 20 KB in size (without JCE security). Once the Applet is loaded, the response time of the user interface is short, as it is running locally on the client side.

The response time resulting from the security key generation and secret key exchange (Diffie-Hellman for example) of the Java Cryptography Extension (JCE) is rather long especially for strong keys and due to JCE's implementation in Java (see discussion in section 4).

Performance of the network communication depends on the underlying infrastructure. With most browsers, servlets will have a more overhead than CORBA or RMI.

The communication framework aims to support three possible client-server bindings: Static (the server name is stored in the client application), semi-static (the client locates the server once, e.g., at login time) and dynamic (the client looks up the server each time it needs to connect). Client server binding uses name resolution to find a suitable ITS server in the network. The toolkit uses a server string such as "***//{hostname|ip-address}/{service-name}***", just like RMI for either underlying communication infrastructure. At client implementation level, the programmer may decide whether to use static, semi-static or dynamic binding.

Together with the way of client-server binding, stateless and stateful client server connections using tickets are possible. User tickets are invented as "high-level" stateful client-server connection for two reasons: first, the underlying ITS needs to know about the caller; tickets provide an easy way to identify the caller during a learning session. Second, encrypted ticket objects can be used to prevent attacks by intercept and replaying messages (see section 4).

Calling a remote function is somewhat dangerous if the programming language used supports *call-by-reference*[2]. For Java, *call-by-reference* is replaced by a *call-by-copy/restore* semantics. (See Java `RemoteObject` for RMI). A *call-by-copy/restore* semantics can be simulated for servlets using the `EventListener` model. In that case, the servlet proxy uses a `RemoteObject` for the server communication if the communication between the servlet proxy and the server is based on RMI and returns the object to the client using the event model. This may also be encapsulated in the framework.

In case of middleware communication such as CORBA/ RMI the *call-by-copy/restore* semantics can directly rely on the appropriate native semantics. The framework supports synchronous method invocations. Asynchronous calls can be realized using *call-by-copy/ restore*.

---

[1] This feature should be omitted for maximum compatibility with old browsers and Java engines (JDK level 1.1).

[2] Function calls that use *call-by-reference* parameter passing deliver a pointer to the value or data the parameter stores. In a distributed system with different address spaces this triggers side-effects[20].

Java's `try-catch`-statements are used for error handling. Therefore, the framework's error semantics is *at-most-once* by default. At application level, return values might be used to signal unexpected behavior. The SYPROS `login()`-Method for example returns `null` for the `UserTicket` if the server can't accept the login request. Although there are several possible reasons for that (e.g., unknown user, wrong password) their origin is not a communication error.

The resulting framework is described using UML notation for scenarios, use cases and object models[2,19]. The API description is given in standard Java notation[9]. The use of our framework is illustrated by the SYPROS sample.

3 A Model for the Communication Framework

Figure 4 shows the UML diagram for the SYPROS server implementation using the communication framework. The diagram shows two possible extensions for `SyprosServer`: `ComCORBA` and `ComRMI`. In the realworld implementation the programmer has to decide either to use CORBA *or* RMI, as Java does not allow multiple class inheritance.

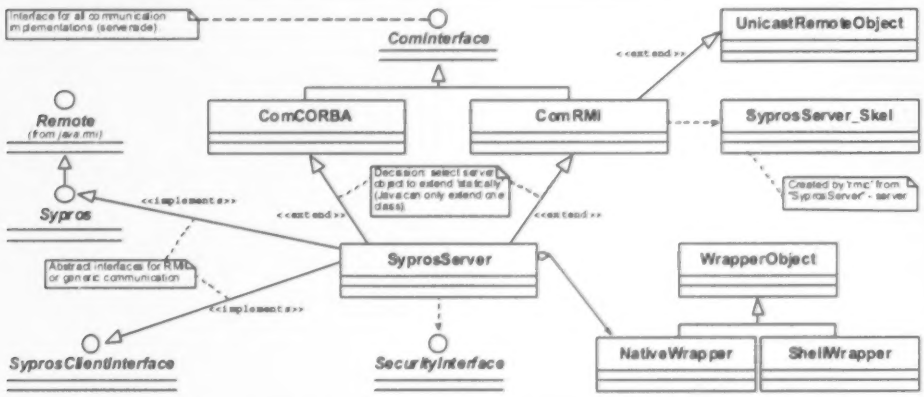


Figure 4. SYPROS server implementation. Class attributes and methods are omitted. (UML class diagram)

Therefore, there are some specialties in the server implementation: depending on the selected communication technology, the programmer has to change the head of the class definition to extend the right `ComInterface`. Further, the server has to implement the `Sypros` interface which defines the exported functions (for the RMI case). `SyprosClientInterface` contains the same definitions like `Sypros` but doesn't depend on the Java RMI classes. This ensures usability for old webbrowsers (with old Java virtual machines, VM) or clients that don't support RMI for other reasons (Macintosh).

```
import sypros.util.*;
import sypros.com.util.*;
import sypros.com.server.ComRMI;

public class SyprosServer extends} ComRMI implements Sypros {
  public  SyprosServer(String hostName, String servName) throws RemoteException
{
    super(serverHost, servName);   // create bindings
  }
  public static void main(String args[]) {
    setSecurity();                 // setup default security
  }
}
```

Figure 5. Client applet implementation for the SYPROS sample.

Figure 5 shows the class definition for the SYPROS server implementation using RMI. The underlined statements would have to be changed for a different type of communication technology.

The client implementation allows dynamic switching of the communication technology. Figure 6 shows the UML class diagram for the SYPROS client Applet. As the client communication model uses an abstract factory pattern [2,19] to create the appropriate concrete communication, the client might be a Java Applet or a Java standalone application. (The server could also be connected using the servlet URLs from HTML or other languages.)

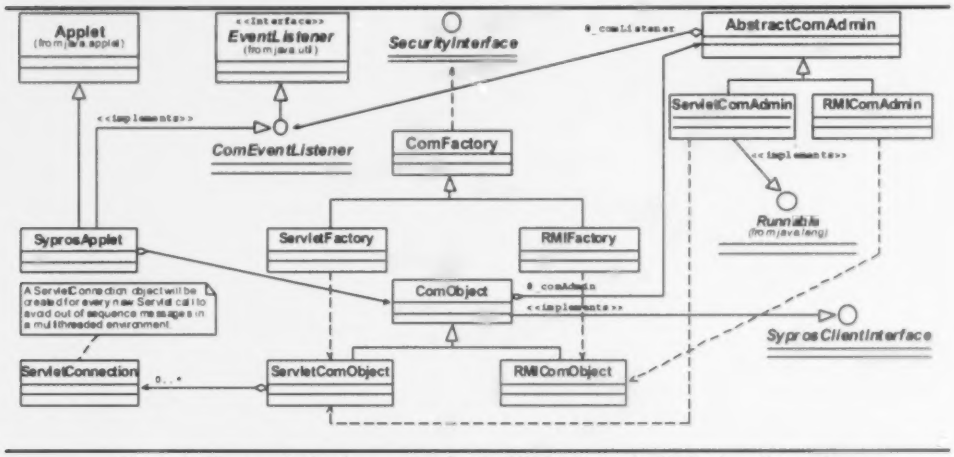


Figure 6. Client applet implementation for the SYPROS sample (UML class diagram).

The classes in the client model can be seen in three categories. First of all, SyprosApplet is the implementation for the SYPROS client interface. (Plus `Applet`, the parent.) As described before, the implementation needs not to be changed for changing communication technologies.

Then the communication classes themselves: `ComFactory`, `ComObject` and their concrete implementations provide the application interface for the implementation. `ServletConnection` is a helper that provides a per-servlet connection for persistent calls in a multithreaded application.

The `AbstractComAdmin` and its concrete implementations for servlets and RMI currently realize notification for server to client messages using the `EventListener` model and can be used for *call-by-copy/restore* type parameter passing.

4 Conceptual Security

Any internet-based application requires a special focus on security issues. The history of designing secure systems, however, teaches the inadequacy of enhancing existing systems with additional security functionality [8]. To integrate the security functionality for secure web-based tutoring, we included security policies in the framework with a top-down approach. We start by specifying the security requirements as part of the security policy:

Authentification:	All subjects and objects of the system have to be authentificated.
Total access control:	Every access to protected units has to be supervised.
Non repudiation:	Every action performed by a subject can be assigned to it's originator.
Communication privacy:	Dataflow over unsafe networks has to be adequately encrypted.
Availability:	Denial-of-Service attacks should be identified.

To meet the authentification, total access control and no-denial requirements, the framework offers integrated functionality that can be adapted or extended to your application needs. Communication privacy

is provided using encrypted transmission (encrypted object serialization) based on the Java Cryptography Extension (JCE). JCE offers secret key agreement protocols (e.g., Diffie-Hellman) and encryption (e.g., Blowfish) with variable key lengths.

Ensuring the availability of a web-based service against denial-of-service attacks is maybe the hardest task. The Servlet-Proxy allows load-balancing, where the typical communication load of an ITS application (little amounts of data, long periods of thinking, infrequent transmissions) can be used to identify attacks.

5 Conclusions and Outlook

Our framework offers an easy and extendable basis for web-based distributed tutoring. The communication technology, security and ITS-integration can be easily adapted to the specific needs of an existing ITS as well as to changing communication or security technologies without rewriting the implementation for the ITS clients or server.

User accounting and access rights deliver the basis to support groups of students. However, support for cooperative work should be included in the ITS itself, like for example in SYPROS.

6 List of tested Browsers

✓: tested ok. no: tested, but failed. –: browser/ OS combination not available for testing.

Webbrowser	Version	Win98/NT		Linux		Solaris/x86		Solaris/Sparc		Macintosh	
		Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI	Servl.	RMI
Netscape	4.04	✓	✓	–	–	✓	–	–	–	✓	no
Netscape	4.05	✓	✓	✓	✓	–	–	✓	✓	-	no
Netscape	4.7	✓	✓	✓	✓	✓	✓	–	–	-	no
Netscape	4.72	✓	✓	–	–	–	–	–	–	✓	no
I-Explorer	4.0	✓	no	–	–	–	–	–	–	–	–
I-Explorer	5.0[3]	✓	✓	–	–	–	–	–	–	–	–
Java Plugin	1.2	✓	✓	✓	✓	✓	✓	✓	✓	–	–

References

[1] Braun, A., "A Client-Server Model for an Intelligent Tutoring System" (transl.), Technische Universität München, Diploma Thesis, May 2000.

[2] Brügge, B., Dutoit, A.H., "Object-Oriented Software Engineering: Conquering Complex and Changing Systems", Prentice Hall, Upper Saddle River, NJ, Oct. 1999.

[3] Brusilovsky, P., Ritter, S., Schwarz, E., "Distributed intelligent tutoring on the Web", in: Proceedings of the 8th. World Conference of the AIED Society, Kobe, Japan, Aug. 1997.

[4] Dijkstra, E. -W., "Cooperating sequential processes", in: F. Genuys (editor), Programming Languages, Academic Press, New York, Oct. 1968.

[6] Duncan Davidson, J., "Java™Servlet Specification v.2.2", Sun Microsystems Inc., Oct. 1999.

[7] Eckert, C., "Matching Security Policies to Application Needs", Proceedings of the IFIP TC11 11th Internation Conference on Information Security, Cape-Town, South Africa, May 1995, p.237-254.

[8] Eckert, C., "On Security Models", Proceedings of the IFIP TC11 12th International Conference on Information Security, Samos, Greece, May 1996.

[9] Flanagan, D., "Java in a Nutshell", O'Reilly & Associates, third edition, 1999.

[3] RMI-Patch applied by Microsoft Service Pack.

[10] Gamma, E., Helm, R., Johnson, R., Vlissides, J., "Design Patterns -- Elements of Reusable Object Oriented Software", Addision Wesley Publishing Company, Reading Mass., tenth edition, 1997.

[11] Harrer, A., Herzog, Ch., "SYPROS Going IDLE -- from a Classical ITS to an Intelligent Distributed Learning Environment", in: Proceedings of ICCE '99, 7th International Conference on Computers in Education, p.836-839, Sep. 1999.

[12] Harrer, A., "Both sides of the coin -- blending cognitive and motivational aspects into a tutoring strategy", in: Proceedings of the International Conference on Computers in Education, ICCE97, p.188-195, 1997.

[13] Herzog, Ch., "Cooperation and competition of syntax-oriented and execution-oriented problem solvers in intelligent programming tutors", in: Artificial Intelligence in Education -- Knowledge and Media in Learning Systems, Proc. AI--ED 97, Kobe, Japan, p.309-316, 1997.

[14] —"Java Native Interface", JDK Documentation, Sunsoft, 1996.

[15] Martha C. Polson, Richardson, J. J., "Foundations of Intelligent Tutoring Systems", Lawrence Erlbaum Associates, Hillsdale, New Jersey, 1988.

[16] —"Java Remote Method Invocation -- Distributed Computing for Java", Whitepaper, http://java.sun.com/marketing/collateral/javarmi.html, Sun Microsystems Inc., 1999.

[17] —"Java Remote Method Invocation Specification", Revision 1.50, JDK 1.2, Sun Microsystems Inc., October 1998.

[18] —"RMI-IIOP Programmer's Guide", http://java.sun.com/products/jdk/guide/rmi-iiop/rmi_iiop_pg.html, Sun Microsystems Inc. and IBM Corporation, 1999.

[19] Rumbaugh, J., Jacobson, I., Booch, G., "The Unified Modeling Language Reference Manual", Addision Wesley Longman, Inc., Reading Mass., Dec. 1998.

[20] Tanenbaum, A. S., "Modern Operating Systems", Prentice Hall Inc., 1992.

[21] McPherson, Scott, "Java Servlets and Serialization with RMI", in: Java Developer Connection, http://java.sun.com/developer/technical/Articles/RMI/rmi/index.html, Maczieg Software, 1999.

[22] —"The Common Object Request Broker: Architecture and Specification", Object Management Group, Wiley, New York, 1995.

A Java-based Interactive Learning System of Junior High School Level Geometry

Yu-Ru Chen*, Tzyy-Leng Allen Horng, and Don-lin Yang***
**Department of Information Engineering*
***Department of Applied Mathematics*
Feng Chia University
100, WenHwa Rd, Seatwen, Taichung, Taiwan407
**Tel: +886-4-4517250 ext. 3743*
***Tel: +886-4-4517250 ext. 5126*
**Fax: +886-4-4516101*
***Fax: +886-4-4510801*
**E-mail:dlyang@fcu.edu..tw*
***E-mail:tlhorng@math.fcu.edu.tw*

In this paper we propose a Java-based CAI system that provides a learning-by-doing environment with hands-on exercise and instant interaction capabilities on the World Wide Web. Our current topics of interest is the Euclidean geometry for junior high school students. To design the system, we adopt the theory of concept map to construct teaching and learning materials. We are currently testing the system and has observed that it does significantly help students in learning geometry.

Keywords: **CAI, concept map, Euclidean geometry, Java applet**

1 Introduction

As computer science and Internet technology make speedy progress at every moment, computer aided instruction (CAI) plays an important role in our life, especially in future education for global citizens at every corner of the world. Many researches focus on the web-CAI, but there are some drawbacks in these systems:

(1) Some of these systems simply use graphs or animations and text to describe the meanings of the teaching materials. Although this way of displaying is more lively than the traditional textbooks, the learners still need to stare at the screen uncomfortably to read the text thoroughly to understand its meanings. Besides, some subjects such as mathematics need to be learned by practicing with examples.
Plain text reading is just not enough.

(2) Most multimedia web-CAI systems requires high bandwidth, which is still a problem for the current internet infrastructure. Long waiting time for response will definitely degrade the effect of learning no matter how well designed the web-CAI system is.

To demonstrate our ability of conquering the above problems, we have developed a web-CAI system in Chinese (http://www.math.fcu.edu.tw/~tlhorng/geometry) for teaching and learning junior-high-school Euclidean geometry (named just geometry in the following context). Students can have great fun in learning on our system owing to its highly interactive and experiment-oriented features. Besides, the system is designed all using small-size Java applets, and is therefore robust enough to tolerate the usual congestion on the internet.

The rest of the paper is organized as follows: Section 2 introduces our design theories such as the concept maptheory and dynamic geometry method; Section 3 shows the implementation and Section 4 summarizes the whole work and some future enhancement.

2 Theories behind our design

First we employ the concept map theory to plan the curriculum, and then apply dynamic geometry method to design the curriculum to be highly interactive, problem-oriented and, most importantly, interesting. In this way, the learners are encouraged to learn by playing with those Java applets, and to construct their knowledge system by concept map theory.

2.1 Concept map theory

In order for learners to make a meaningful learning, Ausubel present a meaningful learning theory [1]. The idea in this theory is that whenever to learn a new concept or a new knowledge it must base on the prior experience. Ausubel's theory considers that the relation between the new concept and learner's prior knowledge plays an important role in the meaningful learning. Whenever the new knowledge, learners' prior concept, and proposition framework are successfully joined, learning is created. In other words, learners can make a meaningful learning by utilizing learners' prior concept to link the new concept to organize the whole knowledge. Novak further presents a concept mapping method for the purpose of verifying Ausubel's theory [1]. Concept map is composed of propositions. Every proposition contains two concept nodes and a relation link between them. In a concept map, concepts are represented in a hierarchical way. A general or summarized concept is put in an upper hierarchy, and a specific or particular concept is put in a lower one. A graph describing the integration of concepts from the lower levels to higher ones and the relation linking among them is called concept map that can represent a knowledge structure effectively.

2.2 Dynamic geometry method

To teach or learn geometry effectively, we usually have the following two aspects in mind [2]: knowledge developing (the deductive method), and knowledge acquiring (the generalizing method).

Both are equally important. However, most of the current geometry curriculum in junior high school has been emphasizing on how to prove a geometric problem by the deductive way, and frequently ignoring how to the generalize a geometry concept by experiments and observation. Our web-CAI system present the curriculum in both ways and particularly emphasizes the latter one.

3 Implementation

In our web-CAI system, the whole curriculum is problem-oriented, and each geometric problem, besides its proof, is designed to be explored by experimentation which is implemented by Java applets. Java applet is selected owing to its full-featured library for designing internet applications and its platform-independent portability [3-5]. The code was written by JDK 1.1 and is entirely in Pure Java™.

3.1 Drawing the concept map

There are four steps to draw the concept map: 1. concept seeking, 2. concept categorization, 3. concept hierarchy, 4. concept relation.

Concept seeking: First list all important concepts to be taught. A concept is the foundation unit stored in the human brain, although everyone may store a same thing by concepts in his own different way. That is why everyone may response differently when seeing or hearing an identical event at the same time. This individual opinion of everybody is called the concept.

Concept categorization: After seeking for concepts, this step is to divide concepts into two parts: event and target. Taking circle as an example in our geometry curriculum, we can list twelve relevant important concepts as categorized in table 3.1

Concept hierarchy: After categorizing the concepts, we further place them into a hierarchy. As mentioned above, a more general concept will be put in a upper level, while a more specific one in a lower level. Figure 3.1 is the hierarchy chart of Table 3.1.

Concept relation: After putting all concepts in a hierarchy, we further denotes those relations among concepts to form a complete concept map. Following the above, the circle's concept map is shown in Figure 3.1.

Event	Target
line	relationship between a circle and a line
chord	relationship between a chord and the diameter
chord and center	relationships between a chord and its distance to center
central angle	relationship between a central angle and a chord
arc	relationship between a chord and a arc
circumferential angle	relationship between a arc and a circumferential angle
tangent	two tangents from an external point to a circle are equal in length
quadrilateral	the opposing angles of a quadrilateral inscribed in a circle is complementary
triangle	three bisectors are concurrent in a triangle
incenter	Distances of the incenter to the three sides of a triangle are equal
two circles	relationship between two circles
two circles and tangent	tow circle' s common tangent

Table 3.1. Concept categorization

3.2 Composing the plan for teaching materials

By the concept map, we can further propose the teaching materials and write down these ideas into a table called the plan of teaching materials. Following the above, Table 3.2 shows a small part of the plan: the relative locations of two circles and their common tangent.

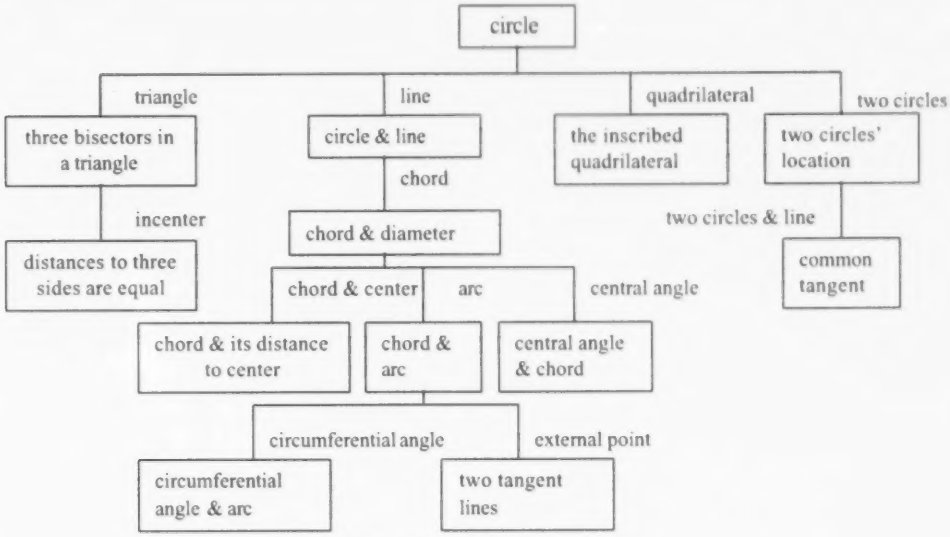


Figure 3.1 Circle' s concept map.

Page	Consist Concept
Circles' locations	There are six kinds of relations for two circles judging from their locations: separated internally, separated externally, tangential internally, tangential externally, intersecting and coincident.
Common tangent	Two circles on a plane can have the following common tangents according to their relative locations: When the two circles are separated externally, there are two external common tangents and two internal ones. When the two circles are tangential externally, there are two external common tangents but one internal one. When the two circles intersect at two points, there are two external common tangents and no internal one. When the two circles are tangential internally, there is only one external common tangents and no internal one. When the two circles are separated internally, there is neither an external common tangent nor an internal one.

Table 3.2 A part of the plan of teaching materials

3.3 Displaying the teaching materials by Java applet

Taking the common tangent of two circles as an example, we display this part of teaching materials by the

Java applet shown in Figure 3.2 (a)-(c). This Java applet is designed that the learner can play around by dragging any center (shown as red dots) of the two circles which will change the distance between these two centers. From the movement, the learner can observe various kinds of common tangents happening for the two circles. If we show it alternatively by some static graph or animation, the learner would have problem catching its meaning effectively.

3.4 The examination module

Besides those Java applets for displaying teaching materials, our web-CAI system also provides an examination module for on-line testing. Through this module, teachers can edit test problems and grade students' answers, and students can take tests and look up for their grades all on our web-CAI system. Four individual applets, in charge of problem editing, examination, grading, and grade looking-up, consist of this examination module. Figure 3.3 particularly shows the problem-editing part, in which teachers can edit a test problem and draw the illustration related to it. Also, all the test problems can be saved in a database server driven by JDBC• Java Database Connectivity. JDBC is a Java-standard SQL database access interface [6]. It provides access to varieties of databases. After teacher edit the examination questions, the students can take the exam on our web-CAI system. On that, students can write down the answers and draw some auxiliary lines on the illustration which may be required for proving a geometric theory or just to help them solve the problem. Teachers can then grade and comment the students' answers, and the students can look up for the grades and teacher's comment later all on our web-CAI system.

4 Conclusions and future work

We have developed a web-CAI system that provides an interactive learning and testing environment on Web. In this way, the learner can learn more effectively than other multimedia-CAI systems. Currently we have chosen Euclidean geometry in junior high school as an example, and plan to extend to other science subjects, the physics and chemistry in the future. Besides, we keep modifying the GUI in our system to be more friendly and interesting. We also plan to choose a junior high school to test our system and evaluate its performance.

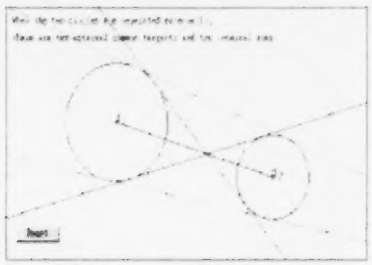


Figure 3.2 (a) A scene of the Java applet of two circles' common tangents. Red points are subject to dragging.

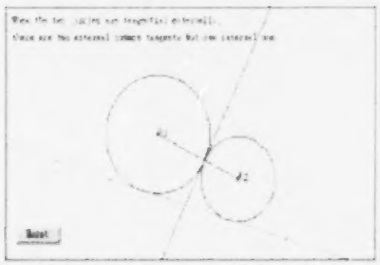


Figure 3.2 (b) Another scene following Figure 3.2 (a).Red points are subject to dragging.

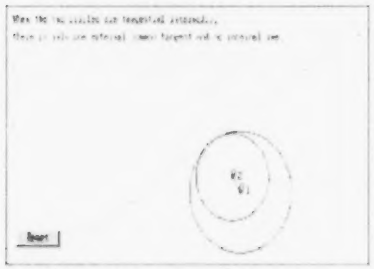


Figure 3.2 (c) Another scene following Figure 3.2 (b). Red points are subject to dragging.

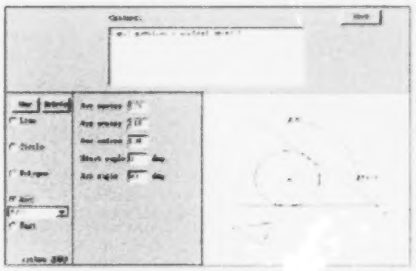


Figure 3.3 Test problem editing part of the examination module.

References

[1] The concept mapping homepage, http://www.to.utwente.nl/user/ism/lanzing/cm_home.htm

[2] Mathematics resources center, National Normal Taiwan University, http://mathsup.math.ntnu.edu.tw/.

[3] Knudsen, "Java 2D Graphics' ', O' Reilly, Cambridge, Massachusetts, (1999).

[4] Arnold and Gosling, "The Java programming language' ', Addison-Wesley, Reading, Massachusetts, (1998).

[5] Deitel and Deitel, "Java : how to program' ', Prentice Hall, Upper Saddle River, New Jersey, (1997).

[6] Reese, "Database Programming With JDBC and Java' ', O' Reilly, Cambridge, Massachusetts, (1997).

A Learner-Centered Navigation Path Planning in Web-based Learning

Akihiro Kashihara, Ryoichi Suzuki, Shinobu Hasegawa, and Jun'ichi Toyoda

The Institute of Scientific and Industrial Research, Osaka Univ., JAPAN
8-1, Mihogaoka, Ibaraki, Osaka 567-0047, JAPAN
kasihara@ai.sanken.osaka-u.ac.jp

The main issue addressed in this paper is how to help learners navigate in existing web-based learning resources. Towards this issue, we introduce a learner-centered navigation path planning. The key idea is to provide learners with a space, in which they can see through WWW pages to plan a navigation path. In this paper, we also demonstrate an assistant system, which is composed of hyperspace map, page previewer, and path previewer. The page previewer generates an overview of each WWW page in the map by extracting representative information from the HTML file. The path previewer helps learners make a sequence of the pages previewed as navigation path plan. These facilities help learners decide which page to visit and plan a navigation path without visiting hyperspace. This paper also describes a preliminary evaluation with the assistant system. The results indicate that the system facilitates learning and navigation in a more complicated hyperspace.

Keywords: Navigation Path Planning, Learner-Centered, Page Previewer, Path Previewer

1 Introduction

An increasing number of hypermedia/hypertext based resources on the Web has been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based learning resources has accordingly become important, particularly as the realization of lifelong and distance learning.

Web-based learning resources provide learners with hyperspace where they can explore domain concepts/knowledge in a self-directed way from a WWW page to others by following the links among pages to achieve a learning purpose. However, learners often fail in making the navigation path since they do not know which link to follow for achieving their learning purpose due to the complexity of hyperspace [3], [9]. They may alternatively reach an impasse due to a cognitive overload, which is caused by diverse cognitive efforts at setting up local learning purposes, comprehending the contents included in nodes, etc., in the exploratory learning [6], [11]. How to facilitate learners' navigation and learning is consequently a major issue in educational hypermedia/hypertext systems [1], [11].

The main topic addressed in this paper is how to help learners navigate in existing web-based learning resources. Current work on educational hypermedia/hypertext systems has provided a number of navigational aids such as spatial/concept maps and adaptive navigation [1], [4], [5]. However, these aids can not be always available to existing web-based learning resources since it is hard to grasp semantic relationships among the WWW pages, on which the navigational aids are founded, without analyzing the contents of the learning resources.

In this paper, we discuss a learner-centered navigation path planning. The key point of this idea is to provide learners with a space, in which they can see through web-based learning resources to make a navigation path plan, apart from hyperspace. Such planning space is also expected to facilitate their learning since they can focus mainly on comprehending the contents of the learning resources in hyperspace. We have accordingly developed an assistant system for the navigation path planning. This system provides learners not only with hyperspace map but also with page previewer and path previewer. The page previewer extracts information attached to some HTML tags in a WWW page, which can be considered representative of the page, from the HTML file, and displays it as an overview of the page. The path previewer also makes a sequence of the pages previewed, and displays it as navigation path plan. These facilities help learners decide which page to visit and make a navigation path plan without visiting hyperspace.

This paper also describes a preliminary evaluation of learner-centered navigation path planning with the assistant system. The results indicate that the system facilitates learners' navigation and learning in hyperspace, particularly in more complicated hyperspace

Before discussing the learner-centered navigation path planning, let us first consider navigation in hyperspace.

2 Navigation in Hyperspace

2.1 Problems

In hyperspace, learners can explore nodes in a self-directed way by following links among the nodes to learn domain concepts/knowledge embedded in the explored nodes. The exploration involves making a path called navigation path [9]. However, learners can not foresee what they can explore next from the current node and can not decide which link to follow for achieving their learning purpose, often failing to make their navigation path [11]. This is mostly caused by the complexity of hyperspace. The learners may alternatively reach an impasse since they need to concurrently make diverse cognitive efforts at setting up local learning purposes, comprehending the contents explored, etc., in exploratory learning [6], [7], [11].

2.2 Navigation Aids

The important points towards the navigation problem are how to give learners an unobstructed view of hyperspace and how to call their attention to making a navigation path.

As current representative navigational aids, there are spatial maps and concept maps. Spatial maps represent nodes and links that compose the structure of hyperspace [4], [8]. Concept maps consists of nodes and links representing the structure of domain concepts to be learned, which nodes are mapped on the corresponding nodes in hyperspace [5]. In both of spatial and concept maps, nodes are tagged with their titles, which are intended to represent the contents of the nodes. In concept maps, links are also tagged with descriptions representing the semantic relationships between the nodes. Although such tag information may be insufficient for learners to make a navigation path plan, the spatial and concept maps provide learners with a space, apart from hyperspace, for considering navigation paths.

Another solution to the navigation problem is adaptive hypermedia, which supports navigation in hyperspace by annotating nodes and links to be visited, hiding nodes and links not to be visited, etc [1]. Such adaptive navigational aids are founded on semantic relationships among domain concepts/knowledge and learners' exploration status.

These above representative navigational aids would generally work well in educational hypermedia/hypertext whose semantic structure has been given or analyzed [2]. However, it is doubtful whether they apply to web-based learning resources [12]. Existing web-based learning resources mostly have no concept maps. It is also hard to identify semantic structure of domain concepts/knowledge embedded in the learning resources. Although there are web-based learning resources with site maps, the anchors included in the maps do not always allow learners to foresee the contents of the WWW pages. In addition, adaptive navigational aids are not always applicable since existing web-based learning resources generally have no clear description of semantic relationships among WWW pages, which is indispensable for executing the adaptation. In order to apply these navigational aids to existing web-based learning resources, it is necessary to analyze semantic structure of the domain concepts/knowledge beforehand. In this paper, however, we address the issue of how to support learners' navigation without the analysis.

2.3 Navigation Path Planning and Execution

Let us now introduce a learner-centered navigation path planning. The key idea is to provide learners with a space where they can plan a navigation path with an overview of each WWW page. In other words, learners have two spaces, which are space for navigation path planning and hyperspace for executing the plan. In the planning space, learners decide which page to visit and the sequence of pages visited. In the hyperspace, they are expected to explore hyperspace as planned. The navigation path planning and plan execution are repeated during learning in hyperspace.

The distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of learning resources in hyperspace. Since the navigation path plan also gives learners an overview of the contents to be learned before exploring hyperspace, their learning can be improved.

3 Learner-Centered Navigation Path Planning

We next discuss how to support learner-centered navigation path planning and demonstrate an assistant system that has been already implemented.

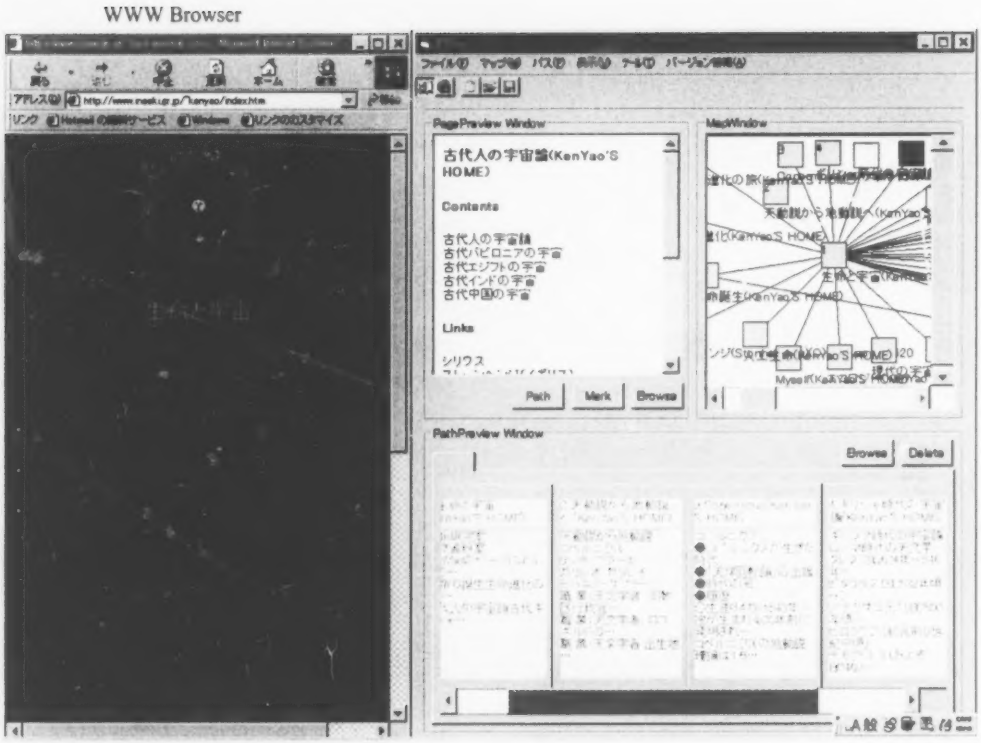


Figure 1. User Interface.

3.1 Framework

Let us first consider what kind of information should be presented for supporting navigation path planning. Although spatial maps of web-based learning resources are necessary for considering navigation paths, the maps alone may be insufficient for learners as mentioned above. It is indispensable to provide them with some additional information. However, planning with the full contents of the WWW pages causes the same navigation problem as hyperspace usually produces. This suggests the necessity to give learners an informative overview of the contents. In this paper, we introduce a page previewer that tries to extract keywords, sentences, or images to be considered representative from a WWW page to display them as the preview of the page.

In addition, the navigation path planning involves considering the relationships between WWW pages explored, changing the plan, and replanning over again. We accordingly introduce a path previewer that makes a sequence of the previewed pages the learners want to visit. The path previewer helps the learners plan, change, and remake navigation path with the sequence of the previewed WWW pages.

Figure 1 shows a user interface of the assistant system for learner-centered navigation path planning. The system is composed of spatial map, page previewer, and path previewer. The spatial map represents hyperspace of a web-based learning resource selected by learners as network of nodes corresponding to the WWW pages. It is automatically generated and displayed in the map window when they select the learning resource. The spatial map represents the WWW pages only within the same WWW site where the homepage selected by the learners is located. The links from the site to others are omitted. Nodes in the spatial map are tagged with page titles indicated by title tags in the HTML files.

In the spatial map, the node corresponding to the WWW page learners currently visit with browser is colored with red. The learners can start planning a navigation path from the current node by following the links. The path planned is restricted by the structure of the spatial map. In left mouse-clicking a node, they can have an overview of the WWW page corresponding to the clicked node in the page preview window. The color of the node previewed is also changed into red. Nodes next to the red node are also colored as yellow. If it is hard to see connections between the red node and the next nodes, a pop-up menu including the titles of the next nodes appears by means of right mouse-clicking the red node. Selecting one title from the menu, learners can see an overview of the corresponding node in the page preview window.

Table 1. HTML Tags Searched.

HTML Tags	Meanings
- About contents	
1.Title	Title of page
2.H1 to H3	Headings of page
3.Font Size/Color/Face	Font size, color, and figure
- About links	
A href	Link to another page
- About images	
Img	Image file

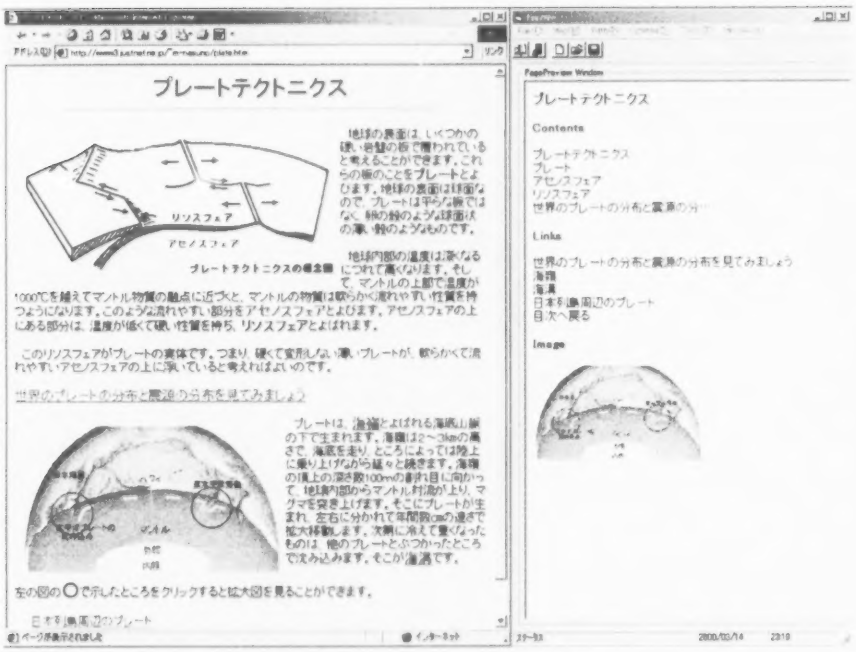


Figure 2. An Example of Page Preview.

The learners can also put the previewed node in the path preview window, making a navigation path plan. The learners are expected to explore hyperspace as planned with browser. When they want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a new path.

In the following, let us explain the page previewer and path previewer in more detail.

3.2 Page Previewer

The important point to generating an overview of a WWW page is how to extract information representing the contents of the page. Assuming that such information is located with the HTML tags shown in Table 1, the page previewer extracts words, sentences, or images indicated by these tags to display them as page preview. We heuristically consider such assumption valid. Figure 2 shows an example of the page preview. The right window shows the preview of a WWW page shown in the left window.

The information extracted from a WWW page is classified into the contents, the links out of it, and images included. As for the contents, the page previewer searches for the HTML tags in order from top to bottom in Table 1, and extracts words or sentences attached to the tags. When extracting a sentence, it displays not all words but

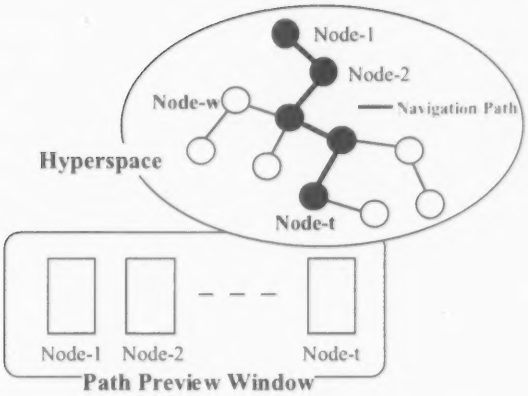


Figure 3. Restriction on Navigation Path Planning.

fifteen words from the head of the sentence. If the number of HTML tags included in the HTML file is large, the page previewer deals with ten HTML tags that are searched from the top in Table 1. For example, let us consider a WWW page including a large number of HTML tags such as one title tag, six *H1* tags, seven *H2* tags, nine *H3* tags, etc. In this case, the page previewer focuses on ten tags, which are the title, six *H1* and three *H2* tags, and displays the information attached to these tags.

As for the links out of the page, the page previewer searches for *A href* tags in the HTML file to display the descriptions of the links. If the descriptions indicate the URL, they are not displayed. If the number of *A href* tags is large, the page previewer displays only five link descriptions to be found from the head of the HTML file. As for the images included in the page, the page previewer searches for *Img* tags in the HTML file, and displays one image whose file size is the largest.

Learners can see the preview of a WWW page by mouse-clicking the corresponding node in the spatial map. Since the node previewed is colored with red, they know where they are previewing in the spatial map. If they can not foresee the contents of the page, they can push the *Browse* button under the page preview window or double-click the node to look at the full contents in browser. However, these operations are not recommended in planning. In making a navigation path plan, the learners can include the node previewed in their navigation path by pushing the *Path* button. Mouse-clicking the *Mark* button, in addition, they can mark the node previewed, which they do not want to immediately put in the path preview but to memorize.

3.3 Path Previewer

In the path preview window, the path previewer sequences the nodes previewed, which nodes are put in order by learners. The order of the previewed nodes represents a navigation path plan. The adjacent nodes are also adjacent each other in hyperspace. If the learners attempt to put a node in the sequence, which is not directly linked to the tail node of the sequence in hyperspace, the path previewer disables the *Path* button. For example, let us consider a learner who works out a navigation path plan as shown in Figure 3. If he/she tries to put *Node-w* in the plan, he/she is provided with a warning from the path previewer since the *Node-w* is not linked to the tail node (*Node-t*) of the sequence in hyperspace. In this way, the navigation path planned has to follow the link structure of hyperspace.

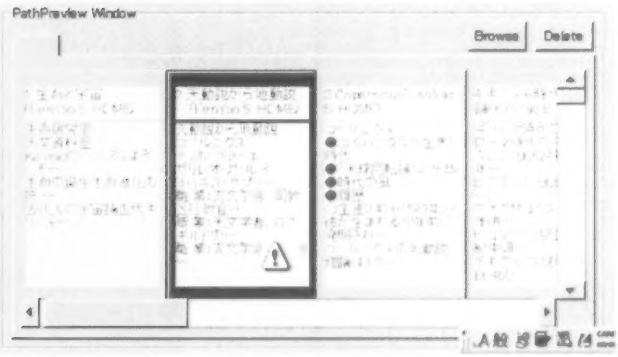
The learners can also delete any node in the navigation path plan by mouse-clicking it and selecting *Delete* button in the upper right corner of the path preview window. In order to help learners select one of some branches from a node, the page previewer additionally displays these branches with some path preview windows concurrently.

3.4 Plan Execution and Replanning

Using the page preview and path preview windows, learners are expected to decide a navigation path and then to start exploration in hyperspace. They are also expected to follow the navigation path plan during the exploration. The node in the plan corresponding to the WWW page, which the learners currently browse, is framed with blue. This allows them to know which node they are browsing. When they put the mouse-cursor on a link in the WWW page, which link indicates the node next to the framed node, the node is also framed with yellow such as Figure 4(a). This also allows them to know which link to follow in the WWW page.

The learners do not always need to follow the plan. They can explore nodes with browser, which are not included

(a) Attention to Next Page.



(b) Warning.

Figure 4. Attention and Warning in Path Preview Window.

in the plan. As shown in Figure 4(b), however, the path previewer put a warning icon on the node at which the learners run off in the plan. When they also want to change or cancel the navigation plan during the exploration, they can return to the navigation path planning windows and remake a navigation path plan from the node corresponding to the current page on browser.

In this way, learners are expected to repeat the navigation path planning and plan execution to accomplish the exploratory learning in hyperspace.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the effectiveness of learner-centered navigation path planning with the assistant system, we have had a preliminary experiment. The main purpose of this experiment was to ascertain if navigation path planning with the system facilitates navigation and learning in hyperspace compared to navigation and learning without the system. We also prepared two learning resources, which had comparatively simple and complicated hyperspace, and ascertained for which resource the system can assist in navigation and learning more effectively.

Table 2 shows the two learning resources, which describes the number of pages, the number of links per page, which was calculated except for navigation links such as *Next*, *Back*, and *Top*, and the longest distance from the homepage to terminal page that has no link. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were 7 graduate and undergraduate students in science and technology.

We set four conditions, which were (1) planning and execution with the system in the learning resource 1 (*Simple-With*), (2) exploration in the learning resource 1 without the system (*Simple-Without*), (3) planning and execution with the system in the learning resource 2 (*Complicated-With*), and (4) exploration in the learning resource 2

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	32	161
Number of Links per Page	1.2	2.2
The Longest Distance from Homepage to Terminal Page	3	7

Domain of learning resource 1: Life and space.
Domain of learning resource 2: Life in sea.

Table 3. Average Scores of Problem-Solving.

Condition	Total	Single Problems	Compound Problems
Simple-With	75%	100%	60%
Simple-Without	71%	78%	67%
Complicated-With	79%	83%	75%
Complicated-Without	62%	78%	50%

Table 4. Average Scores of Revisit per Page.

	Revisit		Revisit
Simple-With	1.58	Complicated-With	1.83
Simple-Without	1.56	Complicated-Without	4.04

without the system (*Complicated-Without*). Subjects were provided with Microsoft Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource without the system and learned the other with the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given several problems as learning purposes for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, the effects on learning were measured by the scores on both problems. The effects on navigation in hyperspace were measured by the number of revisiting pages in hyperspace [10]. The time of learning in each condition was limited to thirty minutes.

The procedure of the experiment with each subject was as follows:

(1)The subject was given the explanation about how to use the assistant system before learning and then single and compound problems for the learning resource 1 or for learning resource 2.

(2)He/she was required to explore answers to the problems. In *Simple-With* or *Complicated-With*, he/she was next required to use the assistant system for making a navigation plan and to use the WWW browser for exploring hyperspace. In *Simple-Without* or *Complicated-Without*, he/she was next required to use only the WWW browser to explore hyperspace. In each condition, he/she was provided with a space where he/she can copy and paste the contents of the WWW page considered as the answers.

(3)When he/she finished finding out the answers or thirty minutes passed, the contents copied and pasted by him/her was checked and the scores was calculated as the percent of corrected answers. The number of revisit per explored page was also checked.

Comparing the scores and the numbers of revisit per page explored under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the effectiveness of the assistant system.

4.2 Results and Discussion

Table 3 shows the average score on each condition. The average score (75 %) on *Simple-With* was slightly higher than the average score (71 %) on *Simple-Without*. On the other hand, the average score (79%) on *Complicated-With* was considerably higher than the average score (62 %) on *Complicated-Without*. The difference between the average scores in the compound problems on *Complicated-With* and *Complicated-Without* was particularly large.

Table 4 shows the average number of revisit per page explored on each condition. Although the difference between the average numbers of revisit on *Simple-With* and *Simple-Without* was very small, there was a great difference between the average numbers of revisit on *Complicated-With* and *Complicated-Without*.

The above results indicate that the assistant system produced good effects on learning such as integrating the contents of some pages in a more complicated hyperspace. As for effects on navigation, the system facilitated navigation in a more complicated hyperspace. In a simpler hyperspace, on the other hand, the assistant system could not be so fruitful since it was able to easily see through the learning resource even without the system. Although we need a detailed experiment with more subjects, the assistant system can effectively help learners navigate and learn in a complicated hyperspace.

5 Conclusion

This paper has proposed a learner-centered navigation path planning for learning with existing web-based resources. The important point is to provide learners with a space where they can see through WWW pages to make a navigation path plan. As the advantages, learning in hyperspace can be improved since the distinction between navigation path planning and plan execution allows learners to focus mainly on comprehending the contents of the learning resources in hyperspace. The navigation path plan can also give learners an overview of the contents to be learned before exploring hyperspace.

This paper has also demonstrated an assitant system including page previewer and path previewer. These previewers allow learners to decide which page to visit and make a navigation path plan without visiting hyperspace. In addition, this paper has described a preliminary evaluation of the learner-centered path planning with the system. The results indicate that the system produces good effects on learning and navigation in a complicated hyperspace.

In the future, we need a more detailed evaluation of the learner-centered navigation path planning. We would also like to provide more adaptive aids in the page and path previews.

References

[1] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia, Journal of User Modeling and User-Adapted Interaction, 6, (1996) 87-129.

[2] Brusilovsky, P., and Eklund, J. A Study of User Model Based Link Annotation in Educational Hypermedia, Journal for Universal Computer Science, Vol.4, No.4, pp.429-448 (1998).

[3] Conklin, J. Hypertext: An Introduction and Survey, Computer 20, 9 (1988), 17-41.

[4] Domel, P. WebMap - A Graphical Hypertext Navigation Tool, in Proc. of Second International WWW Conference (1994), http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Searching/doemel/www-fall94.html.

[5] Gaines, B.R. and Shaw M.L. G. WebMap: Concept Mapping on the Web, in Proc. of Second International WWW Conference (1995), http://www.w3.org/Conferences/ WWW4/Papers/'^4

[6] Kashihara, A., Uji'i, H., Toyoda, J. Visualizing Knowledge Structure for Supporting Exploratory Learning in Hyperspace , in Proc. of HCI International 99, pp.667-671 (1999).

[7] Kashihara, A., Uji'i, H., and Toyoda, J. Reflection Support for Learning in Hyperspace, Educational Technology, Vol.39, No.5, pp.19-22 (1999).

[8] Mukherjea, S., Foley, J., and Hudson, S. Visualizing Complex Hypermedia Networks through Multiple Hierarchical Views, in Proc. of ACM SIGCHI 95 (1995).

[9] Nielsen, J. The Art of Navigating Hypertext, Communication of the ACM, 33, 3 (1990), ACM Press, 297-310.

[10] Tauscher, L., and Greenberg, S. How people revist web pages: empirical findings and implications for the design of history systems. International Journal of Human-Computer Studies, 47, 1 (1997), 97-137.

[11] Thuering, M., Hannemann, J., and Haake, J.M. Hypermedia and Cognition: Designing for Comprehension. Communication of the ACM, 38, 8 (1995), ACM Press, 57-66.

[12] Zeiliger, R., Belisle, C., and Cerratto, T. Implementing a Constructivist Approach to Web Navigation Support, in Proc. of World Conference on Educational Multimedia and Hypermedia '99 (1999).

A Methodology for Learning Pattern Analysis from Web Logs by Interpreting Web Page Contents

Chih-Kai Chang and Kuen-Shan Wang
Department of Information Management
Da-Yeh University
Da-Tsuen, Chang-Hwa 51505 Taiwan, R.O.C.
E-mail: chihkai@mail.dyu.edu.tw

As Web-based course become popular, the Web system accumulates a large amount of log data. Because the log data was generated by learners' behavior on the Web-based course, many researchers agree that analyzing the Web log will bring benefits for learners, instructors, and the Web site manager. In general, one record of Web log can indicate "which Web page was accessed", "who access that Web page", and "when the Web page was accessed". Although many interesting results can be derived merely depending on the general Web log, some important meanings of the Web log were not considered in previous researches. In other words, the content, represented by the Web page, is not included in the general Web log. For instance, a Web page may present homework, a discussion article, a section of curriculum, or a grade reports. However, previous research did not consider the represented content of a Web page in the Web log, in which only the file name of the accessed Web page is generally identified. This paper use data mining technology to analyze learners' online behaviors for mining learner's patterns by transforming general Web log to a content perspective. Hence, the methods of previous research still can be used to find the more meaningful results. Most important of all, our methodology finds patterns based on learning behaviors instead of browsing behaviors.

Keywords: **Web-based course, Web log, Data mining technology.**

1 Introduction

As Web-based course becomes popular, various learning activities can be running on the Web [1]. The asynchronous discussion activity, homework assignment and submission, announcement, and grade reports all can be executed on the Web. Because all the learning activities are represented as Web pages, the Web server will accumulate a large amount of log data for every Web page. Basically one record of the Web log can indicate which page was access by someone in sometime. Hence, many researches analyzed the Web server log to figure out users' motivation, users' response, browsing pattern, and the network traffic [2, 3, 4]. Furthermore, analyzing students' on-line learning behaviors and on-line problem solving activities can also discovery meaningful results [5].

There are at least 116 products of Web log analysis for commercial web sites [6]. The technologies used for analyzing Web server log evolve from traffic-based or time-based assessment to user access pattern analysis. For example, Perkowitz uses access patterns to construct an adaptive Web site [7]. Hence, the interested Web pages will be linked and organized as a proper view for every user according his/her access patterns. The *path* concept, users' sequential Web page access records, is important for constructing user access pattern for Web logs. For instance, Stuart Schechter [8] create users' path profile to predicate users' browsing behavior. Consequently, the field of Web log analysis is growing for the purpose of custom services.

Recently, applications of Web log analysis integrate data mining techniques to focus on the customer behavior patterns. It is because the predictive modeling and link analysis operations in data mining

techniques can be used to answer questions such as "Which of my customs will prove to be good, long-term valuable customers and which will not?", "How can I sell more to my existing customers?", "Is there a recognizable pattern in which my customers acquire products or use services so I can market to them just-in-time?", and so on [9]. Consequently, we intuitively apply data mining techniques to Web log analysis of an instructional Web site.

For Web-based instructors, their requirements for Web log analysis differ from managers of commercial sites. One of the reasons is as Raphen Becker said, "Because many existing systems are targeted toward commercial webs, the answer is yes, course webs require different systems. One reason is simple: most instructors (and even institutions) cannot afford the commercial products, which are priced toward industry and not towards academia."[10]. Although researchers realize the differences between course webs and commercial sites, the proposed methodology for Web log analysis still inheritance from the Web logs analysis products for commercial sites. For instance, Clio project pays efforts to answer the questions such as "What are the more popular parts of the course web?", "How do readers reach particular pages?", and "Can they quickly reach the pages they want?" so on. Unfortunately, most questions of that kind can be answered by existing Web logs analysis products.

When analyzing Web logs of a course Web, we concern that one encounters what specific problems, which can not be answered by existing Web logs analysis products. In other words, only the learning characteristic of the Web-based learning environment can originate the specific problems. Our previous research focus on providing various summary report for Web instructor to solve that problems, which can not be answered by Web log analysis, from any perspectives [11]. Hence, the questions, which a instructor may ask, should be "What are the meanings of the more popular parts of the course web in learning hierarchy?", "What is the concept that leads learners to reach particular pages?", and "Can learners quickly reach the learning goals by reorganizing Web pages?" so on. In other words, the reports of existing Web logs analysis products should be interpreted to mining the pedagogical meanings by instructors, instructional designers, Web designers, and course web architects. Consequently, it is necessary to propose methodology for discovering learner (not user) access pattern in the Web-based course.

To mining the pedagogical meanings from Web logs, the first requirement is to understand the content of every Web page. In other words, the instructor of the Web course not only need to know 'who accessed the Web page', 'when the Web page is accessed', and 'from where the learner come', but also should know 'what the Web page contains'. However, it is difficult to represent the content of a Web page with symbols. The reason is that the content of a Web page may contain many concepts. Consequently, the first step for understanding the pedagogical meaning is reconstructing the Web pages in the site of a Web-based course by endowing only one topic or concept for each Web page. While breaking a Web page into single concept Web pages, one would find that some concepts are not atomic concepts. That is because a major concept will contain many sub concepts. Hence, the second step for understanding the pedagogical meaning of a Web page is to identify its location within a concept hierarchy instead of its location within the hypertext hierarchy.

The second requirement for discovering learners' learning pattern is to mining sequential access paths on previous aforementioned concept hierarchy. Although there are methodologies to reconstruct navigating paths of users' behaviors on a Web site, that information is not enough for a Web instructor to make some pedagogical decisions. The users' access (behavior) pattern can only help Web site manager improving Web site schema because a Web instructor still can not figure out learners' intention merely by analyzing Web logs without supports of the Web page content. The proposed concept hierarchy presents a feasible style for supports of interpreting the Web page content. After learners' navigating paths on a Web site are transforming to navigating paths on the concept hierarchy, a Web instructor can comprehensive how learners learn from the information of what learners read.

This paper proposes a methodology to mining learners' learning pattern by transforming learners' Web page access sequences to sequences of learning a concept in Web logs. The methodology is supported by traditional web logs mining algorithms, which is designed for discovering users' access pattern on a Web site. This methodology is not used to replace traditional web logs mining algorithms nor is arguing that concept hierarchy is a suitable web site schema. Rather, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor get more feedback from learners' navigation on the Web course site. Broadly speaking, this methodology contribute to apply traditional web logs mining algorithms to a specific domain in the technical aspect and progress assessment skills in the Web-based distance learning aspect.

2 Illustrative Example

In overview, there are two steps in this illustrative example of detecting learning status. The first step is data preparation. We design a sophisticate structure of a Web site so that we can recognize the content of the accessed Web page. The second steps will find pedagogical meanings from the contents of the preferred Web pages. In this illustrative example, the result of step two will show that learner is not familiar with the learning topic.

2.1 Data Preparation

The required data was collected from the students in an undergraduate course of Perl programming. Perl is a high-level programming language written by Larry Wall. Perl is a very popular programming language for system administrators and CGI script authors. After a brief introduction of Perl, students were asked to study the Web pages extracted from Perl manual. There are three topics in the prepared Web pages. First topic of Web pages demonstrates how to execute the Perl interpreter, called *Perlrun* in Perl manual. Second topic of Web pages explains the Perl model for declaring importing, and calling a subroutine, called *Perlsub* in Perl manual. Third topic of Web pages describes associativity and precedence of Perl operators, called *Perlop* in Perl manual. Consequently, learners' behaviors recorded by Web logs can be recognized by the topic of accessing Web page.

Synopsis and description compose each topic of Web pages. Synopsis is a summary of a topic and generally contains no more than one page. Figure 1 illustrates the synopsis of the Perlsub topic. Description explains the details of a topic in original Perl manual. For illustration, description for each topic was reorganized into two Web pages. In general, synopsis of a topic is prepared for learners who are familiar with that topic. Learners who are learning a topic will prefer the description of that topic. Hence, we can help a learner just in time if he/she is always looking around the description of a topic.

Aforementioned structure is content structure of learning materials. To present learning materials in a hypertext style, a hyperlink structure is required. We use the full connection style to link all Web pages so that learners can navigate to any destination in any Web page.

Figure 1. Synopsis of Perlsub.

Figure 2 shows the concept structure of the learning materials on the Web site. The notation P_i indicates the Web pages. Although the overview structure is composed of concept hierarchy and contents of learning materials without hyperlink information, the tree structure above the P_i can be used to interpret the content in the page. For instance, the P_1 belongs to concept synopsis, which is the partial content of the Perlrun topic.

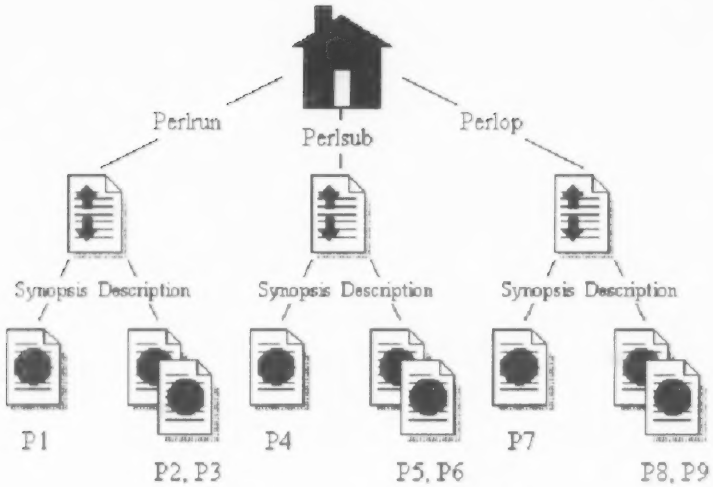


Figure 2. The concept hierarchy of a Web site.

2.2 Mining Processes

There are three learning topics in the Web site, denoted as Perlrun, Perlsub, and Perlop. Each learning topic has two sub concepts, denoted as synopsis and description. The word "synopsis" is used to indicate the Web page for summarizing a topic and the word "description" represents the Web pages that explain a topic in detail. There is an index Web page linking every Web pages to serve as communicating interface with learners. Hence, learners can study any topic in any order through the index Web page. Assume that there is a learner who prefers the "description" Web pages of any topic. In other word, that learner is not familiar with all topics. Hence, the logs of that learner' s browsing behavior on the Web site may be like the sequence:

p2, p3. p2, p8, p9. p5, p8. p5, p1. p2, p5, p6

Because learning can happen in any time, only time nearly browsing behaviors will be related in a learning pattern. Hence, the transaction idea, used in database theory, is involved to cluster learners' browsing behavior. The T*i* means a transaction of the learner' s browsing behavior.

T1: p2, p3
T2: p2, p8, p9
T3: p5, p8
T4: p5, p1
T5: p2, p5, p6

The content of every Web page can be interpreted as a pair of topic and representation style. For instance, p2 belongs to topic Perlrun and is a description of the topic. Hence, p2 is interpreted as (Perlrun, description). After interpreting the transaction data of learner' s behavior, the results are follows.

T1: (Perlrun, description), (Perlrun, description)
T2: (Perlrun, description), (Perlop, description), (Perlop, description)
T3: (Perlsub, description), (Perlop, description)
T4: (Perlsub, synopsis), (Perlrun, synopsis)
T5: (Perlrun, description), (Perlsub, description), (Perlsub, description)

Most of algorithms for mining pattern are derived from aprior [12]. We divide the problem of discovering multi-dimension learner access pattern into four sub procedures, that is litemset phase, transformation phase, sequence phase, maximal phase. Hence, we can use the aprior algorithm for mining pattern. We use the illustrative example to depict the four sub procedures. The litemset phase will generate the large-1 itemset as Table 1.

ID	Large-1 itemset	Support
1	(Perlrun, '*')	3
2	(Perlsub, '*')	3
3	(Perlop, '*')	3
4	('*', description)	4
5	(Perlrun, description)	3
6	(Perlsub, description)	3
7	(Perlop, description)	2

Table 1. Large-1 itemset.

The transformation phase use the feasible IDs of items in the large-1 itemset to substitute items in the transaction of learners' behavior. For instance, the (Perlrun, description) in T1 can be substituted by (Perlrun, '*'), ('*', description), or (Perlrun, description). Hence, the set of feasible IDs is {1, 4, 5}. The result after the transformation phase is following.

T1: {1, 4, 5}, {1, 4, 5}
T2: {1, 4, 5}, {3, 4, 7}, {3, 4, 7}
T3: {2, 4, 6}, {3, 4, 7}
T4: {2, 4, 6}, {1}
T5: {1, 4, 5}, {2, 4, 6}, {2, 4, 6}

The problem is simplified to mining sequential patterns after the transformation phase [13]. Consequently, the sequence phase can generate the large-2 itemset and larget-3 itemset as Table 2 and Table 3.

Large-2 itemset	Support
{1, 4}	3
{2, 4}	2
{4, 3}	2
{4, 4}	3
{4, 7}	2
{5, 4}	3
{6, 4}	2

Table 2. Large-2 itemset.

Large-3 itemset	Support
{1, 4, 4}	2
{4, 4, 4}	2
{5, 4, 4}	2

Table 3. Large-3 itemset.

Finally, the maximal phase will find the most meaningful pattern from large-2 itemsset and large-3 itemset. Initially, the union of large-2 itemset and large-3 itemset is used as the result. Then, some items will be eliminated because they are the subsets of some larger items. For instance, the meaning of {5, 4, 4} is more than its subset {5, 4} and {4, 4}. Hence, the large-2 items, {5, 4} and {4, 4}, will not be deleted from the initial result. Finally, some items will be eliminated because they are less meaningful then items in the result. For instance, the {4, 3} will be deleted because {4, 7} implies {4, 3}. Similarly, the {2, 4} will be deleted because {6, 4} implies {2, 4}. The following table illustrates the result.

Maximal itemset	Real patterns	Support
{6, 4}	{(Perlsub, description), ('*',description)}	2
{4, 7}	{('*', description), (Perlop, description)}	2
{5, 4, 4}	{(Perlrun, description), ('*',description), ('*', description)}	2

Table 4. Maximal itemset.

3 Conclusion

The Web-based learning environment offers opportunities to precisely observe learning processes. However, it is tedious for a Web instructor to discovery useful information from the huge amount of Web logs. Traditionally, a Web instructor uses the Web logs analysis products to realize the unusual parts of a Web site. From the pedagogical standpoint, the results of the Web logs mining algorithms are not very useful for figure out learners' learning process because the contents of Web pages are not considered. This paper proposes a methodology to mining learners' learning pattern, which is related with the Web page contents, from Web logs. The methodology uses Web logs mining algorithms, which is used in Web logs analysis products, and the concept structure embedded in Web pages to mining patterns with pedagogical meanings, so called learning patterns. In our opinions, this methodology presents a framework for integrating traditional web logs mining algorithms with pedagogical meanings of web pages to support Web instructor figure out learners' navigation on the Web course site from the concept hierarchy perspective. Consequently, the approach presented here may be not only a feasible application of traditional web logs mining algorithms, but also a possible direction of Web-based learning assessment research.

Acknowledgements

This project is supported by the National Science Council in Taiwan under contract number NSC 89-2511-S-262 -001.

References

[1] C.K. Chang and G.D. Chen. Constructing Collaborative Learning Activities for Distance CAL Systems. Journal of Computer Assisted Learning, Vol. 13, No. 1, pp. 2-15, March 1997.

[2] R. Fuller and J. de Craaff. Measuring user motivation from server log files. In http://www.microsoft.com/usability/webconf/fuller/fuller.htm

[3] T. Sullivan. Reading reader reaction: A proposal for inferential analysis of web server log files. In Proc. Third Conf. Human Factors on the Web, Denver, Colorado, June 1997.

[4] Sun, C. T. & Ching, Y. T. (1995). Hypermedia Browsing Pattern Analysis. International Journal of Education Telecommunications, 1(2-3), 293-308.

[5] Jihn-Chang J. Jehng. Exploring Learning Potentials in Network-enhanced Learning Environment. In Proc. of ED-MEDIA 99, Seattle, Washington, USA, 1999.

[6] Internet Product Watch (1999). Internet Product Watch: Analysis Products. Online document at http://ipw.internet.com/analysis/index.html (accessed March 25, 1999; no creation or modification date available).

[7] M. Perkowitz and O. Etzioni. Adaptive sites: Automatically learning from user access patterns. In Proc. 6th Int. World Wide Web Conf., Santa Clara, California, April 1997.

[8] Stuart Schechter, Murali Krishnan, Michael D. Smith, Using path profiles to predict HTTP requests. Computer Networks, (30)1-7, pp. 457-467, 1998.

[9] Peter Cabena, et al. Discovering data mining: from concept to implementation. Prentice-Hall, Inc.

[10] Raphen Becker, Kevin McLaughlin, and Samuel A. Rebelsky. Project Clio: Tools for tracking student use of course webs. In Proc. of ED-MEDIA 99, pp. 981-986.

[11] C.K. Chang, G.D. Chen, and Kou-Liang Ou. Student Portfolio Analysis by Data Cube Technology for Decision Support of Web-Based Classroom Teacher. Journal of Educational Computing Research, Vol 19(3), 307-328, 1998.

[12] Rakesh Agrawal, Heikki Mannila, Ramakrishnan Srikant, Hannu Toivonen, A. Inkeri Verkamo: Fast Discovery of Association Rules. Advances in Knowledge Discovery and Data Mining, pp. 307-328, 1996.

[13] Rakesh Agrawal and Ramakrishnan Strkant, Mining Sequential Patterns. ICDE, pp. 3-14, 1995.

A study of collaborative teaching for creative learning in an engineering class

Jiunn-Chi Wu*, Pei-Fen Chang, Shu-San Hsiau*** and Tse-Liang Yeh******

Dept. of Mechanical Eng., National Central University, Chung-Li, Taiwan

**Tel: +886-3-4267335, junwu@cc.ncu.edu.tw*

***Tel: +886-3-4267341, sshsiau@cc.ncu.edu.tw*

****Tel: +886-3-4267339, tlyeh@cc.ncu.edu.tw*

***Center for Teacher Education Program, National Central University, Chung-Li, Taiwan*

***Tel: +886-3-4227151~3853, pfchang@cc.ncu.edu.tw*

We synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of creativity knowledge and skill via web courseware. This paper discusses three main themes of creative learning: 1) the effectiveness of collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via creativity contest and design project. Several findings were observed based on qualitative evaluation of this class. First, the most rewarding course topics identified by the students is the creativity contest and design project because it provides ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, adapting dissimilar teaching style of our collaborative teaching generated anxiety to a number of students, which suggest the structure and sequence of the course development are need to be modified in order to fit students' level of capacity and readiness. Finally, we have demonstrated how problem solving and engineering design procedures can be closely integrated and taught, and what are the necessary knowledge and skills to enhance students' ability to become creative as well as effective problem solvers.

Keywords: **Collaborative teaching, Creative learning, Web-based learning**

1 Introduction

Creativity is inherent and a native intelligence. Many studies, show that the creative cognition can be trained and learned [1, 2]. Therefore, proper education and nourishing environment can foster creativity. *Creative problem solving* (CPS) is referring to use creativity or creative thinking for problem solving, which is a learning model being actively studied [3, 4]. It helps student use systematic method to solve a complex and realistic problem, possibly with multiple solutions. Students brainstorm to generate all possible solutions, categorize and evaluate solutions, develop implementation plan, and finally execute the plan [3]. CPS emphasizes the practice of creative thinking, implementation of creativity, and stresses on the creative leaning process. It can be regarded as a learning model for knowledge synthesis.

It is our responsibility and challenge as teachers to educate student who will be able to succeed in the high-tech environment. To educate students to cope with the rapidly changing world, they must not only to actively acquiring new knowledge, but also to have the skill of creative problem solving. In reflecting such responsibility and challenge, the course of "*Open-ended Creative Mechanical Engineering Design*" was offered in Department of Mechanical Engineering, National Central University for the last three years. The spirit of this course is asking students use their creativity to work as industrial engineers, form several mission-oriented teams, communicate and cooperate with other people, and deal with real industrial open-ended problems.

We wish to demonstrate how problem solving and engineering design procedures can be closely integrated and taught and what are the necessary knowledge and skills to enhance students' ability to become creative

as well as effective problem solvers. Hence, we synthesize a model for cultivating creativity that integrate the tasks of engineering design, and evolves four cognitive processes of CPS knowledge and skill via web-based courseware. An integrated web-courseware [5] is constructed for above purposes. In the following sections, four main themes in our study will be introduced: 1) the collaborative teaching and course modules, 2) tools for fostering creative learning, and 3) interaction on the web-environment via contest and design project.

2 Collaborative teaching and course modules

2.1 Collaborative teaching

Based on the experiences for the past three years, we perceive the need for professionals from other disciplines to stress the importance of communication as well as teamwork skills for engineering students. More importantly, a scientific evaluation of the course and its effects on the students' learning of creativity must be done in cooperating pedagogical experts with engineering ones. The analysis of student outcomes can give information about the success of the innovative course in achieving our objectives.

But the question is: how can professors with engineering background to integrate their technical knowledge with an educational-oriented perspective? Engineering faculties may understand the cognitive and emotional conflict that students encounter, but couldn't verify their teaching approaches in order to take into account students' different learning styles. Besides, an engineering course taught by faculty of non-engineering background face a challenge of given students the new perspectives without accommodating the technology orientation of engineering students.

With above forethought, we propose and implement the collaborative teaching from four professors of interdisciplinary backgrounds: thermal/fluid sciences, mechatronics, education, and network-based learning. Collaborative teaching is a novel teaching approach, it allow teacher deliver lecture in a more efficient way and share mutual teaching experience, improve teaching deficiency, and understand learning difficulty of students. In devising the design-oriented courseware, besides compose the materials for hands-on creativity project, we also strengthen educational idea of cognitive psychology, learning strategy and learning evaluation. Such collaborative teaching team up with the expertise of education and engineering is hoping to build a nourishing environment for rising student's learning motivation, encouraging student to develop mature, diversified cognition and thinking, and then be able to perform higher level of creative thinking.

2.2 Course modules

The contents and modules (see Table 1) are designed to develop competence in mechanical engineering, creativity, and teamwork. Five major units are emphasized: 1) Introduction of creativity, 2) Basic principles of CPS process, 3) Hands-on learning activities to inspire creativity, 4) Engineering design process, 5) Creativity contest and design project. In the first one-third activities is centred on the development and inspiration of creativity and creativity education, and the next one-third of the units enable students to practice the creative mechanical engineering design. The last one-third of the activities finishes the implementation of creativity phase so as to show off student's imagination with the creativity contest and design project.

We use creativity contest and design project as a tool to enhance creative learning of students. One creativity contest is hold in every semester in order to incubate students' learning interest. It is all up to students to decide the material, procedures, requirements, and rules for the creativity contest with teacher's facilitation in order to develop the environment of freedom.

The design project could relate basic principles and concepts to real problems and to improve students' understanding, motivation and creativity [6]. Implementing a project is a way to encourage students to look deeply and laterally at individual topics and consider how they can be applied to real situation. They motivate students to confront both familiar and unfamiliar situations with confidence, providing a sense of achievement and satisfaction. Each team member is expected to be aware of the specific skills of others in order to achieve effective and collaborative working relationships. More importantly, each member needs to take other people's views into account.

3 Tools for fostering creative learning

We construct three tools to assist the creative learning process: 1) the creative activity board, 2) the search engine, 3) the engineering courseware of domain knowledge.

The creative activity board, which is a web-BBS, is employed as the main interface for creative activity. Students are encouraged to actively utilize their own web-BBS for discussing their design projects with teachers and with classmates. They can announce important messages (e.g., resource acquiring) and post their current executing status of their project. More importantly, this board can be used to share their ideas and problem-solving approaches at any times with anyone who is interested in the topic. For convenient discussion of the creative ideas via network, particularly in the format hand-made sketches or the design charts, a FTP (download/upload) function is added in this board. Every user can participate the creative activity through web. The evolution and implementation of creativity can be recorded and exhibited. Properly application of this board can encourage students' morale for continually performing their design projects.

Students may encounter many problems when they execute the design project. The related information may be found in the courseware of domain knowledge or discussed in the creative activity board. Through the search engine, students can find useful knowledge and retrieve information from the integrated courseware more effectively by using appropriate keywords.

The creative activity cannot be successful without domain knowledge as its foundation [7]. When students are working on their team design projects, they need to integrate their domain knowledge based on the previous courses. There are four course modules materials are integrated: 1) Machine Design Course, 2) Electric Circuits and Electronics with Laboratory, 3) Innovative Application of Engineering Software, 4) Creative Mechanical Design. See [8] for detail description of content of these course modules.

4 Results: interaction on the web-environment

In the beginning whether students invest themselves in the class or not, depends on the development of the feedback from teachers. We use the web-BBS as the interaction interface with the students. After each team reported their project status, we will comment their idea and improvement of design prototype. Next, their status report will be upload in the creative activity board, and allow peers to review and comment. Encourage and endorsement from peers and teachers goes to those active teams. All interactions on the web are transparent and will inspire student if teachers can give feedback just-in-time, and guide each team to post their suggestion. In this way, both students and teachers will not be trapped in the classroom, and once the obstacle is encountered, it can be posted in the web and then exchange message. The more people to view these obstacles, the more possibility for the problem can be solved. Since not only teachers can help, peers can assist too. This is what we observed in this class when student performing their design projects. Positively and timely feedback from teacher and classmates enrich the value of the board.

We made surveys based on interviews, questionnaires, and articles of creative activity board. The most rewarding course content identified by the students is the creativity contest and design project because they provide ample opportunities to solve real-life open-ended problems, rather than to deal with dichotomous textbook problems. However, others are disturbed by the open-ended nature of the course materials. They claim that it is tiresome to cope with various teaching styles of four individual teachers. The evidence from our research also suggests that students' problem solving processes were affected by their understanding of the rationale of interdisciplinary course development. Therefore, teachers need to assist students to make their own links with the material they are engaging with in order to eliminate the negative impacts of the course content. For instance, increase the teaching topics involving mechanical hands-on activities might provide students more practice and appreciate the CPS process.

The issues of students' learning difficulties are complex and dependent on several factors, including course organization and development, the subject or topic being taught, teaching style, and students' expectations [9]. Although students see the new learning experience as an opportunity to broaden their scope, some others claim that the challenge of finding a design topic themselves was beyond their ability to manage. In order to set the stage for project design, our data showed that it is crucial that team members to accommodate each other and to devote their personal commitment. It is clear from our interview that failure to do so did

influence the students' motivation to finish the project.

5 Conclusions

We have created a learning environment that facilitates students' development of problem solving abilities, enhances their confidence for cooperative creativity, and finally, provides students knowledge and skills for mechanical engineering design. The collaborative teaching is a novel experience to both of teacher and our student. Each member contributes their expertise and become the tutor to the other members. More importantly, the effort of compromising one another on the process serves as a role model for their students to work cooperatively.

The results of this study suggested significant concern for the students' anxiety created by the need to meet the special requirements of four individual teachers. It leads us to speculate whether the structure and sequence of the course development are appropriate to the students' level of capacities and readiness. Rather than viewing these problems as collection of obstacles and difficulties, we believe that we can make a difference in the learning of our students and chose to conceptualize those dilemmas and challenges in a constructive guide. Hence, we are currently adopting a new teaching approach by dividing the class into expert versus observer groups. The emphasis of the approach is to take responsibility as a learner and to develop the ability to ask questions about the projects done by other groups. We also conduct a peer-evaluation to encourage student to evaluate each other's projects critically and objectively. We wish students to believe, as we did, that creative learning is within reach of anyone who is willing to exert himself and take responsibility.

Acknowledgement

This research work is supported by the Ministry of Education of the Republic of China in Taiwan under grant: Grand Project for Excellence, 89-H-FA07-1-4.

References

[1] Bransford, J. D. and Stein, B. S., *The ideal problem solver: A guide for improving thinking, learning, and creativity* (2nd ed.), New York: W. H. Freeman and Company (1993).
[2] Chance, P., *Thinking in the classroom: A survey of programs*, New York: Teachers College Press (1986).
[3] Sternberg, R. J., & Lubart, T. I., *Defying the crowd: Cultivating creativity in a culture of conformity*, New York: Free Press (1995).
[4] Lumbsdaine, E.& Lumbsdaine, M., *Creative Problem Solving*, McGraw-Hill (1995).
[5] CEdesign, http://lisant.src.ncu.edu.tw/cedesign/ (in Chinese).
[6] Blicblau, A. S. and Steiner, J. M., "Fostering creativity through engineering projects," European Journal of Engineering Education, vol. 23, pp. 55-65 (1998).
[7] Jonassen, D. H., "Instructional design models for well-structured and ill- structured problem solving learning outcomes," Educational Technology Research & Development, vol. 45, pp. 45-94 (1997).
[8] Hsiau, S. S., Wu, J. C., Yeh, T. L. and Tsai, S J., "The web-based learning environment for creative design course," Proceeding of 2000 Internatinal Conference on Engineering Education, Taipei, Taiwan, Aug .(2000).
[9] Pirrie, A., Hamilton, S. and Wilson, A., "Multidisciplinary education: some issues and concerns," Educational Research, vol. 41, pp. 301-314 (1999).

Content Outline	Learning Activities
Orientation to creativity	1. Introduce the importance of creativity to learning
Cognitive process of creative problem solving	2. Illustrate four stages of CPS skills
Thinking styles and contexts for developing creativity	3. Demonstrate pros and cons of various thinking style
Creative personality and teamwork experience	4. Film-viewing to illustrate the characteristics of creative people 5. Interview team members and identify their personality

Principles and strategies of lateral thinking	6. Analogy 7. Simulation activities
Conventional engineering design process	8. Discuss basic rules for invention 9. Apply rules to improve the design of commercial product 10. Brainstorm potential ideas for creativity contest via web
Problem solving in electric circuits and electronics (E&E)	11. Problem solving a case to illustrate the E&E concepts relate to project design
The creativity contest (by individual)	12. Peer-evaluate and select the top three most creative rubberband-powered vehicles
Research for proposal (RFP) of creative design project (by group)	13. Develop a RFP based on all information gathered 14. Oral presentation to class

Table 1 The course modules of the *CEdesign* web-class.

A Study of Networked Constructive CAI System Using Multiplication-Concept of "Transformation of Unity Quantity" on Elementary School

Pou-Yah Wu*, Shu-Fen Tsai, Yao-Quan Li, Jian-Zhi Lin, Jun-Rong Chen, and Xiang -Ting Huang

Department of Mathematics Education, National Tainan Teachers' College

33, Sec. 2, Su-Lin Street, Tainan, Taiwan 700

**Pou-Yah Wu's email:pywu@ipx.ntntc.edu.tw*

The feature of networked constructive CAI system lies in shaping the computer environment in which students clarify and construct the concept by ways of communication, discussion, and dialectics, utilizing the practical pedagogic content edited by the spirit of new curriculum in Taiwan at 1993. Because we stress the concept of "transformation of unity quantity" as main activity in teaching multiplication, students' comprehension of "unity quantity", "unity number", and "combined numbers" plays an important role in establishing networked constructive CAI system. We consider that the greatest difference between the networked learning environment and that of the general classroom pedagogy is the deficiency of interaction. Thus, analyzing the strategy of students' solving problems to establish the effective tool table of operation and judging the mode of the students' thought by checking the tools which students use will strengthen the interactive relationship of the system and the learners. Then, use the networked technology and the principle of the expert system to set up the CAI of constructive pedagogy, so that the learners can communicate with each other and the system can conduct dynamically which formally construct a wholly co-operative learning environment and will help the learners to form the whole mathematics concepts.

Keywords: **Constructive pedagogy, Elementary School, Multiplication of Mathematics, Networked CAI.**

1 Introdution

The characteristic of implementing new curriculum of mathematics at elementary schools in Taiwan now lies in the addition of spirit of constructivism, aiming at expecting students to construct knowledge positively. Thus, the teachers' role, in the process of pedagogy in new curriculums, changes into "problem poser", whereas students' learning activities in class attain socialized mutual sense, chiefly by communication, construct their own mathematical knowledge by way of mutual dialectics [5,6]. However, it takes pedagogy of construction longer than traditional pedagogy. The atmosphere and skill as to how the teacher directs students to construct knowledge and how the students discuss influence the effect of implementing new curriculum. In the light of the fact the trend of the times facilitates pedagogy of network to become widespread, the future construction of leased network lets us expect the popularity of "learning at home" and "long distance pedagogy". Therefore, the possibility of displaying a really approximate leaning setting of constructing pedagogy in the network environment becomes much higher. The establishment of the network system of pedagogy of construction, owing to the trend of current situation, is becoming imminent.

The aim of this study consists in designing a learning environment of network suitable for "multiplication concept in elementary school" . The greatest difference between the learning environment of network and that of the general classroom is the deficiency of mutual response [22,26]. And the pedagogy of construction hopes the communication and dialectics to bring about reflection, inspiring students to construct mathematics self-concept. Therefore, how to promote the mutual relationships between the system and the user is one of the considered points about constructing system in this study. Furthermore, how to develop the characteristic of pedagogy of

construction in the system and how to make the pedagogic contents of the new curriculum manifested in the system wholly and fluently is the second chief point taken into account. Aimed at the above two points, that we use network technology, letting the real-time communication proceeded between the learners, or between the learning and system make up a wholly cooperative learning environment. Furthermore, making use of the principles of the expert system to deal with the learning strategy of the problem solver, through the concepts manifested by the problem solver, the system will feedback suitably, and will communicate with the students properly, which can make the pedagogic activity proceed dynamically [19,25]. The design of the pedagogic content, expect considering the sprit of the new curriculums, the students' learning state, after the teachers' real pedagogy, is mainly considered about designing pedagogy. Hence, this system is much closer to the real situation of pedagogy them CAI sold in the market. And the activities of problem solving given to the learner by system would be more congenial to the learner's mode of thought.

2 Principles of system constructing

2.1 Base of learning theory

"Knowledge is positively constructed by the learner rather than being inculcated passively from outside," which is the fundamental proposition of constructing pedagogic paradigm. The students, with acquired knowledge, enter another stage as an active subject of recognition, with good theory by themselves, instead of ignorance and irrationality [16]. But pedagogy of construction does not mean the teacher's role is unnecessary. On the contrary, we realize the aim of pedagogy is to make children construct the activity types of solving problems. In the light of this, the teachers' role becomes "problem poser" rather than "problem solver" in the process of pedagogy. By way of the teachers' posing problems, children undertake the activity of solving problems by themselves; or children become "imitators" through the activity of solving problem provided by the teacher [4]. By these processes, students are provided sufficient experience of solving problems, and then construct the correct mathematics conceptions. Besides, what we must also pay attention to is the teacher and the learner grasp the intentions of each other aiming at the proceeding actives of each other, through trial and dialectics, until both of them relieve the pressure aroused by the interchange actives. The relief of pressure is limited by the fact if the problem is solved according to the activity, and is also influenced by the affectionate expression of them both present of them both present [24]. Therefore, in pedagogy of construction, socialized communication is an important feature [3].

2.2 Base of system establishing

This system is a learning environment constructed in the network, adopting three-tier client/server system architecture: that is, adding another service server on the original framework of the two-tier client/server system in this three-tier client/server system architecture, the management of Database Server charges learning data. Web Server is responsible for teaching, whereas the user of Client precedes all kinds of learning activities ivies through browser machine.

3 Pedagogic design of Multiplication using transformation of unity quantity

3.1 Concept of multiplication

Multiplication referred to by Davydov (1991) is the problem of transformation of unity quantity, that is, the transformation from composite unit to that of the single item [20]. And Clark and Kamii (1997) think that if children own the multiplicative thinking, they will simultaneously deal with lower level unit such as unit of one and the higher level unit different from unit of one [18]. Tzyh-Chiang Ning (1994) mentions that the so-called multiplication operation contains at least two kinds of relationship: (1)the coordinating relationship of two levels,(2)the part-whole relationship of two levels. The problem of multiplication is in reality that of the transformation of unity quantity, namely, the problem of transforming quantity from higher level unit to lower level unit [7,8,9].

3.2 Pedagogic design of multiplication using transformation of unity quantity

The recognition of new curriculums toward mathematics concepts specifies the activity types of solving problems of interiorization [17,23,26]. And he origin of mathematics knowledge embodies the activity of solving problems, instead of tangible objects [5]. Thus, the ideas of new curriculum do not emphasize the existence of calculating problems. The generation of all forms of calculation is entirely for the need of the practical contexts; also the measurement serves as the source of multiplication in the practical contexts [20]. Hence, the appearance of new curriculums in pedagogic content lets students have the necessary sense of owing multiplicative thinking rather than multiplication directed by "multiplication table" of old curriculums; whereas "transformation of unity quantity" is the pivotal point in designing teaching material of new curriculums, different from the viewpoints that look upon multiplication as "repeated addition" [21] in the design of multiplication of old curriculums. In other words, students' comprehending "unity quantity", "unity number" and "combined numbers" in the process of solving problems plays an important role in the design of material content of new curriculums. Tzyh-Chiang Ning (1993) [8]mentions that there are three classification of difficulty in the management of initiatory material of multiplication in new curriculums:(1)the students can tackle the problem of transformation of unity quantity (2)the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Therefore, in the design of pedagogy of multiplication, the arrangement of new curriculums lies in the fact the teacher set up a problem of multiplication in the practical contexts, and the students handle and record the problem by themselves after conveying the message of the problem. The students' knowledge is chiefly constructing from the consultation, inquiry and dialectic between the teacher and the peers; via the established learning by the concept of constructive pedagogy, the teacher should, in the process and record of the students' solving problems, help the students clarify the existence of "unity quantity", "unity number", and "combined numbers" in the problems. The students should also attain the unanimous compromise of the format of record; that is, the format of the students should wholly suggest "unity number ", "unity number", and "combined numbers". When the process of pedagogy arrives here, students have at least finished the level of the second difficulty mentioned by Tzyh-Chiang Ning. As to the application of multiplication sign, it is the flowing and economic problem of culture and communication. New curriculums, thus, undertake such a linguistic transformation of "a×b=>a lots of b=>b multiplied by a." and then bring multiplication sign serving as the operator of recording format. If the students can make use of multiplication symbol as the operator in the recording format, we may well say that they attain the level of the third difficulty. While the students reach that level, they are equipped with initiatory concept of multiplication; in other words, arrive at the formation of " multiplication" concept gradually through "experience"," perception" and "realization" [4].

4 Simulation of the process in the constructive pedagogy

Since our CAI system stresses the spirit of the constructive pedagogy, we hope that the whole computer environment would become more compatible with the real environment of pedagogy. What we must emphasize is the teacher himself/herself is the most important natural resource in the environment of pedagogy. All our set CAI would attain is how to let the computer simulate the mode of thought in the teachers' real lecturing, even to let the computer "realize" the mode of the students' thought. With a view to achieving such an effect, we design operation tools for users' use. We can discriminate the stages of students' thought by the users' choosing tools, which will let the computer analyze the students' mathematics competence through the stage of the students' operation, and simultaneously let the computer carry on dialectics, clarification and discussion by simulating the role of the teacher or that of the student. We can achieve a process of socialization on the computer by such a process of the design. And via such a process, the user can "experience"," observe", and "realize" the concept of multiplication, and finish three tasks of the stages: (1) the students can tackle the problem of transformation of unity quantity (2) the students can solve and record the process of solving problems concerning about transformation of unity quantity,(3)the students can describe the record of the problem of transformation of unity quantity by multiplication sign. Take Figure 1 as an example, students can move the bone to the bay by the mouse, then the computer system may judge whether does he/she understand the meaning of problem. We hope to make students gain more self-affirmation by manipulating. As show in Figure 2, our system provides the electric board and the tool table. User can simulate the situation in the class to solve the problem and record the format. In additional, system also supports the different operation tools for users. And the system can provide different solving method to help users constructing their operation by judging what kind of tools they choose. The system also can judge users' operation mode by checking their record format, then, the system will master students' learning condition well, and teach dynamically. Besides, the system also provides virtual students to communicate with users as showing in Figure 3. It will increase the users' learning interest. Virtual students that design for guiding user and make the environment of discussion can provide proper help but not answers in

fitting time.

5 Architecture and implementation of system

5.1 Environment of design and tool

This system uses Windows NT server as server. Developing languages include HTML, JavaScript, Active X, ASP (Active Server Page) and so on. ASP is used as the chief method of control, and ASP and ODBC (Open Database Connectivity) are exercised to match. The management of the teaching material's user becomes simplified. As to the edition of the curricular software, Authorware 5 is mainly used for developing tools.

5.2 Process of system

Process of the system we designs just as Figure 4 shows, the general elucidation is as follows,

1. Pedagogic situation of network construction

The system after the analysis of the pretest makes sure the sorts of the user's operation and then to pose problems according to the classification. The system will communicate and clarify the messages of the problems by the tools in tool table. After the sorts of tools by user to discriminate if he/she has grasped the messages of the problems, the system will provide tool table further, letting the user record by the tools. In this stage, along with level of the user's operation, the system will afford problems, via simulating the role of the student or the teacher to carry on the activities of dialects, clarification, and let the user reflect and modify his/her recording format to match the basic requirements of "unity quantity", "unity number" and "combined numbers" suggested in the recording format". Afterwards, adjust the next learning activity according to the learning state of the user until he/she can construct the concept of multiplication on the acquired basis and attain the learning level of the afore-specified third difficulty. Besides, the system can simulate the real learning environment on the network, letting the user's learning environment diverse.

2. 「Student model」 database

Student model consists mainly of three databases:

(1) Student basis database

It chiefly records the students' basis data such as name, age, the experience of using computers and so on.

(2) Database of learning.

It records the unit of teaching materials the student learned, the learning state of each unit and the duration of time, and the positive result of the students' learning.

(3) Database of learning achievement.

It records the students' assessment about answering and the stage of operation.

3. Database about "posing problems of constructive pedagogy"

The content of teaching material about constructive pedagogy include

(1) Phenomenal problem: this sort of problem can facilitate students to "experience" the mathematics concept.

(2) Psychological problem: this sort of problem can facilitate students to "observe" the mathematics concept.

(3) Sociological problem: this sort of problem can make students via discussion; attain the common sense of using recording, which would become the tool of communication.

(4) Anthropologic problem: this sort of problem can make the above – mentioned communicating tools and the correspondent expression in cultural become congenial.

4. Database of " problems"

This database is to store the problems for the pretest and the posttests.

5.3 Function of on-line communication

The system would establish a learning environment more congenial to real teaching situation thus the convenience for the user and for other users on the line to communicate, thereby setting up a network environment for undertake cooperative learning. The system designs a series of functions for on-line communication on the line, illustrated as the followings.

(1) Group of discussion

Group of discussion is an open but not synchronized function on the line. When the user encounters the difficulty in learning, he/she put up his/her questions in the group of discussion, letting other users put forth solutions to these questions.

(2) Room for discussion

As showing in Figure 5, the function of the room for discussion can improve the disadvantages of the personal computer learning CIA's failure to carry on communication, real-time discussion to a large extent, for it is an open and synchronous for communication. Besides calling the virtual teacher or student, the user can enter the room for discussion for help when he/she needs others' help to solve the questions.

(3) On-line Call

On-line call may be inputted simple information to communicate with other on-line users.

5.4 The operating process for the user on the system

When the user enters the system with the browser for the first time, the system will ask he/she to register as showing in Figure 6, thereby acquiring the basic data to establish the Database for "student model", and simultaneously letting the user accept pretest to discriminate the levels of the user's operation, and recording the situation of their answering, and the connection of active modification letting the user join the curricula suitably.

Afterwards, whenever the user enters the system, he/she must key in user name and password to make sure the identification. The system will continue the following activities according to the previous record of the user. The system would record each learning activity the user undertakes one by one, with the view of analyzing the fact if the learning state of the user will attain the expected aim. When the user encounters the line provided by the system: he/she can also check his/her learning state at any moment to grasp the learning progress.

6 Conclusions

The age of computer is that of knowledge explosion indeed. Undoubtedly, "Self-learning" is the best way to enrich self in the age of widespread information. With network becoming so widespread, it is not uncommon for the students of the elementary school to enter the network. It is incumbent on us to let the teaching environment of CAI congenial to the concepts of teaching nowadays. We hope our CAI system will become compatible with the social need now, breaking through the limitation of time and space and overcoming the barriers of learning environment now, giving the learner more space to exert himself/herself. At present, this system has finished the prototype, and plans to precede real teaching experiments and systematic assessment in a few months.

Reference

[1]周筱亭, "數學新課程的趨勢", 研習資訊, Vol. 11, No. 3, pp. 28-50, (1994).

[2]侯志欽, "教學設計的哲學省思—由客觀主義到建構構主義", 國民教育集刊, Vol. 17, pp. 221-229, (1999).

[3]甯自強, "「根本建構主義」—認知研究的另一種架構", 師友月刊, 12 月號, pp. 30-32, (1987).

[4]甯自強, "經驗、察覺、及了解在課程中的意義—由根本建構主義的觀點來看", 論文發表於國立台東師範學院八十一學年度國小理科教育學術研討會, pp. 191-197, (1992).

[5]甯自強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看", 科學教育學刊, Vol. 1 No. 1, pp. 101-108, (1993).

[6]甯自強, "「建構式教學法」之教學觀—由根本建構主義的觀點來看", 國教學報,Vol. 5, pp. 33-41, (1993).

[7]甯自強, "單位量的轉換(一)正整數乘除法運思的啓蒙",教師之友, Vol. 34, No. 1, pp. 27-34, (1993).

[8]甯自強, "新課程對乘法啓蒙教材的處理", 論文發表於國立嘉義師範學院八十二學年度數學教育研討會, 四月二十九日, (1994).

[9]甯自強, "單位量的變換(二)—正整數乘除運思的融合", 教師之友, Vol. 36, No.5, pp. 35-44, (1995).

[10]甯自強, "數學的格式與內容—皮亞傑對維高斯基", 論文發表於台北市立師範學院「皮亞傑及維高斯基的對話」百年校慶學術研討會, 元月二十五、六日, (1996).

[11]甯自強, "劉裕誠的數概念", 1997 海峽兩岸幼兒教育學術研討會論文集, pp. 167-185, (1997).

[12]甯自強, "涂景翰的數概念", 科學教育學刊, Vol. 6, No. 3, pp. 255-269, (1998).

[13]甯自強, "顏淑茹的數概念", 國教育研究學報, Vol. 4, pp. 231-264, (1998).

[14]羅清水, "認知心理學理論對電腦輔助教學設計發展與成效之影響", 研習資訊, Vol. 15, No. 1, pp. 1-15, (1998).

[15]鐘靜, "從疑難問題談乘法文字題教學", 國教月刊, Vol. 36, No. 9,10, pp. 33-35, (1980).

[16]蘇育任, "建構主義式的教育的迷思與省思", 國民教育集刊, Vol. 5, pp. 121-139, (1997).

[17] Bridgaman, P. W.," The way things are", New Your: Viking Compass, pp. 83, (1959).
[18] Clark, F. B. & Kamii, C., " Identification of multiplicative thinking in children in grades 1-5", "Journal of Research in Mathematics Education", Vol. 27, No. 1, pp. 41-51, (1996).
[19] Dalgarno, B., "Constructivist Computer Assisted Learning: Theory and Techniques", http://services.Canberra.edu.au/~barney/articles/ascilite96/paper.htm (accessed on Oct. 21, 1997).
[20] Davydov, V. V., "A psychological analysis of the operation of multiplication", In L. P. Steff (Eds.), Psychological abilities of primary school children in learning mathematics, Soviet Studies in Mathematics Education Series, volume 6, pp. 9-85, (J. Teller trans.) Reston, VA: NCTM. (1991)
[21] Fischbein, E., Deri, M., Nello, M. S., & Marino, M. S., "The role of implicit models in solving verbal problems in multiplication and division", Journal of Research in Mathematics Education", No. 16, pp. 3-17, (1985).
[22] Hiltz, S. R., " Teaching in a Virtual Classroom", http://it.njit.edu/njIT/Department/CCC/VC/Papera/Teaching.html (accessed 1995).
[23] Piaget, J., "The Psychogenesis of knowledge and its epistemological significance", In M. Piatelli-Palmarini (Eds.), Language and learning: The debate between Jean Piaget and Noam Chomsky, Cambridge, MA:Harvard University Press, (1980).
[24] Steff, L. P. & Wood, T. (Eds.), " Transforming Children's Mathematics Education: International Perspectives", Hilsdale, NJ:LEA, (1990).
[25] Squires, D., "Can multimedia support constructivist learning?" http://www.spirit.net.au/ACEC96/papers/squir.htm (accessed on Oct. 21, 1997).
[26] Van Engen, H., "An analysis of meaning in arithmetic Ⅰ& Ⅱ", The elementary School Journal, pp. 321-329 & 395-400, (1949).
[27] Webb, G., " A Theoretical Framework for Internet-Based Training at Sydney Institute of Technology", http://ausweb.scu.edu.au/proceedings/webb/paper.html (accessed on July 5-9, 1997).

Figure 1:The clarification of the problem

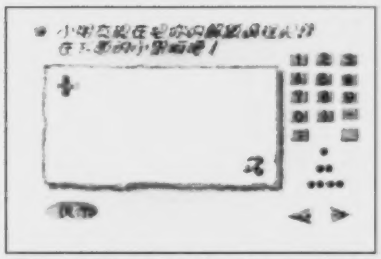


Figure 2: The electric board and tool table

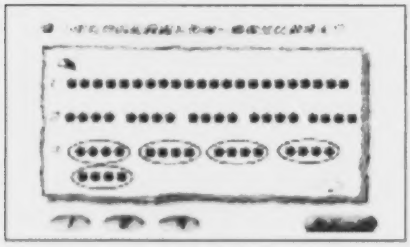


Figure 3:The strategies of virtual students

Figure 5:Room for discussion

Figure 6:The registration

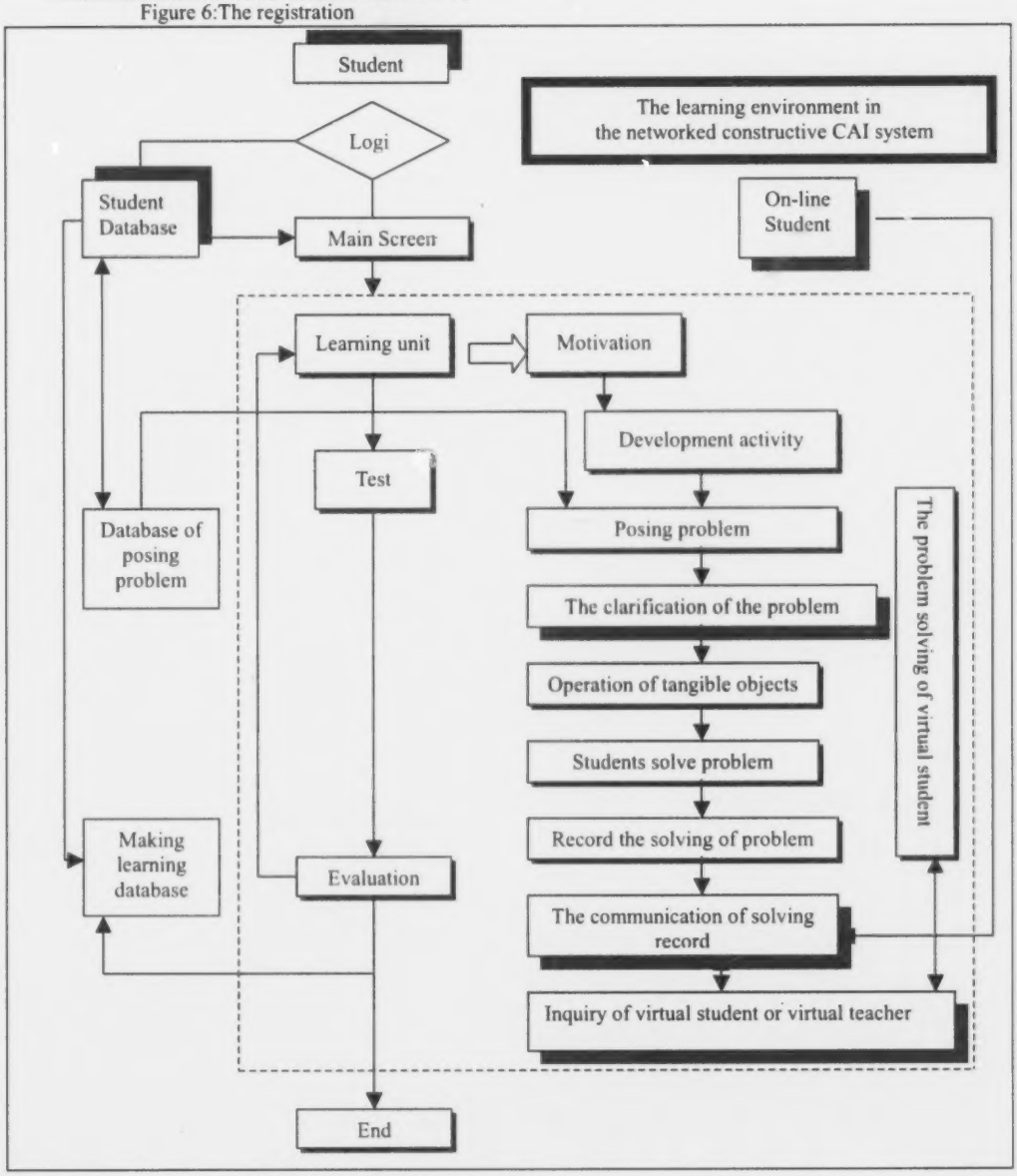


Figure 4: System flowchart

A Study on the Effectiveness of Web-based Collaborative Learning System on School Mathematics :Through a Practice of Three Junior High Schools

Masahiro NAGAI*, Yasuyuki OKABE, Jyunichiro NAGATA*** and Kanji AKAHORI***

**Tokyo Institute of Technology, Graduate School of Decision Science and Technology, Dept. of Human System Science 2-12-1,O-okayama,Meguroku-ku,Tokyo,152-8552,Japan Tel.+81-3-5734-3233 nagai@math.e.chiba-u.ac.jp, akahori@ak.cradle.titech.ac.jp*

***Sumiyoshi School Attached to Department of Human Development,Kobe University 5-11-1,Sumiyoshiyamate,Higashinada-ku,Kobe,658-0063,Japan Tel.+81-78-811-0232 yokabe@kobe-u.ac.jp*

****Junior High School attached to Department of Education,Chiba University 1-33,Yayoicyo,Inage-ku,Chiba,263,Japan Tel.+81-43-290-2493 nagata@jr.chiba-u.ac.jp*

The topic of Internet for educational purposes is currently hotly pursued but there are still not many observations on the effectiveness of it in school mathematics. In this paper, we discuss the findings of Web-based collaborative learning in school mathematics conducted with three junior high school in Japan, March 2000. Students performed asynchronous collaborative learning using bulletin-board type database installed in a Web server set at the Koshikawa laboratory in Chiba University. Students solved several mathematical problems presented on a Web page while discussing with other students in the database. In classes using the Internet, 3 or more methods of the problem solving emerged in the database as compared with a traditional class, and students could study many mathematical views and conceptions as a result of it. Moreover, a research of the student's opinions after the lessons indicated that students wanted to hear the other students' ideas and views and have collaborative learning, breaking down the traditional concept of the classroom wall barrier.

Keywords: **Web, Bulletin Board, Collaboration, School Mathematics**

1 The background and intention of this research

It is now believed that mathematical knowledge is created through collaborative learning, rather than something individual. This is based on social constructivism in recent years. And teachers have come to accept their new position of an advisor to the students as shown by Vygotsky's "Zone of proximal development".

Through using a distributed network such as the Internet, its very features are effectively utilized and allows the externalization of the student's knowledge. These knowledge can then be shared and this learning method is in accordance with the present idea of how learning occurs[4]. Thus, we have researched on web-based collaborative learning on school mathematics from 1998 focusing on this point[1][2]. With Web-based collaborative learning, it efficiently and effectively overcomes whatever physical differences the students may have and thus widely used for science and social studies lessons.

In mathematics, objectivity is the rule and therefore, there is no need for students to be able to express regional difference clearly and there are not many investigations into web-based collaborative learning of school mathematics. In this paper, we describe the qualities and reasons for conducting Internet based

collaborative learning of school mathematics. We also describe the results of the questionnaire distributed to the students after the lesson.

2 The method of collaborative learning

In this research, we used the "bulletin board[1]" system that can be downloaded free from the Web site. As shown in Fig.1, the discussion progresses by entering in one's idea and posing questions to the others' idea or opinion. Students build their knowledge positively and share them in this process. The discussion is displayed by a tree structure whereby a reply to a question or comment is indicated with a new line, separated from the previous note with a slight space. Each new reply is so indicated, forming a tree structure. The symbol[2] is given to each utterance so that the kind of utterance may be understood. This database was installed in the Web server "Topo" at Koshikawa laboratory, Faculty of Education, Chiba University, and linked to the web page that we refer to as "The Page of Mathematics Teaching-Materials Research[3]". Students used this system for its school mathematicsFig.3. Fig.2 shows the notes which students have entered. Students study, choosing between the two screens, i.e. Fig.1 and Fig.2.

Fig. 1

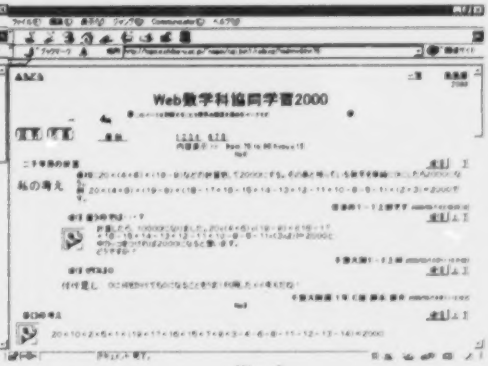


Fig. 2

3 The outline

The Web-based collaborative learning was performed as follows.

O Student participants

Nagaura Junior High School, 1st grade 2 class

Sumiyoshi Junior High School, 1st grade 3 class

Junior High School attached to Chiba University, 1st grade 3 class

O Term March 2000

O Instruction plan

Each junior high school had a 2 hours lesson.

The 1st hour …Students read the problem and produce their own ideas.
And, they enter in their questions and opinions.

The 2nd hour…Students read the others input and enter in their ideas.
And they continue the discussion.

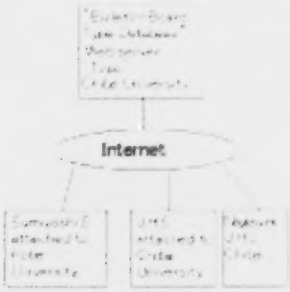


Fig. 3

3.1 Problems given to students

[1] raib-g 2.04 (wakatiai program)

[2] Question="質問"，My Theory="私　考　", etc.

[3] The author's page. http://www2.ak.cradle.titech.ac.jp/nagai/math_room/math.asp

The Grant-in-Aid for Educational Research, Chiba Prefecture(1997), and the Grant-in-Aid for Scientific Research, Japan Society for the Promotion. of Science(Encouragement Research B, subject numbers 10913006,1998 and 11913005,1999) are granted to this page.

The two following problems were shown on the Web page at the beginning of the collaborative learning. Students solved the problem given to them with instructions from the teacher.

○**Problem1**
This year is A.D. 2000. Let's make the following formulas.
(1) The answer is set to 2000, using all the number of 1,2,3,4,～,19, and 20 at least once.
(2) Each number can be used only once.
(3) You may change the sequence of numbers.

○**Problem 2**
How to find, among a set of twelve balls, one which is lighter than any of the other equally-weighted eleven? You have only three chances to use a pair of balances. (Please also consider the reasons and enter it in.)

3.2 The student's activity

First, students read the given problem and create their questions and ideas about the problem. Next, they access the database and enter their notes. They read the others' writing, and if something attracts them, they will write a reply. The activity was performed over 2 hours and problem solving was carried out. A questionnaire shows that students participated in this collaborative learning positively. The teacher's role is only to support the computer operations of the students or problem solving when needed. In the beginning, although there were many students who took time in deciding what to enter or how to operate the database, they got used to it gradually.

4 Analysis and consideration of the collaborative learning

These were two problems and the students solved either one or the other collaboratively. Three junior high schools tackled the problem using the Web-based collaborative learning for 2 hours. Another class was asked to solve the problems not using the Web-based collaborative learning method i.e. traditional method. We describe the difference in the learning produced from the difference between these two methods of instruction. We also analyzed the results of the questionnaire.

4.1 Regarding problem 1

With problem 1, students find as many formula as they can whose answer is 2000 using all the integers from 1 to 20. In the collaborative learning using the Web, students invented 14 kinds of the following methods.

Formulas obtained from the collaboration using the Web (14 methods)

1. 20×10×5×2+(1+3-4)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
2. 20÷10×(19-9)×(18-8)×(17-7)×(16-6)÷(15-5)×(14-4)÷(13-3)×(12-2)÷(11-1)=2000
3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000
4. (3+5+7+8+11+12+13+14+15+16+17+18+19)×(6-2-4)+20×10×(9+1)=2000
5. 10×20×5×2-(9+6)+(8+7)-15÷3+(1+4)-(11+19)+(12+18)-(13+17)+(14+16)=2000
6. (19-18+17-16+15-14+13-12+11-9+8-7+6-5+4-3+2-1)×10×20=2000
7. 20×10×(1+2+3+4)+(13-6-7)×(5+8+9+11+12+14+15+16+17+18+19)=2000
8. 20×10×5×2+(4-3-1)×(6+7+8+9+11+12+13+14+15+16+17+18+19)=2000
9. (1+3+7+9)÷2×(20+15+5)÷4×(6+14+12+8+11+19+13+17)÷10×(18-16)=2000
10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
11. {1+2+3+4+6+7+8+9+10+11+14+16+17+18+19-(5+12+13+15)}×20=2000
12. 20×10×2×5+1×(19+17+16+7+9+3+15-4-6-8-11-12-13-14-18)=2000
13. (1+2+3+4)×10×20+5+6+7-18+8+9-17+16+13-14-15=2000
14. {(11-1)+(12-2)+(13-3)+(14-4)+(15-5)-(16-6)-(17-7)-(18-8)-(19-9)}×10×20=2000

Next, in the traditional class, only four kinds of formulas appeared.

Formulas obtained by the ordinary class (4 methods)

3. (1+19+2+18+3+17+4+16+5+15+6+14+7+13+8+12+9+11+20)×10=2000

10. {10+(11-1)+(12-2)+(13-3)+(14-4)+(15-5)+(16-6)+(17-7)+(18-8)+(19-9)}×20=2000
15. (11-1)×10×20+12-2-4-6+8-3-5+16-7-9+14+15÷19-13-17-18=2000
16. (2×3+4+5+6+7+8+9+10-11+12+13+14+15-16+17-18+19)×20÷1=2000

4.2 Regarding problem 2

With problem 2, students find the lighter weight out of 12, using only a pair of balances and within 3 steps. The following four methods of solving the problem appeared in the collaborative learning using the Web. The notation shows how to divide the 12 weights first. For example, "4 4 4" means to divide the 12 weights into three groups containing four weights in each group first.

◇The first division found in the collaboration using the Web

(6 6) (4 4 4)
(3 3 3 3)(5 5 2)

◇The first division found in the traditional class

(6 6) (4 4 4)
(3 3 3 3) (5 5 2) (2 2 4 4)

As shown above, four kinds of methods appeared in the collaboration using the Web and five appeared in the traditional class.

4.3 Analysis and consideration of the data

In problem 2, the variety of methods for solving the problem did not differ much between the Web-based collaboration and the traditional class. However, in problem 1, the number of methods on collaborative learning using the Web was 3 or more times as compared with the traditional class(Exact Probability Test, $p<.05$). For mathematics problems with limited answers, there is not much difference seen between the two methods of instruction. On the contrary, for problems with many possible answer, students achieve better results when they can do the problem solving with the other students through the Web. We definitely believe that the students are able to solve problems by referring to the other student's notes. This can be seen from the student's interaction. For problem 1, five formulas generally represented as "0 × m+2000(m is an integer)" were produced in the collaborative learning using the Web. This is the formula not produced from the traditional class. We consider that the students become aware of this general formula by referring to the others formulas, and they utilize this general formula to solve the problem. Moreover, the students are also influenced by notes such as those below.

First, 20 ×(4+6) ×(19-9) etc. is calculated, and it is made 2000. Then, it will be set to 2000 if the number which remains is set to 0. Example 20 ×(4+6) ×(19-9)+(18-17+16-15+14-13+12-11+10-8-5-1) ×(2+3) =2000.

2000/03/14 Tuesday 09:25 [9]

Although the formula of this student's example lacks a necessary "7", it is considered that the explanation which means 0×m+2000 was very helpful. This can be read also in the following response to the note " ".

This is a good idea. Every number which is multiplied with 0 is 0. 2000/03/16 Thursday 11:12 [93]

Such examples show that there were some students who didn't only enter their formula, but the strategy as well, and it became a support to other students.

As mentioned above, in collaborative learning using the Web, since the others idea remains on record and can always be referred to, students could utilize this and solve the problem. Problem 1 is asking for many possible formulas whose answers are 2000. That is, we claim that collaborative learning using the Web is effective especially with problems which demand exemplification. And students were able to access many mathematical views and conceptions. This appears also in the result of the questionnaire shown as "Many students' ideas can be known. 49 persons." and "Various methods and ideas which are easy to understand can be known. 36 persons.", and it turns out that the student's incentive and understanding can be improved. These educational effects are obtained by the realization of collaborative learning using the Web, and cannot be obtained in the class which is traditional. We emphasize that the effectiveness of the collaboration using the Internet on school mathematics is demonstrated.

5 Conclusion

In this paper, we referred to the educational effect and influence of the collaboration of three junior high schools using the Web. As we have shown, it has been indicated that students can utilize many mathematical knowledge and conceptions when we use the Web with due consideration given to the type of problems the teacher thinks can extract the most out of the students. This shows that collaborative learning using the Web is useful to train various views and ways of thinking currently emphasized by the Ministry of Education in Japan and National Council of Teachers of Mathematics(NCTM)[3],U.S.A. We emphasize that the database on the Web is effective as an environment where students can tackle open-ended problems in mathematics.Considerations for the future include the improvement of the student's computing skills, the improvement of the system with regards to numerical expressions and careful selection of the kinds of mathematical problems to be given to the students. After all, according to a questionnaire, since it is indicated that 70 percent or more of students are supporting collaborative learning using the Web from various reasons, we want to continue the research wholeheartedly from its educational perspective.

Acknowledgement

We express our sincere thanks to Miss. Cheong. Meng. Mei and the following institution for assistance.
A part of this research is selected as a supporting plan in the Voluntary-Plan of the 100-School Networking Project (Phase II ,1998) and the School-Plan of the E square project (1999) of the Center for Educational Computing.

References

[1]Masahiro NAGAI and Hiroaki KOSHIKAWA . "A Development of Collaborative Learning on School Mathematics Using the Web I" The Mathematics Education Paper Publication Meeting 31, Japan Society of Mathematical Education. 1998 . pp.283-288

[2]Masahiro NAGAI, Yasuyuki OKABE, Junichiro NAGATA, Hiroaki KOSHIKAWA, Tadashi TAKAHASHI, Kanji AKAHORI . "A Design of the Environment Supporting Collaborative Learning on School Mathematics Using the Distribution Network" . The Plenary Session of TSG6(Distance Learning in Mathematics Education) ICME9 at Japan, August 2nd 2000.

[3]NCTM . "Curriculum and Evaluation Standards for School Mathematics" . 1989

[4]Yutaka SAEKI . "New Computer and Education" . Iwanami Pocketbook .1997

[5]Matthew B.Miles, A.Michael Huberman . "Qualitative Data Analysis" . SAGE Publications . 1994

A Survey Study on Corporate Trainers' Experiences, Attitudes and Perceptions towards Intranet-Based Training

Doris Lee
Assistant Professor, Program of Instructional Systems
Penn State Great Valley School of Graduate Professional Studies
30 East Swedesford Rd.,Malvern, PA 19355, USA
Tel: 610-648-3266
Fax: 610-889-1334
E-mail: YDL1@psu.edu

1 Introduction

The Internet is a vast cyberspace where the user can gather, disseminate, and exchange all types of information. The World Wide Web was conceived to allow the user to have a single, unified means to create and access information from anywhere on the Internet [1]. An intranet is an organization's internal networked computer system and is usually protected by a firewall, a form of security software that permits only authorized users to the system [2]. The World Wide Web software also runs on most intranets, providing the same functions as used on the Internet. However, information on an intranet is often organized and delivered around an organization's specific needs rather then randomly shared as on the Internet. An intranet, therefore, grants an organization easier, faster and more secure distribution of information.

The above reason accounts for the rapid growth of intranet-based training (IBT) in American corporations [3]. IBT is the use of intranet to provide employees with instruction for the acquisition of various types of knowledge and skills. Researchers including Cohen [4] and Leong [5] believe that IBTcan increase interaction and collaboration among employees and reduce training cost. However, no empirical data can be found to verify this belief. Besides, the value and effects of IBT have not been scientifically determined. The questions concerning what kind of perception and attitude that corporate trainers have towards IBT, and what kind of factors or obstacles involved in the design and delivery of IBT remain unanswered.

The purpose of this paper is to present a survey study that examined corporate trainers' perception and attitude towards IBT. This study used closed-ended attitudinal questionnaire to investigate the amount of trainers' IBT experiences and their attitudes towards it. This study also included an open-ended written questionnaire to analyze trainers' perceptions concerning the value as well as benefits of delivering training via intranet, the current status of using IBT in the participating trainers' companies, and the design and development issues of IBT.

2 The Results

Fifty-five professional trainers or training managers participated in the study. Their age ranged from 24 to 58. Most of them have about 5 to 6 years of experience in designing or conducting face-to-face training. The average experience of designing or conducting computer-based training is about 1.5 years. The majority of them only have about two to three months of experiences in either receiving or designing IBT.

2.1 Attitudes and Status

The results reveled a positive attitude towards the value and use of IBT among the participating trainers (The mean for the attitudinal questionnaire is 73. 95, with a possible highest ranking of 105.00). Most of them indicated that their companies just began to use IBT. For example, they stated,

" Currently my organization uses very little web-based training. I am lobbying to move more toward web-based training. We use quite a bit of CB/CD training. We also make available a product knowledge training piece on our intranet."

"My Training Department is just getting involved with web-based training. We' ve researched both the content and user interface strategies and are now ready to begin our first billable project. In the past, we' ve created browsable user guides but are now advancing to interactive sites."

"My company uses CBT for upper management. We are currently arguing for web-based training as we are now networked in 12 counties across Pennsylvania. If successful, web-based will be used throughout the year for required 24 hours of training per year, as well as other applicable internal policy mandates. Web-based will be used for front-line middle and upper management teaching regulations, soft skills, medical and psychiatric knowledge, and project management."

2.2 Value of IBT

Most of the trainers believe that WBI is very valuable to their organizations by indicating:

" WBT is extremely valuable to my organization for specific courses such as regulatory compliance and business-specific training. We have multiple sites as well as individuals who work out of their homes. WBT enables us to reach all of these people with consistent and current training in a cost effective manner."

" I think it would provide an additional tool to the face to face training. I think it could be most effective for our line people where most training is visual and hands on. They could see a live version and be able to do activities according to what they saw. I don' t think web-based training could eliminate the face-to-face training. Again, it could be an extremely important additional tool."

" I think the people who use computers often or who are comfortable with computers would welcome web-based training. The people with little or no computer background would probably be less eager to participate in web-based training. Therefore, I think the value of web-based training would be dependent upon the employees. I would like it because it is convenient, although it is not very interactive to me. I like being in a class talking to people better."

2.3 Design and Development Issues.

Most of the trainers also indicated that their organizations either contract their WBI projects out or just follow the design and development procedure for the instructor-led training. For the design and development issues, they indicated.

" Follows same process as instructor-led training: (1) investigate necessity; (2) develop design spec.; (3) Develop; (4) evaluate ongoing."

"Outside vendor; try to start and educate current designers for future of course."

2.4 Other Related Factors.

For other related factors, the participated trainers identified budget, technology, time, and computer literacy of their clients as the major factors:

"Programmers, money and time. We have so many projects in the works and not enough training personnel to put it into place yet. Our operations department is almost there."

"There are two main factors. The first is budgetary; the second is computer literacy of many of our clients; internally most of our associates have the necessary software and hardware and knowledge to handle this."

"The largest concern might be security-competitors might access our training content and somehow "steal" our corporate identity. Also, I would rate the overall skill level for PC usage as rem
arkably low, particularly among trainers. How could we dream of developing web-based training if some of our trainers can' t use File Manager effectively?"

3 Conclusion:

The majority of the participated trainers of this study have about 5 to 6 years in designing and conducting face-to-face training, but only have about 2 to 3 months of experience in designing or receiving IBT. Most of them indicated that IBT would be a valuable addition to their companies, that their organizations have just begun to use IBT for employees or client training, that factors impacting the use of IBT include technology, cost, time, and users' computer background, and that the design and development process for IBT still follow the process used for face-to-face training.

References

[1] Genesis, N., & Hall, D. Build a web site. Prima Publishing, California, 1995.

[2] Filipczak, B. Training on intranet: The hope and the hype, Training, Vol. 33, No. 9, pp. 24-32. 1996.

[3] Majos, R., Curtin, C., Masten, D., & Glassrock, J. D. What's ahead for intranet technology: Some predictions. Training & Development, Vol. 51, No. 2, pp. 53-54, 1997.

[4] Cohen, S. Intranet: A Technology-age tool. ASTD Line, Vol. 9802, pp. 1-16, 1998.

[5] Leong, K. L. Intranet drives Ford's effort. Internetweek, Vol. 738, pp. 47-50, 1998.

A Virtual Classroom for Algorithms with Algorithmic Animation Support[1]

Shyong Jian Shyu*, Yin Te Tsai and R. C. T. Lee*****

** Department of Information Management*
Ming Chuan University
Gwei Shan, Taiwan
Email: sjshyu@mcu.edu.tw

*** Department of Computer Science and Information Management*
Providence University
Shalu, Taiwan
Email: yttsai@pu.edu.tw

**** Department of Computer Science and Information Engineering*
National Chi Nan University
Puli, Taiwan
Email: rctlee@ncnu.edu.tw

A virtual classroom on algorithms with algorithmic animation and reference database supports is presented. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. The hypermedia courseware is designed to ease the navigation. A maintenance program is devised to automatically update the hyperlinks whenever the courseware is updated. Interactive algorithm animations are applied as knowledge construction assistance. It is expected that with visualization aids learners could demonstrate their comprehension of abstract algorithms. A reference database on algorithms is built up for both educational and research purposes. Studying communications such as self-testing, bulletin board, related web links, ..., etc., are also provided.

Keywords: **Multimedia and Hypermedia in Education (15), Virtual Classroom(19), Web-Based Learning(21), Algorithm Animations**

1 Introduction

The technologies of multimedia and networking on personal computers lead the research of computer-assisted learning into a new era in the last decade. Researches on the design issues of the hypermedia courseware recently please refer [17, 3, 4, 19]. Many evaluation studies also reveal positive results on learning via hypermedia courseware [7, 10, 12, 18]. With the popularity and maturity of hypermedia and web technologies, distant learning with a synchronous style via the web attracts many researchers' attention in both of the theoretical and practical points of view. The characteristics of such a web-based virtual classroom encourage the students to actively participate the construction of knowledge with their own pace and without the limitations of time and space. It is our aim in this paper to propose our design and implementation of a virtual classroom for studying algorithms with supports of interactive animations and a research paper database.

Material about algorithms is a core component for undergraduate degrees in computing. A major problem in teaching algorithms is the difficulty of capturing the dynamic movement of data and complicated data structures in static materials such as books and lecture notes [16]. Because different students learn at

[1] This work was supported in part by National Science Council of Republic of China under grant NSC 89-2511-S-126-003

different rates, whatever pace the lecturer chooses will be wrong for some students. A virtual algorithmic classroom would be very crucial to assist students constructing their understanding with their own pace. Further, since the abstraction of algorithms might be challenging to learn and understand, it is hoped with graphical depictions the students' comprehension could be more effective and concrete. Thus we develop animations interactively by Java in our virtual classroom.

An algorithm animation is a dynamic graphical depiction of the data and operations of an algorithm. The animation purpose is to illustrate how the algorithm functions to someone seeking to learn the algorithm [15]. Researches concerning with the studies of algorithm animation or software visualization can be found on [9, 5, 13, 15, 14, 11]. A number of practical algorithm animation systems have been built over the last ten years. Some well-known systems include
BALSA [1], Tango [13], Zeus [2], AACE [6], Zeus (http://www.research.digital.com/SRC/home.htm0),
PAVANE and Opsis (http://swarm.cs.wustl.edu/pavane.html),
ZADA (http://ls4-www.informatik.uni-dortmund.de/RVS/zada.html), ...etc.
These systems typically have been used to create animations to accompany a lecture in an electronic classroom, or to prepare animations for students to observe and interact with outside the classroom. The updated technologies of multimedia tools and web programming and a complete hypermedia courseware helping students' comprehension make our algorithmic animations differ from theirs.

Besides the animations, in order to ease the tracing of the newest research results or referencing the related papers on algorithms, we built up a paper reference database to store research papers of algorithms, which can be queried and appended for educational or research purposes at the remote sites. We also provide some studying communication aids in a asynchronous mode such as self-testing, bulletin board, related web links, ..., etc., to improve the social communication among students in this virtual classroom.

The rest of this paper is organized as follows. The content of our algorithmic virtual classroom and the implementation result of our hypertextbook are presented in Section 2. The implemention of algorithm animations is illustrated in Section 3. The facility of the paper reference database is discussed in Section 4. Section 5 gives concluding remarks and future studying.

2 The Content of Our Algorithmic Virtual Classroom

There are four main themes in our algorithmic virtual classroom: (1) The Fundamentals of Algorithms, (2) Algorithmic Strategies, (3) Algorithmic Reference Database and (4) Studying Communications. Our design focuses on undergraduate students in science or management departments, while the database might have benefits for various kinds of users. The material is mainly based upon [8].

We re-organized the course material on algorithms as the hypermedia courseware (or hypertextbook) which helps the learners' actively exploring the knowledge. Each keyword (term or concept) on the web-courseware is linked onto its explanation page where the meaning is explained and all the links to the other occurrences in our courseware are also listed. A query facility for these keywords also provided. Consider that the course materials might be updated and the linkage relationships among keywords and their positions of occurrences on the web pages might also be changed. We developed a courseware maintenance program in C to automatically re-construct the linkage relation of all hyperlinks into its newest version whenever the courseware is updated. Figure 1 shows our hypertextbook on web. As the left frame shown in Figure 1, a tree-view browser is applied for learners to locate where he is in the courseware space. Figure 2 is the query result page of the keyword "insertion sort" which can also be reached by clicking "insertion sort" on the web content in Figure 1.

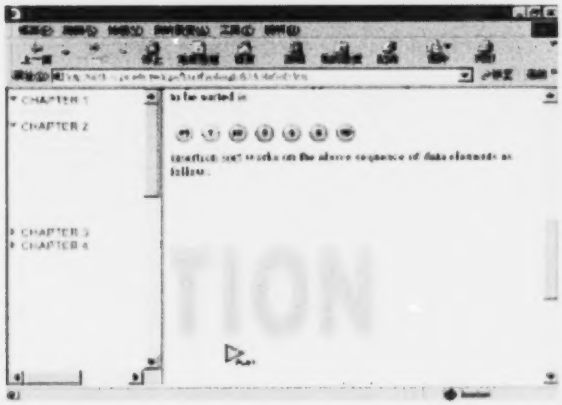


Figure 1 The web page format of our hypertextbook

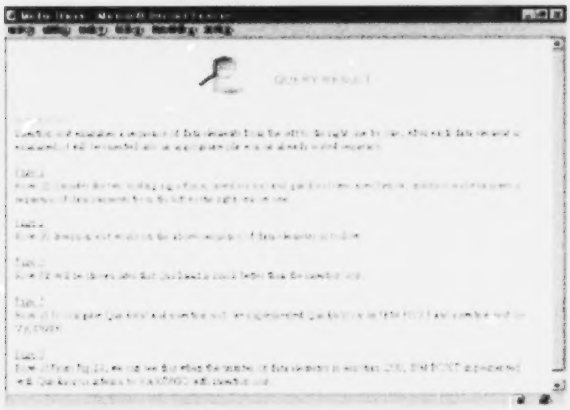


Figure 2 The query result of the keyword "insertion sort"

The content of the four main themes is described more in detail in the following sub-sections.

2.1 The Fundamentals of Algorithms

The content in this subject includes:

(a) Celebrity Hall: The contribution of some well-known computer scientists for algorithmic study such as D. E. Knuth, R. E. Tarjan, R. M. Karp, S. A. Cook, … etc, are introduced here.

(b)The Introduction of Complexity: The concept of complexity such as order, upper bound, lower bound, … etc, are explained.

(c)The analysis of computer algorithms: The analytic models of computer algorithms are explained. Proper examples are presented also.

All of the above materials are prepared as a web hypertextbook to ease the navigation.

2.2 Algorithmic Strategies

In current stage, three strategies are ready in our web classroom: greedy, divide-and-conquer and tree searching strategies. We not only construct the hypermedia courseware but also apply interactive animations as our learning assistants. Three interactively animated examples, i.e., solving the stamp problem, the minimum spanning tree via Kruskal's and Prim's algorithms respectively, are prepared for exploring the spirit of the Greedy method, while three, i.e., finding the maximum, quick-sort and merge-sort, interactive

animations are for Divide-and-Conquer and three, i.e., breadth-first-search, depth-first-search and hill-climbing, for tree searching. The implementation result is illustrated in Section 3.

2.3 Algorithmic Reference Database

It is most critical in almost every research areas, including of course the research of algorithms, to maintain a mostly updated reference database. We construct a web-based database via CGI technology to maintain those important references related to algorithms. Section 4 shows the implementation result in detail.

2.4 Study Communications

To increase the content of our courseware, we collect links of some important related web sites in our external-resource pages which enlarge the learners' view on the studying of algorithms. Meanwhile, to help students to self-evaluate the learning effect, self-tests are provided for learners to answer yes-no question sheets on the web. The system will score the result and give explanations automatically.

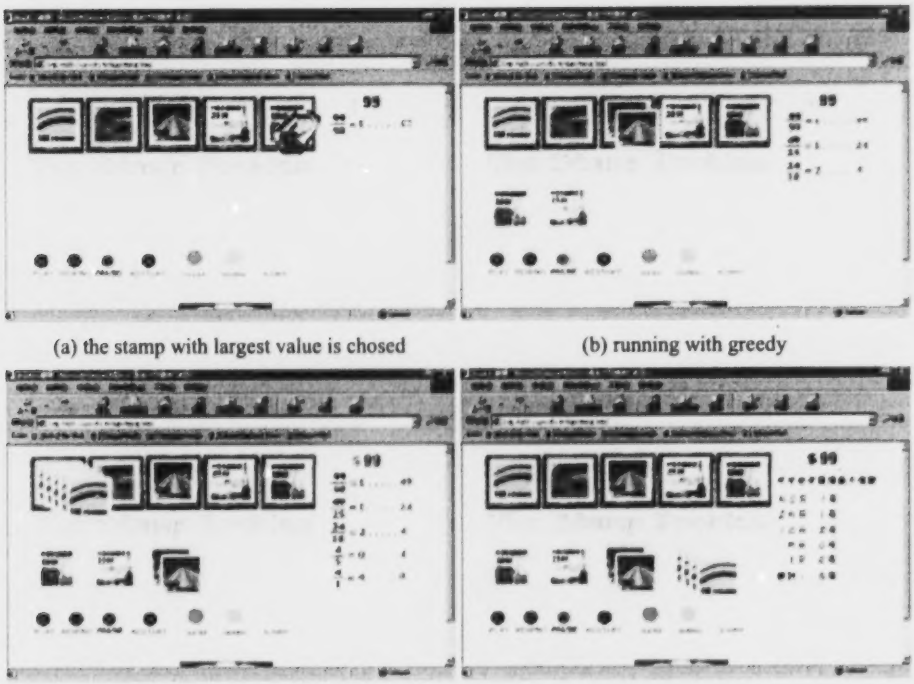
In order to improve the social communications for students in this asynchronous learning environment, we provide some interactive facilities:

(a)Bulletin board: This is an area for learners and teachers to post their idea, suggestions, questions, ...etc., on the web pages remotely. They could share the learning experience or learn from peers without the limitation of time or space.
(b)Paper up-loading: A web interface is provided for users to up-load their finding of new research papers on algorithms.

3 Interactive Algorithm Animations

Algorithm animations might be an effective tool for understanding the behavior and abstraction of algorithms. However, most approaches mentioned in Section 2 have focused on much sophisticated graphical depictions and not on the process of how learners construct their comprehensions via animations. As a way, two categories, static animation and dynamic animation, are considered in our virtual classroom. The former cannot be changed once built, while the latter might be changed according to some predefined parameters. We call the dynamic animation as interactive animation if the learners can assign values to those parameters in an on-line manner. The learners can choose either one to observe the actual data moving and to demonstrate their abstract concept. A control panel is provided for learners to control the running speed.

The static animations by Director offer multimedia presentations. Figure 3 illustrates an animated example of solving the stamp problem, which is to explain the greedy method. The interactive animations by Java allow the learners to change the animated results by assigning input variables with different values. Through observing the various running situations in terms to the given variables, learners can realize how those algorithmic steps are actually executed. It is expected that the conceptual cognition of these abstract strategies can be enhanced via the visualized running examples and the learners' comprehension could be more concrete. Figure 4 shows an example of merge-sort where the number of input instance can be assigned in an on-line manner.



(a) the stamp with largest value is chosed (b) running with greedy

(c) running with greedy (cont.) (d) the final result

Figure 3 The static animation for the stamp problem

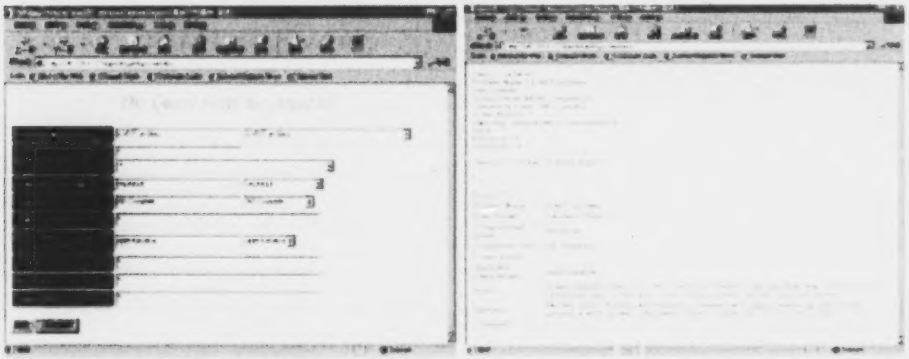
(a) input instance is assigned as 8 (b) the left half balls are sorted

(c) the right half balls are sorted (d) the final result

Figure 4 The interactive animation for the merge-sort problem

4 Reference Database Support

To meet general researchers' requirements, it is designed to supporting query by using various fields such as: problem name, data domain, computational model, complexity class, lower bound, algorithm characteristics, result, reference and comments. It also supports the up-load functionality for interested researchers to up-load their new findings all over the world. This database is valuable not only for the researchers but also for students who could access the newest or related results at their interests. Figure 5 illustrates the query form, where k-MST problem with NP-complete complexity and other constraints are given, and the queried result of our reference database. This service would like to attract interested users' participation to our virtual classroom where discussions via the bulletin board are welcomed.



(a) a query form (b) the quried result

Figure 5 The query and result reference database on algorithms

5 Concluding Remarks and Future Studies

We propose the design and implementation our virtual classroom for algorithms in this paper. The cognition of algorithms might need a process of individual thinking, iterative testing and experience sharing. Our virtual classroom offers learning aids on these respects via the web. It is expected that such a learning environment could help students to learn algorithms more effectively at their own pace. The hypermedia courseware will be increased and updated as a long-term project.

The activities in the traditional classroom are simulated to a great extent in our virtual classroom. However, we are not intending to give up the face-to-face interactions. The authors applied this hypermedia courseware on web as a learning assistant in a part of this semester. Students showed interests on constructing their knowledge via the hypermedia courseware and animations. Some students expressed that they supposed to understand the recursion in quick-sort before feeding data to the interactive animation, however they found their misleading after the visualization of data movement in the animation. This is one of the benefits what we intend to give in this virtual classroom. The construction of the knowledge tree is underway to help tracing the learning pattern of learners. Also an empirical evaluation of the learning effect will be studied in the near future.

The reference database gradually gathers interested researchers' attention. The authors would express their special thanks to those who up-loaded their findings of new papers and those who gave valuable suggestions.

References

[1] Brown, M. H., Exploring algorithms using Balsa-II, Computer, Vol.21, No.5, 1988, pp.14-36.
[2] Brown, M. H., ZEUS: A system for algorithm animation and multi-view editing, Proceedings of the 1991 IEEE Workshop on Visual Languages, Robe Japan, Oct. 1991, pp. 4-9.

BEST COPY AVAILABLE

[3] Carver, Jr., Curtis A., Howard, Richard A. and Lane, William D., Enhancing student learning through hypermedia courseware and incorporation of student learning styles, IEEE Transactions on Education, Vol. 42, No. 1, February 1999, pp.33-38.

[4] Chou, Chien, Developing hypertext-based learning courseware for computer networks: the macro and micro stages, IEEE Transactions on Education, Vol.42, No.1, February 1999, pp.39-44.

[5] Glassman, Steven, Turbo Environment for Producing Algorithm Animations, IEEE Symposium on Visual Languages, 1993, pp. 32-36.

[6] Gloor, P. A., AACE—Algorithm animation for computer science education, Proceedings of the 1992 IEEE Workshop on Visual Languages, Seattle, WA, Sept. 1992, pp. 25-31.

[7] Goodman, J. and Blake, J., Multimedia Courseware transforming the classroom, Computers in Nursing, Vol.14, No.5, 1996, pp.287-296.

[8] Lee, R. C. T., Tseng, S. S., Chang, R. C. and Tsai, Y. T., Introduction to the Design and Analysis of Algorithms, UNALIS, Taipei, 1999.

[9] Najork, M. and Brown, M. H., A Library for Visualizing Combinatorial Structures, IEEE Visualization, October, 1994.

[10] Marchionini, G. and Crane, G., (1994). Evaluating hypermedia and learning: methods and results from the Perseus project, ACM Transactions on Information Systems, Vol.12, No.1, pp.5-34.

[11] Mukherjea, Sougata and Stasko, John T., Toward Visual Debugging: Integrating Algorithm Animation Capabilities within a Source Level Debugger, ACM Transactions on Computer-Human Interaction, Vol. 1, No. 3, 1994, pp. 215-244.

[12] Novick, D. G. and Fickas, S., Collaborative Networked hypermedia education: lessons from the Nero project, International Journal of Computers and Education, Vol.24, No.3, 1995, pp.157-162.

[13] Stasko, J. T. TANGO: A framework and system for algorithm animation. Computer , Vol.23, No.9, Sept. 1990, 27-39.

[14] Stasko, et al, Software Visualization: Programming as a Multimedia Experience, MIT Press, 1998.

[15] Stasko, J. T, Using Student-Built Algorithm Animations as Learning Aids, Proceedings of the ACM Technical Symposium on Computer Science Education (SIGCSE '97), San Jose, CA, 1997, pp.25-29.

[16] Stern, Linda, Sandergaard, Harald and Naish, Lee, A Strategy for Managing Content Complexity in Algorithm Animation, ITiCSE'99, Cracow, Poland, June 1999. pp.127-130.

[17] Sun, Chuen-Tsai Chou, Chien and Lin, Bing-Kuen, Structural and navigational analysis of hypermedia courseware, *IEEE Transactions on Education*, Vol. 41, No. 4, November 1998, pp.347-357.

[18] Thuring, M. Hannemann, J. and Haake, J. M. (1995). Hypermedia and cognition - designing for comprehension. *Communications of the ACM*, Vol.38, No.8, pp.57-66.

[19] Valdes, D., Moure, M. J. and Mandado, E., Hypermedia: A Tool for Teaching Complex Technologies, *IEEE Transactions on Education*, Vol. 42, No. 4, November 1999, pp.361-376.

A Web-based Interactive Exercise System for Learning Mathematical Functions

Takayoshi Yoshioka, Yuzo Higuchi and Hitoshi Nishizawa
Toyota National College of Technology
2-1 Eisei-cho, Toyota, 471-8525, JAPAN
Tel: +81-565-36-5852, 5849, Fax: +81-565-36-5925
E-mail: {yoshioka, nisizawa}@toyota-ct.ac.jp

1 Introduction

Although exercises are important in learning fundamental mathematics, it is not easy to provide an appropriate exercise for every student in a class because the understanding level and the calculating skill of the student usually differs widely. Computer systems storing problems for the exercises and learning histories of the students might help the situation. The system should also have some intelligence in evaluating students' answers for mking it closer to the written exercises and going beyond the multiple choice questions [1].

CAS and graphic calculators have some intelligence in a way. They calculate or operate mathematical expressions symbolically, show the graphs of functions immediately. But the use of them does not always help the students to understand the mathematical concepts or the meanings of the operations [2]. They might become black boxes that hide not only the detailed process of the calculation but also the mathematical ideas lying behind them.

The authors have been developing a Web-based interactive exercise system since 1996 and have been using it as a supporting tool for teaching mathematics to our students [3]. The purpose of developing the exercise system is to change the roles of the students and the CAS. We want the students to think or guess in their exercises and the CAS to assist them for giving some meaningful hints for solving problems by themselves.

2 Interactive Exercise System

The exercise system described in this paper consists of networked computers for students and a WWW server collaborating with a database and a CAS, MATHEMATICA™ as the evaluation engine [4], which allows the students wide variety of mathematical expressions for their inputs. An evaluation is done by MATHEMATICA™ according to the rules described in custom evaluation functions coded with MATHEMATICA™ language [5]. It evaluates the students' inputs symbolically and returns more meaningful comments than correct or not. More detailed description of the structure of the system and some examples of the interactive exercises implemented on it have already been reported [3, 5].

The system, however, needs shorter response time for the exercise of expressing the mathematical function of a given graph. The exercise shows a student a graph of a function, asking to express the function as a mathematical expression (Fig. 1).

It gives the student several input fields for typing his/her expressions in. The expressions are sent to the server and compared with the answer symbolically by MATHEMATICA™. If one of the expression is equal to the answer, a simple comment "right expression" is returned to the student.

If no expressions are equal to the answer, comments describing the difference between the expressions and the answer are returned instead. A graphic image showing both the answer in blue color and the last expression in red color is also displayed, which helps the student to realize the difference visually. Every evaluation gives some hints toward the right expression, which allow the student to learn from his/her

mistakes.

3 Processing Time for the Evaluations

The new exercise needed more evaluation time than the other exercises when Macintosh was used as the server machine. Although the new exercise itself is most popular among the students, the long waiting time hindered it's regular usage. Technically, the biggest difference of the exercise from the others is that MATHEMATICA™ creates a new graphic file dynamically every time at the evaluation and the file is embedded into the HTML for the exercise page. The long waiting time was caused by the process of creating the graphic file.

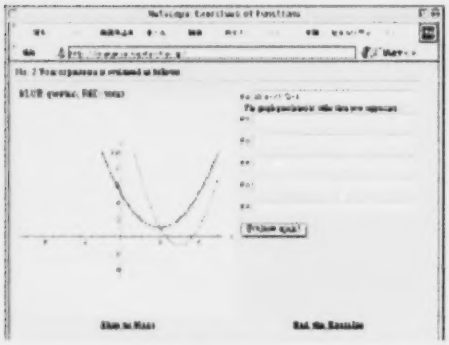


Fig.1 A student' s Web-page after the evaluation

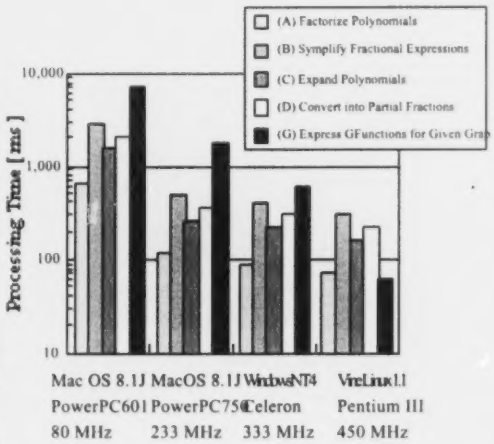


Fig.2 CPUs' processing time for the evaluations

We compared the CPU's processing time needed when MATHEMATICA™ evaluates expressions according to the rules described in the evaluation functions for the system (Fig. 2). There are four exercises of; (A) factorizing a polynomial, (B) simplifying a fractional expression, (C) expanding a polynomial, and (D) converting into partial fractional expressions, each of which needs only symbolic evaluation, and an exercise of expressing the function for given a graph (G) which lets the system create a new graphic file adding to the symbolic evaluation. The measurement was done using several server machines running different operating systems, i.e. Macintosh OS, WindowsNT, and Linux. Although the server machines used to run those operating systems are different in the type of CPU and the clock speed, we thought that the clock frequency of the CPU becomes a rough measure of the performance of a server, which consist of hardware and an operating system.

When we use Macintosh OS or WindowsNT for the operating system of the server, the evaluation of "expressing the function for a given graph" takes more processing time than the other exercises which does not create any graphic files. The processing time decreases with the clock frequency of the CPU and the exercise (G) consumes the longest processing time. If we select a PC running Linux as the server, the tendency is reversed. The evaluation which creates a graphic file becomes the shortest process on the sever while the processing time for the other exercises have same tendency. If we compare the Linux machine (450 MHz) with the WindowsNT machine (333 MHz), the processing time is 1/10 for the exercise (G) while it is 1/1.38 in the exercise (D), and the clock frequency of the CPU is 1.35. Changing the operating system for the server must be the most cost-effective improvement for the response when we put the exercise (G) into wider use.

4 Conclusions

A Web-based interactive exercise system has been extended to serve a new exercise of expressing the function for a given graph. MATHEMATICA™, a CAS used in the system as the evaluation engine, has far

better performance on Linux than on Macintosh OS or WindowsNT for the new evaluation when it creates a new graphic file. The increased performance will make the exercise to be used regularly.

References

1) Pitcher, N., Goldfinch, J., Beevers, C., "Computer base assessment: beyond multiple choice", Proceedings of ICTMT4, P31 (1999).
2) Hong, Y. Y. & Thomas, M., "Super-Calculators and Mathematics Examinations", Proceedings of ICCE'99, vol.2, pp483-490 (1999).
3) Hypermedia Learning Environment, http://orange.ee.toyota-ct.ac.jp/defaultE.html (accessed on July 25, 2000).
4) Miyaji, C., "Network Programming with Mathematica" (in Japanese), Iwanami shoten (1998).
5) Nishizawa, H., Saito, H., Pohjolainen, S., "Evaluation Methods of Mathematical Expressions in On-line Exercises on Expanding Polynomials and Simplifying Rational Expressions", Proceedings of ICTMT4, P52 (1999).

Adaptive Programming Language Tutoring System on the Web

Jin-woo Choi and Chong-woo Woo
Department of Computer Science, Kookmin University
861-1 Chongnung-Dong, Sungbuk-ku, Seoul, Korea
Tel: +82-2-910-4795
Fax: +82-2-910-4799
Email: cwwoo@kmu.kookmin.ac.kr

Many of the web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing proven techniques from the stand-alone Intelligent Tutoring System(ITS). Some recent web-based ITS researches show this efforts by employing the techniques selectively, and this needs to be studied further to support more effective web-based instruction. In this paper, we describe the design and the development of a Web based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting previous ITS techniques into the system successfully. Especially our focus is on the three levels of the instructional planning mechanism, which can generate lesson contents dynamically whenever it is requested. This way we do not need to crate all the lesson contents in HTML forms which must reside in the system in advance. In addition, the system has adapted CORBA structure to support the user more consistent and reliable performance. Together, the system behaves more adaptive and interactive, than the existing non-ITS based web systems. The test domain of the system is learning C programming language for the first year computer science student.

Keywords: **Web-based learning system, Intelligent Tutoring System, Instructional planning**

1 Introduction

Many recent web-based educational systems could not provide an individualized instruction or an interactive problem solving, since they are mostly built upon static hypertext. One possible approach to solve these problems could be adapting the existing techniques from the stand-alone ITS. Brusilovsky[2] states that some ITS techniques can be adapted into a web-based educational system, and divides the techniques into three distinctive parts, such as, automatic creation of curriculum, dynamic problem solving, and intelligent analysis of student model. However, most of the recent web-based ITS research show the efforts by employing the techniques selectively[2][3][4][7], such as adapting student modeling or problem solving capability at some level. Therefore, this needs to be studied further to enhance the overall capabilities of the system at the previous stand-alone ITS level. For instance, automatic generation of curriculum or lesson plan is necessary to provide a flexible instruction for each individual user.

In this paper, we describe the design and development of Web-based Adaptive programming Language Tutoring System(WALTS). The system is designed based on the ITS structure primarily, and it is adapting many techniques from the stand-alone ITS into the web-based systems. First, we designed the knowledge base using the object-oriented method in order to handle flexible management of object inheritance and tutorial strategies. Second, the student modeler can avoid the network traffic by designing the modeler stays in the server-side at the beginning of the session for maintaining necessary administration duties, and creates an individual student model in the client side. And the third important approach is having the instructional planning mechanism, which generates lesson contents dynamically for each individual user. This is important feature for moving towards the web-based system, because most web-based educational systems

creates all the lesson contents in HTML forms in advance, and they must reside in the system physically. And then the user navigates the system for learning, such as in ELM-ART[2] or CALAT[4]. Intelligent navigation strategy might be one of the intelligent way of guiding the user to learn the material, but rather inefficient compare to the dynamic generation of lesson contents. WALTS only generates the necessary lesson contents whenever it is requested by the system, which can be another advantage. In addition, we have approached distributed architecture by employing CORBA(Common Object Request Broker Architecture) structure to support the user more consistent and reliable performance while the user using the system. The initial web-based educational systems are mostly developed by using the CGI(Common Gateway Interface) techniques, which often results in bottleneck problem when many users access the system at the same time. In this sense, our structure might avoid such a problem, and the system could also be easily updated when we need to revise some part of the system. Together, the system behaves more adaptive and interactive, than the existing non-ITS web-based educational systems. The test domain of the system is learning C programming language for the first year computer science student.

The rest of the paper is organized as follows. In section 2 we described a distributed infrastructure of WALTS system. Section 3 presents each components of the system and also some intelligent aspects of the system. We conclude the paper in section 4.

2 Distributed infrastructure

The previous web-based educational systems have been built as either a server-based architecture or a client-based architecture[6]. Each of them has some advantages and disadvantages. The server-side architecture mostly rely on CGI techniques, which has shown some problems of handling complex client/server communication because of its connectionless feature. Also client-side architecture needs to have all the plug-ins installed on client computer before using the system. Therefore the recent web-based applications tend to adapt CORBA or Java based distributed infrastructure. That is free from the connectionless or stateless problem, and also has some advantages of distributed system technology, such as message passing, RPC(Remote Procedure Call), and proprietary communication protocol. The client connects to the server using the HTTP protocol only for the initial connection, and after the downloading the specific mobile code application(for example, client side application, JavaScript, Java Applet, and etc), the client use the proprietary protocol(non-HTTP), so it does not communicates with web server, but communicates with proprietary server(non-Web server).

WALTS employed CORBA to adapt this kind of distributed infrastructure. The system is designed by HTTP server which takes care of user requests and responses, and CORBA-based server which performs the capabilities of the ITS. Also the system could be easily re-organized if we want to modify the structure later on [see figure 1]. In short, one of the major advantages of WALTS is that it can easily avoid the bottle-neck problem of CGI techniques, and also we believe that this style of architecture might be another best solution for building web-based client/server educational system.

3 Basic architecture of the system

The basic architecture of WALTS is designed by typical ITS structure primarily, including expert module, the student modeler module, and the instructional planning module.

3.1 The expert module

The expert module of the system consists of the object-oriented knowledge base, and the problem solver.

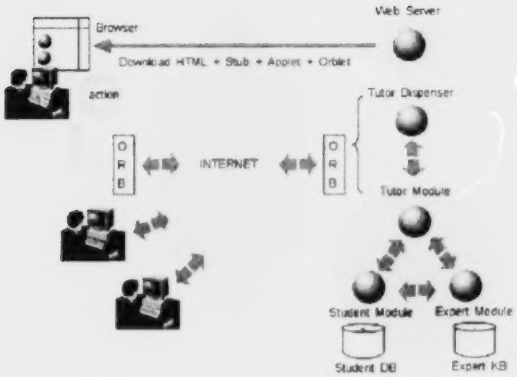


Figure1 The main architecture of the WALTS

Object Oriented-based knowledge base. First, we employed the frame knowledge representation techniques for the main knowledge base. Because the domain knowledge does not require any complex causal relationships, but rather it is consists of simple C language concepts. The object-oriented approach make it easy to modify the data type, can reduce the knowledge base reference by having slot values as member data, and can provide more flexibility for updating or manipulating tutoring strategy [5].

In this system we designed a frame with several meaningful slots, and each frame does not have to have the same number of slots, since the inference engine can get all the necessary informations due to the inheritance feature of the system. The 'type' slot can possess a concept, example, or quiz. The 'source' slot points to its superior frames. The 'Pfame' and 'CFrame' slot is necessary when we need to show the related nodes in linked list structure. The 'reference' slot may contain all the necessary frame names that are related to the current frame. This kind of slot structure is very common in every frame structure, and also important in object-oriented structure, because each frame can have common attributes and can generate an object of having its own attribute. Also, the system allows an abstract class, which plays the backbone of the system, and supports a hierarchical structure, and the definition of the method can be done only in the lower class [figure 2].

Frame Variable Declaration Quiz
[Source] Chapter1-3-1-1
[Type] Quiz
[Title] Variable declaration Quiz
[Template] Data Type | Variable | General Grammar
1 : Select the correct %type variable declaration
2 : ...
[PFrame] Variable Declaration
[CFrame] Null

Figure2 Variable declaration quiz frame

The Problem Solver. WALTS can generate a problem dynamically depending on the current topic. Since the planner knows what is being taught at the moment by generating a lesson unit, the tutor can decides whether it is 'teaching concept' or 'show example' or 'quiz'. At the moment, we have only three styles of lesson unit. If it is a 'teaching concept', the planner sends the lesson unit to the user in HTML form. If it is a 'quiz' type, then planner requests the problem solver to generate a question. The problem solver first creates a problem table by referring to the current lesson unit. The generating and solving a problem occurs at the same time, and the solver stores the correct answer. And then, it presents the generated questions to the user in appropriate HTML form through the HTML generator. This method can provide different styles of questions for different users even though they are accessing the same lesson unit, which can be another advantage of WALTS. Since the column name of the table is object's name, the planner can reply to the user's request, such as hint or help, by referencing this table.

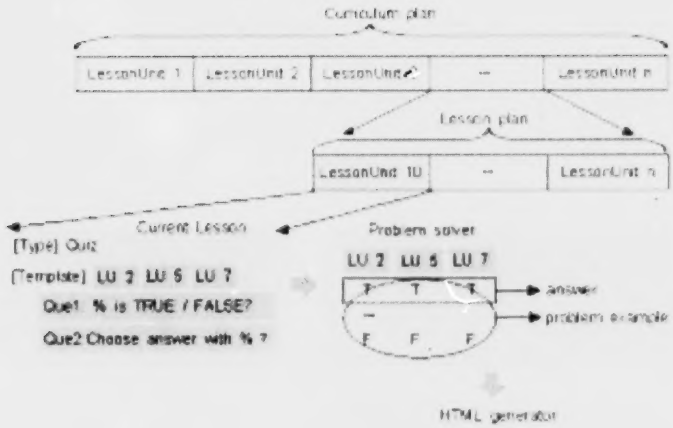


Figure3 Creation of a quiz for 'variable declaration'

The strategy of asking user for answering quiz is multiple choices. So that we need to generate problems along with the appropriate multiple choice answers also. For instance, let us think about a simple quiz about asking user 'a data type'. A typical 'data type' is consists of three parts, for example, 'int x ;'.The 'int' is a data type integer, 'x' is a user-defined variable name, and ';' is needed for ending a sentence in C language. We are trying to generate this simple data type declaration statement sentence as follows. First, the data type 'template' slot consists of three parts as in [Figure 3]. Then we can generate eight different answers as in [Figure 5], since each one part of a statement can be correct or incorrect. And we can select some of them randomly including correct answer; the numbered answers are selected ones in the figure. And also we can obtain designated unit object's content as in [Figure 4]. The generated correct answer is stored in memory, and then later it is compared with the user's answer. For example, if the user selected number 2 as in [figure 5], we can analyze that the user does not know about reserved word. And the planner needs to revise the lesson plan to correct the misconceptions by giving special messages, such as hint or help, and then the planner re-organizes the lesson plan including 'reserved word' lesson unit. The [figure 6] shows a sample session of solving a generated quiz.

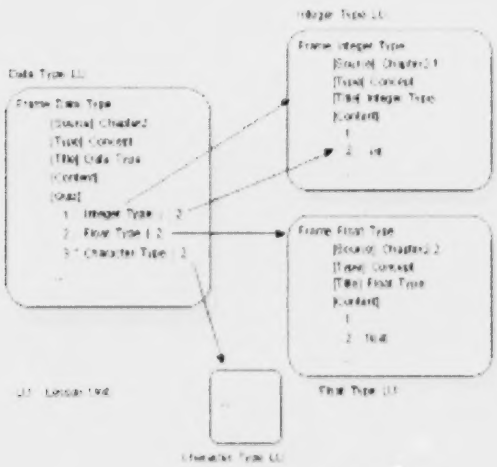


Figure4 Data type unit frame

BEST COPY AVAILABLE

Data Type	Variable	General Grammar	
T	T	T	④
T	T	F	
T	F	T	②
T	F	F	①
F	T	T	
F	T	F	③
F	F	T	
F	F	F	

Figure5 Table for possible answers for data type quiz

3.2 The Instructional Planner

The most web-based educational systems built upon hypertext, which is hard to make hyperlink in every HTML pages, and also needs to have carefully designed navigation strategy[2]. And also all the lesson contents are built as HTML pages in advance, and must reside in the system physically. We believe that generating a lesson plan dynamically, for each individual user, is more efficient than the above approaches. Therefore, we adapted the traditional ITS instructional planning mechanism into the system. The instructional planning of the WALTS can be further divided into 3 steps, a curriculum planning, a lesson planning, and a delivery planning. The curriculum planning of WALTS generates a curriculum in tree structure; the curriculum planner extracts information from the knowledge base and creates a curriculum hierarchically in the order of prerequisites. Then the lesson planning sets up the lesson sequence within a single lesson unit. The role of delivery planning is limited to presenting the selected lesson content to the user.

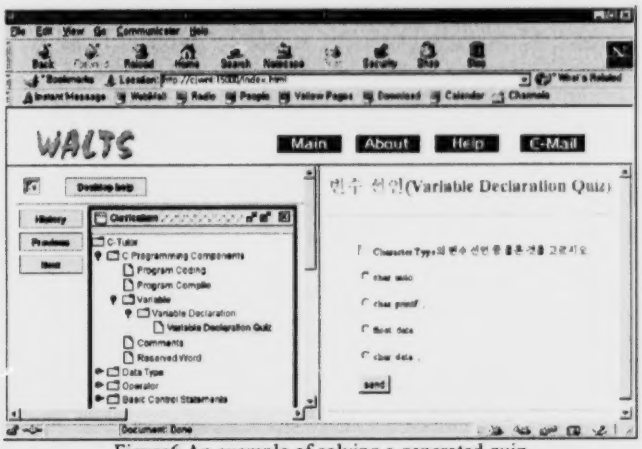


Figure6 An example of solving a generated quiz

Curriculum planning. The purpose of the curriculum planning is to provide a curriculum to the user, in other words, to provide an individualized optimal learning path to the user[1]. The generated curriculum is in the form of a tree structure. It is constructed by creating an initial node by referencing the value of the attributes in the lesson unit slot, and further expands the structure in the order of the way the student must learn, which will be accessed as linked list structure. The lesson unit of the system is organized according to some basic rule, such as the student must learn prerequisite concept first and the move to the next topic. So the curriculum is set up in the form of hierarchical and linear sequence.

Lesson Planning. The lesson planner generates a lesson plan by referencing the curriculum and the student model. The information from the student model shows the results from single lesson unit and based on this record, the planner sets up appropriate lesson plan for the student. When the student selects other learning path on purpose before the current lesson plan is finished, the system must decide what to do next, such as whether to store the current lesson plan and execute the user's request, and then resume the current plan or destroy the current plan and re-plan the whole sequence all over again. In that sense, WALTS uses re-planning strategy when the user wants to quit the current topic, and move to another learning path. Another

case of re-planning occurs when the student made an error on the selected quiz lesson unit. If the student made a mistake on this, the current lesson plan is suspended, and another new lesson plan is created to correct the student's error. After the remediation process is finished, the suspended plan will be resumed.

Delivery Planning. The lesson unit has been generated by lesson planner and needs to be delivered to the user. The possible delivery tactic in this domain could be "present concept, show example, give exercise, and etc". Of course if the system allows mixed-initiative control, the delivery planning needs to be more sophisticated in order to handle all the user request or questions. The delivery planning part of the WALTS is made of simple structure, and will be enhanced further in the next research.

The HTML generator. The very distinctive feature of the system is the HTML generator. This feature can be regarded as the interface part of the system. When the delivery planner decides the immediate unit lesson, the content of the lesson is converted into HTML form by the HTML generator. The HTML generator generates HTML pages according to the HTML2.0 protocol and inserts "next" or "previous" button in order to navigate adaptive learning path. But if the lesson unit contains some applet, the system directly searches the physical location and sends the URL to the student's browser without consulting HTML Generator. The [figure 7] describes the HTML generator sends two different results to two different users, since their learning background is different.

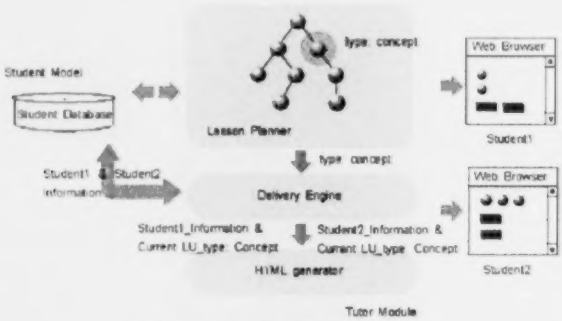


Figure7 The HTML generator

3.3 The student modeler

The strategy for building the student modeler is the simple overlay, which simply reflects user's learning process about current topic. And this should be enhanced by including the buggy information later on. But an important enhancement is that the student modeler of WALTS can avoid the unnecessary network traffic. For instance, if the system maintains the student model in the server-side, then whenever the user accesses the system the server needs to update the user's student model in the server. This may cause another bottleneck problem, and the most CGI-based systems still have this problem. Our approach on the student modeler is as follows. The server-side student modeler creates a table, and keeps all the necessary administrative informations on the server-side, such as initial student's ID, password, e-mail address, the access time[figure 8], which can be used for various administrator purposes. And the information regarding the student's learning process is stored in the student model[figure9], which is created in the client-side machine for each individual user whenever they logged on. The student model has several parameters that reflect the student's learning history, and each parameter has unique meanings. For example, the 'HelpCount', means how many times the user has been helped, and 'HintCount' means how many times the user has requested hints, and they can be updated only when the 'unit lesson' is quiz. The 'ReferenceCount' means the user is weak at the current unit lesson since the specific lesson has been accessed more often than other frames. The 'LessonLevel' stores information about how the level of the current topic, and the 'LessonType' means whether the current unit lesson is concept, example, or quiz, and so on.

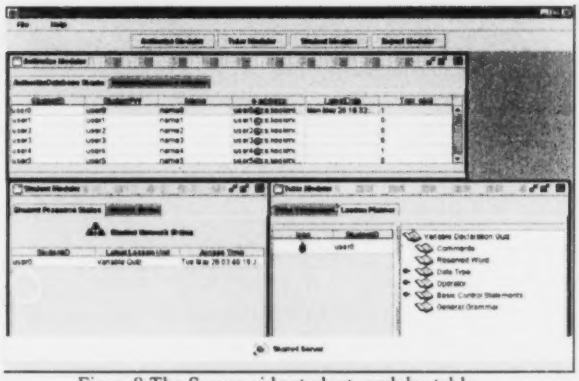
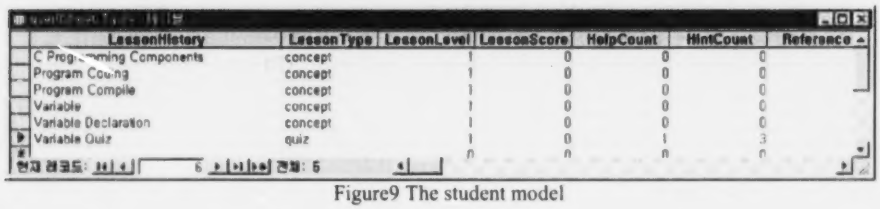


Figure8 The Server-side student modeler table



LessonHistory	LessonType	LessonLevel	LessonScore	HelpCount	HintCount	Reference
C Programming Components	concept	1	0	0	0	
Program Coding	concept	1	0	0	0	
Program Compile	concept	1	0	0	0	
Variable	concept	1	0	0	0	
Variable Declaration	concept	1	0	0	0	
Variable Quiz	quiz	1	0	1	3	
		0	0	0	0	

Figure9 The student model

4 Conclusion

We have designed and implemented a web-based ITS, WALTS, which is a learning C programming language tutor aiming for the first year computer science students. The main goal of this paper is, first, the adaptation of the existing ITS techniques into the web platform. Therefore, we have designed and implemented the system based on the major ITS architecture, and this brings us several advantages over traditional HTML-based educational systems. First, the main knowledge base is created as an object-oriented concept, which can provide more flexibility for manipulating frame objects and tutoring strategy also. Second, we have generated a quiz dynamically by the problem solver and also can solve the problem. Third, we designed a student modeler that can avoid the network traffic in the minimal, by having the modeler in the server-side, and creates an individual student model in the client-side. Fourth, the instructional planner can generate an instructional plan dynamically, and this is another advancement of building web-based ITS, since the current web-based ITS research shows further work on this subject. Additional issue of the paper is that we designed the system as the distributed infrastructure using CORBA as backbone of the system. This structure solves the bottleneck problem of previous CGI dependent systems, and also gives some benefits of better performance and also gives flexibility in the case of further enhancement of the system.

References

[1] P. Brusilovsky. "Adaptive Educational Systems on the World-Wide-Web: A Review of Available Technologies" http://www-aml.cs.umass.edu/~stern/webits/itsworkshop/brusilovsky.html

[2] P. Brusilovsky, E. Schwarz, and G. Weber. "ELM-ART: An Intelligent Tutoring System on the WWW." The Proceedings of ITS'96, pp261-269, Springer, (1996).

[3] J. Kay and R.J. Kummerfeld "An Individualized Course for the C Programming Language." The Proceedings of 2nd International WWW Conference, Chicago, IL, pp17-20, (1994).

[4] K. Nakabayashi, M. Maruyama, Y. Koike, Y. Kato, H. Touhei, and Y. Fukuhara. "Architecture of an Intelligent Tutoring System on the WWW." The Proceedings of AI-ED'97, pp39-46, (1997).

[5] K. Nakabayashi, H. Touhei, S. Hitoshi, and Y. Fukuhara. "An Object-Oriented Architecture for a Web-based CAI System", The Proceedings of EDMEDIA'98, (1998).

BEST COPY AVAILABLE

[6] A. Silva, M. Silva, and J. Delgado. "A Survey of Web information Systems." The Proceedings of WebNet'97, pp520-530, (1997).
[7] M. Stern, B. Woolf, and J. Kurose, "Intelligence on the Web?," The Proceedings of AI-ED'97, pp490-497, (1997).

An Adaptive Navigation Support with Reorganized Learning Resources for Web-based Learning

Shinobu Hasegawa, Akihiro Kashihara, and Jun' ich Toyoda
The Institute of Scientific and Industrial Research, Osaka University,
8-1,Mihogaoka Ibaraki Osaka, 567-0047 JAPAN
Tel: +81-6-6879-8426
Fax: +81-6-6879-8428
E-mail: hasegawa@ai.sanken.osaka-u.ac.jp

On the Web, there are diverse learning resources with the same learning topic, each of which is designed by different authors. Properly using these web-based resources, learners can study the topic from diverse points of view. This is one of the prominent merits of web-based learning. However, learners would have difficulty in finding a learning resource suitable to their learning contexts because there are currently an enormous number of learning resources on the Web and because most web-based learning resources do not have a clear description of their characteristics such as what kind of learners should use, what kind of learning goal can be achieved. Our approach to this issue is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to provide learners with an adaptive navigation support, which recommends them some learning resources to be learned next in accordance with their needs and knowledge states. We also report a preliminary experiment to evaluate the validity of the adaptive navigation support with a demonstration system. From the results of this experiment, we have made sure that it is valid.

Keywords: **Learning Resource, Web-based Learning, Resource Index, Resource Navigation**

1 Introduction

Over the past several years, an increasing number of hypermedia/hyperdocuments based resources on the Web have been available, which are designed from an educational point of view, or which are worth learning. Learning with such existing web-based resources has accordingly become more important, particularly as the realization of lifelong and distance learning [1].

On the Web, there are many learning resources with the same topic, each of which is designed by different authors. Some of them are suitable for augmenting domain concepts/knowledge in the topic. Some are also suitable for having a deeper understanding of the topic with examples/simulation/illustration, or applying knowledge with exercises. Properly using these kinds of learning resources, learners can study the topic from diverse points of view. This is a prominent merit of learning a topic on the Web.

This paper describes a web-based learning environment that makes use of diverse learning resources involving a certain topic to promote learning. The main issue addressed here is how to help learners select some instructive learning resources according to their learning contexts. There are currently an enormous number of learning resources on the Web. In addition, most web-based learning resources do not have a clear description of what kind of learners should use, what kind of learning goal can be achieved and so on [7]. Learners consequently have difficulty in finding an instructive learning resource [4].

The approach presented in this paper is to reorganize web-based learning resources with indexes called resource indexes representing their characteristics, and to build a learning resource database. At present, there exist a number of Web sites collecting URLs of web-based learning resources. These sites use resource indexes, which mainly represent learning topics/subjects, to classify the learning resources. The resource indexes allow learners to know what they can learn beforehand. In other words, they can select learning resources from a "what to learn" point of view. However, the indexes are not enough for them to find a learning resource suitable to their learning contexts since they would usually think of not only "what to learn" but also "how to learn". They would particularly think of in which learning phase they try to learn. There are generally several phases of learning a topic such as augmenting new knowledge/information about the topic, deepening understanding of knowledge, applying/stabilizing knowledge, etc [5]. Which learning resource to select depends on in which phase learners try to learn. Learning phases should be accordingly represented as resource indexes.

In this paper, we propose a way to reorganize web-based learning resources with "how to learn" indexes (HTL indexes for short) including learning phases in addition to conventional "what to learn" indexes (WTL indexes for short), building a learning resource database. We also demonstrate an adaptive navigation support with the database, which recommends learners some resources to be learned next in accordance with their learning contexts such as needs and knowledge states. This aims to promote their learning from knowledge accretion phase to knowledge stabilization phase.

In the following sections, we first describe the way to build a learning resource database with WTL and HTL indexes. Next, we demonstrate the adaptive navigation support with the database. Furthermore, we report a preliminary experiment to evaluate the validity of the adaptive navigation support. From the results of this experiment, we have made sure that it is useful.

2 Reorganizing Web-based Learning Resources

2.1 Learning with Existing Resources on the Web

Before discussing the way to reorganize learning resources on the Web, let us first consider learning with them. In this paper, a learning resource means a hyperdocument, which describes a learning topic within a Web site. It provides learners with a hyperspace that consists of a number of Web pages. Learners can explore the hyperspace to learn domain concepts/knowledge [2], [6]. On the Web, in addition, there are diverse learning resources with the same topic, which could facilitate diverse learning phases such as augmenting and applying domain concepts/knowledge. Properly using these learning resources, learners can study the topic from diverse points of view.

As shown in Figure 1, we view web-based learning as learning a topic in three phases and as the transition between learning phases. The learning phases are as follows: accretion, understanding, and stabilization [3]. Each phase is also explained as follows:

- Accretion phase is the one in which domain concepts/knowledge are augmented;
- Understanding phase is the one in which known concepts/knowledge are understood with examples, simulations, illustrations, etc.;
- Stabilization phase is the one in which known concepts/knowledge are stabilized by means of problem-solving with exercises.

The transition between learning phases is expected to occur according to completion or impasse of learning in a phase. It is also expected to take place from knowledge accretion phase to knowledge stabilization phase or in the opposite direction. Learners' knowledge is finally expected to stabilize. However, learners need not always start learning from the accretion phase. They can start learning from any learning phase according to their knowledge states.

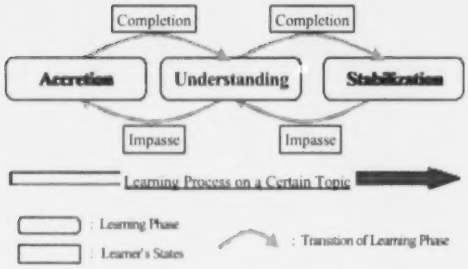


Figure 1 Web-based Learning

Table 1 Resource Index

WTL Index	Academic Year Subject Learning Topic	
HTL Index	Learning Phase	Accretion Understanding Stabilization
	Media	Texts only Graphics Animations Sounds Simulations E-Mail BBS, Chat Others
	Communication Channel	High Immediacy High Interactivit Questions and A

2.2 Resource Index

In learning a topic, learners would select a learning resource according to their knowledge states. However, most existing learning resources on the Web do not usually have a clear description about which learning phase could be facilitated. Therefore, the proper selection of learning resource is not so easy for them. One way to resolve this problem is to provide learners with a learning resource database.

There currently exist many Web sites, which collect URLs of web-based learning resources. In these sites, they are classified with resource indexes that mainly represent learning subjects/topics. These indexes allow learners to select learning resources from a "what to learn" point of view. However, such indexes are not enough for them to find a learning resource according to their learning contexts. When a learner wants to stabilize his/her knowledge of a topic, for example, he/she could select a learning resource suitable for augmenting knowledge about the topic. Learners would usually think of not only "what to learn" but also "how to learn" especially in which learning phase they should learn.

We have consequently provided resource indexes that consist of "How To Learn (HTL)" indexes in addition to conventional "What To Learn (WTL)" indexes, and have proposed a way to reorganize learning resources. In helping learners select learning resources proper for the transition between learning phases as shown in Figure 1, "learning phase" is first most important as HTL indexes. In helping learners continue learning in a phase, second, some HTL indexes are necessary for differentiating learning resources that could facilitate the phase. In fact, some learners may try to resolve an impasse, which occurs in one resource, with other resources that could facilitate the same learning phase. Considering web-based learning resources with the same topic, we can see various media for representing the contents such as text, diagram, chart, illustration, etc. We can also see various interactive/real time environments such as simulation, chat, BBS, etc. Such media and communication channels would have an influence on how to learn. In addition to learning phase, we accordingly regard them as HTL indexes as shown in Table 1.

2.3 Reorganization

Figure 2 shows how to reorganize learning resources with WTL and HTL indexes. First, the learning resources are classified with WTL indexes so that learners can see from a "what to learn" point of view. Next, the resources are classified with learning phases so that learners can select fom a number of learning resources with one topic. Some learning resources may have two or three indexes of learning phase. Finally, indexes of media and communication channels are attached to each learning resource as its attributes so that learners can select from a number of resources that could facilitate the same learning phase.

Following the above way, we have implemented a learning resource database where many existing resources have been indexed. We have also addressed the issue of how to support indexing (See [5] for more detail).

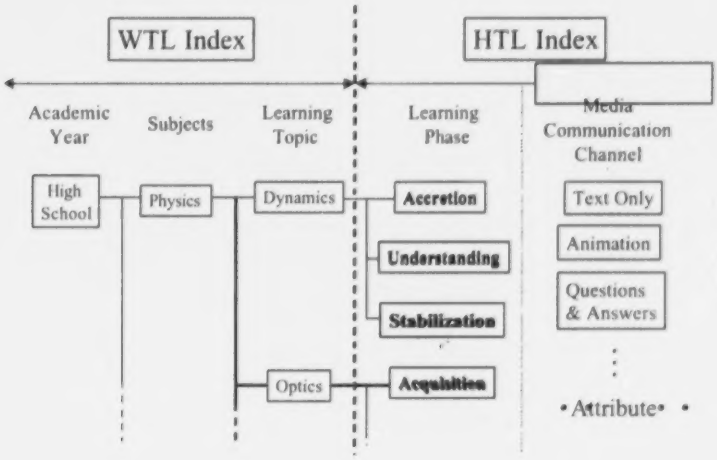


Figure 2 Hierarchy of Indexes

3 Adaptive Navigation Support

3.1 Learning Resource Navigation

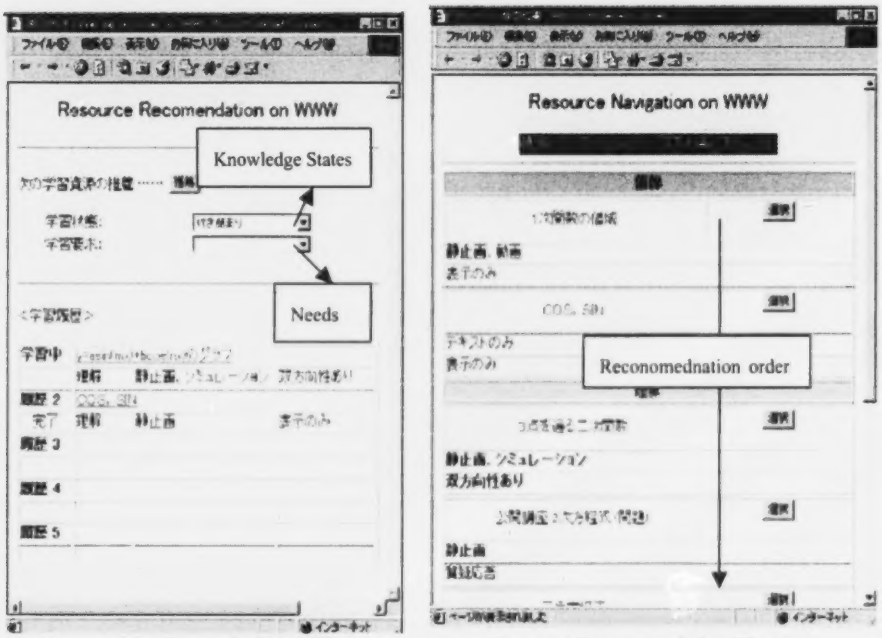
Let us now introduce an adaptive navigation support with the learning resource database. Although the resource indexes allow learners to search learning resources they want to learn, it is still difficult for them to select a learning resource in accordance with their learning contexts to promote learning from knowledge accretion to knowledge stabilization. We have accordingly proposed a navigation support, which recommends learning resources to be learned next according to learners' knowledge states and needs.

The main aim of this support is to promote learning of a specific topic with diverse learning resources so that learners' knowledge can be stabilized. For this aim, in particular, it attempts to facilitate the transition between learning phases and to change media/communication channels for promoting learning in one phase. If a learner reaches an impasse in the understanding phase, for example, he/she is encouraged to return to the accretion phase to resolve it. If he/she completes the understanding phase, on the other hand, he/she is encouraged to move to the next phase that is stabilization phase. He/she is alternatively encouraged to continue learning in the same phase with different resources that have different media/communication channels.

3.2 Recommendation

Let us next explain how to execute the learning resource recommendation in accordance with learners' knowledge states and needs. In the navigation support, we consider two knowledge states: impasses and completion of learning a resource. Learners are asked which state they reach after learning the resource. If necessary, they can also demand change of media/communication channels for a learning resource to be learned next as their needs.

The learning resource recommendation uses the information given by the learners to make a list of learning resources to be learned next. The learning resources are put in the order of priority. The aim of the recommendation is not to give the learners the most instructive resource from the database. The list provides them with a guide in selecting instructive learning resources.



< Learner' s Input Window> <Resource Recommendation Window>

Figure 3 Resource Navigation System Interface

Figure 3 shows the interface of the prototype system for adaptive navigation support. This system, implemented with Common Gateway Interface (CGI), consists of two windows. The left window enables learners to input their needs and knowledge states in learning the current resource. It also shows a history of learning resources used, and encourages the learners to reflect on their learning processes. The right window displays a list that puts learning resources in order of priority for recommendation.

3.3 Procedure

Let us next explain how to decide the order of priority for recommending learning resources to be learned next. It corresponds to deciding which resource indexes should be given priority.

3.3.1 Ordering with Knowledge States

(1) Case of Impasse

When learners reach an impasse in a learning phase, learning resources, which could facilitate the previous learning phase, are first recommended so that they can resolve the impasse. The previous phase as index is accordingly given priority. On the other hand, the next phases are not given priority. Learning resources that have the same media/communication channels are also recommended since the learners may get confused with a change of media/communication channels in addition to the change of learning phase. The same media/communication channels as indexes are accordingly given priority. In case learners' knowledge state is in an impasse, therefore, learning resources that have the previous phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

(2) Case of Completion

When learners complete learning in a learning phase, learning resources that have the next phase as index are first recommended so that they can further their knowledge. The next phase as index is accordingly given priority. The previous phases, on the other hand, are not given priority. The media/communication channels as indexes are given in the same way as the case of impasse. In case learners' knowledge state is in completion of learning, therefore, learning resources that have the next phase and the same media/communication channels as resource indexes are recommended as resources that are more instructive.

BEST COPY AVAILABLE

3.3.2 Ordering with Learners' Needs

In learning a resource, some learners may demand change of media/communication channels for the learning resource to be learned next. Regardless of learners' knowledge states, in this case, the same learning phase and different media/communication channels as indexes are given priority. The same media/communication channels are not given priority. Second, the different learning phases as indexes are not given priority according to learners' knowledge states. In case of impasse, the next phases are not given priority. In case of completion, the previous phases are not given priority. Learning resources that have the same phase and different media/communication channels as resource indexes are consequently recommended as resources that are more instructive. However, the way of ordering discussed in 3.3.1 is executed if learners reiterate learning in the same phase.

3.3.3 Calculation for Recommendation

Let us explain the way of calculation for ordering learning resources with an example. Learning resources are ordered with recommendation score, which is calculated every resource. Each learning resource has a number of HTL indexes. The recommendation score is calculated as follows. It is first scored ten points per learning phase index that is given priority, and is scored minus ten points per learning phase index that is not given priority. Next, it is scored one point per media/communication channel index that is given priority, and is scored minus one point per media/communication channel index that is not given priority. The larger the recommendation score is, the higher the priority of recommendation is.

Figure 4 shows an example of ordering five learning resources. In this example, a learner inputs "impasse" as his/her knowledge states in learning a resource. The learning resource has the "understanding" phase, "text only" media as HTL indexes. In this case, the accretion phase as index is given priority. The stabilization phase is not given priority. In addition, the "text only" media as indexes is given priority, while the other media/communication channels are not given priority. Therefore, the recommendation scores for the five learning resources calculated as shown in the right side of Figure 4. The learning resource that has the accretion phase and "text only" media as HTL indexes is recommended in the highest priority.

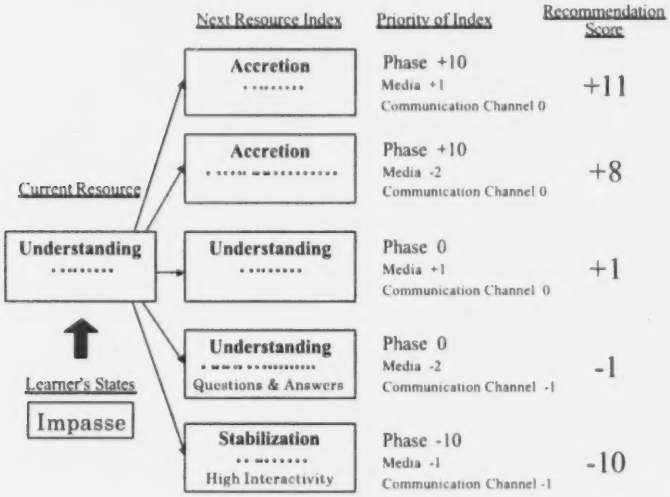


Fig. 4 Example for Recommendation

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the adaptive navigation support with the resource indexes and the learning contexts, we have had a preliminary experiment. The main purpose of this experiment was to ascertain the validity of the way of calculation for the recommendation order.

In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources by reading them carefully. Table 2 shows learning resources used in the experiment, which are described about a learning topic of "Global Warming Issue". Subjects were 12 graduate and undergraduate students in department of engineering. In spite of a well-known topic, the results of pretest indicated that they did not necessarily have sufficient domain knowledge.

The procedure of the experiment with each subject was as follows:
(1) He/she was asked to learn the resource A and then to input his/her knowledge state after learning. If he/she wanted to change media/communication channels, he/she could also input it as his/her need.
(2) He/she was asked to read the remaining resources carefully and place them in the order where he/she felt them more proper for his/her knowledge state and need.

Table 3 shows the order of priority for recommendation in each learning context considered. The order is calculated by the way discussed in section 3.3. For example, the recommendation is done in order of resource C, B, D and E, when a subject's knowledge state is in completion. Comparing the order of priority for recommendation to the order that subjects decided, we evaluated the validity of the learning resource recommendation.

4.2 Result

Table 4 shows the results of this experiment. The vertical axis is the order in which the system placed the learning resources (System-decided Order for short) and the horizontal axis is the order in which subjects placed them (Subjects-decided Order for short). The smaller the number of the order is the higher the priority for recommendation is. Each value in the table means the number of cases that fulfilled the System-decided order and the Subjects-decided order. For example, there were six cases where both System-decided and Subjects-decided orders were the first place.

In order to look into an approximate tendency in Table 4, we divided the order of priority into High and Low. As shown in Table 5, the High order including the first and second places of both System-decided and Subjects-decided orders, and the Low order also including the third and fourth places. We then performed Fisher's exact probability test in Table 5. As a result, there was a significant relevancy between System-decided order and Subjects-decided order($p=0.00867$), and these orders were positively related with a correlation (ö=0.42). It indicates that System-decided order agreed with Subjects-decided order approximately.

Table 2 The Learning Resource for Experiment

	Resource	HTL Index
A	Think about global warming http://www.nature-n.com/g_wrm/index-j.htm	Phase : Accretion Media : Graphics
B	Eco-Life Guide • The Issue of Global Warming http://www.eic.or.jp/ecolife/t001.html	Phase : Understanding, Stabilization Media : Graphics, Others Communication Channel : Questions
C	Kyoto-Earth's Homepage • Environment• Global Warming http://www.pref.kyoto.jp/intro/21cent/kankyo/h3.html	Phase : Accretion, Understanding Media : Graphics, E-Mail
D	Global Warming http://www.wnn.or.jp/wnn-eco/cop3/index.html	Phase : Accretion, Understanding, S Media : Graphics, Others Communication Channel : Questions High Interactiv
E	Tackling to the global environmental problems • Global Warming http://www.epcc.pref.osaka.jp/apec/jpn/earth/index.htm	Phase : Accretion Media : Graphics

Table 3 Order of Priority that the System Ordered

Case of Completion

Resource	Priority			Or
	Phase	Media	CC	
B	+1	+1,-1	-1	
C	+1	+1,-1	0	
D	+1	+1,-1	-1,-1	
E	0	+1	0	

Case of Impasse

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	-1	
C	-1	+1,-1	0	
D	-1,-1	+1,-1	-1,-1	
E	0	+1	0	

Case of Change (State : Completion)

Resource	Priority			Or
	Phase	Media	CC	
B	0	+1,-1	+1	
C	+1	+1,-1	0	
D	+1	+1,-1	+1,+1	
E	+1	-1	0	

Case of Change (State : Impasse)

Resource	Priority			Or
	Phase	Media	CC	
B	-1,-1	+1,-1	+1	
C	+1,-1	+1,-1	0	
D	+1,-1,-1	+1,-1	+1.+1	
E	+1	-1	0	

(CC : Communication Channel)

Table 4 Result of Experiment

System-decided Order	Subjects-decided Order			
	1	2	3	4
4	2	1	4	5
3	1	3	3	5
2	3	3	4	2
1	6	5	1	0

Table 5 Result of Experiment

	Subjects-decided HighOrder	Subjects-decided LowOrder
System-decided LowOrder	7	17
System-decided HighOrder	17	7

5 Discussion

From the results of the experiment, we have made sure that the adaptive navigation support is useful for learners to learn a certain topic with diverse learning resources. However, it does not work well for learners who cannot input their knowledge states and needs by themselves because these are important information for the adaptation. One way to resolve this is that teachers/instructors help such learners input. In addition,

some learners may input their wrong knowledge states. However, this is not a serious problem from a whole learning process point of view since inputting "completion" as knowledge state despite his/her incompleteness of learning would cause a serious impasse in the next learning phase, for example. Alternatively, inputting "impasse" despite his/her completeness of learning as knowledge state would cause a complete learning in the previous phase without difficulty.

Lets us next discuss the adaptive navigation support compared with related work on courseware generation on the Web [8]. Courseware is generally generated in order to facilitate learning of a series of topics and relationships between these topics. Each topic included in a courseware accordingly needs to be designed as learning resource from a specific point of view. In related work on courseware generation, the same designer prepares each learning resource for each topic on the Web. However, it is hard to make a courseware from existing web-base resources since they are usually designed from different points of view. On the other hand, we focus on properly using diverse resources with the same topic, not with related topics, to promote learning of it from diverse points of view.

6 Conclusions

This paper has proposed a learning resource database that reorganizes learning resources on the Web with resource indexes. This paper has also presented the adaptive navigation with the database, which recommends learners some resources to be learned next according to their needs and knowledge states. This allows learners to use existing learning resources with a certain topic to promote their learning. In addition, the paper preliminarily evaluated the adaptive navigation support. In this experiment, we compared the order of priority for recommendation generated with the adaptive navigation support to the order in which subjects placed learning resources. As a results, we have made sure that it is valid.

In the future, it is necessary to evaluate the adaptive navigation support in more detail. We would also like to develop a more practical system and open to the public.

Acknowledgments

This research is supported in part by International Commuication Foundation, and in part by The Telecommunications Advancement Foundation.

References

[1] Brusilovsky, P., "Methods and Techniques of Adaptive Hypermedia", Journal of User Modeling and User-Adapted Interaction, 6, 87-129, (1996).

[2] Conklin, J., "Hypertext: An Introduction and Survey", Computer 20, 9, 17-41, (1988).

[3] Eklund, J., "Cognitive models for structuring hypermedia and implications for learning from the world-wide web", Proc. of The First Australian WorldWideWeb Conference (AusWeb95), http://www.scu.edu.au/sponsored/ausweb/ausweb95/papers/hypertext/eklund/index.html, (1995).

[4] Hasegawa, S., Kashihara, A. and Toyoda, J., "A Framework for Estimating Usefulness of Educational Hypermedia", Proc. of World Conference on Artificial Intelligence in Education (AIED-99), pp.711-713, (1999).

[5] Hasegawa, S., Kashihara, A., and Toyoda, J., "Estimating Design Scenario of Educational Hypermedia on WWW", Proc. Of 7th International Conference on Computers in Education (ICCE 99), Vol. 2, 229-236, (1999).

[6] Kashihara, A., Kinshuk, Oppermann, R., Rashev, R., & Simm, H., "An Exploration Space Control as Intelligent Assistance in Enabling Systems", Proc. of International Conference on Computers in Education '97, 114-121, (1997).

[7] Kashihara, A., and Toyoda, J., "Report on Experiences of Telelearning in Japan", Informatik Forum, Wien, Vol.12, No.1, 39-44, (1998).

[8] Vassileva, J., "Dynamic Course Generation on the WWW", Artificial Intelligence in Education IOS Press, 498-505, (1997)

An Analysis of the Practice of Web-based Learning In Elementary Schools In Taiwan

Jyh-Jong Chiou and Chao-Chen Yang
Department of Information Management Chaoyang University of Technology
168, GiFeng E. Rd., WuFeng, Taichung County, Taiwan 413, ROC
cjjbin@ms43.hinet.net, ccyang@mail.cyut.edu.tw

Advances in computer technology and the Internet with the prevalence of World Wide Web have provided alternatives and changes to our learning styles. We start by discussing the advantages and disadvantages of Web-based learning and the environment, then move on to assess the possibility of applying Web-based learning in elementary schools. The restrictions of computer-assisted learning and distance learning due to the environment and students' capabilities will then be discussed proceeded by its potential problems and solutions. Finally, we will discuss about the model and application of Web-based learning and the future researches. Hopefully, this will be of value to promote Web-based learning in computer classes in elementary schools.

Keywords: **Web-based, Web-based Learning, Distance Education, Distance Learning**

1 Introduction

Between 1998-1999, the computer learning community of Taiwan elementary schools has also changed rapidly. The Ministry of Education has invested 6.4 billion NT in a year furnishing facilities of computer labs in all the elementary schools, and each school is connected to the ADSL net line [1]. This revolutionary act has motivated and enhanced the web-based learning environment in schools.

WWW (World Wide Web) has definitely made great influence to our Web-based learning community. The variety and multiplicity of multi-media from the WWW has created a vivacious opportunity and environment for learners. Through the participation of teachers' posting their teaching materials on the web page, more interactions of teacher and student involvement in web-based learning can be anticipated, which will also be of tremendous help to the expansion of web-based learning in elementary schools. In this paper we will discuss the practice of Web-based learning in elementary schools in Taiwan, and to analyze its advantages and problems.

2 The Advantages of Web-based Learning

2.1 Learning not limited to space:

What used to restrict students in the classroom for learning is no longer a compulsive rule. Learning can be anywhere at any time, whether it is life-long learning for adults or a basic course for kids, as long as you have a computer and are able to get hooked to the Internet, you can surf and search all over the world for information through endless Websites. This new model of learning will definitely impose great challenge and influence on the old traditional learning. In the meantime, Web Paged curriculums provide much more flexibility for students to practice and review their lessons wherever and whenever they want, as long as facility allows. Through numerous Websites all over the world, knowledge and information are observed, exchanged, selected, and discussed among various counterparts. Finally, the concluding of data constructs the knowledge we want.

2.2 Web-based courses are easy to use in distance learning:

The amount of investment in Web-based courses is much less than investment in courses transmitted at Real-Time or Course-on-Demand. For the previous mentioned classes, fine equipment and hardware are required---the case where limitation comes for elementary schools. As for creating web pages, web-sites, and even integrating different means of multi-media, it of smoother manage to elementary schools especially in terms of finance and personnel; besides, the alterations and updating of the information on the teacher' s web-site provides flexibility to the course. Therefore, with the above considerations, there is obviously much room for expansion of web-based learning in elementary schools.

3 Problems of Web-based Learning in Elementary Schools

3.1 Lack of motivation for pursuing knowledge:

Web-based learning is learner-centered and self-directed. It is for learners of high motivation to inspire oneself with massive acquirement and achievement of information. The learner can also find his own way of solving problems and evaluate himself at the end. However, students of the elementary level are young at age and at most times, they depend on parents and teachers to set up their learning habits. It will certainly take more time and effort (to use web-based learning) if not enough self-imposed and active learning are involved. Therefore, it is most important to come up with a method that will stimulate the students' motivation for learning, and perhaps help them form active learning habits.

3.2 Lack of the ability for interchanges among students:

Interactions that occur during the process of web-based learning are usually carried out by means of E-mail, Questions List, News, and even NetMeeting. These may be challenging to elementary kids with the possibility of inferior typing skills or expressing ability. It is then quite necessary to provide special pre-courses as a prerequisite for this learning model and assist the students to obtain the needed skills step by step.
With the overwhelming amount of information available on the Internet, it is rather difficult for children to choose the data they want. It is necessary to have a guardian in assistance to lead them on the right track.

4 Analysis of Applying Web-based Learning to Elementary Schools

4.1 From the view of hardware:

By 1999, all the elementary and junior high schools in all 21 counties of Taiwan have been set up with access to the Internet web-sites [4]. In my opinion, the setting up of Web Server and the supply of relevant curriculums do not appear as a problem; however, the ban-width would be of a more complex issue. The unsymmetrical feature (downloading 1.54Mbps and uploading 384K) of ADSL lines in elementary schools may cause insufficient band-width while delivering data to clients at the remote end, when students accessing the courses on the same time.

At the elementary school where I work (a school in the suburb), about 30%-40% of the students have a computer at home, however, this does not imply direct access with the Internet. This could be the main obstacle for Web-based learning. The "rush hours" for Internet traffic jam occurs at the time when most people are at home which is about from5:00pm to 10:00pm, also the causing the problem of insufficient ban-width. With a 56K modem, this will probably be the most challenging factor of all.

4.2 The Position of Web-based Learning and Its Problems:

Certain computer skills must be required (browsing, downloading, printing out..) as a prerequisite for this type of learning, including means of turning in assignments and on-line examinations. Web-based learning is not just about browsing around, for then it would be merely fragments of learning. It should offer as an alternative channel of learning with careful guidance from parents and teachers.

As mentioned before, elementary children are still immature at mind and at heart, therefore, if Web-based learning is placed as assisted courses with gradual increase with the grade level, it is an opening of another interface to learning. Web-based learning is not suggested for replacement of interactive activities, personal involvement, personality molding, etc. According to my opinion, Web-based learning should be used as assisted teaching which provides another channel for learning.

5 Web-based Learning in Elementary Schools and the Prospects

5.1 About Interface of the Web and Courses Designing:

Vivid images and perhaps merry sounds and music can be attracting to children. It is only when children are attracted and motivated that learning takes place.

Not all courses are suitable for Web-based learning. Physical Education and sports could not be applied on the Internet, thus selective elements are involved in syllabus planning.

Web-based learning is mostly questioned by its lack of interactions. If courses can be designed to increase the interchanges as in real situations, through synthesis of images and sounds, bulletin boards, then the problem of unreality can be reduced. Designs of various types of interfaces is the goal and as for teacher-student interactions, Web-based E-mail, Web-based Chat Room, Questions List, News, IRC are all highly suggested means.

5.2 Objective Environmental Changes:

The construction of Wide Band-width Networks is no longer an impossible task. With the prevalence of ADSL, ISDN, Cable Modem, Direct PC, etc., prices are sure to be lowered. The successful case by SingAREN (Singapore Advanced Research and Education Network) using ADSL & Cable Modem can be a learning sample [2]. With proper combination of the cable TV and the Cable Modem, plus other means like ADSL, Web-based learning can definitely be activated into good use. As long as heavy traffic can be prevented in the Internet, anyone can roam around carelessly in the world of Internet for knowledge; for the Internet is a treasure island with endless sources of information.

6 Conclusions

The educational environments will be the use of highly interactive computing and communication in the future. Web-based learning gives us the chance to reflect on the traditional way of learning; it is not meant to replace the former learning style, but rather to provide an alternative learning model. Computers and network technology have potential not only to support learning for understanding in the classroom, but also to facilitate active guided professional development for teacher [3]. As long as we can have enough band-width, more flexible classes in school, more multiple teaching strategies and models, and assist each student according to his or her individual needs and ability, Web-based learning can certainly be anticipated to be the best tool for in our life-long learning.

References

[1] Chang, S. Y., "The Achievement of Plan in Basic Information Education in 1999", Ministry of Education Computer Center Newsletter, Vol 8810, pp. 1-8, (1999).

[2] Lek-Heng Ngoh, Francis S.C. Yeoh, Manjeet Singh, "SingAREN: The Singapore Advanced Research and Education Network", IEEE Communication Magazine, November 1998, pp. 74-82, (1998).

[3] Martha Stone Wiske, "Teaching for Understanding with Networked Technology", International Conference The Design and Application of Networked Learning Environments for Elementary and Junior High School, Tainan, Taiwan, January 6-7, pp. 28-43, (2000).

[4] Ministry of Education, http://www.edu.tw/information/expand/exestone/exp_summary.html (accessed on April 1, 2000)

An Effectiveness Study of Web-based Application for Mailing List Summary and Review

Satoru FUJITANI* and Kanji AKAHORI**
**Mejiro University College.*
4-31-1, Naka-ochiai, Shinjuku, Tokyo 161-8539 Japan
Tel: +81-3-5996-3127 Fax: +81-3-5996-3125
E-mail: fujitani@mejiro.ac.jp
***The Center for Research and Development of Educational Technology, Tokyo Institute of Technology.*
2-12-1, O-okayama, Meguro, Tokyo 152-8552 Japan
Tel: +81-3-5734-3233 Fax: +81-3-5734-2995
E-mail: akahori@ak.cradle.titech.ac.jp

This paper reports an effectiveness research of e-mail discussion review support system with summary extraction method. The support system we have developed can automatically extract summary sentences from the normal conversational style language in e-mail messages using reference relationship of e-mails that participants have discussed. One could use the summary sentences for looking back on discussion, and use them as an idea database at a glance. Japanese natural language processing technology has been applied in the proposed method. In order to evaluate the effectiveness of the system, we conducted experiments using a questionnaire and protocol analysis. We compared the two system; the system with and without summary sentences in the table of e-mail content. As a result, following fact-findings were obtained. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader pay attention to the detail information such as name of discussing member.
Finally, we concluded that the system with summary sentence is effective for understanding of relationship among various e-mail messages.

Keywords: **Mailing lists, Natural language processing, Distance learning, Learning environment, Summary sentence extraction, Collaborative learning, Factor analysis, Reading strategies**

1 Introduction

Collaborative learning support environments for network-based discussion appear to be investigated quite often [1][2]. For instance, e-mail is extensively used in the classes for learners' communication.

The research topic we reported here is collaboration support tools that intended for e-mail discussion. For the purpose of sharing of participants' activities on computer networks, we have proposed a summary extraction method along the development of mailing list discussions and an outline presentation tool for mailing list [3][4][7][9]. Japanese morphemes analysis system [8] is applied in our researches. This web-based tool supports reviewing the past discussion on the mailing list. As for results of the summary extraction method, we conducted comparative evaluation between the result of human summarization and of the method. The result suggests that the proposed method can detect major sentences in e-mail articles properly [4].

There is a number of preceding researches on the keyword and summary sentences extraction methods of documents [5][6][15]. But the most of extraction methods in preceding researches applied to well-

documented text, like the newspaper manuscript or research paper. On the other hand, this research targets on the conversational style language in text form. For identifying the outline of e-mail discussion, there are many difficult problems in e-mail messages. These are:

- E-mail messages are conversational style language and many summary extraction methods using syntactic information could be not applied.
- The title of e-mail might not be changed as the discussion continues, if so, the title is not meaningful as the summary of documents.
- The method should identify the flow of discussion corresponding with e-mails in order to grasp the topic.

Besides, most of evaluation experiments in summary extraction method with natural language processing technology focus on the validity of algorithm, like adaptability or reproducibility. About analysis of reading comprehension when additional information, e.g. summary, is given, we could refer Ausubel's research on the advanced organizer model [10]. The paucity of reports on sentence comprehension process encouraged us to investigate it.

The purpose of the present paper is to analyze how the summary sentences accomplishes to an actual comprehension process. In this paper we describe an experimental study of e-mail message reading process with or without the extracted summary sentences.

In the first experiment, we investigated e-mail message reading strategies using responses of questionnaire. We conducted comprehension test and reading process analysis. In the reading process analysis, the result was divided into seven factors using factor analysis. The system with summary sentences could promote reading strategy such as utilization of table of contents and comprehension of e-mail message structures. On the other hand, the system without summary sentence makes the reader give attention to the detail information such as names of participating members.

In the second experiment, we analyzed peer discussion processes while reading e-mails on the World Wide Web (WWW) interface. We conducted the comprehension test of the e-mail messages. We also conducted protocol analysis of e-mail reading comprehension. Also hereupon, we compared the results with two conditions, one is a group to which the summary sentence of the e-mail messages was given, and the other is a group without summary sentence of e-mail messages. The results of protocol analysis show some difference in the number of utterance collected during the experiment.

2 Summary extraction method along development of discussion

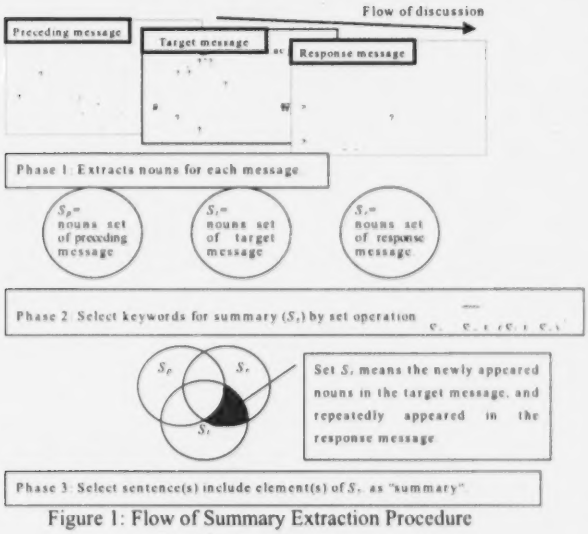


Figure 1: Flow of Summary Extraction Procedure from the target message.

The summary extraction method was discussed in our preceding research [3][4]. In this paper, we de-scribe the outline of the extraction method for better understanding by the readers.

2.1 Idea of the extraction method

We tried the extraction of keywords and summary sentences of the discussion from the document in the mailing list based on the preceding research [11] intended for the discussion such as Netnews. This key-word extraction method can be used in the discussion environment with the following features; (1) The change in the topic does not take place easily in a row. (2) There is a habitual practice that the participants do repeated revisions during the discussion, and

uses the quotation appropriately. But although it is limited in our case, e-mail discussion might develop in many ways, and the topic is changeable. The relationship of e-mail message for the keyword extraction between the target message and the past messages is little in e-mail discussion.

Then, in this paper, we set up a hypothesis: Although there was a dependency on the topic, e-mail messages with new information are tempted to encourage responses later. That is, we can treat them as topic making messages in the mailing list. We proposed a summary extraction method that enables pick up those new information as keywords and summary sentences in the messages [3][4]. Figure 1 shows flow of keyword and summary extraction by this method from the content of the message of the mailing list.

However, this summary extraction method supposes both preceding and response messages must be consecutive in the thread. Therefore, we set some assumptions for these exceptions. When the target message is the beginning message in the thread, the title of the message is also used and extracts common nouns among the title of the target message and the body of related messages. On the other hand, when the target message is the last message in the thread, we choose keywords only from the preceding and the target message, and common nouns in both messages is treated as keywords for the target message. Moreover, summary sentences are regenerated when there is a new message in the mailing list.

2.2 Summary generation and WWW display tool

We implemented summary generation and display tool using the proposed summary extraction method. This can be operated on the World Wide Web (WWW) to refer to past messages of mailing list [7]. Fig-ure 2 shows the display of Web page with and without summary sentences. These Web pages fulfill the role of table of contents (TOC) of mailing list. Readers look for contents from the list view with tree structure along continuity of e-mails. They can trace the body of each message from Web link. TOC shows serial number, writer, date of issue, and the title of the e-mail. In Figure 2(b), under the link to the body, summary sentence obtained by the noun set is displayed. When more than one sentence is extracted by the method, it becomes so complicated that the implication of TOC is diminished. So we referred to the procedure widely used in full-text search system [6], the number of displayed sentence is trimmed off to only one sentence that include maximum different number of chosen keywords. We treat that sentence as important sentence for TOC.

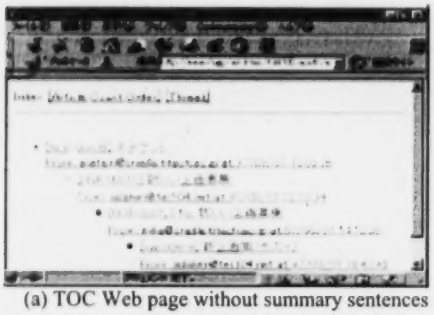
3 Evaluation experiment in the e-mail message comprehension

In this research, we carried out the evaluation experiment on effects of summary presentation while reading past e-mails on the mailing list. We conducted reading comprehension test and factor analysis of reading strategies.

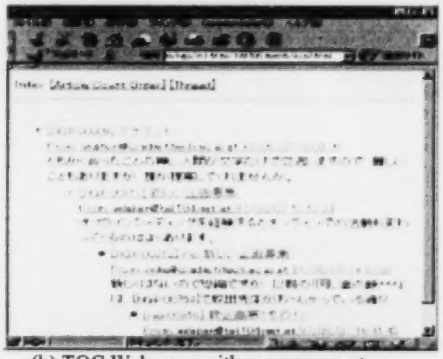
3.1 Methods

3.1.1 Subsubsections

In the experiment, we made the settings resembling the actual Web-based environment of the mailing list.



(a) TOC Web page without summary sentences

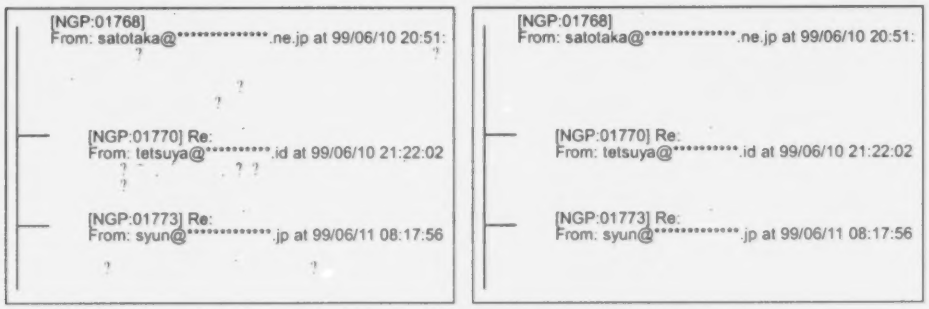


(b) TOC Web page with summary sentences.

Figure 2: "Table of contents" Web pages for review.

BEST COPY AVAILABLE

We printed out the several e-mail messages in a row, referred to as "thread", and the table of contents (TOC) for the e-mail messages in addition. Figure 3 shows the part of the experimental materials. To the semblance



(a) Printed TOC with summary sentences. (b) Printed TOC without summary sentences.

Figure 3: The part of the printed experimental materials

of Figure 2, the summary is generated from the proposed summary extraction method. It appeared in parallel beneath each entry in the TOC, or not appeared. E-mail messages for the summary extraction method consist of nine messages of mailing lists. The topic in the mailing list is the educational use of the Internet for foreign Japanese schools and domestic schools.

3.1.2 Procedures

Subjects of the experiment are 56 undergraduate students. None of the subjects know about the mailing list. The printed TOC as described above is affixed in front of the e-mail messages. The printed experi-mental materials were distributed to the subjects, and the researcher explained the experimental setting: "We are going to try to read past e-mails, and catch up with the exchange of the e-mail discussion." In addition, the participants were asked to use TOC positively.

The subjects read these documents for eight minutes. After the eight minutes, the researcher confirmed all the subjects had read the documents once. After that, the subjects were not allowed to read the docu-ments again, and they did the e-mail comprehension test. They had answered the following questions:
1. Write down the name of places which had appeared on the first e-mail as much as you remember.
2. Write down the episode of the first e-mail as much as you remember.
Later, they answered a questionnaire, which was consisting of 28 items with five-point rating scale and space for writing comments. The items were concerning the e-mail reading strategies. In order to make questionnaire, we referred the preceding research about sentence intelligibility [12] and our preceding researches.

3.1.3 Experimental Design

The factor of the experiment materials is presence of summary sentences in the TOC. We can divide the subjects into two levels. 56 subjects were randomly assigned to both two experimental settings of the materials, and were divided into the two groups of 28. Therefore, it is a between-subject experimental design with one factor.

3.2 Results

3.2.1 The comprehension test

In the question 1: "the name of places which had appeared in first e-mail", we compared the numbers of correct answers between two groups. We leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the number of correct answers

Table 1: Extracted factors and results of ANOVA

Name	Ratio	
1. Read the content in detail and memorize	21.5%	**p<.01
2. Use Table of Contents	10.5%	*p<.05
3. Think about the development of discussion	8.7%	
4. Combine their knowledge	7.1%	
5. Think about the theme of discussion	5.1%	
6. Read back and force	4.3%	
7. Write down a memo	3.9%	
Accumulated Explanation Ratio	61.1%	

(F(1,48)=1.065, p>.10).

In the question 2: "the episode of the first e-mail", we have chosen eight words from the message as answer words of the question beforehand. We compared the numbers of appeared answer words between two groups. We also leave non-response persons off from the analysis. As a result of ANOVA, there was no significant difference in the average number of the answer words (F(1,48)=.415, p>.10).

Table 2: ANOVA for Factor Scores

(a) ANOVA for Factor Score of factor 1.

Source	SS	df	MS	F	R^2
Factor	5.61	1	5.61	7.21	0.0098**
Error	38.11	49	0.78		
Total	43.72	50			

**p<.0

(b) ANOVA for Factor Score of factor 2.

Source	SS	df	MS	F	R^2
Factor	4.62	1	4.62	5.99	0.0180*
Error	37.78	49	0.77		
Total	42.39	50			

*p<.0

3.2.2 E-mail reading strategies

The factor analysis with major factor method and varimax rotation method was applied to the 28 questionnaire items concerning strategies of the comprehension for e-mail messages.

As we shown in Table 1, we sequentially named the seven factors. We extracted these factors from the change in the eigenvalue. The accumulated factor explanation ratio was 61.1%. Next, factor score of seven factors was calculated par subjects.
Table 2 shows results of ANOVA. As a result of ANOVA for seven factors, a significant difference was found in the first factor "Read the content in detail and memorize" (F(1,50) =7.212, p<.01) and the second factor "Use Table of Contents" (F(1,50)=5.988, p<.05).

In addition, we compare the score for each item in two groups.

As a result, the group with summary sentences could promote reading strategies such as "Usefully reading TOC help me to know the content of sentences" (t(51)=3.58, p<.01), and "Refer TOC to read the content in the messages" (t(52)=2.76, p<.01). Those who use summary sentences would have tendency that they try to know the relation between the content and the whole structure of the thread.

On the other hand, the group without summary sentences would take reading strategies such as "Pay attention to the participant's name or the name of places appeared on the e-mail while reading" (t(50)=2.34,p<.05), "Read the content carefully and memorize in detail" (t(51)=1.94, p<.10). Thus, they attempted to give attention to the detail information such as names of discussing members.

3.3 Summary of the experiment

In the experiment, there was a significant difference in the e-mail reading strategies while there was no significant difference in the recognition of e-mail contents. Our proposed method is a kind of new information presentation method for the support of e-mail reference. We might say our summary extraction method and display tool for mailing list could help readers to suppress consideration of detail information in the documents. On the other hand, these supports help to maintain the particular contents easier.

4 Protocol analysis of e-mail reading process

From the suggestion in the preceding section, adding summary sentences possibly provide a hint on the e-mail reading strategies. In this section, we examined changes of e-mail reading strategies when having the benefit of summary sentences using protocol analysis. To put it concretely, the subjects answer questions after reading the content of e-mail messages that is displayed on the WWW pages. We have observed the e-mail reading strategies while participants were reading e-mail messages.

4.1. Methods

4.1.1 Experimental materials

We have used 43 e-mail messages of the mailing list for the summary extraction method. Educational use of the Internet in foreign Japanese schools and domestic schools was focused in this mailing list.

Each e-mail message can be traced back and forth from TOC WWW page shown in Figure 2. We have set two conditions; one was in which summary sentences were given, and the other was in which it was not given.

4.1.2 Subjects

Subjects were 20 undergraduate students forming ten pairs. The reason for making group of two is that the subjects could discuss naturally with each other, and therefore, we could collect natural speech proto-cols easily from the conversation [13][14]. They were randomly assigned to two different experimental settings as described previously in this paper.

4.1.3 Procedure of the experiment

The two subjects were seated in front of the computer and were given an instruction for the present ex-periment by researcher. After the e-mail reading, the subjects were asked to answer some questions on reading comprehension. The subjects were allowed to start reading e-mail messages from anywhere. Then, they read e-mail messages through WWW pages for 20 minutes. After that, they were asked to answer some questions regarding particular content in the e-mail messages within 15 minutes. Finally, they were interviewed about the provision of advance information of the mailing list and the interest on the topic of discussion. None of the subjects know about this mailing list.

4.2. Analysis and Results

In this experiment, we recorded peer protocol with a digital video (DV). Then, we played the recordings and type in the conversation by listening the recordings. During the analysis of utterance, we identify sev-eral reading strategies or procedure for sentence comprehension. For each unit of procedure and strategy, the protocol was classified into the protocol categories [13]. For the classification, we have used the result of the factor analysis as we seen in Table 1. The categories "Read the content in detail and memorize" and "Use Table of Contents" were found to be significantly different on factor analysis. In the first cate-gory, we have considered utterances if the subjects read particular personal name and place name aloud. In the second category, we have considered utterances if the subjects read aloud the summary sentences or pursue continuity of the mailing list by pointing to the TOC. Some subjects pointed using mouse cur-sor's move or their fingers.

Table 3: Frequency of strategies appearance between two categories

Protocol category	With summary	Without summary
1. Read the content in detail and memorize	128	103
2. Use Table of Contents	35	22

Table 3 shows the comparative result with two protocol categories. As the number of subjects is very less, a clear conclusion could not be drawn. But as in Table 3, the frequency of category 1 was relatively higher than that of category 2. As a the result, by means of summary display tool with e-mail messages has been suggested as a method to manage a lot of reading strategies easily. However, though the differ-ence of the frequency does not contradict the results of ANOVA in the previous section, it does not show a significant difference in the comparison of ratios ($\chi^2(1) = 0.67, p > .10$).

In this experiment, a significant difference was not seen in the frequency of the e-mail reading strate-gies. We need to add the number of experiments as well as study the influence of experimental design in peer conversation.

5 Conclusions

The results of this research may be summarized as follows:

1. We applied the summary extraction method for mailing list, and analyzed e-mail reading comprehen-sion and reading strategies for reference. Although the result is limited to the e-mail messages we used, the display of e-mail summary sentences affects experimental subjects' reading strategies. On the other hand,

the result of comprehension test does not show significant differences. We may con-clude at this point that the method of summary sentence extraction is effective in understandings of relationship of e-mail messages.

2. The influence of summary display on the e-mail reading strategies was examined from the analysis of utterance protocol. The use of Table of Contents WWW page along with e-mail summary sentences does not make a difference in the frequency of utterances, but preferential trend for the use of e-mail summary sentences was observed.

As a problem yet to be solved in the future, we are interested in examining the effectiveness of reading strategies when e-mail messages are posted and read in real time.

Acknowledgement

Our special thanks are due to Madhumita Bhattacharya, Ph.D., the National Institute of Education, Singapore, for reading the manuscript and making a number of helpful suggestions.

References

[1] Kusunoki, F. & Sayeki, Y., "We can learn because of the opinions different each other", Journal of Information Processing Society of Japan, Vol. 40, No. 6, pp. 564-568, (1999).

[2] Inaba, A. & Okamoto, T., "The Network Discussion Supporting System Embedded Computer Coordinator at the Distributed Places", Educational Technology Research, Vol. 18, Nos. 1-2, pp. 17-24, (1995).

[3] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method for Web-based Mailing List Review Application and Its Effectiveness Study", Advanced Research in Computers and Communications in Education (ICCE99), G. Cumming et al. (Eds.), IOS Press, Vol. 1, pp. 327-334, (1999).

[4] Fujitani, S. & Akahori, K., "A Summary Sentence Extraction Method of E-mail Discussion and Its Web-based Application to Mailing List Review", Educational Technology Research, Vol.23, Nos. 1-2, *In printing*, (2000).

[5] Sasaki, I., Masuyama, S. & Naito, S., "Proposal on sentence extract method which pays attention to vocabulary coherency", Technical Report of Information Processing Society of Japan, 93-NL-98, pp. 65-72, (1993).

[6] Sumita, K., Tomono, T., Ono, K. & Miike, S., "Generation of Automatic abstract with document structural analysis, evaluations as retrieval presentation function", Journal of The Institute of Electronics, Information and Communication Engineers, D-II, Vol. 78-J, No. 3, pp. 511-519, (1995).

[7] Fujitani, S. & Akahori, K., "Improvement of content summary extraction method along with development of discussion about document of mailing list summary system", Proceedings of 14th annual conference of Japan Society of Educational Technology, 2pB02-3, pp. 691-692, (1998).

[8] Kurohashi, S. & Nagao, M., "Japanese morpheme analysis system "JUMAN" version 3.61", Graduate school of information science, Kyoto University, (1999).

[9] Ken'ichi Fukamachi, "fml" Mailing List Server Package, http://www.sapporo.iij.ad.jp/staff/fukachan/fml/index-e.html (accessed on August 1, 2000).

[10] Ikeda, S. & Tanaka, S., "improvements of experiment diagram in preceding organizer research", Reading sciences, Vol. 29, No. 2, pp. 41-55, (1985).

[11] Ishihara, M. & Akahori, K., "Developments of discussion summary system for discussion support with problem", Journal of Japan Society of Educational Technology, Vol. 22, No. 1, pp. 1-12, (1998).

[12] Uchida, N., "Is the sentence understanding process "top down" or "bottom up?" ": In Shun-ichi Maruno, some controversies in cognitive psychology, Kyoto: Nakanishiya publication, pp. 165-188, (1998).

[13] Kaiho, H. & Harada, E., "Introduction of protocol analysis", Tokyo: Shin-yo-sha, pp. 118-134, (1993).

[14] Madhumita, & Akahori, K., "An Evaluation Method for Audiovisual Software Based on Protocol Analysis", Media and Education, Vol. 1, pp. 19-27, (1998).

[15] Firmin, T. & Chrzanowski, M. J., "An Evaluation of Automatic Text Summarization Systems, Advances in Automatic Text Summarization", The MIT Press, pp. 325-336, (1999).

An Intelligent On-Line Learning System by Combining Assessment and Adaptive Learning

Wan-I Lee* and Bih-Yaw Shih**

** Department of Information Management, Shu-Te University, Yen-Chau, Kaohsiung County, Taiwan, E-Mail: Wilee@mail.stu.edu.tw*

** * Department of Management Information System, Yung Ta Institute of Technology & Commerce, Pin-Tung, Taiwan, E-Mail: Byshih@mail.ytit.edu.tw*

The purpose of this research is the development of an intelligent on-line learning system by combining assessment and adaptive learning to each individual student. It includes two major tasks: (1) Provide different types of students with the most adequate context when he/she is doing on-line geometry learning activity on a university level via the Would Wide Web (WWW); (2) Identify changes in students' van Hiele levels of geometry thought after taking an on-line geometry course. In the research, the Van Hiele Geometry Test developed by Usiskin[11] was first administered to all students to determine their knowledge of geometry as described by Van Hiele[12]. A student's level of geometric thought was identified only by his/her responses to the pretest. Next, different contexts of instruction were selected depending on a student's level. Meanwhile, the on-line assessment of each unit will be performed after he/she completes one learning unit. Also, the results of the assessment are stored as the personal profile in the database and used to generate adaptive learning materials of instruction for the next unit. Finally, when the student completes all materials of a topic, the student is post-tested using the same Van Hiele Geometry Test to identify changes in the student's van Hiele level of geometry thought after taking the on-line geometry course.

Keywords: **On-line learning system, Assessment, Adaptive learning, WWW, Van Hiele Geometry test, Geometric thought**

1 Introduction

Students are usually required to understand the units of a topic assigned by their teacher without concern for individuals' backgrounds in that field. Also, the learning topic is limited to the teachers' subjective thoughts and the schools' policies. Therefore, students cannot choose individual topics, which could increase their interest and improve their performance. Meanwhile, students use the time-consuming way to present their learning knowledge through written papers. This process causes some of the students could not catch up, and they may give up during the semester. If a student does not connect current knowledge with prior knowledge, then improving his/her knowledge can be very difficult.

The technology of the Internet has developed dramatically. Now a day, the Internet and the WWW have proven to be useful tools for improving communications between the instructors and students because of its use of multi-media, short response time, and etc. Therefore, the on-line learning system is a helpful tool to enhance an individual's motivation and learning process. However, an on-line learning system within the context cannot adequately apply to all individuals without understanding their general achievement in the studies. There are many researchers focusing on how to develop adequate on-line lectures to enhance individuals' learning interest, and improve their motivation [1][2][4][5][6]. However, if the on-line lecture cannot be applied to each individual depending on his/her learning performance, ability, and feed back, the effectiveness of the on-line learning will be dramatically reduced. Few studies have applied on-line pre and post tests to identify which learning contexts are more effective for an individual and examined his/her

learning performance during the learning processes.

The van Hiele model of geometric thought successfully describes a student's understanding in geometry. The van Hiele model consists of five levels of reasoning: visual, descriptive/analytic, abstract/relational, formal logical, and rigor [15]. The VHL has been used to judge students' abilities in doing geometric problems. If students are below level III, they are generally unable to construct proofs by themselves. Many researchers [3][4][7][8][10][16] found that student's reasoning abilities and van Hiele levels were related to their proof-writing abilities. Senk reported that students in level IV or level V have the ability to complete mathematical proof problems [8]. Students in level IV have the ability to construct proofs by themselves and not just memorize the proof processes. Therefore, if there are any on-line learning system which could provide the individualized learning material depending on the results of on-line pre-test, assessment, and post-test, the system will be a great contribution in the field of computer assisted learning.

In the following section, the concept of the research model will be described, the on-line Van Hiele geometry test will be explained, the generation of adaptive learning materials will be discussed, and the on-line assessment will be explained.

2 The Concept of the Model

The on-line learning system proposed in the research integrates the pre-test, post-test, assessment and the adaptive learning materials. The pre-test is used to determine the ability of a student before he/she starts the unit of the on-line learning topic. After the student finishes the learning of the unit, the assessment test is given to evaluate the performance of his/her study. This process is repeated until all units of the topic are tested. Finally, the post-test is given to evaluate the performance of a student after he/she has finished all units of the topic. Meanwhile, these records are stored in the database of the users' profiles for the generation of adaptive learning materials. Therefore, adaptive learning materials could be generated based on the records of students' profiles, and their on-line learning performance could be dramatically improved. The concept of the model is illustrated schematically in Figure 1.

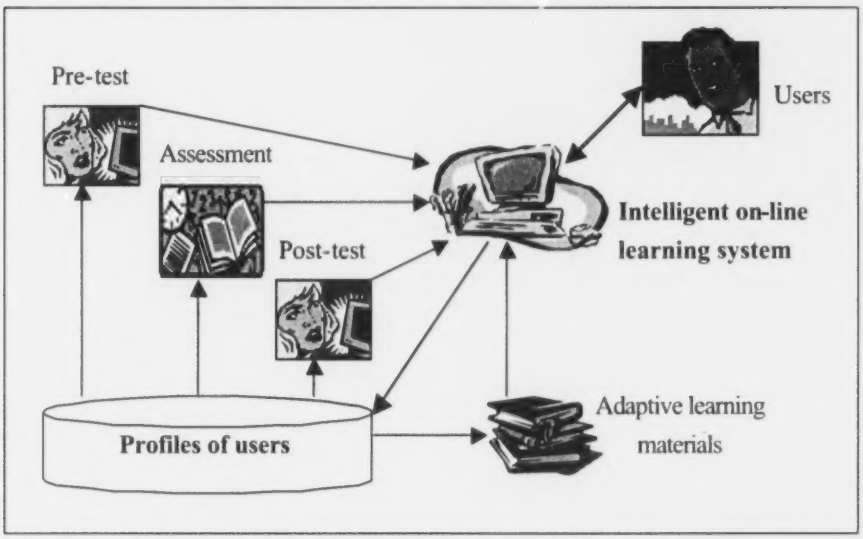


Figure 1. Schematic representation of the model of on-line learning system

3 On-Line Van Hiele Geometry Test

In 1959, P. H. van Hiele, a teacher in the Netherlands, reported on studies that he and his wife, Dina van Hiele-Geldof, had conducted dealing with mental development in geometry [4][13][14][16]. The van Hieles

identified five different and unique levels of geometric thinking. These levels have been scaled in two different ways: from I to V and from zero to IV. Senk pointed out that all results and references from the van Hieles' studies described on the zero through IV scale have been translated to the I through V scale [9]. In this study, the I to V scales were used because students who have not attained the basic or ground VHL could be assigned a 0 rank [9].

Senk' s five levels of development in geometry are listed below:

Level I: Visual
Students recognize geometric shapes based on their visual transformations from their images of these geometric shapes. Students are not aware of the properties of these shapes.

Level II: Descriptive/analytic
Students accurately describe the properties of shapes by observing, measuring, and drawing a model. For example, students at this level would be able to recognize that a rhombus has all sides congruent.

Level III: Abstract/relational
Students can verify figures hierarchically by analyzing the properties of figures. For example, students at this level would be able to recognize that a square is a rectangle.

Level IV: Formal logical
Students can understand the meaning of proof in the context of definitions, axioms, and theorems. For example, students would be able to show that the parallel postulate implies that the angle sum of a triangle is equal to 180°.

Level V: Rigor
Students are able to establish consistency of set axioms and can compare axiomatic systems (e.g., Euclidean and non-Euclidean geometry). For example, students would be able to verify the existence of parallelograms and angles between parallel lines in non-Euclidean geometry.

Using observation data, the van Hieles conjectured several properties that govern the five levels of thinking as students learn geometric ideas. These properties are: (a) individual exploration and reflection on geometric concepts are needed in order to move from one level to another level; (b) one cannot engage in thinking at a higher level without passing though the lower levels; (c) each level has its own language, linguistic development notations, and symbols; and (d) the learning process in each level does not overlap with previous levels.

The van Hiele Geometry Test (VHGT) was scored using the scoring procedures identified by [11] in his report on VHL for the Cognitive Development and Assessment Association (CDASS) Development and Achievement in the Secondary School Geometry Project. The CDASS developed a total of 25 questions to measure students' geometry skills. These questions were used to determine the students' understanding of geometric concepts as identified by [12]. Students were given 35 minutes to complete the test. There were five questions on the VHGT for each VHL, as illustrated in Table 3.

Students were assigned weighted scores for each VHL based on whether their responses met a predetermined criterion on each subset of the test. A score for a student was assigned based on criteria in Table 1.

1 point for meeting criterion on items 1 to 5 (Level I)
2 points for meeting criterion on items 6 to 10 (Level II)
4 points for meeting criterion on items 11 to 15 (Level III)
8 points for meeting criterion on items 16 to 20 (Level IV)
16 points for meeting criterion on items 21 to 25 (Level V)

Items	Measure a student's ability to
1 ~5	Recognize geometric shapes based on an individual' s visual abilities.
6 ~10	Measure properties of geometric shapes by observing and drawing a picture.
11~15	Verify figures, hierarchically, by analyzing the properties of figures.
16~20	Understand proof meaning in the context of definitions, axiom, and theorems.
21~25	Identify the consistency of set axioms and compare axiomatic systems.

Table 1: Summary of Properties of the van Hiele Geometric Test

A student had to correctly answer at least three of five questions in order to meet the criterion. Each VHL corresponds to a weighted sum from the weighted sum scores assigned for each subset of items on the VHGT. According to the van Hiele levels of geometric thought, a student who attains at least level IV would be able to write original proofs. For example, suppose a student has the following results: 3 correct out of 5 questions in level I; 4 correct out of 5 questions in level II;2 correct out of 5 questions in level III; 4 correct out of 5 questions in level IV; 2 correct out of 5 questions in level V. This means, for level I, the student received one point. For level II, the student received two points. For level III, the student received zero points. For level IV, the student received eight points. For level V, the student received zero points. This produces a total of 1 + 2+ 8 =11 points. Students must satisfy the criterion at level n and all preceding levels to be considered for level n. This result indicated that the student's geometry level was not in level IV or V because the student could not skip level III, which, according to the test, the student had not attained. In this case, the student's geometry competency thought was evaluated as VHL II.

4 Generation of Adaptive Learning Material

The adaptive learning material is generated according to the user's profile stored in the database. Because this research focuses on the development of an on-line learning system for a geometry course at the university level, therefore, the way of categorizing the geometry materials is explained in this section. When a student starts to learn geometry, he/she develops geometric knowledge from the basic concept of point, line, to space. Each of these concepts is involved in one-dimension, two-dimension, three-dimension, and extra. Therefore, the methodology of categorizing the geometry materials is based on this learning process and its basic concept map is presented in Figure 2.

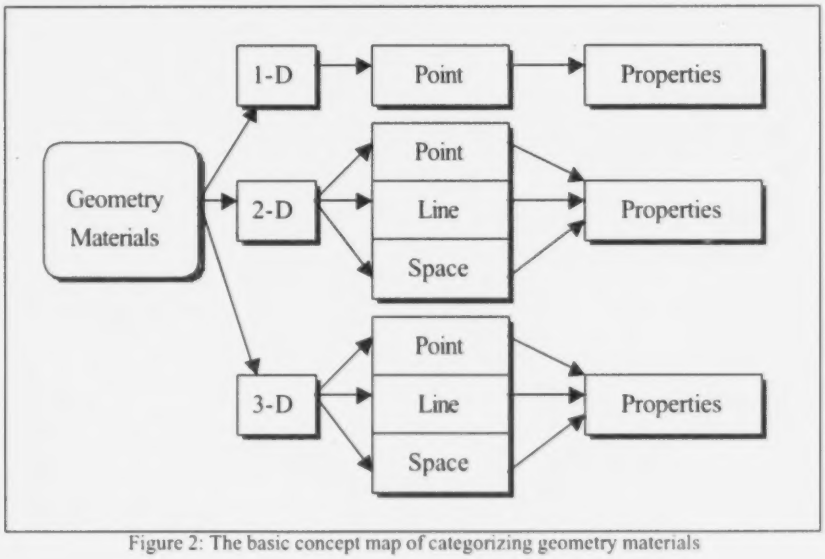


Figure 2: The basic concept map of categorizing geometry materials

5 On-Line Assessment

When an individual completes one learning unit via the on-line learning system, the On-Line Assessment (OLA) of each unit will be performed. All of the testing is multiple-choices questions which involved conjecture of proof processes that consist of one of the five answers given. The result of the assessment is used to selected materials of instruction for the next unit.

The OLA, based on ideas from Yerushalmy[17], was designed by the researchers was used to ascertain the learning style of each student. OLA used a scale from zero to four to rate the ability to analyze an individual student's conjecture of proof processes. For each question, maximum possible OLA score was four. The rating scales used for this OLA are presented in Table 2.

0---No argument is correct. 1---Gives a few arguments, but these are not sufficient to solve the problem. 2---Quotes a related theorem and connects it to the approach. 3---Clearly supports statements in the argument, but there may be minor errors or gaps. 4---Constructs a complete proof.

Table 2: On-Line Assessment Rating Scale

As mentioned earlier, OLA rating score was designed by the researcher and determined to be reliable. Cohen's Kappa is used to assess investigators agreement when the data are nominal categories and Kappa should be high usually greater than 0.7 (Morgan & Griego, 1998). The reliability coefficient using SPSS for Windows (v 8.0) was high (Cohen's Kappa raters for OLA was 0.83).

6 Conclusions

Learning assessment is an important process during learning education but most of the research focus on the computer-based learning world such as implementation of traditional instructions or tests on the Internet, adaptive assessment by the allocation of on-line testing questions, development of virtual classrooms for improving students' learning performance, and etc. However, very little research has been conducted to develop on-line learning system by combining assessment and adaptive learning. This study has successfully proposed a credible and modularized methodology for developing an intelligent on line learning system by combining assessment and adaptive learning for each student.

OLA is particularly important for most students because many teachers may not consider an individual student's background for conducting adaptive instruction and assessment for their students. It is known that many students consistently misinterpret procedures they learn in the classroom. For each on-line user, the OLA system will record and report the mistakes on each learning unit. It will help students identify his/her learning difficulties. As the learning difficulties of each learner are considered in the OLA system, a more adaptive, efficient, and profile-based learning environment will be conducted.

Reference

[1] Baker, P. G. & Benest, I. D., (1999). The on-line lecture concept-a comparison of two approaches. Printed and Published by the IEEE, Savoy Place, London WC2R OBL, UK.

[2] Bjedov, G., (1995). Utilizing the World Wide Web and the Internet to facilitate learning in large classes. Proceedings of the Frontiers in Education Conference.

[3] Frerking, B. G., (1994). Conjecture and proof-writing in dynami9c geometry. (Doctoral dissertation, Georgia State University, 1994). Dissertation Abstracts International, 55/12, 3772.

[4] Hoffer, A. R., (1981). Geometry is more than proof. The Mathematics Teacher, 74, 11-21.

[5] Martin, P. T., (1996). Email and the Internet as a teaching tool: A critical perspective. Proceedings of the Frontiers in Education Conference.

[6] Nicolaidis, M., (1997). On-line testing for VLSI. Printed and Published by the IEEE, 0-7083-4209-7.

[7] Senk, S. L., (1982). Achievement in writing geometry proofs. American Educational Research Association. New York, NY. (ERIC Document Reproduction Service No. ED 218 091)

[8] Senk, S. L., (1983). Proof-writing achievement and van Hiele levels among secondary school geometry students. Unpublished doctoral dissertation, University of Chicago, Chicago.

[9] Senk, S. L., (1989). Van Hiele levels and achievement in writing geometry proofs. Journal for Research in Mathematics Education, 20(3), 309-321.

[10] Stover, N. F., (1990). An exploration of students' reasoning ability and van Hiele levels as correlates of proof-writing achievement in geometry (Doctoral dissertation, University of Oregon, 1989). Dissertation Abstracts International, 51.

[11] Usiskin, Z. P., (1982). Van Hiele levels and achievement in secondary school geometry (Final Report of the cognitive Development and Achievement in Secondary School Geometry Project). Chicago, IL: University of Chicago, Department of Education. (ERIC Reproduction Service No. DE 220 288)

[12] Van Hiele, P. M., & van Hiele-Geldof, D., (1958). A method of initiation into geometry. In H. Freudenthal (Ed.), Report on methods of initiation into geometry (p.67-80). Groningen: J. B. Wolters.

[13] Van Hiele, P. M., (1959). Development and learning process, a study of some aspects of Piaget's

psychology in relation with the didactics of mathematics. Groningen, the Netherlands: J. B. Wolters.
[14] Van Hiele, P. M., (1974). System separation and transfer. Educational Studies in Mathematics, 5(4), 413-417.
[15] Van Hiele, P. M., (1986). Structure and insight: A theory of mathematics education. Orlando, FL: Academic Press.
[16] Wriszup, I., (1976). Breakthriughs in the psychology of learning and teaching mathematics. In space and geometry. Columbus, OH: ERIC/SMEAC, 75-97.
[17] Yerushalmy, M., (1987). Introduction and generalization: An experiment in teaching and learning high school geometry (Doctoral Dissertation, Harvard University). Ann Arbor, MI: University Microfilms, Inc.

An on-line ITS for elementary algebra

Li Yi-Ping*, Chan Kan-Kan**

University of Macau
P.O.Box 3001, Macau
Tel: 853-3974323
Fax: 861095
*fstypl@umac.mo , **fedrc@umac.mo

The objective of this research is to reinforce the concepts and procedures of elementary algebra that students learn in junior schools. Students react to teacher's instructions in various way. However, in a traditional class, the ratio of teacher to student is still too great. The question of how to help all the students with limited number of teachers arises. This paper describes how to achieve the above objective with the help of an intelligent tutoring system. It discusses the design outline and the system architecture of the proposed system. The tutor tracks student's performance and uses this information to provide most suitable instruction to each student dynamically.

Keywords: **Web-based learning environment**, **intelligent tutoring system**, **elementary algebra**

1. Introduction

In a class of forty students, it is hard for teachers serving every student's questions within a class of forty minutes. Teachers teach students concepts and methods or techniques to solve problems in group. Then related exercises are given to students to practice at home. Students who have no doubts in class might cope with the exercise and learn well while some might not master the technique that teacher has taught. They always frustrate when they cannot solve the problem. In this situation, some advice from teacher is very helpful in their learning process. However, teachers are not always available while they need help. Also teachers might not be able to answer many students' doubts at the same time. This research is conducted with the aim of using computers to support the knowledge acquisition process that is adjusted to the capabilities of individual student. Students just need to have a web browser to connect to school network and would get assistance right away.

Many existing CAI applications do help a bit in students' learning process but they do not consider the background knowledge of students. This means that they might provide inappropriate feedback to students which in turn affects student's progress in learning. In order to overcome this situation, research has been investigated on intelligent tutoring system which includes functions for guiding students towards proper knowledge acquisition, according to observation of the student's problem-solving process and identification of the causes of student error.

We first depict the learning environment of our system in section 2and then the overall architecture of our system is mentioned with detail description of main components of ITS in section 3. The final section concludes our work.

2. Learning Environment of on-line ITS for elementary algebra

ITS for elementary algebra is designed as a problem solving environment to be used in class. Therefore we assume that student is familiar with the basic concepts of elementary algebra and know the ways to factorize a polynomial. Students use the system as a tool at home or during class practice. Since the condition that students

use it lacks teacher's support, an interactive problem support should be built into the system. With this feature, students might get help on steps of problem solving where he has difficulty.

In order to access the on-line tutoring system, a student just needs a web browser and types the address where the system locates. An instance of the system will be created in student's computer in the form of ActiveX control. Although it might argue that there is great network delay in loading the system in student's computer, interactivity and userfrindliness deserve a short delay. In fact, in a local environment, the network traffic is not so congested. Therefore this is not a real problem. Instead, students can use it as if any Windows program and do not have to worry about its maintenance or compatibility issues. The control serves as a communicator betweent the system and the student. It transfers student's action to the system and returns the reponse of the tutor to the student.

Every student has his own session during the learning process. When a student enters the system with his user name and ID, a model of student performance is created or opened to set his learning environment. ITS selects a problem according to student's level for him to work or waits for the student to enter a problem which he has doubts. In both situations, the student solves it with the guidance of the tutor in a step-by-step way. The system keeps track of every step of the student in background. If nothing goes wrong, it remains quiet otherwise it prompts student's error. His problem solving procedure is kept in the system for future reference.

3. Overview of on-line ITS for elementary algebra

Our system follows the standard architecture of client-server model. The system resides on the server side. The basic components of the learning system are the domain module, pedagogical module, student modeler and the interface.

The domain expert module consists of two main programs. One is a problem solver which is capable of solving problems in its knowledge base. The other one is question generator that creates new problems according to the instruction of pedagogical module. In order to achieve its mission, the knowledge base is composed of both rules and cases. The expert model is capable of solving general problems by the rules coded in its module. As for miscellaneous problems, they are indexed as cases with problem characteristics and solving techniques so that the domain expert knows how to retrieve the relevant solving technique with the detected problem features.

The domain that we have chosen is factorization of algebraic polynomial for students in elementary classes. Given a polynomial, factorization is to express an integral polynomial as a product of prime polynomial. Therefore a polynomial is not completely factored unless each factor is either a monomial or a prime integral polynomial. Generally, there are 4 basic methods to factorize an algebraic formula. They are: (1) obtaining the common factor (2) using identities (3) cross-method and (4) divide the polynomial into groups and then simplify groups to find factors.

The pedagogical goal is to let junior students master the methods to factorize a polynomial smoothly. Students are taught the basic method to factorize an algebraic formula. However, they always get lost in the actual application to find the factors of a given formula. Therefore, we have organized the pedagogical knowledge by constructing groups of problems according to the level of difficulty, problem characteristics and solving technique. Within each level, there are pre-requisite question types which a student must understand before a certain question type will be generated. Figure 1 shows part of the relation among question types. There are several groups having polynomial problems as bellows:

- Problems, which just need one method to solve. They are polynomial with common factors, problems that satisfies the characteristics of perfect square: $(a\pm b)^2 = a^2\pm 2ab+b^2$, difference of 2 squares: $a^2-b^2=(a+b)(a-b)$, sum or difference of 2 cubes: $a^3\pm b^3 = (a\pm b)(a^2\mp ab+b^2)$, or perfect cube: $(a\pm b)^3 = a^3\pm 3a^2b+3ab^2\pm b^3$ and problems of trinomials with a degree of 2 i.e. $x^2+(a+b)x+ab = (x+a)(x+b)$
- Problems that need 2 methods to solve are posed, for example: ab^2-4a. There are a few combination of solving techniques like common factor with standard equation, common factor with cross method or cross method with standard equation.
- Problems with more than 4 terms that need to be divided into groups of terms before they can be solved by the general methods.
- Problems that require special techniques to solve like adding terms, splitting terms etc.

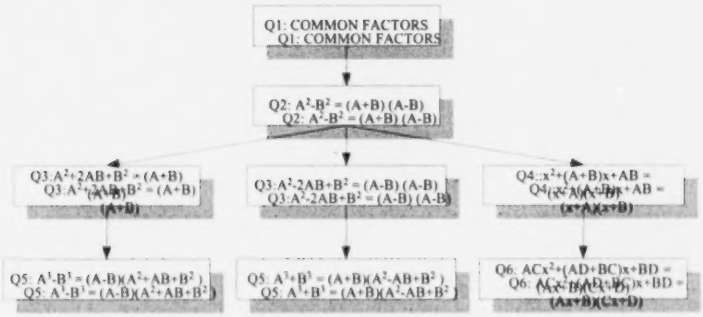


Figure 1. Part of the pedagogical knowledge

A student modeler tries to understand the mental state of a student so as to provide a more accurate estimation of individualized instruction. The task of building a student model is extremely difficult as the amount of information to capture is huge. Although it has been pointed out that this task is intractable[1], an incomplete student model is still very useful in the process of tutoring [2] [3].

The student modeler evaluates the solution of the student and the ways he factorizes the polynomial with respect to the one solved by domain expert. Although the solution path for a given problem of a student might be different from that of domain expert, the student's solution is still correct if it answers to the problem. In our case, if all the factors that the student found are irreducible, his answer is correct. The tutor would suggest him another way to solve the problem if it is found that his solution path is different. In this way, students are guided to know that there is always another way or a better method to solve a problem. Referred to table 1, student is asked to factorize a problem $4a^2-16b^2$, the second column shows the ways that he solves the problem. The student answers the question correctly and his student model is updated accordingly. Although his problem solving procedure differs from the sample, this would not affect his student model. Only the tutor would suggest him its way for the student as reference.

Problem: $4a^2-16b^2$			
Student	Reason	Tutor	Reason
$=(2a-4b)(2a+4b)$	$a^2-b^2=(a+b)(a-b)$	$=4(a^2-4b^2)$	Common factor
$=2(a-2b)2(a+2b)$	Common factor	$=4(a+2b)(a-2b)$	$a^2-b^2=(a+b)(a-b)$
$=4(a-2b)(a+2b)$	Multiply numbers		

Table 1. Procedure that the student and the tutor solves a problem.

The student model in ITS for elementary algebra contains a general information about the student, history of student's performance such as previously solved problem, information about the usage of factorization techniques and what kind of problems he is able to solve according to the pedagogical knowledge. All these information is important to allow students to receive more instruction and perform more problem-solving questions in areas in which they are relatively weak. An array of integer is used to keep the system's belief of student's mastery of a certain skill.

The interface of our system shown in Figure 2 is designed to be user friendly. It is divided into 3 main regions: upper part shows "Check answer" and "New problem" buttons; lower part is the area where the tutor provides feedback. The student interacts with the system mainly at the left side of middle part of interface. He may enter a question by himself or the system might generate one based on his experience. A list of actions is listed for him to explore the problem solving technique. He may select an action to tell the system how he would solve the problem. Every action selected would be given an appropriate feedback to the student. In this way, he might discover what is the consequence of selecting an action. An input area is allocated for the student to enter auxiliary data needed for his selected action. When the answer button is clicked, the student's solution is evaluated and his student model is updated accordingly.

BEST COPY AVAILABLE

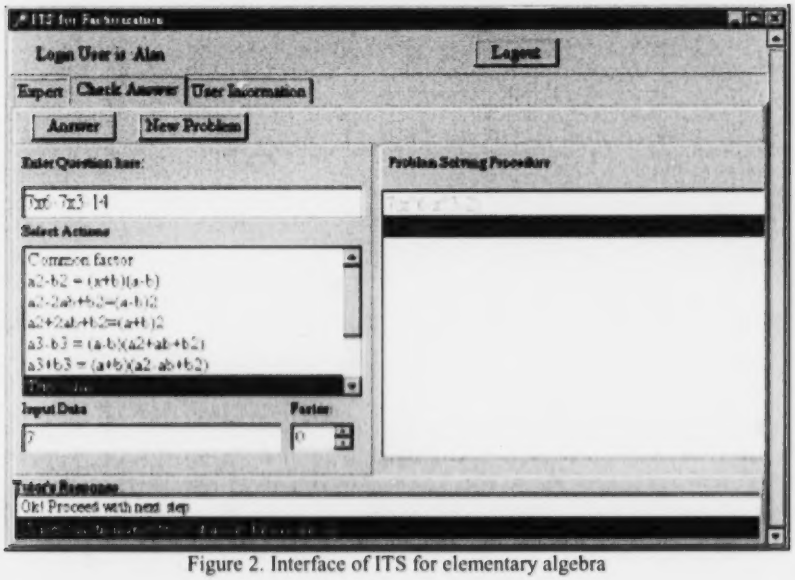


Figure 2. Interface of ITS for elementary algebra

3.1 Evaluation

In our experiments to simulate the problem solving procedure of students using the system, we found that it follows the overall design. It is able to provide individualized instruction, appropriate feedback and model student's performance. For major types of the factorization problem in junior school, the tutor is able to solve and guide the students. However, there are also questions that it fails to solve and guide. There are also cases that the available action for students to use in the problem solving process is not enough.

4. Conclusion

In this paper we have described an on-line intelligent system with interactive problem solving support and curriculum sequencing. A prototype system designed with some learning theory is implemented. The system helps students to reinforce the factorization technique. Our intention of building this system is to increase the learning progress of students and it shows to be a successful tool according to informal evaluation

Since the success of an ITS depends greatly on the student model, we are planning to improve our system with a more accurate student model in the near future. The user interface will be reconstructed to improve the interactivity between users and the system. The implemented domain knowledge is quite limited in this stage and we are developing larger domain knowledge.

Reference

[1] Self J., "Bypassing the intractable problem of student modeling", Intelligent tutoring system: at the Crossroads of Artificial Intelligence and Education, (1990).

[2] Self J., "Formal Approaches to Student Modeling", Student Modeling: The key to individualized knowledge-based instruction, (1994).

[3] Woolf B.P. and Murray T., "Using Machine Learning to advise a student model", Student Modeling: The key to individualized knowledge-based instruction, (1994).

BEST COPY AVAILABLE

Anatomy On The Cutting Edge: Pre-Dissection Lecture-On-Demand At The National University Of Singapore

J.A. Gilles Doiron
Centre for Development of Teaching & Learning, National University of Singapore
10 Kent Ridge Crescent, Singapore 119260
Tel: (65) 874 - 2529
Fax: (65) 777 - 0342
Email: doiron@nus.edu.sg

The NUS Integrated Virtual Learning Environment (IVLE) was developed so that staff and students could use this information technology infrastructure to communicate, exchange documents and information, discuss, chat, and access custom learning materials and course related web sites. IVLE also enabled the university to consider new pedagogical approaches, which would utilise its campus-wide broadband access to meet specific teaching and learning needs. A "lecture-on-demand" (LoD) delivery was seen as a viable tool that would allow students to take more responsibility for their learning and enable them to have greater control over their time schedule. With the collaboration of the Faculty of Medicine, the Centre for Instructional Technology and the Centre for Development of Teaching & Learning, a prototype anatomy pre-dissection LoD, "The Abdominal Wall & Inguinal Canal", was produced. This paper examines the design and development issues addressed in building this prototype. Field test data on the technical reliability, and ratings and comments from student feedback are also presented.

Keywords: **lecture-on-demand, LoD, web-based learning, streaming video, instructional technology**

1 Introduction

After decades of escalating computer use in all faculties, its impact on university teaching is still largely a promise. Although widespread computer use has brought about the development of interesting applications of computer technologies, such as the Integrated Virtual Learning Environment (IVLE) at NUS, the use of computers in the teaching and learning process is still not commonplace.

Some researchers have examined the adoption of computer assisted learning (CAL) technologies (Faseyitan, S. O., & Hirschbuh l, J., 1992) and the diffusion of computers into university teaching (Proulx, M., & Campbell, B. 1997). They note that virtually all faculties use computers, but as Larose et al (1999) points out, the integration of computers and pedagogy remains isolated and sparse, with its implementation depending greatly on the faculty.

With reference to the long-term implications of the integration of information and communication technologies (ICT) into the university fabric, there are of course differing opinions. Some believe that teaching will remain essentially traditional, with its neo-behaviourist epistemological standpoint in which information technologies simply take the place of print or the use of the chalkboard (Tapper, J., 1997). Others are convinced that ICT will, in itself, lead to profound changes in how teachers and students relate to knowledge. They follow the trend towards a "constructivistic" perspective in which the integration of ICT requires a global reconsideration of the

university-level relationship to knowledge.

The prudent approach to implementing institutional change linked to information technology is echoed by those who caution us that the application of some aspects of ICT may go against what we have traditionally valued as good education. Beckett (1998) bemoans that higher education has been colonised by its servitude to new technology and that disembodied learning is a poor substitute for classroom teaching. Other researchers, such as DeKerckhove (1997), suggest that at present the inclusion of ICT in the teaching practice may do more harm than good, since most teachers have not been adequately trained to use them as an effectual teaching intervention.

At NUS, the IVLE provides the ICT infrastructure that enables the university to consider new computer mediated pedagogical approaches. Consequently, because lectures in auditoriums where class sizes are substantially large (two hundred or more) are viewed as not very conducive to learning, these lectures were considered as possible candidates for asynchronous web-based access. The time saved can be better-spent in small group discussion sessions where teaching staff and assistants can focus on getting the students to apply, discuss and reflect on subject matter that has been acquired independently from a pre-produced individually accessible web-based lecture. Thus a "Lecture-on-Demand" (LoD) approach was seen as a viable tool that would allow students to take more responsibility for their learning and enable them to have greater control over their time schedule.

2 Method

In April 1999, a professor of anatomy from the Faculty of Medicine expressed concern that his students were not as well prepared for the hands-on tasks of dissecting a cadaver. His lectures to an audience of over 200 students consisted of showing slides, describing the procedure to be undertaken and providing relevant information on the topic. He felt that his students would benefit from a well-produced instructional video made available prior to entering the dissection room. He wanted a delivery system that would enable each student to access the pre-dissection lecture at their own preferred time, and allow them to spend as much time as needed to view and review the content.

The Centre for Development of Teaching & Learning (CDTL) and the Centre for Instructional Technology (CIT) at NUS were consulted, and agreed to provided the design and the development expertise to build a prototype lecture-on-demand (LoD) web site. In addition to the content expert, the prototype development team would include a team leader/instructional designer, a multimedia producer, a graphic artist/programmer, a video crew, a video editor and assistance from system engineers and technicians for video conversion and computer server set-up.

The initial screen designs and flowcharts were produced and the structure of the content was established. The content was to be broken down into short segments arranged in the normal dissection sequence. Since the actual dissection procedure is a very long process, three cadavers were readied for the video explanation of the dissection. The lecture segments were taped simultaneously from two camera angles to provide the necessary perspectives.

After validation of the edited video, the transfer to a streamable digital format was investigated. The testing phase established that the transfer process required digitising the analogue video to a non-compressed raw AVI (Microsoft Audio/Video Interleave) digital format and then encoding it into an ASF (Microsoft Active Streaming Format) file format. The ASF format enables data to be sent out in "packets" across a network at a specific bandwith or bit rate. The NUS intranet infrastructure has enough bandwidth to accommodate the streaming of ASF files without, at most times, losing any packets. That is to say that at most times ASF video accessed from campus will run smoothly.

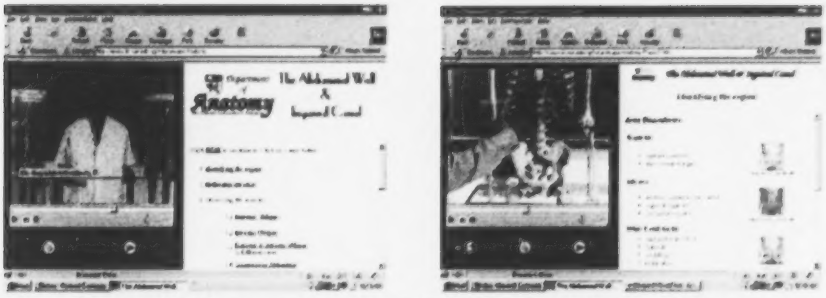


Figure 1. Web site screen shots of Home Page (left) and Topic Segment (right).

The site is programmed to run from either Netscape or Internet Explorer browsers. The screen layout shows three frames: the title frame, the text and graphic frame, and the video player frame (see Figure 1.). The program includes seventeen (17) video clips (40 min. total time) and fourteen (14) full screen graphics with pop-up labels. The final item in the home page selection is linked to an online quiz with multiple choice, fill-in-the-blank, and select-from-a-list type questions.

3 Discussion

A link to a feedback form was added to the site and seven questions, including two with text box input, were designed to examine what the students thought of the LoD approach. Access to the site was restricted to first year Faculty of Medicine students and first year Faculty of Dentistry students, and as of the 01 February 2000, sixty-one (61) students had submitted the online feedback form. The data collected so far is serving as preliminary data for formative evaluation. As the beta version will become available next semester, long before the students need to attend the dissection lab on this particular subject, more feedback will be collected. The following is a summary of the responses provided to date through the online feedback form.

Question #1: How do you rate this prototype program? Not Useful 1 / 2 / 3 / 4 / 5 Very Useful

	Tally	Percent
2.00	02	03.3%
3.00	07	11.5%
4.00	26	42.6%
5.00	26	42.6%
Total	61	100.0%

Question #2: Would you use this program to prepare for a dissection session? No/Yes

	Tally	Percent
No	04	06.6%
Yes	57	93.4%
Total	61	100.0%

Question #3: Would you use this program during a dissection session? No/Yes

	Tally	Percent
No	18	29.5%
Yes	43	70.5%
Total	61	100.0%

Question #4: What do you like most about this program?
The students typed their comments in the text box provided. Many indicated that they were pleased to access the lecture at their convenience. They also pointed out that they liked how the content was organised, the realism of

the video and the fact that they could replay and stop the action as they wished. Some wrote that the on-screen presence and explanations by their own professor of anatomy gave weight to the content. Here are some of the comments:

> "Whenever I' m unclear of a small point, I can easily rewind back and listen to it again, without interrupting a predissection talk that' s held normally."..."I find it comprehensive and useful. More relevant than the usual pre-dissection lecture"..."The lesson is well-organised, and the video shows the real cadaver which aids understanding greatly. As a pre-dissection lecture, it is very good."..."I can access it anytime I want to review the dissection"..."I like the way it's presented. Actual cadaveric structures are shown to us instead of ideal Netter' s pictures. Then we know what to look for in our cadavers. The website can also be accessed many times at our convenience to recollect things during dissection."

Question #5: What do you like least about this program?
The students typed their comments in the text box provided. Many indicated that they would have wanted access from their home. Other comments included problems getting access to university computers, some computers not set up for running the program, and poor quality audio. Here are some of the comments:
"Cannot access it from home. rather troublesome to use it in school since the com. lab is usu. occupied."..." clearity of the things lectureer is saying"..."Cannot access from COFM computers because they lack the video software."..."Can only be accessed successfully on campus, would be much more convenient if it can be accessed at home."

Question #6: Would you like to see more pre-dissection lectures done in this way? No/Yes

	Tally	Percent
No	03	04.9%
Yes	58	95.1%
Total	61	100.0%

Question #7: After going through this program do you feel less confident, or more confident about undertaking the dissection? Less confident/More Confident/No change

	Tally	Percent
Less Confident	01	01.6%
More Confident	54	88.5%
No Change	06	09.8%
Total	61	100.0%

4 Conclusion

During the development, testing and evaluation stages of this prototype, the feedback from the department of anatomy staff and students was very supportive. The experience enabled the development team to establish production guidelines and procedures, and to create a template web site for producing a complete series of anatomy LoDs.

In all, the project involved fifteen (15) individuals (4 Department of Anatomy, 9 CIT and 2 CDTL) who dedicated a total of approximately 1,000 man/hours to the project. Much was learned and can now be applied to reduce the development time of future anatomy LoDs. A reasonable estimate for producing another LoD with similar production requirements would be around 600 man/hours. The cost of production, based on supplying approximately 1,250 students (250 students per year for 5 years), would amount to less than one half man/hour per student.

The "Anatomy Pre-dissection" LoD prototype development is an example of a project making sound and pragmatic use of appropriate information technology tools to provide valuable learning experiences. However there is a need to continually examine and refine instructional design decisions so as to take advantage of new pathways to learning which are made possible through the creative use of ICT.

REFERENCES

[1] Beckett, David. (1998). Disembodied Learning: How Flexible Delivery Shoots Higher Education in the Foot, Well Sort of. Electronic Journal of Sociology: 3, 3.[iuicode: http://www.icaap.org/iuicode?100.3.3.2]

[2] Faseyitan, Sunday O., and John Hirschbuhl (1992) "Computers in University Instruction: What Are the Significant Variables That Influence Adoption?" Interactive Learning International, 8(3): 185-94.

[3] De Kerckhove, D. (1997). Connected Intelligence. Toronto: Somerville House Publishing.

[4] Larose, François David, Robert Dirand, Jean-Marie Karsenti, Thierry Grenon, Vincent Lafrance, Sylvain & Cantin, Judith. (1999). Information and Communication Technologies in University Teaching and in Teacher Education: Journey in a Major Québec University's Reality. Electronic Journal of Sociology: 4, 3.[iuicode: http://www.icaap.org/iuicode?100.4.3.3]

[5] Proulx, Michelle & Campbell, Brian. (1997). The Professional Practices of Faculty and the Diffusion of ComputerTechnologies in University Teaching. Electronic Journal of Sociology: 2, 3.[iuicode: http://www.icaap.org/iuicode?100.2.3.2]

[6] Tapper, J. (1997). Integrating Online Literacy into Undergraduate Education. Higher Education Research and Development, 16 (1), 25 - 40.

Automated Quantitative Extraction Method of Aesthetic Impression from Color Images using the Tone in the HLS Muncell Color Space

Toshinori Yamasaki, Tetsuo Hattori and Yukihiro Matsubara
Faculty of Engineering, Kagawa University
Hayashi-cho, Takamatsu, Kagawa 761-0396 Japan
Yamasaki (hattori, matsubar)@eng.kagawa-u.ac.jp

The students acquire a visual literacy through learning the coloring systematically in the fine arts subject. This paper describes an extraction method for the aesthetic impression of the paintings based on the tone in the Muncell color space for fine arts subject. The impression, which the human being gets from the paintings, depends on the motif, the composition and the coloring. Here, we discuss the evaluation method of the paintings by the computer based on the tone that includes the lightness (intensity) and the saturation (vividness). We perform the evaluation experiment of the paintings that have a unique coloring. The evaluation result approximately resembles the impression of which human being is moved. This method is also useful for retrieving the image database using the ambiguous key words like the impression words.

Keywords: **aesthetic impression of paintings, color tone, color harmony, visual literacy, fine arts subject, image retrieval system**

1 Introduction

Fine arts subject educates the ability of the sense beauty, that is, a visual literacy through recognizing a form and a color. For training such a visual literacy, it is important for the students to understand the nature of color systematically. Visual literacy that is the aesthetic judgment ability becomes the basis of the expression and the appreciation activity in the fine arts learning. The students acquire the visual literacy by experience through repeated practice of painting the picture. On the other hand, there are the empirical rules about the composition and the coloring in the art. As for the color harmony, Ostwald, Muncell and Moon Spencer are well known.

Recently, the multimedia database spreads widely with the development of the network technology. In the multimedia database retrieval, it is useful that we can refer database using the impression words and the ambiguous feeling words in addition to the key words. Recently, an image database retrieving by impression words as beautiful, balmy is reported [1-5].

We report the extraction way of the aesthetic impression degree of the paintings based on the Moon Spencer's color harmony theory [6]. However, in the Moon Spencer's way, we can estimate the degree of the beauty as the numerical value but we cam not know the detail impression like the dark, light, bracing impression which each painting gives. In this study, we describe more concretely the way of extraction the aesthetic impression of the paintings based on the tone in the HLS Muncell color space.

2 The tone and the systematic color names

We call a suitable coloring the color harmony. In the color harmony theory, Ostwald, Muncell and Moon Spencer are well known. Also, a color system is established by JIS (Japanese Industrial Standards) and

PCCS (the Japanese Color & Coloring System).

Here, we use the tone in the Muncell HLS space for estimating the impression of the paintings more precisely. We express a color by the word, which shows the impression of the color like the light green, the dark green. There is a difference between bright and dark, strong and gentle, vivid and muddy in the same color, same hue. We call this difference the tone (Lightness and Saturation). The tone is a concept of the lightness L and the saturation S being compounds and shows an impression of the color, which doesn't depend on the hue well. As the tone has an each image, it is easy to connect the tone the psychological effect of the color. We can evaluate the feeling impression of the paintings by extraction the tone from the image data. In this paper, we adopt the PCCS tone for evaluating the impression of the paintings [7]. The PCCS defines the tone in the lightness L and the saturation S in the Muncell color space and gives color system as the tone and the hue. The PCCS classifies into 12 kinds of tones in each hue and packs the same tone of the every hue. Figure 1 shows the classification of the tone.

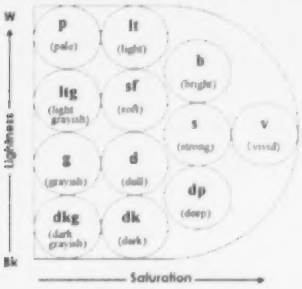


Figure 1 Tone (Lightness – Saturation)

Figure 2 Systematic Color Names

The tone image is defined by the systematic color names in the PCCS color system. The systematic color names is the color expression way that gives a modifier according to each fundamental color like white, red and blue. It sets a way of combining a fundamental color name and modifier. The modifier in PCCS includes an adjective, which shows the hue difference like the tinge of red, green. On the contrary, it has no word, which shows only lightness or a saturation. The bright impression includes not only the high intensity but also the vivid saturation. The mild impression means the high lightness and low saturation. Figure 2 shows the systematic color names of the tone space.

3 Evaluation of the aesthetic impression

After getting the image data through the scanner, we extract the impression feature of the paintings. Figure 3 shows the outline of our method. The resolution and the size of the image data is 120 [pixels/inch] and 640*512 [pixels] respectively. The image data is a full color, bit map.

The image data has RGB color component and doesn't connect with the color sense of the human being straight. Also, it is difficult to adjust the color tone in the color synthesis. Here, we convert the RGB to the HLS value in the Muncell color space, which fits for the color sense of the human being. Mucell color system shows the color as the three components, H (Hue), L (Lightness) and S (Saturation) and is used widely in the coloring. Figure 4 shows the Muncell HLS color space. We get the H[0,360], L[0,1], S[0,1] values through the conversion of the RGB[0-255] value.

BEST COPY AVAILABLE

The number of the colors in the image data is enormous for processing data by a computer. Here, we reduce the number of colors to the degree, which doesn't loose the color tone of the paintings. We divide the H, L and S to 10 and 14 respectively.

Hue (H)	Lightness (L)	Saturation (S)
R	8.5	14
YR	9	13.5
Y	9	13
GY	9	12
G	8.5	11
BG	8.5	10
B	8.5	10
PB	8	11.5
P	8	11.5
RP	8.5	12.5

Table 1 Maximum Values of L, S

Figure 4 HLS Muncell Color Space

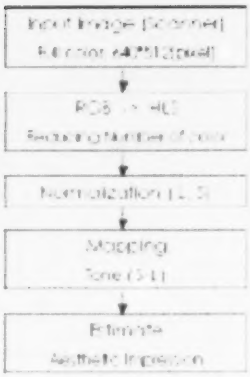


Figure 3 Outline of the Extraction Process

The maximum value of the L and the S depends on the coloring material and each hue shown in table 1. Therefore, the value range of the L and S is different according to each hue. For example, the maximum L, S value of the Red and Purple hue is 8.5, 14.0 and 8.0, 11.5 respectively. Here, we normalize the L, S value 0-10 ranges.

From the above way, we estimate the number of the pixel in the S-L tone space through mapping the image data to the tone space. We can find the aesthetic impression of the paintings by estimating the position of the mapped pixel in the tone space because of the correspondence between the tone space and the impression modifier shown in figure 2. In this experiment, we evaluate the number of the colors, which accounts for 70 % of the color area. However, we cannot estimate the impression because the distribution in the tone space becomes apart. Here, we calculate one position of the tone space from several distributed positions using the weight coefficient of each tone position.

$S = W_i S_i, \quad L = W_i L_i \quad (1)$

Where $Wi = \sum(a_i / \sum a_i)$ a_i is the number of the occupied pixel in each color.

We estimate the impression of the paintings according to the tone index (S, L) defined in equation (1).

4 The evaluation experiment

The simple coloring picture is tested beforehand. As a result, the showy picture of the pure color and the gloomy picture are mapped over the v (vivid) and dkg (dark grayish) tone respectively. Typical paintings and poster works from renaissance to modern are tested in this experiment shown in table 2. Figure 5 and figure 6 shows examples of the paintings and the typical mapping result in the tone space respectively. We can evaluate the aesthetic impression of the paintings using figure 6 and figure 2. The extraction impression is listed as follows.

"Mona Lisa" (2) of Leonardo da Vinci is famous for gently smiling lady. This painting locates near dk (dark) in the tone and gives dark, mellow impression.

Monet's "Water Lily" (5) is said the mystic beauty of the surface of the water and is situated on the tone space near ltg (light grayish). We can say that the water lily has a cooled silent image.

Gogh's "Sun Flower" (8) is painted yellow strongly which he liked most. It is situated on the tone space near s (strong). From this result, we can evaluate that the impression of sunflower is strong, passionate painting.

Figure 7 shows the mapping result of the works in table 2. The above-mentioned results agree with the established reputation and the eye inspection of human being.

BEST COPY AVAILABLE

Table 2 Lists of Paintings and Design Pictures

	Painter	Style	Work	epoch
1	Leonardo da Vinci	Renaissance	Virgin of the Rock	1503
2	Leonardo da Vinci	Renaissance	Mona Lisa	1503
3	Rembrandt	Baroque	Night Watch	1642
4	Rembrandt	Baroque	Raising of the Cross	1633
5	Monet	Impressionist	Water Lilies	1903
6	Monet	Impressionist	Flower Pot	1903
7	Monet	Impressionist	Popies	1873
8	Gogh	Modern	Sun Flowers	1888
9	Gogh	Modern	Self Portrait	1889
10	Signac	Impressionist	Saint-Tropez	1900
11	Renoir	Impressionist	Theater Box	1874
12	Renoir	Impressionist	Les Grands Boulevard	1880
13	Renoir	Impressionist	La Liseuse	1876
14	Klee	Modern	Baldgreis(Senecio)	1922
15	Matisse	Modern	Green Stripe	1905
16	Matisse	Modern	Red Room	1947
17	Munch	Modern	Screem	1893
18	Munch	Modern	Sick Child	1895
19	Poster	Design	Star Wars	
20	Poster	Design	Bug's Life	

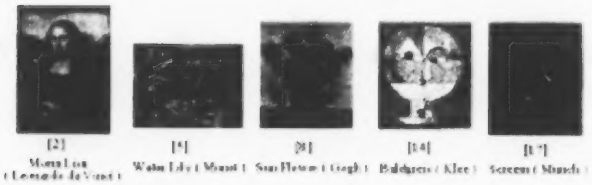


Figure 5 Examples of the paintings

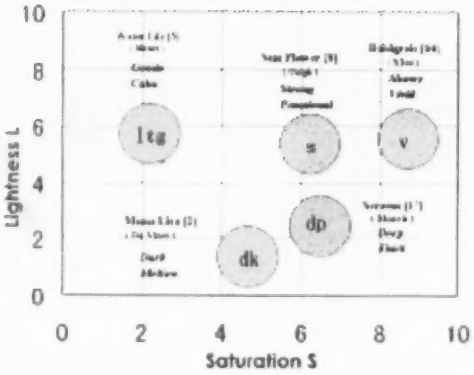


Figure 6 Mapping Result in the Tone (1)

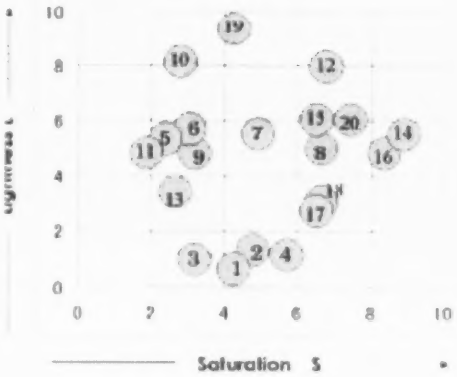


Figure 7 Mapping Result in the Tone (2)

5 Conclusions

We proposed the way of evaluating the beauty and impressive sense of the paintings and design pictures based on the tone in the Muncell color space. We use the tone space, which can concretely express the color impression and a corresponding systematic color names. This method suits the aesthetic impression degree evaluation by the computer because the evaluation processing doesn't depend on the hue.

After getting the image data through the scanner, we convert each RGB pixel the tone space in HLS Muncell color space. We extract the location of the paintings in the tone space by calculating the coefficient of the occupied area. The aesthetic impression is estimated by the location of the used color in the tone space.

The famous paintings from renaissance to modern are tested for extracting the impression feeling. "Mona Lisa" of Leonardo da Vinci and Gogh's "Sun Flower" is estimated as matured darkly and strongly passionate impression respectively. These results tell us that the distinction by the computer coincide with an established reputation of the paintings.

The impression extraction by this way is useful for the students learning how to use color arrangement in their fine arts subject.

Acknowledgments

This research was supported by Grant-in Aid for Scientific Research on priority areas (12040229) from the Japanese Ministry of Education and Culture.

References

[1] K., Hachimura, " Retrieval of Paintings Using Principal Color Information," Proc. 13th ICPR, pp.130-134, 1996.
[2] A., Tojima and K, Hachimura, "Extraction of compositional feature from paintings and application for retrieval," Trans. IPS Japan, vol.40, no.3, pp.912-920, Mar. 1999.
[3] H., Kimoto, "An image retrieval system using impressional words and the evaluation of the system," Trans. IPS Japan, vol.40, no.3, pp.886-898, Mar. 1999.
[4] H. Nozaki and Y. Isomoto, "Information retrieval for fine arts database system," Trans. IEICE Japan, vol.E80-D, no.2, pp.206-211, Feb. 1997.
[5] E., Masuyama, "How to analyze the impression of paintings from the point of KANSEI engineering," Proc. JSISE Conf. '97, K3A32a4, pp355-358, Sep. 1997.
[6] T. Yamasaki, T. Hattori, " An Aesthetic Impression Extraction of Paintings for the Fine Arts Subject," Int. Con. Computers in Education (ICCE99), pp.329-332, 1999.
[7] Nihon Color Research Institute, "PCCS Harmonic Color Charts," 1999.

AWETS: An Automatic Web-Based English Testing System

Zhao-Ming Gao
Department of Foreign Languages and Literatures
National Taiwan University
Taipei 106, TAIWAN
E-mail: zmgao@ccms.ntu.edu.tw

Test items are traditionally created by experts. While this approach has many advantages, it is laborious and time-consuming. Recent advance in corpus-based computational linguistics has shed new light on the feasibility of a computer-based language testing system capable of automatically generating items. This paper describes AWETS, an automatic web-based English testing system developed by the author's research team and used in his freshman English classes at National Taiwan University. AWETS automates test item generation, test delivery, scoring, and record keeping. It can generate random items for each testee in accordance with the input conditions of the test administrator. With AWETS, testers' jobs are reduced to inputting information such as a list of words and the time limit of each question. Besides being a useful tool for creating achievement tests in English vocabulary, AWETS can also generate proficiency tests based on a selected difficulty level without the need to input a word list. AWETS can be seen as a significant step toward future computer-based language testing system.

Keywords: **automatic generation of items, computer-based language testing, corpus-based computational linguistics, vocabulary testing**

1 Introduction

Test databank in current computer-based language testing systems is mostly created by human experts. This procedure is laborious and time-consuming. Moreover, since test databank is difficult to adapt, teachers using the systems have to spend a lot of time creating the tests for their own classes. To solve this problem, several researchers have suggested the feasibility of designing a tool to automatically generate items. For instance, [4] proposes creating a vocabulary test or exercise from a general corpus using a concordancer, and [5] suggests automatically generating CALL exercise from an electronic dictionary and a parsed corpus. Along the same line of research, we build AWETS, an automatic web-based English testing system that can greatly facilitate the creation of multiple choice vocabulary test. The system, designed with the central concern of adaptability, can generate multiple choice vocabulary test items in accordance with the conditions input by test administers. The system consists of three independent yet interrelated modules: the item generation module, the test delivery module, and the record keeping module.

2 The Item Generation Module

The system is developed based on a large collection of electronic texts and natural language processing tools such as a morphological analyzer and a part-of-speech tagger. The procedures of building the system are as follows.

1. Collection of a Text Database: We retrieve free electronic English texts from the internet primarily from Project Gutenburg and the Sinorama Magazine. Texts in Project Gutenburg are mainly literary works, while those in the Sinorama Magazine contain articles about the culture and events in Taiwan. To ensure that the retrieved texts are not too difficult for our learners, we only include works published after 1960.

The corpus size is about 0.2 million words.

2. Lemmatization: All the retrieved texts are processed by a morphological analyzer developed by University of Pennsylvania which changes regular and irregular inflections into their lemmas, i.e. basic forms (e.g. ran => run, happier => happy).
3. Frequency counts of lemmas: After lemmatization, frequency count of each lemma in the entire corpus is conducted.
4. Sorting of the frequency count of the lemmas in descending order.
5. Identification of the difficulty levels of each lemma: Three levels of difficulty are specified. They correspond to college entrance exams, TOEFL, and GRE. Each level has a range of adjustable values. At present, the range of these three values is stipulated as follows.

College Entrance Exam	Words which fall in the range of the most frequently occurring 3000 – 5000 lemmas
TOEFL	Words which fall in the range of the most frequently occurring 5001 – 7000 lemmas
GRE	Words which fall in the range of the most frequently occurring 7001 – 9000 lemmas

6. Tagging: Each text is processed by Eric Brill' s tagger which labels each word its part-of-speech information.
7. Indexing of each word: A database is created which records the documents and position in which a word occurs so that sentences containing a specified word can be retrieved in no time.

   Test administrators can choose the level of difficulty, the part-o f-speech of words, as well as the number of questions to be tested. Once the choices are made, the system will randomly retrieve sentences which meet the input conditions via the index. A subroutine then converts the retrieved sentences into multiple choice questions. The distracters of the questions are chosen from words of the same difficulty level as the target word. Figure 1 is the user interface for inputting conditions. Figure 2 is the automatically generated test items.

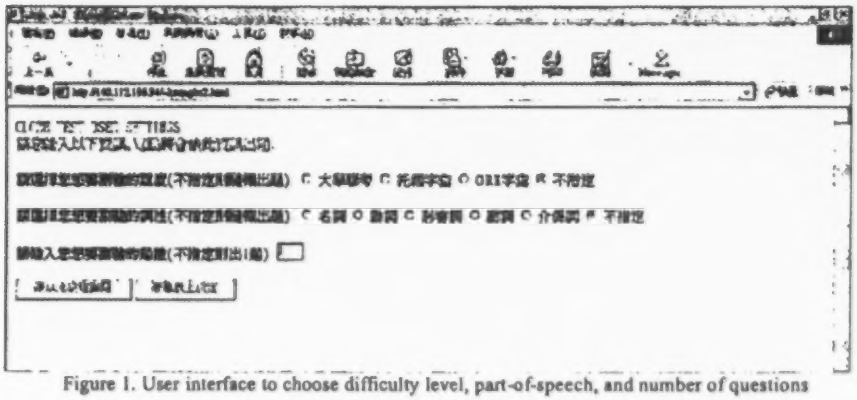


Figure 1. User interface to choose difficulty level, part-of-speech, and number of questions

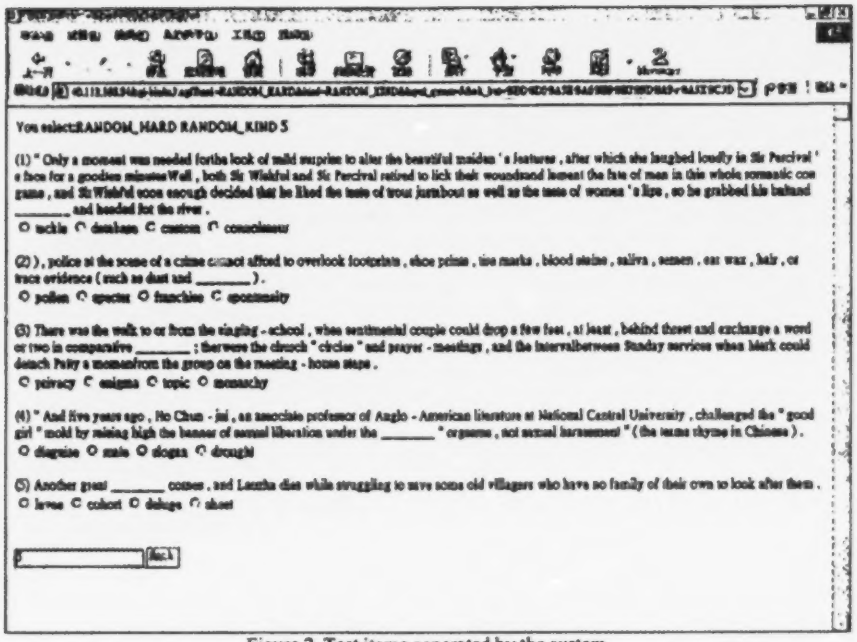


Figure 2. Test items generated by the system

As shown in Figure 2, the system is capable of generating individualized on-line vocabulary tests in the context of cloze tests based on the conditions input by a user. The system can thus be used as an excellent tool for self-paced vocabulary learning. If a learner wants to practice verbs at the TOEFL level, the system can create hundreds of such questions. As soon as he submits his answer, the system can check his answer and immediately present the correct answer to the user. Besides, if a test administer wants to change the difficulty level of the test, he can do it easily by changing the frequency range. To further facilitate the creation of vocabulary tests, the system also allows the test administer to decide which word should be tested. This is particularly useful for creating achievement tests. Once the tester inputs the words and the number of questions, the system can randomly generate multiple choice vocabulary tests in the context of cloze tests. Besides a corpus, AWETS also uses Wordnet, a lexical database developed at Princeton University, to generate items. It extracts the explanation of a lexical item and create multiple choice questions based on the item.

3 The Test Delivery Module

As described above, the item generation module can randomly create a specified number of questions in accordance with the input conditions by a test administer. To make test delivery more efficient, the test databank is created off-line. In other words, all the sentences meeting the input conditions are retrieved before the test starts. These sentences are converted into test items by a subroutine and then stored in the database. A subroutine then randomly retrieves a specified number of items from the databank and present them to the testees when the test starts. To ensure wide and unpredictable sampling, the subroutine is designed in such a way that no two tests are identical and no word will be tested twice in any test. The AWETS database also provides an interface (cf. Figure 3) for the test administer to input specification for the test. The interface allows the test administer to input the name of the test, the number of items, the time limit during which each question should be answered, and the number of times each testee can take the test. The test administer can further choose which classes and which words should be included in the test. After the test information is input by the test administer, testees proceed with the following procedures. They first input their user names and passwords. Before the real test begins, they are given 5 questions for practice. This procedure can help testees become familiar with the format of the questions. An interface and a test item such as Figure 4 is presented to the testees. As mentioned earlier, each question must be answered within a specified time limit. As soon as a question appears on the screen, the system begins to count down

the time left. The randomized questions and the time limit make cheating in the examinations much more difficult. Without these two functions, students might try to find answers from the person who sit next to them or from an on-line dictionary. The countdown device might also achieve a beneficial backwash, because testees need to speed up reading the question in order to finish the questions within the time limit.

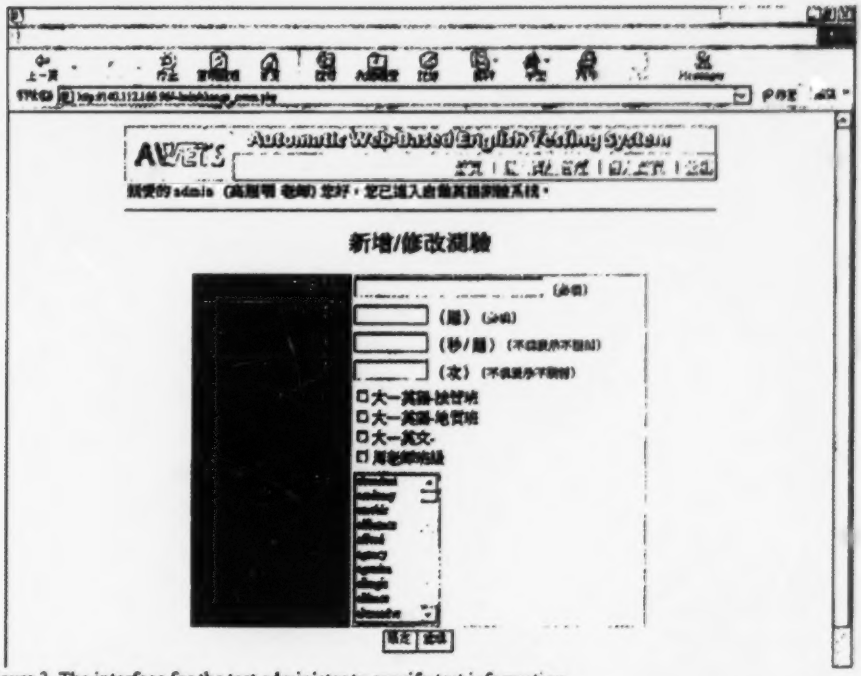


Figure 3. The interface for the test administer to specify test information

Figure 4. The testees' interface and a generated test item

BEST COPY AVAILABLE

4 The Record Keeping Module

After each test, the system records the registration number, the name of the student, the test id number, the name of the test, as well as the student' s score in each test. The database component allows teachers to query a student' s record or the whole class's scores in an exam via the interface in figure 5.

Figure 5. The database interface for querying the whole class' s scores in a test

The database component greatly facilitates the calculation of validity and reliability. When testees are given more than one set of test items in a given test, the correlation of the scores can be easily computed. The system also records all the questions and testees' responses. These data can be used to analyze testees' test-taking strategies. With this function, item analysis is possible although no test candidates have identical tests.

BEST COPY AVAILABLE

AWETS Automatic Web-based English Testing System

admin

最後一次期末測驗: BA8701211 (開永型) 分數: 100

1	O	consumption	the process of taking food into the body through the mouth (as by eating)
2	O	incidence	the relative frequency of occurrence of something
3	O	tribe	a social division of (usually preliterate) people
4	O	appetizer	food or drink to stimulate the appetite (usually served before a meal)
5	O	saturate	make (a chemical compound, vapour, solution, magnetic material, etc.) _____d
6	O	classical	(fine arts) of or characteristic of a form or system felt to be of first significance before modern times
7	O	grill	cook over a _____; "_____ the sausages"
8	O	physiologist	a biologist specializing in physiology
9	O	capacity	ability to perform or produce
10	O	blond	a person with fair skin and hair
11	O	dine	have supper; eat dinner
12	O	course	education imparted in a series of lessons or class meetings; "he took a _____ in basket weaving"; "flirting is not unknown in college classes"
13	O	variation	an instance of change; the rate or magnitude of change

Figure 6. A student's responses to the test items

5 Some Problems of AWETS

Although AWETS performs relatively well, there are some limitations which prevent it from being a completely reliable testing instrument. First, the basic assumption that difficulty of words can be determined by frequency is challenged by some scholars, since there are some words common in everyday life but much less common in texts. Moreover, a word might have several meanings some of which are much more difficult than the others. The approach proposed in this paper cannot distinguish the difficulty of the different meanings of a word. Another question is whether there might be more than correct answer in generated test items. When AWETS automatically creates multiple choice questions, it randomly chooses distracters from the dictionary. Although the distracters rarely fit the context, it might happen that some of them are acceptable. Note that choosing distracters with different parts-of-speech from the target word does not solve the problem, because a word might be used in different parts-of-speech. It should also be admitted that although AWETS can create individualized tests, it lacks a rigid method to ensure equal difficulty for all testees. Another technical problem involved is that the part-of-speech tagging program and the program which identifies sentence boundary is not one hundred percent correct. This might result in undesirable test items. Even when sentence boundary is correctly identified, some sentences might not be appropriate in testing a learner when taken out of context. This is particularly true of short sentences. Long sentences, however, are not always unproblematic. In a vocabulary test, all the words in the sentence are meant to give the contextual clues except the target word. In other words, the target word should ideally be the most difficult word in the sentence. Consequently, if there is a word in the same sentence more difficult than the target word, the test item might not be appropriate. Questions like these all require more rigid methods than those adopted in current implementation of AWETS.

6 Conclusion and Future Research

In this paper, we introduce AWETS, a web-based system that can automatically create vocabulary tests and

adapt items according to the conditions input by test administers. AWETS greatly facilitates the creation of vocabulary tests and has fully automated procedures for item generation, test delivery, scoring, and record keeping. At present, the validity and reliability of the automatically generated test items are being investigated. Future research will focus on solving the problems noted in section 5 by using sense-tagged texts and more rigid methods to identify difficulty of words.

Acknowledgements: The author wishes to thank Miss Lin Gui-Guang, Miss Liang Jing-Xiou, Mr. Zhao Zheng-Ming, and Mr. Lin Zheng-Ru for helping implement AWETS. AWETS is supported in part by a grant from the Computing and Information Network Center at National Taiwan University for the promotion of asynchronous learning.

References

[1] Bulter, Jonathan. Cloze procedures and concordances: The advantages of discourse level authenticity in testing expectancy grammar. System 19, 1/2, pp. 29-38, (1991).

[2] Hughes, Arthur. Testing for Language Teachers. Cambridge University Press, (1989).

[3] Stevens, Vance. Classroom concordancing: Vocabulary materials derived from relevant authentic text. English for Specific Purposes Journal 10: 35-46, (1991).

[4] Wilson, Eve. The Automatic Generation of CALL Exercises form General Corpora. In Wichmann et al. (eds.) Teaching and Lanuage Corpora. Longman, pp. 116 – 130, (1997).

Building the Multi-tier Architecture of Component-Oriented Multimedia CAI Systems on Internet

Min-Huei Lin , Ching-Fan Chen, Chen-Nan Chiang
Department of Information Management
Aletheia University
Tamsui, Taiwan, R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

The popularity of WWW (World Wide Web) produces lots of new instructions or substitutive cases to build a new future, therefore educational units need to develop various computer-assisted instructions. To ensure good learning effect, the instructive strategy adopted by most CAI systems is to provide tremendous amount of multimedia data in order to attract the learner and a complete process of instruction is like the scenario of a presentation. The purpose of this thesis is to discuss how the multi-tier developing architecture can let the multimedia learning resources be used and shared in WWW from a view of organization's requirements, such that teachers, measuring researchers, and learning researchers can perform different tasks according to their own specialties independently. We also propose and implement a multimedia presentation system to let various authors with various identities author and present their presentation, i.e. CAI systems, conveniently and correctly. We compare the general hierarchy of a multimedia presentation system with the multi-tier architecture proposed by us, and we can know how the tasks are divided and assigned to corresponding professionals to accomplish the whole teaching materials through working cooperatively. It is possible to have a suggestion to develop CAI software for educational department.

Keywords: **Multimedia Presentation System, CAI System, Multi-tier**

1 Introduction

Although there exists many arguments, object-oriented is still spread out in 1990's and it seems to be a possible survival direction in software crisis. Besides this, we can use component oriented to build a set of CAI systems via existing papers that can be divided into several areas, e.g. research of interface, learning methods of computer assisted instructions, application of virtual reality, networking exam, virtual classrooms (including distance instruction), individual researcher objects, and etc. For example, the processes of mental model research emphasize the use of information of objects, so researchers just make the analysis components of mental model, the key point of this study is the component of mental model, not the scenario of teaching and the interface of designation. Another example, fuzzy theory should be used in the research of learning analysis, the key point is to provide learning analysis for content of exam, and it can make the analysis component purely. From the two examples, we can find the generation in proper components analysis, so all we have to do is making the component of its own domain. Each researcher only concerns its own theme without being concerned with the entire system, then can reuse the resources and get the complete experimental environment. This thesis constructs the developing architecture of CAI through component oriented and logical dividing of multi-tier structure, and emphasizes that the discussion of developing architecture is the beginning of the series of research.

2 Multimedia presentation system

2.1 General Hierarchy of Multimedia Presentation System

On Internet, the way to play multimedia objects is hypermedia shown in the Fig.1. To display such a scene on homepages, we can divide the designation into two layers, frame layer and resource object layer. The resource object layer stores all the multimedia objects participated in playing, the frame layer records the objects that compose each frame, the schedule of playback, the arrangement of objects on screen, and the events that may change the playing flow of inter-frames.

A multimedia resource may be a picture, a text description, a video, or other materials that can be used in a multimedia computer. A topic is a resource carrier that presents the resource to the addressee. A frame is a composite object that represents related issues that a presenter wants to illustrate. A frame may contain push buttons, one or more topics to be presented, and a number of knowledge. A message with optional parameters can be passed between two frames (or back to the same frame) to trigger a multimedia presentation action.

In the two layers, we make some definitions by referring the various links defined in [7].
An inheritance* (successor or precedence) *link: is a property inheritance between two frames and is used in the process of knowledge collection of an activated frame before the logical inference of the frame proceeds.
A usage link: is a link that represents a message passed between two frames.
An aggregation link: indicates that a frame is using a resource.
A resource association link between two resources: indicates that the two resources are correlated.
A frame association link between two frames: indicates that the two frames are correlated.

2.2 Models of Presentation systems

In 1983, James F. Allen advocated in ACM• There exist thirteen temporal relationships between two intervals, namely, before, meets, overlaps, during, starts, finishes and the other six inverse relations as well as equal. The thirteen corresponding temporal operators constructed from the Allen's interval-based temporal logic are depicted in Fig. 2.

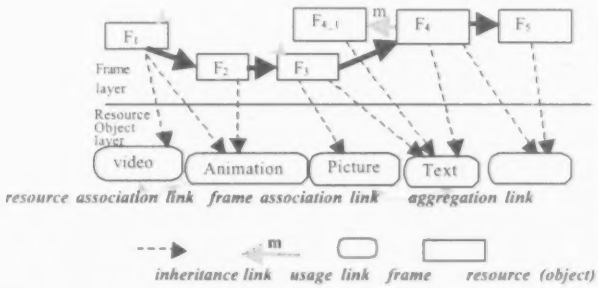


Fig.1 the way to play multimedia objects on Internet is hypermedia

Relation	Diagram	expressions	relation	Diagram	expressions
P before Q	P Q	P; ε(n);Q	P before Q	Q P	P‖ Q
P meets Q	P Q	P;Q	P meets Q	P Q	P‖ Q
P during Q	P Q	P‖ Q	P during Q	P Q	P‖ Q

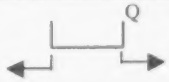
Relation	Diagram	expressions	relation	Diagram	expressions
P finishes Q		P ‖ Q	Start-time		Q End-time

Fig. 2 Temporal Relationships (Allen 1983) and their corresponding temporal operators

2.3 Define the Playback of Multimedia Presentation

We define some notations used in our presentation system. The F_i denotes the frame in the frame layer. The O_i denotes the resource in resource layer. The $F_i.O_i$ denotes that the resource O_i is one component of the frame Fi. The m_i denotes a triggered message when users push a button, a hypertext or a hypermedia. The m_iF denotes that the frame F will be displayed after the message mi is triggered, and the $m_\varepsilon F$ denotes that the frame can be directly displayed not depend whether the message is triggered or not.

For example, a presentation displayed one frame by one frame can be described by the following expression $S = m_\varepsilon F_1\ (m_1F_{21}+m_\varepsilon F_{22})\ m_\varepsilon F_3\ m_\varepsilon F_4\ (m_1F_{51}+m_\varepsilon F_{52})$. According to Fig.1, we know that the $F_i.O_i$ is an aggregation link, $m_\varepsilon F_1$ is an inheritance link, and m_1F_1 is a usage link.

2.3.1 Define the Properties of scenario

A complete process of instruction is just like the scenario of a presentation, and can also be described by the expression $S = m_\varepsilon F_1\ (m_1F_{21}+m_\varepsilon F_{22})\ m_\varepsilon F_3\ m_\varepsilon F_4\ (m_1F_{51}+m_\varepsilon F_{52})$.

2.3.2 Define the Properties of Objects

We denote a media object as O = (N, T, D, UM, OAL, PT), and describe the attributes of an object below:
O_i.N *(Name)*: is the identifier of the object.
O_i.T *(type)*: What multimedia device is used to carry out this resource (e.g. sound, video, text or picture).
O_i.D *(Duration)*: records the display time of the object.
O_i.UM *(Usage model)*: the situation about the usage of objects, such as the object is a background or a referent.
O_i.OAL *(object association link)*: describes the relationships between objects, and is specified like **O_i.FAL**={O_1(*association Keyword description*), O_2 (*association Keyword description*) ,..}, we use association keywords to describe the related relationships between O_i and O_1, the same as O_i and O_2.
O_i.PT *(Player Type)*: describes the way to play the object.

2.3.3 Define the Properties of Frames

A frame F_i is denoted as F_i =(N, O, FAL, L, P, UM), and the meanings of its attributes are listed below:
F_i.N*(Name)*: assign a unique name to a frame F_i.
F_i.O*(resource objects)*: the set of all the resource objects participated in the frame F_i, $O = \{O_i \mid O_i \in O\}$.O is the set of all objects stored in database.
F_i.FAL*(frame association link)*: $F_i.FAL = \{(C_i, F_k) \mid C_i \in \{\Diamond, \odot\}, F_k \in F\}$.The relationships between F_i and F_j are divided into inclusive and exclusive relationships; we denote them by $\odot$ and $\Diamond$ respectively. The $F_i \odot F_j$ represents the two frames are inclusive, that is, whenever the F_i is displayed, the F_j must be displayed also. The $F_i \Diamond F_j$ represents the two frames are exclusive, that is, whenever the F_i has been displayed, the F_j can't be displayed. F is the set of all frames.
F_i.L *(Layout)*: the spatial arrangement of the objects of F_i for the presentation. For example, the (X_{j1}, Y_{j1}) and (X_{j2}, Y_{j2}) are the position on the screen arranged for O_j, $F_i.L = \{O_1\ (X_{11},Y_{11})(X_{12},Y_{12}),\ O_2\ (X_{21},Y_{21})(X_{22},Y_{22}), \ldots\}$.
F_i.P *(Presentation)*: the duration of playback of all objects in the F_i. We use the 13 temporal relations proposed by Allen and use $\varepsilon(n)$ to represent units of time. OP is the set of all operators used to describe the temporal relations between objects. P is a set composed of O_i OP O_j, $P=\{(O_i, op, O_j) \mid O_i, O_j \in O, op \in OP\}$, $OP = \{:, \|, \|, \|, \|, \|, \varepsilon(n)\}$, $F_i.P=\{\cup P_i \mid P_i \in P\}$. For example, $F_i.P=\{(O_1 \| O_2),(O_1 \| O_3),(O_3 : O_4),..\}$.
F_i.UM*(Usage model)*: describes usage of frames, e.g. the frame is designed for teaching or for taking exams. For example, expression F_i.UM = exam means that the frame is an exam frame.

3Three-layer CAI architecture

3.1 Partition the CAI system into Components

The flow of instruction is from teaching course, taking examinations, speculating the advanced contents of instruction according to the result of examination, to achieve the goal of instruction. Generally, the teachers, educators or scholars take part in editing the CAI systems and the computer engineers are responsive for implementing the CAI systems, so they often spent lots of time on mutual communication. We analyze the CAI systems and partition the CAI systems into various components that are designed by various persons respectively, and these persons work together to achieve the whole function of the CAI systems. To partition the components clearly, we use the UML to describe the flow of CAI systems shown in the Fig.3, and we can know the following things:

- Step1 to step4 is for identifying the users.
- Step5 to step8 is for displaying the teaching of courses or questions of exams.
- Step9 to step11 is for analyzing after the exams are finished.
- Step12 to step14 is for designing the advanced courses after the fitting analysis is finished.
- Step15 is for exiting the CAI system.

In Fig.3, we can classify the partitioned components of CAI systems into four kinds listed below.

- The verification component for logging the usage of systems and maintaining the security of system. —is managed by system administrators or computer engineers.
- The course and exam component for instructing students in learning and taking exams. —is managed by teachers, educators or scholars.
- The fitting analysis component for the learning process of students. —is made by educators and scholars.
- The database component for storing the media objects and instruction materials. —is implemented by art designers or computer workers, and is managed by computer engineers.

3.2 Three-layer CAI architecture

From the CAI system described with UML shown in Fig.3, we can know that the course and exam component is the most important one and the other components are discussed in other area. In our system, we propose the Multi-layer CAI architecture to construct the CAI systems, and use the management of components to distribute the resources over the servers on Internet to achieve the goal of resource sharing.

We present a 3-layer CAI architecture model that expresses different points of view and is fully flexible and component oriented [2,3]. Based on the efficiency of systems, the model is partitioned into 3 layers--resource layer, presentation layer and evaluation layer. It raises the productivity of system development and improvement process, also promotes the individual skills and development of distributed computing environment.

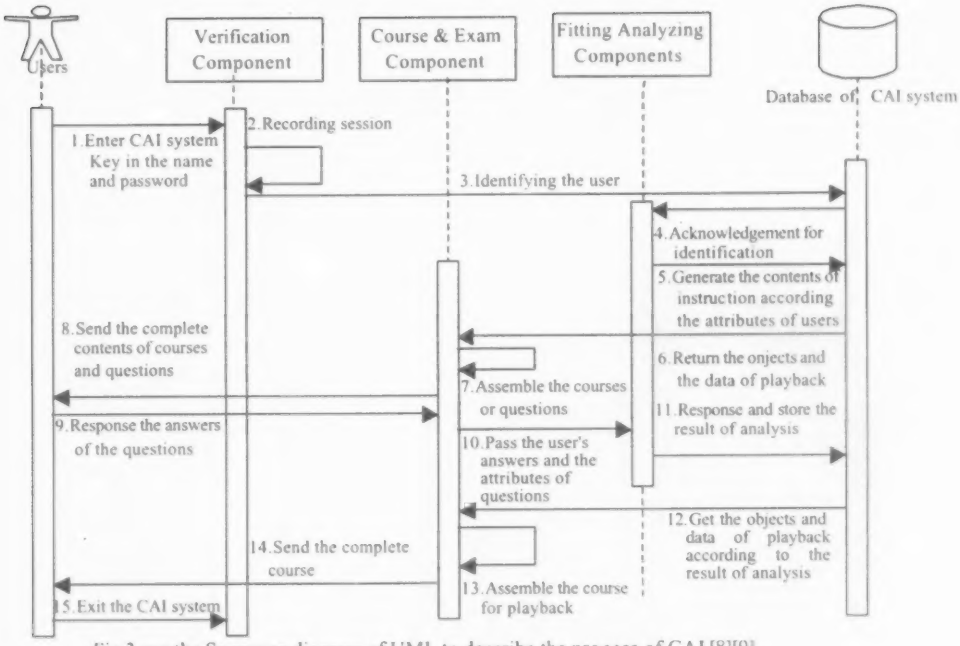


Fig.3 use the Sequence diagram of UML to describe the process of CAI [8][9]

3.3 Relationship between Three-layer CAI architecture and hypermedia

From the Table 1 and the frame and resource objects defined in our multimedia presentation system, we can analyze that to what layer the settings of various objects belong listed in Table 2[2][4]. In the components of scenario, we define the miFi that describes which frame should be displayed after the message is triggered, i.e. we can use the expressions to define the schedule of playback of the frames about designing exams and teaching. The components of plot or story just describe the flow of teaching courses defined by users.

From Table 3, we can design and implement the system on Internet more easily to let teachers or other education experts design their teaching materials or questions of exams conveniently and systematically.

4 Conclusion

Different researchers can benefit from this architecture by studying their own knowledge domain independently. Shortening the time spent on completely developing the whole system is to promote the successful rate of resolving the kernel problems. Researchers can't benefit from studying their own domain only; it's necessary for them to know our open architecture that can easily expand one system into various domains.

Users can acquire an easy-used and reusable system from defining components of multimedia and instructive units of CAI. Our architecture lets teachers have the suitable flexibility and lets various experts and scholars participate in the installation of CAI system. The educational authorities can take our architecture as a referenced architecture for developing the multimedia education. Our system is shown in Fig. 4. The prototype of our system has been completely implemented and published in some various conferences or journals. [1] [5] [9] [10]

Table 1. Three-layer CAI architecture [2][4]

Layer	Researcher	Participants
Resource	Researcher of Interface	Designer of animation , graphic, sound
Presentation	Researcher of learning theory	Teacher, Instructor
Evaluation	Researcher of evaluation	Manager, researcher of educational policy

Table 2. Explanation of part of components [2][4]

First layer (Evaluation layer)	
Components of fitting analysis	This component is made according to some theorem. After analyzing the data acquired from the process that the students take exams and learn, there are some various frames generated.
Components of evaluation and analysis	This component is made according to learning evaluation and learning retrieval of theorist or researchers.
Second layer (Presentation layer)	
Components of scenario	This component is made according to the researchers of learning theory or teaching materials.
Components of structure	This component is made according to learning environment.
Third layer (Resource layer)	
Components of exam	This part must include the parameter or properties which is used broadly
Components of background	Background is concerned to the interest and attention of learner.
Components of referents	To help users of different levels from different method and presentation
Components of multimedia	The components make the CAI lively which may be somebody of cartoon

Table 3. Explanations of part of components

Explanation of part of components		Set the values of necessary item needed
First layer (Evaluation layer)	Components of fitting analysis	
	Components of evaluation and analysis	• F_i.O • F_i.Layout and F_i.UM= exam • F.Presentation and F_i.UM= exam
Second layer (Presentation layer)	Components of scenario	• S
	Components of structure	• F_i.Layout and F_i.UM=learn • F.Presentation and F_i.UM=learn
Third layer (Resource layer)	Components of exam	• O_i.UM = exam
	Components of background	• O_i.UM =Background.
	Components of referents	• O_i.UM = Referents

References

[1] Bal Wang , Ching-Fan Chen, Min-Huei Lin. " A Multimedia Presentation System on Web -- Dynamic Homepage Approach"., The Institute of Electronics, Information and Communication Engineers(IEICE) Transactions on Information and System, Vol.E82-D,NO.4,April 1999. pp. 729-736

[2] Min-Huei Lin, Ching-Fan Chen, Ian-Ru Li, " Building Component Oriented Multi-tier CAI Architecture in the Internet ", ICCE' 98 (The Sixth International Conference on Computers in Education) , Beijing,china,1998,pp.180~pp.186.

[3] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Wei-Yu Li , Ya-Ting Chuang. "A Three-Tier Multimedia Presentation System in Internet", ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 162-166.

[4] Bal Wang , Ching-Fan Chen, Min-Huei Lin , Ian-Ru Li. "Building multimedia component oriented Multi-tier CAI architecture in the Internet".ISMIP 98(International Symposium on Multimedia Information Processing),Taiwan, pp. 158-161.

[5] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE' 99(International Conference on Computers in Education).

[6] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bai Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design—A Scheme to Promote the Effect of Web CAI" . ICCE'99(International Conference on Computers in Education).

[7] Chung, C.-M.; Shih, T.K.; Kuo, C.-H.; Lin, W.-C. . "Supporting the reuse of multimedia presentations" , Information Sciences, Vol: 101, pp. 131-151.

[8] Min-Huei Lin, Zheng-Kui Huang, Bai Wang, , Ching-Fan Chen• ∨Using Object Oriented Method in Network CAI Model" • The 8th International Conference on Computer-Assisted Instruction.

[9] Min-Huei Lin, Zheng-Kui Huang, Bai Wang , Ching-Fan Chen.• ∨Management of the Object–Oriented Resources Application System – an Instance of Distance Education" • Distance Education. Vol. 12 , June 1999. pp.53-61.

[10] Bai Wang, , Ching-Fan Chen , Min-Huei Lin , Chien-Ming Pan , Jen-Shan Huang , Hsing-Ten Chein• ∨An Authoring Tool on Web" • •The 8th International Conference on Computer-Assisted Instruction.

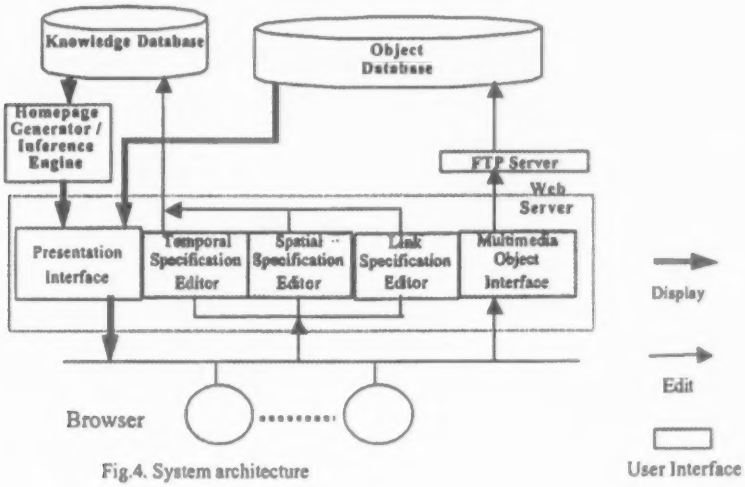


Fig.4. System architecture

CAI System Generator on Web -- using Automatic Trace Recording

Min-Huei Lin, Ching-Fan Chen, Si-Hao Hu, Ming-Hong Taai and Yung-Hsiang Chiu

Department of Information Management
Aletheia University
Tamsui, Taiwan
R.O.C
Email: lmh@email.au.edu.tw, cfchen@email.au.edu.tw

By the prosperity of computer media, many companies treat electric media as their developmental base and use these electric media in more effective way. It goes without saying that the domain of teaching has developed on the Internet and many CAI systems have been already used in the teaching. The goal of our research is to create CAI systems by automatically recording the trace of editing. So in the thesis, we define the actions of users through image, audio, schedule, point and the module of event, and present the generated CAI systems dynamically on web.

Keywords: **CAI System Generator, Multimedia, Web**

1 The goal

Currently, many teachers and students use CAI systems as their teaching tools, and most teaching materials are designed by both teachers and system engineers. But teachers are generally in the passive position, and if they want to make teaching materials according to their own ideals, they have to learn how to use HTML to design homepages. Usually, students may not understand the meanings of teaching materials very well through the static homepages written in HTML. So we propose and implement an auto-recorded multimedia presentation system to let authors construct dynamic homepages of CAI systems directly through browser on web from automatically recording the trace of their editing.

2 Structure of system

We show the structure of our system in Fig. 1. In the auto-recorded system, we can catch the screen of process of users' operations, or insert sound or image information to the process. Then, these multimedia resources and related information are stored in Information Database and Media Database. The information of presentation schedule is recorded in information database. In the media database, contents of multimedia objects are recorded. In Fig.2, we can see the interactions among Image, Sound, Timer, pointer and Event. Image Module is to make necessary pick-ups for required images, decide what images are picked up in the Event Module Database and store their transition and filename in the forms. Sound Module is used to record sound, thereafter the sounds can be played at proper time by temporal scheduling. Pointer Module is to record the location of mouse pointer. When the transition has something wrong, we can make an adjustment in the coordination. In Timer Module, the time sequences are recorded in the form of Timer Pointer. The schedule designed through directly recording or specified by users is stored in the event database, and the generated multimedia objects will be presented according to the schedule built on the Timer Pointer. Event Module will react to all the other modules. It can decide what modules are going to work, and react to them. When users need to present teaching materials, the Java & HTML Generator will generate and send java code and HTML code to users' browser, then users can see the dynamic homepages. In Fig. 3, we can see a dynamically presented Web CAI system that is produced by recording and modified through the authors' edition and arrangement.

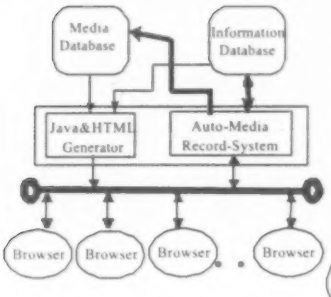


Fig.1 Structure of System

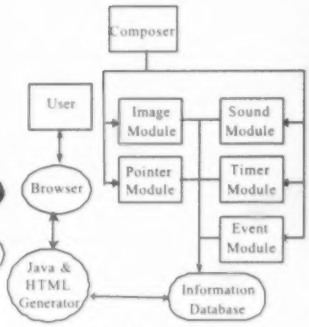


Fig.2 Modules of System

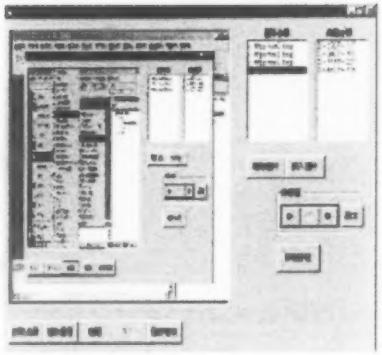


Fig.3 The interface of Auto-Recorded System.

3 Conclusion

We still continuously work on the pack technique of the multimedia file because the transmittance of image and audio are limited by the bandwidth of the Internet. However, teaching through Internet is an inevitable trend in the future, so how to make the best efforts between editing the teaching materials and let the learners learn as efficiently as possible are our goals.

References

[1] Min-Huei Lin, Bal Wang, Ching-Fan Chen, Chien-Ming Pen , Zheng-Kui Huang , Ian-Ru Li. "An Authoring Tool for Teaching Materials on Web- Dynamic Homepage Approach using SMIL". ICCE' 99.

[2] Min-Huei Lin, Chien-Jen Huang, Shang-Zong You, Bal Wang, Ching-Fan Chen ."Using Adjustable Multimedia Homepage Design–A Scheme to Promote the Effect of Web CAI" . ICCE' 99.

[3] James F. Allen "Maintaining Knowledge about Temporal Intervals", Communications of the ACM, Vol. 26, No. 11, 1983.

[4] http://windowsmedia.com

BEST COPY AVAILABLE

CALL with a Web-based Instructional System in Cooperative Learning Environments

Miwha Lee
Pusan National University of Education
Pusan, Korea
E-mail: mlee@ns.pusan-e.ac.kr

This study developed a Web-based instructional system for computer-assisted language learning (CALL) and examined the effects of ability of the student and group composition on achievement in reading, writing, and listening comprehension in Web-based foreign language learning in a cooperative environment. Forty-four students were randomly assigned to heterogeneous and homogeneous groups. The results of the analysis showed that group composition as well as student ability significantly exerted differential effects on the learning outcomes. The implications of these results for CALL in a Web-based cooperative environment were discussed

Keywords: **Cooperative Learning, Computer-Assisted Language Learning, Web-based Learning**

1 Introduction

1.1 Background of the Study

In recent years, the Internet has been increasingly utilized as an effective instructional tool for language learning, since the Web can become a multimedia-based content provider for both verbal and non-verbal elements of communication with versatility and interconnectedness (Clinch, 1999; Harasim et al., 1996; Khan, 1997; McManus, 1995; Owston, 1997; Ritchie & Hoffman, 1996). Recent studies have shown that the computer as an instructional medium also has the potential for promoting interaction and collaboration among students (e.g., Cates & Goodling, 1997; Cavalier & Klein, 1998; Chen, 1995; Johnson & Johnson, 1996). Computer-assisted language learning (CALL) using a Web-based instructional system can, hence, provide a learning environment that facilitates positive interdependence and collaborative efforts among students. The students work together in small groups at the computer; their efforts are directed toward mutual, academically and socially beneficial, goals. In general, extensive research on cooperative learning has shown profound and positive effects on a wide range of students' cognitive and social-affective outcomes (e.g., Johnson & Johnson, 1999; Johnson et al., 1993; Sharan, 1990; 1994; Slavin, 1995; 1996).

One of the key features that characterize cooperative learning settings and distinguish them from other learning settings is the increased opportunity for interaction among students of diverse ability, beliefs, and value systems in the learning process. Researchers have explored interaction as one of the mediating variables in the relationship between cooperative learning and social and academic gains (Hettinger, 1995; Huang, 1995; Sharan, 1990; Webb, 1989). Hence, in a cooperative learning environment, students are typically grouped heterogeneously. The rationale for heterogeneous grouping is based on the assumption that students can encounter wider diversity in heterogeneous groups than in homogeneous groups. Of particular interest in this study are the ability of the student and group composition. Although research indicates that both high- and low-ability students gain social benefits by working in heterogeneous groups, the cognitive effects of ability grouping, heterogeneous or homogeneous, have been inconclusive (e.g., Cavalier & Klein, 1998; Huang, 1995; Mevarech et al., 1991; Webb, 1989; Webb & Lewis, 1988).

1.2 The Purpose of the Study

The purpose of this study was to examine the effects of student ability and the influence of heterogeneous and homogeneous group composition on achievement in reading, writing, and listening comprehension in computer-assisted foreign language learning with a Web-based instructional system in a cooperative learning environment. The achievement in reading, writing, and listening comprehension of high- and low-ability students were compared in heterogeneous and homogeneous groups featuring individual and group accountability.

2 Method

2.1 Subjects

The subjects were 44 undergraduate students enrolled in a required one-semester foreign language course at a university in a metropolitan city in Korea. All the subjects had some previous experience with computers (e.g., word processing, Internet, telecommunications, games, and/or programming). All students had taken English as a first foreign language and French, German, Chinese, or Japanese as a second foreign language in middle and high schools

2.2 A Web-based Instructional System

For the purpose of this study, a Web-based instructional system was designed and developed for French language learning. This instructional system appears to be one of the first Web-based instructional systems for computer-assisted French language learning in Korea. The instructional system was designed to be adaptive to individual learning situations on a non real-time basis. Students can navigate the hyperlinked multimedia contents without a pre-ordered learning schedule. Through their exploration and navigation, thus, they can design their own instruction. The contents of the instructional system are divided into two levels: beginning and advanced. Each level consists of 15 coherent but independent lessons. As shown in Figure 1, each lesson is composed of six sections: reading, writing, listening, speaking, grammar, and games.

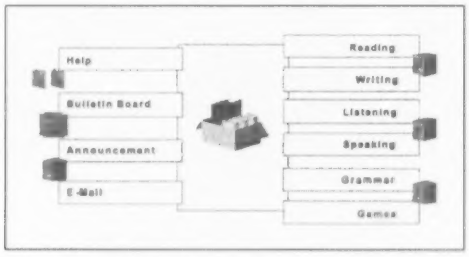


Figure1. Web-based instructional system for CALL

The reading section shows paragraphs in a variety of styles and includes interpretations and in-depth explanations regarding morphological, lexical, syntactical and semantic-pragmatic rules and expressions used in each sentence. The writing section enables students to gain pragmatic competence in their writing skills. It provides questions related to context-based composition. The listening section presents simple expressions with immediate text feedback to improve students' listening comprehension. The speaking section is designed with an emphasis on conversational practice, based on given situations presented as a picture. Concerning the grammatical rules of the previously presented sentences, the grammar section provides charts, pictures, and examples as well as explanations about those points. The game section is an additional unit designed to motivate students through games, songs, or puzzles, which may not deal with the lesson directly.

The instructional system also includes the interactive facilities: help, bulletin board, announcements, and e-mail. The help component includes general instructions regarding the system. The bulletin board deals with management-related interactions such as a school calender and logistics. The announcements show FAQ's (Frequently Asked Questions) on subject materials or technical problems. The e-mail allows for individual communications. These interaction facilities were designed to provide various types of asynchronous communications among three different user groups: teachers or tutors, students, and system administrators.

In designing and developing the user interface of the instructional system, a special emphasis was placed on user-friendliness and efficiency. A simple, intuitive design with a text -based menu, rather than a complicated design, was preferred. In addition, the instructional system utilizes well-designed TrueType fonts, which support Unicodes such as 'Lucida Sans Unicode,' 'Berdana,' and 'Times New Roman.' The basic color of the instructional system was carefully selected based on color-effectiveness studies (Moore, 1996; Pett & Wilson, 1996; Weinman & Heavin, 1996). Given current access speed to the Internet via modems or LANs (Local Area Networks) in schools, a minimum level of animation was used in order not to interfere with students' concentration level in the learning process (Jeong & Yoon, 1998). For consistent and systematic delivery of information, any subsequent hyperlinked information is presented on the same page. To this end, the interface was developed using Active Server Page (Hillier & Mezick, 1998) and Dynamic-HTML (HyperText Markup Language) (Homer, 1997).

2.3 Procedure

Before the study began, students were asked to complete a background survey, which was given in order to assess students' previous experience with computers and language learning and to provide a better description of the subjects. A pretest was administered to all students to identify those with high or low ability. Stratified random sampling was used to assign students to heterogeneous and homogeneous ability groups. Heterogeneous ability groups contained one high-ability student and one low-ability student. Homogeneous ability groups contained two high-ability students or two low-ability students. Students were unaware of the ability composition of the group. Students then received an overview of the Web-based instructional system and instruction for cooperative work. They were instructed to work cooperatively as a group on the task, to help each other learn, and to make group decisions on the course of their actions in the learning process. Students were not assigned specific roles within a group, nor were they allowed to divide the work. Students worked for 50 minutes each day, 2 days each week, for 15 weeks, a total of 30 instructional sessions for one semester.

2.4 Research Design and Data Analysis

The study employed a 2 x 2 factorial design. The between-subjects factors included Ability (high, low) and Group Composition (heterogeneous, homogeneous). The within-subjects factors included Achievement Scores of Reading, Writing, and Listening Comprehension. The analysis of variance (ANOVA) was performed to determine the interaction effects as well as the main effects of ability and group composition on achievement in reading, writing, and listening comprehension. The analysis of covariance (ANCOVA) was also conducted, with students' previous experience with computers and the pretest results serving as the covariates. The level of significance was set at .05 in this study.

3 Results

The means and standard deviations for achievement in reading, writing, and listening comprehension are presented in Table 1. The results of the analysis of variance for achievement scores by ability and group composition are shown in Table 2.[1]

[1] It should be noted that students' previous experience with computers and the pretest results did not significantly correlate with the achievement scores. The results of ANCOVA rarely differed. Hence, for the purpose of clarity, the results of ANOVA are presented in this section.

Table1. Means and Standard Deviations of the Achievement Scores by Ability and Group Composition

		Reading	Writing	Listening	Total
Ability					
High	M	8.39	8.22	5.43	22.04
	SD	1.23	2.13	2.43	4.76
Low	M	7.38	7.00	4.43	18.81
	SD	1.94	2.55	2.06	5.54
Group Composition					
Heterogeneous	M	8.64	8.27	5.18	22.09
	SD	1.33	2.19	2.42	5.26
Homogeneous	M	7.18	7.00	4.73	18.91
	SD	1.68	2.47	2.19	5.04
Total	M	7.91	7.64	4.95	20.50
	SD	1.67	2.39	2.29	5.34

3.1 Reading

Significant main effects were found for Ability, $F(1, 40) = 7.208$, $p < .05$, and for Group Composition, $F(1, 40) = 14.029$, $p < .05$, and significant interaction effects were also found for Ability and Group Composition, $F(1, 40) = 7.268$, $p < .05$. These results indicate that student ability and group composition exerted differential effects on achievement in the reading posttest, as shown in Tables 1 and 2. High- and low-ability students tended to achieve differentially across the groups of different composition on the reading posttest. The students in heterogeneous groups scored higher than did those in homogeneous groups. This pattern is more noticeable among low-ability students than high-ability students.

3.2 Writing

As shown in Table 2, there were significant main effects for Group Composition, $F(1, 40) = 4.401$, $p < .05$, and significant interaction effects for Ability and Group Composition, $F(1, 40) = 3.759$, $p < .05$. Yet, main effects for Ability were not statistically significant. Both high-ability and low-ability students working in heterogeneous groups tended to score higher on the writing posttest than did those working in homogeneous groups. These results indicate that the achievement of high-ability and low-ability students was dependent on the group composition in which they were working.

3.3 Listening Comprehension

No significant effects were found for Ability or Group Composition or for the interaction between Ability and Group Composition. The results indicate that the differences between the posttest means were not statistically significant, probably due to the relatively large standard deviations, as shown in Table 1.

Table 2. ANOVA Results for the Achievement Scores by Ability and Group Composition

	Source of Variation	Sum of Squares	DF	Mean Squares	F	*P*
Reading	Ability	12.750	1	12.750	7.208	.011
	Group Composition	24.817	1	24.817	14.029	.001
	Interactions	12.856	1	12.856	7.268	.010
Writing	Ability	17.892	1	17.892	3.719	.056
	Group Composition	19.442	1	19.442	4.401	.046
	Interactions	18.041	1	18.041	3.759	.050
Listening	Ability	11.600	1	11.600	2.316	.136
	Group Composition	2.759	1	2.759	0.551	.462
	Interactions	11.697	1	11.697	2.335	.134
Total	Ability	125.586	1	125.586	5.818	.021
	Group Composition	122.144	1	22.144	5.659	.022
	Interactions	126.632	1	26.632	5.867	.020

4 Conclusion

This study examined the effects of student ability and group composition on achievement in reading, writing, and listening comprehension in computer-assisted foreign language learning with a Web-based instructional system in a cooperative learning environment. The results of the analysis of variance indicate that group composition as well as student ability significantly exerted differential effects on the learning outcomes. Both high-ability and low-ability students working in heterogeneous groups showed higher achievement than did those working in homogeneous groups. These results corroborate and lend further support to the findings of the previous studies, that heterogeneous group composition benefits students of both high ability and low ability (Larson et al., 1984, Webb, 1982a; 1982b; Yager, 1986). The cooperative learning methods, in non-computer settings, often call for students to be grouped heterogeneously by ability (e.g., Sharan, 1994; Slavin, 1995). The findings of this study suggest that ability grouping can also be utilized as an effective and practical method in Web-based instructional settings

Suggestions for future research should be noted. First, a comparative study of group learning with individualized learning in Web-based instructional settings may be worth further investigation. Second, this study employed pairs; the findings may not apply to larger groups. Some research suggests the importance of group size as well as group composition in computer-based cooperative learning (Guntermann & Tovar, 1987). Finally, this study has focused on the product of group learning. Future research should also analyze the intra-group dynamics among students in the learning process.

References

[1] Cates, W. M. & Goodling, S. C. (1997). The relative effectiveness of learning options in multimedia computer-based fifth-grade spelling instruction. *Educational Technology Research and Development*, 45(2), 27-46.

[2] Cavalier, J. C. & Klein, J. D. (1998). Effects of cooperative versus individual learning and orienting activities during computer-based instruction. *Educational Technology Research and Development*, 46(1), 5-18.

[3] Chen, M. (1995). A methodology for characterizing comp uter-based learning environment. *Instructional Science*, 23, 183-220.

[4] Clinch, B. J. (1999). Web-assisted language learning. *Proceedings of Ed-Media 99*, Seattle, WA. 1334-1335.

[5] Guntermann, E. & Tovar, M. (1987). Collaborative problem solving with Logo: Effects of group size and group composition. *Journal of Educational Computing Research*, 3, 313-334.

[6] Harasim, L., Hiltz, S., Teles, L., & Turoff, M. (1996). *Learning networks*. Cambridge, MA: MIT Press.

[7] Hettinger, G. (1995). Raising the level of the debate: The effects of computer-mediated communication on group dynamics and critical thinking skills. *Proceedings of AECT*, 186-193.

[8] Hillier, S. & Mezick, D. (1998). *Inside programming Active Server Pages*. Redmond, WA: Microsoft Press.

[9] Homer, A. (1997). *Instant IE4 dynamic HTML: Programmer's reference*. Birmingham: Wrox Press.

[10] Huang, J. C. (1995). Effects of types of feedback on achievement and attitude during computer-based cooperative condition. *Proceedings of AECT*, 219-226.

[11] Jeong, H. & Yoon, A. (1998). Interface design of electronic -dictionary developing system: Considering end-user's knowledge. *Proceedings of '98 HCI*, 18-20.

[12] Johnson, D. W. & Johnson, R. T. (1996). Cooperation and the use of technology. In Jonassen, D. H. (Ed.). *Handbook of research for educational communications and technology*. New York: Simon & Schuster Macmillan.

[13] Johnson, D. W. & Johnson, R. T. (1999). *Learning together and alone: Cooperation, competition, and individualistic learning*. (5th Ed.). Needham Heights, MA: Allyn & Bacon.

[14] Johnson, D. W., Johnson, R. T., Holubec, E. J., & Roy, P. (1993). *Circles of learning: Cooperation in the classroom*. (4th Ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

[15] Khan, B. H. (Ed.). (1997). *Web-based instruction*. Englewood Cliffs. NJ: Educational Technology Publications.

[16] Larson, C. O., Dansereau, D. F., O Donnell, A., Hythecker, V., Lambiotte, F. G., & Rocklin, T. R. (1984). Verbal ability and cooperative learning: Transfer of effect. *Journal of Reading Behavior*, 16, 289-295.

[17] McManus, T. (1995). Special considerations for designing Internet-based education. In. D. Willis, B. Robin & J. Willis (Eds.). *Technology and Teacher Education Annual*. Charlottesville, VA: Association for Advancement of Computing in Education.

[18] Mevarech, Z. R., Silber, O., & Fine, D. (1991). Learning with computers in small groups: Cognitive and affective outcomes. *Journal of Educational Computing Research*, 7(2), 233-243.

[19] Moore, F. C. (1996). The do's & don'ts of web site design. [On-line]. http://www.webspertise.com/.

[20] Owston, R. D. (1997). The World Wide Web: A technology to enhance teaching and learning. *Educational Researcher, 26(2)*, 27-33.

[21] Pett, D. & Wilson, T. (1996). Color research and its application to the design of instructional materials. *Educational Technology Research and Development*, 44(3), 19-35.

[22] Ritchie, D.C. & Hoffman, B. (1996). Using instructional design principle to amplify learning on the World Wide Web. [On-line]. http://www.edweb.sdsu.edu/.

[23] Sharan, S. (1990). *Cooperative learning*. New York: Praeger.

[24] Sharan, S. (Ed.). (1994). *Handbook of cooperative learning methods*. New York: Greenwood Publishing.

[25] Slavin, R. E. (1995). *Cooperative learning: Theory, Research, and Practice*. (2nd Ed.). Englewood Cliffs, NJ: Prentice- Hall.

[26] Slavin, R. E. (1996). Research on cooperative learning and achievement: What we know, what we need to know. *Contemporary Educational Psychology*, 21, 43-69.

[27] Webb, N. M. (1982a). Peer interaction and learning in small cooperative groups. *Journal of Educational Psychology*, 74, 642-655.

[28] Webb, N. M. (1982b). Group composition, group interaction, and achievement in cooperative small groups. *Journal of Educational Psychology*, 74, 475-484.

[29] Webb, N. M. (1989). Peer interaction and learning in small groups. *International Journal of Educational Research*, 13(1), 21-39.

[30] Webb, N. M. & Lewis, S. (1988). The social context of learning computer programming. In R. E. Mayer (Ed.), *Teaching and learning computer programming*. Hillsdale, NJ: Lawrence Erlbaum.

[31] Weinman, L. & Heavin, B. (1996). *Coloring Web Graphics*. New York: New Riders.

[32] Yager, S., Johnson, D. W., Johnson, R. T., & Snider, B. (1986). The impact of group processing on achievement in cooperative learning groups. *Journal of Social Psychology*, 126, 389-397.

CBR-TUTOR: A Case-Based Reasoning Approach to an Internet Agent-based Tutoring System

Rhodora L. Reyes and Raymund Sison
ccsrlr@ccs.dlsu.edu.ph, ccsrcs@ccs.dlsu.edu.ph
College of Computer Studies, De La Salle University. Professional Schools Inc.
Manila, Philippines

Providing individualized instruction is an important tutoring task. Different learners have different needs. This task becomes more important when dealing with learners on the web. This paper presents the CBR-TUTOR, an Internet-based tutoring agent system that uses case-based reasoning approach in providing adaptive instruction to its learners. Using CBR in the tutor model enables the tutor to reference from past experiences and identify which instructional strategies were successful given a similar situation or student characteristics. The CBR-TUTOR is designed as a distributed problem solving architecture where each agent performs decision-making tasks and cooperates to help improve the effectivity of the tutoring system.

Keywords: **Intelligent Tutoring Systems, Case-Based Reasoning, Web-based learning, Agents**

1 Introduction

"The Internet now provides a possible new dimension to information technology in education, not only in terms of potential as a vast information resource, but also in respect of interaction and knowledge construction between individuals" (Wood, 1999). Unfortunately, most of the learning systems and electronic textbooks accessible on the web lack the capabilities of individualized instruction and user-adapted learning support that are emergent features of Web-based Intelligent Tutoring Systems [10].In providing individualized instruction, it is important to diagnose the problems of individual learners and identify how to adapt instruction and remediation to the needs of the individual learner. The diagnosis of the learner often involves analysis of learner errors. This is the task of the student model component of an Intelligent Tutoring System (ITS). A student model is an approximate representation of a student' s knowledge about a particular domain, which accounts for the students' solutions to given problems [9]. The tutor model component of an ITS, on the other hand, uses the student model to determine how to provide instruction and remediation [6].

The tutor model must be able to recognize the similarity and differences in the needs of these learners. Different learners have different needs. The task becomes more important when dealing with students on the web. Therefore, Internet-based tutoring systems must be able to reference to past experience in order for it to know which approach will be appropriate given a situation (or case). However, no past situation is ever exactly the same as a new one and domain knowledge for instructional strategies is oftentimes incomplete. This makes the tutor model incapable of using the instructional method appropriate to the learner. It is therefore necessary to create a tutor model that has the capability to understand new situations in terms of old experiences and adapt an old solution to fit a new situation. Cased-Based Reasoning (CBR) suggests a model of reasoning that incorporates problem solving, understanding, and learning; and integrates all with memory processes. CBR can mean adapting old solutions to meet new demands, using old cases to critique new solutions or reasoning from precedents to interpret a new situation or create an equitable solution to a new problem. [5]. CBR cycle has four phases: *retrieving* the most similar case or cases, *reusing* the information and knowledge in the case to solve the problem, *revising* the proposed solution and *retaining* the parts of the experience that is likely to be useful for future problem solving [2].

Using CBR in the tutor model enables the tutor to reference from past experiences and identify which instructional strategies where successful given a similar situation or student characteristics. Existing

Case-based Intelligent Tutoring Systems use cases for teaching the learners the domain, that is, they use cases as pedagogy similar to the way exercises are used as strategy for teaching. Examples of such systems are Case-based Intelligent Tutoring Systems for operators of dynamic systems (CB-ITS) [3], Georgia Tech Case-Based Intelligent Tutoring Systems for Pilots (GT-CBITS) and Case-Based Reasoning Approach to Simulation-Based Intelligent Tutoring Systems for Tactical Action Officers (TAO ITS) [7]. However, none of these systems use CBR as an approach in helping the tutor identify similar experiences encountered when providing individualized instruction to the learners.

CBR-TUTOR is an Internet agent-based tutoring system that uses the CBR approach in providing adaptive instruction to its learners. It is designed as a distributed problem solving architecture where each agent performs decision-making tasks and *cooperates* to help improve the effectivity of the tutoring system. Cooperative agents are agents that are assigned to do specialized tasks to solve a common goal. Section 2 of this paper discusses the architecture of CBR-TUTOR followed by the discussions of its components in Section 3. Finally, the conclusion and future works will be presented.

2 CBR-Tutor Architecture

CBR-TUTOR is an Internet-based tutoring agent system that uses case-based reasoning (CBR) approach to determine how to provide individualized instruction to its learners. This section discusses the architecture of the CBR-TUTOR in terms of its components and their relationships.

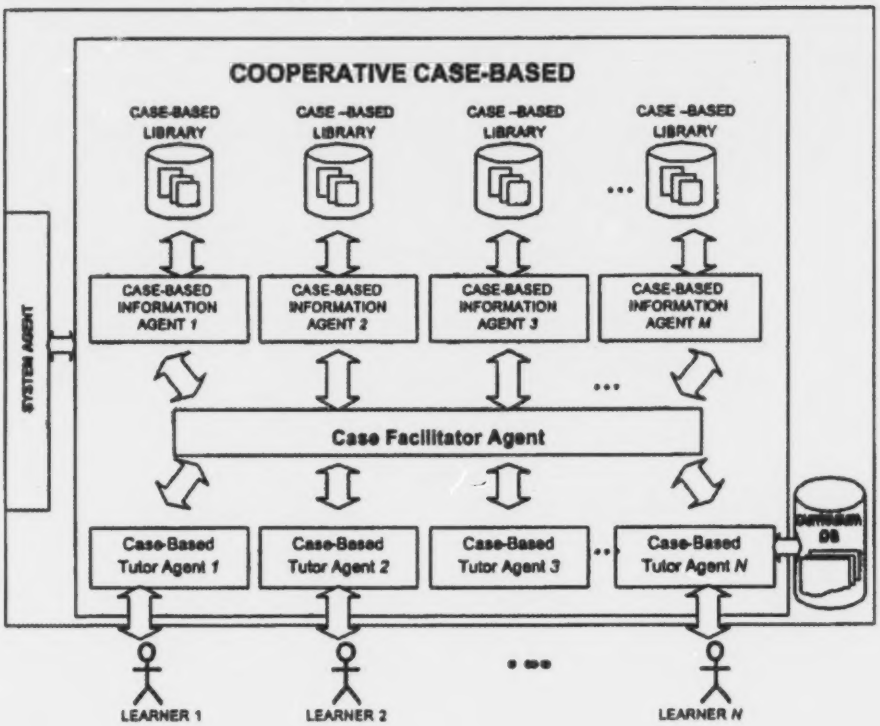
CBR-TUTOR is a distributed problem solving (DPS) system comprised of the system agent (SA), cooperative case-based module (CCBM) and the curriculum database (CDB). Figure 1 shows the architecture of CBR-TUTOR.

The SA serves as the registry module that contains the complete list of all agents initiated in the system. Whenever there is an unregistered learner (i.e., first time user of the system), the SA initializes the agent (or agents) that will be used for tutoring the learner and informs the CCBM about it. Whenever necessary, the SA also decides if there is a need to process the requests of creation of new agents in the system by CCBM.

The cooperative case-based module (CCBM) is the core component of the CBR-TUTOR. It is composed of cooperating agents designed for actual tutoring of the learners, retrieval, filtering, indexing and learning of cases, and facilitation of requests from different agents in the system. Its sub-components are case-based tutor agents (CTAs), case facilitator agent (CFA), case-based information agents (CIAs), and case-based libraries (CBLs). The CTAs are the actual tutors assigned to the learners while CIAs are agents whose tasks are to retrieve, filter, index and modify (or learn) cases in its CBL. A CBL contains the set of cases used in the system. Discussion of the CCBM components is discussed in detail at section 3.2.

Depending on the planned teaching activities, a CTA accesses the curriculum database (CDB) for content presentations. These presentations include the lessons, examples, elaboration, exercises, answers, definitions and descriptions.

Figure 1. The CBR-TUTOR Architecture



3 CBR-Tutor Components

The primary components of the CBR-TUTOR are its specially designed agents. These are COOPERATIVE CASE-BASED MODULE (CCBM) and SYSTEM AGENT (SA). This section discusses the detailed discussion of these components.

3.1 Cooperative Case-Based Module

The COOPERATIVE CASE-BASED MODULE (CCBM) is the heart of the CBR-TUTOR. It is composed of specialized agents that have specific decision-making task that cooperates to help provide individualized and adaptive instruction using the case-based reasoning approach. The major components of CCBM are CASE-BASED TUTOR AGENTS, CASE FACILITATOR AGENT, CASE-BASED INFORMATION AGENTS and CASE-BASED LIBRARIES, as illustrated in Figure 1.

3.1.1. Case-Based Tutor Agent

The CASE-BASED TUTOR AGENT (CTA) interacts directly with the learner. It creates a profile of its learner (i.e., learner type, lessons taken, performance, strategies applied, output from *external student modeling system*, etc.) and this information for evaluating the current scenario. (i.e., case). The CTA uses the case-based reasoning approach in planning for the teaching strategy to use, with the help of the other agents in CCBM.

The CTA has four components: INTERFACE, CASE-BASED MODULE, INSTRUCTIONAL PLANNER, and STUDENT KNOWLEDGE BASE, as shown in Figure 2.

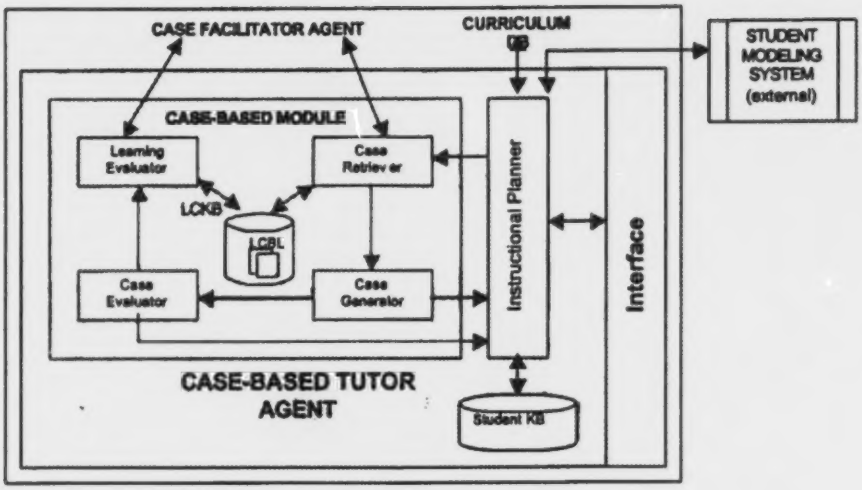


Figure 2. Components of a Case-Based Tutor Agent (CTA)

All communications between the CTA and the learner is done through the *interface*. The *interface* is designed as a *web-based interface* for simplicity and universal access. The system can be used through standard browsers.

The INSTRUCTIONAL PLANNER (IP) is the component of the CTA that assesses the current case (i.e., current teaching scenario), and communicates with the interface and the CASE-BASED MODULE (CBM). Based on the current case, the IP forwards its requests to the CBM for generation of helpful case (or cases). The proposed solution (i.e., result of the request) from the CBM is implemented by the IP. Implementation of the proposed solution requires the generation of content presentation. The IP does this by accessing the CURRICULUM DATABASE (CDB), which contains the lessons, exercises, examples, description, elaboration, answers and definitions.

The IP is also responsible for updating the STUDENT KNOWLEDGE BASE (SKB). The SKB contains information about the user including the name, password, identification number, and student type (i.e., low, medium, high). It also contains the result of the diagnoses of the *external* student modeling system, lessons taken, and performance evaluation of the leaner.

The component of the CTA that uses the Case-Based Reasoning (CBR) approach is the CBM. The CBM's tasks are to retrieve useful case (or set of cases), propose a solution (i.e., teaching plan), test and evaluate the proposed solution, and if needed, learn a new case. The CBM keeps local copies of cases that are frequently used during the tutoring sessions and stores it in the LOCAL CASE-BASED LIBRARY (LCBL). CBM also has a CASE RETRIEVER module, which retrieves cases from the LCBL and/or requests for cases through the CASE FACILITATOR AGENT (CFA). The retrieval approach used by the CASE RETRIEVER is the same as the retrieval approach used by the CIA (discussed in section 3.2.3.). The CASE RETRIEVER, depending on its *certainty factor*, decides whether to request for case retrieval through the CFA or use only the retrieved cases from the LCKB. The *certainty factor* is a measure used to evaluate the appropriateness or availability of cases in the LCBL. If the CTA does not have enough cases to solve the current case, it makes a request to the CFA for retrieval of *good* cases. *Good cases* are those that have potential to make relevant prediction about the new case [4]. This means that cases retrieved either helps the CTA achieve a goal or warns about the possibility of a failure or point out an unforeseen problem [5].

The cases retrieved (or requested) by the CASE RETRIEVER is given to the CASE GENERATOR, which in turn checks which of the retrieved case matches exactly the retrieved case. In the event of finding an exact match, the CASE GENERATOR proposes a solution based on the retrieved case and forwards it to the IP for *reuse*. However, it is seldom that previous case matches the current case exactly. It is therefore necessary for the CASE GENERATOR to revise the retrieved case and propose a new solution. The *proposed new solution* is tested and, if needed, repaired by the CASE EVALUATOR until a *confirmed solution* has been achieved. The

confirmed solution is then forwarded to the IP for implementation. The CASE EVALUATOR also forwards the *confirmed solution* to the LEARNING EVALUATOR for possible learning of the new case. If there is a need to learn a new case, the LEARNING EVALUATOR updates the LCBL and informs the CASE RETRIEVER about the changes in the LCBL. The approach for learning a new case (i.e., case library update) used by the learning evaluator is the same as the approach used by the CIA (discussed in section 3.2.3.). The LEARNING EVALUATOR also informs the CFA that a new case has been learned.

3.1.2 CASE FACILITATOR AGENT

The case facilitator agent (CFA) serves as mediator between the case-based tutoring agents (CTAs) and the case-based information agents (CIAs). This means that the CFA performs matchmaking of services thatcan be provided by CIAs and requests made by CTAs. The CFA tracks all requests for retrieval of cases and monitors the updating (i.e., learning) of new cases. It receives requests from CTAs, sends these requests to the candidate CIA (or CIAs) and returns responses to the requesting CTAs. The CFA has two major components: service request module, and agent information manager (see Figure 3).

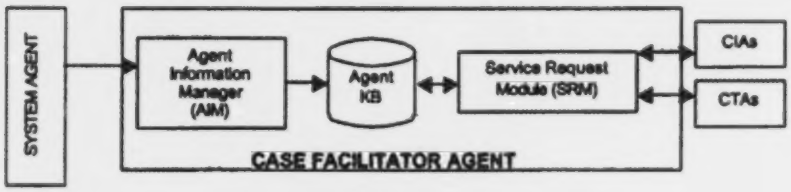


Figure 3. Components of the Case Facilitator Agent

The SERVICE REQUEST MODULE (SRM) supervises all requests from the CTAs. There are two types of requests: retrieval of cases and updating (learning) of new cases. Using the *knowledge* about the capabilities of the CIAs, the SRM performs matchmaking and assesses which CIAs are suitable to process the request. This knowledge includes the *indexing vocabulary*, *specialization* and *taxonomy of indexes* of each CIA. An *indexing vocabulary* is a set of relevant descriptors used to describe and index cases while *specialization* refers to the specific indexes being monitored by the CIA. The *taxonomy of indexes* contains information about the organizational structure of the indexes.

The SRM maps the capabilities of each CIAs to the requests and forwards the requests to the candidate CIAs. The SRM collects the result from all CIAs that responded to the request, checks and eliminates redundant cases before forwarding the result to the requesting CTA.

The AGENT INFORMATION MANAGER (AIM) monitors all the agents registered by the SYSTEM AGENT (SA) in the system. It has the knowledge of the *indexing vocabulary* and *specialization* of each CIA and the CTAs that have been registered. It also supervises the mapping and updating of the taxonomy of indexes. The knowledge about each agent and the taxonomy of indexes are used by the SRM to determine relationships, similarities and differences of the indexes of each CIA. This helps SRM in matchmaking the CTAs request and CIAs capability to process the request.

3.1.3 Case-Based Information Agent

The CASE-BASED INFORMATION AGENT (CIA) performs the tasks of retrieving cases, evaluating and filtering the retrieved cases in the CCBM. Each CIA has an associated CASE-BASED LIBRARY (CBL) for which they are responsible to maintain. Each CIA focuses on particular collection of features (i.e., dimensions) of the case. A *feature* is an attribute-value pair used in the description of the case [5]. This facilitates faster indexing, restructuring, searching and learning of cases. No two CIAs are exactly the same and despite similarities in their structure, they may return different results. A CBL of a CIA may contain cases that are similar to other CBLs (i.e., overlaps) or it may be totally different from the other CBLs .A CIA can also request the SYSTEM AGENT (SA) for *load reallocation* (i.e., creation of a new CIAs), if it is overloaded.

Retrieving Cases

Each CIA uses the combination of searching and matching when retrieving cases. The quality of the search algorithm is closely related to the quality of the organizational structure of the cases. The organizational structure of each CBL is designed, as a *flat library of cases* where cases are stored as simple lists (or array/files). All CIAs who were requested to retrieve cases use the *parallel retrieval approach*. In this approach, each candidate CIA will search for cases and forwards the result to the CFA (if there is any). The CFA will then be responsible for collecting and checking of results for redundancy.

Each CIA uses a SERIAL- SEARCH- PARTIAL- MATCH (SSPM) algorithm (outline shown in Table 1). Since each CIA *specializes* on specific *dimensions* (or set of features), it only searches a relatively small number of cases and searching is not expensive. A *dimension* collectively refers to all descriptive attributes of a case. In the SERIAL SEARCH algorithm, the entire CASE-BASED LIBRARY (CBL) maintained by the CIA is searched. This means that the accuracy of retrieval is a function only of how good the *matching functions* are. The matching function used by a CIA is the PARTIAL- MATCHING FUNCTION. In this approach, cases are indexed using observable features and derived features that capture partial similarities. A *combination of heuristic and numerical evaluation function* is used to compute for the matching and ranking of cases. The *heuristic function* filters cases that had mismatches in important features before comparing cases for their degree of similarity. To measure the degree of match of each pair, the Cognitive System' s (1992), evaluation function is adapted (see Equation 1).

$$\frac{\sum_{i=1}^{n} w_i (sim \ (f_i^{\,l}, f_i^{\,r})}{\sum_{i=1}^{n} w_i}$$

Where w_i is the weight of the importance of dimension (slot) *i*, *sim* is the similarity function for f_i^l and f_i^r primitives and are the values for the feature f_i in the input and retrieved cases, respectively.
The degree of match is represented as numerical values between 0 to 1. Closer matches have value closer to 1. Similarly, the similarity function with a value closer to 1 means that the features have high degree of similarity.

Equation 1: Evaluation Function

Table 1. Outline of SERIAL SEARCH- PARTIAL MATCHING ALGORITHM (SSPM)

1. For every case in memory, partially match input case:
   - Identify observable features and derived features
   - Compute for the degree of match by using the combination of heuristic and numerical evaluation function. The heuristics identifies the important criteria and then the numeric evaluation function is used for matching and ranking.
2. Return all the best case(s).

Learning Cases

Each candidate CIA decides whether the new case should be learned, and which information from the case to retain, in what form to retain it and how to index the case for later retrieval from similar problems. Learning is a natural consequence of using CBR. It learns by accumulating new cases and indexing the cases properly. A CIA learns basically by applying adaptation (or accumulating generalizations) to the cases and re-indexing of cases that are already in its CASE-BASED LIBRARY (CBL). Re-indexing is done when the case is recalled and it can not be used or it is used but results in failure. When a CIA learns a new case, it informs the CFA of the changes in its *indexing vocabulary* if there is any.

Indexing Cases

The indexing of a case indicates when a case should be retrieved. Cases are indexed based on the goal, solutions method and combinations of descriptors responsible for choice of particular solution. This type of indexing helps the CIA generate a case whenever there is a need to solutions to the current problem (e.g., what will be the strategy given the current case). Cases are indexed by CIAs by adapting the Universal Index Frame [8], which is a generally applicable descriptive vocabulary. UIF covers a broad range of domains about the interactions between agents and its goal.

Load Reallocation

Each CIA also has the capability to request the SA for a creation of a new CIA. When a CIA sees that it is already monitoring a large amount of indexes, using a *load factor*, the CIA can request the SA to divide the load by initializing a new CIA (or set of CIAs). A load is divided according to logical divisions and dimensions of the cases. A *load factor* is a measure of how many indexes a CIA can monitor without affecting the balance of the load of each CIA. The SA will then notify the CFA of the newly created CIA including the knowledge about it, and the changes in the knowledge about the requesting CIA.

3.1.4 Case-Based Library

The *CASE-BASED LIBRARY* (CBL) contains the set of stored cases. Cases represents specific knowledge tied to specific situations, it makes explicit how a task is carried out or how a piece of knowledge was applied or what particular strategies were used for tutoring the learners effectively. The CBL is designed as *flat library of cases* where cases are stored in a simple list. Since each CIA specialized on specific dimension of the case, the CBL is designed to be simple for faster accessing of cases.

Each case in the *CRC* has three major parts: *situation description, solution* and *result*. The *situation description* describes the goal (or set of goals), constraints on the goals, and other features of the problem situation. The *solution* part of the case contains the steps used to derive the solution (i.e., tutoring plan of action) and the justifications for decisions that were made. Alternative solutions and/or unacceptable solutions are also included in the *solution* part, if any. Finally, the *result* part of the case contains information about the success or failure of the solution, the explanation for failure or success, the repair strategy and the result of applying the repair.

3.2 System Agent

The SYSTEM AGENT (SA) contains the complete list of all agents initiated in the system. It verifies agent identities and provides their location in the network and transport addresses to the CASE FACILITATOR AGENT (CFA). It also stores additional information about the status of the agent and its type.

The SA communicates directly to the COOPERATIVE CASE-BASED MODULE (CCBM) and performs the following functions:

- Determines if the learner is an unregistered learner, initializes and assigns a CASE-BASED TUTOR AGENT (CTA) for the unregistered learner
- Processes requests from CASE-BASED TUTOR AGENTS(CIAs) for creation of a new CIA
- Monitors the complete list of agents (CTAs and CIAs) in the system and informs the CFA of the status (e.g., newly initialized) and information of these agents.

Aside from these functions, the SA is also responsible for all low-level interfaces. These includes access to the operating system or networking services, enforces access rights and privilege security, backs-up and archives pertinent information, and performs exception handling [1].

4 CONCLUSION

This paper presented the architecture of the CBR-TUTOR, an Internet agent-based tutoring system that uses the case-based reasoning approach in tutoring its learners. The architecture is designed such that it can be implemented for different domains (i.e., programming, problem solving, and others) and can be accessed through the Internet. The architecture differs from other internet-based tutoring systems because it utilizes the advantages of using previously experience cases to enhance the tutoring capability of the system. In addition, the CBR-TUTOR architecture is composed of specialized agents that performs the tutoring of learners, facilitation of requests, and filtering, retrieving and learning of new cases. All of these agents cooperate to achieve the goal of providing individualized and adaptive instruction to the learners. The use of agents in the design of this system is increases the effectivity of the tutor to provide adaptive instruction to its learners. Each of the tutoring agent focuses on the individual needs of its learners. Since the system is Internet-based, the use of agents can accommodate more users compared to non-agent-based systems. The other components of the system were also designed as agents because each of these components is autonomous and requires decision-making capability. Future work will focus on the implementation of

CBR-TUTOR in the domain of programming. Further research regarding the learning of cases where the system has the capability to do situation assessment where the reasoner elaborates a situation description to make the description fit the other case library descriptions will also be done.

References

[1] Abadia, L. (1999). A MultiAgent-Based Information Trading Floor Model for an Organizational Intranet.Graduate Thesis. Master of Science in Computer Science, College of Computer Studies, De La Salle University, Manila.

[2] Aamodt, A., Plaza, E. (1994). Case-Based Reasoning: Foundational Issues, Methodological Variations, and System Approaches. AI Communications. IOS Press, Vol. 7:1, pp. 39-59

[3] Chappell, A. and Mitchell, C. (1997). The Case-Based Intelligent Tutoring System: An Architecture for Developing and Maintaining Operators Expertise. Proceedings of the 1997 IEEE International Conference on System, Man, and Cybernetics. Orlando, Florida. http://www.chmsr.gatech.edu/publications/smc97/arc/abstract.html. (January 2000).

[4] Dingsoyr, T. (1998) Integration of Data Mining and Case-Based Reasoning. http:/www.idi.ntmu.no/ ~dingsoyr/ diploma/report.html. February 29, 2000.

[5] Kolodner, J. (1993). Case-Based Reasoning. Morgan Kaufmann Publishers, Inc.

[6] Reyes, R. (1999). Adaptive Web-Based Intelligent Tutoring System for C Programming. Proceeding of the 1999 International Conference in Computers in Education. Chiba, Japan.

[7] Row, R. (1995). A Case-based Reasoning Approach to Simulation-Based Intelligent Tutoring Systems and ITS Authoring. http:// www.navysbir.brtc.com/ SuccessStories/StottlerP3.html. (January 2000)

[8] Schank, R., and Osgood, R. 1990. A content theory of memory indexing. Northwester University, Institute for the Learning Sciences Technical Report no. 2.

[9] Sison, R . (2000). Multistrategy Discovery and Detection of Novice Programmer Errors. Machine Learning, 38, 157-180. Kluwer Academic Publishers, Netherlands.

[10] Weber, G. and Specht, M. (1997). User Modeling and Adaptive Navigation Support in WWW-based Tutoring Systems. ELM-ART II. http://www.psychologie.unitrier.de:8000/projects/ ELM/Papers/UM97-WEBER.html. (January 2000)

[11] Wood, T. Psychological Access and the Internet (199). Advanced Research in Computers and Communications in Education. G. Cummings et al. (eds.). IOS Press. Pp.973-980.

CedarLearning: The Development of Learner-Centred Environments

Tanya Wilson, Jeanette Muzio, Roger Mundell,
Denise Stockley, and Laureen Vickery
CEDAR, Royal Roads University, 2005 Sooke Road,
Victoria, British Columbia, V9B 5Y2, Canada
tanyawilson@royalroads.ca; jeanette.muzio@royalroads.ca;
roger.mundell@royalroads.ca; denise.stockley@royalroads.ca;
laureen.vickery@royalroads.ca

Royal Roads University (RRU) is a four year old University situated on a 640 acre historic site featuring beautiful grounds and a nineteenth century castle. The mission of the University is to deliver world-class applied and professional programs to Canadian and international adult learners. RRU's degree programs are designed for the mid-career professional and its graduate programs combine periods of on-campus instruction and semesters of distance education. This delivery model (a) aligns with the needs of mid-career professionals, and (b) is dictated by the size of the physical buildings at RRU; currently only 250 learners can be accommodated on-campus at any one time. At RRU's Centre for Economic Development and Applied Research (CEDAR) we have developed tools that allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that creates the truly learner-centred environment. These tools are used in several of the MBA courses, such as finance and e-commerce.

Keywords: **Knowledge Construction and Navigation, Lifelong Learning, Web-Based Learning**

1 Introduction

Royal Roads University (RRU) in British Columbia, Canada is a five year old University situated on a 540 acre historic site featuring beautiful grounds and a nineteenth century castle. For 40 years the facility was used as a campus for Military officers, and became a public University when the Department of National Defense closed the facility and leased the space to the Province of British Columbia.

Although beautiful and steeped in history, The physical facilities limit the on-campus population to only 325 students at any one time. This forced the University to explore alternate delivery methodologies from the very beginning, and has resulted in an innovative and highly effective model that targets mid-career learners.

The University focuses primarily on Masters level programs which are offered at a distance to learners who are still in the workforce and continuing at their jobs. These students come together for a series of brief residencies and complete the remainder of their degree through Web-based distributed learning.

With busy mid-career learners, several issues had to be addressed. In addition to accommodating the usual issues of time and place, the University wanted to adopt a Learner-centred approach that would adjust for such variables as prior learning level; Learning Styles and use of granular knowledge objects. At the same time, designers were cognizant of the significant body of research evidence that points to learning communities and collaborative discourse as critically important components of any online courseware.

The resulting courseware seemed to effectively combine the best of the highly learner-centred techniques used in private sector training with the collaborative techniques that have proven effective in most successful post-secondary online courses.

Using commonly available web development tools the team at Royal Roads University created courses that are database-driven, and use dynamic templates to easily populate and modify course content. They devised a number of online assessment and feedback tools, as well as innovative "jig-saw puzzle" style group assignments to stimulate collaboration. They developed a navigation system to allow learners a choice of delivery styles to suit personal learning style preferences, and a self-assessment mechanism to help learners move through online material on a need-to-know basis.

Additionally, the system provides easy management tools for the instructors to control and modify content, as well as monitor the students' progress, without needing any knowledge of web page creation or HTML.

The development team at Royal Roads University is part of the Centre for Economic Development & Applied Research, (CEDAR). They are continuing to explore and evolve the understanding of what works and what doesn't in online learning. At RRU, the team is fortunate to have a "live" laboratory of more than 900 active online students, and a University-wide commitment to Web-based delivery.

In this presentation, we will demonstrate actual delivered courses, present our findings, and demonstrate our course design. We will show how the use of templates and database driven content allows course designers to adjust for variables of learning style, prior knowledge, and level of effort, in addition to time and place.

CEDAR's methodology is applicable to all forms of electronic distributed learning (EDL) regardless of the delivery mechanism – distance education or classroom delivery, over the Internet or via CD-ROM, instructor-led or instructor-free. Learner-centred EDL courses can be easily designed using commercially available software tools. These tools allow simultaneously for both knowledge-building, collaborative learning and for individual, self-paced learning in the same course. This flexibility provides the opportunity for just in time and just enough information that is demanded by busy professionals seeking a learner-centered environment. These learners have a lifetime of experiences and want a course that is tailored to their needs and takes advantage of their prior knowledge.

Our methodology allows learners to navigate through the content according to learning style. Pre-testing on learning outcomes allows for prior learning assessment, adaptive self-assessment quizzes provide feedback, and technical assistance is built into the course. On-line communities are created through group jigsaw assignments and forum discussions. This allows learners from diverse backgrounds to participate in an on-line environment that is geared to their individual needs.

Some of our unique features include:

1. Learner-centred approach allows learners to navigate throuth the material based on their preferred learning style. This is in contrast to most EDL courses which follow a sequential text-book like approach,
2. Learners can pre-test for prior knowldege. This saves them time as they study only those parts of a course that they do not already know,
3. Self-assessment quizzes allow learners to monitor their progress throughout the course and review as needed,
4. The outcomes-based design of the database allows for the use of shareable courseware objects for different learning needs in different courses.

2 Design and Development of the E-Commerce Course

The development process began with the course designer showing the instructor previously completed courses. By seeing exemplars the instructor was presented with different teaching options that the technology facilitates and allowed the instructor imaginative application of the construction process. (integrating real world/live data, interactive diagrams, and animated examples).

The design and development of the e-commerce course was a three-way communication between the content expert, an instructional designer (who is a specialist in learning styles) and the technical designer. The instructor was actively involved in the course development and provided the learning outcomes for the course. The instructional designers established the appropriate navigation for the different Learning Styles and those navigation methodologies were then tagged into the database templates.

The Web based Discussion Forums were setup and the instructor was given early access. The course

underwent a period of testing before the students were given access and any noticeable glitches were corrected at that time.

3 Student Engagement

Instructional materials are delivered to distance-learners via the Internet or to classroom-based learners via CD-ROM. The primary thrust behind the methodology was to produce courseware that is truly learner-centred rather than content-driven or instructor-centred. The course material is navigated in a variety of database-driven, learner-selected methods, depending upon individual preferences. Students also have access to a 24-hour online support available for any technical problems that they may experience. PDF files or screen prints are available for offline browsing of the course content.

Each course module has a number of self-assessment questions, which allows the learner to measure themselves against the desired learning outcomes for that granule. A learner may choose to try this assessment before working through any of the material, or afterwards for self-formative evaluation of the module content. At the end of the assessment, the learner is informed which areas of the module require study. Learners returning later to the self-assessment questions are asked questions only on those areas incorrectly answered the first time.

The web application allows the learner to optionally take a learning style test that provides information about their preferred learning style. After completing the test, the individual is provided with information about their preferred style and each unit can be approached according to that style. Users can switch freely between styles at any point.

To enhance critical thinking and process skills, and the development of community, the courses have included:
(a) residency,
(b) group jigsaw assignment,
(c) case-based reasoning,
(d) electronic forums, newsgroups and live chat
(e) peer to peer and self evaluation
(f) real-world, just in time articles for on-line discussion,
(g) instructor acting as a guide on the side and not as a sage on the stage.
(h) Integration of real-world projects.

These opportunities provide for (a) immediate transferability to the workplace, and (b) building a knowledge network that extends long beyond the end of the degree program.

4 Lessons Learned

The results of the project were gathered from learners through formative feedback, summative evaluation, and focus group discussions.

In general, it was found that learners reacted positively to
(a) the different navigation styles for the four learning styles,
(b) the look and feel of the user interface
(c) the on-line technical helps,
(d) the internal consistency of links,
(e) the ability to pre-test prior knowledge,
(f) the on-line immediate feedback given in the self-assessment quizzes
(g) collaborating with their peers at a distance, and jigsaw style assignments.
(h) the flexibility of doing the course at a convenient time and place.

Some learners relied heavily on offline reading of the printed material, particularly those with poor connectivity or minimal familiarity with computers.

Some complained that the course required them to do too much on the computer, and they would have

preferred more offline work.

Very technically literate students suggested more use of multimedia in the content. In the finance course, several exercises required the student to use a separate spreadsheet, and it was felt that this functionality should have been incorporated into the online exercise. This can be easily done with the technology that was used.

Some saw the self-assessments as more threatening, (they carried no marks) while most saw them as a tool.

Some suggested allowing the student to mark up the content online, such as with the use of electronic "sticky notes". This suggestion will be implemented in the next course.

Three main lessons that we have learned from this project are:

1. It is possible to produce EDL courseware that is learner-centred and not content-driven or instructor-driven. This results in more satisfied learners who feel that their time, prior knowledge, and learning preferences have been considered,
2. Using off-the-shelf tools save on production time and costs and ensure that tried-and-tested software is utilized,
3. Courses that are database-driven provide opportunities for re-using data elements in different courses.

Computer-Mediated Language learning

Shu Ching Yang
Graduate Institute of Education, National Sun Yat-sen University
shyang@mail.nsysu.edu.tw

1 Introduction

The Web provides a new learning environment with a wealth of pedagogic possibilities. The colorful and visually engaging appearance, rich resources, online audio, video, and other interactive features, combine to make the Web an enormously valuable learning tool. Although it has been argued that web technology has the potential to provide a unique environment for teaching and learning, the psychological implications of its effects on learners' language learning has remained relatively unexplored. The current research does not present much empirical evidence to validate the instructional applications of web technology [1-6]. Furthermore, results of a meta-analytical study, Ayersman found that perceptions and attitudes toward technology are functionally important in promoting effective learning [7]. Therefore, more research needs to be conducted into learners' perceptions toward this new technology so specific guidelines for its successful implementation can be provided.

This study looked at learners' attitudes and perceptions as they conducted technology-augmented projects, and asked what were their affective attitudes and cognitive perceptions toward this tool. The study contributes to an understanding of language learning using the Web, and provides a basis for empirical studies of Taiwanese EFL learners performing real educational tasks with the Web. The insights gained in this small study will help EFL teachers design better learning environments with regard to classroom management, assessment and assignment.

2 Methodology

Participants

The 55 participants in this study were second year students, majoring in Applied English at a junior college. They had taken a 2-credit required course in Tourism English for two semesters.

Web-based Language Project

The goal of this project was to apply the language that the students had learned in an authentic context, to communicate, and to nurture students' global perspectives and information literacy. The project aimed to help students understand the Web with the ultimate goal of using it to create research projects about selected states in the U.S. Specifically, the objectives for the project were to: (1) provide students with background information about American culture, its separate states, cities, food, customs, people, history, travel information, etc. (2) provide students with an information-literate experience in web technology; (3) enhance students' discourse synthesis ability, namely, learning how to search, organize, and compose information for a research project. Students were asked to work on conducting a search of an assigned American state on the Web. Students could create their projects in whatever format they would like.

Instruments

A questionnaire was given to elicit relevant information on the participants' perception of, and attitudes towards, using the Web to complete their Web-based English projects. The first part of the survey pertained to background information. The second part consisted of 40 attitude and perception statements about learning experiences indicating levels of agreement or disagreement on a 5-point Likert-type scale with 5 standing for strong agreement. The Cronbach coefficient alpha of the survey was .87, suggesting the internal reliability to be quite acceptable. The third part included open-ended questions depicting their reflections about the project.

Data Collection and Analysis

After data collection, the quantitative and qualitative methods were performed. The qualitative analysis made from the student responses to the open-ended questions and the researcher' s observation, provided the opportunity to uncover deeper issues than might have been apparent in a quantitative study. Results from the factor analysis (principal axis factoring with varimax rotation) yielded six factors accounting for 64.11 percent of the variance. Following are the interpretations of each factor: cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web.

3 Discussion and Conclusion

The study investigated second-year junior college students' attitudes and perceptions towards the web as an educational resource. Six main factors concerning the learners' perceptions were identified, including cognitive disorientation, learning anxiety, perceived enhancement of language ability, perceived enhancement of cultural understanding, as well as the Web as a potentially useful search tool, and the overall perception of language learning on the Web. The study showed that the reaction of students to technology-augmented assignments was mixed. Analysis of the survey revealed a generally positive attitude towards the project pertaining to the enhacement of cultural awarenss and overall language learning. A few negative responses were noted, as learners experienced varying degrees of disorientation and cognitive overload. In particular, those learners who do not adjust well to reading on the Web appear to have much learning anxiety and cognitive disorientation, and correspondingly, have a lower overall perception of language learning.

Some frustration with the challenges and difficulties in relation to computers and language were found. On the one hand, students' encountered technical difficulties in relation to the use of computers. The problems they encountered were; malfunctioning of the system, the periodic slowness of Internet connections, poor design of web documents, searching complications, time constraints and the inconvenience of being required to work on the project on campus. On the other hand, students commented on the challenges of reading, selecting, processing and evaluating information. For example, some learners had not developed effective searching strategies for locating appropriate information and, further made qualitative judgments as to the accuracy and reliability of specific information. Given the fact that interest is the impetus of learning, and method is the key to knowledge, teachers should inform learners of effective learning strategies and design diversified learning enviroments by providing intellectual, entertaining and interesting assignmets to enhance learners enjoyment. From this study, it could be concluded that computer-learning networks have the potential to empower students in well-designed learning environments. It is emphasized that the central computer-mediated learning experience in Language Studies can not be achieved by itself simply by the introduction of the learner to the web technology. Those learners who show reluctance towards technologically oriented projects need careful guidance and support from the pedagogical and technological applications of this self-directed curriculum. Therefore, providing scaffolding, both in using Internet applications and in orienting the learners to the task, is vital to the successful implementation and integration of technology into the curriculum.

It is undeniable that, being situated at the turn of 21 century as we are, developing the learner' s information literacy of the digital world is important. Learning to navigate and sift through huge amounts of information with speed and accuracy, as well as pursuing a critical level of understanding that goes well beyond literal or surface-level meaning, will prepare students for the challenges they will face as society delves deeper into the Information Age. The study calls for the learners' instrumental use of web technology to achieve language-specific goals. The project challenges learners to become both language and information literate in growing the following skills: awareness of global issues and concerns, the cross-cultural comparison, development of computer skills, enhancement of critical thinking and problem-solving skills, as well as specific communication skills such as arguing, persuading, or defending a particular point.

As the study shows, researching language instruction within a digital learning environment opens up a broader range of connections and meaning-making among learners. The present study is only a stepping stone on the way to examining learners' perceptions and attitudes toward the Web-based language project. Although this activity was conducted in a foreign language class, it could be adapted as an activity in a variety of disciplines to maximize the language dimension, such as social studies, global education, science, and cultural comparison [8]. The researcher believes that the possibilities for research in these powerful network environments will be conducive to broadening and refining language literacy.

References

[1] Bicknall, J., " Promoting writing and computer literacy skills through student-authored web Pages", TESOL Journal, Vol 8, No. 1, pp. 20-26, (1999).

[2] Green, A., "A beginner's guide to the internet in the foreign language classroom with a focus on the World Wide Web", Foreign Language Annals, Vol 30, No. 2, pp. 253-264, (1997).

[3] Garza, T., "The message is the medium: Using video materials to facilitate foreign language performance", Texas Papers in Foreign Language Education, Vol 2, No.2, pp.1-18, (1996)

[4] Lee, L., "Using internet tools as an enhancement of c2 teaching and learning", Foreign Language Annals, Vol 30, No. 3, pp. 410-27, (1997)

[5] Rankin, W., "Increasing the communicative competence of foreign language students through the FL chatroom", Foreign Language Annals, Vol 30, No. 4, pp. 542-546, (1997)

[6] Warschauer, M., "Computer-mediated collaborative learning", Modern Language Journal, Vol 81, No. 4, pp. 470-481, (1997)

[7] Ayersman, D., "Reviewing the research on hypermedia-based learning", Journal of Research on Computing in Education, Vol 28, No. 4, pp. 500-526, (1996)

[8] Moore, Z., " Technology and teaching culture in the L2 classroom: An introduction", Journal of Educational Computing Research, Vol 20, No., 1, pp. 1-9, (1999)

Construct in-service Training Web Site for School Teachers

Jia-Rong Jerome Wen* and Wen-Chin Chen**
**jerome@nknucc.nknu.edu.tw*
***timmy@icemail.nknu.edu.tw*

1 Introduction

Information technology grows rapidly recently. People use Internet to obtain many kinds of information. The Internet has become the most important path in cyber world. In the last five years, using the Internet to carry out distance learning, especially for teachers' in-service training, changes the style of education.

To actualize the policy which was to build an lifelong-learning education environment, Ministry of Education delegated National Kaohsiung Normal University (NKNU) to manage Asynchronous Distance Learning class for high school teachers in Oct, 1999.

2 Construct Asynchronous Distance Learning Web page

Generally speaking, teachers have to control the instructive materials, activities, learning process and evaluation. Every instruction system must include all of the three factors as following:

2.1 Instructive materials and activity designing

If we just put the materials onto web site, they look like electronic books on Internet. It is helpless for students. Therefore, when designing the contents of curriculum, we make it in "practicing" orientation. Activities make teacher and students interact with each other and avoid students to feel humdrum or like reading an electronic book.

2.2 Evaluation

When students finish learning a chapter, we give them an formative evaluation to verify whether students master the thesis or not. If students pass the formative evaluation, they can continue the curriculum. If not, they have to go back and learn it again until they pass the formative evaluation. The system would give some feedback to students, they would know which part of contents they don't understand yet. Then, we always hold an examination when finishing the curriculum, the summative evaluation. (Figure-1)

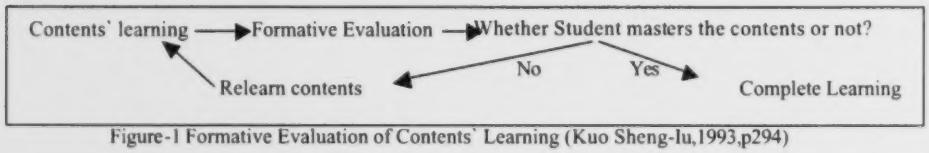


Figure-1 Formative Evaluation of Contents' Learning (Kuo Sheng-lu,1993,p294)

2.3 Learning process

Instead of quantification of examination, we should care about the reflection from students after instruction and learning. Grades cannot decide students' learning efficiency. During designing the materials, we considered every details of students' learning process. These include

- counts in connection
- counts in joining the forum
- contents what student discuss
- chatting situation between teacher and students

- Homework – students work hard or not
- Chapter evaluation (formative evaluation)
- teachers and students communicate by email

All items can be saved into database so that we can estimate student' s behavior in learning.

3 Concepts on designing curriculum

We design several activities and strategies. The activities will make students concentrate on the contents. we consider about the strategies as following:

3.1 Homework:

We assign homework after students finish learning every chapter. They can evaluate themselves through homework to know how much they learn and review contents again.

3.2 Operative Orientation:

In the homework, they have to work some operation by computer, such as computer game.

3.3 Self-determination:

Self-determination means that students have to study by themselves and plan study schedule by themselves.

3.4 Interactive :

We define interaction into two ways : one direction and two direction (Table-1).

	One direction	Two direction
Asynchronous	Announcement FAQ	On-Line Forum
Synchronous		Chat Room

One direction: teacher to student
Two direction: teacher and student

Table-1 Interactive model

3.5 User Interface• •

What users feel about it is very important in internet environment. Hyperlink always be mazes for a novice in the internet. Trying to solve user interface problem , we use several ways as following :

3.5.1 Frame• eut web pages into several frame to reduce confusing

3.5.2 Tree menu• from the reaction of students , the tree menu is easy to access the pages

3.5.3 Learning Path• guideline for students on the web

References

[1] Fred Jevons."Distance Education and Campus-Based Education : Parity of Esteem", New South Wales, Australia : Peter Smith and Mavis Kelly. (1987)

[2] Kuo Sheng-lu(1993). "The Evaluation of Psychology and Education", Chin-Hua , 7th Edition., (1993).

[3] Lisa Neal(1998). "Distance Learning". ACM(http://www.acm.org)(accessed on May 15,2000).

[4] Mei-Sheng Chao, "The Impact of a Systems Approach on Interactive Distance Teaching: The Development of the ATM Video Network System at National Chung-cheng University", ETR&D, Vol 47. No 2. pp. 112-117(1998).

[5] Sun Chuen-tzai, Chu Ching-hao, & Shiu Idi, "The research of constructing hypermedia teaching material", Information and Education• vol. 67• pp 13-25(1998).

[6] Wang Chien-Shin, " Web-based network system for instructive management", Information and Education, Vol. 67• pp 3-12(1998)

[7] Wen Jia-rong, "The research on present Statement and Requirements of junior-high-school Information Education", Information and Education, Vol. 51, pp17-26(1996)

[8] Wen Jia-rong, Wu Ming-lung , "Information Education Theories and Applications in New Age ", Song Kang ,1st Edition.(1999).

[9] Han Shan-ming, "Information Education Fundamental Construction – Speed", Information and Education, Vol. 68, pp14-16 (1998)

Constructing a Real-Time CAD Learning System Based on OpenGL in Web-Based Environment

Wen-Chai Song*, Shih-Ching Ou*,Song-Rong Shiau**
**Department of Electrical Engineering, National Central University, Taiwan*
***Department of Electrical Engineering, National Taipei University of Technology, Taiwan*
4F,NO.184-1,Kee-Kin 1st Road,An Lo District, 204, Keelung ,Taiwan
Tel:+886-2-24325455
Fax:+886-2-24324075
E-mail:songchen@ms10.hinet.net

The purpose of this paper is to apply network technology to make the design of Web-based learning graphics systems for user. Several issues will be addressed in this paper such as the development of an Integrated Interactive Graphics System (IIGS) for a better design environment. In this paper, we attempted to develop a web-based graphics learning system by Bézier, B-spline and NURBS algorithms. The purpose of the research was to increase the effect of Computer-Aided Design (CAD) in network .The other advantages is that network browser is the common platform in internet and intranet, the graphics system can be portable cross different operating system, as like windows 98,linux..etc. In fact, the graphics learning system have attempted to be shared the resource each other.

Keyword: **OpenGL, VRML, NURBS, CAD/CAM, CAI, Curves, Surfaces**

1 Introduction

As the Internet has improved in the last ten years, web-based graphics learning has become very important in Internet. In recent year, the distance learning by Internet has been established and developed in Computer-Assisted Instruction (CAI) system. In this paper, the user can design and learning sculpture curves and surfaces on a personal computer by the interactive way. The graphics system has friendly interface in operating process.

OpenGL is a software interface that allows the programmer to create 2D and 3D graphics images. OpenGL are both a standard API and the implementation of API. In other words, OpenGL is a set of functions which have the same syntax and which act the same way on every platform, even though different vendors have written the actual subroutines, which implemented the API standard.

Graphics programming concepts underlie the function of OpenGL. These concepts are easy for the average application programmer to understand and use. OpenGL is independent of the hardware, operating, and windowing systems in use. Using OpenGL to make a program is easier than using API to do. API is integrated into a windowing system, since learning how to program a windowing system is often quite complicated.

2 Curve Modeling

Curve methods are usually included in different courses such as geometric modeling, CAD/CAM, computer-aided geometric design (CAGD), computer graphics, etc. In teaching this material, it is essential that students have an access to computer graphics facilities. Practical experiences help them to understand the dry theory. There are many books concerning curve and surface modeling and each of them considers

this subject in a different way (with some modifications). Users are confused, especially beginners. The next weakness of method representations is in lack of comparative means. Learning can be more effective if different methods are studied simultaneously on the same data by changing control parameters.

This field is developing very quickly and therefore researchers need also an effective comparative tool for their new improved approaches or methods. For these reasons, a program package for modeling and analysis of parametric curve methods called CM ("Curves Modeling") has been constructed. It is written in OpenGL. Not only 2D but also 3D curves are considered. Three various methods are incorporated in CM in the first menu level. Including all menu levels, there are ten methods or their modifications. In the interpolation methods, a curve passes through all control points, in the approximation methods, however, a curve passes only near to control points.

Figure 1. The Curve modeling interface

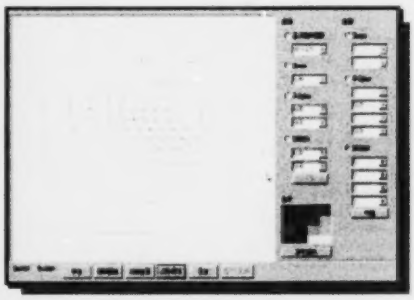


Figure 2. The Surface-modeling interface

A curve is compounded of small curves called curve segments and is determined by an equation in parametrical form (parameter u). In the knot vector for u (Uknot), there are parameter values for segment boundaries.

3 The Bézier, B-spline and NURBS Curves Algorithms.(extract)

NURBS curves:

A pth-degree NURBS curve is defined by

$$C(u) = \frac{\sum_{i=0}^{n} N_{i,p}(u) w_i P_i}{\sum_{i=0}^{n} N_{i,p}(u) w_i} \quad a \le u \le b \tag{12}$$

Where the {Pi} are the control points (forming a control polygon), the {Wi} are the weights, and the {Ni,p(u)}are the pth-degree B-spline basis functions defined on the non-periodic (and non-uniform) knot vector.

$$U = \left\{ \underbrace{a,\ldots,a}_{p+1}, u_{p+1},\ldots,u_{m-p-1}, \underbrace{b,\ldots,b}_{p+1} \right\} \tag{13}$$

4 Surfaces Modeling

In the computer graphics, a surface is usually generated by a surface representation method on a control net (linked control points in a 3D space). Methods for surface representation are divided in two major groups: approximation and interpolation methods. At the interpolation methods, a surface passes through all control points, at the approximation methods , however, a surface passes only near to control points. A surface is compounded of small surfaces, called patches, presented by two families of isoparametric curves.

A program package for modeling and analysis of parametric surface methods called SM ("Surfaces

Modeling") has been constructed .A surface is determined by an equation in parametrical form (parameters u and v). We speak about u and v directions (parametrical view) or about direction X and direction Y respectively (2D screen view). In the knot vectors for u and v (Uknot, Vknot), there are parameter values u and v for patch boundaries.

5 The Bézier, B-spline and NURBS Surfaces Algorithms.(extract)

NURBS surfaces:

A NURBS surface of degree p in the u direction and degree q in the v direction is a bivariate vector-valued piecewise rational function of the form

$$S(u,v)=\frac{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}p_{i,j}}{\sum_{i=0}^{n}\sum_{j=0}^{m}N_{i,p}(u)N_{j,q}(v)w_{i,j}} \quad 0\le u,v\le 1 \tag{14}$$

The $\{P_{i,j}\}$ from a bi-directional control net ,the $\{W_{i,j}\}$ are the weights ,and the $\{N_{i,p}(u)\}$ and $\{N_{j,q}(v)\}$ are the non-rational B-spline basis functions defined on the knot vectors

6 The structure of the graphics learning system:

(1)System operating process and interface:
(2) Graphics algorithms:

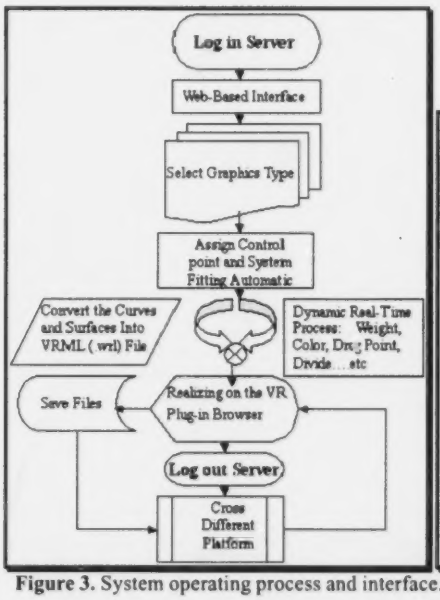


Figure 3. System operating process and interface.

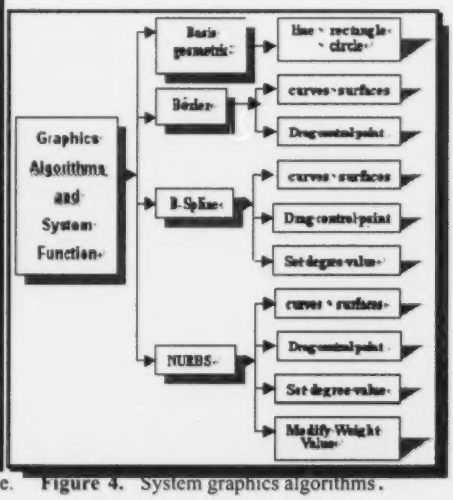


Figure 4. System graphics algorithms.

7 Brief Overview of OpenGL

OpenGL is the premier environment for developing portable, interactive 2D and 3D graphics applications. OpenGL have the following obvious benefits:

(1) Reliable and portable
(2) Scalable

(3) Easy to use

VR as a Training Tool

Virtual Reality training can dramatically reduce the cost of delivering training by decreasing learning time for student and instructors.

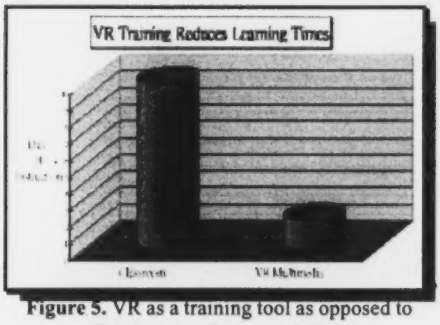


Figure 5. VR as a training tool as opposed to Classroom techniques (RTI)

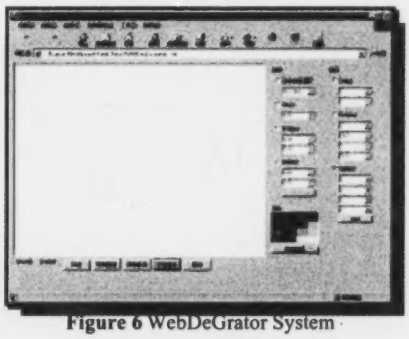


Figure 6 WebDeGrator System

8 Implementation and Example:

(1)The Integrated graphics Learning real-time system:
(2)Drawing NURBS curves and Covert Curves into VRML 3D Type:

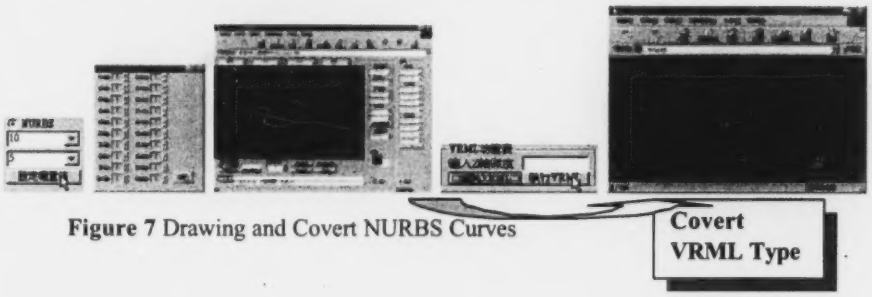


Figure 7 Drawing and Covert NURBS Curves

9 Experiment results:

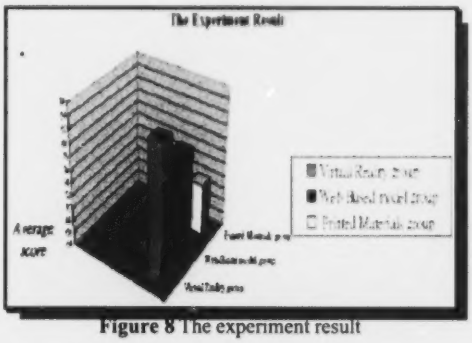


Figure 8 The experiment result

While the differences between the groups were significantly different, the virtual reality group performed is best; the Web-based model group is better than the printed materials group.

10 Conclusion:

The paper describes a new technology that we have established a VR-Based real-time graphics system. In summary, the system offers the following contributions:

1. To accomplish an Integrated Graphics Learning Real-time System
2. To share the resources in network.
3. To establish a computer network assisted learning system.
4. To explore and compare these algorithms of the sculpture curves and surfaces.
5. To integrate VRML with web–based learning system and realize 3D graphics on VR environment

11 Acknowledgments:

We would like to thank the anonymous reviewers for their invaluable and constructive comments that help to improve this paper. This research is working by the Automatic & CAD laboratory under Department of Electrical Engineering National Central University, Taiwan.

12 References:

[1] Ainge D. J., "Upper primary students constructing and exploring three dimensional shapes: a comparison of virtual reality with card nets", J. Educational Computing Research, 14(4), pp 45-369.1996.

[2] Bricken, M. A, "Description of the Human Interface Technology Laboratoryí s Virtual Worlds". Technical Report, Human Interface Technology Laboratory, U. of Washington, Seattle: 1990

[3] Christine Youngblut.."Educational Uses of Virtual Reality Technology". Institute for Defense Analyses. 1998

[4] Clark, R.E. "Reconsidering Research on Learning from Media". Review of Educational Research, winter, Vol. 53, No. 4, pp. 445-459, 1983

[5] Flanagan, D.: "Java in Nutshell, A desktop quick reference - Java 1.1", Second edition, O'Reilly, 1997.

[6] GERALD, "NURBS from Projective Geometry to Practical Use". FARIN,1999.

[7] Les Piegl. & Wayne Tiller." The NURBS Book". .Springer, 1997

[8] Manetta and R. Blade in "Glossary of Virtual Reality Terminology" in the International Journal of Virtual, 1998

Design and Evaluation of Constructivist Web-based Instructional Systems

Yueh-Chun Shih* and Nian-Shing Chen**
Department of Information Management
National Sun Yat-Sen University
*stone@cc.nsysu.edu.tw
***nschen@cc.nsysu.edu.tw*

Recently, there are many web-based instructional systems that have been developed on the Internet. Most of them claim that their system designs are based on constructivism. However, how to really evaluate if a web-based instructional system is a constructivist system or not, we need a complete evaluation guidelines which are derived from learning theories of constructivism. In this study we proposed a set of guidelines for evaluation of constructivist web-based instructional systems by surveying literature articles and analyzing constructivism theory. We then evaluate several popular web-based instructional systems by applying the proposed guidelines. Hope the proposed guidelines have some helps to the design and upgrade of web-based instructional systems, and can be an evaluation guidelines for constructivist web-based instructional systems.

Keywords: **Constructivism, Web-based Instructional System, Distance Education, Cyber University**

1 Introduction

From the 1990, Internet was booming globally in a tremendous speed. The population of people using Internet in the world is growing quickly in an exponential rate. Just like another industrial revolution, Internet has decisively deep and far impacts on our life. Currently the web-based instruction, using new media on the Internet, has the most conspicuous impacts on distance education as well as on traditional instruction type. Lines between these two kinds of instructional methods begin to be blurred [11]. Nowadays, many colleges and universities also begin to put the distance education into practice through Internet, hoping to enhance the learning efficiency by conducting new educational methodologies from Internet media. The asynchronous distance education, enabling teachers and students to interactively share information, to teach, to learn and to discuss anytime by connecting to the web-based instructional system, is one of the examples taking advantage of the computer software and Internet tools to simulate circumstances of giving lessons in the classroom. This leads us to another new kind of instructional schemes. At present researches in the light of this instructional system are continuously going on [12].

According to the architecture of many web-based instructional systems discussed [8,9,10] and the experience of developing this kind of system [3,5,6,7], we found that most of the systems developed were some sorts of system integration based on technical layers, and designers of these systems all thought the features of these systems could realize the circumstances of constructivist instruction. But whether the learning theories of constructivism can be fully achieved or not by the web-based instructional system is still a question which makes system designers and people with intention to establish the system indecisive and needs more guidelines for evaluation.

The objective of this research is trying to propose guidelines for evaluation of web-based instructional systems, hoping to be able to help with system development and become guidelines for evaluation. Besides these guidelines built in this research, case studies of comparison and evaluation on some famous web-based instructional systems will also be conducted.

2 Guidelines for constructivist instructional system design

Yi [13] definitely pointed out five principles for system design in his experimental schema:

(1) The ability to provide a process for knowledge construction.
(2) The ability to provide a circumstance relative to actual real actions for learning.
(3) The ability to provide an experience for viewing the points from each aspect.
(4) The ability to provide an environment to experience the social learning process.
(5) The ability to provide presenting methods for media.

But some of these guidelines nowadays have been essential and existing functions due to the advancement of technology. The ability, which the system has to be equipped with, of providing learning circumstance related to real activities, for example, could be achieved by the multimedia on WWW since it could present information in different types such as text, charts, pictures, video, images and language. And users can select appropriate media for presenting instructional materials so that a realistic circumstance could be simulated with interactive lessons and useful information could be embedded inside. As a result, taking the present technology into account, design of multimedia instructional circumstances can't be classified as the problem of system functions but as the guidelines that require considering.

Furthermore, synchronous (such as videoconference including shared white boards and on-line chat) and asynchronous (such as e-mail and BBS) communication systems also can provide circumstances for social learning experience as well as experience in different observation viewpoints. Students can benefit from the information revealed by the system to learn from other's learning experiences. Therefore, we conclude the above mentioned two points as that the system should provide circumstances capable of forming learning groups.

Thus, the original five guidelines for system design proposed by Yi [13] could be modified as below:

Guideline 1 Capable of providing processes for knowledge construction.
Users can decide the methods of their own to explore the information they need, such as selecting learning contents, determining learning sequences and participating in learning processes actively. Besides, as to the specific problems assigned by teachers, they also can explore the information provided by the system and then add their opinions into their knowledge base according to the information they have collected. They can record the processes of knowledge construction by system functions as well.

Guideline 2 Capable of providing circumstances for forming learning groups.
The system should provide functions for students to interact with each other and social experiences for learning reference. Students can make self-examination on his thoughts by observing the viewpoints of others. The information revealed by the system would determine how users learn.

In response to the requirements for the information society of next age, demands for students' ability should become omnidirecion-oriented. Besides simply knowledge gaining, abilities of high-level thinking, knowledge integration, creation and problem solving as well as human relationship are all required. For this reason, in addition to these two guidelines mentioned above, we propose another five guidelines from the point of constructivism literatures and social requirements.

Guideline 3 Capable of providing an environment for easy use.
The patterns of interactions in class can be defined as between students and teachers, between students and teaching materials, and between learners.

Guideline 4 Capable of providing an environment for dynamically exploring information
Chang [1] indicates that the knowledge will be constructed through dynamically exploring and discovery.

Guideline 5 Capable of providing an environment for observing the operation of other users.
From the point of the learning theory of constructivist psychology, through the cooperative learning of discussing, observing and consulting, it's easier to achieve self-thinking and constructivist learning.

Guideline 6 Capable of providing a cooperative learning environment for groups.

The system should provide an environment for member discussing, team forming and lessons learning with the assistance of Internet. That can lead to the achievement of the requirements which the information society of next age needs, and also fulfill the third principle of modern constructivism.

Guideline 7 Capable of providing an environment for recording the learning process.

The system should automatically record the performance, check the sequence and time of teaching materials, and trace the activity of problem solving and information seeking.

Through the literature review, we conclude the seven principles mentioned above. They should be conducive to the design of new systems and the update of old systems to assist teachers and students in constructivist instructional activities. We will use these principles to evaluate some instructional systems.

3 Evaluation of foreign web-based instructional system

Listed here are some popular web-based instructional systems being evaluated by Chen & Shih [2] with their function analysis. We will use the designing guidelines of constructivist instructional system described above to evaluate these systems again.

- WebCT web-based instructional system (http://www.webct.com)

  WebCT (version 2.0) was a kind of web-based instructional system developed by Department of Computer Science at the University of British Columbia. Table 1 is an evaluation table resulting from the analysis with the guidelines (based on the functions listed in the WebCT White Paper, August 1999). From table 1, we find that the system conforms to some guidelines and provides better function for knowledge construction process and ease of use. But it is deficient in-group learning, which needs further enhancement of related features.

- Learning Space web-based instructional system (http://www.lotus.com/learningspace)

  LearningSpace (LearningSpace Anytime 3.0) was a web-based instructional system developed by IBM. Table 1 is an evaluation table resulting from the analysis with the guidelines (based on the functions listed in the LearningSpace anytime 3.0, June 1999). We find in table 1 that it provides better function for forming learning groups but is deficient in other components such as knowledge construction, records of learning process, and group learning environment.

- Hyperwave web-based instructional system (http://www.hyperwave.com/)

  Hyperwave (Version 5.0) was a system developed by a private corporation in German to build an Internet system. Table 1 is an evaluation table resulting from the analysis with the guidelines (based on the functions listed in the Hyperwave Information Server 5.0 Technology White Paper Version 1.2 6/18/1999). From table 1, we find that it isn't really a constructivist web-based instructional system. More functions should be added.

- TopClass web-based instructional system (http://www.wbtsystems.com/)

  TopClass is web-based training software developed by a private corporation WBT Systems in California, USA. Table 1 is an evaluation table resulting from the analysis with the guidelines (based on the functions listed in the WBT's White Papers, September 1998). From table 1, we find the system has its strength on the ability of learning process recording. Enhancement of the functions on other parts such as knowledge construction, provision of multimedia and group learning should be made.

- The Cyber University of NSYSU (http://cu.nsysu.edu.tw/)

  The Cyber University of NSYSU is a web-based instructional system developed by NSYSU. From the table 5, we know that each function of the system meets the guidelines, especially in the aspects of providing environments for group learning and forming group society.

Table 1. Evaluation of the web-based instructional systems

Guideline	WebCT	LearningSpace	Hyperwave	TopClass	NSYSU
1	✓	×	⊗	×	✓
2	⊗	✓	×	⊗	✓
3	✓	⊗	⊗	⊗	✓
4	⊗	⊗	⊗	⊗	✓
5	×	×	×	×	✓
6	×	✓	⊗	×	✓
7	✓	×	⊗	✓	✓

✓• provided ×• not provided ⊗• partly provided

4 Conclusion

The booming of Internet creates a brand new learning environment. It is also recognized to be the most suitable tools for developing constructivist instructional circumstances. But since a good web-based instructional system plays an important role in developing web-based instructional environment, this research analyzed and summarized a set of guidelines for designing constructivist instructional system after reviewing literatures related to constructivism learning theory. With the guidelines proposed here, we evaluated and compared with some famous web-based instructional systems.

Meanwhile, we found some existing problems and issues worthy of further research. At the evaluation report by Chen & Shih [4], the ranking of these five instructional systems is LearningSpace, The Cyber University of NSYSU, TopClass, WebCT, and Hyperwave. But our evaluation report shows that from the viewpoint of requirements of constructivist education, there is no system but the Cyber University of NSYSU that satisfies the guidelines proposed. In the past, the LearningSpace developed by IBM once owned most complete functions and best reputation. But under the examine principles, it only conformed to part of these guidelines. It reveals that systems in the past were mostly technology-focused but lack of the understanding that the system should meet the nature, the objective, and the theory of the education.

Since the instruction is an extension of learning, designing of instructional activities should conform to the learning theory. We believe that future research should not only pay attention to the technology of the web-based instructional systems but also be designed in accordance with the learning theory without disregarding the nature and the original objective of education. We hope the guidelines proposed in this research could be of great help in designing new systems and upgrading old ones and moreover provide the system design with a clear and definite objective and direction.

Acknowledgement

The Study is supported by the Program for Promoting Academic Excellence of Universities by Ministry of Education of R.O.C..

References

[1] Chang, Shih-Ju, "The Instructional Meaning of Hypertext and Hypermedia: from Constructivism point of view.", Information and Education, No. 58, pp.39-48, (1997).

[2] Chen, N. S. & Shih, Y.C., "The Conceptual Model of Web-Based Instruction System and Its Implementation.", In Cumming G., Okamoto T., & L. Gometz (Eds.), "Advanced research in computers and communications in education: New human abilities for the networked society" (Vol. II, pp. 780-783). Amsterdam: IOS Press, (1999).

[3] Chen, N. S., "Webtitle- education on line", http://www.nsysu.edu.tw/webtitle.html (accessed on July 1, 1997).

[4] Chen, N.S. and Shih Y.C., "Function Analysis and System Implementation for Web-based Instruction System", The 13th Seminar of Computer Aid Instruction, the R.O.C., pp. 81-104, (1999).

[5] Chen, N.S. and Wang Min-Huang, "Web-based Supplementary Tool and Courseware", The Eighth Thesis of International Seminar on Information Management, pp.667-674, (1997).

[6] Chen, N.S., "Web-Based Learning Environment", Information and Education, No. 64, pp. 2-13, (1998).

[7] Chen, N.S., Yang Tsu-Ching, and Lai Hang-Jen, "Learning Environment based on Internet", Journal of Computers, Issue II, pp. 667-674, (1997).

[8] Goldberg, W. M., "Using a web-based course authoring tool to develop sophisticated web-based courses", Educational Technologies Press, July, (1996a).

[9] Goldberg, W. M., "Student participation and progress tracking for web-based courses using webct.", Proceedings of the Second International N.A. , WEB Conference, October 5-8, Fredericton, NB, Canada, (1996b).

[10] Goldberg, W. M., "Communication and collaboration tools in webct.", Proceedings of the conference Enabling Network-Based Learning, May, 28-30, Espoo, Finland, (1997).

[11] Lee, Chin-Pao, Han, Hui-Wen, Tsou, Ching-Ping, Hung, Shih-Chia, Chuang, ShuMi, "The trend and Current State of Information-net Training", Distance Education, Vol. 6, pp. 30-37, (1998).

[12] Okawa, K. & Murai , J., "School of the Internet : a university on the internet", http://power2.nsysu.edu.tw/INET98/7b/7b_2.htm, (accessed on July 1, 1998).

[13] Yi, Lien Hui, "Study of Computer Assisted constructivist Learning", Master Thesis of National Taiwan Normal University, (1993).

Design and Implementation of Teaching Models in Web-Based Teacher Training

See-Min Kim*, Shin-Chon Kang, Young-Kyun Back****
** CRADLE, Tokyo Institute of Technology*
2-12-1, Ookayama, Meguro-ku, Tokyo, Japan 152-8552
Tel: +81-3-5734-3233, Fax: +81-3-5734-2995,
E-mail: kim@ak.cradle.titech.ac.jp
*** Korea National Universty of Education*
Darak-ri, Kangne-myon, Chongwon-kun, Chugbuk, Korea 363-791
Tel: +82-431-230-3431, Fax: +82-431-233-0664,
E-mail: skytop@chollian.net

The reform of teacher training started in May 1995 in the Republic of Korea with reform of the educational system. The core of the reform was reinforcement of teacher training activity and introduction of a DTTS(Distance Teacher Training System). Then, in order to introduce a DTTS, the project for distance teacher training model development started in September 1997. This paper is related to a design and implementation of a teacher model in a DTTS. The teaching models of the following 4 types were carried out. 1) Problem-Solving type, 2) Seminar type, 3) Lecture-Practice type, 4) Courseware type. This system was in operation from October 1998. Current problems of this teacher models include: 1) Poorness of course contents, 2) The difficulty of checking a learning process, 3) Insufficiency of feedback to a trainee etc.

Keywords: **Distance Teacher Training, Teacher Model, Web-Based Learning**

1 Introduction

In Korea, reform of teacher training started on May 31, 1995 with the announcement of a reform of the educational system proposal. Philosophical bases for reform of teacher training are the spirit of the opened education, enshrining the principles of, opened an educational opportunity, the learning speed, the contents of learning, and the learning method, etc. The contents of reform are as follows[5]:

1) Obligation of periodical training;
2) Execution of distance education that introduced high technology of information communication engineering;
3) Reflection to the personnel affairs and the salary of a training result;
4) Authorization of a special course completion result in a graduate school and a social-education organization;
5) Attempt to the improvement of the training organization that enabled selection of the training organization by the teacher and let competition pass in qualitative.

These are summarized the following: 1) reinforcement of teacher training activity 2) introduction of a DTTS(distance teacher training system). It aimed at an expansion of the training opportunity, and overcoming restriction of time and space, with a reduction of training expenses. The project of DTTS development started in September 1997. It was sponsored by the Korea Multimedia Education Center. This project was divided into 4 sub-projects: Develop a training support model, design for teaching model, courseware development, and development for system management model. This paper is related to a design and implementation of a teacher model in a DTTS.

A teacher model is dependent on the contents of course, the learner characteristic, learning environment, etc. [6]. According to the questionnaire for the teachers and educational professionals of Choi [2], the suitable course for distance teacher training is as follows.

1) Various culture subjects (humanities a subject and a theoretical field).
2) Teaching methods expected such as discussion and workshop, then a lecture.

In Korea, as a training course into the distance teacher training, the culture subject of 11 was chosen. These were, "Foreknowledge of the future society and a counter plan", "Understanding of traditional culture", "The world in the 21st century and the Korea", "An information society and a computer", "Environment and education", " Raising of national morality nature", "An information society and multimedia education", "Theory and practice of open education", "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education for a unification counter plan".

In consideration of the characteristic of subjects and learner, strategies of WBI(Web-Based Instruction)[1], the teaching model of the following four types was proposed. 1) Problem-solving type, 2) Seminar type, 3) Lecture-practice type, 4) Courseware type. These are described at length in sections 2-4.

2 Design of the Teaching Model

In this project, the model of distance teacher training was divided into the macro model and the micro model, and was developed accordingly. A macro model is the framework of the whole DTTS, and a micro model is the course of training, that is, a teaching model. A macro model and a micro model are unified and distance teacher training is managed.

2.1 Web-Based Instructional Strategies

The acquisition process of the knowledge in WBI and the approach of the learning of constructivism are very similar. The most basic principles of constructivism concern fundamental philosophical assumptions about knowledge and learning[4]. The first, more generally accepted principle is that what a person "know"is not passively received, but actively assembled by the learner. The second principle is that learning serves an adaptive function. That is, learning is not the storage of "truths,"but of useful personal knowledge. This means the importance of the context of learning. Context has a lot to do with what is perceived as useful knowledge and how what is learned is integrated with existing knowledge. And the assumption that education is about acquiring universal truths. Since each person has different experiences and constructs an individual account of these experiences, each persons' s reality is slightly differenbt. New expereriences are interpreted within the context of these individual realities, implying that each person "know"a particular thing in a slightly different way.

We introduced the application of a repertoire of cognitively oriented instructional strategies implemented within a constructivist and collaborative learning environment, utilizing the attributes and resources of the internet[1]. The instructional strategies may be designed the following ways:

1) Support to the interaction between a lecturer- learner, and a learner-learner.
2) Introduce a hyper-textual function and support individualization learning.
3) Various learning materials provide in real time or non-real time (multimedia support)
4) The contents of learned and an evaluation results are analyzed rapidly and correctly, and it offers feedback to learner and system side.
5) Provide of DB Retrieval Function for learning information
6) It cooperates with other educational networks, and mutual reference can be carried out.

2.2 The contents-characteristic of subjects

The courses designed by the DTTS were culture subjects of 11. Generally, the contents of culture subject in a training course are unlike 'learning subject' that gains new knowledge. The culture subjects are mainly implicated that the contents of knowledge or skill newly asked for with a social change. And it takes into consideration that learning environment is being home, designed so that it might participate in learning not passive position but positively.

1) Show many concrete examples so that positive and concrete study can be performed.
2) Show or introduce the newest data and the newest present condition. And a learner performs creation of a report, discussion, and practice based on this.
3) In order to check rationally learning process which is the blind spot of home study, a small-scale subjectivity formula or report is required of an evaluation item.

4) The teaching contents are selected based on an opinion of the highest specialist of the field.

2.3 The learner-characteristic of in-service teacher and consult the needs analysis

In designing we considered the needs analysis of teacher needs[2]. And also considered the spirit of teacher training reform, that is the open educational opportunity, the learning speed, the learning contents, and the learning method, etc.

3 Proposed Teaching Models

3.1 Problem-Solving type Model

This model is used the following three subjects with "understanding of tradition culture", "information society and a computer "and "environment and education". The characteristics of contents of these subjects have much problem socially now. For example, the latest children cannot have understand about traditional culture, and do not understand value either. Moreover, although environmental problems are scattered in the familiar place, the problem consciousness does not exist. It is the learning which considers how it is efficiently introduced, how solving these problems at an educational field.
Problem-Solving type model is shown in **Figure 3.1**.

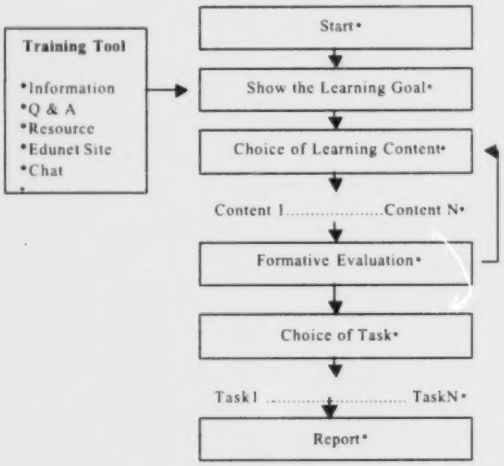


Figure 3.1 Problem-Solving type Model

3.2 Lecture-Practice type Model

Two subjects, "An information society and multimedia education" and "Theory and practice of open education" used this model. It is designed so that it might practice how theoretical knowledge may be reflected in the actual educational field. Through these courses, teacher can to help a child learn the capability that it can count measure to an information society, and how a teacher should just utilize the concept and the technology of multimedia for lesson activity. And more recently, it often pleads the open education. While introducing the concept of the open education and the example of the practice, teacher also gives an opportunity to consider an educational-practical use proposal directly.

3.3 Courseware type Model

Since three subjects, "Foreknowledge of the future society and a counter plan", "The world in the 21st century and the Korea", " Raising of national morality nature" were the contents of the type learned as new knowledge.
After having chosen the learning unit from the table of the learning contents, and learning using various data, composition which finishes a course through formation evaluation and generalization evaluation was designed.

3.4 Seminar type Model

This model uses the following three subjects. That is "The direction of the educational system reform and school reform", "Education of humanity and originality", "Education of a unification counter plan". At first a group is constructed by the theme and to be performed learning in Seminar form so that learner might have an opportunity to expand the view and develop the main point by the mode of opinion exchange.

Seminar type model is shown in **Figure 3.2** below.

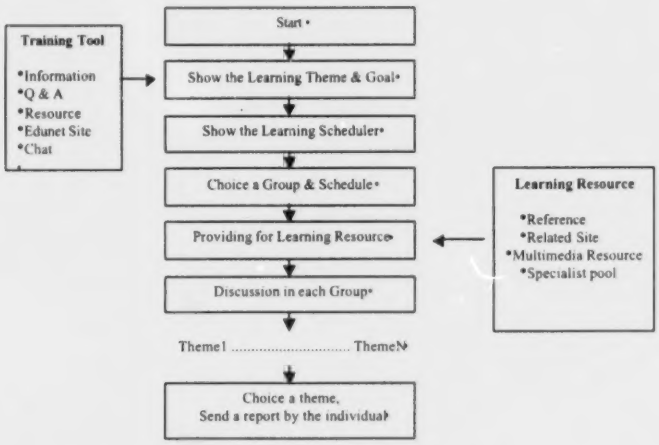


Figure 3.2 Seminar type Model

4 Implementation

The proposed model went into test implementation from October 1998. And now the model is used for qualification study of elementary and the 1st class positive teacher of middle, and general training of an elementary deputy schoolmaster.

As problems of this teaching model the following may be mentioned: 1) Poorness of course contents, 2) The impossibility of checking a learning process, 3) The insufficiency of feedback to a learner etc.

5 Conclusions

The distance education which used the high technology of information communication engineering in Korea started in 1997[3]. Insufficiency of a lecturer and restriction of a training opportunity are well said as a problem in teacher trainings. As one proposal for solving this problem, the project of "Development of a distance teacher training system" started and virtual teacher training actually started from October 1998. Thereby, little by little, teacher training environment becomes better and we think that the opportunity of training and the improvement in qualitative teacher training may also be anticipated.

There are problems that should still be correct and complement continuously in this training system. But the problems that should solved urgently are preparing the method of evaluation, the monitor staff who helps training, and a specialist pool.

References

[1] Bijan B. Gillani & Anju Relan., "Incorporationg Interactivity and Multimedia into Web Based Instruction", Web-based instruction, Badrul H. Khan, (Eds.), Educational Technology Publications, Inc,. pp. 231-237, (1997).

[2] Choi, Sang-gun., "Development of Distance Teacher Training System", Seoul: Korea Education Research Institute, (1995).

[3] C. H. Lee., "Pre-service & In-service Teacher Training for Computer Education in Korea," Advanced Research in Computer and Communications in Education. G. Cumming et al.(Eds.), IOS Press, pp. 433-440, (1999).

[4] Mark Grabe & Cindy Grabe., "Integrating Technology for Meaningful Learning", Houghton Mifflin Company, pp.32-76, (1998)

[5] Pang, Myung-suk., "Teacher's Information Literacy Training in the republic of Korea", Seoul; Korea Multimedia Education Center, (1998).

[6] Willis, B., "Instructional development for distance education," (ERIC Document Reproduction Service NO. ED 351 007), (1992).

DESIGN AND IMPLEMENTATION OF WEB-BASED LEARNING SYSTEM FOR TEACHER-TRAINING PROGRAMME

YIP Wai-ming* and AU Wing Kee**
**The Hong Kong Institute of Education*
10 Lo Ping Road, Tai Po, N.T. HONG KONG
Tel: +852 29487709
Fax: +852 29487726
E-mail: wmyip@ied.edu.hk
***The Hong Kong Institute of Education*
10 Lo Ping Road, Tai Po, N.T. HONG KONG
Tel: +852 29487693
Fax: +852 29487726
E-mail: wkau@ied.edu.hk

The advancement of recent technologies has evoked great impact on education. The Information Technology (IT) revolution has changed the habits of human civilizations immensely. The application of distributed systems, Internet, telecommunications and so on, along with the rapid development and advancement of computer technology, has given profound change to our life style and significant impact to our philosophy of education. Various contemporary issues in the application of IT in education have aroused widespread concern. Nowadays, learning is not necessarily confined within spatial and temporal boundaries. Networked databases, online resources and Internet services provide new opportunities for teachers and students to be engaged in learning and teaching activities which are different from the traditional classroom setting. In this paper, we are going to discuss the initial phase in designing and implementing a Web-based learning system for use in teacher-training programme. The research in building a Web-based supportive learning system for teacher training has the following characteristics: (1) It is a support system that aims to help the enhancement of learning effectiveness with the aids of modern information technologies, particular in the area of course information dissemination, sharing of resources, and computer mediated communication. (2) Future teachers are immersed in the IT learning environment so that a positive attitude and perc eption can be formed towards the adoption of IT in classroom. (3) Student teachers are encouraged to participate actively in the IT-immersion environment. After the initial phase completed, extended future research will be focus on its effectiveness and its empirical contribution in enhancing learning effectiveness.

Keywords: **Web-based Instruction**

1 Introduction

The application of Information Technology (IT) in education has recently generated lots of interests. With the advancement of new technologies, something impossible in the past was found significantly advantageous nowadays. One distinct example would be the use of digital technology and the continuous improvement of computer networks. The integration of text, sounds, graphics, and even video segments has been found more and more efficiently be used than in the past [9]. Undoubtedly, the fast growing multimedia technologies play

a vital role in enhancing better learning and teaching effectiveness. Internet and the use of the World Wide Web (WWW) have been regarded as a powerful media since its development began in early 90's. Networked database and distributed systems make the "knowledge" and information dissemination more efficient and faster. As the Internet and the WWW remove the geographically boundaries, learning and teaching activities need not happen at the same time and at the same place. Furthermore, communications between teachers and students, and among the students, which traditionally relied on face-to-face interactions, can be supplemented by both synchronous and asynchronous modes of communication through recent development of telecommunication and network technologies. In order to meet the new learning needs in the new millenium the idea of learning network is established for promoting life-long learning. With the help of an immersion learning environment using IT, students can construct and refine their knowledge through interactions with other students and teachers at anytime and anywhere. In fact, the number of schools and Universities using the Web to deliver courses are increasing [6].

2 Rationale in using Web-based learning system for teacher training programme.

Khan [5] suggests that the Internet is fast emerging and the WWW is becoming an increasingly powerful, global, interactive, and dynamic medium for delivering instruction. More and more institutions are using the Web to provide instruction and training. Increasing number of these institutions offering Web-based courses are recognizing the fact the Web is a viable and important medium for learning and instruction. As the capabilities of the Web have become more widely known, students and faculty have been quick to utilize its potential [4]. Research on the use of Web-based system in the past decade often focused on its contribution to distance learning, flexible learning or open learning. Each of the above three terms has its own meaning and are different from each other, yet all of them are regarding learning happened at learners' own time, pace and schedule. Internet offers the potential for a classroom reconfiguration through the utilization of WWW as a tool. Teachers are no longer regarded as absolute authority and the fount of knowledge, but the students begin to take responsibility for their individual learning. They become active participants in acquisition of knowledge and need to be responsible for their own development. However, traditional learning system and Web-based system are not necessarily mutually exclusive of each other. On the contrary, they may be employed to support each other. This idea becomes the fundamental principle in establishing a flexible, learner-centred and effective Web-based supportive environment for learning.

To establish an IT-immersion environment for future teacher

Most of the universities in Australia, U.S. and U.K. require their graduates to be information literate. Education faculties within these universities would add stipulations that their pre-service teacher graduates would need to be competent with the application of IT in education.[1]. Another major reason in the development and implementation of Web-based learning system is to create an IT immersion environment, so that future teachers can be immersed in the situation that not only IT skills or literacy be taught, but provide opportunities for student teachers to build up confidence in using IT. As a result, their positive attitude and perception towards the application IT in the classroom can be developed. How IT is used will vary depending on teacher' s understanding of technology and how it may be used to support the learning and teaching process. The development of student teachers' positive, confident attitudes, self-efficacy, and perceptions toward Information Technology is essential. Bandura [2] stated that people who perform poorly might do so because they lack the skills or they have the skills but they lack the sense of efficacy to use them well. General self-efficacy beliefs reflect a sense of personal control, a sense of personal competence and goal-directed determination. The teacher' s beliefs in their personal efficacy, ability to motivate and promote student learning will affect the types of learning environments they create and the level of academic progress their students will achieve.

Practise what we preach

Student teachers need to be IT competent before they enter into the profession. Teacher educators also have a distinct role in preparing competent teachers to teach IT or can teach with IT in the classroom. It would be desirable to enable student teachers immersed in the IT learning environment so that they can experience the possibilities in using networked technology and telecommunication as one of the learning media. More importantly, they are provided a chance to venture out and form the habit of life long learning, which is an essential element in their future success. In view of learning strategies, throughout the use of new

communication tools, students also have chances to collaborative with other students, and most likely they will be benefit from this kind of learning and teaching activities [7].

Flexibility, learner-centred approach

It is generally agreed that the Internet has the potential to revolutionize learning. However Radford [8] pointed out that a flexible and location-independent education is certainly not a replacement for traditional human face-to-face interaction between teachers and students, but on the contrary, provides another means to facilitate better communication. He said not all learning activities should be technology mediated, but in some way some learning tasks may not require people to be in the same room and at the same time. Lai [6] said that many "Web-assisted" courses are designed with the intention to provide students with easier access to course-related materials. Lecture notes, examination scripts and other relevant materials are archived on course Web sites and allow flexible access by course participants. In addition, electronic mail and discussion lists are used to supplement face-to-face communication between students and teachers. In some cases, they are only needed to meet face-to-face once or twice in a course.

3 System design

A pilot scheme has been introduced to explore the possibilities in using Web-based learning system in the Hong Kong Institute of Education since September 1999. The main purpose of this project is to look for the best means to support learning and teaching, and in the long run, develop courses that can be offered to the students in a flexible manner. A number of essential design principles in designing a Web-based learning system can be identified:

- Interactivity: Major considerations to enhance interaction between the learners as well as the teacher, a wide range of synchronous or asynchronous tools are used to supplement and/or enhance face-to–face interactions.
- Collaboration, it is important to establish a supportive environment to encourage collaboration or forming online study groups.
- Social and interpersonal interaction: the cognitive dimension of learning environment, to build up a best environment for learning, and to promote social and interpersonal interaction.
- User control: it should be designed for students and teachers easy to manipulate and most importantly, sense of ownership by providing personal space such as virtual office.
- Structure and management of learning environment, a Web-based learning environment should be a flexible learning environment includes clear and explicit information and simple administrative task.

The pilot system design consists of three components and each one serves different purposes in supporting learning:

Instructional delivery system

The main function is for information dissemination where instructional materials, announcement, lecture notes, tutorials etc. can be delivered via the Web and the learners may access the information at any time at their own pace.

Database

For the purpose of resource sharing, it serves information exchange, link resources, web resources, shared project examples and a platform for collection of assignments and feedback etc.

Internet-mediated Communication

The communication channel between the teachers and the students forms an important part in the Web-based learning system. It aims to provide a platform for Internet-based communication. Although email is a "conventional" way extensively used, other software tools for discussion and collaboration among students are employed. For example, newsgroup, guest book and discussion forum are adopted. Instructors may create a general discussion forum or specific topics to be debated that makes the learning activities more fruitful through student-teacher interaction.

4 Phases of development

This project comprises four phases.

Development and planning

The initial phase focussed on hardware infrastructure, setting up of software configuration, network connection, traffic and loading testing, security control method such as user authorization etc., Existing Web-based learning system were also installed, tested, compared and evaluated, examples included Learning Space, WebCT, Blackboard, etc.

Designing and testing

Course content design and the adoption of appropriate instructional delivery approach are crucial elements to the success of Web-based learning system. In this phase, different subject specialists in the Department of Information and Applied technology were invited to participate in the content design. Subjects included Information Technology, Home Economics, Business Studies and Design & Technology. Overall testing was also carried out in this phase including log on procedures, security control, database maintenance, statistics, Web-survey and evaluation etc.

Implementation

The system is opened for use but limited to specific courses level, which have been developed at the design phase. Formative evaluation will also be carried out to record

- feedback from both teachers and students.
- System stability
- Continuous modification and improvement on the content courseware design

Evaluation

As the Web can be globally been assessed, the use of formative evaluation is very critical where a single error will distribute world widely. An empirical approach will be adopted aims to observe effects on students and teachers using both quantitative and qualitative methods. This is an on-going process from the beginning till the end of the project. A variety of instruments will be employed, some important areas to be concerned are:

- Background study - Students and Teachers perceptions towards web-base learning
- Structure and in-depth interview – to obtain opinions from user point of view on web-based learning
- System analysis – a formative evaluation on the whole system concerning
    - the learning effectiveness
    - effective instructional design strategy
    - effectiveness on computer-mediated communication

5 Conclusion and future research

Information Technology develops at a rapid rate. The advancement of technologies provides new opportunities that never be achieved in the past. In particular the integration of multimedia technology and a new mode of communication using network technology that are greatly differ from our tradition. Brown (1999) states that there will be no doubt that the Internet is a major force in reshaping the nature of school. As the nature of Web-based system is open and flexible, the Web technology still has lots of potentials that can be contributed to education, especially in course design and development. On the other hand, the application of Web-based learning systems are continually to grow, it suggests future directions for educator and researcher to investigate how this new learning technology can contribute to along with educational and learning theories.

The initial phase of this project is to build up a platform for web-based learning systems. Extended future research will mainly focus on evaluation of such systems in enhancing teaching and learning effectiveness and its contribution to instructional strategy.

Reference

[1] Au, W.K., Kong, S.C. Leung, K.P. Ng, M. W. E., Pun, S.W.. "Levels of Information Technology (IT) competency core course elements and assessment tools for teacher training in IT in education". Hong Kong: Hong Kong Government. (1999).

[2] Bandura, A."Perceived Self – efficacy in cognitive development and functioning", Educational Psychologist vol 28 No.2 pp 117-148 (1993).

[3] Brown M.E. "The wired curriculum, a choice of content, connectivity or community?" In Lai, K.W. (Ed.) Networking, teaching, learning and professional development with the Internet. New Zealand: University of Otago Press. (1999).

[4] Crossman, D.M."The evolution of the World Wide Web as an emerging instructional technology tool". In Khan, B.H. (Ed.). Web-based Instruction. New Jersey: Educational Technology Publications. (1997)

[5] Khan, B.H. "Web-based Instruction". New Jersey: Educational Technology Publications. (1997)

[6] Lai, K. W. "Net-Working : Teaching, Learning and Professional Development With the Internet". New Zealand: University of Otago Press.(1999)

[7] Ma, J. Huang, R & Shih, T.K. "The Concepts, Framework and Architecture of an Integrated Educational System for Virtual Universities". In Cumming G, Okamoto, T.,& Gomez, L. (Eds.) Advanced Research in computers and communications in Education. IOS Press. (1999).

[8] Radford, A.J. "The future of Multimedia in Education", First Monday, Issues 2 Volume 11 (1997)

[9] [illegible] (1999)

Designing A Web-Based Action Learning Environment - Integrating Learning and Working in One Environment

Feng-Kwei Wang* and John Wedman**
**University of Missouri - Columbia*
221-I Townsend Hall, Columbia, MO 65211, USA
Tel: +2-573-8843918
Fax: +2-573-8844944
wangfeng@missouri.edu
***University of Missouri - Columbia*
303-H Townsend Hall, Columbia, MO 65211, USA
Tel: +2-573-8824546
Fax: +2-573-8844944
wedmanj@missouri.edu

Action learning has become a popular approach to management education. Many advocates of "work while you learn and learn while you work" define action learning as an experience-based approach to developing workers by integrating real workplace problems and dilemmas in development programs as a way to work and learn concurrently. In tandem with the increasing acceptance of action learning, Web-based learning has become a common practice in both school and work settings. The authors contemplate that Web technology be utilized to build a Web-based action learning environment. In this environment, the tools and resources selected and devised are intended to facilitate the pedagogical processes of action learning. The biggest advantage of this environment is that learners are able to conduct action learning without constraining to time and space boundaries. The authors also argue that any technology-based learning environment would be flawed without a sound design framework and strong cultural and leadership supports for implementation.

Keywords: **Action Learning, Web-based Learning Environment, Knowledge Repository**

1 Introduction

Recently, learning based on socio-cultural theories such as situated learning [1] and cognitive apprenticeship [2] have gained attention in academic education and corporate training. There are three core doctrines of socio-cultural learning theories [2,3,4,5]. First, knowledge is situated in meaningful tasks that the learner carries out. Second, learning is a social process in which the learner interacts with peers or experts. Third, mediated tools and signs in the socio-cultural milieu of the learner affect learning processes and results. In other words, these theories hold that learning occurs in a socio-cultural context where the learner carries out authentic tasks. Thus, it becomes essential to combine working and learning contexts in the workplace if learning is to be effective. In parallel with the development of socio-cultural learning theories, action learning has become an emerging paradigm for workplace learning [6,7]. The tenet of action learning is learning through action [8,9]. In action learning, learners learn with and from each other, with the help of facilitators, by working on real problems and reflecting on their own experiences.

In addition to the emerging learning theory that has changed today's landscape of learning design and implementation, learning technology is another area that has a deep impact on the construction of learning environments. The technological advancements that the Internet and the Web have brought about have outpaced pedagogical and human learning theories [10]. The interactive, distributed, and collaborative features the Web offers present unprecedented opportunities for experimentation in creating an online learning environment that allows learning to occur without temporal and spatial constraints. Learning anytime, anywhere through the Web has become a common practice in the educational circle [11].

This paper intends to provide the design framework of a Web-based action learning environment (WALE) that combines contemporary learning theory and learning technology to facilitate and support the process of action learning. We begin with an overview of action learning and groupware technology, which a WALE is built upon. Then, we introduce the design framework of a WALE. We also present an actual WALE we built to give readers a better understanding of this WALE framework.

2 Action Learning

The concept of action learning made its appearance in 1954 as a method of problem solving. In 1967, Revans first implemented action learning in Belgium as a method of management development. Revans [12] defines:

> "Action learning is a means of development, intellectual, emotional or physical, that requires its subject, through responsible involvement in some real, complex and stressful problem, to achieve intended change sufficient to improve his observable behaviour henceforth in the problem field" (p. 4).

According to Revans [9], learning (L) is the sum of acquired programmed knowledge (P) and questioning insight (Q) and is denoted as:

$$L = P + Q$$

P represents the traditional instruction received in formal academic institutions such as business schools, and is deployed by experts. Q represents one's own findings from managerial experiences and is exercised by leaders. It should be noted that P and Q are complementary parts of a total development process [13, 14].

In a typical action learning program, programmed instruction might be given on a designated theory or theoretical topic. In conjunction with the programmed instruction, learners are asked to apply their prior and new knowledge to a real project that organizational sponsors have sanctioned. Throughout the program, learners continue to work on the project with assistance from qualified facilitators or advisors as well as other learners who help them make sense of their project experiences.

Action learning situates learners in a real-life problem in which they learn from and with others as they solve organizational problems. While there are many variations of action learning, Beaty, Bourner & Frost [15] argue that four essential elements of action learning are

* real problems,
* group reflection,
* personal responsibility, and
* action based

First, learners learn from tackling organizational problems they face within their work contexts. Second, learning is a social interaction in which learners learn with and from a group of others who are also engaged in managing real problems. Third, members of the group are accountable for solving their own organizational problems. Fourth, action learning does not stop with theoretical solutions. It is concerned with implementing the actions that the group has explored.

Action learning holds that learning for learners means learning to take effective actions [14], which only occurs

when learners actually engage in taking actions. The best actions for learning are those that solve an organization's real problems, those actions that are significant to the learners themselves. The learning process is a social interaction in which a group of learners work together as a team on the problems. The learners learn best with and from one another through peer interactions and discussions.

"Action learning is holistic in its view of the person [learner], the management process, and learning. It is highly situational, flexibly treating elusive problems and combines a social process with individual needs" [14, p37]. Its value lies in the situated characteristics of knowledge and skills acquisition. Through hands-on experiences with peers in solving real-life problems, learners can develop their own theories of learning and management in action, which are tested against real-world experiences as well as established tenets [16]. Learners are able to sharpen their problem-solving, communication and critical-thinking skills and to build skills that are germane to their own particular organizational needs. Furthermore, action learning, in a broader sense, has much in common with the concept of the learning organization [14]. The critical features of action learning are in accordance with the five disciplines of the learning organization: system thinking, personal mastery, mental models, building a shared vision, and team learning [17]. From this perspective, action learning is not only a matter of individual learning and action but is also an organizational transformation process that deals greatly with organizational dynamics and culture.

3 Augmenting Action Learning with Technology

While action learning is taking off and is proven to be effective in management education [18, 19], we believe that Web technology can augment its effectiveness. First, the use of Web technology to communicate organizational information, to coordinate workflows, and to collaborate on work tasks becomes indispensable in solving today's organizational problems. Since action learning emphasizes that learning comes out of business actions, we believe Web technology is instrumental for learning, in that the common Web functions can concurrently support working and learning. Second, the most vital resource in action learning is the participants' own experiences and resources. The sharing of these experiences and resources often occurs only when participants convene in action learning meetings where the majority of problem diagnosis, group discussion, solution planning, and collective reflection take place. Consequently, these valuable experiences and resources are not captured, widely disseminated, or even lost outside action learning meetings or programs. Third, time and geographical boundaries often put constraints on where and when action learning meetings can occur. The communication functions of Web technology such as e-mail and online bulletin boards provide the means to break the limitations of space and time. These functions enable the continuity of learning process beyond face-to-face meetings. Furthermore, the collaborative features of Web technology can be used to engage people in the action learning process. Although well-designed action learning programs do a good job of involving participants in learning and action, the ability to let people collaborate anytime, anywhere creates an expectation that action learning is a collective effort and every participant is contributing.

4 Web-based Action Learning Environment

With the characteristics of action learning and Web technology in mind, we develop a framework for designing a Web-based action learning environment (WALE) as shown in Figure 1. In this framework, learning occurs when learners engage in action learning to solve organizational problems with the support of Web tools and resources. The tools and resources selected and devised for the learning environment are intended to facilitate the pedagogical processes of action learning. The design of action learning and technological support has to take into account the organizational context and should be constantly evaluated and improved accordingly. The Web tools and resources are devised into three categories: knowledge repository, collaborative tools, and cognitive tools.

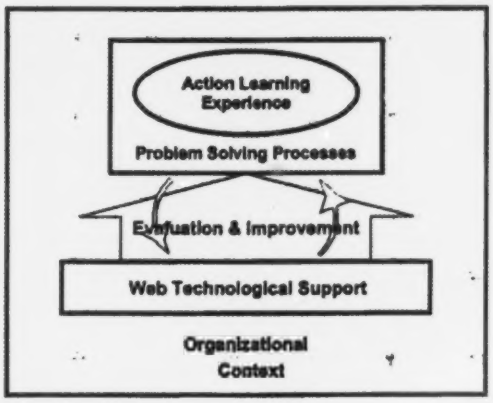


Figure 1. The design framework of a Web-based action learning environment

4.1 Knowledge Repository

At the conceptual level, a knowledge repository is about capturing and preserving the theory and practice of practitioners in an organization. The theory component represents what Ravens called programmed knowledge (P). In action learning, there is much in theory that can inform action. For one thing, it allows practitioners to see problems in a new light. Further, it might even reveal problems undiscovered for lack of recognizable solutions. The practice component is Revans' Q that represents practitioners' own findings from their experiences. These experiences are transformational and knowledge-based in a way that is useful to an organization. They provide the means of organizational learning, from which organizational members can gain insight and understanding. In action learning, experiences edify the program participants' past success and failure of actions. They also provide the questioning insights upon which the participants can reflect and guide their future actions.

At the detailed level, a knowledge repository is a collection of electronic documents that contains basic concepts in a subject domain and extracted experiences from practitioners including cases, lessons learned, best practices, techniques, tips, references, and other knowledge granules with powerful searching functions and easy navigational tools.

4.2 Collaborative tools

Collaborative tools, which include computer conferencing, electronic mail, and shared workspace, are used to promote collaboration among participants in an action learning program. Participants take on problem solving collaboratively through this online environment built on computer networks. Through the networks, multiple perspectives and diverse learning approaches can be stimulated, with each reinforcing the others [20]. Computer conferencing permits the development of online, asynchronous, many-to-many person discussions. Electronic mail allows each participant to send messages relating to personal issues to a specific person or group [21]. Computer conferencing and electronic mail extend the time and space boundaries of action learning beyond action learning meetings and moves learning directly into the workplace. They enable action learning anytime, anywhere and make action learning an ongoing process. The shared workspace serves as the group memory, recording group activities and information in action learning. It is capable of tracking a participant's or a group's action patterns and learning paths, which indicates what actions have been performed and what information has been accessed. Each participant can either reflect on his or her own action learning history or can learn from others by reviewing the group processes.

4.3 Cognitive Tools

Kozma [22] explains that the computer can alleviate the learner's information processing burden, thereby extending human cognition. In case problem solving activities, computer tools are used to ease and enhance the performance of cognitive tasks. Such tools in a WALE include performance support, hypermedia, and navigation functions. First, performance support functions are a set of Web tools or electronic job aids that participants use to facilitate problem solving. These functions ease the cognitive load of many arduous but necessary work and/or learning tasks and make learning and problem solving more efficient. The use of problem diagnosis forms and online action learning guidelines are two examples. Second, in a hypermedia environment, knowledge is purportedly organized by mirroring the structure of human thinking. The process of imitating human thinking proceeds through associating one piece of information to a related piece of information. It functions as "knowledge on demand" and exhibits the capacity to branch from one thought to related knowledge or experiences [23]. That being so, an appropriately structured hypermedia system should be able to mirror the semantic network of an experienced or knowledgeable performer or expert [24]. Third, navigation functions such as searching, navigation maps, indices, history, and bookmarks prevent learners from getting lost in the spacious knowledge ocean and point participants in the right direction. Navigating with such tools quickly brings participants the part of knowledge that they are looking for. Navigation maps show where participants are and where they have been in knowledge repository. Similarly, indexes offer participants different ways of identifying and viewing knowledge. In contrast, the history function keeps track of navigational paths and allows participants to trace their learning processes. Finally, bookmarks register particular knowledge locations for later quick access.

5 Learning and Working in a WALE

From the process standpoint, building a WALE encompasses a set of interrelated processes that engage participants in the problem-solving activities. These processes become a way of identifying and understanding interrelated factors while helping fill gaps, minimize redundancies, and eliminate conflicts toward common goals. They enable participants to develop themselves by building, reflecting on, renewing, and sharing what they know and how they do things in solving organizational problems. In this way, a WALE integrates learning and working in one environment through: 1) online action learning activities with peers and facilitators, 2) the utilization of Web-based learning and performance support tools, and 3) full-time access to problem solving resources and results (see Figure 2).

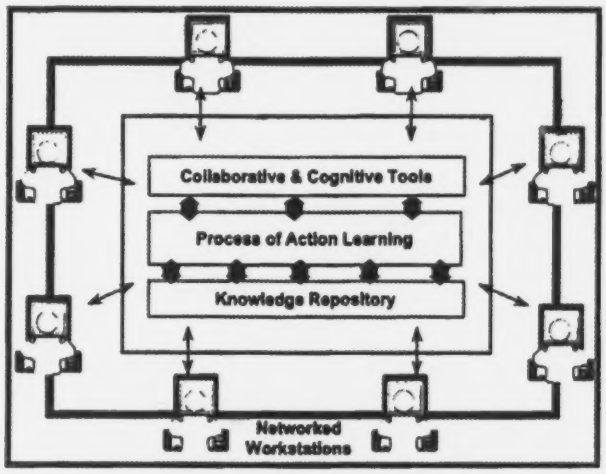


Figure 2. Working and Learning simultaneously in a WALE

BEST COPY AVAILABLE

6 A Case in Point

Teacher education programs have been challenged to respond to advances in technology. Unfortunately, these programs are criticized for not adequately preparing teachers to use technology in their teaching. The Office of Technology Assessment (1995) reported on technology in teacher education and noted significant limitations, including 1) faculty not modeling technology use; 2) students learning about technology – not with it; 3) field experiences not designed to model the use of technology; and 4) technology isolated from the main curriculum and pedagogy of teacher education. These limitations point to the need to revamp teacher education programs at many universities.

While teacher education faculty are central to the problem and its eventual solution, individual faculty are typically powerless to address these limitations. Deans, Directors of Teacher Education, Department Chairs, and other college and school-level leaders are best positioned to make a response, but seldom are these individuals prepared to deal with the many complexities, technical and otherwise, creating barriers to integrate technology in teacher education. Moreover, the rate of technological changes makes technology integration in teacher education a perpetual endeavor. Learning to solve problems means taking action in solving problems.

Funded by a grant from the U.S. Department of Education, a consortium of teacher education programs at the Universities of Missouri, Nebraska, Oklahoma, and Kansas, and Texas A&M was established to tackle many similar problems found in integrating technology in teacher education. This consortium is grounded with a common vision: teachers and students enabled by new and emerging technology and building a better future for all. The common mission is to better educate future generations of teachers to use technology. Recognizing that accomplishing the mission is an ongoing endeavor and the means to the end is constantly in flux due to fast emerging technology innovations and student needs, the leaders of consortium programs take the action learning approach to prepare themselves and their programs.

Adopting the WALE framework, the consortium, led by the University of Missouri, initiated a WALE development project to deploy a knowledge repository to support action learning programs engaged by respective consortium members. The Technology Integration Process (TIP) knowledge repository captures, organizes, and disseminates the collective knowledge about technology integration in teacher education, thereby leveraging the professional knowledge across many programs. Figure 3 shows the entry screen of the TIP system.

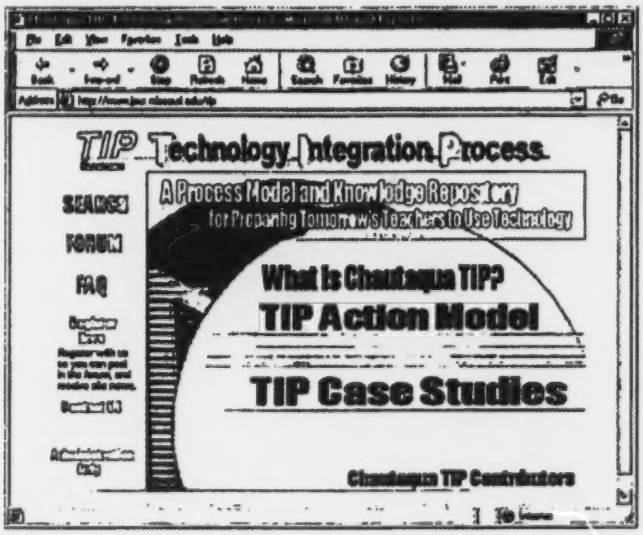


Figure 3. The entry screen of the TIP system

BEST COPY AVAILABLE

To start with, the TIP design includes a process model for technology integration in teacher education. The model consists of five inter-related processes: research, design, development, delivery, and evaluation. Two or more subprocesses were identified for each process. This TIP action model represents the P component of Ravens' learning model: the theory of technology integration in teacher education. To capture the TIP experiences (the Q component) of participating programs, dedicated project staff was sent to collect knowledge about TIP actions in each participating program. These experiences categorized according to five TIP processes were written as descriptive documents enhanced by multimedia elements. Each experience is titled as a TIP case and can be searched by name, by category, and by program as well as through a full-text search engine spanning the entire database.

Following the action learning approach, knowledge collection at each participating program began with a two-day self-study facilitated by the project facilitator. The self-study process opened with an orientation to the goals of the project and a demonstration of the knowledge repository from the functional and conceptual perspectives. Attention then turned to identification of the strengths and limitations of the program in relationship to the elements of the TIP action model. More site visits followed for problem diagnosis and solution implementation. In these follow-up meetings, in light of presented problems with the program and illuminating TIP cases in the system, the participants reflected upon the problems and solutions to develop action plan. It was then up to the participants of each program to carry out the plan. In the meantime, project staff continued the tasks of TIP knowledge discovery and collection and preserved the knowledge in the system that also facilitates the information exchange and knowledge dissemination throughout project lifespan. Individuals from participating programs are periodically notified when new knowledge (i.e., documents) was added to the system. Also, notifications are sent out when a new threaded discussion is initiated or when existing discussions are active. In this way, TIP action learning becomes an ongoing and collective effort from all contributing partners of this consortium.

7. Conclusion

The utilization of the Web for action learning is one possible efficient and effective way to leverage the intellectual capital of an organization in solving organizational problems. In this paper, we have laid out the design framework of a Web-based action learning environment. We illuminate our design with an actual WALE that we built to integrate technology in teacher education. We also understand a successful WALE is more than a design framework and a new technology implementation. While Web technology may have the advantage of removing boundaries of space and time to facilitate and enhance action learning, it may cause other difficulties by eliminating ordinarily desirable interpersonal communication channels necessary for effective action learning. Our experience has shown that the successful application of a WALE relies upon a judicious marriage of a sound design of Web technological tools and resources and inner strengths of participants, with reflections upon learnings from experiences of action in the real world of work and life. It must focus on critical successful factors that include fostering a conducive learning culture, marshaling true leadership support, deploying a nurturing process model, and sustaining the change throughout the organization. Also, it must move us to a view that sees learning in the context of the workplace so that higher individual and organizational performance can be achieved.

References

[1] Lave, J. & Wenger, E. "Situated learning: Legitimate peripheral participation", New York: Cambridge University Press, (1991).

[2] Brown, J. S., Collins, A., & Duguid, P., "Situated cognition and the culture of learning. Educational Researcher", Vol. 17, pp. 32-42, (1989).

[3] Bonk, C. J. & Kim, K. A., "Extending sociocultural theory to adult learning", In Smith, M. C. and Pourchot, T. (Eds.), Adult learning and development: Perspectives from educational psychology, Mahwah, NJ : Lawrence Erlbaum Associates. (1998).

[4] Tharp, R., & Gallimore, R., "Rousing minds to life: Teaching, learning, and schooling in a social context", Cambridge, MA: Cambridge University Press, (1988).
[5] Wertsch, J. V. "Voices of the mind: A sociocultural approach to mediated action", cambridge, MA: Harvard University Press, (1991).
[6] McLaughlin & Thorpe. R., "Action Learning: A Paradigm in Emergence", British Journal of Management, Vol. 4., No. 1., (1993).
[7] Yorks, L., "The emergence of action learning", Training & Development, Vol. 54, No. 1, pp. 56-56. (2000).
[8] McGill, I. & Beaty, L. "Action learning: A guide for professional, management and educational development", London, UK: Kogan Page, 2nd Edition (1995).
[9] Revans, R., "Action learning: New techniques for action learning", London, UK: Blond and Briggs, (1983).
[10] Salomon, G., "Novel constructivist learning Environments and novel technologies: Some issues to be Concerned with. Research Dialogue in Learning and Instruction", Vol. 3, No. 1, pp. 3-12, (1998).
[11] Morris, K., "Wiring the ivory tower", Business Week, pp. 90-92. (1999, August 9).
[12] Revans, R., "The nature of action learning", Management Education and Development, Vol. 10, No. 1, pp. 3-23. (1979).
[13] Korey, G. and Bogorya. Y., "The managerial action learning concept-theory and application", Management Decision, Vol. 23, No. 2, pp. 3-11, (1985).
[14] Mumford, A., "Learning in action", Personnel Management, Vol. 23, No. 7, pp. 34-37, (1991).
[15] Beaty, L., Bourner, T., & Frost, P., "Action learning: reflections on becoming a set member", Management Education and Development, Vol. 24, No. 4, pp. 350-367, (1993).
[16] Marsick, V. J., "New paradigms for learning in the workplace", In V. J. Marsick (Ed.), Learning in the workplace (pp. 11-30). New York: Croom Helm, (1987).
[17] Senge, P. M., "The fifth discipline: The art and practice of the learning organization", New York: Doubleday/Currency, (1990).
[18] Froiland, P., "Action learning: Taming real problems in real time", Training, Vol. 31, No. 1, pp. 27-34, (1994).
[19] Keys, L., "Action learning: Executive development of choice for the 1990s", Journal of Management Development, Vol. 13, No. 8, pp. 50-56, (1994).
[20] McCarthy, R., "Multimedia: What the Excitement's All about", Electronic Learning, Vol. 8, No. 8, pp. 26-31, (1989).
[21] Harasim, L. M., "Global Networks: An Introduction", In Linda, L. M. (Ed.) Global Networks: Computers and International Communication. Cambridge, MA: The MIT Press, pp. 3-13, (1993).
[22] Kozma, R., "The Implications of Cognitive Psychology for Computer-based Learning Tools", Educational Technology, Vol. 27, pp. 20-25, (1987).
[23] Amthor, G., "Interactive Multimedia in Education: Concepts and Technology, Trends, and Model Applications, Megamedia and Knowledge Systems", T.H.E. Journal, Special Issue: IBM Multimedia, pp. 2-11, September, (1991).
[24] Jonassen, D. H., "Acquiring Structural Knowledge from Semantically Structured Hypermedia", A paper presented in the AECT annual convention, Washington, D.C, (1992).

Developing a research instrument for measuring the effectiveness of Web-based learning materials

Eugenia M. W. Ng* and Wing Kee Au**
Department of Information and Applied Technology
The Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T.
Hong Kong SAR, China
Tel: +852 2948 7645, Fax: +852 2948 7726,
*E-mail: *eugenia@ied.edu.hk, **wkau@ied.edu.hk*

The World Wide Web (Web) is growing at an exponential rate and has been adapted to learning free from constraints of time and place around the globe. Increasing resources have been devoted into developing Web-based learning materials (WBLM) worldwide. Although some researchers had proposed guidelines for designing Web-based instructions, most WBLM are primarily designed by the course co-ordinators. This phenomenon could be problematic especially when there is little empirical research investigating the perceived factors affecting the effectiveness of WBLM. Thus, the main research objective of this study is to develop a survey instrument to evaluate the critical factors which might affect the effectiveness of WBLM. This research comprises four phases. This paper reports the findings of the first phase. Interviews, focus group meetings and questionnaires were adopted to develop the measuring instrument. Focus group meetings were conducted to solicit opinions from academic and technical experts on the critical factors affecting the effectiveness of WBLM. Their viewpoints on course management, user interface, technical considerations, content features and assessments were summarized and presented in this paper. The future research plan which will lead to the development of a refined questionnaire will also be discussed.

Keywords: **World Wide Web, Web-based learning materials, survey instrument**

1 Introduction

The World Wide Web (Web) is increasingly being used as a vehicle for flexible learning, where learning is seen to be free from time, geographical, and participation constraints [27, 33]. Many tertiary institutions invest considerable resources in the Web to deliver pedagogical materials to learners who have a diversity of needs and backgrounds, many of these learners take courses whilst working full-time or part-time and/or raising a family. In addition to flexibility, the Web facilitates student-centered approaches, creating a motivating and active learning environment [3]. There are suggestions that, in providing for browsing and thematic exploration, the Web facilitates higher order cognitive processes, such as transfer and knowledge application [15]; whilst at a more conceptual level, there has always been a case made for hypertext mirroring the ways in which much of human thinking occurs, by association rather than linearly or procedurally [4].

On the practical side, the Web not only provides economic and powerful resources, it also opens up an alternative arena for learning as it permits the work of individuals to be shared with the world, and much content of the Web cannot be found in any other format [11]. Kearsley [19] elaborated on the attributes of the Web, "[T]he most significant aspect of the Web for education at all levels is that it dissolves the artificial wall between the classroom and their "real world". (pp. 28). However, Marchionini [24] argued that most

students did not make appropriate use of hypertext system because they were still using mental models of print versions of encyclopaedias. Similarly, many learners do not necessarily make use of valuable resources available to them [9] and they do not possess the appropriate metacognitive ability to monitor their learning processes [5]. Research also showed that learners did not utilize the available choices most effectively because they were unable to appropriately monitor their cognitive functions [8]. As a consequence, learners may find it difficult to adjust to this new learning environment [25].

It is apparent that the Web itself is only a medium for conveying information. Hypermedia is frequently adopted to transmit the information on the Web and yet it does not possess a single or normative information structure. The structure might be highly ordered, supported by a constrained and sequential set of links or the hypermedia may be nonsequential and supported only by referential links. In many cases, a Web site might comprise a mix of these structures. It is often the nature and application of these structures that determine the effectiveness of carrying and delivering Web-based learning materials (WBLM). Very often paper-based information resources are converted into "electronic page-turning" materials for Web-based learning (WBL). There is little regard for appropriate pedagogic design models and strategies for exploiting the Web as a learning medium [1, 31, 35]. Most WBLM are designed by the course coordinators with a view to covering the content rather than on improving learning outcomes [6]. While many learners might possess the basic information and navigational skills to access information on the Web, instructional designers have yet to consider those aspects of this medium that determines its effectiveness for all learners.

Some researchers perceived the importance of Web-based instruction (WBI) and have proposed guidelines for designing it (for example, [6, 20, 28]). Words, numbers, graphs and pictures (animated or non-animated) are often used to communicate visually. Text leads readers along a particular train of thought [17]. Animations were thought to make user interfaces easier to use, more enjoyable, pleasurable and understandable [2, 32]. Jones [16] explained how the relationship between instructional design and world views had molded and was molded by contemporary symbolic and materials culture artifacts and concluded the form of cultural artifacts, in the case of computer graphics, expressed our symbolic relations with the world and influences how we constantly (re)inventing ourselves. Reeves [30] had identified fourteen dimensions to judge the pedagogic worth of interactive multimedia (IMM) instructional design, and Henderson [13] argued an instructional design cannot and does not exist outside of a consideration of culture. Yet there is very little information on how to create an interface for instructional purposes [18, 23]. Since it is very costly, in terms of human, time and financial resources, to develop WBLM, it is imperative that a validated survey instrument be developed to assess the effectiveness of WBLM to enhance learning effectiveness.

2 The importance of developing a survey instrument

Survey is a popular research approach used in information systems research and is also gaining importance in recent years [10]. Kraemer and Dutton [22] commented that survey was ill suited for addressing the subtle dynamics of information technology in complex social settings. Galliers [7] thought this approach revealed little information in the underlying meaning of data and there might be possible bias in the respondents, researchers and the moment in time when the research was conducted. However, Porter [29; p. 289] argued that " surveys can add dimensions to our understanding of the kinds of problems we are studying". King [21] suggested survey research could play a major role in exploratory investigations. Survey has been chosen for this research not because it is the tool most suited but rather because of a lack of a better method.

3 The study

Despite the popularity of survey, poorly designed and executed survey is of little or no value. Survey instrument must be validated before being adopted fully. This research comprises four phases. Interviews, focus group meetings and questionnaires have been adopted to develop the measuring instrument. In the first phase, interviews and focus group meetings were conducted to solicit opinions on the critical factors affecting the effectiveness of WBLM. Interview is the most widely applied technique for conducting systematic social inquiry [14]. Interviews provide us with a means for exploring the points of view of our research subjects [26] and generate data which give an authentic insight into people' s experiences [34]. In the second phase, an initial questionnaire will be furnished from ideas generated from the focus group meetings and from in-depth literature review. In the third phase, the questionnaire will be pilot-tested and

follow-up interviews will be conducted to refine the items of the questionnaire. In the fourth and last phase, a refined questionnaire will be developed. This refined questionnaire will be used to gather quantitative data from a large sample and these data can form a data bank for future referencing.

This paper reports the findings of the first phase. An in-depth interview was conducted in February and three separate focus group meetings were carried out in March 2000. The interviewee, Julie Ziller, was an expert in Web-based design from Canada whilst all the participants of the focus group meetings were staff of the Hong Kong Institute of Education. The first meeting was attended by academic colleagues who had some experience in developing WBLM or computer-assisted learning materials. The second meeting was attended by technical colleagues who had experiences developing WBLM whilst the third meeting was attended by both academic and technical colleagues who were not available to attend the first two meetings. There were a total of fifteen participants who attended the meetings. The researchers, assisted by a research assistant, acted as facilitators to prompt participants during brain-storming sessions. The facilitators guided participants to put forward factors related to the content, graphical user interface, assessments and course management [12] which might affect WBLM. All the meetings were tape-recorded and the main points were transcribed.

4 Findings

In general, the academic colleagues had more concerns on the technical aspects of the design whilst the technical colleagues had more concern on the content of the Web sites. Some participants believed that the nature of a course might be a factor affecting Web-based learning. The participants believed that the course designers should have a clear notion of why they chose the Web as the medium of instruction and if it was the right medium to deliver the specified course materials. When the Web was considered the best medium or could provide an alternative medium of instructions, the course designers have to consider if the learners possess the necessary software, hardware and skills to access to the WBLM. Their detailed discussions concerning course management, technical considerations, content features, user interface design, interactions and assessment are encapsulated below.

4.1 Course management

Participants suggested that an introductory seminar should be organized to enhance learners' understanding on the course objective, the course material, and the learning environment on Web. As many learners may not be familiar with learning from online material, hard copies of study guide or reference lists and content lists should be provided as supplementary materials. This was deemed to be essential in helping learners to step into a Web-based learning environment.

4.2 Technical considerations.

The design of the WBLM should allow for a wide range of equipment required and bandwidths. Several versions of Web pages should be provided for different transmission rates, for example, HTML, Flash and multimedia versions. Although participants believed that broadband would be common within two to three years, course coordinators should consider that the majority of learners are using narrow band currently. Except for the main page, transmission time from page to page should preferably be in a few seconds.

4.3 Content features

Since the purpose of this study is to develop a general survey instrument, no specific content was considered. The features of WBLM, like text/documents, hyperlinks to related materials, chat rooms, discussion forums, assignments, home button, previous button, next button and so on, were basic features of a WBLM's interface and will not be covered here. All contents shown must mean what it is – learners must not be made to guess. Some academics at the focus group meetings thought that rich resources existed on the Web and these should facilitate learning. Some believed courses designed to teach skills rather than concepts could be better delivered through the Web. Statistical counts and logs were recommended as indicators for future enhancement of the Web contents or design. For example, the most popular sections/pages, the most common errors in assignments, the average reading time, and so on should be tracked. These counts could assist course coordinators when they needed to amend the instructional materials from time to time.

4.4 User interface design

Participants agreed that user interface was important. They were concerned with the diversity of learners' perception which exist in different societies and how a framework or design can cater for this diversity. The interface should be easy and comfortable to use. Each Web page should not have too much text within one or two paragraphs. The contrast of text and background in color should be distinct. Different font sizes were suggested to differentiate the importance of information. They also criticized that many Web Sites' printing function and settings were poor - they were not convenient for learners to use – requiring users to select and to set up printing functions.

Site map - An academic suggested that there should be a site map on the home (main) page to facilitate an understanding of the overall structure of WBLM.

Multimedia - Some participants mentioned that multimedia offered a distinct advantage of delivery on the Web especially for demonstration purposes and suggested that animated graphic should be used to enhance learners' memory; video and sound should be used in different sections of the Web. However, others thought that these features might affect learners' concentration. It had been suggested that learners should be able to play back/ repeat multimedia materials easily and it would be better if learners could control the speed and timing. Furthermore, if learners could search for any piece of information from the multimedia files just like in the text environment, it could reinforce their learning. Parts of or all the multimedia materials could be stored on a CD-ROM to reduce the transmis sion effort and time.

Hyperlinks - During the meeting, participants suggested that learners could be given some supportive information through "help" or hyperlinks. There were different viewpoints on hyperlinks though these were considered to be very usual tool for WBL. Some participants expressed that too many hyperlinks embedded in a Web Page could distract learners from concentrating on theirs studies, i.e. there should not be too many hyperlinks in a page. However, when there were valuable ideas not directly related to the actual contents, course coordinators could recommend them to learners. Another approach was that, the hyperlinks could be classified into different categories according to coordinators' opinion, hit counts, or learners' comments. The learners could be encouraged to post recommended references and top 10 reading hyperlinks were to be updated regularly.

Scroll bars - Participants had strong views on using the scroll bar - using left and right scroll should be discouraged, whilst using up and down scroll should be handled carefully. Correspondingly descriptive dialogue should appear over the bar while learners were using the scroll bar. Learners should be able to click out different sections easily. The contents table and searching tool should be placed on the left side of the Web page. In order to maintain learners' interests and to keep them informed when downloading, it was suggested that the learners should be informed instantly when such an action was triggered.

Interactions - The participants believed that interactions were important to make WBLM effective. They were concerned about how to build up interactions between coordinators and learners, among learners, and between learners and WBLM. They had suggested varieties of methods to promote interactions, such as hands-on periodic on-line assignments, on-line multiple-choice as a checkpoint, discussion forums, chat rooms and e-mails. Learners' participation could be stimulated if they are frequently prompted to discuss open-ended questions on discussion forums. Their motivation would be reinforced by coordinators' responses especially when the responses were quick. However, discussion forums might not be sufficient to build up a close relationship between learners and coordinators and among learners as learners were not accustomed to this kind of discussions. Furthermore, the reliability of information posted on the discussion groups had been doubted.

Recording function - The group suggested that a record sound function should be added to the Web pages. When learners have questions, they could speak and record their problems directly instead of writing them in text format. Similarly, the coordinator could play back these recorded questions and reply in voice as well.

Assistance – There should be assistance buttons such as "Help" to be placed at the bottom part of a Web Page and all linked pages

4.5 Assessments

Most participants agreed that WBL offers the ideal environment for continuous assessment and self progress

monitoring. Assessments could be held on-line or off-line. Participants were concerned about the authenticity if assessments were on-line. Some participants argued that users could concentrate more in an interactive learning/assessing environment, such as answering several short questions within sections, then followed by an assignment within chapters. Some participants believed that the style of quizzes should be presented in a friendly manner. There should not be too many quizzes, otherwise, the learning pace might be slowed down. The balance between on-line and off-line assessment should be considered carefully.

5 Conclusion and further research plan

This paper has discussed the findings of the first phase of a project to develop a survey instrument for measuring the effectiveness of Web-based learning materials. Various key elements which facilitate and impede WBL were identified. The findings form the basic items of a survey instrument. The appropriateness of the items to the domain of the construct will be assessed. It can be done through considerations of the theoretical basis for the items in the literature or a panel of experts who are well versed with the domain. Experts are asked to separate items that are relevant to the domain from those that are not. After sorting, similar items will be eliminated to come up with a reasonable length of the instrument. Following the development of the preliminary instrument, pre-testing with users will lead to the second phase of this project.

5.1 Second Phase

This phase is to pre-test the instrument created in phase one. A pilot test on the survey instrument will be conducted from a representative sample size of the population under study to purify the measure. The participants will give their opinion on each questions based on the Likert scale, ranging from strongly disagree to strongly agree. The researchers, assisted by research assistants, will also interview the respondents to gather further opinions on the questionnaire such as the wording, length and instructions of the questionnaire. The aim is to ensure that the mechanics of compiling the questionnaire would be correct and adequate.

A further study will then be conducted with more respondents using the refined questionnaire. Similarly, participants will be asked for comments to improve the questionnaire. The aim is to make an initial reliability assessment of the questionnaire. It is essential that the instrument developed must be valid and reliable. There are several methods for investigating the validity of an instrument, including content, criterion and construct approaches. The most important element is construct validation, namely, factor analysis, will be used to establish construct validity. If the items for each variable load together in factor analysis but do not cross load onto other variables, there is evidence of construct validity. The items are also grouped by the factor (dimension) they are loaded on. Those factors under minimum acceptable loading will be discarded.

5.2 Third Phase

This phase consists of validating a research instrument through surveys and interviews similar to the second phase. Participants will be asked to rate each question using a refined instrument at the beginning and at the end of the semester. Some of them will also be interviewed. Convenient participants who take courses taught by the researchers or their associated colleagues will participate in this stage of a study. The purpose of conducting this survey is to understand if there are any differences among participants of different programs at different time frame. The results will be compared and contrasted to explore if there is any statistically differences among the learners from different programs and if there is statistically differences at the beginning and at the end of a semester.

5.3 Fourth Phase

This phase consists of re-validating the measuring instrument and establishing the norm if the instrument is validated. However, this stage will be to refine and modify the instrument if the questionnaire is found to be not valid. If the questionnaire is found to be valid, the same instrument will be distributed to a larger sample of about sixty participants. The larger sample can further validate the instrument and provide additional evidence of reliability and validity. The same participants will be asked to rate the survey instrument again which is to be used as a confirmative measure. Other learners in a much wider context will also be surveyed

so as to form a more reliable data source. Quantitative analysis will be performed to find out if there is any difference between the demographics of learners such as gender, level of studies, areas of studies versus the items of the instrument. The re-validated instrument and research findings can then be used as a norm for future research and development.

References

[1] Alexander, S., "Teaching and learning on the World Wide Web", Paper presented at AusWeb95: The First Australian World Wide Web Conference, Southern Cross University, New South Wales, 30 April - 2 May, (1995).

[2] Baecker, R. M., Small, I., "Animation at the Interface". In B. Laurel (Ed.), The Art of Human-computer Interface Design (pp. 251-268), Reading, MA: Addison-Wesley, (1990).

[3] Becker, D., & Dwyer, M., "Using hypermedia to provide learner control", Journal of Educational Multimedia and Hypermedia, Vol. 3, No. 2, pp. 155-172, (1994).

[4] Burton, J. K., Moore, M., & Holmes, G. A., "Hypermedia concepts and research: An overview", Computers in Human Behaviour, Vol. 11, No. 3 & 4, pp. 345-369, (1995).

[5] Cho, Y., "The nature of learners' cognitive processes in learner-and program-controlled hypertext learning environments", Unpublished doctoral dissertation, University of Texas at Austin, (1995).

[6] Dillon, A., and Zhu, E., "Designing Web-based instruction: A human-computer interaction perspective", In B. H. Khan (Ed.), Web-Based Instruction (pp. 221-224) Englewood Cliffs, NJ: Educational Technology Publications, (1997).

[7] Galliers R. D., "Choosing information systems research approaches", In R. D. Galliers (Ed.), Information Systems Research - Issues, Methods and Practical Guidelines (pp. 144-162) Blackwell Scientific Publications, (1992).

[8] Garhart, C., & Hannafin, M., "The accuracy of cognitive monitoring during computer-based instruction", Journal of Computer-Based Instruction, Vol. 13, No. 3, pp. 88-93, (1986).

[9] Gay, G., Trumbull, D., & Mazur, J., "Designing and testing navigational strategies and guidance tools for a hypermedia program", Journal of Educational Computing Research, Vol. 7, No. 2, pp. 189-202, (1991).

[10] Grover, V., Lee, C. C., and Durand, D., "Analyzing methodological rigor of MIS survey research from 1980-1989", Information & Management, Vol. 24, pp. 305-317, (1993).

[11] Hackbarth, S., "Introduction to special issue on Web-based learning", Educational Technology, Vol. 37, No. 3, pp. 5-7, (1997).

[12] Hansen, L, and Frick, T. W., "Evaluating guidelines for Web-based course authoring systems", In B. H. Khan (Ed.), Web-Based Instruction (pp. 299-312) Englewood Cliffs, N.J.: Educational Technology Publications, (1997).

[13] Henderson, L., "Instructional design of interactive multimedia: A cultural critique", Educational Technology Research and Development, Vol. 44, No. 4, pp. 86-104, (1996).

[14] Hyman, H. H., Cobb, W. J., Feldman, J.J., Hart, C. W., and Stember, C. H., "Interviewing in Social Research", Chicago: University of Chicago Press, (1975).

[15] Jacobson, M., & Spiro, R., "Hypertext learning environments, cognitive flexibility and the transfer of complex knowledge", Journal of Educational Computing Research, Vol. 12, No. 4, pp. 301-333, (1995).

[16] Jones, B., "Cultural maintenance and change", Media Information Australia, 69 (August), pp. 23-37, (1993).

[17] Jones, C. V., "Visualization and Optimization", Norell, MA: Kluwer Academic Publishers, (1996).

[18] Jones, M.G., Farquhar, J.D., & Surry, D. W., "Using metacognitive theories to design user interfaces for computer-based learning", Educational Technology, Vol. 35, No. 4, pp. 12-22, (1995, July – August).

[19] Kearsley, G., "The World Wide Web: Global access to education", Educational Technology Review, Winter No. 5, pp. 26-30, (1996).

[20] Khan, B. H., "Web-Based Instruction (WBI): What is it and why is it?", In B. H. Khan (Ed.), Web-Based Instruction (pp. 5-18) Englewood Cliffs, N.J.: Educational Technology Publications, (1997).

[21] King, J. L., "Commentary" In K.L. Kraemer (Ed.), J. I. Cash, Jr., and J. F. Nunamaker, Jr. (Series Eds.), The Information Systems Research Challenge: Survey Research Methods, 3 (pp. 291-29). Harvard Business School Research Colloquium, Boston, MA.: Harvard Business School, (1991).

[22] Kraemer, K. L., and Dutton, W. H., "Survey research in the study of management information systems", In K.L. Kraemer (Ed.), J. I. Cash, Jr., and J. F. Nunamaker, Jr. (Series Eds.), The Information

Systems Research Challenge: Survey Research Methods, 3 (pp. 3-57), Harvard Business School Research Colloquium, Boston, MA.: Harvard Business School, (1991).

[23] Lohr, L., "Development of a procedure for GUI design". In R. E. Griffin, W. L. Gibbs, & B. Wiegmann (Eds.) Visual literacy in an information age: Selected readings from the Annual Conference of the International Visual Literacy Association (pp. 225-233). Blacksburg, VA:IVLA, (1999).

[24] Marchionini, G., "Making the transition from print to electronic encyclopaedias: Adaptation of mental models", Journal of Man-Machine Studies, Vol. 30, pp. 591-618, (1989).

[25] McCombs, B. L., "Motivation skills training: combining metacognitive, cognitive, and affective learning strategies", In C. E. Weinstein, E. T. Goetz, and P. A. Alexander (Eds.), Learning and Study Strategies: Issue in Assessment, Instruction, and Evaluation (pp. 141-165) San Diego: Academic Press, (1988).

[26] Miller, J., and Glassner, B., "The 'inside' and 'outside' finding realities in interviews", In D. Silverman (Ed), Qualitative Research, Theory, Method and Practice, (pp. 99-112) London: Sage, (1997)

[27] Nguyen, A. T. A., Tan, W., & Kezunovic, L., "Interactive multimedia on the World Wide Web: Implementation and implications for the tertiary education sector", In M. Nott (Ed.), Proceedings of AusWeb96: The Second Australian World Wide Web Conference. Gold Coast, Australia: Southern Cross University, (1996).

[28] Nielsen, J., "Top Ten Web Design Mistakes, Jakob Neielsen's Alertbox for May", [On-line] Available http://www.useit.com/alertbox/9605.html, pp. 1-3, (1996).

[29] Porter, L. W., "Commentary to methodological issues in information systems survey research", In K.L. Kraemer (Ed.), J. I. Cash, Jr., and J. F. Nunamaker, Jr. (Series Eds.), The Information Systems Research Challenge: Survey Research Methods, 3 (pp. 287-289), Harvard Business School Research Colloquium, Boston, MA.: Harvard Business School, (1991).

[30] Reeves, T., "Effective dimensions of interactive learning systems", Information Technology for Training and Education Conference (ITTE' 92) St. Lucia, Brisbane: University of Queensland, September-October, pp. 99-113, (1992).

[31] Reeves, T., "A model of the effective dimensions of interactive learning on the world wide web", In P. Carlson & F. Makedon (Eds.), Interactive multimedia and hypermedia, 1996 Charlottesville, VA: AACE, (1996).

[32] Robinson, E. P., Jr., Gao, L., and Muggenborg, S.D., "Designing an Integrated Distribution System at DowBrands, Inc.", Interfaces, Vol. 23, No. 3, pp. 107-117, (1993).

[33] Rossman, P., "The emerging worldwide electronic university: Information age global higher education", Westport: Greenwood Press, (1992).

[34] Silverman, D., "Interpreting qualitative data: Methods for analysing talk, text and interaction", London: Sage, (1993).

[35] Wild, M., "Invited Presentation: The future of flexible learning and the use of technologies in tertiary education", Open Learning Seminar, University of Technology, Sydney. 15 July, (1996).

Acknowledgements

We are very thankful to all the participants and our research assistant, Miss Judy Mok, for their support to this research study. We are also grateful for the Hong Kong Institute of Education's financial support for this project RG4/1999-2000.

Developing a Web Concordancer for English as Foreign Language Learners

Howard Hao-Jan Chen
Division of Foreign Languages
National Taiwan Ocean University
2, Pei-Ning Road, Keelung, Taiwan 202.
E-mail: b0240@mail.ntou.edu.tw

Quite a few tools and techniques of corpus linguistics have been applied to foreign language teaching and learning. One of the most popular learning tools is the concordancer. It helps language learners to efficiently uncover hidden linguistic patterns in large amount of data and to answer their own questions about the target languages. This type of data-driven language learning has been highly recommended by second language teachers and researchers. However, good concordancing programs and suitable corpora in fact are not widely accessible for second language learners, so many learners cannot participate in data-driven learning. As Internet/World-Wide-Web has become the best platform for distributing educational resources, a web concordancer will provide a data-driven learning environment to students from anywhere at anytime. This paper first reviews several web-based concordancers for ESL/EFL learners (CobuildDirect Corpus Sampler, Hong-Kong Polytechnic Web Concordancer, and Web Concordancer for Gutenburg texts). Then the strengths and weakness of each of these web sites are identified and compared. The last section describes how language faculty at National Taiwan Ocean University (NTOU) develops a web concordancer for Taiwanese EFL learners. It is expected that this web concordancer will be able to provide Taiwanese EFL learners a fast, reliable, and user-friendly environment for data-driven learning.

Keywords: **Web-based English Learning, Data-Driven Learning, Concordancer**

1 Introduction

1.1 Corpus and Concordancer

Linguists working in the Chomskyian paradigm have been using native speakers' intuitions as the key data for linguistic research. More recently, some linguists no longer rely on their intuitions as the main data source, and they have also begun to analyze large amount of written and spoken texts (i.e., corpus) to uncover hidden linguistic generalizations. McArthur & McArthur [7] provided a very clear explanation regarding corpus and corpus linguistics.

> CORPUS [13c: from Latin corpus body. The plural is usually corpora]. (1) A collection of texts, especially if complete and self-contained: the corpus of Anglo-Saxon verse. (2) Plural also corpuses. In linguistics and lexicography, a body of texts, utterances, or other specimens considered more or less representative of a language, and usually stored as an electronic database. Currently, computer corpora may store many millions of running words, whose features can be analyzed by means of tagging (the addition of identifying and classifying tags to words and other formations) and the use of concordancing programs. Corpus linguistics studies data in any such corpus ...

In the past several years, since corpus linguistics has become a very exciting subfield of linguistics. Numerous electronic corpora were created, some of the most well known ones are the followings: Brown Corpus (text samples, American English), Lancaster-Oslo-Bergen Corpus (LOB; text samples, British

English), London-Lund Corpus (spoken British English), BNC (British National Corpus). Since a corpus often contains millions of words, corpus linguists need to use concordancing programs to uncover the patterns hidden in the huge amount of linguistic data. A concordance, in its simplest form, is an alphabetical listing of the words in a text, given together with the contexts in which they appear. The most common form of concordance today is the Keyword-in-Context (KWIC) index, in which each word is centered in a fixed-length field (e.g., 80 characters). Concordances of the word 'trust' are given below in Figure 1.

Figure 1. Concordances of the word Trust

[p] FOREIGN & Colonial Investment **Trust** has bowed to pressure from its 100,
being able to go one step further and **trust** in the love of another. [p] It took
for his friends, the House put its **trust** in him and together they faced the
all of his AIDS work. He cajoled the **Trust** into recognising its international
Status [/h] [p] T U European **Trust** is an Authorised Unit Trust Scheme
is that Sinclair, like most second **trust** lenders, doesn't want a 30-year
his grandfather was of Hitler. We **trust** many other Tory MPs will follow his
told him. I don't think he will ever **trust** me again but he had to admit he had
is a unit trust or investment **trust**-only PEP, as you can look up the trip. [p]
[p] Visit the National **Trust's** amazing Victorian folly garden at

More than a dozen of good concordancing programs are available, some well-known programs are the followings: MonoConc Pro, TACT, Word Cruncher, and WordSmith. One computer screen shot of MonoConc Pro is shown below in Figure 2. The lower window shows all the single-line concordances and the upper window shows the larger context of a certain selected concordance.

Figure 2. The Screen Shot of the MonoConc Pro Program.

The applications of corpus linguistics are numerous. According to Cathy Ball [1], these applications can be further divided into the following major domains.

1. Linguistics: to study linguistic competence or performance as revealed in naturally-occurring data. Most applications will require or lead to the creation of annotated text.
2. Diachronic linguistics: texts are all we have; introspection worthless; better to analyze a systematic collection of data than to reuse/reanalyze others' examples.
3. Computational linguistics: to train/test a natural language processing system on a representative sample of the kinds of texts the system is expected to process; to build large lexicons in a given domain ...
4. Applied linguistics: First/second language acquisition research: supplement/replace elicitation, as in 'Linguistics' above
5. Language teaching/learning: language for specific purposes (e.g. use newspaper corpora, corpora of scientific texts); to prepare vocabulary lists based on high-frequency lexical items; to prepare CLOZE tests; to answer ad hoc learner questions ('What's the difference between few and a few?'); to discover facts about language.

Geoffrey Leech [5], a prominent corpus researcher at Lancaster university, pointed out that "...while computers were limited to large mainframes available to the initiated few, computer corpora were largely restricted to research use. But as computers have grown smaller, cheaper, and massively more powerful, their use in teaching has grown immeasurably."

1.2 Data-Driven Learning and Classroom Concordancing

BEST COPY AVAILABLE

In recent years, the use of corpus in language teaching and language learning has grown steadily both in Europe and United States. One key approach to corpus in language teaching is the Data-Driven Learning (DDL) or Classroom Concordancing advocated by Tim Johns at Birmingham University. According to Odlin [8], Data-driven learning is an approach to language teaching that gives central importance to developing the learner's ability to "puzzle out" how the target language operates from examples of authentic usage. This approach is particularly associated with the use of computer concordances in the classroom but can be extended to other situations where the students has to work inductively from authentic data. According to Johns [3] data-driven allows language learners to explore a large amount of authentic target language texts by using the searching and indexing power of computer. This approach to second language learning is not only innovative but also powerful since it can help learners to resolve their own learning problems and help them to become independent second language learners.

Kettemann [4] and Stevens [9] suggested that there are several advantages of using data-driven learning. First, concordances give students easy and immediate access to authentic language production with many different styles and genres. Second, a concordancer is an extremely powerful hypothesis testing device on vast amount of data. It allows controlled speculation, makes hidden patterns of language use readily apparent, thus, enhances inductive thinking and exploratory leaning. Through using the concordancer on a regular basis, learners begin to develop strategies for dealing with a wide variety of texts. As a result of this kind of text analysis, learners are able to use concordance as a way of increasing their knowledge of English. Third, DDL allows students to interact with text actively and analytically and allow students to question, explore the word forms, usage, vocabulary, collocation, grammatical features, syntax, and stylistics. Learners assume control of the learning process.

2 The Underuse of Concordancing Tools

As mentioned above, the data-driven learning or classroom concordancing is such an empowering and innovative learning environment. It is an extremely useful tool for learning word usage and grammar of a foreign language. Leech [5] stated that "there is every reason to believe that language corpora will have a role of growing importance in language teaching." Researchers in different locations have been recommending it to language teachers and learners around the world. Nevertheless, classroom concordancing remains not as popular as it deserves to be. Why such a powerful learning tool and environment cannot be more popular?

John Flowerdew [2] pointed out several problems encountered when working with this new and exciting medium. First, many of the concordance lines will contain language which is beyond the proficiency level of the learners. Second, if single-line concordances are used, not all concordance lines may provide enough contexts to make the meaning clear. Third, depending on the size of the corpus and the frequency of the item chosen for concordancing, the concordancer may provide too few or too many examples of the particular usage to be illustrated. Moreover, Ma [6] also highlighted the importance of learner training. It is essential to familiarize learners with the new learning tool and environment before they can benefit from exploring the new environment.

In addition to the problems pointed out by Flowerdew, we believe that the accessibility to searching tools and corpora is another serious obstacle of making data-driven learning more popular. Both good concordancers and corpora mentioned above are not widely accessible to language learners. School or Institutes need to purchase and install good concordancing software on personal computers. Moreover, though there are many electronic texts available on the CD-ROMs and Internet, most texts are copyrighted and teachers cannot freely distribute them to second language learners. Furthermore, some hand-on training on the uses of the concordancing software is necessary since programs have rather different searching interface and functions. Even some educational institutes want to purchase the license of commercial concordancer and some electronic texts are available, students still need to go to the computer laboratory or computer center to use these precious learning resources. These difficulties and inconvenience in accessing concordancer and texts prevent second language learners from engaging in data-driven learning.

If language teachers and researchers can make a concordancing system easily and widely accessible to learners, it is more likely that second language learners will be more willing to explore the new learning environment. In the following sections, we will discuss how the Internet and web might be able to resolve some of the problems we outlined above.

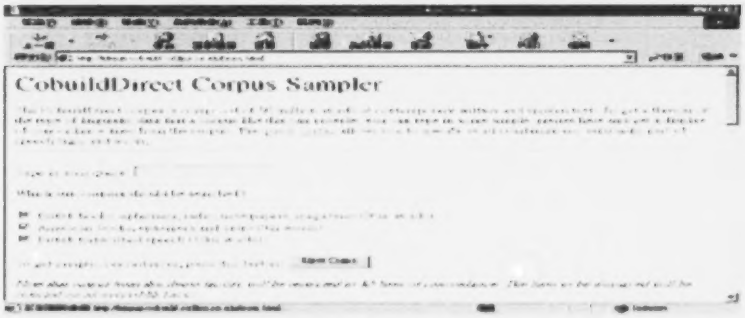
3 Web-based Concordancers

Internet and World-Wide-Web has been recommended as the most powerful platform for delivering/distributing learning materials to many learners. If a concordancing system can be made available via the Internet, second language learners can use any popular web browser to gain access to the web-based concordancing system at anytime from anywhere. They do not need to go the computer center and open the concordancer on a certain computer and load the corpus during the limited open hours.

The ideas of setting up an online concordancer loaded with text corpora have been implemented in several countries. One excellent web concordancer project is provided by Collins COBUILD project in Britain, the project generously provides a web concordancer- CobuildDirect Corpus Sampler, as an extra service for English language learners and teachers. The CobuildDirect corpus is composed of 50 million words of contemporary written and spoken text.

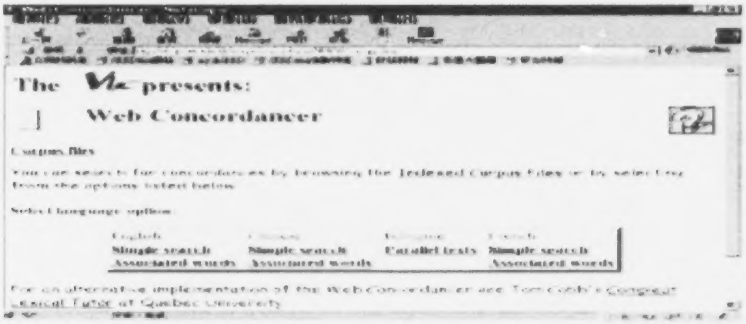
The interface of CobuildDirect Corpus Sampler is shown below in Figure 3. The user can type in some simple queries and get a display of concordance lines from the corpus. The query syntax allows users to specify word combinations, wildcards, part-of-speech tags, and so on. Because the corpus has been tagged automatically with a statistical tagger, we can specify a search on word/TAG combinations by appending an oblique stroke and a part-of-speech tag.

Figure 3. The Interface of CobuildDirect Corpus Sampler



Another interesting project is created and maintained by Chris Greaves and his associates at the virtual language center of Hong-Kong Polytechnic University. The interface of web concordancer is shown below in Figure 4.

Figure 4. Web Concordancer at Hong-Kong Polytechnic University



One interesting web site in the U.S. which is completely based on the Gutenburg electronic texts offers a simple Web-based concordancer, as shown in Figure 5. Although the searching options of this site are not as comprehensive as those of the other two sites mentioned above, it offers an easy-to-use web system for language learners to explore.

Figure 5. The Interface of Gutenburg Concordancer

4 The Strengths and Weakness of the Existing Web-Based Concordancing Systems

All these web sites mentioned above are useful for ESL/EFL learners. However, each of these web sites has different strengths and weakness. In the following sections, we will examine the three web concordancers more closely and compare their strengths and weakness.

4.1 CobuildDirect Corpus Sampler

CobuildDirect Corpus Sampler is one of the most powerful web concordancer. Its strengths include the wider coverage of texts (50 millions words), tagged corpora which allow learners to specify words and their specific POS (part of speech) or a certain POS tag followed by a keyword. With this powerful search option, learners can specify the words with their part-of-speech. For instance, if they want to find the usage of trust as a verb, they can simply specify the query as trust/VERB.

Its weakness for ESL/EFL learners outside of Britain includes the slow connection speed, single-line concordance output without larger contextual information, and the limited numbers of concordance output. Many students in our writing classes complain that the connection to this site via TANET (Taiwan Academic Network) is fairly slow. They often lose their patience to search the words they want to know more about because of the poor Internet connection. Besides, the system only generates single-line concordance, so the contextual information is fairly limited. The users cannot look at the larger contexts to better understand the usage of the keyword. Last, since this is a sampler, the system at most can only supply about 40 examples for a particular query; this might not be enough for words with complicated meaning and usage.

4.2 Hong-Kong Polytechnic University

Compared with the CobuildDirect Sampler, the Hong-Kong Polytechnic University web concordancer has a faster connection. In addition, it also allows learners to click on the keyword to expand a single-line concordance to view its larger context, as shown in Figure one above. As for its weakness, the connection speed to this site is still not adequate but it is faster than the speed to COBUILD site. Besides, the corpora available online at Polytechnic University are not tagged with part-of-speech tags, so the Polytechnic web concordancer does not allow for words plus POS tags search. Students indicate that they sometimes need to search a word with a particular part-of-speech so that they can locate the specific information they need more efficiently.

4.3 The Gutenburg Concordancer in the U.S.

This site is not as popular as the two sites mentioned above. All of its corpora came from the well-known Gutenburg free electronic text project, and it contains about 80 million words. Gutenburg offers the electronic texts without copyright problem. However, based on our test, this site has the slowest connection from Taiwan. Moreover, the users can only search one text file at a time, so they often cannot find the words they want to know about. All the texts are also not tagged.

BEST COPY AVAILABLE

The following table summarize all the strengths and weakness of these three different web concordancers.

Table 1. The Comparison of Three Different Web Concordancers

	Hong-Kong PolyTechnic Web Concordancer	COBUILD Sampler	Gutenburg Web Concordancer
Connection Speed	Moderate speed	Slower	Slowest
Larger Contexts for Keywords	Available	Not available	Not available
Tagged Texts	Not tagged	Automatic tagged	Not tagged
Text Coverage	Several million-word text files	Several large corpora about 50 million words	About 80 million words
Learner Corpora	Available	Not available	Not available

5 National Taiwan Ocean University (NTOU) Web Concordancer

With a research grant from NSC (National Science Council) of Taiwan, a research team at National Taiwan Ocean University created a web concordancer. In this project we not only try to provide a faster and more reliable concordancing system open to all interested English teachers and users but also try to overcome some weakness of currently existing web-based concordancers.

Based on the comparison of the three major web concordancers. We would like to create a web concordancer with the following features and options for Taiwanese EFL learners and teachers.

1. Fast and reliable connection and quick response.
2. Large corpora for ESL/EFL learners and teachers (including both NS corpora and NNS learner corpora).
3. Larger contexts for any searched word.
4. Tagged corpora files that allow learners/teachers to search words with POS tags.

Since we have only limited funds, we do not expect to surpass the commercial web site such as Collins COBUILD or the well-funded project of Hong-Kong Polytechnic University. We aim at creating a fast, reliable, and friendly web concordancer for Taiwanese EFL learners and teachers. We will discuss the four goals outlined above in details in the following sections.

First, the connection to NTOU web concordancer can be faster since it is built on the TANET. For TANET user, our web concordancer will be able to respond to learner's queries within 15-20 seconds. Moreover, to increase the searching speed, we reduce each corpus size to around 10-15MB. This is a technique adopted at Hong-King Polytechnic University.

Second, we expect to have large corpora. Due to the copyright restrictions, we have to rely mainly on the free electronic texts from Gutenburg projects. We are also negotiating with several local English newspapers about putting their electronic texts online for educational purpose. In addition to the native speaker corpora, we also have a smaller learner corpus available. During the past three years, we have been collecting English writing samples of Taiwanese college students. Now we have a 200,000-word EFL learner corpus, and this corpus will be a very precious resource for language teachers or researchers to better understand Chinese EFL learners' interlanguage. The interface of NTOU web concordancer is shown below in Figure 6.

Figure 6. Interface of NTOU Web Concordancer

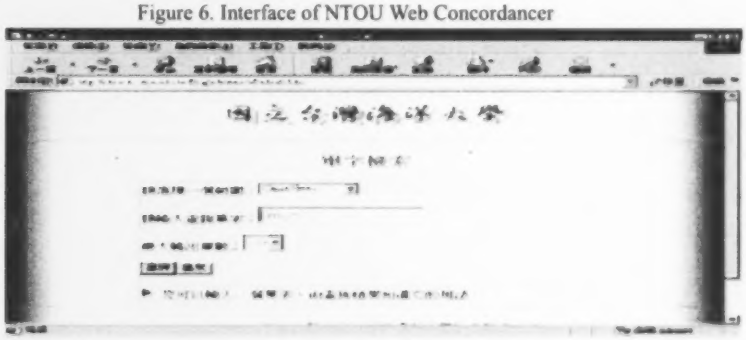


Figure 7. The Web Concordance Output

Third, since the display of larger linguistic contexts are fairly important when learners analyze the usage or the meaning of particular words or phrases. To make the data-analysis process more efficiently, NTOU web concordancer allows learners to have a convenient access to the larger context by clicking on any single-line concordance, as shown in Figure 7. An instance of the contextual information is shown below in Figure 8.

Figure 8. Larger Linguistic Context of a Concordance

Last, some learners indicated that they prefer to have the option of searching both words/phrases and POS tags when using web-based concordancers since a tagged corpus can help learners to filter out irrelevant information and help them locate the information they need more efficiently. Though the text tagging process could be time-consuming and difficult, we have adopted some tools to create tagged corpora. The tools and techniques used in our project are described below.

5.1 Tagged Corpora

Tagging a corpus with millions of words manually is not feasible. How can COBUILD project provide such a wonderful service? In fact, they use their automatic POS taggers to carry out the POS tagging. For our project, we also purchase a useful tagger to accomplish the daunting tagging tasks.

In fact, there are quite a few taggers available. We have compared various taggers and consider the limited resources we have in hand. We decided to adopt the inexpensive automatic POS (part-of-speech) taggers, the TOSCA tagger, to annotate the corpora. The TOSCA Research Group is a team of corpus linguists at the University of Nijmegen. One focus of their research is on the development of Tools for Syntactic Corpus Analysis (TOSCA). Its tag set consists of 17 major wordclasses. With features for subclasses and additional semantic, syntactic and morphological information, the total number of different tags is 220.

It is not possible for ESL teachers or learners to use the 220 tags. So we decide to keep the system simple by converting the detailed tagging system into to the major 17 word classes so users can use these tags more easily. For instance, if one needs to know the usage of 'issue' as a verb, then he/she can input a query, issue/VB, to the system. The outcome of word plus tag search is shown below in Figure 9. The POS tags would allow users to search the corpora more efficiently.

Figure 9. Search Outcomes of Word plus Tag

be so confident. The tribunal will **issue** indictments whether or not suspects
within seven days. [p] 3.4 We can **issue** instructions to you and Cardholders
be inflationary, the Fund would only **issue** notes when they were backed by its
KITCHEN Ideas [p] Welcome to **issue** number two of 'Kitchen Ideas',
papers. 'The 13th Air Force can't **issue** orders for you to travel to
on May 16 and September 14 to **issue** passenger service requirements in
but warranted clubs are entitled to **issue** permits to members' yachts as long
The Board has no immediate plans to **issue** preference shares. However, it
A limited company that does not **issue** shares for public subscription, and
Welna: The Swiss, in fact, do plan to **issue** statements similar to the EC's
complaints is that Greece will not **issue** visas at the border as Yugoslavia

6 Conclusion

Although NTOU web concordancer has been set up and running for a short period of time, students at NTOU show positive attitude toward this new learning tool. Some students suggest that the web site should be introduced to the whole university community since they found the searching tool to be useful for English learning. It is rather encouraging to receive students' positive feedback.

However, there are still difficulties in using web concordancers. According to Sun [10], the problems of using web concordancers can be divided into two categories: one related to computing resources, another related to the difficulties of using or interpreting the concordance output. For computing resources, NTOU web concordancer still has much room for improvement. For instance, we need put in more suitable text corpora and the search speed should be faster. Besides, the automatic tagging of texts still contains some serious errors.

As for the difficulties of using or interpreting the concordance output, Ma [6] and Sun [10] pointed out that learners need training on using concordancer. For learner training, we might create an online tutorial on the use of concordancer so learners can use the system more effectively. Sun [10] also indicated that it is rather time consuming to do data analysis. Sun pointed out that the concordance output seems too large to be manageable in some cases, and learners can be overloaded with information. In fact, a corpus contains either too much or too little information would cause troubles for language learners. Flowerdew [2] points out that we need to choose our corpora more carefully and make sure the corpora will meet the needs of learners. We will continue to collect users' feedback and further improve our concordancing system.

References

[1] Ball, C., "Tutorial notes: Concordances and corpora", http://www.georgetown.edu/cball/corpora/tutorial.html, (1996).

[2] Flowerdew, J., "Concordancing in language learning", The Power of CALL, Athelstan, pp. 97-113, (1996).

[3] Johns, T., "From printout to handout: Grammar and vocabulary teaching in the context of data-driven learning", Perspectives on Pedagogical Grammar, Cambridge University Press, 293-313, (1994).

[4] Kettemann, B., "On the use of concordancing in ELT", TELL&CALL, VOL 4, pp. 4-15, (1995).

[5] Leech, G., "Corpus linguistics and language teaching", Teaching and Language Corpora: a Convergence. Longman Press, pp.1-24, (1997).

[6] Ma, K. C., "Classroom concordancing: How and what students learn", Unpublished M.A. thesis, City Polytechnic of Hong-Kong, (1993).

[7] McArthur, T. & McArthur, R. "The Oxford companion to the English language", Oxford University Press, (1992).

[8] Odlin, T., "Perspectives on pedagogical grammar", Cambridge: Cambridge University Press, (1994).

[9] Stevens, V., "Concordancing with language learners: Why? When? What?", CAELL Journal, VOL 6, No 2, pp. 2-10, (1995).

[10] Sun, Y. Z., "Web-based concordancing: challenges and opportunities for English language teaching", The proceedings of the Eighth International Symposium on English Teaching, Taipei, Taiwan, pp. 517-526, (1999).

Developing an Effective Web-Based Learning Environment for Overseas Chinese Education

Grace Chen and Kent Wang
Potomac Institute
47618 Loweland Terrace
Potomac Falls, VA 20165, USA
Grace@pidcusa.com

The world of education is in a period of rapid change. Technology in the education has recently become a primary goal of Overseas Chinese Education. Yet with all these new resources available to teachers, the opportunity for improved teaching is eclipsed by the intimidating task of finding ways to utilize computers and the Internet in a classroom environment. Overseas Chinese demographics are placing pressure on educational institutions to develop more cost-effective instructional delivery systems. In response to this pressure, education is exploring new ways of defining classrooms and utilizing distributed resources. The direction of this exploration is being guided by newly evolving technologies and information delivery systems, advances in neuropsychology and the cognitive sciences, and new philosophies and educational paradigms. The introduction of the Internet in Overseas Chinese Education has been the seminal event precipitating the emergence of one such paradigm characterized by fluidity of roles, individual learner-directed content, distributed resources, virtual facilities, and asynchronous class times. It uses technology to create learning environments with neither walls nor clocks. This paper will explore these technologies and how to develop an Effective Web-based instruction Learning Environment for Overseas Chinese Education.

Keywords: **WBI, Web-based Learning, Instruction Design, Overseas Chinese Education**

1 Introduction: The Need for WBI

As education explore new delivery systems and environments, it is necessary to observe and evaluate their effects on instructional quality and student learning. Some seek to shift the bulk of instruction to distance and distributed environments as a solution to the problems facing Overseas Chinese education today. Traditional, synchronous delivery methods utilizing physical facilities, teachers, and students have been through countless iterations and refinements. Their interactions and effects have been measured. The role of reading materials, visuals, lectures, feedback, demonstrations, and student dynamics has all been observed over many years. Before abandoning or reducing the traditional, it is necessary to ensure any modifications of existing paradigms will result in instruction that is at least as beneficial to both learners and educators as the existing one. Numerous reform movements and technical innovations have been introduced into classrooms in recent years. We have learned that these changes will not be accepted unless they are perceived to be beneficial for both teachers and students.

2 The Web Impact Instruction Design

Several things generally happen as teachers begin to use the Internet. The first occurs as teachers realize their pedagogical style needs to change if they intend to use the Internet significantly for teaching. This is typically a gradual shift but pedagogical styles do seem to change because of the robust nature of resources

available and the difficulty of control over Internet usage. Some research on non-Internet network teaching activities also supports this idea. Generally, studies have found that when technology is introduced into the classroom, students experience an increase in motivation and self-esteem, accomplishment of more complex tasks, development greater technical skills and utilization of outside resources. Few studies, however, exist on the effects on student learning in distributed environments.

By combining the attributes of both Delivery of Content and System Management, and by answering in the positive the questions/issues unique to each, the instructional web-page developer will be more likely to create a strong and viable system/program that will teach, train, instruct, etc, all those whom they hope to educate via their instructional web sites. By adhering to these attributes, such a system can truly be called an Instructional System.

3 Creating good Web-based instruction

Not only does Web-based instruction need to follow good instructional design principles, but it needs to conform to good teaching practices and sound Web design principles as well. The first question educators should ask themselves before deciding to convert a course to the Web is, under the existing circumstances, is the Web itself an appropriate delivery medium.

Simply putting a course online because it is a new technology is not sufficient cause to justify the development time and cost. Another major concern is whether the online course will provide for the same level of quality teaching that a traditional class offers. Students will not accept the course if they perceive that it will be inferior.

Creating good Web-based instruction is not simply putting lecture notes online nor is it merely creating a virtual library of links to content related sites. It includes ensuring that good instructional, teaching, content, cognitive, visual, and usability design principles are followed as well as ensuring that it fulfills both teacher and student needs. Users need to perceive WBI as following objectives:

- **The Online Syllabus**
  An online syllabus provides the instructor with a way to change course material easily, and the student with a complete and up-to-date picture of the course requirements. The format need not duplicate the print version. Hypertext links to sample relevant disciplinary web sites may be helpful in giving students a sense of the disciplinary context for the course.

- **Personal Home Pages**
  Personal home pages can be used to foster the sense that the class is not just a collection of isolated individuals but a community of learners who can profit from interacting with one another. Home pages encourage students to learn about each other so as to encourage contact and mutual interests.

- **Interactivity**
  Adding discussion forums and chat sessions to your online course is a common way to add an interactive component to a web-based course. There are many implementations of bulletin board and chat session software to choose from. A second method of interactivity is, of course, e-mail. It's a good practice to have an online list of the e-mail addresses of all students.

- **Assignments**
  The web page listings of homework assignments, upcoming events and exams can be more interactive than the familiar print counterparts. If some homework assignments, for example, are based on online materials, they can be directly linked to the class schedule.

- **Announcements**
  To be effective, announcements need to be read; for that to happen, students need to know when a new announcement has been posted. Alert sounds or perhaps a blinking link added to a page can let students know of new announcements, or perhaps, even a mass e-mail to all students in the course.

- **Testing**
  Online drill or practice testing can be used to reinforce material, even if the results are not used as part of a grade. Reading comprehension questions, for example, in short answer or multiple choice

formats can provide students with an assessment of their level of understanding of text.

- **Content**
  Perhaps the most difficult part of developing a web-based course is creating the online content. You can begin by transferring your basic lecture materials to the web and integrating media such as sound, images, and video. Remember, to experiment with incorporating some of the new web-based learning paradigms described above.

4 Summary

In conclusion, developing an effective Web-based learning environment for Overseas Chinese education is not simply putting lecture notes online nor is it merely creating a virtual library of links to content related sites. It includes ensuring that good instructional, teaching, content, cognitive, visual, and usability design principles are followed as well as ensuring that it fulfills both teacher and student needs.

Developing an IT-immersion Environment to Enhance Learning and Teaching in Design and Technology

LO Ting Kau*, AU Wing Kee, and YIP Wai Ming*****
The Hong Kong Institute of Education
10 Lo Ping Road, Tai Po, N.T., Hong Kong
*E-mail: * tklo@ied.edu.hk, ** wkau@ied.edu.hk, *** wmyip@ied.edu.hk*

Design and Technology (D&T) as a school subject aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society. Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. This article discusses the ways that IT can be made relevant to the learning and teaching of D&T and in teacher education. It then describes the development of an ongoing project[#] which aims at developing an IT-immersion environment to enhance learning and teaching of D&T at a teacher education institution in Hong Kong. The setting up of this information-rich, collaborative learning environment is to complement "traditional" lab-based approach to learning and teaching of Computer Aided Design (CAD) and Computer Aided Manufacture (CAM).

Keywords: **IT-immersion, Learning Environment, Design and Technology, Teacher Education**

1 Introduction

Design and Technology (D&T) as a school subject "aims to provide learning opportunities for students to develop the technological awareness, literacy, capability and lifelong learning patterns that they need to live and work effectively in an ever changing technological society." [3] Information Technology (IT) is quickly transforming education by breaking down the traditional boundaries of learning and teaching. [5] IT is also being regarded as an effective tool for learning and teaching D&T in two main areas, namely:

- ***IT as a tool.*** IT can support many aspects of designing and making in D&T. For example, information processing and presentation, modelling, computer-aided design and manufacturing, control and communication.
- ***IT as a source of knowledge.*** Here, IT is being regarded as a source of knowledge to learn about materials, equipment, designing and manufacturing. This encompasses CD-ROM information systems, and the use of local or online databases accessible over the Internet. [2] [6]

2 IT in Education Policy in Hong Kong

The Hong Kong Special Administrative Region (HKSAR) Government launched its IT in Education Policy in 1998. [1] [5] According to this policy, Hong Kong teachers will be required to reach different levels of IT Competency in Education over the next few years; and IT-supported instruction will become one of the essential instructional strategies in future. Consequently, teacher education institutions in Hong Kong will be

[#] The project entitled "Development of an IT-immersion Environment to Enhance the Teaching and Learning of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM)" is supported by the Teaching Development Grant (TDG) administrated by the HKIEd, which is granted by the University Grants Committee (UGC), Hong Kong.

required to integrate in their pre-service programmes IT competency elements such as producing courseware, applying the skills of computer-aided instruction, and using various electronic networks for peer support and collaborative learning.

3 The Project

The following sections describes an ongoing project which aims at developing an IT-immersion environment to enhance learning and teaching in D&T at the Hong Kong Institute of Education (HKIEd), the major provider of D&T teacher education in the territory. This project is a response to the HKSAR Government's urge for the integration of IT to enhance the effectiveness of learning and teaching in teacher education institutions. [1][5] The initial target group of the project is student teachers undertaking D&T at the Institute. This target group will continually widen and might eventually include practising teachers in D&T and other technology-related subjects in Hong Kong secondary schools.
The project aims to:

- develop an IT-immersion learning environment for student teachers majoring in D&T, especially focused on areas of CAD and CAM;
- develop appropriate courseware for the enhancement of learning and teaching of basic and selected topics on CAD and CAM;
- develop an appropriate web-interface for students and staff to enhance face-to-face classroom interactions;
- enable students to appreciate modern techniques of product design and prototype making through the use of CAD and CAM technologies.

4 IT-immersion Learning Environment for D&T

Davies [4] suggests that an ideal learning environment for D&T is one where the learners have maximum autonomy and are working on self-directed projects and teachers are constantly assessing with pupils where they are and where they need to go. The IT-immersion learning environment under discussion utilises some of the attributes and resources of Web-based learning and adopts a constructivist approach to create a meaningful learning environment where learning is fostered and supported. This IT-immersion environment, we believe, would facilitates greater interaction between the teacher and students, and students and students; assist D&T student teachers transit to the new mode of learning and teaching, and enable them to develop habits of life-long learning. To effect the paradigm shift from a largely teacher-centred approach to a more interactive and learner-centred approach, it is important that D&T student teachers appreciate the need for the change and are receptive to the challenge of taking up their new role as a learning facilitator in future.

Key features of the IT-immersion environment include:

- ***Learner-centred, time and space independent learning***. With the use of Web-based instructional materials, students are allowed to progress at their own pace and at any time and space.
- ***Changing Roles of Teachers and Students***. In the IT-immersion environment, the role of the teacher changes from knowledge provider to that of facilitator and guide. Conversely, students are no longer passive learners. They become participants, collaborators in the creation of knowledge and meaning.
- ***Self-directed Learning***. One increasingly important competency in the future society will be "self-directed learning". In the IT-immersion environment, students continually learn to use IT tools for the accessing, processing, and transformation of information into new knowledge.
- ***Just-in-time Learning***. "Just-in-time learning" [7] implies a high level of individualisation and self-direction in the learning process. Each student learns just what he/she needs at the time when he/she needs it. This is a radical diversion in the instructional delivery system from place-based and time-fixed group instruction to one that is fully under learner-control.
- ***Individual differences accommodated***. Learning is a complex process that takes place as an interaction between learners and their environment. The interactive multimedia and hypermedia capabilities of Web-based and CD-ROM based instructional materials would enable student control over timing and pacing and provide interactivity and active learning.
- ***Collaborative / Cooperative Learning***. Collaborative learning in this IT-immersion environment regards that both teachers and students be active participants in the learning process. The Web, for

instance, presents an especially good environment for asynchronous collaboration in which students work together but not necessarily at the same time. This IT-rich environment also provides ground for cooperative learning that students and teachers interact together in order to accomplish a specific goal or develop an end product which is content specific. For instance, an ad-hoc group of students, teachers, and perhaps outside experts, can come together for a particular task or design project. The group splits into distributed design teams to tackle design challenges. The design teams interact over the computer network, working cooperatively and drawing on different expertise. The design is shared over the network, evaluated, and combined into an integrated artefact or system.

It is perhaps worthwhile pointing out that in an IT-immersion learning environment, IT is still considered as a supportive tool. Its introduction supplements, and indeed may change the "traditional" learning and teaching approaches in D&T. However, it is not intended to and will not replace traditional teaching altogether. For one reason, D&T is intrinsically an action-based subject. Engagement with designing and making requires students to be active cognitively and physically. Besides, lab-based activities serve a variety of different purposes that would be unlikely replaced by other means [8], for example: (a) first hand experience of using a variety of materials, equipment and processes safely; (b) actually realise high quality products, test them and evaluate them in use; and (c) face-to-face interaction among peers and the tutor.

5 Basic Components

The IT-immersion environment comprises two major components, namely: (a) the physical component, and (b) the virtual component (Figure 1).

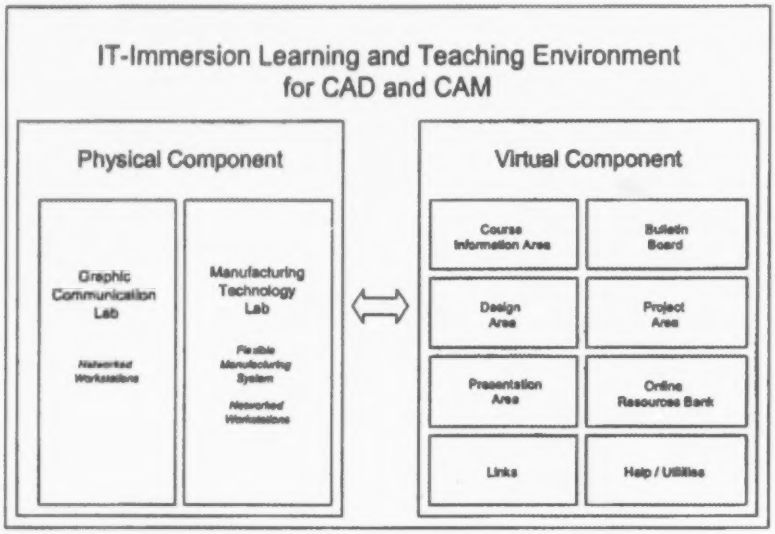


Figure 1. Major Components in the IT-immersion Learning and Teaching Environment.

The ***Physical Component*** includes facilities installed in the two labs at the HKIEd for CAD and CAM:

- ***Manufacturing Technology Lab***: A Flexible Manufacturing System (CNC Lathe, CNC Mill, and Robot), a CNC micro-router, 15 networked PC workstations, video-conferencing systems, appropriate software and peripherals, etc.
- ***Graphic Communication Lab***: 21 networked PC workstations, video-conferencing systems, digital camera, appropriate software and peripherals, etc.

The ***Virtual Component*** of the IT-immersion environment include:

- ***Course Information Area*** - for students to gain access to course-specific information such as course outlines, schedules, course materials, assignments and other course-related information.
- ***Bulletin Board*** - for teachers and students to post up announcements.
- ***Design Area*** - for supporting both synchronous communication (e.g. real-time interactive chat, used to brainstorm with teachers or peers) and asynchronous communication (e.g. e-mails) to facilitate design activities. For example, students can "talk" online and discuss their design ideas via video-conferencing and/or Internet technologies with peers, teachers or experts outside the campus who can provide them with suggestion for improvement on the design. Digital cameras can be used to record the development of models/products and to present design ideas.
- ***Project Area*** that houses students' individual and collaborative design projects. A Data Bank will be set up for students to store their design works. The Data Bank will become a central design database, accessible by all members of each of the design and manufacturing teams to ensure that all team members are working with identical information.
- ***Presentation Area*** - for students to present their projects and showcase their design work beyond the classroom and to a wider audience.
- ***Online Resource Bank*** - for teachers to upload and retrieve interactive instructional and reference materials.
- ***Internet links*** - to support teachers and students using the Internet to locate professional materials and content resources in D&T and other related disciplines.
- ***Help / Utilities.***

6 IT-enhanced Activities and Learning Experiences

In the IT-immersion environment, student teachers are provided with the opportunities to use IT to explore, develop, model, communicate and realise their design ideas in a variety of ways. As such, IT becomes an integrated and natural part of their study in D&T. More specifically, to take as an example, video conferencing technology can be used as an effective medium for developing new ways of learning and teaching D&T and introducing teachers and students to various aspects of information, communications and design technologies. Using the latest information and communications technology provides the opportunity for expertise and resources to be made available to pre-service and practising D&T teachers off-campus from the HKIEd. Via video conferencing systems or the Internet, they can work collaboratively together on concurrent design projects, discuss problems and jointly solve them, and exchange ideas and information.

In brief, working in an IT-immersion environment would help D&T student teachers to understand how to become discerning users of available hardware and software. This in turn, would help them to understand what IT can and will do to enhance their future pupils' learning in D&T.

7 Conclusion

This paper discussed the potential of an IT-immersion approach to provide D&T student teachers with a richer, more meaningful education relevant for the future workplace and learning environments. It is also suggested that this IT-immersion approach can be used in a mixed-mode manner to support traditional lab-based approach to learning and teaching CAD and CAM. This adjunct or mixed-mode seems appropriate for a wide range of learning and teaching activities in D&T where real world experience and face-to-face interaction are essential. By using a mixture of traditional and IT-immersion instructional methods and tools, the learner can experience recent technology development and its impacts on learning. The point is to find out the right balance.

The project is still at its developmental stage, the effectiveness of the IT-immersion approach to learning and teaching D&T has yet to stand the test of time. However, the experience so far suggests that the project will be a success and will bring substantial benefits to both teaching staff and students.

References

[5] Au, W. K., Kong, S. C., Leung, K. P., Ng, M.W. & Pun, S. W., "Level of Information Technology Competency, Core Course Elements and Assessment Tool for Teacher Training in IT in Education: The Final Report", Hong Kong: Education Department, HKSAR, (1999).

[4] Barlow, J., "Computers in Technology Education", in J. Williams & A. Williams (Eds.), "Technology Education for Teachers", pp. 136-179, South Melbourne: Macmillan Education Australia, (1996).

[1] Curriculum Development Council (CDC), "Syllabus for Secondary Schools: Design & Technology (Secondary 1-3)", Hong Kong: CDC, (1999).

[6] Davies, L., "Virtually There! The Millennium", The Journal of Design and Technology Education, Vol. 4, No.1, pp. 61-64, (1999).

[2] Education and Manpower Bureau (EMB), "Information Technology for Learning in a New Era: Five-Year Strategy 1998/99 to 2002/03", Hong Kong: Education and Manpower Bureau, (1998).

[3] National Association of Advisers & Inspectors in Design and Technology (NAAIDT), "Enhancing Design and Technology through the Use of IT", Wellesbourne: The Design and Technology Association (DATA), (1995).

[7] Romiszowski, A., "Web-Based Distance Learning and Teaching: Revolutionary Invention or Reaction to Necessity? ", in B. Khan. (Ed.), Web-based instruction, pp. 25-37, Englewood Cliffs, NJ: Educational Technology Publications, (1997).

[8] Wankat, P. & Oreovicz, F., "Teaching Engineering", New York: McGraw-Hill, (1993).

Developing Web Courses Systematically

Ming-Chou Liu
National Hualien Teachers College, Taiwan
123, Hua-Hsi Rd., Hualien, Taiwan 970
Tel: +886-3-8226724
Fax: +886-8-234225
E-mail: liu@sparc2.nhltc.edu.tw

This article first examines the development needs of web-courses from a panoramic viewpoint, contemplating what is required in terms of content, user-interface and pedagogy, or CUP in short. Then the process of web-course development is studied as a system and the various stages in the process are explored. Finally graphs and tables as management tools are designed to enable the effective development of web-courses.

Keywords: **web-course, learning theories**

1 The significance of web-course

Generally speaking, the advantages of learning in the World Wide Web environment include breaking the barrier of time and space, learning without walls, and just-in-time learning [4]. The effect of learning on the Web can be analyzed with 3Ws(What, How, Why). In addition to the "know-what" of conceptual knowledge and the "know-how" of procedural knowledge, there is also the "know-why" of collaborative learning brought about by communication on network. Obviously, whether a web-course can achieve its intended effect is under the influence of the three major factors stated above. 1) Content, the proper choice of materials to be used and good design is the first step to successful learning with a web page. 2) User-interface: now that we have the teaching material as the content of the page, what about presenting the materials? That is another major issue of concern. For example, studies by Nielson(1998) and others indicate that the way many web users read web pages is scanning the pages in its entirety. Therefore, it is important to grasp the learner's attention with neatly designed web pages in which all the data are effectively organized. That leads to the learner's perception and learning of the information on the pages. Complying with the learner's cognitive process is an important issue to be considered in the design of user-interface. This definitely involves the design and arrangement of learning activities and environmental influences. 3) Pedagogical foundations: we've seen the what-to and the how-to of the way things are done, but we can't help asking why they are done this way. Creed & Plank(1998) maintain that "good web site design begins with good pedagogy." Also, Duchastel & Turcotte(1996) think that instruction design in an information-rich environment must deviate greatly from that in the traditional learning environment. For a web-course to be effective, the theoretical foundation of relevant pedagogy is indispensable; and cognitive psychology is the most important among the relevant theories.

2 Developing web-courses

From the perspective of software engineering, there are procedures and stages in the development of web-courses. Like designing traditional computer-assisted instruction (CAI) programs, various procedures and stages are involved, from choosing the subject, designing teaching materials and methods, writing the story board, to programming, testing and finishing the product. The most significant difference between web-courses and traditional CAI programs is that the former can be built incrementally; that is, new content can be added into the course at any time. In contrast, the latter is more fixed and closed in nature, usually with no possibility to make modification of addition to the content before upgrading the program to a new version. Many scholars come up with their own theories of how many stages there are in the development of web-courses [3][4], but generally their ideas are based on the structure shown in Fig.1.

The first stage spans from the conception of idea to feasibility study. If the factors of technicality, obtaining of content and effectiveness are all under control, and if the budget allows, then the developer can proceed to the second stage of detailed planning. Table 1 can serve as an excellent tool for assisting the planning in this stage.

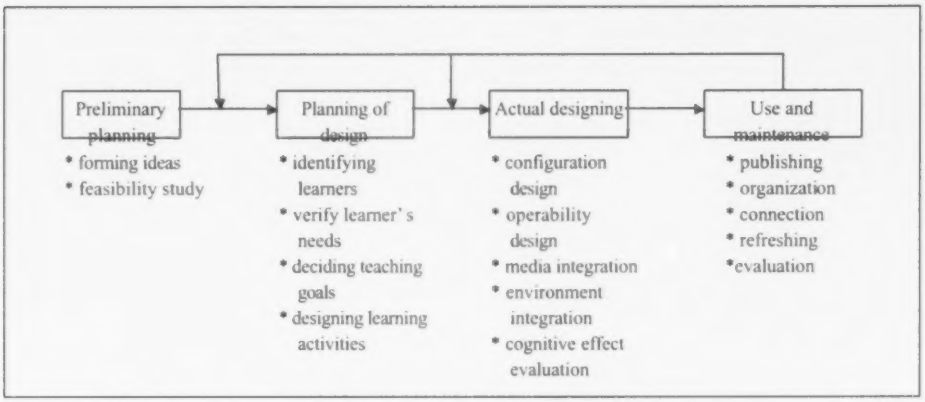


Fig.1 Stages in the development of web-courses

If the level of difficulty in the chart falls on the right side of the dotted line, then there may be practical difficulties in implementing the project. Although that does not necessarily mean the project is "dead on arrival," it surely means that further analysis and more contemplation is required. Take the planning of human resources for example: individual tasks can be put into a two-dimensional chart together with human resources for analysis, which brings about further understanding of the demand for manpower in the project and helps identifying the source that potential workforce comes from. The use of this kind of chart can also be extended to the analysis of demand for workforce in other stages (stage x manpower) and other aspects. Table 2 is an example to help the analysis of tasks and demand for manpower.

Table 1 Feasibility analysis chart for web page planning

Subject of the web page:						
Targeted users:						
Features of function: 1. 2. 3.						
Possible difficulties		**Level of difficulty**				
		None	Supposedly none	Unsure	Possibly insurmountable	Insurmountable
Technicality	1. Media production	• •	• •	• •	• •	• •
	2. Media integration	• •	• •	• •	• •	• •
	3. Interactive skills	• •	• •	• •	• •	• •
	4. programming	• •	• •	• •	• •	• •
	5. Database processing	• •	• •	• •	• •	• •
Content	1. Subject a	• •	• •	• •	• •	• •
	2. Subject b	• •	• •	• •	• •	• •
Management	1. Human resources	• •	• •	• •	• •	• •
	2. Time restraint	• •	• •	• •	• •	• •
	3. Budget restraint	• •	• •	• •	• •	• •
Projected benefits (effect on learning results)		• •	• •	• •	• •	• •
		high	medium-high	medium	medium-low	low

Table 2 Chart for analysis of tasks and demand for manpower

Task / Manpower	A.	B.	C.	D.	E.	F.	G.	H.

A. Choice of material
B. Planning of material
C. Media production
D. Media integration
E. Web page design

1. Domain expert	• •	• •			• •			
2. Teaching expert	• •	• •			• •			
3. Testing expert	• •	• •						
4. Media expert	• •	• •	• •	• •	• •			
5. Programming expert	• •	• •	• •	• •	• •	• •	• •	
6. Artwork expert			• •	• •	• •			
7. Story-board expert		• •			• •			
8. Management expert	• •	• •	• •	• •	• •	• •	• •	• •

Legend: • • : demand of high urgency • • : demand of medium urgency• • : demand in low urgency

It is more difficult to be educational with the commonly used design of web pages in general, and the ideas of education experts should be consulted. An evaluation chart as Table 3 adapted from Reeves & Reeves(1997) is very useful as a reference.

Table 3 An evaluation chart for the educational merits of a web-course

Quality	Distribution		
1. Pedagogical philosophy	Instructivist	• • • • • • • • • • •	Constructivist
2. Learning theory	Behavior	• • • • • • • • • • •	Cognitive
3. Goal orientation	Focused	• • • • • • • • • • •	General
4. Tasks orientation	Academic	• • • • • • • • • • •	Authentic
5. Source of motivation	Extrinsic	• • • • • • • • • • •	Intrinsic
6. Teachers role	Didactic	• • • • • • • • • • •	Facilitative
7. Meta-cognition	Unsupported	• • • • • • • • • • •	Integrated
8. Collaborative learning	Unsupported	• • • • • • • • • • •	Integrated
9. Cultural sensibility	Insensitive	• • • • • • • • • • •	Respectful
10. Structural flexibility	Fixed	• • • • • • • • • • •	Open

From a wider perspective, it is not advisable to limit web-courses to a fixed kind of teaching method. The nature different subjects of instruction should be considered, and a suitable corresponding teaching method should be adopted.

Although there can be many teaching methods, their intended goal is one: the optimum learning results. There is paradigm shifting in instruction design, and the resulting new trend emphasizes that the design must be learner-centered. This is learning environment development based on constructivism. Problem-based learning is a design principle pretty much in keeping with this new trend. Simply stated, the way it works is to lead learners to think and solve problems using embedded questions, therefore achieving learning results.

In the actual construction stage, the main issues for web-courses are the design and integration of content, and the user-friendliness. These are the factors that ensure the smooth delivery of the instructional content and unfettered proceedings of learning activities. When web-course development comes to the "use and maintenance" stage, the well-constructed content is published to the Internet, the IP addresses organized and managed, and all links made sure to work. The content should be updated as frequently as possible to keep it up-to-date, making the pages alive and fresh. Moreover, evaluation can be made to see whether the web-course has achieved its goals as planned, and whether the content conforms to the CUP standards. The evaluation can be formative, with the focus on whether systematic methods are used to facilitate the effectiveness of development. Or it can be summative, with the content, educational merits, user-interface, measurement design, and course design and management being examined. The content refers to the richness, organization and level of difficulty of the materials for learning. Educational merits refers to the presence of an educational objective, whether effective instruction methods are employed, etc. User-interface means whether there are well-designed page layout, well-organized components, tools provided to users to ensure easy capture of teaching material and effective learning. Measurement design refers to the presence of interaction and tests, and the validity and effectiveness of the tests. Finally, course management focuses on the effective operation of the system to facilitate

smooth progress of learning and maintaining the coherence of all data on the web site. Based on the indicators discussed above, we can develop an evaluation chart as in Table 4. Each item is rated in A(high), B(medium) or C(low), and the number of times A, B and C appear are calculated. This provides system developers timely control on the construction and content of the web-course.

Table 4 Web-course evaluation chart

Topic	Item	Effect	Note
Content	1. A clear learning subject	• A • B • C	
	2. Good analysis of users	• A • B • C	
	3. Suitability of teaching method	• A • B • C	
	4. Richness of teaching materials	• A • B • C	
	5. Organization of teaching material	• A • B • C	
	6. Difficulty level of materials	• A • B • C	
	subtotal: ___A ___B ___C		
User-interface	1. Smoothness of operation	• A • B • C	
	2. Organization of web page	• A • B • C	
	3. Availability of learning tools	• A • B • C	
	4. Interactive design	• A • B • C	
	5. Measurement design	• A • B • C	
	6. Multimedia effects	• A • B • C	
	subtotal: ___A ___B ___C		
Pedagogy	1. Instructional goal	• A • B • C	
	2. Instructional method	• A • B • C	
	3. Course management	• A • B • C	
	4. Motivational design	• A • B • C	
	5. Evaluation of learning results	• A • B • C	
	subtotal: ___A ___B ___C		
Total: ___A ___B ___C			

3 Conclusion

The development of web courses takes time and good planning ahead. Thorough consideration about the content and teaching methods can result in effective learning. It is important not to be overwhelmed by the colorful effects of multimedia to the extent that the emphasis on content is compromised. We have proposed C, U and P as three dimensions that serve as directions along which ideas about web-course design can be developed. A few charts are developed as tools that can help systematically developing web-courses. This will supposedly make the web-course development process more manageable, and the instructional effects of web-courses more worth our wait.

Reference

[1] Creed, T. & Plank, K., "Seven principles for good course Web Site design.", The National Teaching and Learning Forum, 7(3), 8-10., 1998.

[2] Duchatel, P. & Turcotte, S., "On-line learning and teaching in an information-rich context", Proceedings of the 1996 Internet Conference of the Internet, Montreal. (1996)

[3] Hackbarth, S., "The educational technology handbook: A comprehensive guide--Process and products of learning.", Englewood Cliffs, NJ: Educational Technology Pubs. (1996)

[4] Nichols, G. W., "Formative evaluation of Web-based instruction". In B. H. Khan (ed.). Web-based instruction. 369-374. Englewood Cliffs, NJ: Educational Technology Pubs. (1997)

[5] Nielsen, J., "Designing Web site with authority: Secrets of an information architect.", Indianapolis: New Riders Pubs. (1998).

[6] Reeves, T.C. & Reeves, P. M., "Effective dimensions of interactive learning on the World Wide Web.", In B. H. Khan (Eds.). Web-based instruction. 59-66. Englewood Cliffs, NJ: Educational Technology Pubs.(1997).

Developing Web-Based Language Learning Environment

Yun Du
Second Language Teaching and Curriculum Center
Moore Hall 255, East-West Road
Honolulu, Hawaii 96822
Tel: (808) 956-5130
E-mail: ydu@hawaii.edu

The World Wide Web is becoming a popular media to conduct distance learning. However, using the Web for distance language learning is still a challenge. This paper introduces a Web-based language learning environment which is used to deliver upper-level second language courses. The three major design considerations (instructional design, interaction design and knowledge-building capability design) are discussed. The functions and major features of the learning environment are also described.

Keywords: **Web-based learning environment, computer-assisted language learning**

1 Introduction

Today's distance learning no longer assumes that knowledge is static and education is a certain years' procedure. Instead, knowledge is changing and evolving, so that education is a life long process. Education should be able to meet people's needs, no matter how old they are, where they are, or what jobs or positions they hold. The World Wide Web, with its worldwide access and friendly interface, becomes the desired media for conducting distance learning today. Compared with traditional classroom teaching, Web-based learning offers new opportunities:

- It extends the boundaries of learning so that learning can occur at any time, in any place. As a result, learners have more flexibility of choosing the way to learn.
- It emphasizes on collaboration and interaction that can be effectively employed toward learning. Using the Web, learners can not only communicate with the instructors or classmates, but also can go beyond the classroom to collaborate with people from other schools, institutions, organizations, and to ask questions to professionals and experts.
- Various resources of information on the Web extend the content of the instruction. Students are able to access multimedia information on almost every subject and in multiple languages.
- Web-based instruction offers opportunities for more creative activities. Students can search information on the Web, create their own resource repository, meet virtually with classmates and instructors, and do a lot more.

In this paper, a Web-based learning environment for language learning will be introduced. This learning environment is used for delivering instructional resources in Chinese at the 3rd/4th-year level and in Korean at the 2nd/3rd-year level to learners nationwide via the Web. The first Web-based class using the learning environment, CHN399 *Chinese Reading and Writing Course,* was officially offered to the students at University of Hawaii in the spring semester, year 2000. The last two units of the course also involved students from Taiwan to collaborate with students at UH. The course is a success. Twelve students have completed the course. In the

fall semester, in addition to this course, a *Chinese Listening and Writing Course* and a *Korean Reading and Writing Course* will also be offered, using the same learning environment.

2 Major Design Considerations

The design of the Web-based language learning environment has been focused on three parts: instructional design, interaction design and knowledge-building capability design.

2.1 Instructional Design

Instructional design addresses the pedagogical issue of language learning. It determines the goal and format of the course, the instruction approach, the activities involved and the evaluation criteria. For this learning environment, we adopt an instructional model that contains the following five stages:

- Stage 1 Pre-activities: aim at activating students' prior knowledge, and helping them predict the content of the text
- Stage 2 Global activities: emphasize on helping students master the content and the main points of the text
- Stage 3 Specific information activities: use various language-centered tasks to train students to memorize the main points of the text while reading
- Stage 4 Linguistic activities: allow student to use the new knowledge after the they have mastered the content and main points of the text
- Stage 5 Post activities: integrate what have been learned from the previous four stages and help students accomplish a language task that involves using the new words, concepts and knowledge

Based on these stages, a series of activities have been designed. Students are evaluated mainly by the quality of their writings, and also by the quiz conducted at the end of each unit.

2.2 Interaction Design

Communication is very important for language learning. Communicative language learning theory emphasizes on interaction between learner and instructor as well as between learner and learner. Underwood [3] proposed a series of "premises for communicative CALL" (CALL refers to Computer-Assisted Language Learning), including "focuses more on using forms than on the forms themselves", "Teaches grammar implicitly rather than explicitly", "allows and encourages students to generate original utterances rather than just manipulate prefabricated language", etc. Interaction has been carefully designed to embed these principles into the learning environment. Different Web-based forums were developed for different learning purposes: asking questions about the text, practicing language through task-based group discussion, diagnosing grammar mistakes and writing essays on a specific subject. The asynchronous communication mode provides the following advantages:

- Students can have more flexible schedule; they can access the class at any time.
- Students have more time composing messages, and can modify messages even after they have been submitted. This is good for language learners who not only concern the content of the message but also the form of the language.
- Students can save specific messages for future reference.
- Students can search and retrieve specific messages afterwards.

2.3 Knowledge-building capability design

There are three major aspects of current learning theories. First, learning is a process of knowledge construction, not of knowledge recording or absorption. Effective learning depends on the intentions, self-monitoring, elaboration and representational constructions of the individual learner [2]. Second, learning is knowledge-

dependent, and knowledge-driven [1]. People use current knowledge to construct new knowledge. Third, learning is highly tuned to the situation in which it takes place. Knowledge is not independent of the contexts (mental, physical, and social) in which it is used [2]. These theories indicate the importance of supporting knowledge building in a learning environment so that students can acquire, record, share, and integrate knowledge.

In our Web-based language learning environment, in addition to allowing students to discuss and share ideas in the forums, based on the characteristics of language learning, the knowledge building also includes following processes:

- Store resources related to the subject
- Build word vocabulary
- Compile grammar rules
- Collect and comment on writing examples, commonly used phrases and idioms, etc.

3 Major features of the Web-based language learning environment

The components of the final system are shown in Figure 1.

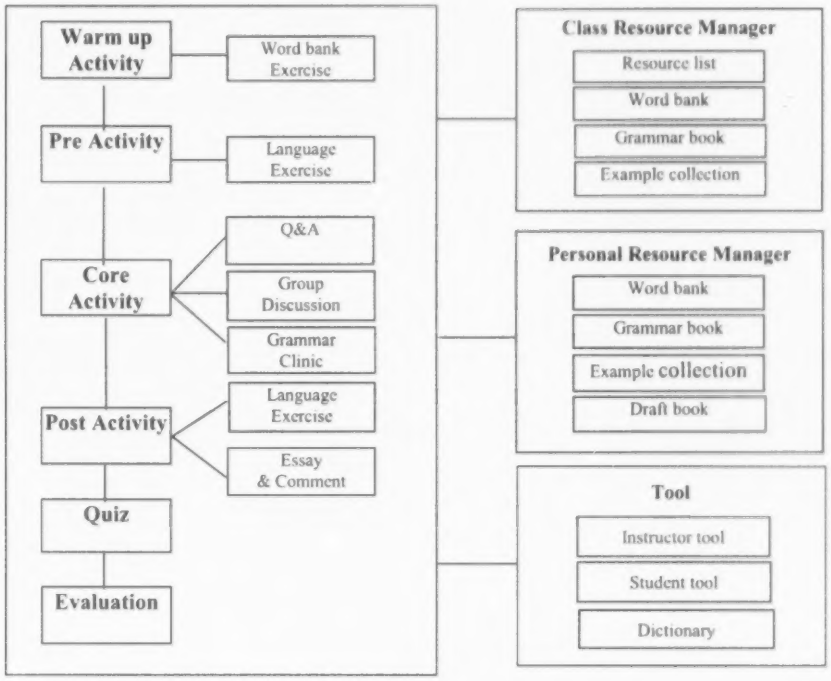


Figure 1. Components of the Web-based language learning environment

3.1 Language teaching/learning support

The system supports language teaching based on a specific instructional model that sequences the learning process into several stages. The goals, processes, activities and tasks are well integrated into the functions of the system. Different rights and privileges are assigned to instructors and students to ensure that the teaching and learning procedure is followed. Using the system, the students are able to do language exercises, share

information, ask questions, participate in task-based group activities, write essays, comment on fellow students' writing, build vocabulary, summarize grammar points, and so on, while the instructors are able to teach reading and writing skills, answer students' questions, correct grammar mistakes and evaluate students' progress.

Based on the instructional model, the learning process is sequenced into the following activities:

- Warm up activity: involves students' building word vocabulary (called *word bank*). This activity corresponds to the first stage of the instructional model: pre-activity that aims at activating students' prior knowledge about the topic.

- Pre-activity: involves doing language exercise such as matching words. This activity is also part of the first stage of the instructional model.

- Core activity: contains three parts. The first part involves students reading text (that is stored on CD-ROM), doing reading comprehension exercises and asking questions. This part corresponds to the second stage: global activities, and the third stage: specific information activities. The second part of the core activity is for students to participate in small group discussion to accomplish a given task, e.g. decide where to eat dinner. In the third part, instructors select mistakes from students' messages and post them in a forum called grammar clinic, and the students are asked to correct these mistakes. These two parts are designed to fulfill the goals of stage four: linguistic activities.

- Post activity: requires students to write an essay on the given topic. This activity is designed to integrate the knowledge they have learned, which corresponds to the fifth stage of the instructional model.

In addition to these activities, each unit of the class also has quiz, aiming at evaluating students' mastery of the material through quantitative criteria.

3.2 Database support

The system is developed using database technology. The database system is implemented on Microsoft SQL server. Basically the database system collects the data generated by the activities involved in the class.

- Stores the information of students and instructors
- Supports word bank
- Supports forums for class interaction
- Supports class and personal resource manager
- Supports quiz and grading
- Supports collecting survey data
- Collects data for administration such as login records

3.3 Asynchronous interaction

Web-based forums support the interaction among users. The asynchronous forums allow students to do the following things:

- To participate in the activity at any time
- To edit a message even after it has been submitted
- To save a specific message for future reference or as a knowledge item
- To search and to retrieve messages

The class interaction is supported by five forums:

- ***Class news forum***
  This forum is for instructor and students to exchange information including class announcement, cultural trivia, etc. Both instructors and students can post threads as well as replies.

- ***Essay forum***
  This forum is for students to post their essays and comment on essays written by fellow students. Both instructors and students can post threads as well as replies. (See Figure 2.)

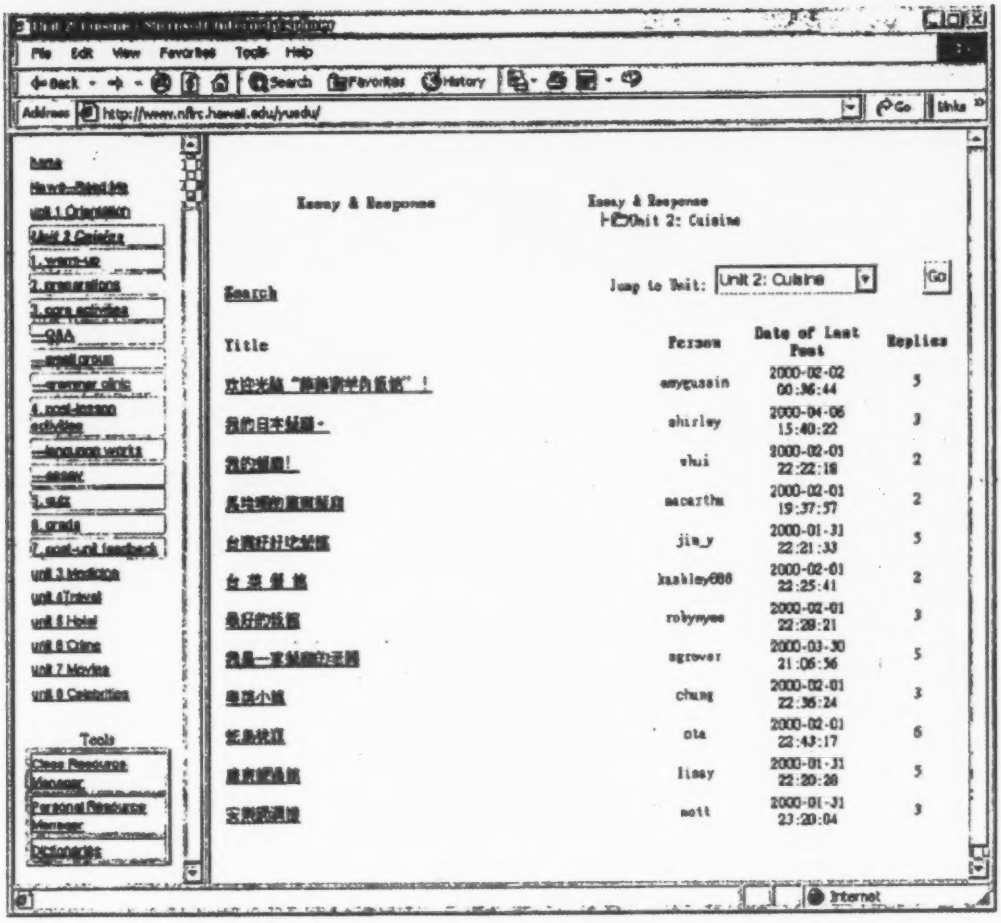


Figure 2. Essay forum in the Web-based language learning environment

- ***Q&A forum***
  This forum is for students to post questions regarding the content of the text as well as the usage of the CD-ROM. Both instructors and students can post threads as well as replies.

- ***Small group discussion forum***
  This forum is for students to participate in task-based group discussion. Students will be directed into their group when they enter the forum and they can post messages there. They can go to see other groups' interaction, but they cannot post any messages in other groups' discussion area.

BEST COPY AVAILABLE

- ***Grammar clinic forum***
  Instructors select grammar mistakes from the students' posts, put them in this forum, and ask students to correct them. Only instructors can post threads, students can only post replies.

Designing individual forum for each activity or task makes it possible for forums to serve different purposes and to have different controls over students' privilege of posting messages. For example, in grammar clinic forum, only instructors can post threads (students can only post replies), but in class news forum, everybody can post threads. In all the forums, the instructors reserve the rights to delete messages.

3.4 Knowledge building

The system provides knowledge-building capability that allows users to gather information, discuss ideas with others as well as generating, storing and retrieving knowledge. The knowledge building process is facilitated using two tools: class resource manager and personal resource manager. Both the resource managers include resource list, word bank, grammar book, and example collection. In order to support knowledge building at both collective level and individual level, the knowledge- building tool has two types: one for the whole class (class resource manager), and one for the individual student (personal resource manager). Class resource manager can be accessed by the whole class, while personal resource manager is individualized and can only be accessed by student himself or herself. The personal resource manager also includes a draft book for the student to store his or her writing drafts. The instructors have most of the control over class level knowledge-building tool, but the students have full control over their own knowledge-building tools. The knowledge-building functions provided include:

- Allows knowledge-building at both class level and individual level
- Allows users to collect information resources (Web sites, article, etc.) into *resource list*
- Allows users to collect words into *word bank*
- Allows users to collect or compile grammar rules into *grammar book*
- Allows users to collect writing examples or idioms into *example collection*
- Allows users to save messages from discussion forums to the resource managers
- Allows users to write note or comment on resource or knowledge items

Currently, the grammar book and the example collection in class resource manager are controlled by the instructors, meaning that instructors summarize grammar points and select examples and put them in the class resource manager. Students can read them but they cannot put their own notes there.

3.5 Online quiz

Students can take quizzes online. The quiz contains multiple choices and is graded automatically so students can get their grade immediately after they submit the answer. Instructors can check students' quiz grades along with the information such as how long the students complete the quiz and their answers to each question.

3.6 Tracking capability

The tracking system built for this learning system record student's clicks into the database while they are navigating the class. The information recorded include the location of the student, the action the student makes, the time of the action and other relevant data such as the message the student is reading. The tracking system offers the following benefits:

- The tracking system can provide valuable information for system developer. Users use a system in different ways. Therefore, how users navigate our the learning system, how they use the interface and how they use the various functions become interesting questions whose answers will help the system developer understand the operation of the system so that the system can be improved to better meet users' needs.

- The tracking system also provides valuable information for the instructors. It tells the instructor how students do self-learning in the distant environment, how they follow the process designed for the course, how they participate in the activities, how they approach a task, how they respond to a teaching strategy, and so on. The information will help the instructors understand students' behavior (e.g. learning strategy) and adjust their teaching methods to make the course more effective.

3.7 Monitoring and evaluating performance

The system provides ways for the instructors to conduct teaching as well as monitoring and evaluating students' performance:

- Monitor students' participations according to their login records, frequency and length of their posts, and so forth
- Evaluate students' performance according to their participations, contents and form of their writings, and so forth
- Give grades and feedbacks to students
- Understand students' learning behavior by analyzing tracking records

4 Conclusions

Observations from the Web-based Chinese reading course show that this Web-based language learning environment successfully support the class operation. Students and instructors are able to choose their own time, place and pace to work on the course. And, they have been engaged in active interactions during the course. The functions provided by the learning environment meet the instructional goals and requirements.

References:

[1] Glaser, R., "Education and thinking: The role of knowledge", American Psychologist, Vol 39, pp. 93-104, (1984).
[2] Resnick, L. B., "*Knowing, learning and instruction*", Hillsdale, NJ: Lawrence Erlbaum Associates, (1989).
[3] Underwood, J., "Linguistic, computers, and the language teacher", Rowley, MA: Newbury House, (1984).

Development and Evaluation of a CALL System for Supporting the Writing of Technical Japanese Texts on the WWW

Jie Chi Yang* and Kanji Akahori**
**National Central University,*
38, Wu-Chuan Li, Chung-Li, Tao-Yuan, Taiwan 320
E-mail: yang@src.ncu.edu.tw
***Tokyo Institute of Technology*
2-12-1 O-okayama, Meguro-ku, Tokyo 152-8552, Japan
E-mail: akahori@cradle.titech.ac.jp

This paper describes the development and evaluation of a Computer Assisted Language Learning (CALL) system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, cohesive expressions are used as cue words. The rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts is developed using Natural Language Processing (NLP) techniques. The main functions of the system are: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study. Furthermore, two evaluation experiments are conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the two experiments, respectively. The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning.

Keywords: **Computer Assisted Language Learning, Natural Language Processing, evaluation, technical Japanese texts**

1 Introduction

The aim of this research was to construct a Japanese learning environment for foreign students on the Internet. For students in science and technology universities, there is little time for enrolling in a regular Japanese language course, which involves spending a lot of time on experiments, studies and research, etc. The Internet environment is provided in almost all laboratories and can become an excellent virtual learning environment if there is a Japanese learning system which can be accessed on the Internet anytime and anywhere. The Internet has stimulated many new approaches to language instruction and learning, and it provides a great opportunity to learn one of the most important skills, writing. This is especially true for students in the science and engineering fields who need to write technical texts.

However, almost all CALL systems are concerned with learning how to improve one's reading and listening skills. Few systems are concerned with writing because of the difficulty of implementing an analysis of sentences typed by students who need to learn to phrase their own sentences freely without following any predefined rules. More and more researchers, therefore, use Natural Language Processing (NLP) techniques to analyze learners' typed sentence [9][16]. Recently, NLP techniques designed for use with CALL have attracted special attention (see, for example, [21][22], etc.), as this is expected to help improve writing skills.

Yang and Akahori [28][29] developed a Japanese writing CALL system using NLP techniques which can be used for learning and producing the Japanese passive voice on the WWW. Comparison of two Web-based CALL systems showed that the method of 'free input' and 'feedback corresponding to learners' typed sentence' is better than the method of 'multiple choice' and 'feedback that only displays the correct answer' [31]. Furthermore, an evaluation of the learning histories of the subjects who have actually used the system through the Internet shows that the system obtained a high degree of accuracy and instructional effectiveness [29]. These results demonstrate the effectiveness of the CALL system for writing using NLP techniques on the Internet.

Having sufficient vocabulary and grammatical knowledge is important when learning a foreign language. However, although vocabulary and grammatical rules are provided for correct sentence building in a foreign language, this knowledge alone is not enough. Being able to form correct sentences is by no means enough when it comes to expressing complex thoughts. The major problem for most foreigners learning Japanese is, apart from the writing system, the building of sentences: that is, knowing the corresponding words, the postfixes signaling the word's function (*de*, *ni*, etc.) and the position of the words (verbs final form). It is of paramount importance to learn how to structure one's thoughts: i.e., how to make an outline, how to signal the relative importance of a piece of information, and how it relates to the whole. Therefore, in order to write or to comprehend a structured sentence, it is necessary to learn how to associate sentences, in addition to having a good command of vocabulary and grammar. The connection between sentences can be described as conjunction of adjacent sentences, which is an important criterion for writing a good text as per research in *cohesion* or *discourse structure* [1][3][13][17][26]. Unfortunately, discourse structure is not amenable to single-sentence grammatical analysis, because there are no 'discourse grammars' [11].

Many methods concerning the analysis of discourse structure have been proposed in previous related works. Mann and Thompson's [18][19] rhetorical structure theory (RST) is an influential theory of text structure that is being extended to serve as a theoretical basis for computational text planning. RST postulates that a set of about 25 relations suffices to represent the relations that hold within normal English texts. Most relations have a cue word or phrase which informs the listener how to relate the adjacent clauses. RST can be applied to a computational model. There have been attempts at text generation using RST for the implementation of a prototype of the theory [10][20]. Cue words are also widely used in the identification of rhetorical relations among portions of a text [8][15][24]. Hobbs claims that coherence in conversations and in texts can be partially characterized by a set of coherence relations, which are classified into four categories. Hovy [10] collected and taxonomized the discourse segment relations; this set of relations contains three taxonomies of approximately 120 relations. Hirschberg and Litman [7] also summarize the proposed meanings of items classed as cue words in six computational and linguistic treatments.

In most of these earlier works, emphasis was put on the knowledge that is necessary for recognizing discourse structure. The problem of inference based on that knowledge was also emphasized. However, this does not mean that knowledge can be constructed easily from information available on computers. Constructing common knowledge to implement a practical system is often beyond the capabilities of current NLP techniques. Kurohashi and Nagao [14] proposed an automatic method for detecting discourse structure by checking surface information in text sentences. The information included 'clue expressions', 'occurrence of identical/synonymous words/phrases', and 'similarity between two sentences'. Their result indicates that, in the case of technical Japanese texts, considerable portions of discourse structure can be identified by incorporating the three types of surface information.

Since there are few practical CALL systems that use discourse analysis, the purpose of this study is to develop such a system for helping learners to write technical Japanese texts on the WWW. Section 2 describes the implementation of the system using NLP techniques. The authors took a similar approach to Kurohashi and Nagao [14], namely using surface information in texts. The rules for analyzing technical Japanese texts are based on micro-level (cohesive expressions) and macro-level (headlines) information. Section 3 describes the study that evaluates the effectiveness of the system in two experiments.

2 Implementation of the system

2.1 Method

The combination of cohesive expressions and headlines are employed in the implementation of the system. To examine discourse structure of technical Japanese texts, the classification of basic expressions by Yamazaki et al. [27] is adopted in this study. The reason for this is that their classification covers most of the

elements of technical Japanese texts. Based on their findings, the authors have classified cohesive expressions into 15 categories as follows: *comparison, contrast, analogy, cause and reason, basis, composition and enumeration, presentation, definition, classification, hypothesis and conditions, change of state, process of change, change with prerequisites, means and methods, selection*. The total number of expressions is 82. All of the expressions are converted into regular expressions to make the rules. In all, 654 distinctions in the regular expressions were extracted from the 15 categories of cohesive expressions. These formed 654 original rules, which are used in the process of analysis.

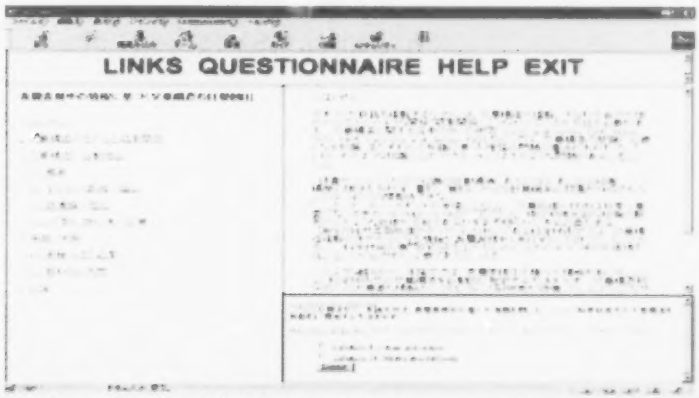
There are two patterns of rules: one is for 'simple pattern matching' and the other is for 'discourse analysis'. The former, called rule set A, is written as a regular expression form and the latter, called rule set B, is written as a regular expression combined with the result of morpheme analysis and syntax analysis. The rule in rule set B is written in a more restrictive form to improve the accuracy of discourse structure analysis. For example, if a sentence is applied to rule set A, it is then analyzed by the morpheme analysis and syntax analysis and the result will be matched to rule set B.

There are many text books on good writing, which nearly all contain a lot of material concerning the different kinds of categories or conceptual bricks at the discourse level out of which texts are built (see, for example, [4][5][6][12][25][26]. However, it is difficult to detect the text structure by just using their framework because it is too extensive and the varieties of different formats used by people for building technical texts too numerous. Instead of predefined framework, headline is used as macro-level information in this study. There are several reasons why the authors decided to use 'headline' instead. First, a well-chosen headline allows the reader to infer the text structure. Second, different formats of texts can be analyzed independently of the texts' style by using the headline. Third, it is easier to understand when the headline is displayed rather than a tree structure because the headline is a part of the original text.

2.2 The discourse structure analysis module

The discourse analysis module of the system contains 'simple pattern matching', 'morpheme analyzer', 'syntax analyzer', and 'discourse analyzer' components. First, the headlines are extracted and the Japanese texts are divided into sentences using several heuristic rules. Then all the sentences in all texts are matched with all the rules in the 'simple pattern matching' component. The 'rules for pattern matching' is used during the process of pattern matching. Because of the exclusive character of almost all of the rules, they are written in order of frequency to reduce the running time on the computer. The frequency of rules is made from the 'rules corpus'. The present system analyzes Japanese text sentences with the morpheme analyzer and syntax analyzer to check the dependency of sentences in the case grammar. Therefore, each cue word in the rules is not only matched against the word itself, but also against the 'parts-of-speech' of the cue word. Only sentences that match the rules written in restrictive form are needed for morpheme analysis and syntax analysis. This takes into consideration the problem of computer running time. The 'rules for discourse analysis' is matched again in restrictive form after the process of syntax analysis. The additional information (parts-of-speech, tense, etc.) is checked to identify the cohesive expressions, especially in the case where one sentence is matched with two or more rules.

Figure 1. One screen shot of discourse structure analysis



The learning page shows a list of technical Japanese texts. Learners can choose any one text by clicking the hyperlink on the list. When learners choose one of the texts from the list, headlines of the selected text are

BEST COPY AVAILABLE

analyzed and displayed first to help learners grasp the whole text structure. Secondly, learners can click on the headline of any part of the text that they want to read. Then the original sentences corresponding to the headline are displayed with the extracted cohesive expressions. The cue words in the cohesive expressions are displayed in color to enable learners to focus on it more easily. Learners can click on any cue words to further find out the cohesive expressions corresponding to the sentences. They can also refer to examples that correspond to the cohesive expressions from the 'examples corpus'. Figure 1 shows one screen shot of the system (text source: [14]). As shown in this figure, the headlines of the Japanese text are analyzed and displayed on the left side of the browser. The headlines show the structure of the text. On the right side, the original sentences corresponding to the selected headline are displayed on the upper part with the cohesive expressions extracted and a link made. When the cue word '*kotoniyori*' (in the first line of the third paragraph) is clicked, the matched cohesive expressions are displayed on the bottom right side of the browser.

2.3 System evaluation of the discourse structure analysis module

A system evaluation is conducted to evaluate the performance of the discourse structure analysis module on 24 technical Japanese texts. The system evaluation is designed for text analysis in two stages (pattern matching in Stage 1 and discourse analysis in Stage 2). The analysis consists of 3 items on both stages: *headline extraction*, *cohesive expression extraction* and *frequency of the rules*. The accuracy ratio of the headline extraction in Stage 1 is 95.22% on average. After a heuristic rule is added, the result of the headline extraction using the revised rules in Stage 2 gained an exceedingly high accuracy rate of 99.17%. The accuracy of the cohesive expression extraction in Stage 1 is 70.23% on average. On the other hand, the accuracy in Stage 2 improved to 92.70% on average. This result shows that using the rules combined with morpheme analysis and syntax analysis gained a higher degree of accuracy than only using the rules of simple pattern matching. After the cohesive expression extraction, the frequency of rules is calculated. The result of 'frequency of the rules' is saved to the 'rules corpus'. The order of frequency is taken as the order of the rules to reduce the running time on the computer.

2.4 The system for supporting technical Japanese texts writing

A CALL system is developed to help learners in the writing of technical Japanese texts. The system is implemented in terms of headlines and cohesive expressions, which is based on the method of the discourse structure analysis module. For headlines supporting, a connection between headline and texts corresponding to the headline is made automatically. Learners can click on any headline to immediately link to the content of texts corresponded to it. For cohesive expressions supporting, examples with the selected cohesive expressions are automatically extracted from the corpus of technical Japanese texts. Learners can refer to these examples to help them improve their writing skills.

The flow of the system is as follows:

(1) Learners register themselves to use the system. An ID number is given after registration. The ID number is used to identify the learner because a log of all learning histories is registered during the operation of the system.
(2) The page for headlines input is appeared. Learners can free input their headlines here. When learners completed their construction of headlines, each headline is automatically linked and displayed on the left side of the browser. The left side of Figure 2 shows an example of linked headlines.
(3) When learners choose one of the headlines, a text box is appeared on the top right side of the browser. Learners can compose their texts corresponded to the clicked headline in the text box. The top right side of Figure 2 shows an example of texts input.
(4) When learners click on the 'basic expressions' button on the bottom right side of the browser, the categories of cohesive expressions is appeared on a new page. Each category is classified further into sub-categories. When learners choose one of the sub-categories from the list, examples are automatically extracted from the corpus of technical Japanese texts and the result is displayed on the bottom of the browser. Figure 3 shows that examples are displayed corresponded to the selected sub-category of cohesive expressions.

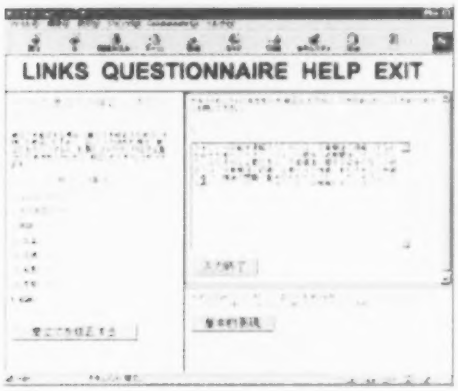


Figure 2. One screen shot of the linked headline and texts input

Figure 3. One screen shot of examples extracted from corpus

3 The study

Two evaluation experiments were conducted to examine the effectiveness of the system. The system is evaluated in terms of subjects' intuitive impression and actual usage of the system in the experiment 1 and the experiment 2, respectively. Thirty-three subjects participated in the experiment 1; the other seven subjects participated in the experiment 2. The subjects almost use the WWW and computer everyday.

3.1 Experiment 1

The purpose of the experiment 1 was to examine the functions of the system in terms of subjects' intuitive impression. Therefore, the experiment was designed to make a comparison between the system with the popular and well-known word processor: the MS-Word. During the experiment, the subjects were asked to look at the operation of the system and the MS-Word using video for duration of 10 minutes. The subjects were informed that they would be asked to fill in the questionnaire concerning the comparison of the two systems. The questionnaire consisted of 3 categories: *items of technical sentences writing*, *items of general sentences writing*, and *items of system operation*. The subjects were asked to rate 24 items on a 5-point scale. The subjects were also asked to make comments on the system.

Figure 4 shows the rating of the system and the MS-Word for each item with the 3 categories in experiment 1 and 2. The result of the experiment 1 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing. For those items of general sentences writing and system operation, the result shows that the MS-Word obtained a higher rating than the system or there was no significant difference on the two systems. However, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning').

Comments on the system are summarized as follows: Almost all of the subjects answered that it is necessary to involve the functions to access other objects, such as figures, tables and numerical expressions, etc. Since the system is emphasized on the discourse analysis of technical Japanese texts using NLP techniques, the target of the system is limited to 'texts'. However, figures, tables and numerical expressions are important components of technical texts. Therefore, development of such visual tools for supporting these objects is expected.

3.2 Experiment 2

The result of the experiment 1 suggests that the system is preferred to the MS-Word on technical texts writing. However, actual usage of the system is not evaluated. Therefore, in order to examine the effectiveness of the system in terms of actual usage of the system by foreign students, experiment 2 was conducted. During the experiment, the subjects were asked to compose a technical Japanese text using the system. The subjects were asked to write sentences concerning their specialization instead of a given task because a variety of subjects' different fields. After the composition is completed, the subjects were asked to fill in the questionnaire concerning the comparison of the system and the MS-Word. The questionnaire is identical to experiment 1, which is divided into 3 categories. Finally, the subjects were interviewed based on

BEST COPY AVAILABLE

their response to the questionnaires.

From Figure 4, the result of the experiment 2 shows that the system obtained a higher rating than the MS-Word on all of the items of technical sentences writing, which is consistent with the result of experiment 1. For those items of general sentences writing and system operation, the result shows that the subjects preferred the system, or the MS-Word or there was no significant difference on the two systems. Comparing this result to experiment 1, the system obtained a higher rating than the MS-Word on items 18 ('Sentences can be efficiently made') and 15 ('It is suitable for learning'), which is consistent with the result of experiment 1. On the other hand, some items obtained different result between the two experiments. These items can be divided into 3 types: First, items 7 ('I want to recommend it to my friends') and 24 ('I want to use it more') are rated from 'no significant difference' to 'a higher rating to the system'. Second, item 2 ('It is friendly') is rated from 'a higher rating to the MS-Word' to 'no significant difference'. Third, item 11 ('It is easy to see') is rated from 'no significant difference' to 'a higher rating to the MS-Word'.

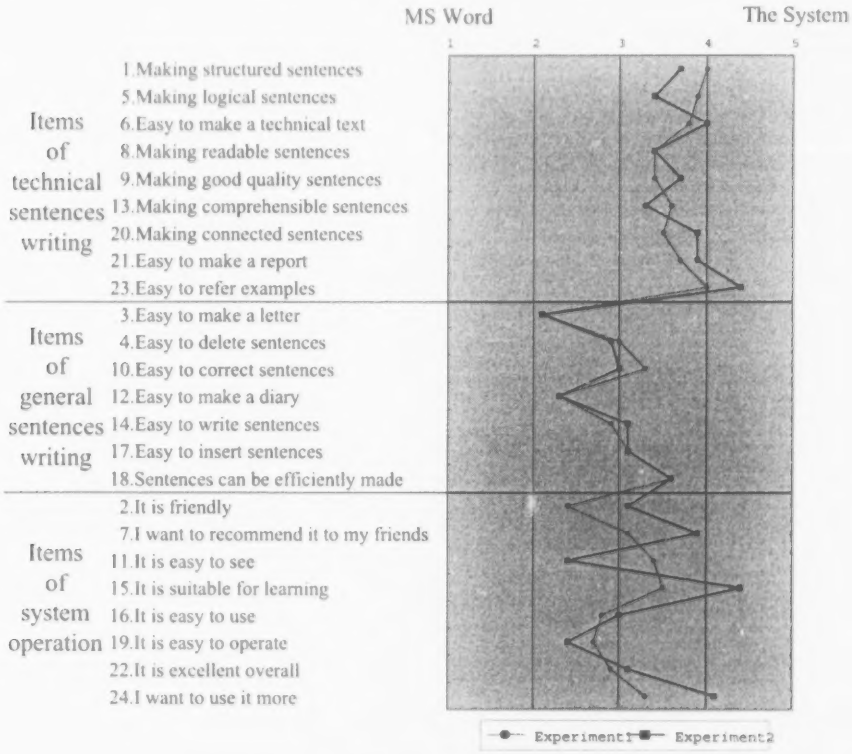


Figure 4. The rating for each item in Experiment 1 and 2

The subjects were asked to give reasons for their responses to the questionnaire items during the interview. The result of the interview concerning the functions of the system is divided into 4 types and summarized as follows: First, for automatically analyzing and displaying headlines, almost all of the subjects answered that it is very useful because they can click on any headline to immediately read the content of texts corresponded to it. The subjects also answered that headlines can be treated as an important role to help them to grasp the whole structure of the texts. Second, for automatically analyzing and displaying cohesive expressions, almost all of the subjects answered that it is very useful because they can find it is easier to convey their thoughts using explicit cohesive expressions. The subjects also answered that it is easy to find their errors because cohesive expressions in the texts are highlighted. Third, for referring to examples from corpus, almost all of the subjects answered that it is very efficient to writing because they can save a lot of time for finding examples from other references. The subjects also answered that they can imitate and learn more examples from the output of corpus. They can learn very much from the process of referring to examples in different texts, especially if there are many different usages in an expression. Fourth, for

Japanese language learning, almost all of the subjects answered that the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts. The subjects also answered that they can learn not only new cohesive expressions but also correct usages of cohesive expressions even they already know one of them.

Other comments on the system are summarized as follows: Almost all of the subjects answered that it is desired to improve the system to support the functions of electronic dictionary, thesaurus, grammar checking, etc. Therefore, construction of a good electronic dictionary for technical texts writing is considered as an important issue. Moreover, some subjects answered that it is better to extract examples form corpus according to learners' specialization than only random accessing to the corpus. From this result, constructing a corpus should not only consider the number of texts but also the balance of texts in each field.

4 Conclusion

In this paper, the authors describe the development and evaluation of a CALL system for supporting the writing of technical Japanese texts on the WWW. To analyze discourse structure of technical Japanese texts, the rules for analyzing texts are based on micro-level and macro-level information, namely cohesive expressions and headlines. A CALL system for helping foreigners to learn to write technical Japanese texts has been developed using NLP techniques. The system has the following functions: automatically detecting headlines and cohesive expressions in technical Japanese texts, displaying this information on the WWW, and extracting examples from the corpus of technical Japanese texts. The results of a system evaluation show that the system obtained a high degree of accuracy on extraction of cohesive expressions and headlines by using the revised rules set proposed in this study.

The results of the study show that the instructive effectiveness of the system. The result of the interview also shows that the system is not only suitable for technical Japanese writing but also for Japanese language learning. Based on the functions of the system, these results can be explained as follows: First, headlines can be treated as an important role to help learners to grasp the whole structure of the texts. Second, cohesive expressions often explicitly appear in the surface expressions of technical Japanese texts. Thus, it seems important and necessary to use these explicit cohesive expressions to structure one's thoughts in technical Japanese texts. Foreign learners especially may find it is easier to convey their thoughts using explicit cohesive expressions because these can be treated as an indicator of a discourse. Third, the corpus consists of the actual usage in technical Japanese texts from different fields. Instead of predefined examples, examples are automatically extracted from the corpus. Therefore, learners can learn very much from the process of referring to examples in different texts if there are many different usages in an expression. They can also save a lot of time for finding examples from other references.

In conclusion, the system is suitable for learning because the system supports learners to learn technical Japanese writing in a structural way in terms of automatically analyzing and displaying headlines and cohesive expressions in technical Japanese texts.

Acknowledgements

The authors would like to thank Dr. Kikuko Nishina (Professor in the International Student Center, Tokyo Institute of Technology) for her kind help during the analysis of technical Japanese texts. The authors would also like to thank Ms. Cheong Meng-Mei (Tokyo Institute of Technology) for her suggestions and comments on an earlier version of this paper. This study is funded by the Scientific Research Grant from the Ministry of Education of Japan (Subject No. B(2)10558019, Period: from 1 Apr 1998 to 31 Mar 2001).

References

[1]Chan, S.W.K. and T'sou, B.K. (1998). Analyzing Discourse Structure using Lexical Cohesion: A Connectionist Tool. In *Proceedings of the 1998 IEEE International Joint Conference on Neural Networks*, V1: 657-662.

[2]Hajicova, E. (1996). The information Structure of the Sentence and the Coherence of Discourse. In Hovy, E.H. and Scott, D.R. (Eds.), *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, 97-107. Berlin: Springer – Verlag.

[3]Halliday, M.A.K. and Hasan, R. (1976). *Cohesion in English*. London and New York: Longman.

[4]Hamada, M., Hirao, T. and Yui, K. (1997). *Paper Workbook for University/Foreign Student*. Tokyō: Kuroshio. [In Japanese.]

[5]Hayes, J.R. and Flower, L.S. (1980). Identifying the Organization of Writing Processes. In Gregg, L. and Steinberg, E. (Eds.), *Cognitive Processes in Writing: An Interdisciplinary Approach*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[6]Hayes, J.R. (1989). Writing as Problem Solving. In Hayes, J.R (Eds.), *The Complete Problem Solver*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[7]Hirschberg, J. and Litman, D. (1993). Empirical Studies on the Disambiguation of Cue Phrases. *Computational Linguistics*, 19(3), 501-530.

[8]Hobbs, J.R. (1979). Coherence and Coreference. *Cognitive Science*, 3: 67-90.

[9]Holland, V.M. and Kaplan, J.D. (1995). Natural Language Processing Techniques in Computer Assisted Language Learning: Status and Instructional Issues. *Instructional Science*, 23: 351-380.

[10]Hovy, E.H. (1993). Automated discourse generation using discourse structure relations. *Artificial Intelligence*, 63: 341-385.

[11]Hovy, E.H. and Scott, D.R. (Eds.) (1996). *Computeational and Conversational Discourse: Burning Issues – An Interdisciplinary Account*, Berlin: Springer – Verlag.

[12]Kinoshita, K. (1981). *The Techniques of Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[13]Kuno, S. (1978). *The Grammar of Discourse*. Tokyo: Daisyukan. [In Japanese.]

[14]Kurohashi, S. and Nagao, M. (1994). Automatic Detection of Discourse Structure by Checking Surface Information in Sentences. *Journal of Natural Language Processing*. 1(1): 3-20. [In Japanese.]

[15]Litman, D.J. (1994). Classifying Cue Phrases in Text and Speech Using Machine Learning. In *Proceedings of the Twelfth National Conference on Artificial Intelligence*, V1: 806-813.

[16]Loritz, D. (1992). Generalized Transition Network Parsing for Language Study: The GPARS System for English, Russian, Japanese and Chinese. *CALICO Journal*. 10(1): 5-22.

[17]Mann, W.C. (1984). Discourse Structures for Text Generation. In *Proceedings of the 10th COLING*. 367-375.

[18]Mann, W.C. and Thompson, S.A. (1987). Rhetorical Structure Theory: Description and Construction of Text Structures. In Kempen, G. (Eds.), *Natural Language Generation: New Results in Artificial Intelligence, Psychology and Linguistics*, 85-95. Dordrecht: Martinus Nijhoff Publishers.

[19]Mann, W.C. and Thompson, S.A. (1988). Rhetorical Structure Theory: Toward a Functional Theory of Text Organization, *Text*, 8(3): 243-281.

[20]Moore, J.D. and Paris, C. (1994). Planning Text for Advisory Dialogues: Capturing Intentional and Rhetorical Information. *Computational Linguistics*, 19(4), 651-694.

[21]Nagata, N. (1996). Computer vs. Workbook Instruction in Second Language Acquisition, *CALICO Journal*. 14(1): 53-75.

[22]Nerbonne, J., Dokter, D. and Smit, P. (1998). Morphological Processing and Computer-Assisted Language Learning, *CALL Journal*, 11(5): 543-559.

[23]Nishina, K. (1997). The Fundamental Research for the Development of Learning System of Technical Japanese. *Doctoral Dissertation*. Tokyo Institute of Technology, Tokyo. [In Japanese.]

[24]Reichman, R. (1985). *Getting Computers to Talk Like You and Me: Discourse Context, Focus, and Semantics*. The MIT press, Bradford Books.

[25]Shimizu, I. (1959). *The Manner of Japanese Writing*. Tokyo: Iwamani. [In Japanese.]

[26]Sugihara, K. (1994). *The Manner of English Writing for Scientist*. Tokyo: Chuoukouronsya. [In Japanese.]

[27]Yamazaki, N., Tomita, Y., Hirabayashi, Y. and Hatano, Y. (1992). *Handbook of Technical Japanese*. Tokyo: Soutakusha. [In Japanese.]

[28]Yang, J.C. and Akahori, K. (1997). Development of Computer Assisted Language Learning System for Japanese Writing Using Natural Language Processing Techniques: A Study on Passive Voice, In *Proceedings of the 8th World Conference on Artificial Intelligence in Education (AI-ED97)*. 263-270.

[29]Yang, J.C. and Akahori, K. (1998a). Error Analysis in Japanese Writing and Its Implementation in a Computer Assisted Language Learning System on the World Wide Web. *CALICO Journal*, 15(1-3): 47-66.

[30]Yang, J.C. and Akahori, K. (1998b). A Discourse Structure Analysis of Technical Japanese Text. In *Proceedings of the Sixth International Conference on Computers in Education (ICCE98)*. Beijing, China. 643-650.

[31]Yang, J.C. and Akahori, K. (1999). An Evaluation of Japanese CALL Systems on the WWW Comparing a Freely Input Approach with Multiple Selection. *CALL Journal*, 12(1): 59-79.

[32]Yang, J.C. and Akahori, K. (2000). A Discourse Structure Analysis of Technical Japanese Texts and Its Implementation on the WWW. *CALL Journal*, 13(2): 119-141.

Development of a Web System to Support Computer Exercises and its Operation

Hajime Kitakami, Sueda Takashi, Yasuma Mori and Susumu Kuroki
Faculty of Information Sciences Research, Hiroshima City University
3-4-1 Ozuka-Higashi, Asa-Minami-Ku, Hiroshima 731-3194, JAPAN
Tel: +81-(0)82-830-1587
Fax: +81-(0)82-830-1587
E-mail: kitakami@its.hiroshima-cu.ac.jp

This paper describes the development and operation of a Web-based system to support computer exercises used in a course on data structures and algorithms. To develop such a system, this paper proposes using the functions of a Web-based system to deal with a learner's state transition model based on computer exercises. The Web system developed by us has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participant and teacher, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of this system resulted in students' heightened motivation to work, good communication between participants and teachers, and a reduced workload for teachers.

Keywords: **Web, Database, Exercise, Autonomous Learning, Domain Model, Communication, Questionnaire, Data Mining, Operation, Evaluation**

1 Introduction

The new curriculum of the Department of Intelligent Systems at Hiroshima City University has added computer exercises to subjects related to algorithms and programming, thus encouraging students, from freshmen to sophomores, to make the most of their ability for practical programming with representative algorithms. The curriculum offers two ongoing three-hour courses that include theory and practice.

This paper focuses on computer exercises for the course "Data Structures and Algorithms," which is a part of the core curriculum for sophomore students. The general objective of the course [1, 2] is to facilitate the transition from computer literacy to a professional level of information processing. Even though students have considerable knowledge of computer operations, they do not have perfect command of them. Moreover, they do not have enough experience in basic programming techniques. In order for them to have command of the theory and the practice, we have developed many exercises to improve the management of participant registration and learner's goals, information about the exercises, mutual interaction between participants and teachers, management of report submissions, and collection of questionnaires, among others. However, a problem arises because the workload for both teacher and students increases in the process. To solve this problem, we have developed the necessary support Web system dealing with a learner's state transition model based on computer exercises. Moreover, we report the operational results obtained from real exercises.

2 Assessment of learners' situation before the training

The contents of the courses "Data Structures and Algorithms I" and "Data Structures and Algorithms II" were divided into two courses, each including both theory and practice, using C in the new curriculum. The former includes major elements such as stack, queue, list, naive sort, recursive function, quick sort, tree structure, and binary sort in the second semester of the first year. The latter includes major elements [3, 4] such as complexity, file processing, linear search, binary search, hash, B-tree, pattern matching, graphical

searches, Kruskal, and Dijkstra in the first semester of the second year. Since students can easily understand the content of many classes if they have attended C in an earlier semester, "Structured Programming" was also organized into two courses including both theory and practice using C in the first semester of the first year. This course includes major expressions such as if-, while-, and for-statements, array, data types, pointer, function, and structure in C. Moreover, the teaching of computer literacy includes major elements such as word processors (e.g., LaTex), programming tools (e.g., mule, e-macs), drawing tools (e.g., TGIF), the input tool for Japanese characters, electronic mail, X-window, and the shell command on UNIX, among others, in the same semester.

An evaluation of the learners' situation before starting the course "Data Structures and Algorithms II" that is the focus of this paper provided the following results:

(1) Students did not have much knowledge about algorithms and data structures with practical usage. They had learned simple and short programs but did not have much experience with longer programs. For example, they did not have experience in how to update longer programs by themselves.

(2) They did not have enough motivation for autonomous learning. They were less eager to learn than freshmen. For example, they did not consult textbooks or dictionaries on their own when they had trouble understanding an exercise.

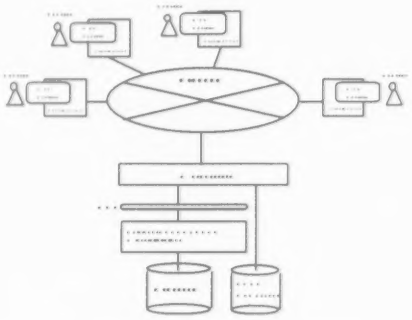


Figure 1. System Configuration

(3) Twenty-five percent of the students did not understand the C language. Seventy-five percent of the students tended to forget the C language, since they had not had a chance to practice it for more than 2 months after the second semester of the first year.

(4) Many students did not have sufficient skills to attain perfect command of software tools such as TGIF or LaTex.

3 Conceptual view of the computer exercise

Figure 1 shows the system configuration to support the exercise. Since each learner does his exercises at a workstation connected to the Internet, he can access information managed by the Web server. The Web server stores the exercises as HTML documents. The application program located in the CGI (Common Gateway Interface) manages information related to his registration, personal goals, and questionnaires. The application program is implemented in Parl, Shell, and SQL. The information inputted by the Web browsers is stored in the database and used by the learners.

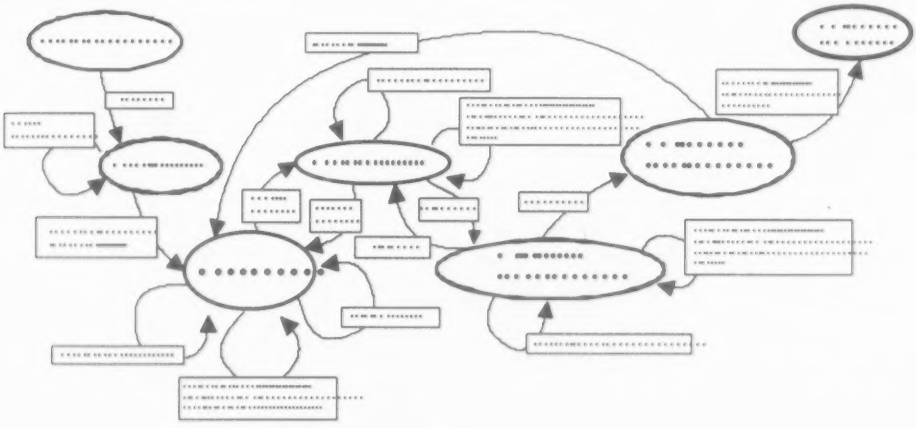


Figure 2. Computer Exercise Model

We tried to computerize human work as much as possible in the existing computer exercise. Notice of all 15 exercises included in the course was given on the Web page. We connected both basic programs and measurement data to the Web page for each exercise. Using a Web browser, both could be downloaded from the Web server to a student's site. Before starting on the first exercise, students had to fill out an electronic registration form for the class using the Web browser. When a student inputted his school number, name, password, and e-mail (electronic mail) address in the registration form, the system issued him a registration number using e-mail and the Web page. If the student needed any information about the exercises after that, he could get it by inputting his registration number and password using the Web browser.

Figure 2 represents the state transition for the computer exercise model. "Starting the Course," located at the left side of Figure 2, represents the state before starting the class. The student moves to the state of "Completing the Course" if he finishes all exercises successfully. If the student inputs personal data in the class registration form, the student moves to the state of "Class Participant." If the participant replies to the first questionnaire and inputs his personal goals for the exercise using the Web browser, he moves on to the state of "Exercising." At this stage, the learner is allowed to solve the exercise. If the learner inputs a question to the teacher on the Web page, he receives a reply from the teacher on the Web page. After finishing the exercise, the learner moves on to the state of "Making the Report" and can answer our questionnaire for the exercise as he finishes the exercise. If the learner submits his report to the teacher, he moves on to the state of "Waiting for the Evaluation." If the evaluation is poor, the teacher contacts the student, helps him, and asks him to re-submit the exercise. The Web system does not support their interaction in the situation, since we believe that face-to-face communication is preferable. This situation is different form Fujimoto's Classroom Management System [5]. After the learner reaches the state of "Completing the Submission," he will input his personal goals for the next exercise. After that, he will move to the state of " Exercising."

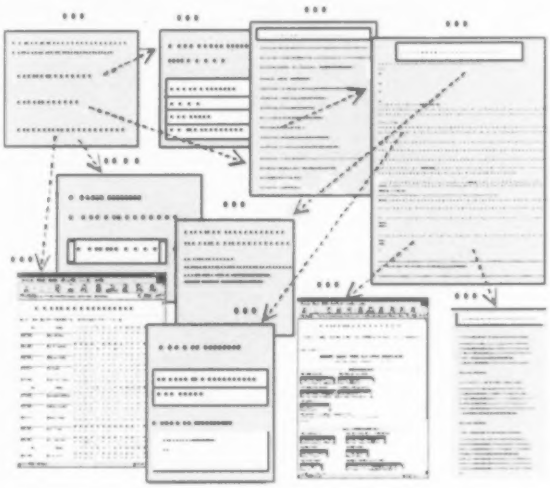


Figure 3. An Example of System Operation

We place great importance on the use of educational methods [6, 7] including "Reading, Writing, and Using an Abacus" to achieve the goal of "autonomous learning and thinking." For students belonging to the categories (1)-(4) mentioned above, the computer exercise model includes the following educational methods. Students in (1) and (3) are asked to read longer programs downloaded from the Web server, write the respective flowchart, update the subparts, and measure their performance in the state of "Exercising" shown in Figure 2.

Students in (2) are asked to define their personal goals before reaching the state of "Exercising" and write a self-evaluation in the state of "Making the Report." In the state of "Exercising," students are given an ambiguous exercise to learn the value of searching for information. In this way, students are encouraged to develop their creativity skills. Moreover, students are strongly advised to use textbooks and dictionaries if they have unresolved questions. Students in (4) are strongly encouraged to use such tools as TGIF and LaTex when preparing a report that includes figures and text. We believe that longer programs particularly enhance their proficiency in using tools. In order to determine an accurate grade for each exercise, we evaluate the reports submitted by the students and their answers to the questionnaires. Since we receive the results of the questionnaires immediately through the Web, we use such results to improve the exercises and coach the students. Moreover, the students can also receive their scores in a very short time. Students can compare each other's scores if they are given access to the statistics. Giving students access to the statistics is regarded as the key to ensuring an environment of awareness [8].

4 The results of system operation

Figure 3 represents an example of the operation of the system. Web page number (1) in the figure relates to the state of "Starting the Course." Page (2) is the class registration form. Page (3) gives anchors for information about all 15 exercises included in the course. If a learner selects one of the exercises on the page, he can use the exercise page (4). He can access his record of submissions and re-submissions using Web page (5). After inputting his personal goals using Web page (6), he moves on to the state of "Exercising." When he finishes the exercise, he moves on to the state of "Making the Report" and inputs the questionnaire on Web page (7). The results of the questionnaires are immediately stored in the database. Not only the teacher but also the learners are able to compute the statistics of the results from the database in real time. Page (8) relates to the statistics. Pages (9) and (10) are for teachers' use only. In page (9), each student has 15 check boxes, each divided into an upper and a lower section. If the report evaluation is good in the state of "Waiting for the Evaluation," the teacher puts a checkmark in the upper check box. If not, he puts the checkmark in the lower check box and helps the student so that he re-submits his work. Page (10) is useful for analyzing questionnaires stored in the database. The analysis includes the method of data mining [9] implemented in SQL.

Application of the system operation started at the Department of Hiroshima City University in April 1999. This system motivates students to do their exercises, provides good communication between participants and teachers, and reduces teachers' workload. The evaluation results of questionnaires and examinations related to the exercises are as follows:

(1) Ninety percent of students studied for 0.5-2.0 hours at their homes and were interested in the lecture.
(2) Twenty-six percent of students spent less than 2.0 hours preparing the report and exercising, 53% spent 2.0-5.0 hours, and 21% spent more than 5.0 hours, not including class work.
(3) Seventy percent of the 12 students (25%) previously mentioned understood the C language. Moreover, all students made progress in their studies.
(4) Ninety-five percent of the students reported good understanding of the algorithms used in the exercises. Eighty-seven percent of the students passed the examinations.
(5) The students acquired good skills at using TGIF, LaTex and other programs to write reports.
(6) Seventy percent of the students felt that the teacher did his best in the classroom, and 17% of them barely approved of his performance.

5 Conclusions

We proposed a computer exercise model for the course of "Data Structures and Algorithms II" and developed a Web support system for computer exercises using the model. We place great importance on educational methods including "Reading, Writing, and Using an Abacus" so that our students acquire the skills of "autonomous learning and thinking." Computer exercises using the Web system give students a chance to enhance their capabilities of "autonomous learning and thinking" and "creativity." The system run on the Web server has useful functions, some of which are the management of participant registration, identification of learner's goals, web service of exercises, mutual interaction between participants and teachers, management of report submissions, and both provision and analysis of electronic questionnaires to participants. The use of the system resulted in students' motivation to do the exercises, good communication between participants and teachers, and a reduction of teachers' workload. In order to achieve more concrete results, the students studied more at home and were enthusiastic about doing their exercises. Moreover, the students learned how to make a report using TGIF, LaTex and other programs.

Acknowledgements

We thank Assistant Professor Dr. Akira Sato of Hiroshima City University for his help with the exercises. We also thank Mr. Jun Ogawa, Mr. Takashi Maesako, and Mr. Kohei Matsumoto, TAs (Teaching Assistants) of Hiroshima City University, for their help with the exercises. This work was supported in part by a Grant-in-Aid of Scientific Research (C) from the Japan Society for the Promotion of Science and a Hiroshima City University Grant for Special Academic Research.

References

[1] Denning P. J., Comer D. E., Gries D., Mulder M. C., Turker A., Turner A. J., and Young P. R.: Report of the ACM Task Force on the Core of Computer Science, Association for Computing Machinery Press (1988).
[2] Computer Science Educational Curriculum for B. A. Degree Program in Computer and Engineering J97, Information Processing Society of Japan, 158p. (1997).
[3] Aho A. V., Hopcroft J. E., and Ullman J. D.: Data Structures and Algorithms, Addison-Wesley (1983).
[4] Leendert A.: Programs and Data Structure in C, Second Edition, John Wiley & Sons (1992).
[5] Fujimoto R., Suganuma A., and Mine T.: Development of a Classroom Management System on the Web, Advanced Research in Computers and Communications in Education (ICCE'99), Ed. by Cumming G. et al., Vol. 55, IOS Press, pp. 756-759 (1999).
[6] Angelo T. A.: Beginning the Dialogue: Thoughts on Promoting Critical Thinking, Teaching of Psychology, Vol. 22, No.1, pp. 6-7 (1995).
[7] Kuhar M. B: Critical Thinking: A Framework for Problem Solving in the Occupational Setting, AAOHN JOURNAL, Vol. 46, No.2, pp.80-81 (1998).
[8] Dourish P. and Bly S.: Portholes: Supporting Awareness in a Distributed Work Group, Proc. of CHI'92, pp.541-547 (1992).
[9] Fayyad Usama M., Piatestky-Shapiro G., Smyth P., and Uthurusamy R.: Advances in Knowledge Discovery and Data Mining, AAAI Press/ MIT Press (1996).

Development of CAI System with Character Code Discrimination on WWW Environment

Hiroyuki Watanabe and Katsuhiro Kato
Department of Electrical and Electronic Engineering, College of Engineering, Nihon University
1 Nakagawara, Tokusada, Tamuramachi, Koriyama, Fukushima 963-8642, Japan
E-mail: {hiroyuki, kkatoh}@ee.ce.nihon-u.ac.jp

1 Introduction

The CAI systems on the Worldwide Web are accessed by learners all over the world. However, the server-client type CAI system has a problem in that the character code does not translate into other character codes. Therefore, in the previous CAI system[1], the S-P chart used for data analysis was readable only in the Japanese version[2]. The new client program runs Java applet corresponding to the character code of the learner's language and the character code in the tag is transferred to the server together with the learner's data. The character code in the tag is decoded on the server side, and the HTML file provides the S-P chart. As a result, even if the CAI system is accessed from various countries, the character code of the learner's language, such as Japanese or English, can be decoded by one server program and the SP chart corresponding to the character code can be provided.

2 Flowchart for the Character

Code Decoding

This CAI system is constructed through the WWW client program with Java applet corresponding to the character code of the learner's language, and the WWW server program with the Java application[1]. Below is a description of the process. (see Fig. 1).

(1) The Japanese or English learner selects Java applet in Japanese or in English, respectively. The questions or hints are displayed. The learner's answer is judged via the WWW client program which is online.

(2) When the WWW client is only one Java applet, the WWW server has a character code error for the difference between the languages of the client and the server. For character code decoding the following code is added in the tag by Java applet.

<GET> M dir_name learner_name JPN
..for Japanese
<GET> M dir_name learner_name ENG
..for English

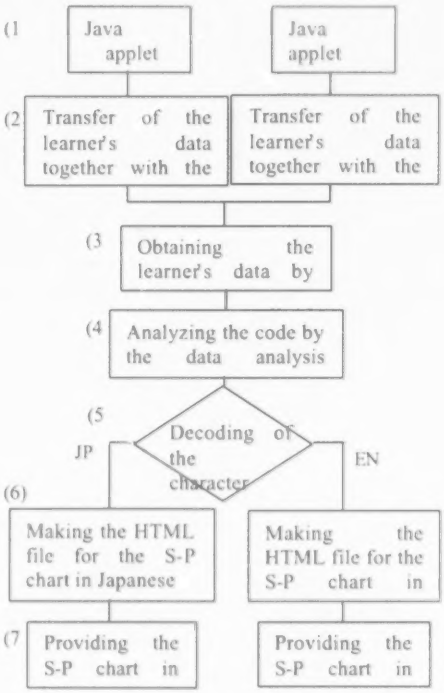


Fig. 1: Flowchart for the character code

The "<GET>" is one of the tags transferred from the client to the server. The code "M" is the data management related to the language. The "dir_name" is the directory name of the courseware for the saving of the learner's answers. The "learner_name" is the learner's name. The last code "JPN" or "ENG" is the character code of each learner's language.

(3) The character code together with the learner's data, which includes the learning score and its time, are obtained by the WWW server program through the Internet or the Intranet.

(4) Even if the language code is different, the learner's data is saved with the same file name in the same directory for the courseware. The learner's data is managed collectively, and the data analysis program analyzes the character code in the tag.

(5) The character code difference between Japanese and English is decoded.

(6) The learner's ranking is placed with the data of all learners, which has been stored in the server for each courseware. The S-P chart and the result of the statistical analysis which is formatted by the HTML are made corresponding to the character code of each learner's language.

(7) The S-P chart with the character code of each learner's language is provided to the WWW client.

3 Results

Fig. 2 shows the S-P chart in English for the score. The score for each learner is sorted vertically to the smallest value, which is the S-curve, and the score for each question is sorted horizontally to the smallest value, which is the P-curve. The S-P chart displays the learner's ranking. The attention coefficients for each learner and each question are shown. Furthermore, the evaluation of the learner, the average and its standard deviation are also shown. The S-P chart can also be accessed and displayed in Japanese.

Fig. 2: S-P chart in English.

4 Conclusions

For a good study, it is important that the S-P chart be provided for the learner. In this paper, the character code corresponding to Japanese or English, together with the learner's data, is transferred to the server from the client by Java applet. The S-P chart, which is written in Japanese or in English, could be provided by one server program making the HTML file corresponding to the character code of the learner's language. As a result, many server programs will not need to prepare character codes for the learner's language. This should increase the number of learners and give learners more definitive rankings. Each learner can access the courseware by typing the following URL through the Internet.
http://133.43.15.87/~ hcai/index_e.html

References

[1] H. Watanabe & K. Kato, "Development of the ICAI system in WWW for individualized education", Proceedings of the 5th International Conference for Young Computer Scientists (ICYCS'99), Nanjing, China, Aug.17-20, pp.966-970, (1999).

[2] H. Watanabe & K. Kato, "An analysis of response time distribution for CAI courseware", Proceedings of the 7th International Conference on Computer in Education (ICCE' 99), Chiba, Japan, Nov.4-7, pp.125-132, (1999).

Development of Cross-Cultural Communication System and Web-based Japanese Education

Lumi Tatsuta, Yaeko Nakanishi , Masayuki Ohnishi, Atsuo Iguchi*, Giichi Tomizawa and Kimiko Gunji*****

**Dokkyo University(Japan) • •*

***Science University of Tokyo(Japan)*

****University of Illinois(UA)*

1-1 Gakuen-cho Soka, Saitama Japna 340-0042

tatsuta@dokkyo.ac.jp

In 1998 we presented a framework and system construction of "Images of Japan," a learning system of the Japanese culture and language in Beijing, China. In this paper, we discuss the results of our initial evaluation of its framework and system based on personal feedback from students and on the responses to the survey carried out in the form of questionnaires. Even though the overall assessment was positive, we have received a few suggestions for improvement. We are now working on the implementation of improvements, some of which we also introduce here.

Keywords: **Cross-Cultural Communication, Japanese Education, Communication Tool**

1 Introduction

"Images of Japan" was constructed to develop an effective network-based learning environment of cross-cultural communication: disseminating information on Japanese culture and providing opportunities to learn Japanese. In order to encourage active participation and to keep the users motivated to share their knowledge and develop a deeper understanding which they could not achieve alone, we have had Japanese students and non-Japanese students select items which they want to introduce or they want to know. More than 300 items have been collected. The data also reveal that there is a wide gap in their perception of Japanese culture, particularly between Japanese and non-Japanese students. We expected that this perceptional gap between the Japanese and foreign students would serve to facilitate cooperative and collaborative learning and sharing of knowledge among the users and to lead to their active participation in the program.

2 The Framework of the System and its Evaluation

Users can jump from the top page to any pages by clicking the icons installed in the index. Since this courseware is primarily constructed to show the diversity of Japanese society and to encourage Japanese and non-Japanese students to think about Japanese culture and to share opinions and ideas with each other, the pages of Classification and Collaboration are the central parts of this framework. Over 300 cultural items are presented in the Classification page. In the Collaboration page, "Bulletin Board," "E-mail," and "Voting," devices are installed. The "Bulletin Board" serves not only to link together Japanese students and non-Japanese students giving them opportunities to chat or exchange information, but also to provide data to evaluate the effectiveness of this collaborative learning program.

In the "Voting" users are encouraged to vote for the items in which they are interested. Users can also add new items of their own choice in the existing page. The ranking is continuously updated so that users can feel a sense of participation and maintain their interest. In addition to "Bulletin Board" and "Voting,"

"Questionnaire Page" was later added to obtain direct opinions from the users and to evaluate how much collaboration and development of knowledge has been achieved. The Questionnaire basically consists of multiple-choice questions. As evaluation based on these means should be carried out through a long span of time, however, we have decided to perform an experimental assessment in the form of a questionnaire in the meantime. The number of responses collected was 63 in total (51 Japanese and 12 non-Japanese students.) Questions focus on the following themes; (1) the overall framework, (2) information on the Japanese cultural items, and (3) the Japanese language learning program.

3 Results of the Questionnaire on the Overall Framework

In the evaluation of the overall framework, the following issues were addressed. The responses turned out basically positive.

Table.1

	Good	bad
Accessibility of items	78%	22%
Layout	92%	8%
Linking	98%	2%

Table.2

	very good	good	not good	bad
Size of the letter and presentation	12%	80%	6%	2%
Screen presentation	12%	80%	8%	0%
Control of Screen	8%	80%	10%	2%

Table.3

	Very interesting	Interesting	Not interesting
Photo picture	8%	78%	16%
Illustration	14%	53%	33%
Animation	20%	68%	12%

With regard to question of "Accessibility of items," however, 22% of the students responded negatively. The reasons could be multifold. The list of cultural items could be too numerous for participants to screen them thoroughly. The instructions on how to use the page might have been inadequate. A few students might not be able to plug in the page. Also, a minor technical problem might be present. However, the quantity of photos, illustrations, animations and sound is controlled so that users will not find them overwhelming. In any case, improving the accessibility is one of the issues that requires further study. On the other hand, we feel that the number and wide variety of cultural items, which might look overwhelming to some viewers, is in fact an important advantage. At the moment each one of those items is categorized into sixteen major subjects, and the users have to select one of the major subject first to reach the page of each item. How to arrange topics so that the users will find them easy to access is an issue to be studied as well.

4 Japanese Cultural Items

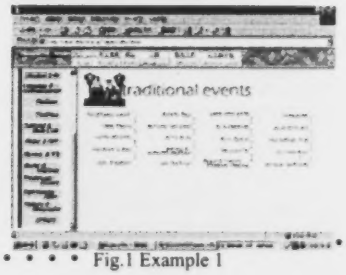


Fig.1 Example 1

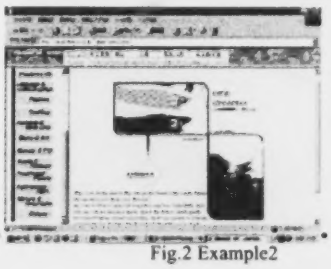


Fig.2 Example2

The above are examples of a cultural page. Each item basically consists of two pieces of visual information either in the form of photos , illustrations or animations, followed by the comments or brief information given by the students who participated in the original survey are given. In the survey, the following four questions were asked. As shown in the figures, their responses turned out less positive than those on the "Overall Framework".

(1) Could you understand the ways young students grasp Japanese culture?

Japanese students	Yes 76%	No • 24%
Non-Japanese students	Yes 100%	No 0%

(2) What do you think of this home page on Japanese culture introduced by students?

Japanese students	Useful 55%	Not useful 6%	Interesting 31%	No Answer 8%i
Non-Japanese students	Useful75%	Not useful 0%	Interesting 25%	No answer 0%

(3) After having read these pages, have your ideas towards Japanese culture changed?

Japanese students	Yes 37%	No 63%
Non-Japanese students	Yes 100%	No 0%

(4) Do you want to exchange your ideas with others on the "Bulletin Board?"

Japanese students	Yes 71%	No 29%
Non-Japanese students	Yes 100%	No 0%

The reason for the negative response is in part due to lack of sufficient information on each item. Particularly, the responses from Japanese students are much less positive than those from foreign students. On the other hand, written responses from foreign students were quite favorable: saying, e.g.,

"This is a fascinating resource to learn more about Japanese culture," "I think the items introduced here are very thorough, everything from traditional to modern culture." This wide difference in the response between Japanese and non-Japanese students is basically due to the fact that those non-Japanese students are the ones who are already interested in Japanese culture and willing to learn more, while most of the Japanese students are not necessarily interested in Japanese culture, or the items presented here are not enticing but too familiar to them. The objective reasons for the negative reactions should be sought for, too. It is also evident that we have to improve the Japanese Cultural Page so as to encourage students to share their knowledge and opinions actively and enhance their cross-cultural communication skills.

5 Improvements

In order to ensure that students will use our program as a source of information about Japanese culture and as a tool for cross-cultural communication, we have to make it more attractive for them. As a first step, we are now working on a construction of a "Discussion Room.," where two groups of students, Japanese and non-Japanese, exchange their ideas, feelings, and opinions on a series of scenes excerpted from Japanese movies (one is "Funeral" and the other is "Shall We Dance?") These two movies not only reflect ways of thinking of Japanese people but also its conventions of daily life and will serve as an interesting source of cross-cultural communication. Another group of students is assigned to discuss "Bushidoo vis-a-vis Knighthood," and the fourth group of students should discuss a topic of their own choice. We expect that through these activities the students will experience both satisfaction and frustration in communicating with other people of different cultural backgrounds. The conversations recorded in the Discussion Room are being accumulated and will be analyzed as a source of studying cross cultural communication.

As for the Japanese language Program, we could not obtain sufficient feedback from the foreign students The language program was made for intermediate students. However, since the number of foreign students who have reached intermediate level Japanese in this first experimental evaluation was limited, we could not obtain concrete comments or reactions on the program. At the time when we constructed the language program, we could not provide appropriate audio information nor video due to the problem of network speed. Since this problem has been solved, however, we are now not only adding sound to the original program but also constructing a new listening comprehension page. The listening comprehension is geared to basic level students. By doing so, a more active use of this program will be expected. It will be also used in class starting this October and the feedback from the students will be duly analyzed and be used for further improvements.

6 Future Plans

The results of the initial experimental evaluation have suggested that this home page could be a good source of information on Japanese culture. However, they also have revealed that some changes in the framework as well as in the content of the cultural and language pages should be made in the near future. Some of those changes are now being made as mentioned above. The program also needs to expand to include the participation of other universities, particularly those which they have a Japanese language program or course on Japanese culture. After implementing further improvements and having obtained a sufficient number of responses, we will reevaluate the home page.

References

[1]Barthel, Alex(1998)"The user of computer technology in the teaching of speaking touniversity students" Proceedings of ICCE98 Global Education on the Net Japanese Learning System: hhtp://www2.ak.cradle.titech.ac/jp/japanese

[2]Murphy, Kare L.(1998) "A Constructivist Look at Interaction and Collaboration via Computer Conferencing" International Jl. of Educational Telecommunications 4 (2/3)

[3]Nakanishi,Y. (1999) "On Evaluation of a Collaborative Learning System for Japanese and Japanese Culture" Dokkyo University International Center

[4]Ogata, Hiroaki & Yano, Yoko(1998) "Knowledge Awareness: Bridging learners in a CollaborativeLearning Environment" International Jl. of Educational Telecommunications 4(2/3)

[5]Tatsuta, Rumi, et.al (1998)• "Images of Japan" -- "Collaborative Learning System for Japanese and Japanese Culture" Proceedings of ICCE98 Global Education on the Net Japanese Learning System

[6]Tatsuta, Rumi, et.al (1998) "Development of a collaboration system on Internet in order to enhance t he understanding of Japanese Culture" Dokkyo University Studies of Economics Nol68

[7]Y. Nakanishi, L.Tatsuta, et.al (1999)• "On Experimantal Evaluation of a Collaborative Learning System for Japanese and Japanese Culture" Advanced Research in Computers and Communications in Education

Domain Specific Information Clearinghouses – A Resource Sharing Framework for Learners

Wong Pei Yuen*, Yeo Gee Kin*, David Crookalland Lua Tse Min***
**Department of Information Systems*
School of Computing
National University of Singapore
Building S-15, Level 5, Room 12
3, Science Drive 2, Singapore 117543
Tel: +65 874 2908 Fax: +65 779 4580
E-mail: {wongpei1, yeogk, luatsemi}@comp.nus.edu.sg
***UNSA, Langues, 98 bd Herriot, BP 209, 06204 Nice cedex 3, France*
E-mail: crookall@jaydemail.com

The World Wide Web has presented researchers and learners all over the world with unprecedented opportunities to find and distribute information. An increasing number of valuable resources are made available online. This provides an excellent knowledge base for learners. However it is often very difficult to find these useful resources. This paper describes the framework of a domain specific information clearinghouse and how these clearinghouses can collaborate with one another to enable cross-domain learning. The resources in a domain-specific clearinghouse are submitted by trusted domain experts to ensure its quality. Learners with multiple domain interests can also effectively retrieve the information they need using the cross-domain collaboration framework presented. This is achieved with a union agent that manages the collaboration and sharing of resources between different domains. We also present a toolkit that facilitates the rapid deployment of such clearinghouses by domain experts.

Keywords: **Collaborative Learning, Educational Agent, Knowledge Construction and Navigation, Web-Based Learning, Domain Specific Information Clearinghouse**

1 Introduction

The tremendous success of the Internet and the World Wide Web has resulted in a global information revolution. With more and more information easily available online, people are now increasingly reliant on the Web for their information needs. They are constantly faced with the problem of finding relevant information that will suit their learning needs. Most commonly used tools for finding information, in particular search engines and Web directories, often return huge amounts of information which are neither useful nor relevant to the learners' needs. A more effective way of assisting these learners in finding information is lacking.

A possible solution would be the use of a domain-specific information clearinghouse managed by human domain experts. In a nutshell, a *Domain Specfic Information Clearinghouse*, or *DSIC*, is a Web-based clearinghouse and resource repository for information resources available on the Web. Learners would be able to find relevant and higher quality information from these resources. However, most information and research nowadays do not dwell on a single domain. Cross-domain learning requirements need to be met. This can be achieved through collaboration between multiple DSICs. With this cross-domain collaboration, we are able to discover and learn more about how each domain is related to one another.

In the following sections we will discuss the various approaches that are currently adopted by learners and

the concept of the Domain Specific Information Clearinghouse. Section 4 describes the framework of a Domain Specific Information Clearinghouse network to facilitate cross-domain learning. In Section 5, we describe a toolkit currently under development for the quick deployment of a domain-specific information clearinghouse. Finally, we would conclude with Section 6.

2 Current Approaches for Finding Information Online

The primary means by which learners find information on the Web are tools like search engines, Web directories and metasearch engines [1] [5].

Search engines operate by plowing through the Internet and indexing web pages. Typically, only keywords are indexed. Some examples of search engines are AltaVista[1] and Hotbot[2]. Using this method, a lot of information can be retrieved. However, there is a trade off between quantity and quality. In this huge list of results, though it may contain many relevant items, most of the search results are usually irrelevant. Learners will lose a lot of time following useless links.

Web directories like Yahoo![3] and Excite[4] are maintained manually by a dedicated group of catalogers. These directories contain user-submitted resources that are indexed categorically. These indices are usually human-created or computer-generated. They would usually include some description that helps the user in determining the usefulness of the resource. As the resources contained by Web directories are user-submitted, there is the problem of scalability: it is impossible to scale personnel to match the rate at which the Web is growing. Web directories are outdated rapidly due to the ever changing and ever growing Internet. Important resources for the different categories and topics are often missing.

Metasearch engines are web tools that poll multiple sources like search engines and Web directories. The compiled resources are then processed and returned as results to the user. Metacrawler[5] and SavvySearch[6] are examples of metasearch engines. However, as pointed out in [4], although metasearch engines can significantly increase coverage, they are still limited by the engines they use with respect to the number and quality of results.

After looking at the above approaches, the problem of finding relevant and useful resources is not solved. Although these approaches may be adequate for a casual Web user, they do not serve learners who require specific information from certain domains well. We shall discuss our proposed solution in the next section.

3 Domain Specific Information Clearinghouse

Figure 1 below depicts the DSIC model.

---

[1] http://www.altavista.com
[2] http://www.hotbot.com
[3] http://www.yahoo.com
[4] http://www.excite.com
[5] http://www.metacrawler.com
[6] http://www.savvysearch.com

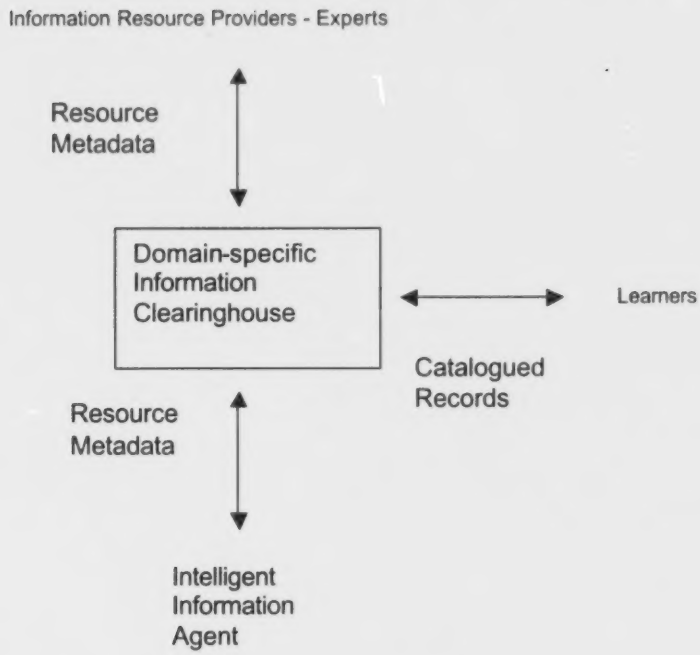


Figure 1: Domain-Specific Information Clearinghouse Model

As mentioned earlier, a Domain Specific Information Clearinghouse is a web-based clearinghouse and resource repository for domain-specific resources available on the web. One or more domain experts maintain the resources found in the clearinghouse. From now on, we will refer to *experts* as people who supply information to the clearinghouse and *learners* as people who access the clearinghouse for information.

The clearinghouse contains a classification of topics found in the domain and an intelligent information agent. With a good classification, the clearinghouse would be better organized and would increase learners' ease in finding the information they want. An intelligent information agent should be made available to facilitate the knowledge sharing and exchange both within and outside the clearinghouse.

An expert registers with the clearinghouse as a trusted information provider. He will then be able to submit resources that are in turn classified and cataloged. Using information found in these submitted resources, the intelligent information agent could scour the Web for more resources that can be added into the clearinghouse. The quality of these resources is much higher as they are being submitted by domain experts. What is useful and relevant to these experts are also usually useful to the learners as well. With all these information clearly classified, learners can then search or browse through the resource collection effectively in the domain specific clearinghouse.

4 Cross-Domain Learning

The DSIC caters to the needs of experts and learners in a single domain. However, learners often have not just one but multiple domains of interest. It would be useful for a learner with multiple domains of interest to be able to find the information he needs across all the different domains. Moreover, there are often no clear boundaries between domains, as the figure below shows. Resources from different but related domains may overlap.

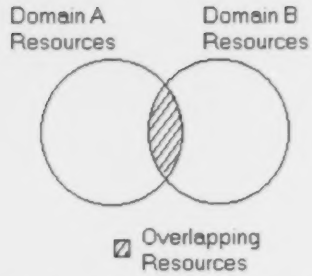


Figure 2: Overlapping Domain Resources

This potentially allows for different DSICs to collaborate and share resources with each other. To provide such a resource sharing framework, two issues needs to be addressed: distributed service and metadata exchange.

4.1 Distributed Service

The proposed framework for collaboration between multiple DSICs is essentially a distributed service. Domain experts maintaining each individual clearinghouse would register it with the *information union agent*, which is a central service that keeps track of all the existing clearinghouses that has been set up. This is illustrated in Figure 3 as follows:

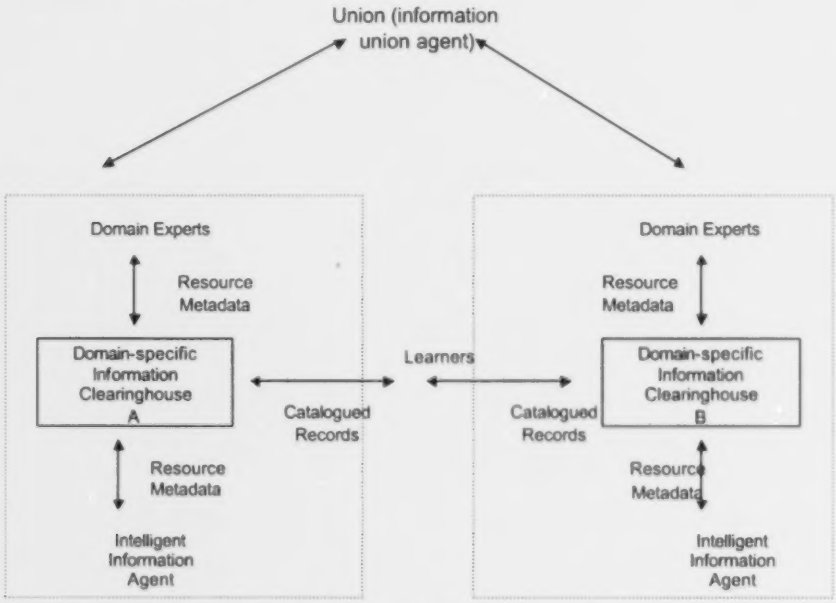


Figure 3: Multiple Domain Resource Sharing

Upon registration with the information union agent, each clearinghouse would declare the metadata attributes that are used to describe resources in that particular clearinghouse. Relationships with other domain clearinghouses are also declared. This information is then broadcasted to all the clearinghouses in the union to facilitate metadata exchange, which will be discussed in section 4.2

Besides maintaining the relationship links between the different domains, the information union agent would

also apply data mining techniques to learn and discover relationships between resources in the different domains. For example, when the number of similar resources that are found in two different categories of different domains exceed a threshold value, the union agent would automatically update the union with this relationship if it has not already done so. Through this process, the union agent can learn and discover new information and relationships between different clearinghouses in the union and update the respective clearinghouses with the new information. This allows the clearinghouses to provide learners with higher quality information.

4.2 Metadata Exchange

A DSIC union needs to provide a mechanism to facilitate the exchange of machine-understandable information among different DSICs. Being domain specific, each DSIC has its own set of metadata attributes and values. A mechanism needs to be provided for a DSIC to automatically interpret metadata that comes from another DSIC of a different domain and transform it to a human-readable form. This problem is non-trivial because classification schemes and metadata formats can vary widely between different DSICs.

The *Resource Description Framework* [7], or *RDF*, is an evolving specification developed by the World Wide Web Consortium. RDF's nucleus is an archetype for depicting named properties and their values. The properties are representations of resource attributes as well as the relationships between resources. This data model provides a syntax-independent means of representing RDF expressions.

We have developed a mechanism adapted from the RDF standard that would suit the needs of the DSIC union. We called this mechanism the *Metadata Schema*.

A metadata schema is simply a set of attribute names that is used to describe all the resources cataloged in a particular DSIC uniformly. Each DSIC is associated with exactly one metadata schema at any one time.

A metadata schema is unambiguously represented by an ordered n-tuple of the form

$$< N_1, N_2, N_3, \ldots, N_n >$$

In the above notation, each N_i, $i \in \{ 1, 2, 3, \ldots, n \}$ can be any sequence of alphanumeric characters, including spaces, that starts with a letter. Usually, these would correspond to attribute names such as "Author", "Company", "Description" and "E-mail Address".

The Metadata Schema, together with the information union agent, are the main mechanisms for interoperability between different DSICs. The following scenario illustrates how the Metadata Schema is being used.

A learner using a particular DSIC X to search for information can indicate that he wants to cross-search another DSIC Y. Through the union agent described in Section 4.1, DSIC X would already know the Metadata Schema of DSIC Y and would request DSIC Y for metadata records that correspond to the user's search request. DSIC Y would then respond with a set of results of the form

$$R = \{ R_1, R_2, R_3, \ldots, R_m \}$$

where each R_i, $i \in \{ 1, 2, 3, \ldots, m \}$ is an ordered n-tuple of the form

$$<V_1, V_2, V_3, \ldots, V_n>$$

Each element in the set R is then mapped to the known Metadata Schema of DSIC Y, after which the results are formatted and displayed by DSIC X.

The above scenario can be extended to more than 2 DSICs by simply requesting metadata tuples from each DSIC in turn. In this way, the DSIC union can be regarded as a single, distributed service with multiple access points, providing high quality cross-domain information to learners seeking such information.

5 An Example

An example of a domain specific information clearinghouse is the Simulation/Gaming eXchange [6]. This is a clearinghouse for resources in the simulation and gaming domain. Most of the resources in the clearinghouse are submitted by domain experts and are of high quality. Some entries are submitted by the *SGX Information Agent*, a software agent which uses techniques found in [2] and [3] to scour the Web and retrieve resource related to those submitted by the domain experts. A typical entry in [6] is show in Figure 4.

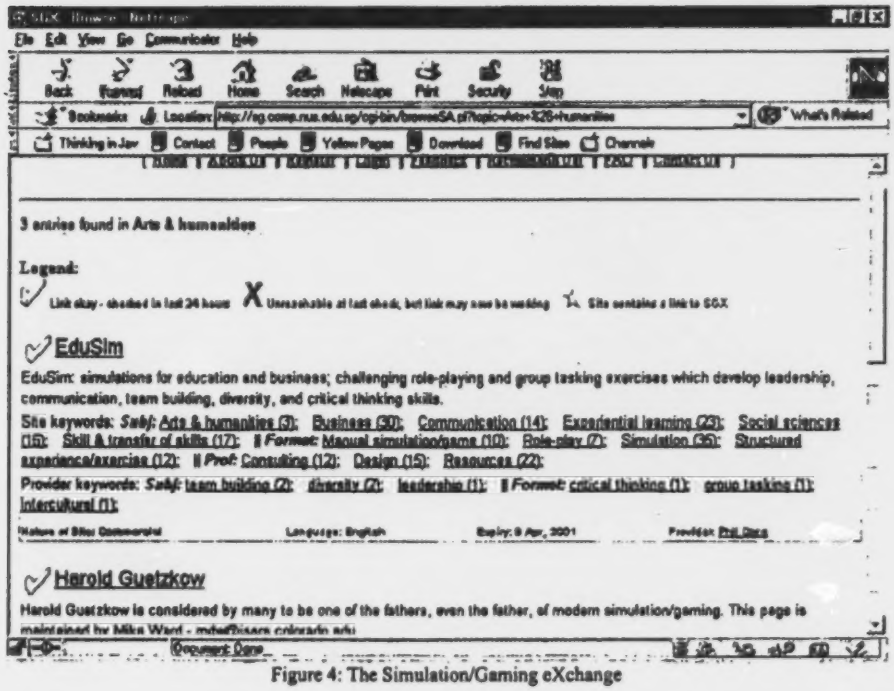


Figure 4: The Simulation/Gaming eXchange

Assuming that there is another information clearinghouse in the domain of CAI. This information clearinghouse also has its list of classifications and resources that have been submitted by experts. Upon registration into the union, the CAI clearinghouse will identify its relationship and links with the other clearinghouses that are already in the union. In this case, the CAI clearinghouse has to determine its relationship with the simulation/gaming domain. Some of the overlapping regions between CAI and simulation/gaming include edutainment, the use of simulations and virtual reality in learning. These resources can be applied to both the simulation/gaming domain and CAI domain when simulation/gaming is used as a tool in teaching using computers

Both CAI and simulation/gaming experts have submitted resources to their respective domain-specific information clearinghouses. Some of these resources are similar and will overlap each other. Using the overlapping regions as a starting point, the information agent in each clearinghouse will collaborate by sharing the resources they have. When a learner searches for virtual reality related resources in the CAI domain clearinghouse, he will be prompted that more resources are available in the simulation/gaming domain. He will also be linked and directed to these resources found in the simulation/gaming information domain. In this way, more resources can be retrieved without compromising on the quality of the results. This is very useful for learners with multiple domain interests. Furthermore, learners are also able to see how other domains relate to his domain interest. This sharing is done with the help of the union agent.

6 DSIC Toolkit

Although different domain specific information clearinghouses catalog resources in different domains, they have the same main functionality as follows:

- **Registration** – Users can register as information resource providers via online forms
- **Catalog** – Registered domain experts can login to the system and catalog resources. In addition, an automated information agent is used to gather resources from the Web automatically. Authors are identified by the agent and invited to refine the catalog of their own resources.
- **Browse** – Web users can browse through the resources cataloged in the clearinghouse using the classification scheme employed
- **Feedback** – A feedback mechanism must be provided for users to give feedback to the DSIC administrator
- **Administration** – An authorized administrator is allowed to make administrative changes to the system as an administrator

These similarities in different clearinghouses provide the foundation for the development of a generic, flexible toolkit for the rapid deployment of a domain-specific information clearinghouse. Domain experts with little or no Web development expertise but wish to deploy and maintain an information clearinghouse can make use of this toolkit to rapidly set up one.

The DSIC toolkit is designed as an integrated package with the following components:

- Web server
- Classification Scheme Editor
- HTML Template Editor
- Administration Module
- User Module
- Information Agent Module

A set of default templates are provided together with the toolkit so that a domain expert who wishes to set up a clearinghouse can selectively use the components of the toolkit and set it up in a short time span instead of having to start from scratch.

7 Conclusions

In this paper we have proposed a framework that allows learners to collaborate and share resources. With the use of domain specific information clearinghouses, learners are able to find useful, valuable and related resources. The clearinghouse union is a mechanism that allows different domains to come together and share their resources. This is especially useful for researchers and learners who have multiple domain interests. They are able to find resources across the different domains without compromising on the quality of the results.

Knowledge discovery and sharing is also made possible with the help of the union agent that overlooks all the domain clearinghouses in the union. The union agent not only helps learners retrieve related resources in other domains but also searches through the huge databank of resources to find hidden relationships about the different domains, giving us information on how different domains are linked and related to one another.

Finally, we also presented a clearinghouse toolkit currently under development for the rapid deployment of an information clearinghouse. Through the use of the toolkit, domain experts can quickly specify a classification scheme and set up a clearinghouse. The newly deployed clearinghouse is automatically registered with the union and start sharing resources with other clearinghouses already in the union.

References

[1] Loren T., Will H., and Brian A., "Constructing, Organizing, and Visualizing Collections of Topically Related Web Resources", in ACM Transactions on Computer-Human Interaction, Vol. 6(1), March 1999.

[2] Neri, F. and Saitta, L., "Machine Learning for Information Extraction", in Proceedings of the International Summer School on Information Extraction, SCIE '97 (Frascati, Italy, July 14-18, 1997.) Springer-Verlag Berlin Heidelberg, 1997, pp. 171 – 191.

[3] Theilmann, W. and Rothermel, K. "Domain Experts for Information Retrieval in the World Wide Web", in Proceedings of Second International Workshop on Cooperative Information Agents (Paris, France, July 4-7, 1998.) Springer-Verlag Berlin Heidelberg, 1998, pp. 216 – 227.

[4] Eric J.G., Steve L., William P. B. and C. Lee G., "Architecture of a Metasearch Engine that Supports User Information Needs", in Proceedings of CKIM 1999.

[5] http://www.usatoday.com/life/cyber/tech/review/crg842.htm

[6] http://sg.comp.nus.edu.sg

[7] http://www.w3.org/RDF

The Gathering and Filtering Agent of Education Newspaper for NIE

Chul-Hwan Lee, Sun-Gwan Han, Hee-Seop Han
Inchon National University of Education
Dept. of Computer Education
Tel +82-32-540-1284
#59-12 Geysan-dong Geyang-gu Inchon 407-753 Korea
chlee56@compedu.inue.ac.kr {fish,hansg}@compedu.inue.ac.kr

This paper presents the ENIG Agent to gather distributed information of educational newspaper in the web as well as student to provide the sound information for the NIE learning. The ENIG Agent gleans an appropriate newspaper headline of educational news portal site for real-time provision of the information. For gathering the optimized information, The ENIG agent performs the pre-process of educational news site, information noise filtering, pattern matching. The gathered educational newspaper information is removed a harmful data by using the pattern matching in the inference engine. The student can show the result of sound data through the web-browser as well as can use to learning with another application. For efficiency of this system, we evaluate the performance of the ENIG system by the experience of the NIE learning.

Keywords: **NIE, Newspaper Information gathering, Intelligent Agent, Supervised learning**

1 Introduction

These days, the web brings about a great change of education by a rapid growth of the Internet. It is not an easy work that a student finds the education information in the web. For searching the suitable information, a various search engines were developed and it provided a service for all. However, the general search engine is not fit that a student use at learning directly, because the information of search engine can contain a many data unconcerned learning. The learning requires the filtered information that can apply learning directly. Therefore, for efficient education, new type of search engine needs for the information retrieval and gathering [9].

Besides, the NIE means "Newspaper In Education", it is a method that student and teacher increases an efficiency of learning by using newspaper. The late web is used a good place for the NIE learning and a collaborative learning. However, when student and teacher study on the NIE learning through the web sites, they spend much time and repetitive efforts to find the newspaper contents. The student can lose a basic purpose of the NIE learning by the wasteful spending. The NIE learning needs an intelligent searching agent that searches automatically an important content about newspaper on the web. Moreover, because the gathered educational newspaper can contain harmful data, the data can remove by using the pattern matching in the inference engine [8].

Consequently, this paper describes about the ENIG Agent for the NIE learning. For providing the student just wants newspaper contents, we designed and implemented the intelligent agent system. In the following section, the NIE and the agent for information retrieval will be surveyed and the basic structure of the ENIG Agent will be designed. Furthermore, the next section will be discussed about implementation and experiment of ENIG Agent system. Finally the conclusion and future works will be described.

2 NIE and intelligent gathering agent

The NIE is the initials of 'Newspaper In Education'. It is the education method for individual who make friend with newspaper and improves the achievement of learning using the contents of newspaper. The newspaper, "a living text book", is applied with open education through the NIE learning.

Roles of newspaper for education are listed below [5].

- The newspaper is a bridge that can connect the disparity gap between school and society.
- The newspaper is the reflective of actual world.
- The newspaper reappears the scene of the history and is researching material of present society.
- The newspaper is the most suitable of clear text model and is used with subject matter of language learning.
- The newspaper is the unique textbook that everybody can read in ones lifetime continuously.

For the reasons stated above, we can expect a advantages that the NIE learning is originality, thinking power, ability to read and understanding and writing text, the establishment of sociality through ones sense of values, ability to practical use of information and so on[8].

When teacher will teach using NIE content on the web, we must consider below list.

- The newspaper is not be made data for the NIE. Because it is made for adult, it has a very difficult vocabulary. Therefore, teacher must supply to student a vocabulary database.
- The newspaper has an article about negative contents of society. Such contents must be edited or deleted by using an intelligent agent.
- Because the web is opened to everyone, the newspaper may have contents that student never see. In special, an article of obscene, crime, violence must be deleted.
- The contents of a newspaper are best the events of the day. But the NIE is used the contents of old newspaper. Such contents are good saving at scraping DB.

The method of information retrieval is variety. For information retrieval of educational homepage, intelligent agent used a very suitable tool [9]. The intelligent agents having the characteristics of autonomy, social ability, reactivity, pro-activeness and cooperative relationship can provide the searching results of a user demanded through machine learning [11].

An agent gathers information instead of the user. Because the agent system does not deal with basic data, instead it deals with knowledge information, can easily process the knowledge of education homepage. Moreover, an agent system is capable of using effectively gathering of information on the dynamic web environment. Therefore, the web based instruction using the NIE learning needs intelligent agent system [3].

3 ENIG System

Generally, the web document has many added tag information in contents. This added tag can represent efficiently information and data of HTML document. However, the user does not use the tag information but can use only the text or the multimedia information. The tag information treats only an unnecessary noise to users. If an unnecessary noise tag in a content is removed, the filtered document is translated a regular expression in the ENIG system. The pattern of information is extracted at transforming regular expression by the string matching method.

The extracting information of content is interpreted the accuracy of information by inference engine. Inference engine has the knowledge base augmented with a rule-based system, and it has function of learning and inference by a supervised learning.

3.1 Structure of the ENIG agent system

The structure of the ENIC Agent system is shown figure 1. This system consists of four parts. The document of homepage on web filters tags by the noise-filtering module in analyzer. The information of filtered document is translated from HTML document into regular expression. The regular document is matched with the string pattern provided by string matcher in an agent and it extracts the information of articles in educational newspaper. The information of an articles is removed harmful data by the knowledge base in an inference engine. The interface module consists of two screens. The rule and knowledge is edited and added, deleted through the knowledge manager and gathering information is supplied to student by using the result viewer. The learning environment is a learning space that studies the NIE learning through web browser and a learning application programs.

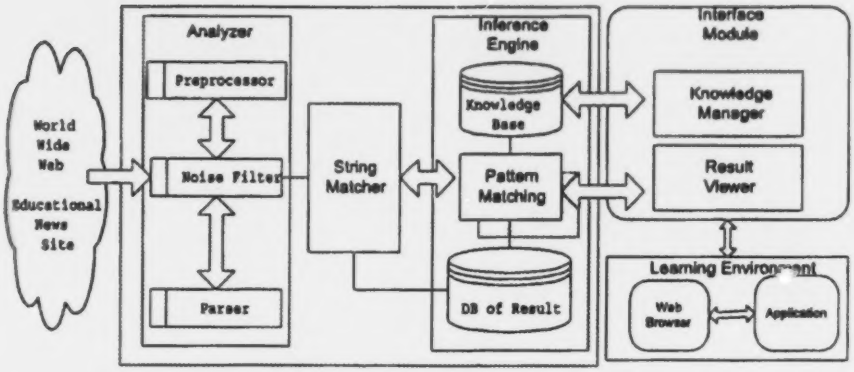


Figure 1. Structure of ENIG Agent

3.2 Noise filtering

Figure 2. Homepage of educational newspaper

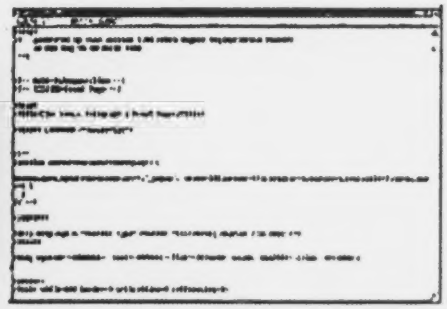


Figure 3. Source of homepage

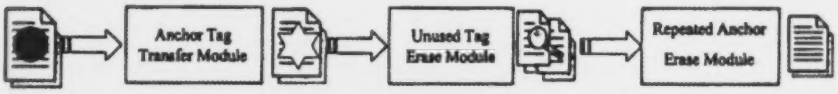


Figure 4. Steps of noise filtering

The example of educational newspaper site is shown figure 2. The tag information is not shown to user on the web-browser. While, the source of newspaper homepage is shown figure 3. The source is represented with a text and a complex tag information. Such tag information represents the arrangement of a document data and a multimedia information, a hyperlinked information.

The noise filtering is used to remove duplication data or an unnecessary data. For processing data called by HTTP, the noise filter processes work that removes a useless portion of the input data. The tags of HTML document have an irrelevant information to user, because tags only represent the formation of homepage and information of hypertext.

The noise filtering of the ENIG agent system removes an unnecessary tags in the document of an educational newspaper homepage except <A>...</A>tag, anchor tag of hyperlink and text data. The HTML sources are a difficult document to process noise filtering unconditionally, because the tag of document includes important information for the contents of document. Therefore, the noise filtering work must require a preprocessing module. Three steps of the noise filtering work is shown figure 4.

The preprocessing work for the noise filtering converts from basic <A>...</A> tag into suitable information and the works is listed below.

- Convert relative path for absolute path
- Change the URL of ASP form for the URL of HTML form
- Convert the path of CGI for general HTML form
- Change the path of script for absolute path
- Convert the hyperlink of image for absolute path

At the next step, the preprocessed documents are removed unnecessary tags by the noise filtering method except following items. <TABLE>,<TR>,<TD>,<LI>,<P>,
 tags are necessary the tags to keep the information of documents. The HTML document is composed one line of text or a record of table by such tags. Because most results of searching are represented with form of list or table, such tags is very an important information and may be not removed.

The final step of noise filtering is a work that gets rid of the duplicate from the URL of a document. The filtered document of educational newspaper homepage is show figure 5. We can know that the filtered document is ease for content analysis upon deletion of an unnecessary HTML tags. The advantage of noise filtering is that, it can process the same analysis about another newspaper homepages through removing tag.

```
Newspaper=Electronic Telegraph
URL=http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=3mmquqwM&atmo=3mmquqwM&pg=/
title=updatednews
date=2000.8.14
<table>
<tr>
<td>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
nhon14.html"
Honda to double British factory output
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
njake14.html"
Boy, 5, vanishes on trip to beach
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wiraq14.html"
West's raids spark Iraq fury
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
npaed14.html"
Labour welcomes Hague's paedophile plans
</a>
<a>
href="http://www.telegraph.co.uk:80/et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/
wthai14.html"
Murder hostel was notorious for drugs
</a>
```

Figure 5 Result of a noise filtering

3.3 Pattern matching

The filtered document is translated from each information and data into regular expression. The pattern of regular documents is extracted with sequence of regular expression by the method of string matching. The hyperlink information of image may infer by using the pattern matching through regular expression, because the hyperlinked image do not contain the text information on hyperlink. The pattern matching is executed to extract text data and information of hyperlink in HTML documents. Specially, if image has been including hyperlink, the pattern matching is a very important work. The article information of the educational newspaper site has information of hyperlink as followed.

***< a href= .....> ..... text ..... ***

Generally, the hyperlinked text information exists between <a> tag and tag. If an image exists between the anchor tags as " <img src=...> ", then text information can exist at front or back of the anchor tags. In this case, each tag and the text information is changed the defined tokens previously. In addition, each data is created a string of a regular expression by the pattern matching.

The portion of tokens for creation of regular expression is shown table 1.

Table 1 Token for regular expression

<table>	</table>			<tr>	</tr>	<td>	</td>	<a>		href	text
T	T	P	p	R	r	D	d	A	a	H	M

If the filtered document is represented with regular expression by tokens of table 1, the content of figure 5 is converted a tag page into the sequence of the alphabet as "TRDAHMaAHMaAHMaAHMa...". And the string pattern of regular expression has the process of pattern matching. This study used the three types of pattern for pattern matching as followed.

- *"AHMa" : "< a href= ..... > ..... text ..... "*
- *"MAHa" : "... text ... <img src=...> "*
- *"AHaM" :" <img src=...> ... text ... "*

The extracted string by pattern matching restores to the original tag and text information in HTML document. The extraction strings are reverted with source records. Figure 6 shows result that article is extracted through pattern matching of regular expression.

The translation of regular expression and the pattern matching have a many advantages. The advantage of pattern matching method is that the complex matching of string can extract only one time by matching of substring, and that agent can easily learn the rule of pattern.

Therefore ENIG system eases the addition of new educational newspaper site and pattern by the addition of URL and the type of pattern.

```
Electronic Telegraph|updatednews|2000.8.14|Honda to double British factory output|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/nhon14.html
Electronic Telegraph|updatednews|2000.8.14|Boy, 5, vanishes on trip to beach|http://http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/njake14.html
Electronic Telegraph|updatednews|2000.8.14|West's raids spark Iraq fury|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wiraq14.html
Electronic Telegraph|updatednews|2000.8.14|Labour welcomes Hague's paedophile plans|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/npaed14.html
Electronic Telegraph|updatednews|2000.8.14|Murder hostel was notorious for drugs|http://www.telegraph.co.uk:80/
et?ac=003278937115627&rtmo=fqqM3Mas&atmo=HXp8RRpL&pg=/et/00/8/14/wthai14.html
```

Figure 6 Example of string exchanging for regular expression

3.4 Inference and learning method

The extracted newspaper information is not provided all good information to student. In case of an inserted advertisement site, such site can become an obstacle of learning by the useless content. Moreover, a negative content or a harmful page too must be not suitable site to student. Such sites can be provided about a lustful content and a crime, an slang, a violence and so on. The harmful data can be removed in advance learning by inference engine and knowledge base. Reasoning rule uses the rule-based production system. The representation of knowledge is shown below

IF A THEN B

The production system has a merit that it is simple and easy the representation of rule as well as the addition of knowledge. The learning method of the ENIG Agent system uses the supervised learning learned by human teacher. If new rule is occurred, teacher input new rule and knowledge in knowledge base. For example, if the extracted information contains harmful text as a sex and a narcotic, a knife, then teacher input new rule and knowledge as *"IF sex AND narcotic AND knife THEN delete"*.

The harmful site at gathering site reason a rule by the analysis of content and the rule are stored in knowledge base by teacher. The bad information of extracted document is removed by the vocabulary DB and the rule of knowledge base. For forbidding the access of the student, the addition and deletion of rule and fact in the knowledge base can be control only by a teacher.

4 Implementation and Experiment

The implemented ENIG Agent can extract only the important information of newspaper site. In addition, it can be had with only a text and URL information at various homepage. For implementation of the ENIG Agent, we used Visual C++ and the CLIPS DLL. The CLIPS is rule-based a production system shell and it is used as an inference engine.

The execution screen of the ENIG agent system is shown figure 7. The ENIG system is composed of three parts. The left side of the screen is a part that the directory manager manages and edits educational newspaper sites, and the mid-screen is a part to view the result of the gathering information, and the button of right above is part to add a rule for inference and machine learning. If 'gathering' button is clicked, the ENIG agent gathers and extracts an article from an educational newspaper site. If 'learning' button is clicked, a rule and knowledge is added and edited by teacher in the ENIG agent.

This ENIG agent system can be applied directly at the homepage of different domain without change of system. If site is constructed standard HTML document, an agent can search and gather even the document of a foreign site.

The applying example of NIE learning using the ENIG system is shown figure 9. This example is used the ENIG system and the Web Browser and word processor. The screen is the NIE learning about music using the ENIG agent system and the Window application. The information of newspaper on the web can be applied directly at a web-based instruction (WBI).

One of the advantages of this system is that the extracted information uses a mobile environment directly. Because the extracted information is very small data and hyperlinked information, such data can be inserted the mobile communication as a cellular phone, a PDA, a notebook computer, a portal computer, and so on. Furthermore, the information of this system can transmit the WML by WAP.

Figure 7 ENIG Agent system

BEST COPY AVAILABLE

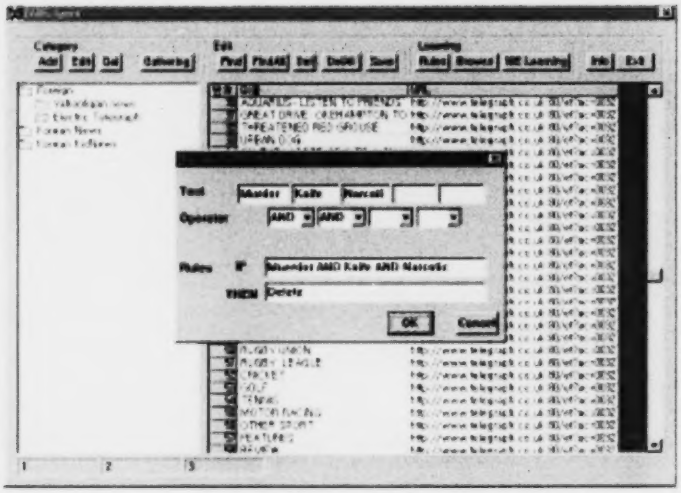


Figure 8 Addition of knowledge

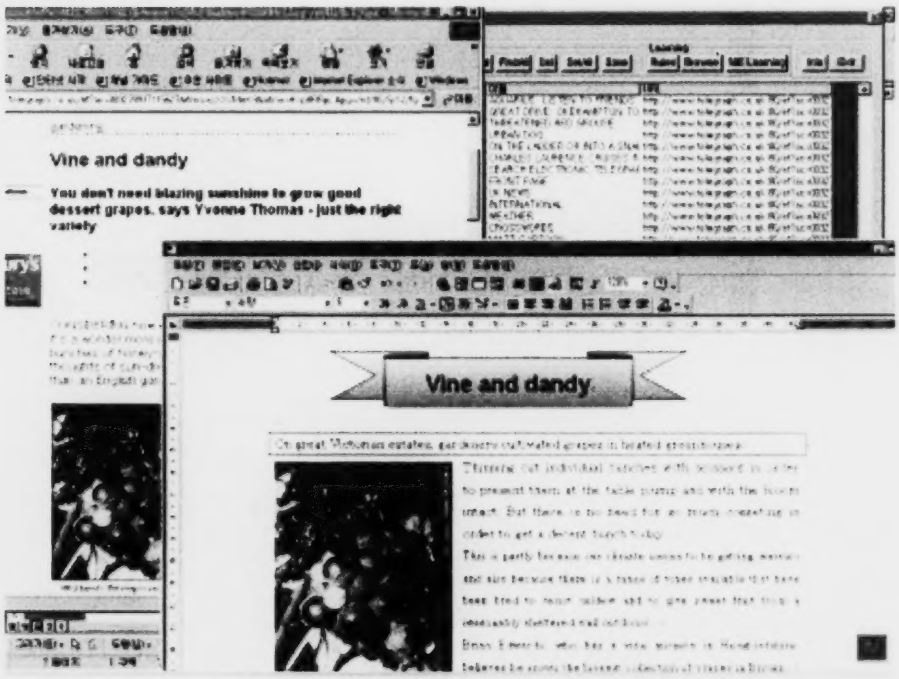


Figure 9 Example of NIE learning using ENIG agent

5 Conclusion and Future works

As mentioned above, we described about the ENIG agent system for the gathering information of educational newspaper homepage. In addition, we designed the method of noise filtering and pattern matching for suitable information. The method of noise filtering was used to remove unnecessary tags at source of HTML document and the method of pattern matching was used to extract necessary URL and text

BEST COPY AVAILABLE

information. The learning of agent was used to provide with good information to student by supervised learning. Most a web-based instruction was mainly learning about information retrieval. As student spent a lot of time to find learning information and data, so these lead deficiency of time for the essential learning.

Consequently, the ENIG agent system can provide not only to student for the learning of information retrieval but also can help them capturing the genuine NIE learning. And this system can execute the role of information treasury for the whole education through scraps of information.

The future works are that we improve the faculty of agent for information gathering of all sites; moreover, we need research about unsupervised learning of agent and not supervised learning. In addition, we need research to remove gathering information of header and footer through addition of heuristics and pattern type that requires the study about the method of keyword searching it. Finally, for providing a location of information to the agent, we will research the extension method of URL.

References

[1] Barbara Hayes-Roth. "An Architecture for adaptive intelligent agent systems", Artificial Intelligent, Vol. 72, pp.329-365, 1995.

[2] David Pallmann, "Programming Bots, Spiders, and Intelligent Agents in Microsoft Visual C++", Microsoft Press,1999.

[3] Erik Selberg, Oren Etzioni, "Multi-Service Search and Comparison using the Metacrawler", Proceedings of the 4th World Wide Web Cinference, Boston, MA, USA, pp 195-208, 1995

[4] Filippo Menczer, Alvaro E. Monge, "Scalable Web Search by Adaptive Online Agents: An InfoSpiders Case Study", Intelligent Information agents, Springer, USA, pp 323-347, 1998.

[5] Frances Anderson, "Classroom Newspaper Activities: A Resource for Teachers, Grades 1-8", Charles C Thomas Pub, 1985

[6] Henry Lieberman, "Personal Assistants for the Web: An MIT Perspective", Springer, USA, pp 279-292, 1998.

[7] Josheph Giarratano, Gary Riley, "Expert System, Principles and Programming", PWS Publishing Company, 1994.

[8] Paul Sanderson, "Using Newspapers in the Classroom: Cambridge Handbooks for Language Teachers", Cambridge Univ. Press, 1999.

[9] Ricardo Baeza-Yates, Berthier Ribeiro-Neto, "Modern Information Retrieval", Addison-Wesley, 1999.

[10] Sandip Sen and Gerhard Weiss, "Learning in Multiagent systems", The MIT Press, USA pp 259-298, 1999.

[11] Wooldridge, M., Jennings, N. R., "Intelligent Agents", Springer-Verlag, 1995.

Empowering Secondary School Teachers to Effectively Exploit Internet Resources for the Enhancement of Teaching and Learning

Y. T. Yu* and B. C. Chiu**

**Department of Computer Science, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong. Email: csytyu@cityu.edu.hk*

***Curriculum Development Institute, Education Department, HKSAR, 24 Tin Kwong Road, Kowloon, Hong Kong. Email: scdodp1@ed.gov.hk*

There are great potentials for the use of computers in the enhancement of teaching and learning in secondary schools, but in some subject areas, the realisation of these potentials is critically limited by the lack of appropriate educational software. Custom development of this kind of software is often not a viable alternative, since such a task is well known to be non-trivial and time-consuming that is frequently beyond the capacity of individual secondary school teachers. As computer science researchers and educators, we are aware that vast amount of teaching resources are freely available on the Internet. Such resources are often used by tertiary educators for enriching their teaching, but largely under-utilised by secondary school teachers. This paper reports our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources for use in their schools. Our approach is enabling in that it fosters participants' lifelong learning beyond the contents of the present course, and is applicable to a broader context than ours.

Keywords: **Teacher education, lifelong learning, program visualisation, algorithm animation**

1 Introduction

For a long time, educators and computer scientists have been exploring the use of computers in education [9]. The rapid drop in hardware price and the tremendous improvement in computing power in recent years have rendered computers more affordable to schools, teachers and students. Hardware is no longer the bottleneck that hinders the integration of information technology (IT) into the school curriculum. There are increasingly great potentials for using computers to enhance teaching and learning at all levels of education. In some subject areas, however, the realisation of these potentials is severely limited by the lack of appropriate educational software.

The development of good quality CAI software is well known to be a non-trivial and time-consuming task that calls for the combined expertise of programmers, experienced educators, graphics/multimedia designers, and others [10]. Such a task is often beyond the capacity of individual teachers in primary and secondary schools, due to their limited time, technical expertise and perhaps monetary resources. More fundamentally, it would not be realistic to require every teacher to develop their own CAI software from scratch for use. This is even true for most university educators. As Resmer [13] argues, "if every professor in a university had to write their own textbook, typeset it, print it, publish it, bind it, and distribute it before their students could use it, [textbooks] would not be a viable learning resource". Likewise, for widespread and effective use of computers in education, there is a need for teachers to be well informed of the source of available

educational software.

The Internet promises to be a source of many valuable teaching resources that are frequently available freely or at affordable costs. There are many advantages of exploiting Internet resources for use in teaching. Apart from cost savings, software tools on the Internet are more likely to be kept up-to-date as technology advances, and their evaluation versions could be put to trial use before making actual purchases.

By nature of their work, many university educators are accustomed to the exploitation of Internet resources for both research and teaching purposes [14]. In contrast, these resources have largely been under-utilised by secondary school teachers due to various reasons. Firstly, many teachers are not aware of the existence of such resources on the Internet. One example is the use of visualisation and animation tools that are great aids to program understanding. Although the existence and effectiveness of these tools have been well known to computer science researchers in the field, our experience is that few secondary school teachers are aware of this.[1] Secondly, teachers might not know where these resources are, even if they are aware of their existence. Blind searches on the Internet are likely to be inefficient and sometimes not productive, in terms of the time taken to retrieve useful materials. Thirdly, the use of some resources requires a level of technical competence that a typical secondary school teacher might lack. Finally, some software tools have to be adapted to suit the needs of individual teachers, and without any support or assistance, such tasks could be daunting.

In this paper, we report our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources. Our approach is enabling in that it fosters participants' self and lifelong learning beyond the contents of the present course. We believe that our approach is actually applicable to a broader context than ours and therefore would be of interest not only to secondary school computer teachers, but also to teacher educators and teachers of other disciplines at all levels.

The rest of this paper is structured as follows. Section 2 introduces the context and goals of our short course. Section 3 provides the background of the subject area: computer programming and visualisation tools. Section 4 describes how we exploit Internet resources for use in the course. Section 5 describes the implementation of the course and the feedback from participants. Section 6 discusses our approach. Section 7 concludes this paper.

2 The Teachers Update Course

2.1 Background and objectives

Our university has been organising the Teachers Update Course (TUC) annually as a service to local secondary schools. It aims at refreshing practising school teachers with updated knowledge on the subject areas they teach, and offering advice and assistance on the teaching and learning of the subjects. It serves to show our university's concerns to secondary education, to share our professional expertise, and to promote communication and cooperation between our university and secondary schools.

TUC consists of a series of half-day short courses that encompass many subject areas such as Use of English, Mathematics, Computer Studies, Physics, and others. This paper reports our experience in the design and delivery of the course on Computer Studies. Participants of the course were mainly secondary school teachers of computer subjects such as Computer Studies and Computer Literacy.

2.2 The local secondary school context

In Hong Kong, school teachers are often heavily loaded with both teaching and non-teaching commitments. Typically, a teacher has to conduct six to seven lessons per day, each lesson lasting for 35-40 minutes. In

[1] One author of this paper previously taught a class of student teachers in a Postgraduate Certificate in Education programme who were major in Computer Studies, and none of them were aware of the existence of program visualisation and algorithm animation tools. Similarly, none of the practising computer teachers who participated in the Teachers Update Course described in this paper were aware of such tools.

addition to such work as lesson preparation, setting and marking tests and examinations, most teachers have to share school administrative work as well as leading students to participate in extra-curricular activities.
In recent years, the Government of the Hong Kong Special Administrative Region (HKSAR) has undertaken numerous initiatives to promote the integration of IT into the school curriculum [3]. Since teachers of computer subjects are usually more acquainted with the use of computers than other colleagues, they are often busily involved in the setting up and management of the IT infrastructure of their schools, and they are generally expected to assist other teachers in solving various problems in using IT.

Increasingly, there are pressures for teachers of all subjects to apply IT in their teaching activities. Many teachers have to spend a great deal of time after school hours to attend in-service IT training courses [8,9]. However, one common problem they encounter is the limited availability of appropriate educational software, and few of them have the time and expertise to develop their own courseware. Moreover, budgets are limited in schools for the purchase or development of courseware.

2.3 Goals and strategy

During the planning and preparation of the short course on Computer Studies, the following goals were formulated in an effort to maximise the usefulness of the course to the participants:

- *The course had to provide materials that are directly relevant to teaching in schools.*

  The course in the previous year was intended to broaden the computer knowledge of school teachers by providing updated information on multimedia and their applications. As such, the course was organised in the form of a condensed lecture of part of an undergraduate subject, supplemented by demonstrations of the applied research work of our staff in the area. Although the subject materials were interesting, many teachers subsequently indicated a preference of topics that are more directly related to their own teaching in schools. Simply acquiring further knowledge in the computing field was not as welcome as knowing something directly useful for solving the problems they encountered in their teaching.

- *The course had to offer practical assistance to teachers.*

  Considering the heavy workload of secondary school teachers, any teaching resources must be easy to use and demonstrably useful, or they would not be used at all. In selecting the course materials, preferences were given to those that are easily and practically applicable in the secondary school context. This strategy is also in response to the feedback by teachers in the previous year of their desire to learn something that is "more relevant [to their teaching]".

- *The course should motivate teachers' interests and empower them to pursue further via self-learning.*

  The course was a short one and naturally limited in the amount of teaching materials we could possibly provide. Even with a much longer duration, it would still be impossible to inform the teachers everything they had to know about the topic. Moreover, even for the same topic, there are considerable variations in their needs (for example, due to different teaching styles or their students' background). The same technique useful to one teacher might not work for another. What is more important is to foster their ability to pursue the topics further beyond what we offer, whenever they have the need to do so. Therefore, from the outset the course was designed to "have an empowering or enabling effect on the participants" [9]. We hoped that the course could enable school teachers to acquire what they need via self and lifelong learning.

Setting the right goals was important, but the real challenge was how to achieve these goals within a few hours of contact with the participants. We now outline our strategy as follows. Firstly, we selected a topic that would likely interest most computer teachers: computer programming and algorithms. This topic is clearly directly related to their teaching. Secondly, we collected useful information and software tools for the enhancement of teaching and learning of this topic. Most of these resources were originated from overseas and would be hard to access were they not put on the Internet. Thirdly, among them, we selected only those information and software tools that were judged to be practically useful in the local secondary school context. Finally, we demonstrated to teachers how they could have found and utilised these resources on their own through the Internet.

In retrospect, we believe that although the first step (topic selection) is important in ensuring the relevance

of the course, it is our approach in the remaining steps (use of the Internet resources) that would have more profound influence to the participants. Our approach will be discussed in detail in Section 6. Meanwhile, we briefly introduce the subject area in Section 3 and then elaborate on what we did in the course in Sections 4 and 5.

3 Computer programming and visualisation tools

3.1 Computer programming as a common major part of many computing curricula

Computer programming and algorithms is usually considered a significant and fundamental component in undergraduate computer science education [6]. In most universities, introductory programming and the design of elementary algorithms are the first courses that a computing major undergraduate student has to take (unless these courses were exempted due to credit transfer or advanced standing). Elementary programming courses are also frequently offered as electives to non-computing students with a broad variety of backgrounds [10].

At the secondary school level, computer programming is historically the major component of a typical computer subject. Although the emphasis of learning programming has now been reduced as compared to the past, there is, arguably, still a place for it to be included in the secondary school curriculum. In Hong Kong, both the Computer Literacy subject (offered to almost all junior secondary students) and the Computer Studies subjects (offered as electives to senior secondary students) include programming as a major part of the curriculum [2].

3.2 Difficulties of teaching and learning computer programming and algorithms

The teaching of computer programming and algorithms presents a great challenge to educators at both the secondary level and the tertiary level [15]. To understand a computer program or an algorithm, the student needs to have a good understanding of the internal execution model of computers, as well as the dynamics of variables, data structures and control flows in the algorithm [7]. Such concepts are abstract in nature and could be difficult to even novice programmers [16], let alone non-computing major undergraduates and secondary school students. Indeed, according to our survey to secondary school teacher participants of our short course, about 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.

There is usually considerable overlap between the contents of a computer subject in a secondary school and those of a first year course on computer programming in a university. As such, the difficulties encountered by secondary school teachers are in many ways similar to those faced by the professors in universities, as far as the teaching of basic computer programming and elementary algorithms is concerned.

Nevertheless, usually only the academically more capable students will enter universities. As a whole, the secondary school student population is less mature in intellectual development and more diverse in their academic ability. Compared with university students, many of the secondary school students tend to be less motivated and less capable of independent learning; they normally require more guidance in their studies.

Secondary school teachers are generally less well informed and possess far less resource under their disposal than university educators. To our knowledge, a great deal of research has been done in many universities to address the difficulties in learning computer programming and algorithms [1,5,6,7,12,15]. Unlike universities, however, secondary schools seldom have the resources and expertise to perform similar work to solve their problems. In fact, they might not be aware of such research activities. Our approach in the course is to facilitate the use of university resources on the Internet by secondary school teachers to solve their own problems.

3.3 Program visualisation and algorithm animation

Program visualisation refers to the use of graphical artifacts to represent both the static and dynamic aspects of a program [11]. Algorithm animation portrays the dynamics of the execution of an algorithm by means of animation tools [7]. Educators and researchers have long believed that visualisation and animation are useful in helping students understand the abstract concepts and dynamics involved in computer programming and

algorithms [15]. It is believed that visualisation and animation tools help the learners by displaying in concrete form the mental model of the execution of computer programs. Indeed, many universities worldwide have been actively researching and experimenting with the use of visualisation and animation tools. As a result, a variety of such tools have been developed for different purposes [1,5,6,7,12,15]. Many experimental results have been reported that favour the use of such tools for enhancing program understanding [6,7,15].

4 Exploiting Internet resources for useful educational software tools

Despite years of active research, program visualisation and animation tools are still not widely used in secondary schools, and few such tools designed for teaching and learning are available commercially.2 As discussed in Section 2.2, it is often impractical for secondary schools to develop their own tools.

As computer science researchers and educators, we are aware that many program visualisation and algorithm animation tools have been developed as results of research work in various universities. Even though some tools have been developed mainly for demonstrating the research ideas and therefore might not have as many features as commercial software, most have been designed for teaching and learning. More importantly, they are usually available for free and easy access through the Internet for educational purposes. To our judgment, there are great potentials of utilising such tools in enhancing teaching and learning in secondary schools.

The idea of utilising research tools on the Internet for enhancing secondary school education is obviously appealing and has many advantages over acquiring similar tools by other means. We shall discuss these further in Section 6. However, before being convinced of the practicality of this idea, we had two concerns. Firstly, although these tools had been successfully applied in the tertiary education context, would they be useful in secondary schools as well? Secondly, would secondary school teachers be competent enough to make use of these tools that have originally been designed for use by tertiary educators who are technically more proficient?

To develop this idea further, we set out to evaluate the practicality of using Internet resources as teaching and learning aids in secondary schools. As program visualisation and algorithm animation do not fall into our own research areas, we started our search from only the scarce information that we had. Beginning with the Web sites of two well known researchers in these areas that we incidentally came across and made note of a few years ago, we followed links over links, and so on. It turned out that there was little difficulty in the search of relevant Internet resources. The more tedious and time-consuming task was to evaluate the contents of these resources one by one. Even so, within a few weeks' time, we were amazed to have collected and evaluated almost a hundred sites of related interest! These resources range from the innovative use of common spreadsheet software by researchers in the University of Helsinki [12], to ambitious laboratory projects such as the DYNALAB project of Montana State University [1], and university students' research projects such as Jeliot [5].

We selected and evaluated the resources according to several criteria: (1) relevance in content and level to the syllabus of secondary school computer subjects, (2) accessibility, (3) flexibility (customisability), (4) software and hardware requirements, (5) difficulty in technical content, (6) ease of setup and customisation. After evaluation, we decided to recommend about 30 web sites. The contents of these web sites range from ready-made animations of common algorithms, to downloadable program visualisation tools that support both forward and backward execution [1], and even online animation of user-defined algorithms using customisable 'actors' in a 'theatre-like environment' [5].

Through the process of selection and evaluation, we are increasingly convinced of the practicality of our approach. Many of the tools we found could be effectively used by people with some elementary knowledge of computer programming and concepts of program visualisation. Our participants were computer teachers who clearly possess knowledge of the former but not necessarily the latter. Therefore, part of our short course was to explain the program visualisation concepts and how they could be useful to aid program

---

[2] Although most commercial program development environments do provide some limited facilities such as the display of the contents of variables during program execution, these are primarily designed to aid software development (particularly to aid debugging) by programmers. These facilities are not targeted to beginner learners and usually not well suited for the purpose of teaching and learning.

understanding.

5 Course implementation and feedback

Our course began with discussions on the common problems in developing CAI software. Then we introduced various sources from which useful CAI software could be obtained freely or at nominal costs for topics in computer subjects in general. These sources included higher educational institutions, students pursuing higher education, professional educational bodies, textbook publishers and others. The use of these Internet resources was more straightforward and requires no further elaboration other than the provision of pointers.

Next, we introduced the concept of utilising program visualisation techniques for the enhancement of teaching and learning, and the corresponding selected Internet resources. For ready made animation tools that were straightforward to use, we simply provided pointers and made two representative demonstrations, leaving the participants to try and pursue the tools at their own pace after the course.

A few selected tools, however, were introduced in much more detail. These tools have one or more of the following characteristics: (1) they were technically more advanced; (2) they could be used in several ways to suit different educational purposes; (3) they had features that were particularly useful or illuminating; (4) their designs were based on notions that were innovative and less obvious to understand but practically very useful. Fortunately, the participants were mainly computer teachers whom could be safely assumed to possess the necessary programming skills and concepts to perform the required customisations. Were we to simply show the links of these resources, it could be difficult for them to tap the potential benefits of these tools effectively.

The participants were so interested in the selected Internet resources that the course was substantially overrun. At the end of the course, participants were requested to complete a questionnaire about their background (for planning of future courses) and about how well they felt the course had been organised (for evaluation of the present course). Some of the statistics obtained are as follows:

1. About 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.
2. About 90% of the respondents agreed (with 26% strongly agreed) to the statement that "I will try to make use of the course materials at school when appropriate". None disagreed; the rest were undecided.
3. About 87% of the respondents agreed that the course was useful to them; none disagreed and the rest were neutral. The same number of respondents agreed that they were satisfied with the course. Some felt that the course could have been improved by extending the duration to allow more time for further discussions.
4. All respondents agreed that the demonstration of the Internet resources for teaching was the most useful part in the course.

6 Summary and discussions

6.1 Characteristics of our approach

We began with the ideas that program visualisation tools are useful for learning computer programming, but such tools are not widely known, of limited availability and hard to develop by secondary school teachers themselves. Yet Internet resources abound that could be effectively exploited for use in secondary schools. As researchers in the university, by nature of our work we are usually better informed with the availability of such resources and the advancement of the latest technologies. In planning and designing the short update course for teachers, we positioned ourselves as mentors in the search of relevant teaching resources. We aimed at offering practical assistance to secondary school teachers by providing the source of relevant information on the Internet, by demonstrating the potential benefits of utilising such information, and by guiding them through the solutions to the technical problems that might arise in utilising such information. We attempted to motivate the interests of participants, to help them overcome the initial barriers (that is, to make "jump start") so that they could eventually help themselves exploit the vast potentials of Internet resources via self and lifelong learning. Incidentally, in so doing, we have exemplified our course as an alternative model of "teaching in the information age" in which teachers serve more like a mentor than an

authoritative knowledge provider.

Our approach is characterised in several ways which distinguish it from that of a traditional teacher education course. Firstly, our goal was modest yet pragmatic in trying to address a specific but real problem that a typical secondary school computer teacher encounters daily: the difficulties of teaching computer programming. Secondly, we demonstrated to the participants how Internet resources could be effectively and practically utilised for addressing their problems. What is even more distinctive is the recommended use of tools developed by researchers with the latest software technologies of the field for use in tertiary education. We have argued that both tertiary educators and secondary school teachers share many common problems that call for similar solutions. Secondary school teachers could learn a great deal from the experience of educators in universities when dealing with their common problems. Finally, the course was designed to be enabling and empowering, with the explicit a priori goal that participants could pursue the subject further via self and lifelong learning.

6.2 Reflections and discussions

On completion of the course with encouraging feedback from the participants, we reflect on the factors contributing to our success. We note that a key factor is our decision to take advantages of the use of selected Internet resources, especially those from universities worldwide. Firstly, these resources are easily *accessible* to teachers and students alike, as long as they are connected to the Internet. The ease of access also minimises the problems that might occur in the distribution and installation of custom developed or commercial software. Moreover, the use of educational tools on the Internet is *cost-effective*. Many of these tools have been demonstrated to be effective through their use in universities. They are typically designed by computer scientists for demonstrating the advantages of applying their research ideas in education, and have subsequently been experimented and evaluated for continuous enhancements, with such evaluations adequately documented in their research papers. More importantly, they are available freely or at affordable costs. Cost is often a critical factor determining whether an educational software tool will be widely used in secondary schools, as resources at their disposal are usually fairly limited.

Some of the software tools we recommended were developed as prototypes with source codes publicly available [12]. They are usually based on sound theoretical principles and accompanied by technical or educational papers describing the theory and implementation in detail. Teachers may customise these tools to suit their specific needs that might vary due to differences in teaching styles, objectives, and students' backgrounds. They may choose to use the whole or part of the tool, or write small program components to be integrated with these tools. For computer teachers who are acquainted with and probably interested in writing programs, such "lightweight customisation" is usually easier and more feasible than building a complete CAI system from scratch. Customisation by users is not normally adequately supported by commercial software that comes with no source code and only limited documentation such as operational guides.

Technologies and knowledge have been advancing very rapidly. On the Internet, new resources keep emerging as results of continuous research by academics who explore the latest technologies for the enhancement of teaching and learning. An example is the experimentation of using 3D visualisation, multimedia and virtual reality technologies in education as they emerge [4]. Teachers who are well informed of such activities through self-learning on the Internet will be in a better position to make use of the latest research results and technologies for continuous improvements to their teaching and learning in ways that are not otherwise possible.

The use of research tools for teaching and learning is not without problems. However, most of these problems would not be deterrent; they could be solved or avoided. Other problems are present in the use of other sources of educational software anyway. For instance, research tools are often imperfect, with some functionality not fully implemented; but as long as the implemented features are considered useful, the tools can be used in part rather than in full. There might be a lack of instant technical support, but many researchers who develop the prototypes are keen to collect feedback, as these might be crucial for their continuous research work. Inevitably, frequent revisions might occur to these tools for research purposes, but if the teacher finds an earlier version useful, that version could be downloaded and kept for use instead of relying on its availability at the source.

7 Conclusions

University educators possess the necessary resources, expertise and freedom to fulfil their roles of performing experimentation and researches, and producing prototypes to demonstrate the usefulness of their innovative ideas. In comparison, secondary school teachers are too occupied with teaching activities and other professional commitments. Most teachers cannot afford the purchase of expensive commercial software for teaching, nor do they generally have the capacity of developing appropriate educational software on their own. Success of integrating IT in the school curriculum is critically determined by the availability of easy-to-use and adaptable tools that satisfy the diverse needs of teachers and students of a variety of backgrounds in different contexts.

The Internet has provided a medium on which tertiary educators can make their resources and experience publicly available to be shared by all, including secondary school teachers. Around the world, numerous tertiary educators have gladly done so as part of their service to the community. Unfortunately, such resources are largely under-utilised by secondary school teachers, due to reasons such as the lack of knowledge and technical competence. For computer teachers, these barriers are relatively easy to overcome, as long as appropriate support and assistance is provided. For teachers of other disciplines, more help might be required. Ultimately, secondary school teachers have to learn, adapt and use these resources by themselves, and to keep themselves updated via self and lifelong learning to respond to the rapid changes that the world has been undergoing.

In this paper, we have reported our experience in the design and delivery of a short course that has progressed towards this direction. Our course also exemplifies itself as one possible model of "teaching" as "facilitating the self and lifelong learning of the participants". Most tertiary educators have now become regular users of Internet resources for enhancing their teaching and learning. It should not be long before secondary school teachers have to follow suit. What we have contributed is but a small part of the continuing collaborative effort to empower teachers to use IT effectively in secondary schools, and ultimately to better education of our younger generations.

References

[1] Boroni, C. M., Eneboe, T. J., Goosey, F. W., Ross, J. A. and Ross R. J. (1996). "Dancing with DynaLab – Endearing the science of computing to students". In *Proceedings of the Twenty-Seventh SIGCSE Technical Symposium on Computers Science Education (SIGCSE'96)*, 135-139, Philadelphia, USA, February 1996.

[2] Curriculum Development Council (1993). *Syllabuses for Secondary Schools, Computer Studies (Secondary 4-5)*, Hong Kong Government Press.

[3] Education Manpower Bureau (1998). *Information Technology for Learning in a New Era: Five-year Strategy 1998/99 to 2002/03*. November 1998, HKSAR.

[4] Gloor, P. A. (1998). "Animated algorithms". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (eds), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[5] Haajanen, J., Pesonius, M., Sutinen, E., Tarhio, J., Terasvirta, T. and Vanninen, P. (1997). "Animation of user algorithms on the Web". In *Proceedings of IEEE Symposium on Visual Languages (VL'97)*, 361-367, Isle of Capri, Italy, September 1997.

[6] Kalayar, M., Ikematsu, H., Hirashima, T. and Takeuchi, A. (1999). "Intelligent learning support system for algorithm learning". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 840-843, Chiba, Japan, November 1999.

[7] Kann, C. and Lindeman, R. W. (1997). "Integrating algorithm animation into a learning environment". *Computers and Education*, **28**(4): 223-228.

[8] Kong, S.-C., Au, W.-K. and Pun, S.-W. (1999). "A case study on the implementation of information technology education pilot scheme in Hong Kong". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 27-34, Chiba, Japan, November 1999.

[9] Law, N., Wan, J., Lau, M. F., Lee, R. and Yuen, A. H. K. (1999). "Towards a model of IT training for inservice teachers". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 51-58, Chiba, Japan, November 1999.

[10] Mulholland, P. and Eisenstadt, M. (1998). "Using software to teach computer programming: Past, present and future". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[11] Price, B.A., Baecker, R.M., and Small, I.S. (1993). "A principal taxonomy of software visualisation". *Journal of Visual Languages and Computing*, **4**(3): 211-266.

[12] Rautama, E., Sutinen, E. and Tarhio, J. (1997). "Excel as an algorithm animation environment". In *Proceedings of Annual Joint Conference Integrating Technology into Computer Science Education (ITiCSE'97)*, 24-26, Uppsala, June 1997.

[13] Resmer, M. (1999). "IMS – Distributed learning standards". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 567-570, Chiba, Japan, November 1999.

[14] Sloane, A. (1997). "Learning with the Web: Experience of using the World Wide Web in a learning environment". *Computers and Education*, **28**(4): 207-212.

[15] Stasko, J. and Lawrence, A. (1998). "Empirically assessing algorithm animations as learning aids". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[16] Yu, Y. T. and Poon, P. L. (2000). "An approach for evaluating the quality of software developed by novice programmers". In *Proceedings of the 4th World Multiconference on Systemics, Cybernetics and Informatics (SCI'2000) and the 6th International Conference on Information Systems Analysis and Synthesis (ISAS'2000)*, **2**: 485-490, Florida, USA, July 2000.

Examining Problems of Student Teachers to Build a Web-supported Environment

Shihkuan Hsu* and Hsiou-huai Wang**
Center for Teacher Education, National Taiwan University
1, Sec. 4, Roosevelt Road, Taipei, Taiwan 10617
**Tel: +886-2-23692364 ext. 214*
E-mail:skhsu@ccms.ntu.edu.tw
***Tel: +886-2-23692364 ext. 215*
E-mail:wanghs@ccms.ntu.edu.tw

Student teaching is an important part of teacher training programs. With the emerging and the widespread use of the Internet, it is important to consider how this crucial stage of teacher development can be facilitated by the use of the technology. In order to create for a user-oriented and research-based web environment, this project was designed to explore problems that student teachers experience. During the internship year, student teachers filled out a self-report critical problem questionnaire five times in two periods, one in each semester. The student teachers were asked to pick one critical problem that they had tried hardest to solve in the day or the week. In the survey, they wrote down the ways to solve the problem as well as the resources they used in the process. The results showed that peer student teachers were those whose help were mostly sought. Over 90% of the means to solve the problem was face-to-face. It is summarized that student teachers may need three types of proximity for problems: Professional, emotional and physical. To provide rich interpretation to the problems, it is suggested that an experience database with focused case study discussion forum may be of help to student teachers' problems.

Keywords: **Student teacher, Student attitude, Teaching experience, Internet use**

1 Introduction

Student teachers are in the process of becoming a teacher. Fresh from the university, student teachers are often full of ideals and enthusiasm. Entering the real world of teaching, however, they are likely to experience problems and difficulties that can be termed "reality shocks" (Wubbels, Creton, Hooymayers & Holvast, 1982). With the Internet technology becoming more accessible and versatile, there are an increasing number of web-based projects to assist student teachers (Georgi & Crowe, 1998). Instead of building the technology first and assessing the student teachers later, this project intends to design a research-based and student teacher-oriented web environment.

This study proposes to examine the needs of the student teachers and use the results as basis to construct a web environment. During a one-year internship, a class of 76 student teachers were asked to participate in the survey and interviews for their problems and difficulties, as well as the resources they used to resolve their problems. The analysis of the problems will be used to develop the guidelines and the structure of the website.

2 Theoretical Background

2.1 The problems of the student teachers

Numerous studies have been done to understand the problems and "reality shocks" that student teachers encountered. In an extensive review, Veenman's (1984) collected 91 research studies in the last two decades.

His summary of the findings suggested eight categories of problems, including managing student, motivating students, dealing with individual differences, evaluating students' work, communicating with parents, organizing class work, obtaining supply and teaching material, and tackling individual student's problems. Chen & Chen (1999) critiqued the previous researcher-designed surveys and used student teacher's journals as a means to understand their problems. They collected 800 student teachers' journals and used Multidimensional Scaling to analyze the data. The major categories of student teacher's reality shock included status uncertainly, students' attitudes and disciplines, conflicts between the decision maker and the doer, the negative-reinforcement style of management, the working ethics of teacher and staff, as well as the relationships among school members (Chen & Chen, 1999).

While many studies addressed the problems that student teachers encounter, most of them focused on why the problems occurred and how to solve the problems for them. Very few, on the contrary, investigated how student teachers solved their problems. Questions regarding whom student teachers asked for help and what resources they used in solving their problems were seldom discussed. The purpose of study, therefore, is not to postulate another possible cause of the problems, rather, is to find out what resources student teachers use to solve their problems, and how technology can help expand this access.

2.2 The problems with the technology

The use of Internet technology for teacher training has received growing attention. E-mail is perhaps still the most widely used means to encourage communication between the supervising teacher and student teachers (Nabors, 1999). More recent developments include more sophisticated design such as electronic portfolio to promote reflection and performance-based assessment (Georgi & Crowe, 1998). Morley's (1999) project uses WebCT, an Internet-based interface, for course syllabus, class notes, hyperlinks, as well as bulletin boards for faculty and students in pre-service method courses. The National Science Council in Taiwan in recent years has funded several projects in building web-supported environment student teachers in areas such biology, math, science and technology (Guo, 1999).

When new technology is added to student teaching, however, some precautions are warranted. As an add-on, the help it provides may not be critical to the user's needs nor adopted by the user in a long run. Examples can be observed in many websites where only few messages are found in the discussion area. As Hsu & Bruce (1998) observed, teachers in distance education often fail to communicate with their distance students because their pedagogical strategy with the new technology does not supply the necessary cues that is acquainted by the students in their face-to-face environment. Therefore in this project we want to explore student teachers' current situation before designing the website.

3 Methods

A total of 35 student teachers from 11 subject areas of junior and high schools participated in this one-year study. The participants were all recent graduates from university or graduate schools of the same university. To sample the student teacher's experiences with problems and difficulties across the internship year, the critical problem survey involved two rounds of sampling periods, once in the end of the fall semester and once at the end of the spring semester.

During the first semester, student teachers were asked to fill out a questionnaire once a week for five weeks. Every week they had to pick one most critical problem in the past week. Three open-ended questions were designed to elicit the most critical problem that demanded the most of the student teachers' time and energy to solve. The three open-ended questions were: 1) What is the most critical problem you have experienced during the week? 2) How do you resolve the problem? And what resources do you use? 3) At the end of the week, was the problem resolved? If not, how would you like it to be solved?

In addition to the open-ended questions, there was a chart where student teachers had to check boxes for the people they had talked to regarding to the problems they were trying to resolve. The choices included the cooperating teacher, the supervising teacher, the student teachers in the same subject area and different subject area from the same university, the student teachers in the same school but from different university, the family, the roommate, none, and others. They were also asked how many times they have made the contact and by what means the communication was made. The choices included face-to-face, phone, e-mail, and others.

The questionnaires were first mailed out to the student teachers. After the initial data collection, it was found that the returned rate was too low. Therefore, additional short telephone interviews with 25 students were arranged. The interview also provided a little more in-depth background for their problems and difficulties. At the end of the spring semester, the same questionnaire was filled out daily for five days with the help of telephone interviews. Regular attendance to the student teacher's monthly meeting and small group discussions also informed the interpretation of the data collected.

4 Results

4.1 Student teacher's problems

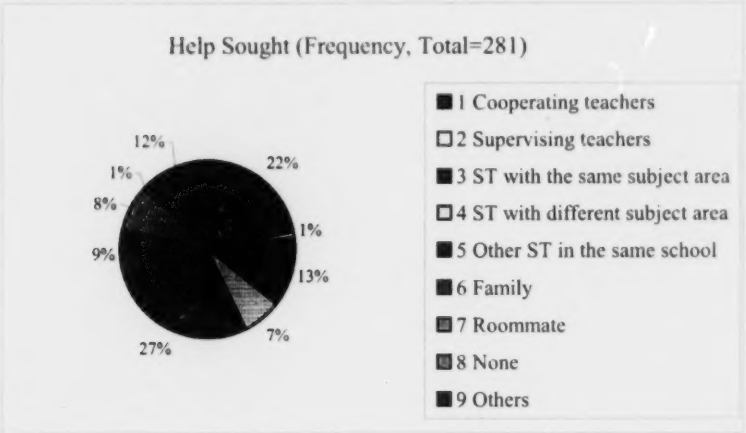
The results of the self-reported questionnaire and the transcript of the interview were coded by two researchers and two research assistants. The coding scheme originally used was Chen & Chen's (1999) findings of six categories, but the emerging themes of the data yields to the following four major categories in student teachers' problems. 1) Ambiguity of the status, including conflicts with the cooperating teachers for competing authority in the class; conflicts with school administrators in terms of task assignment; and conflicts with the school culture in terms of the feeling of unfit to the school physical environment, goals, and life styles. 2) Lack of professional knowledge, including subject knowledge, teaching skills, class management skills, and skills for student discipline problems. 3) Relationship with cooperating teachers, administrators, and students; including problems in making their needs known; and in dealing with small groups and gender issues. 4) Confusion in teaching as career goals, including conflicts between the ideal and reality.

4.2 Ways to solve the problems

When stressed by a problem, student teachers did not always know how to solve it. They usually consulted people for solutions. Categories of people whose help were sought after were coded from both the questionnaire and the interview. 1) Cooperating teachers, to ask for assistance or professional suggestions on classroom management and teaching skills. 2) Other teachers of the same subject area, for content knowledge and student discipline problems. 3) Other student teachers, to seek answers and condolence from others about conflict with the cooperating teacher and students' disciplines; also for relationship and cultural adjustment. 4) Solving the problem by oneself, such as trying out ones' own new ideas, making more effort to learn new things, adjusting attitude, accepting the reality, or simply enduring it.

Depending on the nature of the problem, other resources were sought for specific information For legal issues, for example, some student teachers sought help from higher up authorities. In terms of technology, a few student teachers used the Internet to find teaching material and lesson plans. Not every problem had a solution, however. During our talk during the interview and in informal settings, quite a few students indicated that they often choose to passively accept the situation or to give up thinking for solutions. The following figure is a summary of the results from the questionnaire about the help the student teachers sought (see Figure 1). The results showed that about 47% of talks were with the other student teachers, where 27% were from the student teachers in the same school. About 22% of help was received from the cooperating teacher, and another 17 % were from family and roommate. Only 1% was from their supervising teachers. Among all the communication means, 92% were face-to-face, 6% were by phone, and 2% were by e-mail.

Figure 1 People whose help student teachers sought from



5 Discussion

According to the analysis, the problems of student teachers ranged from personal to professional. The solutions, although ranged from professional guidance to personal camaraderie, are limited to face-to-face communication. To contemplate what will help student teachers in solving their problems, it may be useful to postulate what they needs are. 1) Professional proximity. Being a novice, a student teacher may eager to know how others would have done differently. Those who are authoritative in professional fields, such as cooperating teachers, are likely to be pursued for instructional and managerial guidances. 2) Emotional proximity. Besides professional guidances, student teachers need to find emotional support to feel that they were not alone. It is also safer to talk to peers for issues of role adjustment and interpersonal relationships in schools. 3) Physical proximity. Those who are physically close (66%) are more readily to help. Therefore, when physical gatherings are not available, the help seeking channels can become seriously impeded.

Based on the above findings, we can begin to think about the design of a web-supported environment. The employment of a student teacher website should have features that provide additional or alternative support that take the above three types of proximity into account. The complexity of the problems and the limited access to solutions suggested that a case method that the user can criss-cross for multiple interpretations may be appropriate for learning in a complex knowledge domain (Spiro & Jehng, 1990). The following components are proposed in the website to be built. 1) A student-teaching case database. To provide experiences of other student teachers in a form of journals, including description of and reflection on various aspects of student teaching. This database is both outlined and keyword searchable. Hyperlinks to other similar cases can be also built. Student teachers can access to a peer's life lessons without having to have an appointment with him. 2) Guidelines and suggestions. Also included in the database are written guidelines and suggestions from academics, experts, experienced teachers and student teachers on the same topics as the above case database. Links to other web resources regarding professional information will also be added. Student teachers can reach specific information for guidance without much effort. 3) Focused case study discussion forum. To provide threaded bulletin boards on selected cases from the database. With shield identity, student teachers can find emotional support without being exposed. The cases can be rotated on weekly bases and among different subject matters. 4) Annotated video components of teaching. Also included in the database can be video clips of exemplar teaching of cooperating teachers as well student teachers' teaching. Written comments can be added by both the cooperating teachers and supervising teachers. This is a good place to engage a productive conversation among the triad of the student teacher, the cooperating teacher, and the supervising teacher.

It is hoped that with the aid of the technological power, the student teachers will have better chances to solve their problems and they should feel more empowered in their first full-time exposure to the real world of teaching.

References

[1] Chen, F. C. & Chen, H. L., "The experience of probation teacher's reality shock--The first season analysis." Proceedings of the Conference on the Exemplar and Practice of Educational Internship. Taipei, Taiwan, April 30-May 1, pp. 51-74, (1999).

[2] Georgi, D. & Crowe, J., "Digital Portfolios: A Confluence of Portfolio Assessment and Technology." Teacher Education Quarterly, Vol. 25, No. 1, pp. 73-84, (1998).

[3] Guo, Y. W., "Planning and promotion of the research on improving the science teacher quality." National Science Council Monthly, Vol. 27, No. 8, pp. 866-880, (1999).

[4] Hsu, S. & Bruce, B., "The missing borders: Pedagogical reflections from distance education." Teaching Education, Vol. 10, No. 1, pp. 47-54, (1998).

[5] Morley, L., "Expanding preservice teachers' tools for effective teaching." Paper presented at the Annual Conference on Technology in PE and Sport. Chattanooga, TN, USA, July, (1999).

[6] Nabors, M. L., "New functions for "Old Macs": Providing immediate feedback for student teachers through technology." International Journal of Instructional Media, Vol. 26, No.1, pp. 105-107, (1999).

[7] Spiro, R. J. & Jehng, J. C., "Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter." In D. Nix & R. Spiro (Eds.), Cognition, education, multimedia. NJ: Lawrence Erlbaum Associates, (1990).

[8] Veenman, S., "Perceived problems of beginning teachers." Review of Educational Research, Vol. 54, No. 2, pp. 143-178, (1984).

[9] Wubbels, Th., Creton, H. A., Hooymayers, H. P., & Holvast, A. J. C. D., "Training teachers to cope with the 'reality shock'." Studies in Science Education, Vol. 9, pp. 147-160, (1982).

Factors in Web-based learning: Student learning styles, motivation, learning strategies, and achievement

Ching-Chun Shih
Iowa State University
E016 Lagomarcino Hall
Ames, IA 50011
Tel: +1-515-294-1941
Fax: +1-515-294-9284
Email: ccshih@iastate.edu

This study analyzed the relationships between student achievement and the following variables: learning styles, motivation, learning strategies, and selected demographics. It was a population study that included 99 students taking two non-major introductory biology courses offered over the Internet by one Land Grant University in U.S. in the fall of 1997. Seventy-four (75%) students completed a learning style test, an on-line questionnaire, and received a grade by the end of the semester. The learning style test was the Group Embedded Figure Test (GEFT), which classified students as either field-dependent or field-independent. The on-line questionnaire consisted of two scales (motivation and learning strategies), whose pilot-test reliabilities were .70 and .79, respectively. Over two-thirds of the students taking the Web-based courses were field-independent learners; however, there were no significant differences (.05 level) in achievement by learning style. Also, different backgrounds of students with different learning styles learned equally well in Web-based courses. The students were motivated by competition and high expectations. They used most the learning strategies of finding important ideas from lectures and memorizing key words of important concepts. Motivation and use of learning strategies were the two significant factors that explained more than one-third of student achievement measured by class grade.

Keywords: **Web- based learning, learning styles, motivation, learning strategies, and achievement**

1 Introduction/Theoretical Framework

As the popularity of the WWW increases, its use as a means of delivering instruction is also growing. Alexander (1998) indicated, "the greatest potential of the Web, however, lies in the fact that we have a chance to learn from the lessons of the previous faded technologies, and an opportunity to develop new learning experiences for students that have not been possible before" (p.3). Furthermore, Parson (1998) and Alexander (1998) argued that while implementing a new technology, educators should evaluate how students learn via the new technology so as to help with curriculum and instructional designs. Parson (1998) added that it is important to understand how the new technology can affect learning when it is used by different types of learners.

Identifying students' learning styles helps educators understand how people perceive and process information in different ways. According to Cano, Garton, and Raven (1992), one of the most widely studied learning style theories contrasts field-dependence and field-independence. The Group Embedded Figure Test (GEFT), a standardized cognitive test, can be administered to determine the preferred learning styles of the learners as either field-dependent or field-independent (Oltman, Raskin, & Witkin, 1971). Literature (Witkin, Moore, Goodenough, & Cox, 1977; Raven, Cano, Garton, & Shellhamer, 1993; Miller, 1997) on learning styles suggests that field-dependent learners tend to approach a problem in a more global way, are socially oriented, prefer collaboration, and are extrinsically motivated. In contrast,

field-independent learners tend to approach a problem more analytically, rely on self-structured situations, prefer competition, and are intrinsically motivated. According to Ginger and Guild (1984), both field-dependent and field-independent people make equally good learners.

Like the literature on learning styles, the literature on learning strategies explores different ways of learning. However, in assuming stability as well as lack of individual control, learning style literature suggests that it may be difficult for students to change their learning styles (Pintrich & Johnson, 1990), whereas learning strategy literature assumes that students' motivation and use of learning strategies can be controlled by learners and changed through teaching. According to Cross and Steadman (1996), learning strategies are methods learners can use to improve their understanding, integration, and retention of new information. Learning strategies include a wide variety of cognitive processes and behavioral skills (Weinstein & Meyer, 1991). General learning strategy components include rehearsal, elaboration, organization, comprehension, metacognition, and resource management (Weinstein & Meyer, 1991; Cross & Steadman, 1996).

Pintrich and his colleagues developed a learning strategy instrument, *Motivation Strategies for Learning Questionnaire (MSLQ)* (Pintrich, Smith, Garcia & McKeachie, 1991). This instrument includes two main sections: one on motivation and one on learning strategies. The learning strategies section consists of two components (cognitive and metacognitive strategies, and resource management strategies) and eight scales, which are rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, and help seeking (Pintrich, Smith, Garcia & McKeachie, 1991).

The other section of the *MSLQ* is on motivation, which consists of three general components (value, expectancy, and affective) and six scales (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety). Several researchers (Pintrich, 1995; Pintrich & Schunk, 1996; Garcia, 1995; Bandura, 1986; Zimmerman, 1989) believed that students may use different motivational strategies in different learning situations and that students are able to learn to become self-regulated learners.

Motivation was found to be the best predictor of student achievement in the two studies that investigated factors influencing student achievement and effects of the factors on students' achievement in learning the Japanese language through the medium of satellite television (Oxford, Park-Oh, Ito, & Sumrall, 1993a; 1993b). It was also found that gender and learning styles played potentially important roles although they were not significant factors. Moreover, in the study on predicting student success with the learning and study strategies inventory, Hendrickson (1997) found that motivation was one of the best predictors of student grade point average.

Moreover, Curry (1990) used the concepts of motivation, learning styles, student achievement to explain the process of learning. Learning styles consist of a combination of motivation, engagement, and cognitive processing habits, which then influence the use of metacognitve learning strategies such as situation analysis, self-pacing, and self-evaluation to produce a learning outcome. Curry's taxonomy (1990) seemed to suggest that motivation, learning styles, learning strategies, and student achievement are associated.

Based on the previous literature review, student learning styles, motivation, and learning strategies seem to be associated with achievement. Research is needed to understand student motivation and learning strategies with different learning styles via WWW. Also, research is needed to obtain more understanding of the learning factors that influence student success in Web-based learning. This type of research will assist educators in planning, organizing, and delivering quality Web-based instruction in a manner that will improve student learning.

2 Purpose and Objectives

This study was a formative evaluation designed to enhance teaching and learning. Its purpose was to study how students with different styles learned in Web-based courses that were offered through Project BIO by Iowa State University, and to determine what factors influenced their learning. The objectives of the study were to identify: (a) the demographic characteristics of the students in relation to learning styles; (b) how students' motivation and learning strategies differed by their learning styles; and (c) relationships among student learning styles, motivation, learning strategies, demographics, and achievement.

3 Methods and Procedures

The population for this study included 99 students taking the two non-major introductory courses, Zoology 155 and Biology 109, offered through Project BIO by Iowa State University in the fall of 1997. These two Web-based courses developed by Project BIO were stand-alone courses in which most course materials and resources were accessed and delivered by the Internet (Parson, 1998). More than 60% (60) of the population were on-campus students and almost 40% (39) were off-campus students. Thirty-two out of the 39 off-campus students were high school students. Before the study was conducted, a letter was sent to the high school teachers to seek permission for their students to participate in this study.

The Group Embedded Figures Test (GEFT) was used to determine preferred learning styles, either as field-dependent (FD) or field-independent (FI). Individuals scoring greater than the national mean (11.4) were classified as field-independent learners, whereas those scoring less than the national mean were considered to prefer a field-dependent style. The total possible raw score on the GEFT was 18. The reliability coefficient for the GEFT was .82 (Witkin, Oltman, Raskin, & Karp, 1971).

An on-line questionnaire was designed by the researchers and included two scales plus demographic questions. The questionnaire, written in HTML (HyperText Markup Language) format, was posted on the web. Nine statements representing the motivation scale and thirteen statements representing the learning strategy scale were selected from the MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1991). The students were asked to rate themselves according to how well the motivation and learning strategy statements described them while they were taking the Web-based course by using a five-point scale with response options ranging from (1) Not at all typical of me to (5) Very much typical of me. Demographic variables included gender, Web-based courses they were taking, whether or not they were university students, types of students as off-campus, on-campus, or adult students, limited or unlimited access to a computer, number of courses previously taken in the subject area, and study and work hours per week.

Content and face validity for the questionnaire were established by a panel of three faculty members associated with Project BIO and three graduate students in Agricultural Education. The 5-point scales were pilot-tested for reliability with 38 students taking a different undergraduate Project BIO Web-based course, Biology 201. Cronbach's alpha coefficients were .71 and .80 for the motivation, and learning strategy scales, respectively. When a post-hoc reliability analysis was performed, the reliabilities for the two scales were .70 and .79 respectively.

The researchers administered the learning style test (GEFT) to on-campus students and proctors administered it to off-campus students. A total of 78 (79%) students completed the GEFT. The on-line questionnaire was posted on the web three weeks before the final exams. A follow-up electronic letter to nonrespondents of the on-line questionnaire yielded a total of 94 responses for a 95% return rate. For purposes of analysis, the learning style scores, questionnaire responses, and students' grades, which were provided by the instructors at the end of the semester, were matched. This yielded a final response rate of 74 (75%), which was considered to be an acceptable representation of the population. Data were analyzed using the Statistical Package for Social Science, Personal Computer Version (SPSSx/PC). Analyses of data included frequencies, means, standard deviations, t-tests, Pearson correlations, and multiple linear regression. The alpha level was established *a priori* at the .05 level.

4 Results

4.1 Objective 1: Demographic characteristics of the students in relation to learning styles

The usable responses included 29 (39%) in the Zoology class and 45 (61%) in the Biology class. Less than half (29; 39%) of the usable respondents were males. Twenty-eight (38%) were high school students and forty-six (62%) were university students. More than two thirds (51; 69%) of the respondents were field-independent learners. On average, the students had previously taken 1.45 courses in the subject areas of Zoology or Biology. The students spent an average of 4.55 hours per week studying, ranging from 1 to 20 hours and worked on an average of 16.97 hours per week, ranging from 0 to 80 hours. No significant differences by learning styles were found in the number of courses taken previously, study hours per week, or work hours per week.

While comparing respondents' learning style scores by gender, it was found that the male learning style mean score (mean = 14.07) was significantly higher than the female mean score (mean = 11.76). The learning style mean score of all respondents was 12.66. This was consistent with the preliminary norms data on GEFT, in which college men (mean = 12.00) performed slightly but significantly higher than college women (mean = 10.8) (Witkin, Oltman, Raskin, & Karp, 1971). However, in this study, the GEFT mean scores of both males and females were higher than those of the norm data (mean = 11.4).

4.2 Objective 2: How students' motivation and learning strategies differed by their learning styles

Although field-independent students had a mean of 3.51 and field-dependent students had a mean of 3.42 on motivation scale, no significant difference was found on student motivation by learning style (Table 1). The mean scores on the nine items ranged from 2.81 to 4.21. Four statements were rated above 3.50. The highest rated motivation was that the students wanted to get better grades than most other students (mean = 4.21). The second most highly rated item was that they expected to do well in the class (mean = 3.77). They also believed that they could do better if they studied in appropriate ways (mean = 3.70), and they preferred course material that aroused their curiosity (mean = 3.66). Only one statement, "I think of how poorly I am doing," was rated below 3.00. The overall mean for student motivation in Web-based learning was 3.48 with a standard deviation of .52.

Field-dependent students (mean = 3.27) had almost the same mean on the learning strategy scale as did field-independent students (mean = 3.25), and no significant difference was found in the t-test when comparing the overall use of learning strategies by learning style (Table 2). Moreover, four mean scores of the thirteen learning strategy items were rated above 3.50. The highest-used learning strategy was to find the most important ideas from lectures (mean = 3.85). The second most highly used strategy was to memorize key words of important concepts (mean = 3.76). The third most highly used strategy was to relate concepts to what they already know (mean = 3.70). The next most highly used strategy was to determine the concepts they did not understand well (mean = 3.68). The two lowest used strategies had mean scores under 2.50. They were "to give up the difficult parts and study the easy" (mean = 2.16) and "make charts or tables to organize the material" (mean = 2.14). The overall mean score for students' use of learning strategies was 3.25 with a standard deviation of .51.

Table 1.' Means, Standard Deviations, and t-test for Respondents' Motivation by Field-Dependent (FD) or Field-Independent (FI) Learning Style (n = 74)

Statements	Total Mean (SD)	Learning Style FD Mean (SD)	Learning Style FI Mean (SD)	t-value
I want to get better grades than other students	4.21 (1.01)	4.26 (.96)	4.18 (1.04)	
I expect to do well in this class	3.77 (.84)	3.78 (1.00)	3.76 (.76)	
Studying appropriately, I can learn the material	3.70 (.89)	3.43 (.84)	3.82 (.89)	
I prefer course material that arouses my curiosity	3.66 (.80)	3.48 (.67)	3.75 (.84)	
I am satisfied with trying to understand content	3.49 (.80)	3.48 (.67)	3.49 (.86)	
Course material is useful to learn	3.49 (.83)	3.52 (.85)	3.47 (.83)	
I think of the questions I cannot answer[a]	3.30 (1.08)	3.30 (1.15)	3.29 (1.01)	
I am interested in the content area of this course	3.14 (.93)	3.00 (.95)	3.20 (.92)	
I think of how poorly I am doing[a]	2.81 (1.51)	2.83 (1.67)	2.78 (1.35)	
Total	**3.48 (.52)**	**3.43 (.57)**	**3.51 (.50)**	**-.64**

Note: Scale 1=Not at all typical of me, 2=Not very typical of me, 3=Somewhat typical of me, 4=Quite typical of me, and 5=Very much typical of me.

[a]Negatively stated items. Means of these statements were reversed in the total mean

4.3 Objective 3: Relationships among student learning styles, motivation, learning strategies, demographics, and achievement

A hierarchical regression analysis was conducted to ascertain the amount of variance in students' standardized achievement scores by the variables of interest (Table 3). The three main learning factors of this study, learning styles, motivation, and learning strategies were entered into the regression model. The dependent variable was student standardized achievement. Student motivation was loaded first and explained 28% of the variance in their standardized achievement scores. Use of learning strategies was entered next into the regression. This variable explained additional 7% of the variance in student achievement. Then the learning style variable was entered into the regression model, and it explained an additional 1% of the variance in student achievement. Motivation (t=3.19) and use of learning strategies (t=2.98) were the two significant variables for the explanation of variance in achievement scores. The results from the analysis revealed that a total of 35% of the variance in student achievement was accounted by a combination of two significant variables, motivation and use of learning strategies.

Table 2. Means, Standard Deviations, and t-test for Respondents' Use of Learning Strategies by Field-Dependent (FD) or Field-Independent (FI) Learning Style (n = 74)

		Learning Style		
	Total	FD	FI	
Statements	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**t-value**
Try to find most important ideas from lectures	3.85 (.82)	3.87 (.92)	3.84 (.78)	
Memorize key words of important concepts	3.76 (.86)	3.78 (.85)	3.75 (.87)	
Try to relate to what I already know	3.70 (.92)	3.74 (.92)	3.69 (.93)	
Determine concepts I don't understand well	3.68 (.85)	3.65 (.88)	3.69 (.84)	
Connect the readings and concepts	3.47 (.88)	3.65 (.98)	3.39 (.83)	
Read notes and readings over and over again	3.08 (1.12)	3.43 (1.20)	2.92 (1.06)	
Relate my ideas to what I am learning	2.99 (1.04)	2.74 (.92)	3.10 (1.08)	
Decide what I am supposed to learn from topics	2.93 (.93)	2.96 (.93)	2.92 (.93)	
Make good use of my study time	2.84 (.91)	2.87 (1.06)	2.82 (.84)	
Think of possible alternatives for conclusions	2.81 (.90)	2.61 (1.03)	2.90 (.83)	
Rarely find time to review notes or readings for tests[a]	2.79 (1.22)	2.65 (1.47)	2.86 (1.11)	
Give up the difficult parts and study the easy ones[a]	2.16 (.76)	2.26 (.75)	2.11 (.77)	
Make charts or tables to organize the material	2.14 (1.10)	2.09 (1.20)	2.16 (1.07)	
Total Mean	**3.25 (.51)**	**3.27 (.64)**	**3.25 (.45)**	**.17**

Note: Scale 1=Not at all typical of me, 2=Not very typical of me, 3=Somewhat typical of me, 4=Quite typical of me, and 5=Very much typical of me.

[a]Negatively stated items. Means of these statements were reversed in the total mean.

Table 3. Hierarchical Entry Regression of Selected Variables on Standardized Achievement (n = 74)

Variables	**R^2**	**R^2 Change**	**B**	**t-value**
Overall motivation mean score	.28	.00	.68	3.19*
Overall learning strategies mean score	.35	.07	.65	2.98*
GEFT (learning style) score	.36	.01	0.03	.95
(Constant)			-4.70	-6.12*

Standard Error = .81, Adjusted R^2 = .34

F for the Model = 13.26 $p < .05$ (df 3, 70)

*$p < .05$

5 Conclusions/Recommendations

Males were more likely to be field-independent students, although the female scores on the GEFT also fell into the field-independent range. More field-independent students took the Web-based Zoology and Biology courses than did field-dependent students. This was similar to Miller's finding (1997) that the distant learners were relatively more field-independent than the norm groups.

Student learning styles and student characteristics--gender, Web-based courses they were taking, whether or not they were university students, types of students as off-campus, on-campus, or adult students, limited or unlimited access to a computer, number of courses previously taken in the same subject area, study and work hours/week--were not related to their Web -Based learning achievement. Moreover, field-independent students did not differ from field-dependent students in their motivation, learning strategies, and achievement in Web-based courses. The researcher concluded that students with different learning styles and backgrounds learned equally well in Web-based courses. And learning styles did not affect student motivation and use of learning strategies.

Students were undecided about their motivation and the use of learning strategies in Web-based courses. Getting better grades than other students and expecting to do well were the two most highly rated motivators for Web-based learning. Moreover, trying to find the most important ideas from lectures and memorizing key words of important concepts were the two most highly used learning strategies. These two learning strategies fell into the rehearsal and elaboration components of learning strategies in the MSLQ (Pintrich, Smith, Garcia & McKeachie, 1991). Students used least the learning strategy of making charts or tables to organize the material. In conclusion, students were motivated by competition and high expectations and used more rehearsal and elaboration learning strategies in Web-based learning.

Educators should provide students with information and opportunities to maintain healthy student competition and high expectations in Web-based learning, such as announcing mean scores of class tests for comparison and setting clear expectations for assignments and tests. Likewise, educators should understand student motivational factors so that they can stimulate student motivation and get students actively involved in the learning process. Additionally, educators should provide students with learning opportunities by using a variety of learning strategies to assure students' understanding, integration, and retention of course concepts.

Motivation and learning strategies seemed to be the most important factors in Web-based learning and accounted for more than one-third of student achievement. Student motivation and use of learning strategies by the students correlated significantly with student achievement. The higher the student scored on motivation and a general use of learning strategies, the higher the student's overall achievement in the class.

Motivational and learning strategies are crucial aspects of self-regulated learning. Self-regulated learning involves use of motivational and learning strategies to the degree that students are motivationally, metacognitively, and behaviorally active participants in their own learning processes (Zimmerman, 1989; Pintrich, 1995). This study found that motivation and learning strategies play important roles in Web-based learning, and this could be an effective support of self-regulated learning.

Further study is needed to identify motivation and use of learning strategies between high achieving and low achieving students in Web-based courses. Are the most highly used motivation and learning strategies used by the higher achieving students? Additionally, the cause and effect of use of motivational and learning strategies (self-regulated learning) should be investigated in the future studies.

References

[1] Alexander, S., "Teaching and learning on the World Wide Web," http://www.scu.edu.au/ausweb95/papers/education2/alexander/ (accessed August, 1998).

[2] Cano, J., Garton, B. L., & Raven, M. R., "The relationship between learning and teaching styles of student performance in a method of teaching agriculture course," Journal of Agricultural Education, Vol. 33, No. 3, pp. 8-15, (1992).

[3] Curry, L., "Learning styles in secondary schools: A review of instruments and implications for their use," ERIC Document Reproduction Service No. D 317 283, (1990).

[4] Cross, R. C., & Steadman, M. H., "Classroom research: Implementing the scholarship of teaching," San Francisco: Jossey-Bass Publishers, (1996).

[5] Garcia, T., "The role of motivational strategies in self-regulated learning," Understanding self-regulated learning, New directions for teaching, (1995).

[6] Garger, S. & Guild, P., "Learning styles: The crucial differences," Curriculum Review, Vol. 23, No. 1, pp. 9-12, (1984).

[7] Hendrickson, A. B., "Predicting student success with the Learning And Study Strategies Inventory (LASSI)," Unpublished master's thesis, Iowa State University, Ames, (1997).

[8] Miller, G., "Are distance education programs more acceptable to field-independent learners?" ERIC Document Reproduction Service No. 409854, (1997).

[9] Oltman, P.K., Raskin, E., & Witkin, H.A., "Group Embedded Figures Test," Consulting Psychologists Press: Palo Alto, CA, (1971).

[10] Oxford, R., Park-Oh, Y., Ito, S., & Sumrall, M., "Japanese by satellite: Effects of motivation, language learning styles and strategies, gender, course level, and previous language learning experience on Japanese language achievement," Foreign Language Annals, Vol. 26, No. 3, pp. 358-371, (1993a).

[11] Oxford, R., Park-Oh, Y., Ito, S., & Sumrall, M., "Learning a language by satellite television: What influences student achievement?" System, Vol. 21, No. 1, pp. 31-48, (1993b).

[12] Parson, R., "An investigation into instruction available on the World Wide Web," http://www.oise.utoronto.ca/~rparson/abstract.html, (accessed August, 1998).

[13] Pintrich, P.R., "Understanding self-regulated learning," Understanding self-regulated learning, New directions for teaching and learning, No. 63, pp. 3-12, (1995).

[14] Pintrich, P. R., & Johnson, G. R., "Assessing and improving students' learning strategies," The changing face of college teaching, New Directions for Teaching and Learning, No. 42, pp. 83-92, (1990).

[15] Pintrich, P. R. & Schunk, D. H., " Motivation in education: Theory, research, and application," Englewood Cliffs, NJ: Prentice-Hall Inc., (1996).

[16] Pintrich, R., Smith, D. A. F., Garcia, T., & McKeachie, W. J., "Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ)," Educational and Psychological Measurement, Vol. 53, pp. 801-813, (1991).

[17] Raven, M. R., Cano, J., Garton, B. L., & Shellhamer, V., "A comparison of learning styles, teaching styles, and personality styles of preservice Montana and Ohio Agricultural Teachers," Journal of Agricultural Education, Vol. 31, No. 1, pp. 40-50, (1993).

[18] Weinstein, C. E. & Meyer, D. K., "Cognitive learning strategies and college teaching, College teaching: from theory to practice, New directions for teaching and learning, No 45, pp.15-26, (1991).

[19] Witkin, H.A., Oltman, P.K., Raskin, E., & Karp, S.A., "Group Embedded Figures Test manual," Palo Alto, CA: Consulting Psychologists Press, (1971).

[20] Witkin, H. A., Moore, C.A., Goodenough, D. R. & Cox, P.W., "Field-dependent and field-independent cognitive styles and their educational implications," Review of Educational Research, Vol. 47, No. 1, pp. 1-64, (1977).

[21] Zimmerman, B.J., "A social cognitive view of self-regulated academic learning," Journal of Educational Psychology, Vol. 81, No. 3, pp. 329-339, (1989).

Gold Peach Web Community 2000: A Research on Developing Web-Based Interactive Learning Environment

Wu, Tung-Xiung*; Yui-Liang Chen**
Dept. of Information Management, Shih Hsin University
#1, lane 17, Mu-Cha Rd. Sect. 1, Taipei, 116, Taiwan, ROC
**Email: txwu@cc.shu.edu.tw*
***Email: ychen@cc.shu.edu.tw*

This series research was based on the progressive concepts of web community, cultural and cultivation features to develop an interactive learning environment for children. The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface has been developed and tested. There were four functions in this community: total Web-Based CAI, interactive learning navigation, collaborative learning classroom, and community management.

Keywords: **Web-Based Learning, Interactive Learning Environments, Web Community, Culture and Cultivation**

1 Introduction

This series research attempted to access the specific objectives as follows:
Developing an interactive learning platform 'Gold Peach' for children based on the fundamental ideas of 'web community'.

Initiating the 'cultural' and 'cultivation' features on designing web environment.
Conducting a field study on focus groups to testify the usability of 'Gold Peach'. Two pretest groups have been done. A well-designed quasi experiment including 3 primary schools is still under going.

The series was conducted from 1996 to 2000. There were four generations of web-human interaction and user interface that had been developed and tested.

2 Literature Review and Problems Defining

2.1 Web Community

Web community was a progressive and extended concept from 'network-based learning community' that was introduced by Lave ea al. (1991)'s 'situated learning' and modified by Qiou (1996).

The components of network-based learning community were:
The organization of community: There were hardware, tools, and members. The community could be in an open or a closed form.

The learning activity: Lave et al. (1991) indicated it should have legitimate peripheral participation (LPP). Such participations included access, communication, learn to talk, collaborative learning and knowledge sharing.
The learning material: There were both existing material that was prepared in the learning database and

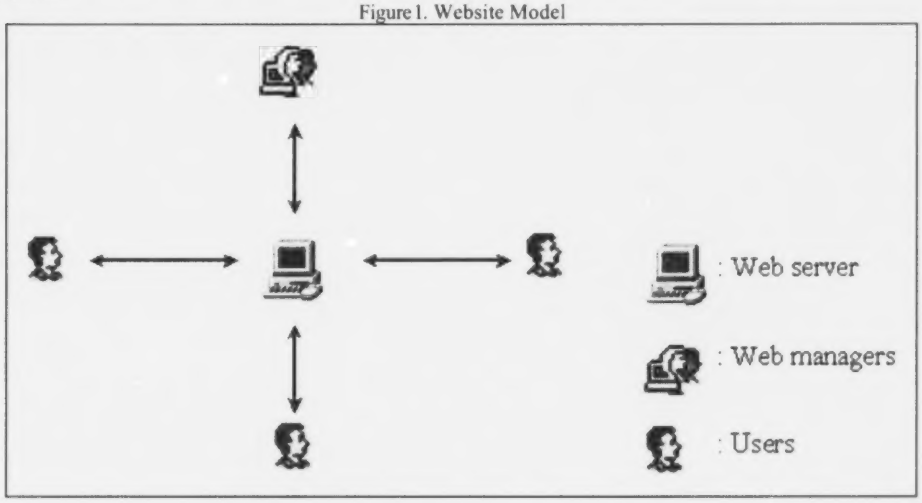
ongoing knowledge that was shaped by the collaborative learning processes.

The moderation: Lave et al. (1991) did not point out any leader in the community while Qiou (1996) advocated the necessary role of 'moderator' who would be the teacher to the other users (students). However, Kearsley (1997)'s idea could be noted here. He emphasized an online teacher is to coordinate the learning direction more than to dominant dogmatism.

After examining the literature above, the author suggested there should be the fifth element: 'the integrated interaction model'.

In general, the conceptual modes of websites interaction could be described as 'radiation model' (see Figure 1):

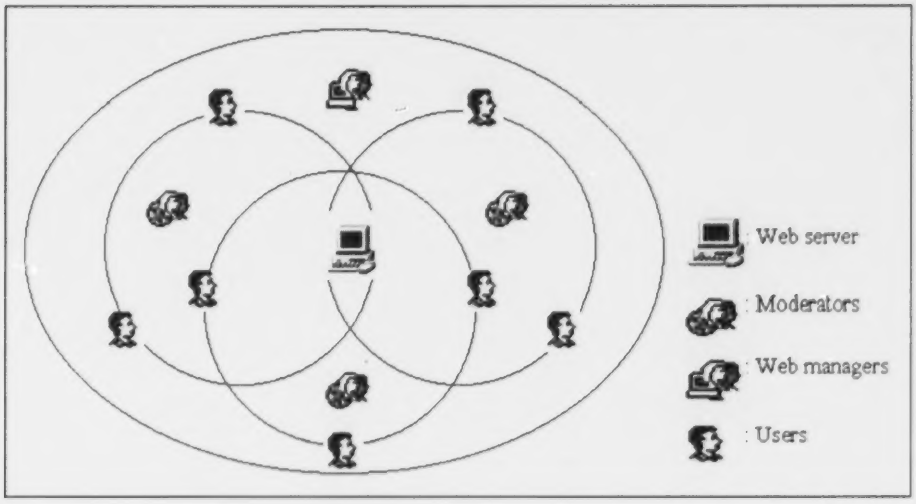
Figure 1. Website Model



The website manager has a 'one to multiple' interaction with users through internet. The website manager will provide all web function, service content and all learning activities.

n practice, it is impossible to prepare complete and sophisticated learning material, achievement test, and all peripheral participation by a single manager or few individuals. It reflects the facts that a lot of existing learning websites that are lacking of updating or content depth.

Figure 2. Web Community Model



Therefore, the author brought a new ' web community model' as Figure2.

This model designed two different interactions: systems functions and information contents. The website manager would only take the former responsibility. The information contents would be divided into more sub communities or interest groups that would be coordinated by external moderators. It was expected that there would be some interlaced area between groups, thus it would be linked as an integrated community. Group moderators did not have to worry about the web techniques; they could be concentrated to develop the learning behavioral interaction for users.

2.2 Culture

Internet makes the earth smaller, brings the world into a village. When we are celebrating the international boundary is falling down; do we regret that the pluralistic colors are also vanishing?

Though there are millions web sites, we have found the inevitable trend that the web characters grow similar faces, wear same uniforms, their interactions are more and more following consistent pattern. We cannot tell which web site is from a certain corner of which continent.

It worried him when the author called for a seminar of designing a new web with his college students. When we needed an innocent leading actress, there was only Snow White left in students' mind; when we made up a worrier model, the Black Knight came out; when we set up exploring plots, they were thinking of Star Trek. They ignored or forgot there are plenty of symbols and scientific fictional stories in Chinese history and mysteries. The young generation is losing its heritage of cultural imagination. (Wu, 1997)

The author suggested that we should remind web designers to consider ' cultural feature' to be an essential factor for designing web. It would be not interesting, if there were no cultural differences in the cyber world. (Wu, 1998; Wu et al. 1999)

2.3 Cultivation

Media' s form (or environment) is as well as content may produce cultivation effect to children, according to Gerbner et al. (1979)' s series work concerning Media Sociology perspective. This idea may come from a long tradition of ' The Medium is the Message' (McLuhan, 1966). It argued that media itself would affect audience' s recognition, attitudes, and even behavior.

There were rich studies and documents on ' TV cultivation theories' in 1970s and 1980s. (Anderson, 1980; Hughes, 1980) Scholars advocated that there are heavy effects influencing children by television. They also

found television would build up a 'media reality' which is far different from the 'real reality'. 'TV children syndrome' was discovered and considered a serious problem.

However, there was still a positive angle to this effect. We could conclude that although media might distort one's behavioral development, while it also might inspire one's mental potential especially in his/her childhood.

WWW is the most powerful media next to television. When we reviewed the lessons from television, the author wanted to suggest that developing web is not only defining a mechanism but also initiating an organism that might cause cultivation between community members.

The effect of cultivation could be operationalized and explored by users' behavioral changes after their experiencing the new media's form and environment. Therefore, the web community also needs a two-way feedback system to collect, measure, and interpret data that real users' innovation behavior, if there is any.

2.4 Current Learning Webs

The author thoroughly investigated ten significant current learning webs in Taiwan to understand if they also noticed the above three concepts. The observation could be summarized as:

Table 1.

	Web Community	Culture	Cultivation
Yes	2	0	1
No	8	10	9

Most of learning webs were in radiation model, one way teaching, and without any culture consideration. This fact explained the emerging need and encouraged the author to develop an integrated web learning community environment.

3 Methodology

As an application research, four methods were employed:
1. Literature reviews.
2. Depth interviewing with experts whose major is in children education.
3. Web systems analysis and design. Four requirements had been defined, they were:
-Total Web-Based CAI: including structural learning materials, systematic learning achievement tests, scores database, users demographic database, parameters base, and analysis tools.
-Interactive learning navigation: guiding users how to solve problems with internet resources instead of telling them the answers.
-Collaborative classroom: creating an online virtue space for the moderator and users to allocate assignments, talk over problems, display output, and share knowledge.
-Community management: verifying the applications for moderators, recognizing the rights of them, providing tools and interfaces for moderators to prepare learning materials, tests, and other collaborative activities.
4. Field study on focus group: two primary schools, one in Gi-Lung City and the other in Tau-Yuan County, had been selected as focus group, interaction and users' feed back had been analyzed for further rigid experiments.

4 Results

4.1 Community Environment and User Interface

The web was named 'Gold Peach Web Community'. Gold Peach is a magic fruit in West Holy Mother's garden based on Chinese ancient legend. You could navigate the cloud and explore unknown world after eating the Peach. The sprit of scientific fiction is as keen as modern imagination.

Since Gold Peach also appears in the famous Chinese classic fiction ' The story of the venture tour to West' , we adopted and inherited the background, characters and plots from the story to create the cyber environment of the web as Figure3.

After logging in the community, the child users could play roles as Magic Monkey, Pig, Sandman, Dragon Horse or other genius etc. They could follow Master Monk to break in 81 forbidden area that were controlled by different monsters and demons. They could steal Gold Peach to surf the WWW to find out the answers for their questions. Or, they might join one of parties in Flower Island where they could chat or work out a task together.

Figure3. Gold Peach Entrance

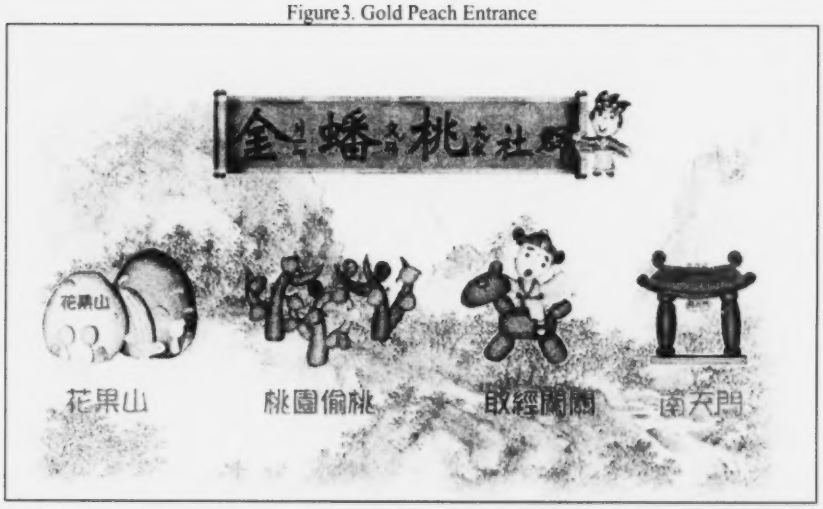
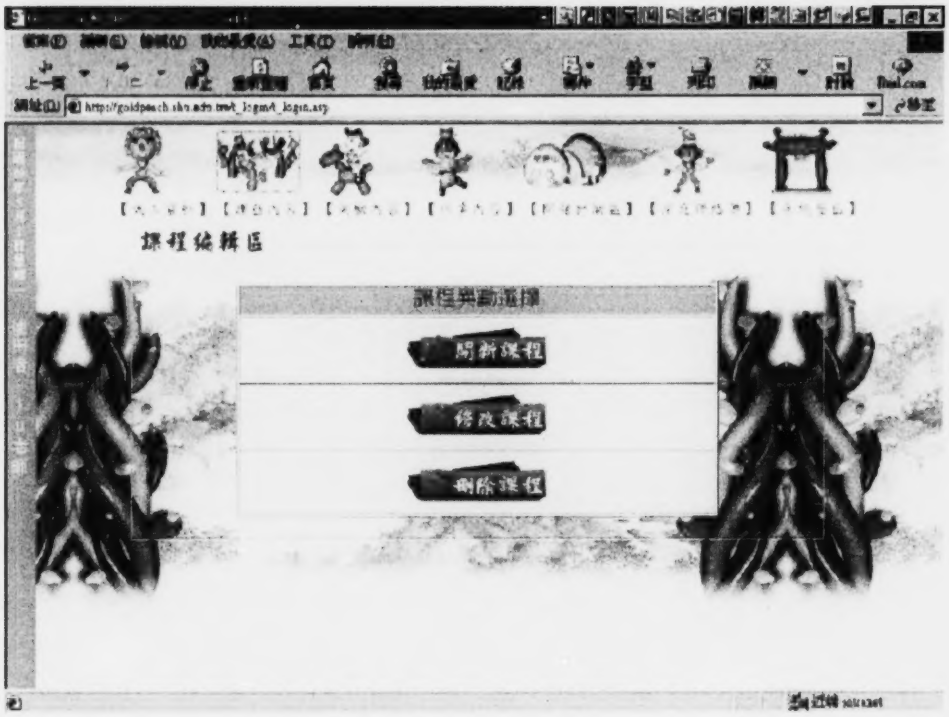


Figure4. Design Process



4.2 Interactive Learning Design Process

The moderator (teacher or expert) users could apply to be god or goddess in South Heaven Palace. After verification procedure, they would be authorized to be in charge a specific interest group to develop the learning interaction with child users.

With a easy, step-wise, and flexible tool (see
Figure4), they could plan their syllabus and learning units. It was easy to reorganize and modify chapters and sections.

There were multiple functions to support moderators to arrange test. They could use either closed-ended or open-ended questions, single option or multiple choices. They also wanted to design some hints for the users who did not pass the test. They could set links to the internet resources where buried the treasure of answers.

They could also direct a virtue seminar or assign a fieldwork. All participants could exchange their idea or experiences upon moderators' requests.

All closed-ended questions in tests would be graded automatically while moderators would mark the open-ended questions.

The users scores and evaluations would be computed and organized in database. A parameter framework would be derived from a certain amount of accumulative data later on. In the same time, a report of user's learning achievement would be prepared for use's parents through web connection. Parents also could reply their comments to the moderators.

5 Conclusions and Discussions

5.1 Web Community: A progressive idea for learning environment

Web Community could be considered as a progressive idea for learning environment. It improved traditional one-way teaching and display and realized total peripheral participation and interaction.

The specification of ' Gold Peach Web Community' could be summarized as the following:
Developing interactive learning platform and environment where all community members could learn, solve problems, and share knowledge.

Consolidating learning contents that were combined primary schools' curricula with internet resources and information.

Reviewing and categorizing current information and webs that are suitable and interesting for children.

5.2 Culture: A deficiency, excess and integration trace

Three generations of the user interface were developed during last a few years. It revealed the introspection on seeking the cultural feature of web design.

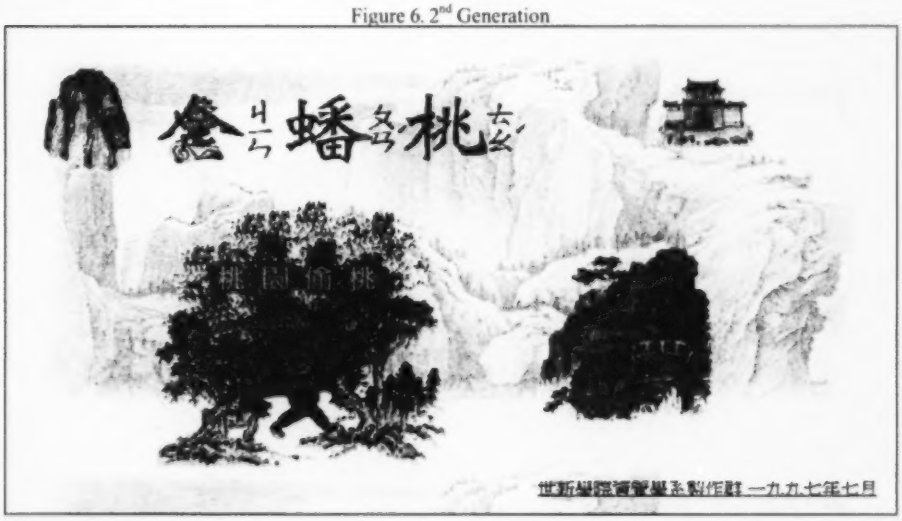
Though the 'culture requirement' was highlighted according to the web developing strategy for the 1st generation, the implement was relatively unsuccessful. The artists in the project team were still lost in the long term Westernized training. The leading role, Magic Monkey, was cute, but lack of originality. The presentation of icons and background were inevitably under European shadow. (See Figure5)

Figure5. 1st Generation

The effort on discovering lost tradition inspired the using of Chinese ink and calligraphy art to stylize the home page for the 2nd generation. The cultural specification was distinguished, however, the black-and-white idea was too abstract to attract children' s attention. (See Figure 6)

We did not find a balance between cultural skill and modern technique until the 3rd generation. We inherit the 3-D model of Chinese flour idol and the styling interest of folk drama to cerate cyber characters. The objects in the background were Chinese materials with modern simplified geometric outlines. The real culture should be a living idea that contented historic and current context. (See Figure3)

Figure 6. 2nd Generation



5.3 Cultivation: A ferment attempt

The result of this research 'Gold Peach Community' was expected to guide a new direction and a new method for children to develop their abilities of learning and problem solving under silent and positive cultivation.

The effort to discover the cultivation effect was still under ferment period. However, this research

BEST COPY AVAILABLE

investigated and accomplished some feedback mechanisms in the systems. They could detect and reveal possible cultivation effects by comparing users learning behaviors and achievement. Since cultivation is more likely a time series effect than a sudden change, the author suggests a large scaled and longitudinal experiment on this issue in the future studies.

References

[1]Anderson, James A. (1980); The Theoretical Lineage of Critical Viewing Curricula; Journal of Communication; Vol.30, No.: 64-70

[2]Hiltz, S. R.; Teaching in a Virtual classroom; Proceedings of the 5th International Conference on CAI;Taipei: NSC; invited paper; 1995

[3]Kearsley, G.; A Guide to Online Education; http://gwis.circ.gwu.edu/~etl/online. html; 1997

[4]Lave, J. & E. Wenger; Situated Learning: Legitimate Peripheral Participation; London: Cambridge Univ. Press; 1991

[5]McLuhan, Marshall(1966); Understanding Media: The Extensions of Man; NY: McGraw-Hill; Ch.1

[6]Gerbner, George, Larry Gross, Michael Morgan and Nancy Signorielli(1979); Television Viewing and Fear of Victimization: Specification or Spuriousness; Annenberg, Penn.: The Annenberg School of Communications, Univ. of Penn.

[7]Hughes, Michael; (1980); The Fruits of Cultivation Analysis: A Reexamination of Some Effects of Television Watching; Public Opinion Quarterly; 46: 287-302

[8]Qiou, Guei-Fa; (1996); Situated Learning Concept and Computer Assisted Learning; Taipei: National Normal Univ. Press

[9]Wu, Tung-Xiung and Yui-Liang Chen; (1999) Cultural and Cultivation Features on Web Designing: A Case Study of Gold Peach Community; In Bullinger, Hans-Jorg and Jurgen Ziegler (eds.) Human-Computer Interaction: Communication, Cooperation, and Application Design; Mahwah, N.J.: Lawrence Erlbaum Associates; Vol. 2, p:66-70

[10]Wu, Tung-Xiung; (1998); Gold Peach Web Community: A Research and Production Project; Taipei: Project of NSC: NSC-87-2515-S-128-001-CH

[11]Wu, Tung-Xiung; (1997); A Research on 'Educational function' and 'Cultural Specifications' of Internet Services; Shih Hsin Journal; No. 6:115-27

Group Composition Methods for Cooperative Learning in Web-based Instructional systems

Yi-Hui Lee* and Nian-Shing Chen**
Department of Information Management
National Sun Yat-Sen University
** m8742618@mis.nsysu.edu.tw*
*** nschen@cc.nsysu.edu.tw*

The objective of this research is to find effective group composition methods to increase the interaction among students in asynchronous distance education using the theories of cooperative learning, group dynamics and social cognitive theory as foundations. The outcome can be a reference for the design of network cooperative learning activity and web-based instructional system in the future. This study is conducted in NSYSU Cyber University (http://cu.nsysu.edu.tw) using surveys and observations to investigate the influence of cognitive style on cooperative learning when different types of tasks are assigned. This research concludes that the choices of discussion tools in the chat room are different under intellective and decision-making tasks. Moreover, regardless of the task types, the heterogeneous groups outperform the homogeneous group during the cooperative learning process. Finally, the cognitive style is significantly related to group satisfaction in a cooperative learning environment

Keywords: **cooperative learning, web-based instructional system, cognitive style, group efficacy, group goal commitment**

1 Introduction

Group cooperative learning is defined as forming a group of two to six people with different abilities, genders or racial backgrounds. These differences may lead to effective interaction. If during the pursuit of personal goals, the group member can also consider other members and the group learning objectives, the learning efficacy can be improved [6]. Many of the previous researches use "gender" as group decomposition variable in investigating the effectiveness of cooperative learning under different task types. They find that the male groups usually outperform the female groups when computer is used in solving the tasks. However, "gender" should not be the only variable affecting the group performance. Thus, it is essential to conduct a research based on individual characteristics. Moreover, many scholars also point out that task types are one of the important variables in cooperative learning. When facing with different task types, the participants' discussion process evolved, skills required, communication tools used, and the communication methods adopted will all be varied.

From the social cognition point of view, group cognitive behavior, which is often ignored in-group performance experiment, is an important factor affecting group performance. In addition, group members' participation is another significant issue. The higher the participation rate, the more focused the members are in completing the tasks assigned. The group satisfaction will also increase [2]. Thus, this research chooses cognitive behaviors such as group participation rate, group efficacy and group goal commitment as important variables in cooperative learning. The objective is to find their impacts on group performance in different group types with different task types. Nunamaker et al. [5] point out that group; task, environment and technology are the four variables affecting the decision-making process in electronic meeting. In turns, they will affect the outcomes of the discussion. They are part of the input-process-output structure. This structure can be applied to this research on investigating the group cooperative learning in a web-based instructional system.

2 Literature Review

we consider those factors as follows• •

- Cognitive style - Theory of field-independence

  When individual is having perception judgment, he/she is field-dependent if he/she tends to make decisions based on the surrounding. Otherwise, he/she is field-independent, i.e. the judgment is resulted from some inner reference.
- Task types

  The task types in this paper are the intellectual and decision-making task types under the "choose" category. According to McGrath [4] and Johnson [3], Intellective tasks are tasks with a "correct" solution. The solution may be obtained from calculating, choosing or creating. Decision-Making tasks are tasks with the most appropriate solution instead of the best solution.
- Group efficacy

  Bandura [1] thinks that group efficacy directly influences the extent to which group members can mobilize and coordinate their skills, the amount of effort they will put into the task ,and their persistence when group efforts fail to produce results. In addition, individual efficacy theory is widely applied to management, computer skill training and education. It is found that the individual with high efficacy level performs better.
- Group goal commitment

  Goal commitment plays an important role in goal setting. When group members identify with the goal of the mission, the main purpose is then to achieve the appointed or self-set goals and improve the group performance. Thus, there is a positive relationship between group goal commitment and group performance.

3 Research Methodology

The research structure is modified from the Electronic Meeting System (EMS) proposed by Nunamaker et al.[5]. Task types and cognitive types are the independent variables. This research focuses on finding their effects on cooperative learning process and performance in a web-based instructional system.

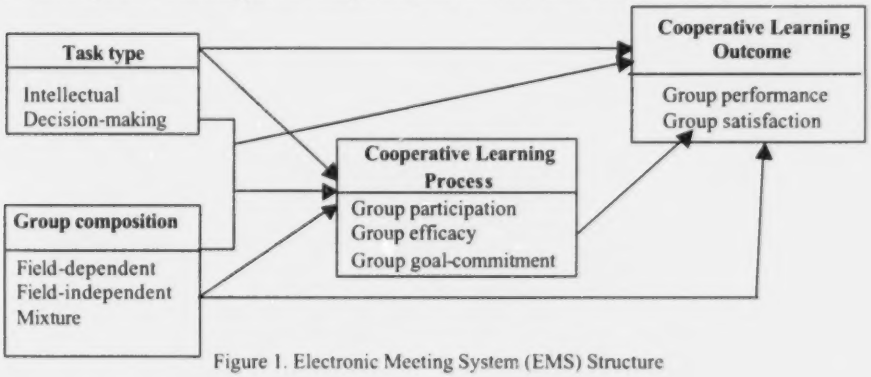


Figure 1. Electronic Meeting System (EMS) Structure

- **Samples**

  The samples are taken from master students of asynchronous Computer Networks and Internet course in NSYSU Cyber University. Most of the students are part-timed. The total number of students is 191. After rejecting students who did not complete the experiment, the valid sample size is 80 with an average age between 31 to 35. There are 59 males and 21 females. According to Group Embedded Figures Test, individual cognitive types are classified into two categories: field-dependent and field-independent. As a result, 35 people belong to field-independent category and the other 45 belong to field-dependent.
- **Group composition methods**

  Based on field-dependency, three types of groups are formed. They are groups with all field-independent individuals, all field-dependent ones and a mixture of the two. The average number in each group is about four or five. Since the field-independent samples are ten less than the field-dependent ones, there is a group with three field-independent and one field-dependent student.

For observation convenience, this group is classified as the 'all field-independent' class. Overall, there are six field-independent groups, seven field-dependent groups and seven mixtures, which add up to a total of 20 groups in this experiment.

- **Research procedure and its implement**

  At beginning of the semester, students are asked to complete a "Hidden Figural test" so that their cognitive types are known for later group composition. The experiment would start after groups are formed. There are three parts to the experiments where a task is assigned to each part. The sequence of the type of assigned tasks is intellective, decision-making and intellective tasks. All group members are new to each other. Thus, there is no previous interaction between them. The intellective task - 1 is therefore used as a warm-up exercise. Data from the other two tasks will be collected and analyzed. The samples are not informed of the difference between groups. The duration for each task would be one week. In addition, the cooperative learning process is sub-divided into two phases. After the tasks are given, the group members would have discussions on job assignment. This is called the "prepare phase". Each group member has to complete the group efficacy and group goal commitment surveys. After the groups complete the tasks and are aware of the group performance, the so-called "task complete phase" begins. Within this phase, each group member has to fill the surveys regarding the group satisfaction. Among the variables measured, group performance is graded after three experts have evaluated the task reports of each group.

- **Research Tools**

  Each group uses the discussion tools offered by NSYSU Cyber University for communication during the experiment. The tools available include group discussion board, chat room and mailing group. Group participation is measured based on the records of the use of the proceeding discussion tools. Regarding the group discussion board, the number of posting is recorded, whereas in the group chat room, the numbers of times individuals express themselves are recorded. In the mailing group, number of message sent is recorded.

- **Task Performance**

  Three experts review the outcomes of each group and they give each group an overall grade. Thus, the outcomes have a certain level of credibility.

4 Results and Analysis

This research uses t-test with independent variable - task type, to see if there is any difference between the average of group cooperative learning and its outcomes. The results show that the p-value for the group chat room category is less than 0.05. Thus, there is a significant difference. Since decision-making tasks encompass more areas than intellective tasks, more time and efforts are spent on them. Therefore, it is expected to find more frequent communication when this type of tasks is assigned. Many of the past researches find that groups communicate face-to-face outperform groups communicate via computers. This is not only because body languages can be used when members can see each other but also there can be instantaneous discussion on issues. Among the discussion tools, only group chat room is synchronous and allows instantaneous interaction. Group discussion board and group mailing list do not provide the same advantages.

When assigned with intellective tasks, there is a significant difference between the heterogeneous group (i.e. the mixtures) and the homogeneous groups in "group discussion board", "group chat room", group efficacy group satisfaction and group performance under the group cooperative learning category. This finding is consistent with the past researches because heterogeneous groups contain people with different characteristics and thinking pattern so that they can supplement and stimulate each other.

Our outcome shows there is a significant difference between heterogeneous group and the homogeneous groups in "group discussion board", "group chat room", and group efficacy when assigned with decision-making tasks. In the past, many researchers find that homogeneous group will perform better in communicative tasks but this is inconsistent with the finding of this paper. However, the paper is consistent with Johnson [3] who thinks that heterogeneous group outperform the homogeneous groups in creativity and decision-making tasks. In addition, it is found that there is a significant difference in goal commitment between field-dependence group and mixture during the cooperative learning process but not in Cooperative Learning outcome. According to the writer's experience in tutoring the class, it is concluded that the outcome may be affected by the performance of the previous intellective tasks. Part of the field-independent groups holds different opinions regarding the answers to the first and the third questions. This, in turn, affects the group members' answer to goal commitment survey in the decision-making tasks. This is related

to the characteristics of field-independent members who often have more autonomy over outside messages. They process and decode messages according to their own cognitive reorganization style. They will not accept answers that are doubtful and uncertain to them.

The interaction of different task types and cognitive style have no significant impact on there is no significant difference on cooperative learning.

It is respectively concluded that to intellectual and decision-making tasks group cooperative process and its outcome have the following in common:

- 1. There is a positive relationship between the number of posting during the group participation and group satisfaction level of group cooperation outcome.
- 2. There is a positive relationship between the group efficacy during the group cooperation process and group satisfaction level of group cooperation outcome.
- 3. There is a positive relationship between the group goal commitment during the group cooperation process and group satisfaction level of group cooperation outcome.

However, there is no significant positive relationship between group cooperation process variables and group performance when assigned with intellective tasks. This research concludes that since the intellective tasks have the one 'correct' solution, once the group members have deviation about the task, the group performance will be affected regardless of group efficacy or goal commitment.

5 Conclusion

From the survey, 86% of the participants agree that cooperative learning do increase the interaction among students. Moreover, 92% of the students are satisfied with the group discussion environment in the NSYSU Cyber University. This indicates that cooperative learning indeed reduces learning isolation and also heightens the students' learning motivation and willingness. Besides, it is concluded that heterogeneous groups outperform homogeneous groups in both group cooperative learning process and its outcomes within a web-based instructional system. However, field-dependent groups perform worse than the other two groups in both intellective and decision-making tasks. Since the field-dependent members are easily influenced by their surroundings and require the guidance of either teachers or well-performed students, they should not be grouped together when conducting cooperative learning in web-based learning environments. In addition, from the viewpoint of group dynamics and social cognition, group efficacy and goal commitment will affect the performance of the group cooperation. This research finds that there is a significant relationship between these variables. Under different task types, the group satisfaction is also significantly different. Thus, group efficacy and goal commitment can also be used as measurement in quantifying the outcome of group cooperation.

Acknowledgement

The Study is supported by the Program for Promoting Academic Excellence of Universities by Ministry of Education of R.O.C..

Reference

[1] Bandura, A.., "Social foundations of thought and action. A social cognitive theory", Englewood Cliffs, NJ. Prentice Hall, (1986).

[2] Cooper, M.R. & Wood, M.T., "Effects of Member Participation and Commitment in Group Decision Making on Influence, Satisfaction, and Decision Riskiness." Journal of Applied Psychology, 59(2),127-134, (1974).

[3] Johnson, D. W., & Johnson, F. P., "Joining together: Group theory and group skills", Boston: Allyn & Bacon, (1997).

[4] McGrath, J.E., "Group: Interaction and Performance", Prentice Hall, Englewood Cliff, NJ, (1984).

[5] Nunamaker, J.F. Dennis, A.R. Vslscich, J.S. Vogel, D.R. & George, J.F., "Electronic Meeting Systems to Support Group Work.", Communications of the ACM, 34:7,pp. 40-61, (1991).

[6] Spink, K. S., "Group cohesion and collective efficacy of volleyball teams", Journal of Sport and Exercise Psychology, 12, pp. 301-311, (1990).

A Web-based EFL Writing Environment: Integrating Information for Learners, Teachers, and Researchers

David Wible*, Chin-Hwa Kuo, Anne Liu* and Nai-lung Tsao****
** Graduate Institute of Western Languages and Literature*
Tamkang University
Tamsui, Taipei Hsien, Taiwan
dwible@mail.tku.edut.w
lieor@ms7.url.com.tw
***Computer and Networks (CAN) Laboratory*
Department of Computer Science and Information Engineering
Tamkang University
Tamsui, Taipei Hsien, Taiwan
chkuo@mail.tku.edu.tw
g6190173@tkgis.tku.edu.tw
Taiwam

With the rise in the popularity of web-based education, there is a pressing need for the design of web-based systems that are domain-specific. This need is particularly acute for the domain of second language education, where generic web-based systems fall short of fulfilling the potential of the Internet for meeting the particular challenges faced by language learners and teachers. A novel interactive online environment is described which integrates the potential of computers, Internet, and linguistic analysis to address the highly specific needs of second language composition classes. The system accommodates learners, teachers, and researchers. A crucial consequence of the interactive nature of this system is that users actually create information through their use, and this information enables the system to improve with use. Specifically, the essays written by users and the comments given by teachers are archived in a searchable online database. Learners can do pinpoint searches of this data to understand their individual persistent difficulties. Teachers can do the same in order to discover these difficulties for individual learners and for a class as a whole. The modular system provides interfaces with functions to facilitate an array of user tasks such as teachers' correction of essays and learners' writing and revision processes. Researchers' error analysis of learner essays feeds an active online help function as well.

Keywords: **applications in subject areas; architectures for educational technology system; interactive learning environments**

1 Introduction

The purpose of this paper is to describe one module in a highly integrated language learning environment called IWiLL (Intelligent Web-based Interactive Language Learning: http://www.can.tku.edu.tw/iwill) The module within IWiLL which we focus on in this paper is a novel web-based writing environment designed for EFL composition classes.

The design of the IWiLL writing environment is based upon certain general assumptions. First, the ideal online system for EFL writing classes should be interactive. Second, the system should exploit the computers' capacity to track the content of the interactions between users and to enable users to do pinpoint searches of the record of these interactions. This feature makes available invaluable information that can serve as a cumulative source of insight for both learners and teachers, information which in traditional writing classrooms remains scattered, ephemeral, and highly inaccessible. Third, while the system described here is designed for second language writing classes, it is more accurately seen as one component in an integrated language learning environment that includes other skills, such as reading and listening (Kuo, Wible, and Chio, 2000; Kuo, et. al., 2000). The modularized and integrated design is intended to accommodate recent trends in language pedagogy which view language skills as best learned in an integrated whole rather than as a set of separate, independent skills. Finally, while the IWiLL environment is designed specifically to meet the needs of certain type of language course (second language composition) it is intended to provide as much freedom as possible for teachers within this domain to use their own approaches and materials of their choice.

2 The Organization of the System

2.1 The Teacher's View

A registered teacher who logs onto the system is presented a display screen of various links to components within the system. To correct student essays, the teacher links to a page which displays their student roster.

From this roster screen, the teacher retrieves the essay by clicking on the button that represents that essay on the roster page. To mark the essay with a comment (for example, to mark a run-on sentence or subject-verb agreement problem), the teacher first chooses the portion of the essay targeted for comment using the mouse. Once the relevant text has been selected, there are two ways for the teacher to provide the student with a comment on it. The first is to simply type the comment in the empty text box provided especially for the teacher's comment and then, once the comment has been composed, append it to the intended portion of the student's text by clicking on the appropriate button ('Give the comment'). The second way of providing a comment is to choose one that has been stored in a "Comment Bank." This second way deserves some elaboration.

The Comment Bank provides each teacher with a convenient means for storing and reusing frequently used comments. To retrieve a stored comment and append it to the portion of the student essay, the teacher simply selects that comment from a drop-down menu and clicks on it. The teacher can add new comments to her Comment Bank at any time. (See Figure 1)

At this stage, research is needed to understand the factors effecting how beneficial various sorts of comments are in helping students with their writing. An advantage of this system is that, with it, researchers can control the crucial variables (such as the precise form and content of the teacher feedback being investigated), and it makes readily available the data needed for such research since the marked and unmarked essays are archived in forms that can be queried. Moreover, the revised versions of an essay can be examined along side the teacher's comments that were given to the student on the original version of the essay, making it possible to easily track the influence of various types of teacher feedback.

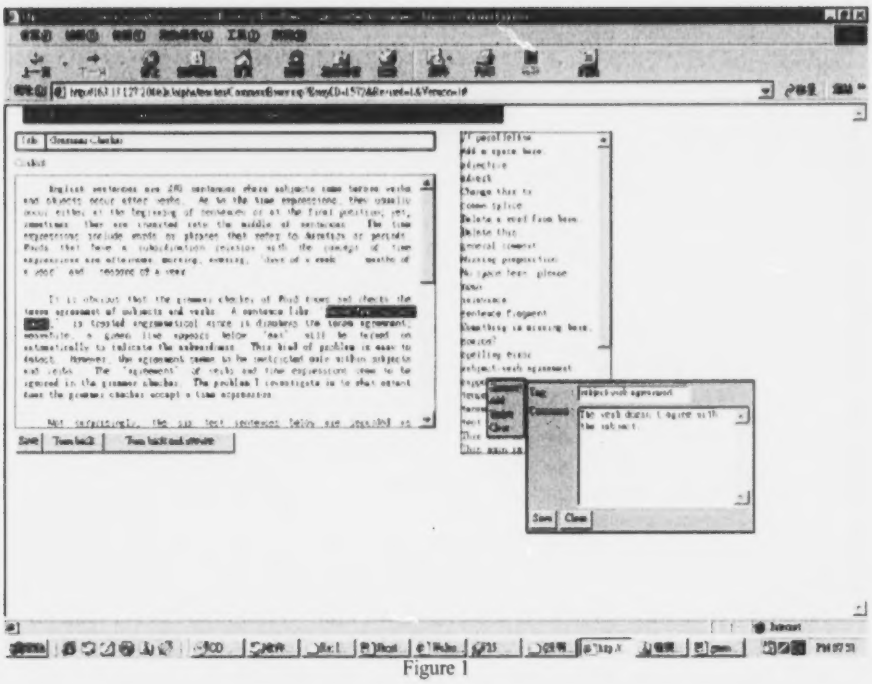


Figure 1

It is important to notice the distinction between this essay-marking function and the superficially similar functions offered in commercial word processors such as Microsoft Word. Like our system, those programs allow users to select portions of text and annotate them with comments. While the convenience that this provides to users as a communication tool is essentially the heart of the function's role in these commercial word processing systems, in our system this convenience is a relatively incidental (though valuable) advantage. For us, the substantial value comes from a set of related features which the word processing programs do not offer. Specifically, all of the annotations provided in our system by teachers when they mark essays are permanently indexed, by way of database technology, to the portions of text that the teacher has marked. Moreover, the essays themselves along with the indexed teacher comments enter a permanent corpus of learner essays that can be searched on line. Information extraction techniques, then, make it possible to provide learners and teachers with instant cumulative profiles of the trouble spots of individual learners, of whole classes of learners, or subtypes of learners selected by a wide variety of criteria. For example, the system enables teachers to retrieve all tokens that have been marked with a particular error type either from the essays of a single learner or from the essays of groups of learners. Moreover, teachers can retrieve the tokens of every error type and display them in order of frequency, with the error type that has been marked on the highest number of text portions listed first.

The role which our commenting function can play is deepened greatly by the highly integrated nature of our system design. Not only does it support profiles of entire groups of learners, but the analysis of the common errors can be immediately used by researchers to analyze the sources of learner difficulties. This sort of data makes it possible to investigate pervasive patterns of difficulty in the learners' English (that is, to investigate what some applied linguists call the 'interlanguage' of learners). Results of such analyses can directly enhance the entire web-based writing platform. Specifically, we have developed an authoring tool for designing online help which targets precisely the problems uncovered in the analysis of learners' errors. Moreover, based upon this sort of data, researchers can improve the design of teaching and reference materials. (See section 2.3 below for more details.)

BEST COPY AVAILABLE

2.2 The Student' s View

A registered student logging onto the system is first shown a menu of links, including a link to a discussion board dedicated to the students in that class and links to helpful websites for ESL writers. To compose or turn in an essay, the student links to a page that displays a row o f colored buttons, basically each button (or cluster of buttons) representing a different essay the student has written or is in the process of writing. From this page, the student can opt to resume work on an unfinished essay or revision, or to submit or compose a new essay. (See Figure 2)

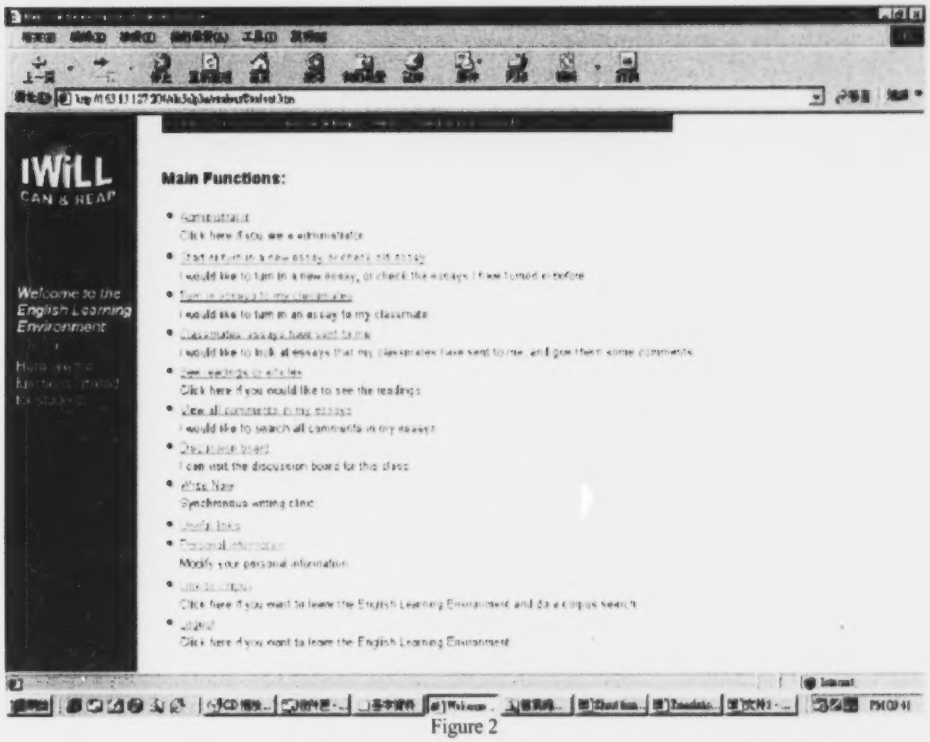


Figure 2

To compose an essay, students can elect either to compose online by typing their essay within a designated text box on the appropriate page or to copy and paste into that box an essay composed off-line. The latter essays are imported as text files.

From this screen where the essay has been composed or imported, students can submit the essay to the instructor. Alternatively, through a drop-down list of all of their classmates' names they can send the essay to any number of their classmates for peer editing or commenting. The methods of selecting portions of text for comment and for submitting comments are basically the same as under the teacher' s view described above.

When a student views an essay that has been marked by the teacher, the essay itself appears almost identical to the student's original, unmarked essay. None of the teacher' s comments are immediately visible. The only difference in the appearance of the marked and unmarked version of an essay is that in the 'corrected' version some of the student's text shows up in blue. These are portions of the essay that the teacher has marked for comment. To see the content of the teacher's comment, the student places the cursor on the blue text and the comment appears.

An important feature offered to students is a specific sort of search function which they can access through a link labeled: "Search all comments in my essays." With this function, a student can access a list of all of the comments that the teacher has marked on his essays. The comments are listed in descending order of frequency as they occur in the entire set of that particular student's essays.

By clicking on the View button for any of these comments that appear on this display, the student retrieves a cumulative listing of all of the instances where this comment appeared in his own essays. To give the minimum context that would allow the student to see the nature of the marked problem, this search function retrieves complete sentences from the student's texts even if the teacher had marked only a word or phrase or other proper subpart of that sentence for comment. In instances where the teacher has marked off a chunk of text which spans a sentence boundary in the student essay, the entire text of both (or all) of those sentences is displayed. By clicking on any of the tokens that have been retrieved, the student links to the complete text of the essay from which that token was extracted, thus accessing the full context.

What the "View Comments" function provides is the opportunity for the student to see patterns of difficulty, to see in one glance a set of tokens of one type of difficulty from his own writing. Of course, what is needed here is research on the differential effects of the two approaches to providing feedback. Moreover, the effectiveness of the View Comments function will almost certainly depend not simply on the fact that the system allows searches of the essays according to teacher comments, but also upon the quality and clarity of the comments themselves. An important property designed into the system is that it can track precisely the kinds of data needed for investigating these sorts of issues.

2.3 The Researcher's View

The system has been designed to create a corpus of student essays as a byproduct of the teacher-student interaction on the system. Specifically, each essay that a student submits to his teacher over this system is, with the permission of that student, copied into a corpus of "learner English." Consequently the corpus itself grows as the system is used by students and their teachers.

The creation and analysis of corpora of learner language data is an extremely new and promising field of research (see Granger 1998). One of the formidable obstacles in this field is a practical one of how to input the learner data. Granger (1998:11) mentions three methods, all extremely tedious, time-consuming, expensive and the first two prone to error: (1) scanning essays from hard copies and (2) keying in data manually (3) downloading electronic data. Granger implies that the latter refers to collecting student essays that are on disks. Our system offers another way of creating learner corpora which goes a long way toward eliminating these prohibitive drawbacks. The texts created by students enter the corpus virtually unaffected by any intermediate steps for "inputting" them because the exact text that the student sends to the teacher over the system is copied into the corpus. Moreover, when students first register to use the system, they provide relevant metadata about their years of studying English, their gender, age, mother tongue, and the relevant fields of metadata are updated every semester. Each essay a student turns in is automatically indexed to this information and annotated with the date when that specific essay was submitted. This indexing allows for longitudinal studies of learner writing as well as cross-sectional studies that consider variables such as gender, age, or years of study. Researchers can add other fields of metadata to track other variables for specific studies.

Researchers are not only able to search the corpus of essays collected from learners. The results of the researcher's analyses of learner difficulties can be translated into the content of an active online help function for those learners. The system includes an authoring environment for content administrators (ICPs) where they simply indicate what string of text in a learners essay should trigger help, and then write the content of the help which should be displayed for that particular string. Research on the learner corpus has revealed, for example, that the word 'ever' was misused by learners in 25% of the cases where it appeared in their essays. Further analysis attributed this to negative transfer in which learners associated the English expression 'ever' with a Chinese counterpart expression (*cheng jing*). These two expressions while overlapping in use and meaning, diverge in important ways, and it is precisely in these diverging respects where students misused the English expression. Based on this linguistic analysis, the authoring environment for online help was used to design advice concerning the word 'ever' addressing precisely the difficulties it poses for Chinese learners. When learners request general help on an essay, the help function actively detects instances of 'ever', highlights them

and creates a link to this advise.

3 Conclusion

The underlying goal of the project described above has been not only to create an online writing environment that connects teachers and students by way of a user-friendly interface, but also to provide ways to exploit the valuable data that is created when the environment is used. The learners' essays themselves are stored in growing corpus of ESL language production. The comments that teachers append to the particular segments of the learners' texts in the course of essay correction are treated as annotations of those texts, which can be searched and retrieved. An authoring environment for online help permits content administrators to turn interlanguage research results into highly specific help concerning attested difficulties which traditional language education has neglected. It is hoped that increasingly sophisticated and dynamic manipulations of these sorts of data will lead to the delivery of evermore useful and useable information to learners, teachers, and researchers both online and off.

References

[1] Chang, Hsiu-Chen, "Web-based EFL learning and teaching" (manuscript), (2000).

[2] Ferris, Dana, "The case for grammar correction in L2 writing classes: a response to Truscott" ,(1996). *Journal of Second Language Writing* 8-1:1-11, (1999).

[3] Granger, Sylviane, "The computer learner corpus: a versatile new source of data in SLA research.", In Sylviane Granger, *Learner English on Computer*. New York: Longman, (1998).

[4] James, Carl, "Errors in Language Learning and Use.", New York: Longman, (1998).

[5] Kearsley, G., "Computer-aided instruction, intelligent", In S. Shapiro (ed.) pp. 154-9, (1987).

[6] Kuo, C.-H., David Wible, and Chia -Lin Chio, "On the design of a synchronous virtual writing clinic." (manuscript), (2000).

[7] Kuo, C.-H., David Wible, Meng-Chang Chen, Li-Chun Sung, Nai-Lung Tsao, Chia-Lin Chio, and Chih-Chiang Wang "The design and implementation of an intelligent web-based interactive language learning system." (manuscript), (2000).

[8] Krashen, S., "The input hypothesis and its rivals", in Ellis, N. (ed.) *Implicit and Explicit Learning of Languages*, London: Academic Press, (1994).

[9] Ogata, Hiroaki, Yano, Yoneo, and Wakita, Riko CCML —"Exchanging marked-up documents in a networked writing classroom.", *Computer Assisted Language Learning*, 11-2:201-214, (1998).

[10] Nerbonne, John (ed), "*Linguistic Databases*. Stanford": CSLI, (1998).

[11] Neuwirth, M.C. and Wojahn, G.P., "Learning to write: computer support for a cooperative process.", In T. Koshmann, CSCL: Theory and Practice of an Emerging Paradigm. Lawrence Erlbaum Associates, pp.147-70, (1996).

[12] Selinker, L., "*Rediscovering interlanguage*.", London: Longman, (1992).

[13] Selinker, L., "On the notion 'IL competence' in early SLA research: an aid to understanding some baffling current issues.", In Brown, G., Malmkjaer, K. & Williams, J. (eds.). *Performance and competence in second language acquisition.*, Cambridge: Cambridge University Press, 92-113, (1996).

[14] Truscott, John, "The case against grammar correction in L2 writing classes.", *Language Learning* 46-2:327-369, (1996).

Integrating Web-based Materials into Course Design

Lilly Lee Chen
Rice University
6100 Main Street, Houston, Texas, USA 77005-1892
Tel: 713-348-2820
Fax: 713-348-5846
E-mail: Lchen@ruf.rice.edu

1 Introduction

This paper is a report on a project in which Web pages were crucially incorporated in the design of a new college course titled anguage and Culture in Taiwan." There were two main reasons for making the Internet an integral part of the course: (1) the wide range of topics covered in this very general introductory course requiring the wealth of information sources easily accessible on the Internet and (2) necessity of frequent updates of information due to the fast and volatile nature of the political evolution in Taiwan, particularly during the presidential election year when this course was offered. The consideration of user factors was also important. The Internet responds well to today's college students who demand relevance (of issues that pertain to the here and now) and immediacy, and are as adept in clicking on the keyboard surfing the Internet as flipping the pages of a book.

More serious, though, in our course design is the educational philosophy that a college's mission is not so much to transfer knowledge as to create environments and experiences that bring students to discover and construct knowledge for themselves [1]. Exposure to the vast amount of knowledge on the Web necessitates focus and careful choice of relevant materials. As part of course assignments students were expected to present on topics of their choice. This ensured that they researched the subject matters in greater depth before presenting them in class, as they would be presenting to an audience of their peers.

2 Method and content

The ready accessibility of the Internet for both the students (practically all students have a PC) and instructor (to add to or update the course page), especially outside of class, altered in-class activities from those of traditional teacher-centered instruction to student-centered discussion and presentation. The utilization of e-mail also facilitated out-of-class preparation. Students were informed by e-mail to go to a certain new site or link for a new development of events. Similarly, the student e-mailed the instructor for information or help. The more out-of--class preparations the students have, the better the quality of in-class discussions the instructor can expect.

The syllabus was essentially a structure of links organized according to the class schedule of topics and activities. It is also a display of the scope and structure of the contents of the course. It changed dynamically as new links were discovered and added throughout the semester. The syllabus appears as a navigation bar. To facilitate learning we have minimized visual search by displaying this syllabus bar consistently on top of each page[2]. Students can easily navigate from site to site, not only to preview but also to review. Besides a general page of topics with their links to available Web sites, the page of each session further highlights some particular links to topics of the session, along with a list of references available on reserve in the library.

The contents of this course consist of two major areas: (1) culture and (2) language. The former includes a wide range of topics, such as a profile of Taiwan, history, political parties, customs, festivals, family relations, literature, world view of Taiwan, and the future of Taiwan. Generally each topic or a group of related topics was covered at a weekly session, which lasted two and a half hours, of which the first half was devoted to cultural discussions and the second half, instruction of language. The culture part of the course

was conducted in a seminar format along with presentations by students.

By dividing the content area into culture and language, we were not forgetting that language always operates in a culture [3]. Besides teaching phrases and sentences applicable in social situations, other aspects of the language, such as kinship terms, nursery rhymes, proverbs, songs, etc., abounding with traditions and cultural values, were also taught. The language part of the course contained sound files. Some had two types of reading, a slower one and a faster one, to facilitate learning. Taiwanese expressions in each language lesson generally contain both literal and free translations. This makes self-study very easy and convenient, as long as they could access the Web. Sound files were indispensable as Taiwanese is a tone language and furthermore has seven tones and possesses an elaborate tone sandhi system [4].

This Web program was produced entirely in the instructor's office by using Netscape Composer, SoundRecorder, and other freeware downloaded from the Internet [5]. The exercise part of the course, which features filling in of blanks, multiple choice, short answer, etc., was made possible by the ExTemplate program developed at Rice University Language Resource Center [6]. The ExTemplate application creates exercises that will be stored in a database for future retrieval [7]. It allows students to submit exercises via the Internet and be graded by the instructor also via the Internet. The language lesson sound files were integrated into ExTemplate. This feature was very useful particularly for tonal distinction exercises.

Our classroom was equipped with a multimedia Podium which allowed us to go on the Internet, show videos, movies, documents, play CD , etc. The Podium came in handy when a demonstration on the classroom screen was called for. Not only did the instructor use the Podium, students were encouraged to do their class presentations by using PowerPoint or by going to their own personal homepages where they collected Web links or images related to their topics for classroom presentation.

3 Conclusions

By incorporating the Internet into course design, we were able to create a more accommodating learning environment for the students and to give students more control over the learning process. As this was our fist attempt at teaching the course with Web-based materials, further refinements of many aspects of the course need to be made. For example, we can make pages less cluttered with text and add more digitized videos. Also researches can be conducted to determine students' reactions in terms of attitudinal factors and learning efficiency. Taiwanese on the Web is an on-going project. We solicit help and comments. This project attempts to raise awareness in the global community of the vitality of a culture less known and rarely covered in college courses. As universities generally suffer from budget constraints, by making this program available on the Web we hope to encourage teaching of this subject matter.

References

[1] Bar, Robert B., & Tagg, John, "From teaching to learning - a new paradigm for undergraduate education", Change 27-6 Nov./Dec., pp. 13-25, (1995).

[2] Aspillaga, M., "Screen design: Location of information and its effects on learning", Journal of Computer-based Instruction, 18(3), 89-92, (1991).

[3] Walker, G., & Noda, M., "Remembering the future: Compiling knowledge of another culture", Reflecting on the Past to Shape the Future, (eds.) Birckbichler & Terry, National Textbook Company, pp. 187-212, (2000).

[4] Chen, L., "Grammaticalization and Tone in Taiwanese", the 27th Forum of Linguistic Association of Canada and the United States (LACUS Forum 27), (2000).

[5] Chen, .L., Chang. J., Lai, S., & S. Yuen, S., "Web Based Instruction", Proceedings of the 8th International Conference of Chinese American Educational Research and Development Association (CAERDA2000), St. John's University, New York, September 16-17, (2000).

[6] Chen, L., Bartlett, C., & Verm, J., "ExTemplate: a tool for foreign language web editing", Proceedings of the South Central Association for Language Learning Technology (SOCALL 2000), Louisiana State University, Baton Rouge, Louisiana, April 7-8, (2000).

[7] ExTemplate Lesson Server: Online courseware authoring, http://lang.rice.edu/extemplate/, (accessed on August 1, 2000).

Is Everyone on Board: Learning Styles and the Internet

Michelle Hsiang*, Ellen Storey Vasu, Marsha Alibrand***, Nancy Atkins**** and Jane Steelman*******

** Research Triangle Institute/ NC State University. Email: mhsiang@rti.org*
*** NC State University. Email: esvasu@unity.ncsu.edu*
****NC State University. Email: marsh@cape.com*
*****NC State University. Email: atkinsn@he.orange.k12.nc.us*
******NC State University. Email: ravendoc@aol.com*

For many years, educators and practitioners have been implementing, enhancing and innovating variety of teaching methods to best fit students learning styles for eliciting the potential of students. As stated by Corno and Snow [2], "the success of education depends on adapting teaching to individual differences among learners", the teaching methods taught are to accommodate, meet, and elicit the diverse learning needs. Technology is becoming accessible to most segments of the United States population. As more and more classrooms are connected to the Internet and online-lesson plans are adopted to teaching and learning, it is important for teachers to ensure that the diverse needs of every student is addressed. This research study contained the quantitative analyses relative to learning styles and web design.

Keywords: **Humanities and Learning Technology, Instructional Design, Web-Based learning**

When computer technology increased its popularity in 1980's, Computer-Assisted-Instruction (CAI) in the form of drill, practice and tutorials was superior to traditional instruction [1] and outperformed those who received traditional instruction [7]. While providing feedback to reinforce learning in CAI, Pritchard [6] recommended that the use of computers in CAI require a specific learning style of paying attention to details for accuracy, so that students are able to work alone. Davidson et al [3] further examined learning styles and performance in computer concept and programming skills in BASIC, and found that learning styles had a significant effect on performance of a computer course. By 1997, 72% of the schools in the USA had online access. As teachers adapt their teaching to the use of the World Wide Web as a medium for resources, and to publish their class websites, the information delivery system has been changed from paper format to digital format and from fixed text to unlimited hypertext. The visual graphic representation has been switched from static to animated/multi-dimensional and from limited colors to millions of colors. With the advance of the technology, sound and movies can be incorporated into webpages to enhance teaching and learning environment. With the release of many HyperText Markup Languages (HTML) editors, e.g., Adobe PageMill, DreamWeaver, Front Page, it becomes very easy for anyone to create and publish webpages, therefore it is essential for educators to investigate the different learning styles of individual students when designing webpages.

Study Purpose and Sample Setting

The purpose of this study is to examine two different webpage designs regarding to students learning styles. A total of 44 students who enrolled college courses in graphic design, computer application and web design were selected in the study. Students in these classes had little or some knowledge of the Internet and Webpage design.

The two web designs were developed by the authors and used for the study: one-frame versus two-frame designs with the incorporation of colors, animation, buttons, and hypertexts. The one-frame design used a top-down sequential technique for web design. To begin, users must access from the main menu in order to navigate to other pages. The two-frame web design contained two displays located side-by-side. The left-frame normally contains the potential links, the right-frame displays the corresponding information. Users can make random selection of different links at any given time provided on the left-frame that served as the main menu.

Measurement and Procedures

In the beginning of the semester, the Gregorc Style Delineator [4] was administered and the scores were tallied to determine students prefer learning styles in (1) Concrete sequential; (2) Abstract sequential; (3) Concrete random; or (4) Abstract random. At the end of the semester, students were given an Uniformed Resources Links (URL) to review the two different styles of web designs as mentioned earlier. After review, an instruction was provided for the students to fill out an open-ended questionnaire to reflect their selection and to make their comments.

Selected Results:

Two-frame selection: Students preferred the two-frame design to the one-frame arrangement with a ratio of approximately 3:1. This again stressed the importance of design in CAI that emphasized gaining attention, guiding learning, informing learners of objectives, and presenting stimuli with distinctive features. The reasons why users were in favor of the two-frame design included that it was easier to navigate with left-frame controlling the right-frame. With all the links listed on one-frame and information displayed on the other, it provided a quick access to the viewer.

One-frame selection: Students who preferred the one-frame design to the two-frame one like the fact that it was easy to follow and less confusion, simple but effective. Information straight down on a page was easier to read and to understand than a two-frame design. It kept attention intact and was readily for research. Some found that it was easy to use for computer illiterate people.

Discussion

The two-frame design is a newer approach than the single frame design. Students used to the one-frame design and some still prefer the same way of accessing information, even though the two-frame design has pleasing results and is reportedly easier to use than the one-frame design. In summary, this research suggested that the major reasons why the students disliked the two-frame design were because they were simply unfamiliar with the structure. Additional training and more exposure to the two-frame design would help them overcome the barrier. As the popularity of the Internet increases and the HTML editors become easier to use, it is important to emphasize these design factors, so that the webpages can be designed more accessible and user friendlier as technology advances.

Reference

[1] Burns, P. K. & Bozeman, W. C. (1981). Computer Assisted Instruction and Mathematics Achievement: Is there a Relationship? Educational Technology, 21, 32-37.

[2] Corno, L., & Snow, R.E. (1986). Adapting teaching to individual differences among learners. In Handbook of research on teaching, 3rd ed. Ed. M.C. Wittrock, New York: Macmllan.

[3] Davidson, G., Savenye, W., & Orr, K. (1992). How do learning styles relate to performance in a computer applications course? Journal of Research on Computing in Education, 24, 348-358.

[4] Gregorc, A. (1976). Learning Styles Inventory. Storrs: University of Connecticut.

[5] Kulik, J., Bangert, R. & Williams, G. (1983). Effects of Computer-Based Teaching on Secondary Students. Journal of Educational Psychology, 75, 19-26.
[6] Pritchard, W.H. (1982). Instructional Computing 2001: A Scenario. Phi Delta Kappan. 65, 322-325

KnowDisLC: A Knowledge Distributed Web-Based Learning Community for University Students

Chi-Cheng Chang
Graduate Institute of Technological and Vocational Education
National Taipei University of Technology
No 1, Sec. 3, Chung-Hsiao E. Rd., Taipei, Taiwan 106
Fax: +886-2-27812897
E-mail: samchang@mail.tku.edu.tw

The study has constructed and evaluated a knowledge distributed web-based learning community (KnowDisLC), in hopes that it will help students form a virtual learning community through web-based learning, which they can use to facilitate learning and gowth. Ultimately they would like to accomplish the goals of knowledge sharing, resource sharing, information interchange, and emotion exchange. Both a point accumulation mechanism and a web-based learning record have been the features of the KnowDisLC system which prove to stimulate student involvement by allowing them to know about the performance and involvement of themselves and their peers. Most students agree that the community could help them learn more and faster, and most students also confirm that the overall operation and implementation of the system is generally good.

Keywords: **Learning Community, Distributed Knowledge, Web-Based Learning, Virtual Community**

1 Research Background

There are a few true web-based learning community systems whose foundation is built on a knowledge community and a learning buddy, with focus on knowledge sharing and creation, and corporate growth of community membership. However, a good deal of successful cases of web-based learning community can be are found in the USA. For example, CoVis (Learning trough Collaborative Visualization) link experts, teachers, students and field workers together to form a learning community of the visualized collaborative science learning (Pea, 1993); CSILE (Computer Supported Intentional Learning Environment) is based on a collaborative database and tries to promote student thinking and meta-cognition without emphasis on any specific field of knowledge (Scadamalia, Beriter & Lamon, 1994); The LabNet, a learning community aims at cultivating middle school teachers' academic specialties (Spitzer & Wedding, 1995); TENet (Texas Educational Network), a learning community targeting middle and elementary school teachers, as well as government officials, college professors, graduate students, and field experts involved with middle and elementary school education; Wired for Learning which helps teachers, students, parents and other members to establish a collaborative learning community (Kuang, Grueneberg & Lam, 1998); OWLink system which encourages teachers to use technology to cultivate learning ability and to form a distributed learning community (Miller, 1998); Thought system of learning the Mission to Mars, a collaborative learning experience between peers and experts (Brown & Campione, 1994).

A learning community has three features: (1) spontaneous learning and the active knowledge construction of individual learners; (2) idea sharing and information providing for all members of the learning community; and (3) distributed knowledge and expertise. Accordingly, no one will possess a special knowledge. It is distributed among different people, objects or tools. It is through interaction, discussion, communication, instruction, sharing or utilization of tools that such knowledge will be shared. When a student is faced with a specific problem, the distributed expertise that the members of the learning community possess can give him

support and aid, and the goal will be accomplished through their shared collaborative activities. The intelligence of the community members will be improved through their sharing of expertise.

Distributed intelligence, distributed knowledge and distributed expertise are similar ideas, and they are the fundamental concepts of the learning community. According to Goodyear (1995), the term of 'distributed knowledge' with two sets of connotations. One emphasizes that knowledge is distributed in a community of practice, which means an expert in one field may a novice in another. Another emphasizes that working knowledge is situated in various manners, e.g. embedded in the practice of workers; made articulate in reading, discussion, and conferences.

The CTGV team of Lin et al. (Lin & CTGV, 1996) also mentions the effective use of distributed expertise to achieve multiplicity, creativity and flexibility of learning. In this research the author has constructed a web-based knowledge distributed learning community based on the distribution, sharing and provision of knowledge. The system has been experimented on subjects of the university to evaluate its functions and effectiveness. The purpose of the research is:

1. to explore the learning concepts of a knowledge distributed web-based learning community (KnowDisLC);
2. to construct a knowledge distributed web-based learning community (KnowDisLC) and to evaluate its functions and effectiveness; and
3. to propose an environmental framework for a knowledge distributed web-based learning community (KnowDisLC).

2 Framework and Features of KnowDisLC Environment

2.1 Framework of the System Environment

The framework of the KnowDisLC system environment is shown in terms of user, system functions and database files. (see Figure 1)

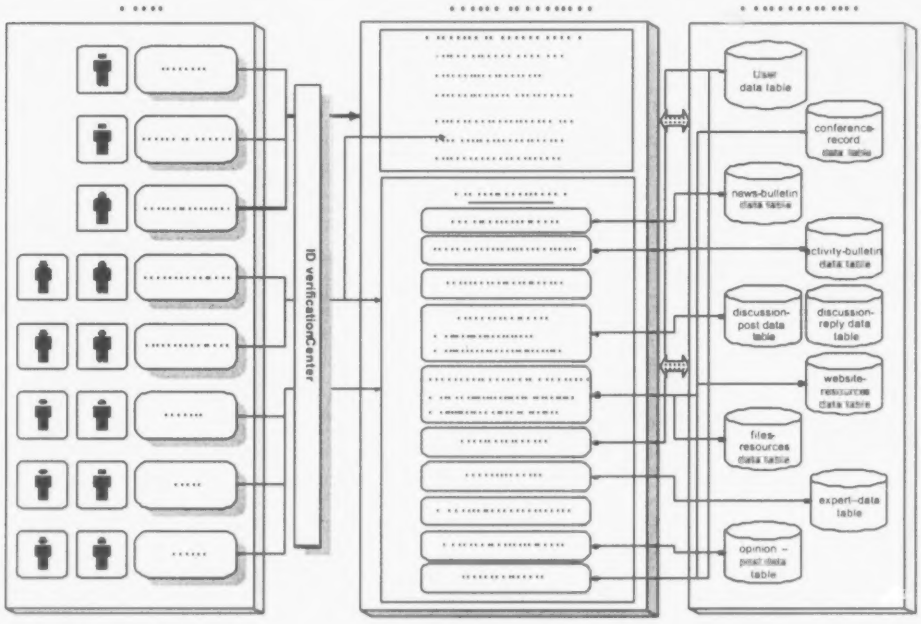


Figure 1. *Framework of the KnowDisLC system environment*

2.2 System Features

The construction of a point accumulation system of learning activity is one of the features of the KnowDisLC system (http://www.etwblc.et.tku.edu.tw) to display both the learning score and number of visits of each user. It is a reference for performance evaluation of students. To increase student motivation, the system will give users different scores according to their involvement in the web-based learning, e.g., logging on to the system (1 point a day), provision of a learning resource, provision of a file resource, provision of related sites, participation in discussion (raise questions and make replies), hosting a discussion or conference. The second feature of the KnowDisLC system is the provision of a web learning status log, including learning log statistics, conference minutes, assignment upload statistics, performance statistics of discussion or conference host, etc. so that students can know their learning status at anytime and use it as a reference for correction. The web site and file resource sharing and provision functions are based on the concepts of sharing and provision of knowledge, distributed knowledge, knowledge building, and information exchanging. This is the third feature of the KnowDisLC system. Community members can register or link to the URL address of a related learning resource site and upload or download files and materials related to course subject for the goals of collaboratively academic growth.

3 Data Bases of KnowDisLC

There are six database files in the KnowDisLC system, including ten different data tables. Here is a description of the functions and utilizations of the data tables.

User data table. User ID is the primary index key of the data table. There is no associate column. It is a record of a user's basic data and learning activity such as ID, name, log-in password, learning resources sharing record, discussion post/reply involvement record, log-in record, and accumulated point value.

Expert data table. Expert ID is the primary index key of the data table. A one-to-one association is adopted to associate the user ID in the user data table and the user ID of the expert data table. It is a record of the experts basic data, including educational background, present employment, and the expert's specialty.

Website-resources data table. Website URL address is the primary index key of the table, and there is no associate column. It is a record of the basic data of the websites shared by the community members such as site organizations, site fields, applicable users, approval status, and suppliers.

File-resources data table. Filename is the primary index key of thedata table, and there is no associate column. It is a record of the basic data of files shared by the community members such as file name, size, format, description, approval status, and suppliers.

Discussion-post data table. Discussion Issue ID is the primary index key of the data table, and there is no associate column. The data table chiefly provides a discussion board for users to post their articles. It is a record of discussion issue ID, discussion issue, and basic writer data, such as writer name, article contents, date of posting, and the total number of articles of the same issue.

Discussion-reply data table. Discussion Issue ID is the primary index key of the data table, and a one-to-multiple association is adopted to associate the discussion issue ID in the discussion- post data table with the discussion issue ID of the discussion-reply data table. The data table chiefly provides a discussion board for users to reply their ideas to discussion. It includes such items as discussion issue ID, reply ID, replier basic data, such as replier name, reply contents, and date of reply.

Opinion-post data table. Opinion ID is the primary index key of the data table, and there is no associate column. It is a record of user opinions, such as user basic data, opinion contents, and date of posting.

Activity-bulletin data table. Activity bulletin ID is the primary index key of the data table, and there is no associate column. It is a record of community learning activity bulletins, such as announcer basic data, bulletin contents, and date of bulletin.

News-bulletin data table. New bulletin ID is the primary index key of the data table, and there is no associate column. It is a record of community news, such as announcer basic data, bulletin types (system bulletin, school bulletin, curricular bulletin, information report), bulletin contents, and date of bulletin.

Conference-record data table. Conferencing minute ID is the primary index key of the table, and there is no associate column. It is a record of the online conferences of the community, including date of initiation,

date of completion, and contents of conference.

4 System Functions of KnowDisLC

The KnowDisLC System functions are as follows:

Account authority level. Account authority level is a means to classify the authority for access to the system by different users. There are 5 levels at the moment: system manager, conference host, discussion host, general user, and guest.

ID verification center. This is to verify the ID and password of users at login and registration. After registering, the system will send a letter of ID verification to the user's e-mail box; the letter will include a randomly assigned password for the user to log-in the system for the first time. The e-mail verification is to further confirm the e-mail account of the user to facilitate the delivery of mail from the system in the future.

News bulletin board. It provides dynamic up-to-date information, including a 'system bulletin', 'school bulletin', 'class bulletin', and 'information bulletin'. Bulletins that have been posted for over one week will be automatically moved to the 'old bulletin box'; users can browse old news or information there. Dynamic HTML flexible menu has been adopted in the system to avoid a problem of long screen resulting from too many sub-menus.

Online user display. A dynamic user number is displayed on the left bottom corner of the screen to enable users to know the number of visitors online, so that they won't feel lonely during their learning on web, and they can call another member of the community online.

Discussion board. This provides 'synchronous online conferencing', 'host conferencing', 'asynchronous discussion', 'online calling' and 'host list' functions. Users may partake in distance conferencing, or they may publish and discuss articles through asynchronous discussion board. In addition, the discussion board provides a conference/discussion host, system manager, online assistant and teacher with management functions. For instance, a host may use the conference-record function button for the host conference to take down all the contents of the discussion as a reference for teachers and students. A host can also announce or remove the time and topic of a web conference. The host may also modify or remove from the academic discussion all articles of an improper issue or content which have been put online.

Curricular data center. It provides online curricular outlines and multimedia presentation materials for users to online browse or download for offline reading, which can be used for preparation before class and revision after school.

Learning activity bulletin. A teacher may reveal the newest learning activities here, such as personal assignment, project-based assignment, problem-based assignment, collaborative learning, group list, examination information. The bulletin includes 'bulletin announcement' and 'bulletin browse'. The 'bulletin announcement' function is only assigned to the system manager, teacher, and online assistant); while the 'bulletin browse' function is assigned to students.

Learning resources share and provision. This is designed in stays true to the spirit of 'knowledge share and provision and distributed knowledge' to provide 'website-resources share', 'website-resources provision', 'files-resources download' and 'files-resources upload' functions. Users may enter information and URL address of related websites or link to related websites and upload or download related materials for knowledge sharing, resource sharing and information interchange.

'Website-resources share' enables users to link to related websites; websites are listed by site nature, field, user suitability, and site organizers. The function also displays the new websites provided by users within the last 1-4 weeks and 1 month. 'Website-resources provision' function enables users to enter information and URL address of websites related to respective curricula.

In the 'files-resources download', files are classified as 'descriptive documents (.doc)', 'presentations (.ppt)', 'related tools (.exe)', and 'others'. Users may download or browse these. The 'files-resources upload' function enables users to upload data files by means of a web-based FTP, so that users can exchange their data on the web for resources sharing and interchange.

User data center. The center provides ' personal data inquiry' , ' personal data edit' , ' user inquiry' and ' user data list' functions to enable a user to query and modify his own data, view the data of other users, browse the learning status of his own or other users and accumulated point record. The 'user data list' contains information such as user ID, Chinese name, nickname, log-in frequency, last-log-in date, last-log-in time, total accumulated points. This enables users to know the log-in status of other users.

Expert inquiry. There are three functional modules in this area, including 'expert list', 'expert registration', and 'management' module. The term ' Expert' refers to both ' experts' and ' little teachers' (students); users may ask them questions through e-mail. A user may become an expert or little teacher by using the expert registration function provided by the system once his log-in accumulated points have reached a certain standard and he is interested in becoming one to help other students. Users who are given system management authority (teachers, system manager, and online assistant) can remove data provided by unqualified experts.

Website resource search. The most often used and prominent search engines are provided to enable users to run a remote search by inputting key words. In addition, the function enables users to link to websites not directly related to curricula (such as libraries, related organizations and institutions, net bookstores, and other websites), so that a user may use other resources from within the system.

Opinion bulletin board. This enables users to state their own opinions and to browse the opinions of others in order to establish a humanistic virtual community. A user may choose from within a set of 16 emotional patterns provided by the system to express his feelings. The system will automatically display a week' s worth of contents on the bulletin board when a user logs in.

Point accumulation system. To encourage user involvement in learning activities, we have designed the 'point accumulation system'. When a user participates in any of the community activities, he will be given a set number of points. Furthermore, the point accumulation system will provide a reference for teachers to evaluate student involvement and to open advanced functions. (see Figure 2)

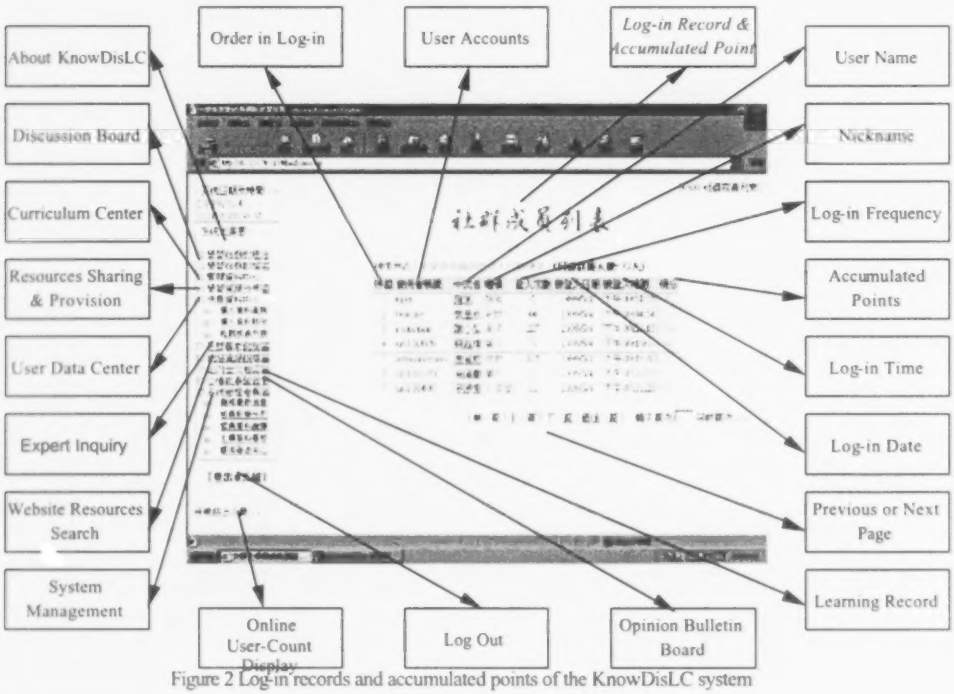


Figure 2 Log-in records and accumulated points of the KnowDisLC system

Web-based learning record. This provides information about a user's learning status on web, including 'learning record statistics', 'browse conferencing record', 'assignment upload statistics', and 'host performance' to enable students to understand their own progress, learning status, and performance by viewing other users' learning activity records and summaries. This will stimulate the visit of log-in and revision of learning. The current problem, however, is that the system is unable to detect what students are doing when they are actually on the site, including what and when they are browsing. This is what we are trying to improve the KnowDisLC at the moment.

System management. This provides online system management to teachers, online assistants and system managers, and includes 'news announcements', 'user log analysis', 'user data maintenance', 'upload data reviews', 'mail delivery center' (see Figure 7), and 'web conferencing record' functions. The system can automatically identify a user's account authority level according to his user ID, and no additional password is needed.

5 Implementation and Evaluation of KnowDisLC

5.1 Implementation

During the 3-month (mid March to mid June of 1999) implementation of the learning community, there were 96 users; this includes 32 undergraduate students taking the 'Distance Education' course, 35 undergraduate students (including in-service teachers getting on-the-job training) taking 'Computer and Instruction' course ('Distance Education' is included in the curricula), 1 professors, 1 system manager, 1 online assistant from the Department of Educational Technology of Tamkang University, 2 experts from outside of the university, 1 guest account (but 86 access frequency), and 23 users from other schools recommended by community members.

The system runs in cooperation with the classroom instruction. Students are required to visit the website and participate in the learning activities, including browsing the online materials (for preparation and revision), learning activity bulletin and news bulletin, hosting conferences and discussions every term, and participating in online synchronous conferencing and asynchronous discussions. Moreover, students are required to participate in problem-based learning, project-based learning, problem exploration and knowledge interchange in collaborative groups, for the production of mid-term examination questions, assignments, electronic presentations (e.g. Powerpoint files), and term projects, etc.

5.2 Evaluation of Functions and Effects

Its purpose is to understand the effects and pertinence of the implementation of the KnowDisLC in university education. The evaluation of the system covers user-based evaluation, expert-based evaluation, and in-depth interviews.

5.2.1 User-Based Evaluation

The evaluation is conducted through a questionnaire survey; a self-developed Likert's 5-point rating scale evaluation form has been distributed to the students. The questionnaire includes six main evaluation items, system contents, screen design, user interface, system functions, learning effects, and system uses.

Users comment on the four evaluation items, the system contents, screen design, user interface, and system functions with an average of over 4.0. With regards to the results of learning effects (see Table 1), most students consider that the KnowDisLC can help one learn more and facilitate his/her professional growth. They are more than happy to join learning activities and other learning communities of such a nature in other classes; some students, however, have had contrary opinions which reveal that the learning effects of a web-based learning should be improved more and discussed in further research.•

With regards to system use, most students approve of the overall operation and instructional application of the KnowDisLC system. The items that have received negative feedback are the less-frequently used functions such as 'expert inquiry', 'online calling', and 'online synchronous conference.' The results show that although the system functions and learning effect are generally both good, there is still room for improvement with uses, operation, implementation and management of the system functions.

Table 1 Percentages and averages of student agreement in KowDisLC impacts on learning

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible] *Opinion bulletin board* make me know the feelings of other students and achieve the goal of emotion exchange•	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Note. The numbers of 5, 4, 3, 2, 1 denote a 5-point rating scale with 5 being strongly agree and 1 being strongly disagree.

5.2.2 Expert-Based Evaluation

The evaluation was conducted by three experts with backgrounds in both education and information technology. The evaluation is aimed at the system contents, interface design, system functions, and system application. The evaluation includes two parts. One was a presentation by us on the objectives of our research and system functions of the KnowDisLC system; this presentation was complete with onsite operation afterward. Then there was an in-deep interview with the experts. For the second part, we sent the URL address of the KnowDisLC to the experts to let them use the system alone. Then they gave their opinions return by mailed back their evaluation forms in a few days.

In conclusion, the experts believe that the system functions are quite serviceable, the system architecture is pretty complete, and the menu arrangement is appropriate. It should satisfy the needs of both students and teachers. Nevertheless, the automatic management and learning management sections can both be further improved.

5.2.3 In-Depth Interviews

According to several factors such as the log-in frequency and accumulated points from the user data center and the web-based learning record and academic performance, 6 subjects were chosen by group sampling

from three different learning performance groups (3 from each) (high score group A, middle score group B and low score group C). Then an in-depth interview was conducted according to the results of the user evaluation questionnaire to understand the details of the system effects and to collect data concerning the problems, difficulties and impacts on the learning of the system from the case studies. In addition, interviews with the teacher were scheduled to better understand the learning status of the students from the viewpoint of instructor.

The results show that students who have a better performance in web-based learning (e.g. group A—more motivated in web-based learning and active in related activities) are also those who have better class performance. Similarly, students with a worse performance in web-based learning (e.g. group C—low involvement in web-based learning and related activities) are those who have a worse attitude towards learning in class. From the interviews with the 6 subjects, we discovered that students from groups A and B could make more constructive and solid suggestions, while students from group C were unable to make any clear comments on the learning community (e.g. What kind of improvements does the KnowDisLC system need? What is your strategy for using the learning community to learn?).

In general, we discovered that factors affecting willingness to get involved in the web-based learning community included self-expectation of learning, individual learning attitude and motivation, experience in computer and Internet use, individual preferences, and other personal factors.

6 Conclusions and Suggestions

The research has constructed and evaluated a distributed knowledge learning community as an aide to web-based learning, in hopes that it will help students form a virtual learning community through web-based learning, which they can use to facilitate learning and growth through the curricular data center, discussions, conferencing, learning resources sharing and to provide, expert inquiry, web resource searching, and an opinion bulletin board. Ultimately they would like to accomplish the goals of knowledge sharing, resource sharing, information interchange, and emotion exchange. Both a point accumulation mechanism and a web-based learning record have been the features of the KnowDisLC system which prove to stimulate student involvement by allowing them to know about the performance and involvement of themselves and their peers. The system has been officially implemented in a university course for 3 months, and both the implementation and operation are running smoothly. The system evaluation shows that most users are satisfied with the system contents, screen design, user interface, and system functions. Most students agree that the community could help them learn more and accelerate their professional growth, and most students also confirm that the overall operation and implementation of the system is generally good.

In the future, we will reinforce: system function expansion and maintenance; the automatic management, and the learning management in particular (such as a mechanism of learning resources establishment and management); web page browsing record and learning path management; web-based learning duration and log-out time; learning resources and website browsing time; automatic approval functions of website upload; graphic display and full text indexing of discussions board and activity bulletin; cross-disciplinary uses of the system; an online assessment (e.g. web-based portfolio), in order to optimize the system. Subsequent research will also include qualitative and quantitative experimental studies of the system application, in order to understand more about the students' learning behavior pattern and its substantial effects on the students.

References

[1] Brown, A.L. & Campione, J.C., "Guided discovery in a community of learners", K. McGilly (Ed.), Classroom lessons: Integrating cognitive theory and classroom practice, Cambridge, MA: MIT Press, pp.229-270, (1994).

[2] Goodyear, P.,."Situated action and distributed knowledge: A JITOL perspective on EPSS", Innovations in Education and Training International, Vol32, No.1, pp.45-55, (1995).

[3] Kuang, L., Grueneberg, K., & Lam, R., "Education on the net: Constructing collaborative learning communities", Proceedings of the 6th International Conference on Computers in Education (ICCE'98), Beijing, China, pp.543-545, (1998).

[4] Lin, X. & CTGV., "Instructional design and the development of learning communities", B.G. Wilson

(Ed.), Constructivist learning environments: Case studies instructional design, NJ: Educational Technology Publications, pp.203-220, (1996).

[5] Miller, L. M., "Teacher's users of an electronic environment: A case study of project OWLink", Proceedings of The 6th International Conference on Computers in Education, Beijing, China, pp.459-465, (1998).

[6] Pea, R., "The collaborative visualization project", Communications of the ACM, Vol.36, No.5, pp.60-63, (1993).

[7] Spitzer, W. & Wedding, K., "LabNet: An international electronic community for professional development". Computers and Education, Vol. 24, No.3, 247-250, (1995).

[8] TENet (Texas Education Network), URL: http: //www.tenet.edu, (1997).

Learner Control in Technology-mediated Learning within a Constructivist Model

Manuela Perez and Jun H. Jo
School of Information Technology
Faculty of Engineering and Information Technology
Griffith University, Gold Coast, QLD, Australia
PMB 50 – Gold Coast Mail Centre
QLD 9726 – Australia
Tel: + 61 7 5594 8266
Fax: + 61 7 5594 8066
E-mail: M.Perez@gu.edu.au and J.Jo@gu.edu.au

This paper explores current strategies on learner control within a technology-mediated learning environment, with a special emphasis on constructivism as the underlying learning theory. An adaptive learning model, based on constructivism is presented. The model addresses the issues of learner control and its implementation within a technology-mediated learning environment. The model's major components: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module are outlined and analysed. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible. We propose a system that is dynamic and merges the capacity to deliver educational material with the ability to analyse learners performance, based on navigational patterns and results, and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

Keywords: **Learner Control, Technology-mediated Learning, Constructivism, Technology-mediated Adaptive Learning Model.**

1 Introduction

Technology has impacted greatly on education. Since the introduction of technology, new delivery methods, as well as new challenges, have emerged. One of the most important delivery methods introduced has been flexible delivery or flexible learning as it is now preferably called. Flexible learning is learning that can be achieved at your own pace and independently of time and place. Several technology-mediated approaches, for example, Web Based Instruction (WBI) and Competency Based Instruction (CBI), have been used to provide the flexibility required to deliver flexible learning.

Technology-mediated learning is versatile. It can be used as the only means to deliver education or as an aid to traditional up-front teaching. Although technology has been embraced by education, there are areas of concern over its use, or more precisely, over its misuse. Areas of concern include: access to the medium, measurement of students learning, testing the validity of the Internet as an instructional medium and the cost of producing technology-based learning materials (Rickard, 1999; Eckert *et al.*, 1997). Selwyn (1996) points out that the Internet can become a trap for both teachers and students as it can go from the '*tool to the toy*' in education if its use is not properly guided and monitored. Phillips (1980) also expresses concern about the quality of on-line materials on the Internet. In spite of these issues the proliferation of courses designed and developed for a technology-mediated environment continues to increase.

This paper explores current trends on technology-mediated learning environments with an especial emphasis on learner control. The paper also proposes an adaptive learning model based on constructivism. The model addresses the issue of learner control and its implementation within a technology-mediated learning environment.

2 Technology and learning control

A technology-mediated environment offers the learner a number of choices and alternatives that were inconceivable in a traditional educational setting. Traditional education, both on-campus and distance learning, is highly structured, teacher centred, mostly one-way communication and directed to passive learners. In contrast, technology-mediated learning, within a constructivist approach, can be learner centred, unstructured to suit the learner's individual learning needs and context-based. It also allows the learner to take control of the learning process, promotes social discourse and collaboration and contributes to the personal growth of the learner.

2.1 Learner Control in Technology-mediated Learning

The definition of *learner control* often appears to be elusive. In its broadest sense, learner control refers to the level of self-determination that the learner has in making decisions about his/her learning (Doherty, 1998). Learner control is often being addressed in combination with other factors. For example, learner control and attitude towards the technology-based system used (Ivanoff and Clarke, 1996; Mitra, 1997) and learner control and epistemic beliefs (Jacobson, *et al.*, 1996). Learner control, within the scope of this paper, refers to the degree of autonomy that learners have in organising, pacing, sequencing and using the available learning resources. That is, the ability and power of adapting the technology-mediated environment to suit their individual specific learning needs. Control over their learning direction and pace is made possible by the many alternatives and choices that a technology-mediated learning system offers the learner (Bagui, 1998). The level of control that the learner needs to exert over the learning environment is not constant over time. Learners will engage in different levels of control depending on their individual learning style (Rasmusen and Davidson-Shivers, 1998), prior knowledge of the material or related material (Fitzgerald and Semrau, 1998), attitude towards information technology (Ivanoff and Clarke, 1996; Mitra, 1997) and past experience, initiative, intellectual and social maturity, metacognitive proficiency, and insights (Ewing *et al.*, 1998).

2.2 The role of the teacher in Technology-mediated Learning

Frank Wydra anticipated a learning environment in which the teacher's role focus changed from delivering instruction to designing the instruction (Wydra, 1980). By the hand of technology we may transform the teacher from the "*sage on stage*" to the "*guide at the side*" (Andrews, 1997). Within a technology-mediated learning environment, the educator's role, far from becoming redundant, metamorphoses into a more challenging and active one. The educator becomes the leader, designer and manager of the learning environment (Doherty, 1998). Other vital functions are initiating the learning process; supporting, encouraging and motivating the learner and mediating between the learner, the technology and the resources (*Ewing et al., 1998*).

The new role of the teacher, in technology-mediated learning, is a very demanding one. *Ewing et al.*, (1998) emphasise the great deal of effort that goes into planning and preparing technology-mediated learning materials and environments. The design and development of multimedia teaching material, especially for distance education, is a time-consuming process. For one hour of CBT software approximately 200 hours of development time are required (Kawalek, 1995). The educator's role does not stop after the planning, designing and preparation of the technology-based materials. It must also facilitate the learning, monitor learners' progress and evaluate the performance of the system, the learners' and his/her own in order to further improve the system. "*The need for the teacher does not go away*" in a technology-mediated environment with emphasis on learner control (Andrews, 1997).

3 Constructivism

The introduction of technology-mediated learning has called for a revision of learning strategies.

Constructivism is gaining momentum and has been heralded as the most appropriate learning theory for the technological classroom. Constructivism was introduced by Piaget's and Vygotsky's learning theories. Piaget's learning theory involves two cognitive stages: assimilation and accommodation (West *et al.*, 1991). During the assimilation stage the learner attempts to fit the environment with existing mental schemata. The accommodation stage is reached when the learner is confronted with a new experience, for which no schemata exists, or one exists but does not conform to the new experience. As a result, equilibrium occurs when, through an alternate process of assimilation and accommodation, the learner achieves cognitive stability. Externally in-coming experiences find a corresponding mental schemata and the learner is aware of this fact. In order to achieve high-level cognition the learner must be aware that learning has indeed occurred. Otherwise, learning will stop at the behaviourist level where it is ascertained by an external party, usually the teacher, or in the case of a technology-mediated environment by a computer program.

Vygotsky's learning theory differs from Piaget's in that he sees learning taking place within a social and cultural context. He argues that social interaction affects the way the learner sees the world. That is, it contributes to the way the learner constructs his/her schemata. Therefore, the quality of the learning will be determined by the quality of the social interactions or what Vygotsky terms *zone of proximal development* (Oliver, *et al.*, 1997).

In a learning environment the cultural and social interactions translate to interactions between teachers and peers. Within this collaborative learning environment the teacher becomes the facilitator of learning. The facilitator's role should be to design, promote and guide the learning but not to enforce it as learning is an individual process. Knowledge in this environment is socially constructed and has no absolute value but a socially agreed value.

4 The proposed learning model

The aim of the proposed model is to offer an adaptive learning system that caters for different types of learners and learning styles with an especial emphasis on learner control. The proposed model operates within a constructivist approach to learning (Ewing, *et al.*,) based on the following points:

1. **All learners are different**
2. **Learning is individual to each learner**
3. **A learner can learn at different speed levels in different situations**
4. **A learner can engage in different learning strategies simultaneously**
5. **Learners learn best with a context**
6. **Learners construct and re-construct knowledge as they seek to understand and explain their environment**

4.1 Proposed model learning variables and controls

The concepts of learner individuality and learner control are essential to constructivism. Table 1 below depicts the main variables involved in the proposed model in relation to learning control and learners' choices and options.

VARIABLES	CONTROLS	
	INSTRUCTOR	LEARNER
Learning Objectives	Overall	
Amount of information provided	Overall	
Amount of information used **Addition/removal of material**		Desirable
Material appearance and mode		Desirable
Pacing, time	(When necessary)	Desirable
Sequencing	(When necessary)	Desirable
Place, location		Desirable
Monitoring learners' individual progress	Overall	
Interaction and collaboration	Shared	Shared
Assessment	Overall	

Table 1. Control Variables and Controllers

The term ***desirable***, rather than ***overall***, is used in the learner control column because the proposed model's aim is to empower learners not to force them to take control. For example, a learner that possesses prior knowledge of a topic is more likely to exercise control over his/her learning than a novice learner is. The second is more likely to follow a linear approach to learning until he/she too acquires prior knowledge.

Learning objectives
Learning objectives within the model are explicit, clearly specified and achievable. The acquisition of non-anticipated learning objectives is possible within the system, especially, when the learner accesses more information that is required to complete a task. This is a positive feature of the model as far as the specified learning objectives have been reached.

Amount of information provided and used
The system contains all the information necessary to achieve the specified learning objectives or provides references to acquire it. However, the learner controls the amount of information that is actually used. A learner can discard a particular learning material piece in favour of another, which has been acquired from external sources, just because is easier to understand or is visually more appealing. Learners' performance can be improved by designing materials that can be adapted to satisfy different learning styles (Rasmussen and Davidson-Shivers, 1998).

Learning material appearance and mode
A genuinely adaptive technology-mediated learning system must allow learners to customise the appearance and mode of the material displayed. This may include: changing background and text colours and choosing between text, graphics, audio and video modes.

Pacing and timing
The learner has the autonomy of pacing his/her learning and scheduling his/her study time. However, in some instances this has to fit within the general time-frame allocated to the course or subject. The designer controls the general time-frame, if one exists.

Sequencing
Learning materials must be accessed in the order that most benefits the learners' learning style. The model is able to cope with the demands of linear as well as non-linear approaches to learning. Figure 1 displays an example of the progression or navigation path of a learner who prefers to be guided by the system. '*Learner 1*' uses all the material provided and in the order provided until she encounters difficulties and seeks the help of an instructor or other learners. Then, revises the previous lesson and again continues with the linear path provided. In contrast, '*Learner 2*' feels confident enough to discard material provided and adds material from external sources. Both learners achieve the corresponding learning objectives through the use of different learning strategies. Beginners often benefit from having a structured learning path (Eaton, 1996). A graphical representation or map of the entire unit or lesson must be made available to the learners to guide their navigation decisions (Barba, 1993).

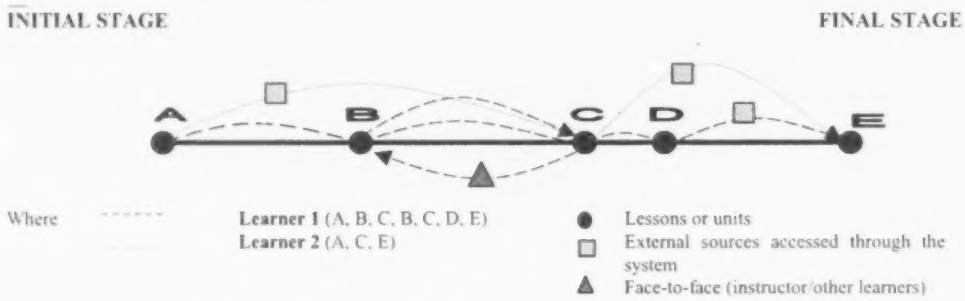


Figure 1. Learning Sequence Patterns – Linear and Non-linear

Learners must be free to use forward and backward navigation through the system as long as it does not compromise the learning itself. For example, if the completion of a task is the pre-requisite for another,

allowing the learner to move onto a task for which a pre-requisite has not been completed might result in a waste of time and unnecessary added frustration for the learner. For example, moving into algebra without knowing how to multiply.

Place and location
Technology-mediated learning offers the possibility of accessing and using learning materials at different locations. Using the proposed model, learners can now study at home, at appropriately equipped learning centres or at traditional classrooms.

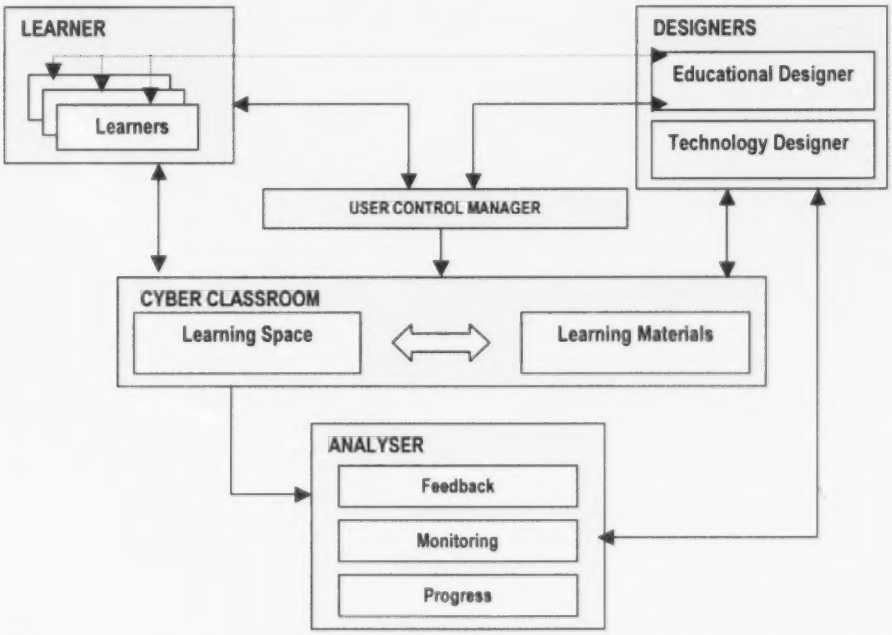
Monitoring learners' individual progress
Instructors are in control of monitoring the learners' individual progress. Based on the analysis of the learners' performance instructors can either guide or advise the learners through different strategies or modify the system.

Interaction and collaboration
The system must provide the capabilities to allow learners to interact with each other and with their instructors. This communication may occur, for example, through e-mail, and on-line forums. Physical, or face-to-face, communication is also a part of the model.

Assessment
Assessment is designed and administered by the instructor. This is to evaluate the students' learning performance and to provide feedback both to the educator and to the students.

4.2 Technology-mediated Adaptive Learning Model

The proposed model, the Technology-mediated Adaptive Learning (TAL) model, is composed of five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and Analyser module, Figure 2.



Where → Technology-mediated communication (web browsing, down/uploading, email, forum, database updates, ...)
→ Physical communication

Figure 2. The Technology-mediated Adaptive Learning (TAL) Model

4.2.1 Learner Module

The learner module comprises the learner group. Learners interact with the TAL system through the Learning Space. Communication with instructors and other learners occurs within the Learning Space or physically, as indicated by the dotted line in Figure 2.

4.2.2 Designers Module

The designers' module can be composed of an educator, instructional designer, multimedia designer and technicians. This module is concerned with three main areas: the educational design, multimedia design, and computer and Internet technology. The educational designer is in charge of designing quality learning materials within a constructivist approach. This includes being aware of the subject matter as well as the pedagogical theory in use. The multimedia designer and the instructional designer help the educator to appropriately formulate the teaching materials for CBI or WBI. The technology designer provides the means to make the learning materials available to the learner group through a technology-mediated environment. Good skills and tools for multimedia authoring and technical services are required in this module, which may cause production cost issues.

4.2.3 User Control Manager Module

The User Control Manager allows the learner to customise the learning space. Through this module the learner can select the display mode to suit his/her own learning needs and preferences, for example, text, graphics, audio or video mode. Pacing and sequencing of the learning material can also be controlled from this module.

4.2.4 Cyber Classroom Module

The Cyber Classroom module is composed of two sub-modules: Learning Space and Learning Materials module. The Learning Space is where the learning is delivered. This is generally a kind of display unit, such as a personal computer or a network terminal screen. It may also include equipment for sound and video. It must be easy to interact with and be self-explanatory. Within the Learning Space the learner has the option of accessing learning materials provided by the educator, such as lecture notes, or external resources such as Internet sites or libraries

4.2.5 Analyser Module

The purpose of the analyser module is three-fold. First, it gathers statistics on the performance and progress of learners. Second, it records learners' perceptions about the learning material presented and about the overall working of the system (learner feedback). Finally, it monitors and records students' navigation patterns into a database. These will provide an indication of the learners' preferred learning styles. This information can be used to provide advice for the learner and to improve the system (Chavero *et al.*, 1998) by evaluating the existing materials and options and formulating new ones. The optimal implementation of the system will be to incorporate an Intelligence module to automatically generate and administer changes, based on the information within the database.

The TAL model is being implemented in a couple of different programming languages and database tools.

5 Reviewing learner control, constructivism and the TAL model

5.1 The TAL Model and Learner Control

The main objective of the model is to provide a technology-mediated learning system able to support learner control within a constructivist approach. The learner control variables, identified in Table 1, have been built into the model. Learning objectives, amount of information provided, monitoring of learners individual progress and assessment are overall controlled by the instructor, while the amount of information used/added/removed, material appearance and mode, pacing, timing, sequencing, place and location are potentially controlled by the learners. Interaction and collaboration can be initiated by either party as the need arises.

5.2 The TAL model and Constructivism

The underlying pedagogical theory governing the TAL model is based on constructivism, and specifically on the constructivist elements represented in the table below. The model addresses all elements, however, its concrete effectiveness will only be determined after development and implementation, in practice.

TAL Constructivist Approach Checklist	
EXPECTED CONSTRUCTIVIST ELEMENTS	**TAL MODEL**
• All learners are different	The model allows for learner differences in needs, learning styles, and skills.
• Learning is individual to each learner	Learners can customise the learning materials to suit their learning styles and needs through the User Control Module.
• A learner can learn at different speed levels in different situations	Learners can control pacing and sequencing of learning materials.
• A learner can engage in different learning strategies simultaneously	Learners can engage in linear and non-linear strategies. Also they can learn independently and/or seek collaboration.
• Learners learn best within a context.	Learning materials (provided by the TAL model) are always presented within a context.
• Learners construct and re-construct knowledge as they seek to understand and explain their environments	This feature is intended within the model but only after implementation will it be ascertained.

Table 2. TAL Constructivist Approach Checklist

6 Conclusion

This paper has addressed current educational trends on learner control within technology-mediated learning environments. The roles of the learner and the teacher have been reviewed and analysed in the light of technology-mediated environments.

The TAL model, based on constructivism, was presented, and its major functions were explained. The model includes five modules: Learner module, Designers module, User Control Manager module, Cyber Classroom module and the Analyser module. The aim of the model is to offer an adaptive learning system that caters for different types of learners and learning styles, with an especial emphasis on learner control. The model presented, empowers the learners and provides them with the means for constructing and re-constructing knowledge at their own pace within a constructivist framework that is learner centred and flexible.

From the designers point of view the model is a dynamic system that merges the capacity to deliver educational material with the ability to analyse learners performance (based on navigational patters and results) and system performance in order to either advise and guide the learner or to modify learning materials or their presentation.

References

[1] Andrews, E.A., A non-euclidean view of teaching, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[2] Bagui, S., Reasons for increased learning using multimedia, *Journal of Educational Multimedia and Hypermedia*, **7**(1), 3-18, (1998).

[3] Barba, R.H., The effects of embedding an instructional map in hypermedia courseware, *Journal of Research in Computing and Education*. **25** (4), 405-412, (1993).

[4] Chavero, J., Carrasco, J., Rossell M.A. and Vega, J.M., A graphical tool for analysing navigation through educational hypermedia, *Journal of Educational Multimedia and Hypermedia*, **7**(1), 33-49, (1998) .

[5] Doherty, P.B., Learner control in asynchronous learning environments, *ALN Magazine*, **2**(2), (1998). URL:http://www.aln.org/alnweb/magazine/vol2_issue2/doherty.htm.

[6] Eaton. M., Interactive features for HTML-based tutorials in distance learning programs, *AusWeb96*, (1996). URL:http://elmo.scu.edu.au/sponsored/ausweb96/educn/eaton/paper.html

[7] Eckert, A., Geyer, W. and Effeldberg, W., A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[8] Ewing, J.M., Dowling, J.D. and Coutts, N., Learning using the World Wide Web: A collaborative learning event, *Journal of Educational Hypermedia*, **8**(1), 3-22, (1998).

[9] Fitzgerald, G.E. and Semrau, L.P., The effects of learner differences on usage patterns and learning outcomes with hypermedia case studies, *Journal of Educational Multimedia and Hypermedia*, **7**(1), (1998).

[10] Ivanoff, G. and Clarke, J., The use of the world wide web for teaching: things to consider before putting materials on-line, *Australian Communication Conference: Teaching Communications Skills in a Technological Era*, Monash University, Australia, (1996).

[11] Jaconson, M.J., Maouri, C., Mishra, P. and Kolar, C., Learning with hypertext learning environments: theory, design and research, *Journal of Educational Multimedia and Hypermedia*, 5(3/4), 239-281, (1996).

[12] Kawalek, J., in (Eckert, A., Geyer, W. and Effeldberg, W. (1997). A distance learning system for higher education based on telecommunications and multimedia: A compound organisational, pedagogical, and technical approach, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada), (1995).

[13] Mitra, A., Categories of computer use and their relation with attitude toward computers, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Alberta, Canada, June, (1997).

[14] Oliver, R. and Omari, A. and Herrington, J., Exploring student interactions in collaborative world wide web learning environments, *Proceedings of ED-MEDIA 97 & ED-TELECOM 97*, Canada, (1997).

[15] Phillips, R., What research says about learning on the Internet, *in* C. McBeath, C. McCoughlin and R. Atkinson (*eds.*), *Planning for Progress, Partnership and Profit, Proceedings EdTech '98*, Australian Society for Educational Technology, Perth, (1998).
URL:*http://cleo.murdoch.edu.au/gen/aset/confs/edtech98/pubs/articles/p/phillips.html*.

[16] Rasmusen, K.L. and Davidson-Shivers, G.V., Hypermedia and learning styles: can performance be influenced? *Journal of Educational Multimedia and Hypermedia*, 7(4), 291-308, (1998).

[17] Rickard, W., Technology, education, and the changing nature of resistance, *EDUCAUSE, Educom Review*, Vol. 34 (1), 42-45, USA, (1999).

[18] Selwyn, N., The Internet and schools: An uneasy alliance? *Compute-Ed*, Vol 4, (1998).
URL: *http://www.edication.uts.edu.au/projects/comped/Vol4/selwyn.html*.

[19] West, C. K., Farmer, J.A. and Woiff, P.M., Introduction to Cognitive Science and instructional design, *Instructional design: implications from a Cognitive Science*, pp.3-27, Allyn and Bacon, Sydney, (1991).

[20] Wydra, F.T., Learner controlled instruction, *Englewood Cliffs, Educational Technology Publications*, New Jersey, (1980).

LEARNERS' STRUCTURAL KNOWLEDGE AND PERCEIVED DISORIENTATION IN A HYPERMEDIA ENVIRONMENT: THE EFFECTS OF INFORMATION CONVEYING APPROACHES AND COGNITIVE STYLES

Jim Jiunde Lee
Department of Mass Communication, Chinese Culture University, Taiwan
jiulee@giga.net.com

The flexible nature of hypermedia allows it to be tailored to an individual's needs. Despite the many degrees of navigational freedom, however, users of hypermedia often find difficulty locating information, feel disoriented, or even become "lost in hyperspace" within such large seas of data. Research findings suggest that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. How a learner can acquire correct structural knowledge of the information becomes an important issue to affect their learning performance in a hypermedia environment. Variables such as the different ways of structuring or conveying information and cognitive styles may affect learners' cognitive abilities in knowledge structuring and should be taken into account together. The results of this study will show whether the interactions between information conveying approaches and learners' cognitive styles have significant effects on learners' performances in terms of structural knowledge and feeling of disorientation.

Keywords: **Structural knowledge, Cognitive style, Concept map, Disorientation, Hypermedia**

1 Introduction

One of the recent developments in computer technology now applied in many educational institutions is the technology of hypermedia (Liu & Reed, 1994; Paolucci, 1998), in which users can access specific information by various paths. The flexible nature of hypermedia allows it to be tailored to an individual's needs. Reading in hypermedia allows more andom access and offers overt ways of accessing (Tierney, 1994). However, users of hypermedia often experience difficulty locating information, feel disoriented, or even become "lost in hyperspace" (Elm & Woods, 1985) within such large seas of data. Scholars (Beasley & Waugh, 1995) have suggested that the disorientation problem could be solved if users are able to hold a conceptual overview of the hypermedia structure. In other words, if users can substantially construct a structural knowledge (Jonassen, Beissner, & Yacci, 1993) of the information provided in the hypermedia system, their learning performance could be improved.

Ways to structure or convey information in the physical sense should not be the only concern when the instructortry to facilitate the formation of the learner's structural knowledge. Factors such as learners' characteristics that could affect their cognitive abilities in knowledge structuring should also be taken into account. Few studies have been conducted in this domain. The purpose of this study is to investigate

learners' cognitive characteristics in the dimension of cognitive styles and their effects on the acquisition of structural knowledge through the application of different information conveying approaches: the Less Explicit approach and the More Explicit approach.

2 Background of The Study

Learning is a process of reorganization of knowledge structure. Based on the concept of meaningful learning (Ausubel, 1963), in one way, learners structure knowledge to serve as a framework that helps them to associate new information with previous knowledge. As this framework becomes more complex, learners may in turn rely on this conceptual structure to filter the important from the irrelevant points (Anderson, Reynold, Schallert, & Goetz, 1977). The acquisition of correct structural knowledge has become a critical issue in learning. Among other computer technologies, hypermedia is a potential tool to mediate the structural knowledge of the target domain to learners. One of the current theories about mind structure, the "mind as rhizome" (MAR) metaphor (Eco, U., 1984), hypothesizes that the human mind is organized like an underground rhizome. Hypermedia tangibly simulates the learning assumptions of this mind metaphor in that learners can filter, link and search for new or existing information. These features have made hypermedia an ideal environment where experts' knowledge structures are made visible and navigable for learners in a graphical or a textual form (Wilson & Jonassen, 1989). Compared with novice users of a subject domain, expert users in this domain are believed to possess a better knowledge structure that enables them to effectively solve problems. The learning strategy of externalizing experts' knowledge structures to provide "idiosyncratic" intellectual thinking (Schwen, Goodrum, & Dorsey, 1993) has been deemed a pragmatic way to empower learners.

In comparing hypermedia with linear text in book-bound printed material, Conklin (1987) noted that any piece of text that the user wishes to locate in a book can only be further forward or further back from where the user is currently located. Hypermedia, on the other hand, is often designed to store or to locate information in a non-linear manner. Instead of a long run of narrative text on sequentially numbered pages, hypermedia is typically organized into small segments of text and learners control the reading flow of the materials (Berk & Devlin, 1991). Regardless of claims about the benefits of using hypermedia, however, Charney (1987) and Dias & Sousa (1997) pointed out that the ordering of topics and points as well as various traditional orientating devices, such as overviews and summaries which are usually taken for granted in books and papers, are non-existent in hypermedia. Without such orientating devices or narrative cues, and lacking the knowledge of hypermedia structure, users can barely determine where they are, what they want, and how to get there (Beasley, 1994; Tripp & Roby, 1990). These issues raise a number of questions. Is knowledge of the material's structure as important as scholars suggest? Can one attempt to represent the structure of a document cognitively, and if so, what form might it take?

3 Theoretical Framework

Learning in Hypermedia

Hypermedia is a developing concept that perhaps first originated with Bush (1945), who envisioned a text that was organized like the human mind. Unlike a traditional learning environment, hypermedia mainly relies on self-directed learning. With this system, the responsibility for identifying what is useful information and the selection of search strategies for locating that information are largely left to the user (Small & Grabowski, 1992). Instead of having an instructional-base, like conventional Computer-Based Instruction (CAI), the format of hypermedia is information-based. CAI materials normally include objectives, presentation of information, and drill-and-test activities (Gange, 1976). These materials lead users to engage in intentional learning, in which all learning activities are arranged to accomplish the pre-determined learning goal.

Conversely, the learning that occurs in hypermedia is a type of incidental learning: the instructional content is provided without a specific learning goal (Spiro & Jehng, 1990). Learners in a hypermedia environment are encouraged to interact with and explore the information by developing their own paths or knowledge structures.

Although hypermedia has had remarkable impacts (Jonassen & Grabinger, 1990; Mcaleese, 1991) on human

learning modes, accessing immense amounts of information within a hypermedia system is often not an easy task, especially for novices. As Hammond and Allinson (1989) indicated, people may encounter a number of common problems when they use hypermedia. They may have difficulty using interface tools in order to gain an overview and to locate specific information; they are also likely to wander without a strategy or goal and finally get lost. It is necessary that we investigate what types of cognitive characteristics might affect learners' performances involved in hypermedia learning and how hypermedia can thus be customized to fulfill learners' cognitive needs.

Hypermedia and Cognitive Styles

Hypermedia appears to be an ill-structured and non-linear type of conceptual networking environment. It seems to avoid prescribing a particular path for navigating information. Such a structure could be questionable for a learner who is in need of guiding pathways. A learner's performance in hypermedia may be affected by his / her individual cognitive style. Many variables, such as age, motivation, cognitive style, and prior knowledge / experience with the system (Heller, 1990; Lai, 1994; McAleese, 1989; Paolucci, 1998; Rhee, 1993) have been proven to be influential factors in the user's performance. Some of these studies were conducted in a conventional computer-based instruction environment. In those that were conducted in a hypermedia environment, cognitive style was found to be an essential factor in learning (Chang, 1995). Research findings support this notion that individual cognitive differences affect learning results among adults (Davidson, Savenye, & Orr, 1992; James & Blank, 1991). Understanding these differences can help instructors cope with the variations in performance exhibited by their students (Moore, 1994).

Cognitive style refers to a learner's information processing habits, this being manifestly reflected in his / her perceptual ability and in personality as well (Greco & McClung, 1979; Witkin, et al., 1977). It is "a superordinate construct involved in many cognitive operations that accounts for individual differences in a variety of cognitive, perceptual, and personality variables" (Vernon, 1973, p.141). There are no good or bad cognitive styles. They could only to be described as effective or ineffective in terms of their influence on a specific task (Strother, 1982). Studies on cognitive styles initially stemmed from the field of individual differences. These issues were extensively studied during the 1960s and remained popular in the early 1970s, but have since tended to fade out. As Riding and Cheema (1991) stated, this decline left the whole field of exploration fragmented and incomplete. In spite of their attracting little interest in the last two decades, cognitive styles are now once again being considered more seriously by scholars due to the coming of hypermedia technology.

In this research proposal, cognitive style will be examined in the two dimension of Wholist / Analytic and Verbal / Imagery. After reviewing work on the cognitive style study, Riding and Banner (1986) found that there was an interaction effect between Field-dependence / independence style and verbal / imagery style on the learner's performance. Riding and David (1991) concluded that the Group Embedded Figures Test (GEFT)(Witkin, 1962) that has frequently been used to identify Field-dependence / independence style has limitations. In order to overcome some weaknesses of the traditional method for assessing Field dependence / independence like GEFT (e.g. Witkin, 1962), the Cognitive Styles Analysis (Riding, 1991) was developed. This approach classifies learners' cognitive behaviors into four different categories: Wholist-Verbaliser, Wholist-Imager, Analytic-Verbaliser, and Analytic-Imager. In this classification, Riding felt that for educational and training purposes it is more meaningful to term Field-dependent as Wholist and Field-independent as Analytic. The Wholist trainee tends to view the information in whole and the Analytic trainee tends to separate out the individual parts of information. Riding method differs from GEFT in four significant ways. First, it positively measures the wholist tendency and does not simply assume that if a person does poorly on a disembedding task that they are Field-dependents. This overcomes a major objection to the notion of Field-independence being a learning style raised by those who have argued that since generally Field-independents are superior to Field-dependents, it is simply a correlate of intelligence or general ability. Secondly, it compares a person's relative performance on the to halves of the continuum. Thirdly, by using computer presentation, it allows more sensitive timing of the task. And finally, Riding's Cognitive Styles Analysis refines the GEFT method and incorporates the assessment of the second fundamental dimension: Verbal-Imagery cognitive style. The Wholist-Analytic (Field-dependence-independence) / Verbal-Imagery classification is considered to be particularly valuable when it is used to examine different learners' behaviors in a non-linear environment such as hypermedia (Roberston, 1982; Riding, 1997). These two dimensions of cognitive styles that reflect on learning involve the various cognitive restructuring skills and analyzing ability for incoming information that are especially demanded in an ill-structured environment such as hypermedia. It is likely that the best performance on learning task comes from combinations of these two style dimension that offer the greatest strengths, namely Wholist-

Verbalist learners and Analytic-Imager learners, whereas Wholist-Imager learners and Analytic-Verbalist learners are less complementary and might result inferior performances.

Hypermedia and Structure Knowledge

According to Conklin (1987), disorientation is one of major problems for hypermedia systems. Elm and Woods view this "disorientation" in terms of degradation rather than as a subjective feeling of being "lost". One of the assumptions in their 1985 study about users' performance is that users might attempt to create a comprehensive cognitive map of the knowledge domain. The problematic issue of getting lost in a display network is caused by the user lacking a clear conception of the relationships within the system, or as Jonassen, Beissner, & Yacci (1993) call it, *Structural knowledge*. Structural knowledge is a memory / cognitive structure, a collection of bits of information and relationships among concepts. It could also be termed the internal structure (Korthauer, R. D & Koubek, R. J., 1994), which refers to the knowledge structure of users who are experienced in the domain, and to a type of mental model that users must create and bring to bear as they work in an electronic information space (diSessa, 1986; Gentner & Stevens, 1983; Russell, 1986). The acquisition of structural knowledge, according to Ausubel (1963), involves the linking of new information to existing information, which results in a dynamic framework of knowledge. That is, through the information processing procedure, learners experience new information and refine or reconstruct their knowledge frameworks as needed.

In hypermedia, there are two approaches to help learners construct their structural knowledge (Korthauer, R. D. & Koubek, R. J., 1994). The first is the use of *hyperlink approach*. Hyperlink approach is designed according to the intrinsic attributes of the information; the designer finds the best way to organize it so that the information structure is salient to the user (Gordon & Gill, 1993). This approach could commonly be seen as the underlying organization embedded in the hypermedia database, such as the hierarchical, associative, and networking structures. The second is the use of *navigational aid approach*, which is usually based on the hyperlink approach but graphically represents hyperlinks (such as the concept map) to make the information hierarchy more explicit for learners (Nelson, 1990). It is thought that instead of relying on hyperlink approach, as experienced users do, novice users may rely more upon the navigational aid approach, as they have no knowledge structure of their own (Korthauer, R. D. & Koubek, R. J., 1994). In addition to the external factor, like the hyperlink and navigational aid approaches, learners' cognitive styles are the internal factor suspected to particularly affect novice users, by affecting the degree to which they can draw out the embedded structure of the hypermedia document.

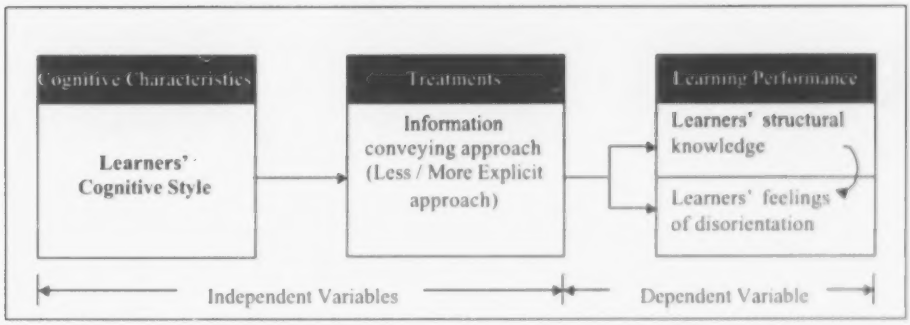
As Mandler (1983) indicated, "Meaning does not exist until some structure, or organization, is achieved" (p4). For designers and instructors, it would seem wise, then, to balance structural knowledge acquisition and the knowledge that users expect to learn in their consideration of learning results. Mental constructs could not be formed without structure. Learners might be able to remember each single object without structural knowledge, but they could not relate these isolated ideas to each other to form abstract knowledge, or even translate them into procedure knowledge (Jonassen, Be issner, & Yacci, 1993). It is important that the learner first develop an accurate structural knowledge of the knowledge domain being studied. Once the learner has a grasp of the bigger picture, he / she will be released from the burden of trying to organize the structure of the information while he / she is also required to study the content at the same time.

4 Methodology

Independent Variables

There are two independent variables in this study. First are the two types of information conveying approaches which mediate the hypermedia-based instruction. The second independent variable is the learner's cognitive style which is identified by a standard test. Figure 1 outlines a conceptual model for the variables of this study.

Figure 1. The conceptual model of variables for this study



Information Conveying Approach

In this study, there are two types of information conveying approaches:

1. The Less Explicit (LE) approach: the instructional material with the hierarchical-associative hyperlink

The More Explicit (ME) approach: the instructional material with an interactive concept map

Cognitive Style

The second independent variable is the learner' s cognitive style in the combination of the dimension of Wholist-Analytic and the dimension of Verbal-imagery.

1. Wholist-Verbaliser
2. Wholist-Imager
3. Analytic-Verbaliser
4. Analytic-Imager

A subject's particular style is determined by the subject's score on the Riding' s Cogntive Style Analysis (Riding, 1991).

Dependent variables

There are two types of dependent variables in this study: learners' structural knowledge and learners' feelings of disorientation.

Structural knowledge

Structural knowledge is defined here as the compilation stage of a knowledge development theory (Anderson, 1982, 1987, & 1990). It is a transition knowledge that helps learners to associate their declarative knowledge with their procedural knowledge (Jonassen, Beissner, Yacci, 1993). It represents the interrelationships between concepts that the learner forms in his or her memory.

Feeling of Disorientation

The second dependent variable in this study is a learner' s feeling of disorientation which results from his / her use of different types of information conveying approaches.

Subjects

The researcher plans to collect a total of one hundred twenty subjects participating in this study. All of the subjects will be current students enrolled in Indiana University at Bloomington (IUB). Subjects' ages range from 19 to 45, and they have various majors in the School of Education in IUB. Before this experiment, a Human Subject Form shell be completed by each subject and has been approved by the University Committee for the Protection of Human Subjects.

A two-stage filtering procedure will be administered to identify the most appropriate subjects for this study.

In the first stage of the filtering procedure, subjects will be recruited by means of an Email flyer. Experienced subjects will be excluded according to their replies on the computer background questions sent together with the E-mail flyer. The remaining respondents will receive a confirmation message from the researcher to thank them for their participation and to set up a possible time with them to come for this study. The subject filtering procedure moves to the second stage.

In the second stage of the subject filtering procedure, Riding's Cognitive Styles Analysis (Riding, 1991) will be administered to all remaining students to determine their cognitive styles: Wholist- Imager, Analytic-Imager, Wholist-Verbaliser, or Analytic-Verbaliser. This computer-based test will give measure of a subject's position on both the Wholist / Analytic and Verbal / Imagery cognitive style dimensions.

Instructional Materials

Content

The topic of this web-based instruction – "Building a Homepage", was about building a personal homepage in the IUB domain. The categories of "Building a Homepage" were adopted from the "IU Webmaster" web site (http://www.indiana.edu/~wmhome/), which is maintained by the University Information Technology Service (UITS). This web site provides information for those who wish to build or maintain a web page by themselves.

Interface layout

Two different versions of hypermedia-based instructions were developed in this study: the instruction lesson using the Less Explicit approach (hierarchical-associative hyperlink) and the lesson using the More Explicit approach (concept map). Both versions contain the same instructional content but convey it through different interface layouts. The interfaces were functionally equivalent in terms of the amount of content available in each node, and both allowed access to top-level pages at all times. Therefore, one design was not viewed by the researcher as less functional than another. These two types of hypermedia-based instructions could be accessed through using Web browsers like Netscape Navigator or Internet Explorer. Additionally, in order to control the learning environment and also to remove unpredictable factors that might affect learning, the browser's (Internet Explorer) toolbar and address bar were removed and did not appear in either approach. This was viewed as necessary in order to attempt to isolate any learning effects that may have resulted from use of the "Back" function (Boling et al., 1996).

Experiment Procedure

Upon the completion of the two-stage filtering procedure, the selected subjects will be informed of the time and the place for this experiment by E-mail. Before the study, subjects are randomly assigned into two groups – the group using the Less Explicit approach and the group using More Explicit approach. Only one group is measured at each time. In this experiment, subjects will be required to study a hypermedia-based instruction lesson. The content of this lesson is designed to help subjects acquire the knowledge to build homepages in the IUB domain. In the beginning of this experiment, subjects will be given five minutes to practice and master the tutorial web page that had been loaded on their screens. After this five minute tutorial session, subjects are required to spend at least fifty minutes (or even longer time, depending on their wishes) to read through the "Building a Homepage" web site.

When subjects complete the self-directed study, they will be required to complete a three-part post-test and a disorientation questionnaire in order to measure their structural knowledge and perceived disorientation. Subjects have a total of twenty-five minutes to finish the post-test and the questionnaire and return them together with the signed consent form to the researcher.

5 Conclusions

This study attempts to make a contribution to our understanding of how learners' cognitive attributes affect their learning performances while using hypermedia. The study results should provide some useful design concepts for hypermedia development, especially when a hypermedia material is designed for novice learners.

Learning functions play a central role in theories regarding the regulation of learning processes (Vermunt, 1989). However, the question of how students carry out these functions in a hypermedia context, or the way in which this execution is regulated by internal and external factors has largely gone unproved (Burton, Moore, & Holmes, 1995). It is worthwhile to explore whether the hyperlink or the concept map is better for different cognitive-styled learners in the acquisition of structural knowledge. As structural knowledge has been proven to be a crucial predictor of problem solving skills (Chi & Glaser, 1985; Gordon & Gill, 1989; Robertson, 1990), the information regarding whether supplied models are useful and for what kinds of users is also important for hypermedia developers.

In addition, it is hypothesized that users could overcome the disorientation problem if they could acquire a more correct structural knowledge of the knowledge domain. The findings of this study may result in insight and shed light on the importance of acquiring structural knowledge as a learning goal. Hypermedia developers may accordingly develop guidelines for designing interfaces that help users to access information and which will accommodate their needs while preserving the quality of independent learning. This should improve the effectiveness of their designs.

References

Anderson, R. C., Reynolds, R. E., Schallert, D. L. and Goetz, E. T. Frameworks for comprehending discourse. American Educational research Journal, 14(4), pp. 367-381, (1977).

Anderson, J. R. Acquisition of cognitive skill. Psychological Review, 89, pp. 369-406, (1982).

Anderson, J. R., Skill acquisition: Compilation of weak-method problem solutions. Psychological Review, 94, pp. 192-210, (1987).

Anderson, J. R., The adaptive character of thought. Hillsdale, NJ: Erlbaum, (1990).

Altun, A., Patterns in cognitive processes and strategies in hypertext reading: a case study of two experienced computer users. Journal of Educational Multimedia and Hypermedia, 8(4), pp. 423-443, (1999).

Ausubel, D. P., The psychology of meaningful verbal learning: An introduction to school learning. New York: Grune & Stratton, Inc., (1963).

Berk, E. and Devlin, J., A hypertext timeline. In E. Berk and J. Devlin (Eds.), Hypertext / Hypermedia Handbook, NY: McGraw-Hill, Inc. pp. 13-16, (1991).

Beasley, R. E., The effects of three browsing devices on learner structural knowledge, achievement, and perceived disorientation in a hierarchically organized hypermedia environment. Doctoral dissertation, University of Illinois at Urbana-Champaign, (1994).

Boling E., Kira K., Avers D., Hsu Y. C., Lee J., and Frick T., Naviagting backward: concrete vs. abstract representation in hypertext buttons. Canadian Journal of Educational Communication, 25(2), pp. 161-176, (1996).

Bruner, J. S., Toward a theory of instruction. Cambridge, MA: Belknap, (1966).

Bush, V., As we may think. The Atlantic Monthly, 176(1), pp. 101-108, (1945).

Burton, J. K., Moore, D. M., and Holmes, G. A., Hypermedia concepts and research: an overview. Computers in Human Behavior, 11(3-4), pp. 345-369, (1995).

Chang, C. T., A study of hypertext document structure and individual differences: effects on learning performance. Doctoral dissertation, University of Illinois at Urbana-Champaing, (1995).

Charney, D., Comprehending non-linear text: the role of discourse cues and reading strategies. Proceedings of Hypermedia' 87, Chapel Hill, North Carolina, November 13-15. pp. 109-120, (1987).

Chi, M. T. and Glaser, R., Problem solving ability, In R. S. Sternberg (Ed.), Human abilities: an information processing approach. NY; W. H. Freeman, (1985).

Conklin, J., Hypertext: An introduction and survey. IEEE Computer, 20(9), pp. 17-41, (1987).

Duffy, T. M., and Cunningham, D. J., Constructivism: Implications for the design and delivery of instruction. In Jonasson D. (Ed.) Handbook of Research in Educational Communication and Technology, pp. 170-198, (1997).

Elm, W. and Woods, D., Getting lost: a case study in interface design. In Proceedings of the Human Factors Society 29th Annual Meeting, pp. 927-931, (1985).

Eco, U., Semiotics and the philosophy of language. Bloomington, IN: Indiana University Press, (1984).

Gagne, R. M., Instruction & conditions of learning. In L. Siegel (Ed.), Instruction: Some contemporary viewpoints , pp. 291-313. San Francisco: Chandler Publishing Company, (1967).

Greco, A. A. and McClung, C., Interaction between attention directing and cognitive style. Educational Communication & Technology, 27(2), pp. 97-102, (1979).

Hammond, N. V. and Allinson, L., Extending hypertext for learning: an investigation of access and guidance toos. In A. Sutcliffe and L. Macaulay (Ed.), People and Computer V, Cambridge University Press, Cambridge, (1989).

Jonassen, D. H. and Grabinger, R. S., Problems and issues in designing hypertext/hypermedia for learning. In D. H. Jonassen and H. Mandl (Ed.), Designing Hypermedia for Learning. Springer Verlag. Berlin, NY. pp. 3-25, (1990).

H., Beissner, K., and Yacci, M., Structure Knowledge: Techniques for Representing, Conveying, and Acquiring Structural Knowledge. Lawrence Erlbaum Associateds, Publishers. Hillsdale, New Jersey, (1993).

Keefe, J. W., Learning Style: Theory and Practice. Reston, VA: national Association of Secondary School Principals, (1987).

Korthauer, R. D and Koubek, R. D., An empirical evaluation of knowledge, cognitive style, and structure upon the performance of a hypertext task. International Journal of Human-Computer Interaction, 6(4), pp. 373-390, (1994).

Landow, G., Hypertext: the convergence of contemporary critial theory and technology. Baltimore, MD: Johns Hopkins University Press, (1992).

Liu, M. and Reed, M. W., The relationship between the learning strategies and learning styles in a hypermedia environment. Computers in Human Behavior, 10, pp. 419-434, (1994).

McAleese, R., Navigation and browsing in hypertext. In R. McAleese (Ed.), Hypertext: theory into practice. Oxford, England, pp. 5-38, (1993).

Nielsen, J., The art of navigating through hypertext. Communications of the ACM, 33, pp. 297-310, (1990).

Paolucci, R., The effects of cognitive style and knowledge structure on performance using a hypermedia learning system. Journal of Educational Multimedia and Hypermedia, 7(2/3), pp. 123-150, (1998).

Riding, R. J. and Banner, G.E., Sex and personality differences in second language performance in secondary school pupils, British Journal of Educational Psychology, 56, pp. pp. 366-370, (1986).

Riding, R. J. and Cheema, I., Cognitive styles – an overview and integration. Educational Psychology, 72, pp. 59-64, (1991).

Riding, R. J., On the nature of cognitive style. Educational Psychology, 17(1/2), pp. 29-49, (1997).

Robertson, W. C., Detection of cognitive structure with protocol data: Predicting performance on physics transfer problems. Cognitive Science, 14, pp. 253-280, (1990).

Schwen, T. M., Goodrum, D. A., and Dorsey, L. T., On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), pp. 5-9, (1993).

Spiro, R. J. and Jehng, J. C., Cognitive flexibility and hypermedia: Theory and technology for the nonlinear and multidimensional traversal of complex content domains. In D. Nix and R. J. Spiro (Ed.), Cognition, Education, and Multimedia: Exploring Ideas in High Education. Hillsdale, NJ: Lawrence Erlbaum Associates, (1990).

Tripp, S. D. and Roby, W., Orientation and disorientation in a hypertext lexicon. Journal of Computer-based Instruction, 17(4), pp. 120-124, (1990).

Wilson, B. G. and Jonassen, D. H., Hypertext and instructional design: some preliminary guidelines. Performance Improvement Quarterly, 2(3), pp. 34-49, (1989).

Witkin, H. A., Psychological Differentiation, Studies of Development. New York, Wiley, (1962).

Witkin, H. A., Moore, C. A., Goodenough, D. R., and Cox, P. W., Field-dependent and field-independent cognitive styles and their educational implications. Review of Educational Research, 47(1), pp. 1-64, (1977).

Learning with Computer Mediated Communication in Remote Off-campus Cross-Cultural Contexts: Bridging the Information Gap

Lyn Henderson*, Frank York*, Gail Jose, and Anne McGowan***
**School of Education, James Cook University, Townsville, Queensland. Australia 4811*
Lynette.Henderson@jcu.edu.au, Frank.York@jcu.edu.au , Anne.McGowan@jcu.edu.au
***Education Queensland, P.O.Box 2268, Cairns, Queensland. Australia. 4870*
gail.jose@qed.qld.gov.au

The research examined the anxieties and perspectives of first and final year Australian Indigenous Bachelor of Education students as they learnt with Computer Mediated Communication. The paper reports a qualitative study that utilised Likert Scale Questionnaires and focus and individual interviews in order to ascertain the factors involved in reducing the information rich/information poor gap through the use of Computer Mediated Communication. The factors identified involved technical, time, skills, costs, tutors, and "learning style" issues as well as isolation as tertiary students studying in offcampus remote communities. The students reported more positive attitudes and competency skills and less isolation with email than the WWW. There was general optimism concerning the role the Internet would play in their future lives as students, teachers, and, as they took their knowledge beyond the classroom, in their communities, particularly in terms of reducing the information gap.

Keywords: **Computer Mediated Communication, information gap, cross-cultural, Internet**

1 Introduction

Tertiary education institutions are rapidly investing considerable resources and faith in the Internet as a means of conveying both the administrative and the pedagogical materials for student learning [1, 2]. As vehicles for flexible learning, email and the World Wide Web (WWW) are seen to be free from geographical, time, and participation restraints [3, 4]. This is juxtaposed against international concerns that the Internet is widening the gap between the information rich and information poor [5, 6]. Tertiary institutions are amongst those that continue to widen the gap between information rich and information poor in Australia as technical, cost, and inappropriately designed distributed learning environments (email and the WWW) impose implementation restraints. This paper reports a case study of how Australian Indigenous students, who are studying in remote communities, and one Australian tertiary institution, James Cook University, are bridging that information gap.

The study was interested in the tertiary students' perspectives of the influences that impacted their interpretation of that gap and how it was being bridged. We therefore investigated the students' perceptions of (a) their attitudes and anxieties concerning email and the WWW and (b) the role email and the WWW played in teaching and learning in their degree program and their lives as Indigenous peoples in remote areas.

2 Methodology

Since mid-1990, James Cook University (JCU) has offered a Bachelor of Education to Aboriginal and Torres Strait Islander students through the Remote Area Teacher Education Program (RATEP). As in the rest of Australia, Queensland's Aborigines and Torres Strait Islanders have lived, and many continue to live, under various separatist legislation. The state government long held an isolationist and racist view of what constituted an appropriate education for them. As the official view was that they could achieve little academically, secondary education was withheld from Aborigines until 1964 and, for Torres Strait Islanders, education was left in the hands of the Department of Native Affairs, rather than the Department of Education, until 1984. RATEP was conceived as a program that would seek to redress issues of geographical remoteness, racial discrimination, economic exploitation, educational marginalisation, linguistic plurality, land alienation, and enforced dependency of the Indigenous communities. It was driven by the concepts of social justice, culturally contextualised education, empowerment, and use of information technologies. It is an inter-systemic teacher education program providing preservice teacher education studies to Indigenous students on-site in remote locations throughout the State of Queensland. The RATEP delivery partnership consists of James Cook University, the Far North Queensland Institute of Technical and Further Education, the Queensland State Education Department, and, importantly, the Indigenous communities. Multi-systemic collaboration is effected through the RATEP Management Committee which oversees finance and site selection, contributes to various corporate decisions, and provides for direct Indigenous input.

The program caters for eight to 35 Indigenous students in any year's intake with four to 12 students at any one site. The location of the 10 James Cook University RATEP centres is usually in a primary or secondary school classroom in locations where the population ranges from 250 in Aboriginal and Torres Strait Islander communities, in which non-Indigenous people are a very small minority, to 700 in the small townships. Typically, the centre consists of one classroom which houses the computers, modem, printer, facsimile machine, teleconference phone, conference table, and study desks as well as a sink and fridge. There are no community libraries available to the students.

RATEP is a mirror of the Bachelor of Education on-campus program, differing mainly in modes of delivery. RATEP students study the same courses, are taught by the same lecturers, complete assessment tasks at the same standard as their on-campus counterparts, and receive exactly the same award as students who undertake preservice teacher education at the Cairns and Townsville JCU campuses. RATEP uses various distance education technologies, materials, and delivery strategies: textbooks, workbooks, teleconferences, audio and video tapes, facsimile, JCU developed interactive multimedia (IMM) courseware, on-site tutors (self-labelled teacher-coordinators), and, now, the Internet.

The delay in accessing the Internet as part of their program was mainly due to the costs of hardware, long distance telecommunication fees, and the unreliability of sustained telecommunication connections. With support through a Telstra learn-IT research grant, the Bachelor of Education students through RATEP were able to enrol in two undergraduate information technology courses that utilised the Internet as a teaching-learning tool. The courses were a first year core on-campus course and a fourth year elective: *Information Technologies in Education* and *Design of Educational Media*, respectively. The first year course had the equivalent of two interactive lectures on the World Wide Web (WWW). Assessment included reactions to tutorial readings sent as email attachments, and the option to create a WWW home page. Interaction with the lecturer was via email and teleconference. The fourth year course required the students to access the WWW for key readings as well as to critique educational sites. In addition, they were responsible for conducting weekly email tutorials in which two students posed email questions about the set tutorial readings. All students replied individually. The tutorial leaders were also required to synthesise these responses in a culminating email. All students were encouraged to critique any of the contributions. Except for two teleconferences, interaction with the lecturer was via email. In both subjects, the students had previously met formally and informally with their lecturers during a short orientation oncampus program.

Twenty-three out of 33 Indigenous students volunteered to participate. Their ages ranged from 21 to 49 years. Reflecting teacher education enrolments generally, all but seven were female. The students generally speak either a traditional language, Aboriginal English, or Torres Strait Creole as their first language. Standard Australian English is their second or third language. When researching in cross-cultural contexts it is important that researchers acknowledge the cultural, linguistic, and individual differences existing within and across the student group. However, the historical-socio-cultural similarities are strong enough to speak in generalities in referring to Aboriginal and Torres Strait Islander patterns of experiences, values, and ways of

learning.

Audiotaped focus interviews were conducted either face-to-face (Yarrabah) or via teleconference (Normanton and Woorabinda) with students as a group at these three RATEP sites. The interviews involved open-ended questions to gather information about the issues identified by the students and teacher coordinators as relevant to learning with the Internet. A five-point Likert Scale Issues and Course Questionnaire for the first and final year courses were compiled from the focus interview data and the literature. It was administered towards the end of the courses, either along with audiotaped individual interviews conducted on site with students at six RATEP sites (Thursday Island, Bamaga, Napranum, Cairns, Palm Island, and Cunnamulla) or via fax or email attachment to the other four sites (Yarrabah, Normanton, Worrabinda, and Doomadgee). Another five-point Likert Scale questionnaire assessing Computer Mediated Communication Anxiety [7] was also administered at the beginning and end of the two university courses involving the Internet via fax or email.

3 Data Results and Discussion

The five point Likert scale questionnaires were reduced to a three point scale (see Table 1) for data analysis. Overall there was a positive swing on the Computer Mediated Communication Questionnaire (Items 1-13, Table 1) and the Issues and Course Questionnaire (Items 14-23, Table 1) that sought first and final year student anxieties and perceptions about current and future usage of email and the World Wide Web (WWW). (Ten items out of the 42 item Issues and Course Questionnaire are reported here; the other items included those that are common in end-of-course evaluations and, therefore, not relevant to this paper). The individual interviews supported this trend. The interviews revealed a decidedly positive emphasis on keeping but improving the use of CMC in RATEP subjects.

Table 1: Comparison of Pre to Post Test Changes on Selected Items from Computer Mediated Communications and Comparison between End-of-Semester First Year and Final Year Issues and Course Evaluation Questionnaires

Computer Mediated Communications Questionnaire: Responses of Students' Studying First and Final Year Course							
Item		Pre-Test			Post-Test		
		SA-A	U	D-SD	SA-A	U	D-SD
1	E-mail could open up new communication channels for me.	92%	8%		94%	4%	
2	My usage of e-mail will increase in the future.	67%	33%		91%	9%	
3	The thought of using e-mail makes me nervous.	50%		50%	30%	9%	61%
4	The Internet could open up new areas of communication for me	100%			100%		
5	I expect I will use the Internet in the future	83%	8%	8%	96%	4%	
6	I get nervous at the thought of using the Internet	50%		50%	39%	13%	48%
7	I believe that there are many useful ways to use the Internet.	67%	17%	17%	68%	17%	14%
8	The thought of learning from the Internet intimidates me.	36%	27%	36%	30%	17%	52%
9	Information overload frightens me.	50%	8%	42%	43%	30%	26%
10	I feel very negative about the Internet in general.	33%	17%	50%	26%	30%	43%
11	I would prefer not to use the Internet because of the uncensored material	25%	8%	67%	30%	22%	48%
12	Using the Internet could be more trouble than its worth	25%	33%	42%	17%	17%	65%
13	I think there is too much emphasis placed on	67%	17%	17%	35%	26%	39%

	the Internet						

First and Final Year Issues and Course Evaluation Questionnaire Responses

	Item	First Year Course			Final Year Course		
		SA-A	U	D-SD	SA-A	U	D-SD
14	I am more confident using email than the WWW	73%	9%	18%	67%	11%	22%
15	If I had the choice, I would use the WWW for serious information searches	100%			100%		
16	If I had the choice, I would use the WWW to catch up on what' s happening in soap operas.	27%	9%	63%	33%	22%	44%
17	The WWW is a diversion from having to do RATEP work.	20%	20%	60%	22%	33%	44%
18	I don' t feel as isolated as a university student now that I can use WWW	54%	36%	9%	56%		44%
19	I don' t feel as isolated as a university student now that I can use e-mail	82%		18%	100%		
20	I appreciated the flexibility in scheduling my learning times	73%	18%	9%	89%	11%	
21	The subject has made me feel a more independent learner	50%	30%	20%	78%	22%	
22	I no longer see the computer as just a word processing tool	100%			80%	20%	
23	I intend using the computer in the classroom with my students.	100%			100%		

* SA-A = Strongly Agree/Agree; U - Undecided; D-SD = Disagree/Strongly Disagree.

Students were originally divided on their willingness and nervousness to use email. By the end of the semester there was a substantial increase in their perception that their future usage of email would increase (67% to 91%) and a 20% decrease in their nervousness (Items 2 & 3, Table 1). This is encapsulated in one student' s interview statement: "I was a bit apprehensive at first because I think the newness with everybody was a bit scary. But, after I got the knack of things, I really loved it" (Interview). Most students acknowledged the efficiency and speed of communicating via email with their lecturers and fellow students; as one student explained: "..you don't have to fiddle around faxing or posting your assignments. You just type it right onto the computer and send it on the email and it's there!" (Interview). Some reasons for the maintenance of apprehension involved concerns about costs ("the time I' m using is costing money"), typing skills ("my typing speed is not up to my thoughts; that' s a bit slower so that' s what holds me back"), and privacy ("..the teacher-coordinator seemed as if to be spying" (Interviews). This last factor involved the way email accounts were established. Because of costs, only one modem was provided at each site. Thus, at the time of the research, the teacher coordinator accessed and therefore could read all exchanges as the single email account for each RATEP site was registered in their name. (This year, all students have a private email account.) Despite their concerns and apprehensions, 94% agreed that email would open up new communication channels for them while 91% indicated they would increase their use of email in the future (Items 1 & 2 respectively, Table 1).

Compared with email items, there was more initial negativity and some smaller positive swings concerning the WWW items. Indeed, at the end of the semester, both first and final year students admitted they were "more confident using email than the WWW" (73% and 67%, respectively; Item 14, Table 1). In the pre and post Computer Mediated Communication Questionnaire, for instance, although in the post test 68% agreed with the item, "I believe that there are many useful ways to use the Internet", there was little variation from the pre test (67%) (Item 7, Table 1). Other small positive results occurred in the following items as fewer students indicated agreement with the following statements: "I get nervous with the thought of using the Internet (50% pre test to 48% post test); "The thought of learning with the Internet intimidates me" (36% to 30%); and "Information overload frightens me" (50% to 43%) (Table 1, Items 6, 8, & 9, respectively).

However, it is noteworthy that on three of these items such positive swings were offset by a noticeable

increase in the "undecided" category. For instance, in the above item about nervousness and using the Internet, 50% agreed and 50% disagreed on the pre-test while 39% agreed and 48% disagreed on the post-test (Item 6, Table 1). The change in attitude was counteracted by an increase in the "undecided" (0% to 13%; Item 6, Table 1). Although more students felt less negativity about information overload (Item 9) and the WWW in general (Item 10), 30% reported being "undecided" in the post test compared with 8% and 17% in the pre test, respectively (Items 9 & 10, Table 1). As explained later, many of the first year students were prevented from hands-on use of the WWW course materials online. In the fourth year subject, the greater emphasis was on email tutorial interaction; in comparison, finding relevant resources and obtaining set readings from the WWW were the only compulsory WWW tasks. This paucity of "compulsory" usage, influenced the students perceptions concerning the Internet. During the interviews, most students equated the Internet with the WWW. The experiences that the students did have seemed to have resulted in understandable ambiguity concerning their anxiety and general attitudes about the WWW; the reality of their experiences was a contributing factor.

More substantial changes occurred when, in the post test, fewer students agreed with the statement, "I think there is too much emphasis placed on the Internet" (67% to 35%) (Item 13, Table 1) and more students confirmed that they would use the Internet in the future (83% to 96%) (Item 5, Table 1). As one student commented: "You have to keep up with the technology and pass it on; it's never-ending learning" (Interview). Additionally, regardless of their concerns and experiences, an optimism remained: all confirmed an unchanged hope that the Internet would open up new areas of communication for them (100% on both pre and post tests, Item 4, Table 1).

There were several factors affecting these data results, such as technical issues, time, skills, costs, and tutors (self-labelled "teacher-coordinators").

Technical problems were a significant factor. Getting hooked-up took two sites one month after the commencement of the courses. The reliability of the telecommunication links and difficulty in logging into the James Cook University site when 500 on-campus students were trying to log into the same first year course site influenced the RATEP students' perceptions (Interviews). The one computer that had the RATEP modem connection was also used for studying with the IMM courseware and wordprocessing assignments. An extra major inconvenience for two sites was having just one line for Internet access, facsimile, telephone, and teleconferencing. There was a ratio of approximately four students to this one line.

These factors obviously limited the time each student could spend using the WWW and email. Their other study commitments - described as "a mountain of work" by one student - imposed further time constraints reducing their usage of the Internet (Interviews). This was exacerbated by having English-as-a-second/third-language with respect to deconstructing academic genres. "If we'd had more time to explore it and build up that confidence, well, then, I probably wouldn't be feeling as bad as I do about getting onto it," was one student's summary of the effects that lack of time had on her self-confidence (Interview). Others echoed the impact that minimum usage had on their confidence to use the WWW (Interviews). The printout of procedures on the wall did not seem to inspire usage or confidence; it was the personal input from the teacher-coordinator or a peer that some students' maintained was crucial. This emphasis on the personal coach would seem to reflect Aboriginal and Torres Strait Islander preferred ways of learning and doing [8]. In this period of apprehension with using the Internet, students required the comfort zone of traditional ways of teaching and learning [9].

Underdeveloped procedural knowledge constrained student progress using the WWW. One student's clarification echoed other students' comments: "..it's just a matter of not being able to get where I want to be straight away ...and then I'll get real frustrated" (Interview). Students justifiably argued that this was compounded by the fact that the first year course did not encourage understanding or reinforcement of WWW searching strategies by requiring assessable activities in this area.

There was evidence of self-imposed moderation in usage by students (Interviews). In spite of their understanding that costs involved in browsing the WWW were met through the Telstra learn-IT grant, students were reluctant to abuse what they saw as a privilege.

The students who reported most positively in their interviews were those who perceived their teacher-coordinators as having competence in using the WWW and being able and willing to impart that confidence

to the students. Unfortunately a few students cited perceptions of teacher-coordinator reluctance or inability to share their knowledge. Also most of the teacher-coordinators printed out the first year course's WWW lecture notes. The teacher-coordinators contended they chose this strategy because of time constraints, technical hiccups, and, perhaps, admitted one, procedural insecurities. For them, this allowed a more efficient usage of time as they could conduct tutorials based on the printed text without having to wait for all the students to study from the WWW. In effect, it prevented students acquiring more proficiency with the Internet and, hence, much needed self-confidence. As well it prevented students (and these teacher coordinators) from obtaining a better understanding of how the WWW could be utilized as a learning tool as they had no chance to participate with the in-built question-answer-feedback interactions, the video clips of school children voicing their perceptions of various aspects of the Internet and its relevance to their lives, and the hypertext/hypermedia functions of the WWW.

These conditions would have influenced the differing perceptions about the courses allowing "me to feel a more independent learner" (Item 21, Table 1): only 50% of the first year students felt such independence with a further 30% being undecided; in comparison, 78% of the final year students reported that the Internet activities had helped them to take more self-responsibility for their learning. Of course, one would expect that final year students would be more independent learners than first year students. Nevertheless, the item required them to express an opinion if the Internet subject had made them "more" independent.

Even if many had not had much opportunity to browse the Web, all students reiterated the commonly quoted advantages of the WWW: up-to-date information, variety of topics, exploration, multiple sources relating to the same information, and flexibility (Interviews). With respect to flexibility, more final year students (89%) compared with first year students (73%) valued this attribute (Item 20, Table 1). The enforced tutorials without personal access to the WWW would have influenced the first year students' perceptions. One student situated her comment in the context of the realities of Indigenous community life: "We've had multiple tragedies in our class [deaths, suicides, and serious illnesses]; at least with the WWW lecture notes, we can come back and get them; we're not missing out [as we would have with teleconferences]" (Interview). For students who had taken opportunities to surf, the WWW was "Exciting!"; "It gets me; it draws me. I could see myself seriously getting hooked"; "It's like a big book; you don't want to put it down!" (Interviews).

Students unanimously agreed that they would use the WWW for serious information searches (Item 15, Table 1). It was reassuring to see that their usage went beyond the two courses requiring utilisation of the Internet. The following Web searches were mentioned by different individual students: green ants (for their science curriculum course); background information on a son's medical disease; solutions for our farm's fruit tree problems; Indigenous sites such as the internationally famous Aboriginal band, Yothu Yindi. Serious play [10, 11] was involved, too: finding out what was on at movie theatres; joining a jokes' listserv; 30% admitted to catching up on soap operas (averaged first and final year, Item 16 Table 1); and 21% reported using the WWW as an occasional diversion from their studies (averaged first and final year, Item 17 Table 1). Such responses demonstrate these students' awareness of the types of information available on the WWW and an ability to conduct searches and find out how to subscribe to a listserv. Because of the Internet and other computer requirements in the two courses, 90% (averaged first and final year students, Item 22, Table 1) agreed that they no longer perceived the computer as just a word processing tool.

The role of email and the WWW in their lives as students in remote Indigenous communities involved reducing isolation and person, societal and professional issues.

Feeling part of the wider JCU student cohort was an issue raised in the research. Both cohorts of students felt that isolation as a university student was decreased through use of email - 82% for first year students and 100% for final year students (Item 19, Table 1). One student put it succinctly: "Yeah. It took away the isolation a lot" (Interview). In comparison, approximately half (54%) of the students studying the first year course reported that they "did not feel as isolated as a university student now that I can use the WWW" (Item 18, Table 1). A further 36% were undecided. Likewise, only 56% of the final year students felt that isolation as a university student was reduced through access to the WWW (Item 18, Table 1). The course requirements and amount of access would have been significant issues in the differing percentages with respect to email and WWW as factors in lessening isolation. With respect to the first year students, these percentages are not surprising considering the large number of reports of inadequate access to the WWW, working from a print version rather than on-screen interaction of the first year information technology course, and technical constraints. The fourth year course demanded that the students conduct weekly email tutorials

and interact via email for a fortnight with students at the Royal Melbourne Institute of Technology as well as the fact that their compulsory WWW activities were limited. The results may also have been affected by the fact that the WWW activities were not people orientated whereas the email tasks were obviously so.

However, isolation was not just a matter of the difficulties imposed by distance learning with respect to cultural induction as university students. It was also a personal and community issue. A few students reported keeping in touch via email with relatives and friends living in other parts of Australia; for instance, one student was able to regularly contact her son who was in jail. This is a poignant reminder of the systemic injustices involved in Aboriginal and Torres Strait Islander peoples' reality and the role that email can play in helping families maintain contact at a geographical distance. The WWW was threatening for one student: " ... a whole new world, and I'm afraid in a way to experience all these different things" (Interview). For others, their world was expanded. This was insightfully expressed by one student: "When you're living in a remote community all you know is what's happening around here or what you get from your teleconference and stuff like that. You're living in your own world ...Well, then, when you get onto the Web, it's just like: 'Wow! There's a big world out there. All that information you can access'." (Interview).

The content in the first year course *(Information Technologies in Education)* appeared to have been influential in changing perceptions about the negative affects of the Internet. One involved society's concern that the Internet would significantly reduce or even prevent socialisation. For example, "I've changed", said one student. "I've done a complete [voice faded out] ...with the whole idea of technology taking away the emotional side of life and that we've been becoming too dependent on it, and I think, after going through the semester with it, that maybe as long as people are educated in the right way about it, it's not going to prove to be a big problem. It's probably going to prove to be a big asset, you know." Some students' comments highlighted their fear of children and themselves encountering pornographic sites: "It scares me - to come across something like that on the Internet"; "Children shouldn't have access to them" (Interviews). However, the 19% pre to post drop in their disagreement with the statement, "I would prefer not to use the Internet because of the uncensored material" (Item 11, Table 1), probably reflects a more realistic understanding of avoidance strategies and the general unlikelihood of a user encountering such sites; these were issues that were discussed with relevant hotlinks in the WWW course.

All the pre-service teachers reported their intention to use computers in the classroom with their students in order to enhance teaching and learning (Item 23, Table 1). One student commented that hers was a commitment to creating a new kind of learning environment for all, but particularly remote Indigenous, students. Another student saw that this would occur during her next practicum: " ..I think that I can go to the Web and find out interesting lessons, which is one of my main concerns. Kids sit down and get stuff poured into them that is not interesting." The students' commitment demonstrates a broader consideration of the role that the WWW and email needs to play in school and, as the students' take their understandings home, their communities.

4 Conclusion

Overall, at the end of phase one of the project, there was a favourable response to the introduction of the Internet into the students' Bachelor of Education course. Importantly, the research highlighted a number of issues that the RATEP Academic Coordinator, lecturers, and RATEP Management Committee can consider to help improve the incorporation of the Web and email for improved teaching and learning: technical issues such as the provision of more than one modem per RATEP site; incorporation of assessable items to do with effective searches on the WWW; meaningful use of email and Web discussion forums in various subjects across the degree program; seeing serious play that helps develop WWW procedural skills as part of the course structure; examination of the nature and role of WWW lectures in developing conceptual as well as procedural understanding of the WWW; and creating purposeful "authentic" links between the Internet subjects and their community.

It is argued that the Internet will prove to be an effective tool to combat colonisation. For instance, geographically dispersed Aboriginal communities and Torres Strait Islander communities are able through the Internet to set their own agendas to communicate and consult (network) on issues of mutual concern, such as the current attention concerning land and sea rights claims. In the second phase of the learn-IT research

grant, we conducted an Internet WebBoard International Conference linking Indigenous and non-Indigenous peoples interested in teaching and learning with the Internet. Once analysed, the rich data from this conference should provide further ideas for bridging the information gap, not only to empower, but to provide ownership of the Internet in school, tertiary, and community life.

5 References

[1] Paulsen, M. F., "Computer mediated communications and distance education around the world", Vol. 7, pp. 31-37, 1992

[2] Rudra, A. (1994). AARNet and ERNET: An era for fostering international academic research. In N. F. Ellerton (Ed.), Proceedings of International networking: Education, training and change (pp. 104-109). Perth, Western Australia: Edith Cowan University.

[3] Nguyen, A. T. A., Tan, W., & Kezunovic, L. (1996). Interactive multimedia on the World Wide Web: Implementation and implications for the tertiary education sector. In M. Nott (Ed.), Proceedings of AusWeb96: The Second Australian World Wide Web Conference. Gold Coast, Australia: Southern Cross University.

[4] Rossman, P. (1992). *The emerging worldwide electronic university: Information age global higher education*. Westport: Greenwood Press.

[5] Provenzo, E. (1986). Beyond the Gutenberg Galaxy. New York: Teachers College, Columbia University.

[6] Rowe, H. (1993). Learning with personal computers. Hawthorn, Vic.: Australian Council for Educational Research.

[7] King, J., Henderson, L., & Putt, I. (1997). Measuring affective aspects of www and e-mail use in course delivery. In Muldner, T., & Reeves, T. (Eds.), Educational multimedia/hypermedia and telecommunications, 1997, (Vol. 1), (pp. 595-600). Charlottesville: Association for the Advancement of Computing in Education.

[8] Osborne, A.B., (1982). Field Dependence/Independence of Torres Strait Islander and Aboriginal Pupils. Journal of Intercultural Studies, (3)3, 5-18.

[9] Henderson, L. "Instructional design of interactive multimedia: A cultural critique". Educational Technology Research & Development, Vol. 44, No. 4, pp. 85-104, 1996.

[10] Provost, J. (1990). Work, play and type: Achieving balance in your life. Palo Alto, CA: Consulting Psychologist Press.

[11] Rieber, L. (1996). Seriously considering play: Designing interactive learning environments based on the blending of microworlds, simulations, and games. Educational Technology Research & Development, 44(2), 43-58.

Making Exploration History Interactive for Web-based Learning

Akihiro Kashihara, Masanao Sakamoto, Shinobu Hasegawa, and Jun'ichi Toyoda

The Institute of Scientific and Industrial Research, Osaka Univ., JAPAN
8-1, Mihogaoka, Ibaraki, Osaka 567-0047, JAPAN
kasihara@ai.sanken.osaka-u.ac.jp

The main problem addressed in this paper is how to help learners reflect on knowledge that they have constructed in exploring existing hypermedia/hypertext based learning resources on the Web. Our approach to this problem is to provide each learner with a kind of reflection support proper to his/her exploration process. In this paper, we describe an interactive history that encourages learners to annotate their exploration history with the reasons why they have explored, which reasons have a great influence on knowledge construction in hyperspace. It also generates a knowledge map, which spatially represents the semantic relationships among the WWW pages visited by the learners. This paper also describes a preliminary analysis and evaluation with the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system produces good effects on learning such as integrating the contents of some nodes in more complicated hyperspace.

Keywords: Exploratory Learning, Hyperspace, Reflection, Interactive History

1 Introduction

Hypermedia/hypertexts generally provide learners with a hyperspace within which they can explore the domain concepts/knowledge in a self-directed way [3], [7]. The exploration often involves making cognitive efforts at constructing the knowledge from the contents that have been explored [12]. These cognitive efforts would enhance learning [2], [6]. However, learners often fail in knowledge construction since what and why they have explored so far become hazy as the exploration progresses. To what extent the learning has been carried out also becomes unclear [10], [12].

A possible resolution of this problem is to encourage learners to reflect on what they have constructed during exploration in hyperspace [11], [12]. The reflection also involves rethinking the exploration process that they have carried out since it has a great influence on their knowledge construction. In particular, exploration purposes, which mean the reasons why the learners have searched for the next node in hyperspace, play a crucial role in knowledge construction [8], [9]. For instance, a learner may search for the meaning of an unknown term to supplement what is learned at the current node or look for elaboration of the description given at the current node. Each exploration purpose would provide its own way to shape the knowledge structure. The reflection support accordingly needs to adapt to their exploration activities and the knowledge structure being constructed by the learners.

In this paper, we discuss a proper reflection support with a careful consideration of exploration process in hyperspace. This paper also describes an interactive history for learning with hypermedia/hypertext based learning resources on the Web. The interactive history system enables learners to annotate their exploration history with exploration purposes that have arisen during exploration. It also transforms the annotated exploration history into a visual representation called knowledge map. It spatially shows the semantic relationships among the WWW pages that the learners have visited [8]. Using the interactive history system, the learners can view and reorganize the exploration history to rethink their exploration process that they have carried out so far. They can also view the knowledge map to reflect on what they have constructed in hyperspace.

This paper also describes a preliminary evaluation of utility and effectiveness of the interactive history system. The results indicate that the system facilitates a rethink on exploration processes, and that the system facilitates learning such as integrating the contents of some pages in more complicated hyperspace.

Before discussing the interactive history, let us first consider exploration process in hyperspace.

2 Exploratory Learning

In hyperspace, learners can explore in a self-directed way from one node to others by following the links among the nodes. The exploration often involves making cognitive efforts at constructing the knowledge structure from the contents that have been explored. In order to shape a well-balanced knowledge structure, it is necessary for the learners to recall what and why they have explored so far, and to properly direct the subsequent exploration [10], [12], [13]. However, these efforts may cause cognitive overload [6].

In this paper, we consider learners who attempt to learn domain concepts and knowledge in a constructive way. Some learners may not make the cognitive efforts of knowledge construction. In this case, they may only browse or surf in hyperspace. Supporting such browsing or surfing is out of our scope.

Table 1. Exploration Purposes and Visual Representation.

Exploration Purposes	Visual Representation
Supplement	Inclusion
Elaborate	Set or Part-of tree
Compare	Bidirection arrow
Justify	Vertical arrow
Rethink	Node superposition
Apply	Arrow

Starting node Terminal node

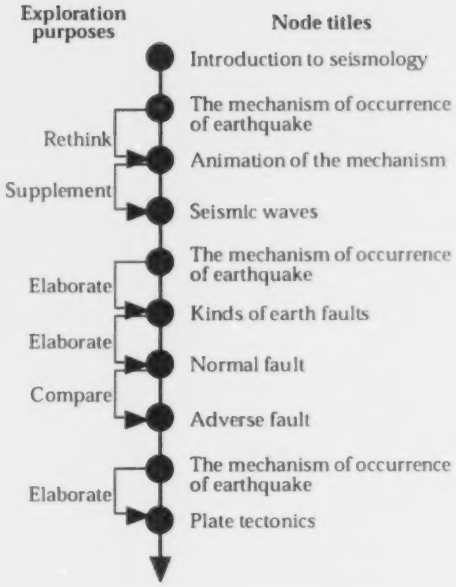


Figure 1. An Exploration History.

2.1 Primary Exploration Process

Learners generally start exploring hyperspace with a learning purpose. The movement between the various nodes is often driven by a local purpose called exploration purpose to search for the node that fulfills it. Such exploration purpose is also regarded as a sub purpose of the learning purpose. We refer to the process of fulfilling an exploration purpose as primary exploration process. This is represented as a link from the starting node where the exploration purpose arises to the terminal node where it is fulfilled.

An exploration purpose may have several terminal nodes with one starting node. Exploration purpose, represented as verb, signifies how to develop or improve the domain concepts and knowledge learned at the starting node. We currently classify exploration purposes as shown in Table 1, which are not investigated exhaustively.

An exploration purpose arising from visiting a node is not always fulfilled in the immediately following node. In such case, learners need to retain the purpose until they find the appropriate terminal node/s. While searching for the fulfillment of the retained purpose, it is possible for other exploration purposes to arise. The need to retain several exploration purposes concurrently makes the knowledge construction more difficult to achieve.

The exploration process can be modeled as a number of primary exploration processes. Let us give an example where a learner uses a hyperdocument on a WWW server with the learning purpose of understanding the occurrence of earthquake. In this example, he/she explores a number of nodes (WWW documents) with various exploration purposes. Figure 1 gives the exploration history, which shows the sequence of the nodes visited and primary exploration processes. For example, he/she visited the node *Animation of the mechanism* in order to rethink the description in the node *The mechanism of occurrence of earthquake*. He/she then visited the node *Seismic wave* since he/she did not know the meaning of the term used in the previous node.

2.2 Knowledge Structure

Exploring hyperspace in a self-directed way, learners make semantic relationships among the domain concepts and knowledge explored to construct a knowledge structure [12]. In hypermedia/hypertext systems with concept maps representing domain concepts to be learned, learners can derive such semantic relationships from the maps. Most existing web-based learning resources, on the other hand, do not specify the semantic relationships. In this case, learners need to explore WWW pages and to identify the semantic relationships by themselves for the knowledge construction.

The knowledge structure constructed is shaped according to learners' exploration process, especially the exploration purposes. Each exploration purpose provides its own way to make relationships among the domain concepts and knowledge explored and to shape the knowledge structure [8].

2.3 Reflection

Knowledge construction in hyperspace requires learners to reflect on their exploration process. Some work on analysis of exploration process in hyperspace has also shown that revisiting nodes to rethink the contents explored often take place [11], [13].

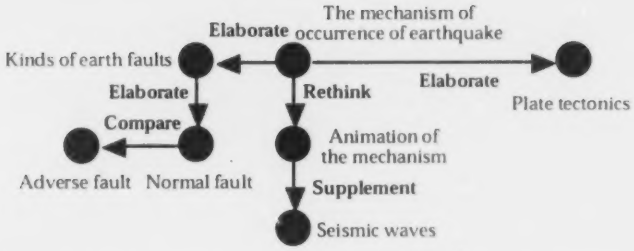


Figure 2. A Semantic Network Composing Primary Exploration Processes.

In reflection, it is important for learners to rethink not only the nodes visited but also the reasons why they have visited since these reasons have a great influence on how to shape a knowledge structure. In other words, they should pay attention to primary exploration processes included in the whole exploration process.

3 Interactive History

Let us now discuss what kind of reflection support is indicated by the above consideration.

3.1 Problems

There are the following important problems to be addressed towards a proper reflection support. The first problem is how to help learners retain the primary exploration processes that they have carried out. The retention may cause cognitive overload on exploration. It is also hard for computer to infer their exploration purposes, which arise in the learners' mind. These suggest that learners should be encouraged to note down the exploration purposes, starting nodes, and terminal nodes that compose the primary exploration processes.

The second problem is how to assist learners in reconstructing their exploration process. In reflecting on their exploration process, they would not only look at it but also reconstruct it such as modifying/deleting the primary exploration processes and adding new primary exploration processes. It is accordingly necessary to provide learners with a space where they can reconstruct their exploration process after exploring hyperspace.

The third problem is how to facilitate learners' reflection on a knowledge structure constructed. One way to resolve this is to spatially show semantic relationships between nodes explored. We represent a semantic network that comprises a number of primary exploration processes. Figure 2 shows a semantic network comprising the primary exploration processes shown in Figure 1. The semantic network does not obviously represent the contents included in the explored nodes, which may be summarized by the node titles. However, this summarized information would be substantially fruitful for learners to reflect on what they have learned.

In order to resolve the above problems, we have developed an interactive history that helps learners reflect on their exploration process and knowledge structure by means of an exploration history annotated with primary exploration processes. Let us next demonstrate the interactive history.

3.2 Overview

The interactive history system first displays an exploration history, which includes the nodes sequenced in order of time learners visited. In order to help learners note down primary exploration processes during exploration, the system provides them with a list of exploration purposes, and requires them to select one from the list when an exploration purpose arises. The learners are also asked when they find the terminal nodes. The interactive history system annotates the exploration history with the information noted down. The annotated history enables the learners to retain their primary exploration processes.

The learners are also allowed to directly manipulate the annotated exploration history to modify/delete the primary exploration processes and to add new primary exploration processes after exploring hyperspace. Such direct manipulation allows them to reconstruct their exploration process without revisiting hyperspace.

Although the annotated exploration history is represented as semantic network shown in Figure 2, it may be difficult to understand. It is accordingly transformed into a visual representation called knowledge map by means of visualization scheme that describes the correspondence of an exploration purpose to a visual representation.

3.3 Annotated Exploration History

In the interactive history system, learners can use a user interface as shown in Figure 3. They can also explore a hyperdocument on a WWW server with one learning purpose in the left window. When they want to set up an exploration purpose in visiting a node, they are required to click one corresponding to the purpose in the *Exploration Purpose Input* section of the right window. The clicked purpose is added to the *Exploration Purpose List* section. The node visited currently is also recorded as the starting node of the exploration purpose.

The learners can also add the object of the verb describing the exploration purpose. It means what to develop/

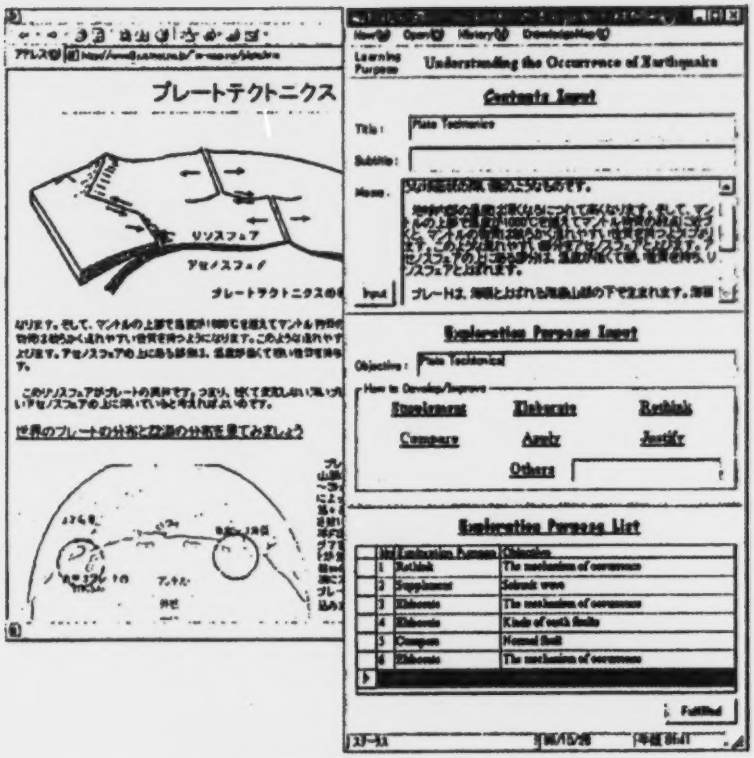


Figure 3. User Interface of Interactive History.

improve in the current node whereas the exploration purpose specifies how to develop/improve. When the learners do not add this object, the system adds the title of the current node, which is the title tag in the HTML file.

When the learners find a terminal node of the exploration purpose, they are required to mouse-select the exploration purpose in the *Exploration Purpose List* section, and to push the *fulfilled* button. The node visited currently is then recorded as the terminal node of the exploration purpose.

The system also provides another support for helping learners store part of the contents of the node visited currently with Cut&Paste function in the *Content Input* section although they may not always need this support. In hyperdocuments on WWW, in addition, the title tags of the nodes do not always represent the contents of the nodes. If the learners want to change the node titles, they can input new titles in the *Content Input* section, which new titles should represent the contents the learners explored in the nodes. The pasted information and the changed node titles are also used in the annotated exploration history.

Using the information inputted from the learners, the system generates the annotated exploration history as shown in Figure 4 so that the primary exploration processes can be viewed clearly. In the annotated history, the nodes learners visited are sequenced in order of time. Each node has the node title. The starting node of each purpose is linked with the corresponding terminal node/s. There may be some primary exploration processes without terminal nodes since they have not been found yet. The learners can look at the annotated exploration history on their demand during exploration. They can also click the nodes in the history to review the content information, which they have inputted with Cut&Paste function.

Learners are not always required to input the above information whenever they visit nodes. Nevertheless, inputting the information during exploration may be troublesome for learners. On the other hand, it enables the learners to make their exploration more constructive, facilitating their exploratory learning. This point is discussed later in detail.

3.4 History Manipulation

Directly manipulating the annotated exploration history, the learners can reconstruct their exploration process without revisiting hyperspace. Each manipulation is done by means of mouse-clicking/dragging parts of the primary exploration processes. There are three basic manipulations: deleting and changing exploration purposes/links between starting and terminal nodes, and adding new primary exploration process.

BEST COPY AVAILABLE

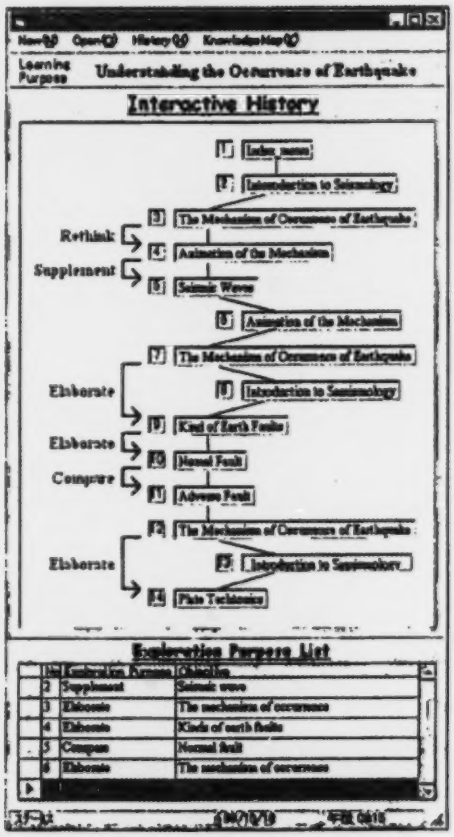


Figure 4. An Annotated Exploration History.

3.5 Knowledge Map Generation

In order to make the knowledge map understandable, we have adopted a visualization scheme shown in Table 1. This table shows the correspondence of an exploration purpose to a visual representation of the relationship between the starting and terminal nodes. For example, an exploration purpose to *Elaborate* is transformed into a set that visualizes the starting node as a total set and the terminal node as the subset. An exploration purpose to *Rethink* is also transformed into a visual representation that superposes the starting node on the terminal node. Following such correspondence, the system generates a knowledge map by extracting the primary exploration processes from the annotated exploration history. The knowledge map generation is executed on learners' demand before/after manipulating the annotated exploration history.

Figure 5 shows an example of the knowledge map that is generated from the annotated exploration history shown in Figure 4. Viewing this map, the learner can reflect on his/her knowledge construction. For example, he/she can recall that he/she rethought *The mechanism of earthquake occurrence* by exploring *The animation of the mechanism*. He/she can also recall that he/she compared *Normal fault* and *Adverse fault* to elaborate the description about *Kind of earth faults*.

3.6 Discussion

Let us now discuss several points to notice in utilizing the interactive history. The interactive history system requires learners to input information about primary exploration processes that have been carried out. Such inputting, in addition, requires a meta-cognitive skill that is indispensable for managing knowledge construction process in existing web-based learning resources. The interactive history system could distract learners, who do not have it, from their learning tasks in hyperspace. We believe, however, it is educationally important to train the learners to improve the meta-cognitive skill so that they can learn in the Web. The interactive history can be viewed as a potential tool for this training.

Before using the interactive history system, in addition, learners need to know how to interpret the visual repre-

BEST COPY AVAILABLE

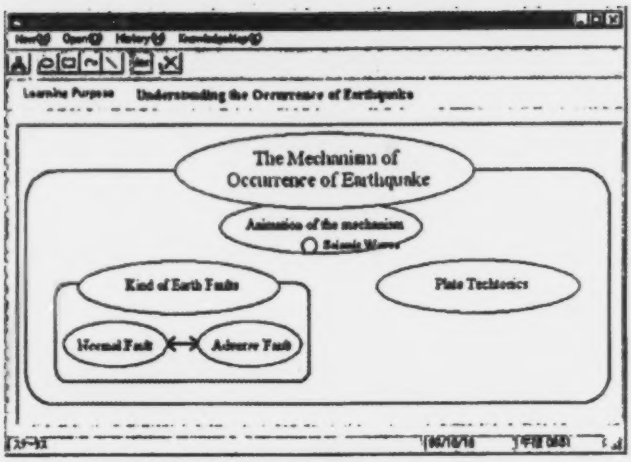


Figure 5. A Knowledge Map.

sentation used for the knowledge mapping. In order to explain it, the interactive history system demonstrates few examples of annotated exploration history and knowledge map before starting the actual learning support.

Let us next compare with related work on reflection support to consider the usefulness of the interactive history. The general browsers such as Netscape and Internet Explorer enable learners to revisit nodes with back buttons, and provide browsing history. However, these facilities do not always make the retention of their exploration processes easy [11]. As the retention support, there are several kinds of annotation systems that allow learners to take a note [1]. However, there is little discussion of what kind of annotation should be done for the success in exploratory and constructive learning. In the interactive history, we claim that the reasons why learners search for the next nodes should be particularly noted down.

Current work on adaptive hypermedia/hypertext systems has often provided spatial maps and concept maps as reflection support, which are originally used as navigational aid. Spatial maps display the nodes and links that compose the whole structure of hyperspace. These maps can visually represent the subspace where learners have already visited [4]. This subspace is represented as the partial structure of hyperspace. This visual representation can inform the learners where they are, what they explored, and to what extent they explored. However, the reasons why they visited the nodes are not clearly shown.

Concept maps consists of the nodes and links representing the structure of domain concepts to be learned. Each node is mapped on the corresponding node in hyperspace. The scope where the learners have already visited in hyperspace is mapped on the corresponding part of the concept maps. The learners can look at the partial structure of the concept maps to reflect on what they learned in hyperspace [5]. Such maps are more helpful for learners who have lower capability of exploring hyperspace in a constructive way since the direction of knowledge construction is visible to them. However, learners who have higher capability of the exploratory learning may identify semantic relationships among the domain concepts explored in a self-directed way, which relationships may be different to those defined in the concept maps [12]. In other words, they do not always construct the same knowledge structure as the structure of domain concepts that the designers of concept maps make.

The interactive history, on the other hand, provides the learners with a more proper support since it enables self-directed exploration and generates a knowledge map according to their exploration process. In addition, the interactive history can provide the reflection support even for most existing web-based learning resources of which concept maps are not prepared and even in ill-structured domains of which concept maps cannot be defined.

4 Preliminary Evaluation

4.1 Experiment

In order to evaluate the interactive history system, we have had a preliminary experiment. The main purpose of this experiment was to analyze the utility of the system and to ascertain if the interactive history improves learning compared to learning without the system. We also prepared two web-based learning resources, which had comparatively simple and complicated hyperspace, and ascertained in which resource the interactive history system enhances its own utility and facilitates learning more effectively.

Table 2 shows the two learning resource, which describes the number of nodes, and the number of links per node, which was calculated except for navigation links such as *Next*, *Back*, and *Top*. These can be viewed as the indicators of the complexity of hyperspace each learning resource provides. The learning resource 2 accordingly had a more complicated hyperspace. Subjects were five graduate and undergraduate students in science and technology.

We set four conditions, which were (1) learning in the learning resource 1 with the system (*Simple-With*), (2)

BEST COPY AVAILABLE

Table 2. Learning Resources.

	Learning Resource 1	Learning Resource 2
Number of Pages	73	161
Number of Links per Page	1.2	2.2

Domain of learning resource1: Mechanism of earthquake
Domain of learning resource2: Life in Sea

learning in the learning resource 1 without the system (*Simple-Without*), (3) learning in the learning resource 2 with the system (*Complicated-With*), and (4) learning in the learning resource 2 without the system (*Complicated-Without*). Subjects were provided with Internet Explorer as WWW browser under each condition. In this experiment, each subject learned one learning resource with the system, and learned the other without the system. In other words, he/she was assigned two conditions, which were *Simple-With* and *Complicated-Without* (or *Simple-Without* and *Complicated-With*).

Before learning, subjects were given a learning purpose for each learning resource. Under *Simple-With* or *Complicated-With*, they were also given the explanation about how to use the interactive history system, and were asked to try it in a sample learning resource whose hyperspace is simple. They were then asked to explore hyperspace with or without the system to accomplish the learning purpose. After subjects finished learning, they were given several problems about the contents for each learning resource. The problems were classified into (1) single problems whose answers could be found within one WWW page, and (2) compound problems whose answers could be found in the relationships among two or three pages. In this experiment, effects on learning were measured by the scores on both problems. The utility of the system was analyzed with the dispersion of pages visited, the number of revisit per page [11], the number of primary exploration processes executed, and the number of revisiting pages that were included in the primary exploration processes. Comparing the averages of them under *Simple-With* and *Simple-Without* or under *Complicated-With* and *Complicated-Without*, we evaluated the utility and effectiveness of the interactive history system.

4.2 Results and Discussion

Table 3 summarizes the analysis of the utility. The average numbers of revisit per page on both *Simple-With* and *Complicated-With* were slightly higher than the average numbers of revisit per page on both *Simple-Without* and *Complicated-Without*. The average dispersion of pages visited on both *Simple-With* and *Complicated-With*, on the other hand, was lower than the average dispersion of pages visited on both *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* was large. These results indicate that the interactive history system makes learners' exploration more intensive, particularly in a more complicated hyperspace. We further analyzed the utility of the interactive history system on *Simple-With* and *Complicated-With* as shown in Table 4.

Table 4 shows the average number of primary exploration processes executed, the average number of starting and terminal nodes (pages), and the average number of revisting pages that are included in the primary exploration processes. The average numbers of starting and terminal pages on *Simple-With* and *Complicated-With* corresponded to about half of the average numbers of pages visited as shown in Table 3 (56% on *Simple-With* and 52% on *Complicated-With*). In other words, half of the visited pages were related to the primary exploration processes. The average numbers of revisiting the starting and terminal pages on *Simple-With* and *Complicated-With* accounted for 67 % and 78 % of the whole revisits shown in Table 3. The ratio on *Complicated-With* was particularly high. These results indicate that the interactive history system can direct learners' attention to primary exploration processes, particularly in a more complicated hyperspace. In other words, the system can encourage learners to rethink exploration processes. This would improve learning.

Table 5 shows the average score of problem-solving on each condition. As for the single problems, the average scores on *Simple-With* and *Complicated-With* were lower than the average scores on *Simple-Without* and *Complicated-Without*. As for the compound problems, on the other hand, the average scores on *Simple-With* and *Complicated-With* were higher than the average scores on *Simple-Without* and *Complicated-Without*. In particular, the difference between *Complicated-With* and *Complicated-Without* were large. These results indicate that the interactive history system can produce good effects on learning such as integrating the contents of some nodes by means of exploration purposes, particularly in a more complicated hyperspace.

5 Conclusions

This paper has claimed that exploratory learning in hyperspace requires learners to reflect not only what but also why they have explored, and that the reflection support needs to adapt to their exploration process and knowledge structure being constructed by them.

This paper has also demonstrated the interactive history with knowledge mapping as a proper reflection support. The interactive history encourages learners to annotate and manipulate the exploration history to rethink their exploration processes. It also generates a knowledge map from the annotated exploration history, which allows the

Table 3. Analysis of Utility.

	Total Number of Pages Visited (a)	Number of Pages Visited (b)	Dispersion (b/a)	Revisit (a-b)	Revisit per Page ((a-b)/b)
Simple-With	69	19.5	0.283	49.5	2.53
Simple-Without	72	22.3	0.31	49.7	2.23
Complicated-With	67.3	21.3	0.317	46	2.16
Complicated-Without	59.5	32.5	0.546	27	1.25

Table 4. Utility of Interactive History.

	Number ofPrimary Exploration Processes	Number of Starting and Terminal Pages	Revisit
Simple-With	9.5	11(56%)	33 (67%)
Complicated-With	8	11(52%)	36 (78%)

Table 5. Avarage Scores of Problem-Solving.

	Total	Single Problems	Compound Problems
Simple-With	60.5%	75%	66.7%
Simple-Without	66.7%	91.7%	50%
Complicated-With	51.8%	55.6%	50%
Complicated-Without	41.1%	66.7%	25%

learners to reflect on what they have constructed during exploration.

In addition, this paper has described a preliminary evaluation of the interactive history system. Although we need a detailed evaluation with more subjects, the results indicate that the system facilitates a rethink on primary exploration processes particularly in a complicated hyperspace. The system can also improve learning, particularly integrating the contents of some WWW pages.

In the future, we will have a more detailed evaluation. We would also like to classify exploration purposes in detail to represent learners' exploration process more precisely.

Acknowledgments

This research is supported in part by Grant-in-Aid for Scientific Research from the Ministry of Education, Science, and Culture of Japan. We also want to thank Dr. Noriyuki Matsuda for his valuable comments for implementation of the interactive history.

References

[1] Brusilovsky, P. Methods and Techniques of Adaptive Hypermedia, Journal of User Modeling and User-Adapted Interaction, 6, (1996) 87-129.

[2] Chan, T.W., Lin, C.C., Lin, S.J., and Kuo, H.C. OCTR: A Model of Learning Stages, in Proc. of 6th World Conference on Artificial Intelligence in Education '93 (1993), 257-264.

[3] Conklin, J. Hypertext: An Introduction and Survey, Computer 20, 9 (1988), 17-41.

[4] Domel, P. WebMap - A Graphical Hypertext Navigation Tool, in Proc. of Second International WWW Conference (1994), http://www.ncsa.uiuc.edu/SDG/IT94/Proceedings/Searching/ doemel/www-fall94.html.

[5] Gaines, B.R. and Shaw M.L. G. WebMap: Concept Mapping on the Web, in Proc. of Second International WWW Conference (1995), http://www.w3.org/Conferences/ WWW4/Papers/ 134 .

[6] Kashihara, A., Hirashima, T., and Toyoda, J. A Cognitive Load Application in Tutoring, Journal of User Modeling and User-Adapted Interaction, 4, 4 (1995), 279-303.

[7] Kashihara, A., Kinshuk, Oppermann, R., Rashev, R., and Simm, H. An Exploration Space Control as Intelligent Assistance in Enabling Systems, in Proc. of International Conference on Computers in Education '97 (1997), 114-121.

[8] Kashihara, A., Uji'i, H., and Toyoda, J. Reflection Support for Learning in Hyperspace, Educational Technology, Vol.39, No.5 (1999), 19-22.

[9] Murray, T., Condit, C., Piemonte, J., Shen, T., and Kahn, S. MetaLinks - A Framework and Authoring Tool for Adaptive Hypermedia, in Proc. of World Conference on Artificial Intelligence in Education 99 (1999), 744-746.

[10] Nielsen, J. The Art of Navigating Hypertext, Communication of the ACM, 33, 3 (1990), ACM Press, 297-310.

[11] Tauscher, L., and Greenberg, S. How people revist web pages: empirical findings and implications for the design of history systems. International Journal of Human-Computer Studies, 47, 1 (1997), 97-137.

[12] Thuering, M., Hannemann, J., and Haake, J.M. Hypermedia and Cognition: Designing for Comprehension. Communication of the ACM, 38, 8 (1995), ACM Press, 57-66.

[13] Zeiliger, R., Belisle, C., and Cerratto, T. Implementing a Constructivist Approach to Web Navigation Support, in Proc. of World Conference on Educational Multimedia and Hypermedia '99 (1999).

Models and Strategies for Promotion of Distance Learning in Primary Schools and High Schools

Jia-Rong Jerome Wen * Chia Chin Li and Jian Jie Dung***
**jerome@nknucc.nknu.edu.tw djj@icemail.nknu.edu.tw*
116,Ho-Pin 1st Road,Kaohsiung,Taiwan,R.O.C
***april@ficnet.net*

The information education in Taiwan has been progressing rapidly since the Network Technology was adopted on a large scale.Under the Nine-Year Consistent Courses policy the by Ministry of Education, the information education will be integrated into other subjects and all teachers need to use computer and Internet resources to assist teaching .The plentiful education web sites on Internet also provide the student with materials for assisting learning .The essay presents the development process of information Education in Taiwan ;through it, we point out the obstacles we meet when promoting information education in primary schools and high schools.Meanwhile ,through introducing two education web sites :Gas Station for Learning and Schoolfellows' English Adventure Land, which were constructed in different models ,we offer the workable models and strategies for promotiing distance education in primary schools and high schools.

Keywords: **Distance Learning, Nine-Year Consistent Coures ,Teaching Material Resources Center, Schoolfellows' English Adventure Land**

1 Introduction

1.1 Analysis of Current Situation

"Nine-Year Consistent Syllabus" implemented in 2001, all schools will no longer especially establish the subject of Information Education, but enlist it in the learning area of "Nature and Technology." Nevertheless, in order to train students to have the basic abilities to make use of technology and information, teachers have to emphasize the application of information in the teaching of different subjects. And all teachers of different subjects are expected to take computer as a tool of instruction, integrate via network the traditional teaching materials and the teaching materials on Internet, and provide students with broader and more diversified learning resources.[2][3]

1.2 Problems Faced by Distance Learning:

To apply information education to the teaching of various subjects will really be a consistent trend in the education of Taiwan in the future. However, when confronted with the important educational reform, the actual implementation encounters difficulties because of Taiwan's restricted environment for information education.

The ratio of the number of class computers to the number of the students of a class is such a wide gap.If teachers are requested to use the limited computer classrooms to apply information to the teaching of various subjects, obviously, it is not an easy job to promote this at the current stage.[5][7]

2 Distance Instruction and Distance Learning

After the Ministry of Education implemented "Foundation Establishment Plan of Information Education," the computer and network equipment of various schools are increased. Besides, it also promotes the establishment of "Information Education Software and Teaching Materials Resources Center" at primary schools, junior high schools, senior high schools and vocational schools, in order to enrich the network teaching materials for subjects of primary schools and high schools.[1][8]

Besides, the famous distance instruction network of primary schools and high schools in Taiwan is illustrated as follows (Table1):

Web Site Name	Address	Institute	Object
Gas Station of Learning	http://content.edu.tw	Ministry of Education	Grade 1 to 12 student
Schoolfellows' English Adventure Land	http://192.192.186.8/seal/	San Hsin Institute of Housework and Commerce	Grade 1 to 12 student
Pathfinder	http://pathfinder.ntntc.edu.tw/	National Tainan Teachers College	Grade 1 to 9 student
Computer Assisted Instruction	http://www.wcjs.tcc.edu.tw/	Wu Chi Junior High School	Grade 7 to 9 student
Teaching Resource	http://www.ctjh.tpc.edu.tw/ctjh/resource.htm	Chiang Tsui Junior High School	Grade 7 to 9 student

Table1: Virtual Classroom Web Site for Grade 1 to 12 student

3 Teaching Materials Resources Center Focusing on Systematic Subjects

3.1 Concept and Idea:

The Ministry of Education in Taiwan starts "Foundation Establishment Plan of Information Education" not only to establish hardware environment, train teachers, carry out promotion activities, etc., but also to establish Information Education Software and Teaching Materials Resources Center, simply called "Education Resources Center" or "Gas Station of Learning."(http://content.edu.tw)

3.2 Outline of Resources Center:

The Ministry of Education advises various school to develop the on-line teaching materials of different subjects. The center can effectively integrate the resources of all primary schools and high schools and develop a series of network instruction resources with its own characteristics. "Teaching Materials of Subjects" are divided into four divisions: primary school, junior high school, senior high school and vocational school. In each group there are: 14 subjects in primary school, 19 subjects in junior high school, 17 subjects in senior high school, and 21 subjects of 4 categories in vocational school (the divisions of senior high school and vocational school was established in January 2000). The information integrated and collected by web sites cover the education resources of the Chinese's Five Education: virtue, wisdom, physical, group and aesthetics.

Through a united interface of users, it decreases the learners' load in adaptation to learning environment. The establishment of "Education Resources Center" is expected to achieve the following objectives: [6]

- Strengthen the applied network resources for teachers and students, and make the educational environment more diversified .
- Lay a foundation for a lifelong learning environment.
- Strengthen the quality and quantity of the resources of information learning so as to reach the aims of sharing of resources
- Shorten the distance between city and village [1]

4 Schoolfellows' English Adventure Land Focusing on Self-Learning

4.1 Concept and Idea

Teaching Materials Resources Center mainly edits the teaching materials according to the contents of the systematic teaching materials of various subjects. Therefore, they are suitable for teachers to adopt in class and for students to review after class. However, in the age of information explosion, the knowledge in books can no longer satisfy most of the students' thirst for knowledge. Therefore, with network being the media, distance education must have more diversified contents. It also has to create an interacting relationship between school and students. It can hold various kinds of activities and offer substantial awards to encourage all the students to participate. Then an activated distance learning environment can be created beyond system. Kaohsiung municipal government is positively involved in the activity. The "Schoolfellows' English Adventure Land , SEAL "(http://192.192.186.8/seal/) established by the municipal government at San Hsin Vocational School is based on this idea. It has the following characteristics :(1)Diversified Contents and Scope.(2)Individualistic Learning Environment.(3)Internet Learning without Limitation of Time and Space. (4)Flexibility of Time, Holding of Activities.(5)On-Line Contest,Internet Pen Pal Society.(6)Teacher Mechanism--Student Groups Management and Inquiry of Students' Learning Process:,Self-Made Test Paper Management:

4.2 Evalutaion on SEAL

The working group of Seal held an investigation in December 1999, towards the junior and elementary school teachers that used this website to assist their teaching. The questionnaire adapted Likert's five point scale from extremely disagree(1) to highly agree(5). In the 73 effectively retrieved questionnaires, there're 67 English teachers and 6 are not English teachers.

The statistics results of the questionnaire, in the curriculum arrangement and management session, show that sample teachers think the arrangement of the curriculum in SEAL is appropriate and the related activities that go with the curriculum is successful. (M=4.10 ,SD=0.82) ◦ Sample teachers think that the recording of learning profile on the website of each student helps teachers to understand the student's learning style and problems. (M=4.26,SD=0.83) ◦ Sample teachers think that the idea of designing language games and holding on-line composition contest is appropriate. (M=4.16,SD=0.83 ;M=4.03 ,SD=0.93) ◦ About the learning interaction, most teachers thinks that English pen pal club will help to enhance the interaction between students, M=4.18 SD=0.93) . Most teachers think that SEAL is worth popularizing in assisting traditional learning. (M=4.59,SD=0.66) ◦

5 Workable Model and Strategy

In the implementation of distance education in primary schools and high schools, besides the consideration of the contents of teaching materials, how to make use of the characteristics of Internet appropriately to activate instruction is an important topic that cannot be neglected for discussion. Focusing on the above-mentioned analysis, we propose a model and strategies for distance learning be carried out in primary schools and high schools:

5.1 Four Elements for Activating Web Site:

According to the discussion above,there are four elements to activate the web site teaching materials :the content, interactivity, learning profile and activity. We have to take these four elements into consideration when designing the learning web site. The detailed function of the four elements is as follow:

5.1.1 Content

Text, image, sound , photo , animation chip and other mutimedia components should be included in an excellent education web site.Through multiple information styles supplied , the student can obsorb knowledge easily

5.1.2 Interactivity

With more interactivity function the education web site is more attractive and effective .The interactivity machanism encourages the student to use higher -level cognition skill..

5.1.3 Learning Profile

The learning profile lets the student know what he has learned and what to learn .The porfile also provides the teacher information about the student.

5.1.4 Activity

Not only in classroom but also in virtual classroom, well-designed activities are very important to improve the effectiveness of learning . Besides, through holding an activity , the student can cooperate and compete with others .

5.2 Strategy for Promoting Distance Learning

From this point of view, we will suggest applicable strategies for school administrators,teachers and students.

5.2.1 As for school adminstrator:

∗ **Establishment of Web Site by Full-time Professionals:**
The school administrator should know there should be full-time professionals to put teaching materials on Internet, hold Internet activities and carry out the maintenance work of systems.

∗ **Strengthening of Propaganda:**
The education departments or general affairs units of schools should positively introduce such an environment in the learning of students, and positively hold activities of relevant kind.

5.2.2 As for teacher and related professional:

∗ **Development of Excellently Activated Web Site:**
A web site must have substantial contents , diversified activities as well as interactivity machnism and learning profile to make the web site become a dynamic and lively learning environment.

∗ **Material Making:**
Teachers need not learn the establishment of web site. Teachers' job should be an all-effort studying of suitable contents of teaching materials for the learning of students.

∗ **Resource Assisted Teaching:**
All the related teaching web sites need the teacher to use them .Many web sites are well constructed ; however,few teachers use it to assist teaching . The teacher can provide the web site constructor with feedback for promoting the funciton or the rescources of the web.

5.2.3 As for Students:

∗ **Participate in activities :**
Only students' participation can make web sites activated and meaningful; otherwise, web site is merely an empty shell in a waste of information development.

∗ **Resource Assisted Learning:**
The student can make good use of on-line material to assist learning after class ; meanwhile , the student's feedback also helps the web constructor refine the web .

6 Conclusion

After the implementation of "9-year consistent" new syllabus in primary schools and junior high schools, information will be applied to various subjects and the application of network resources will become broader. The information-application-oriented network learning functions can be facilitated more effectively. The "Plan of Teaching Materials Resources Center" undertaken by Ministry of Education integrates various schools' resource to establish a garden that provides teachers with instruction resources and students with learning resources.The Plan not only can reach the purpose of resources sharing, but also decrease the load of learning through united interface environment. Besides, the distance learning environment beyond system, as provided in "SEAL," is also a good example for primary school students and high school students to involve in distance learning.

In term of positive implementation of information education, it is important to cooperate with the existing instruction environment and choose a workable model. For the government, based on the principle of effective utility of resources, it is necessary for her to integrate the establishment and the sharing of instruction resources. For schools, they have to encourage teachers and students to use Internet positively to assist in their teaching and learning. For teachers, they might not be required to allocate teaching materials on Internet, but they have to use the existing Internet resources and teaching materials positively, adopt suitable instruction methods, and correctly use Internet to communicate with students or parents. For students, they should meet the instruction of schools, use the teaching materials on Internet to assist in their learning, and learn new knowledge themselves.

References

[1]Bates A.W.,"Technology, Open Learning and Distance Education",Routledge. (1995)

[2]Chin Nian-Shing , "The World Wide Web Integrated Learning Environment", Information & Education ,vol 64, Taichiung Home Economical and Commercial Vocational School . (1998)

[3]David H. Jonassen:,"Computers in the Classroom: Mindtools for Critical Thinking", Prentice-Hall. (1996)

[4]Hung Ming-Jou,"Teaching On Internet", Hua-chai Software. (1999)

[5]J. Mark Pullen (1999):Synchronous Distance Education and the Internet. George Mason University.

[6]The Preface of "Gas Station of Learning,http://content.edu.tw/new/intro1.htm(2000)

[7]Wang Chuan-Shi: "Experimental Research on Adoption of Information Technology in Subject of Chinese Language at Primary School.",Research Plan of Graduate School of Information Education of National Kaohsiung Normal University, unpublished.

[8]Wang Wen-Ke,"Research Approach of Education (new ed.)", Taipei City: Wu Nan. (1999)

Multimedia Whiteboard Design in* WWW-Based Remote Cooperative Education System

Xueli Yu, Zongxia Du and Shiping Li
Taiyuan University of Technolygy, Taiyuan, Sahnxi, PRC
E—mail: xlyu@tyut.edu.cn

Computer Supported Cooperative Work (CSCW) is combined into the remote education, and the WWW-based Remote Cooperative Education System (RCES) is designed and realized in the paper. RCES adopts Browser/Serer model and makes users be able to run the client over the Internet without the need of installing special client software. And the real-time communication tool in RCES - multimedia whiteboard is also designed and realized which is also the major tool of CSCW. A set of Control Transport Protocol (CTP) is proposed to transmit the data and realized with Java and Java Media Framework (JMF). The new system enhances the interaction capability and realizes live transmit of multimedia data including graphics, images, audio and video etc.

Keywords: **CSCW, RCES, CTP, whiteboard**

1 Introduction

The theory of Computer Supported Cooperative Work appeared along with the progress of society, development of science and technology and raise of the complicated level of work. It provides a "being face-to-face " and What You See Is What I See (WYSIWIS) environment for the users scattered on different time and in different space and makes it possible for computer system to raise group work efficiency as well as traditional individual work efficiency. Since Engelbart first demonstrated CSCW in the 1960s, a variety of CSCW applications have developed at several research laboratories and universities. Education is an inherently cooperative activity involving at least one teacher and one student. Now, we combine CSCW into remote education, design and realize the WWW-based Remote Cooperative Education System (RCES). It adopts Browser/Server model and makes users can run the client over the Internet without the need of installing special client software.

Whiteboard is an important tool in the WWW-based RCES. The whiteboard provides a real-time interactive environment among people. In the traditional education, teacher and students face to face exchange their opinion through blackboard in classroom. While in the WWW based RCES on-line exchanging opinion and consulting are fulfilled through whiteboard over the Internet. Except the basic function, the whiteboard adds some functions such as drawing, loading images etc. The existing whiteboard system can roughly be divided into two kinds: systems based on Client/Server model and systems based on Browser/Server model. The whiteboard based on C/S model can solve well the interaction problem and provide powerful function for users. Its defect is that the users have to install the client software as server does. That limits the application scope of the system. Compared with it, the whiteboard based on B/S model can run over the Internet and the client doesn't need special software, but a

*Supported by the Foundation of Returned Overseas Students and Scholars in Shanxi Province browser such as IE or Netscape navigator is needed. Apparently B/S model gives a more convenient environment to the users. But its interactivity is less than C/S model and most present whiteboards based on B/S model only transmit the information such as texts, graphics, images, but do not support the transmission and playback of the time-based information such as audio and video.

We design and realize a new real-time communication tool in RCES—multimedia whiteboard that is also the major tool of CSCW. It absorbs the advantage of systems mentioned above. New system adopts B/S model

and makes users can run the client over the Internet without the need of installing special client software. In addition, we design a set of Control Transport Protocol (CTP) in order to transmit the data and implement it adopting Java and Java Media Frame (JMF). Compared with the present whiteboard, the new system enhances the interaction capability and transmits multimedia data lively including graphics, images, audio and video etc. And the live audio and video can be transmitted and played back on this new whiteboard to make the system more practical.

2 Control Transport Protocol Design

TCP/IP and UDP are the major protocols of the Internet and they are well supported by Java. The multimedia whiteboard runs over the Internet, so the system is mainly based on TCP/IP. When multimedia information is transmitted, Real-time Transport Protocol (RTP) is used, which is a protocol based on UDP so as to get better playback effects. In order to transmit and deal with the system information over the Internet, we design a new control protocol of application layer—Control Transport Protocol (CTP) that is special for the whiteboard system. We design it on the basis of the whiteboard function and build it in the request/response model.

Owing to assuring the accuracy of data transmission by TCP / IP, therefore, the design of CTP should be as succinct as possible under the promise that the function is guaranteed.

The CTP set can be represented as a multi-element set (D, F, n, a_1, a_2, … a_n). Here D represents the transfer direction. If data is transmitted from server to client, and then D="S", whereas D="C"; F represents the catalog of transfer data. For example, if a user wants to transmit the login data, and then F="login"; n represents the number of associated information and the concrete associated information is represented by a_1, a_2, … a_n. For a line, n=6, a_1="line", it is one of graphics styles. a_2 =color of paintbrush, it is an integer, a_3, a_4, a_5, a_6 are the starting and end point coordinate of this line. If the number of associated information is uncertain, and then n=-1, the subprotocol is ended with "ok". This protocol set can be expanded easily. For example, we want to transmit the polygon, we can add ("C","polygon", -1, the color of paintbrush, abscissa of starting point, ordinate of starting point, abscissa of the second point, ordinate of the second point, …abscissa of end point, ordinate of end point, "ok") to the CTP set.

Table 1 Control Transport Protocol Set

Tasks	Protocol
User applies* to join in a discussion room	("C", "join", 1, the topic of discussion room)
User applies to pause the communication	("C", "pause", 0)
Server demands** to refresh the room and the user lists	("S", "refresh", -1,the topic of room 1,the user 1's ID in the roon $_1$,e the user 2's ID in the room $_1$, "complete", the topic o room $_2$,e the user 1's ID in the room $_2$…"complete", the topi of room $_n$ the user 1's ID in the room $_n$,"complete", "ok")
User applies transmit the graphics	("C", "draw", 6, graphics style***, the color of paintbrush, ab scissa f of starting point, ordinate of starting point, abscissa o end point, ordinate of end point)
Server demands transmit audio data	("S", "audio", 1, IP Multicast address)

Note: * The data from client is transmitted to server only;
** The data from server is transmitted to all clients in the same room;
*** The style of graphics includes line, point, oval and rectangle etc.

3 The method of solving key problems

The whiteboard is a major tool to help the cooperative education system to fulfill the cooperation. We have solved the key problems including technical problems about CSCW, problems occurred during multimedia transfer and so on. The method of solving key problems in the whiteboard is described as following:

1) The method of solving CSCW technical problems in the whiteboard

CSCW technical problem generally includes role-control, data consistency, conflict clearing, concurrency control and so on.

① Role control
Every user who logs in the system will play a role. In the education system, users are divided into 2 class: Teachers and students. By means of User ID, users get their roles and authority from existed user information database soon after they log in. Then according to their different roles and authority, related system functions are given.

② Data consistency
We use the method of Client/Server to solve the problem of data consistency. The whiteboard server maintains a set of global data and the data on each client PC are same as those on the server. When users operate with the data on client PC, this PC sends message to the server first. The server updates the global data and then informs the clients of the modification. At last, the clients update local data to keep the coherence of the whole system.

③ Conflict clearing
The conflicts in whiteboard mainly refer to data resource conflicts during transfer. They are due to the limited bandwidth and the high frequency outburst during data transfer. When several users send data at the same time or a certain user sends a mass of data, the congestion will occur in the web. Hence, data may be discarded or errors may be caused. Further, valid data have to be sent again and the congestion will be more serious. This problem is solved by way of data priority (PRI) when designing the system. That is to send the vital data first. Data PRI can be divided into 5 levels. They are listed in orders from higher to lower. i) Data such as users login information or screen-refreshing data, because these data will influence all users; ii) texts and graphics; iii) images; iv) audio; v) video. Data in higher level are always sent first.

④ Concurrency control
Concurrency control mainly indicates the conflict of shared resource used by users at the same time. Solving this problem is very important to fulfill cooperation; this factor must be taken into account in. Because the system belongs to distribute one, hence the concurrency control is very complex. Typical method of dealing with concurrency is the locking or time stamp. Relatively, the former is more simple and valid. The method of locking is adopted in the paper.

In our Server/Client system, synchronous block is created in each subprotocol of the protocol set. All operation of the subprotocol is performed in its synchronous block, so as to limit output stream or input stream that accesses to the web at random. As a result, when a thread processes a subprotocol, it can monopolize the shared resource and the other threads cannot access the resource. Thus a thread is able to process a subprotocol without disturbance from the other threads and system error can be avoided. The disadvantage is that efficiency of thread operation will be decreased. So the code in a synchronous block should be limited as little as possible under the promise of correct subprotocol operation.

2) The method of solving problems in the multimedia transfer

Multimedia information can be divided into 2 classes. One is information irrespective of time, such as text and graphics. The other is time-based information, such as audio and video. Because audio or video restrictively demands real time, discarding errors and ignoring lost data will achieve better effects. So audio and video information are transmitted by the way of UDP-based real-time transport protocol----RTP. It provides real time media transport services, such as live audio or video. These services include data type, sequence number, time stamp and transfer supervising. In fact, RTP itself cannot fulfill data-transmitting service without the help of protocols in lower level of the networks. The head of each RTP data packet includes time stamp and sequence number. With the time stamp, the receiver can resume the original data sequence. With the sequence number, the receiver can deal with lost, repeated or error data packet.

On the other hand, because the audio or video information is usually a large amount, and needs long time to transfer, it will take up too high bandwidth. In the situation of multi-users over the Internet, the method mentioned above cannot achieve good effects. We take advantage of IP Multicast Technique to save bandwidth, and the transferring and playing back audio or video smoothly in narrower bandwidth can be realized. IP Multicast Technique is a complement to the standard protocols of network level. It uses D-Class IP address

that possesses the same byte length as A-Class, B-class or C-Class address. And the scope of D-Class address is from 224.0.0.0 to 239.255.255.255 in decimals.

D-Class address is a kind of temporary address that is assigned and recovered dynamically. Each multicast group is corresponding to a dynamic D-Class address. After the multicast group finishes, its related D-Class address will be taken back to be used later. D-Class IP address is the multicast address for a whole group and the members in this group share the same D-Class IP address. So the information from the source node is sent only to members in this group. Furthermore, only one packet is sent to the site on the same route and the action of copying is performed only when needed. This process is different from point-to-point system (in point-to-point system, each destination site needs a copy). So we are able to save lots of bandwidth resource, increase the members on networks and eliminate the aimlessness of broadcast with the multicast way.

Because the standard JAVA API doesn't support transfer and playback of video information, the Java Media Framework produced by Sun Company can be applied. In fact JMF is a group of Java class library, which is created specially to remedy the incomplete support to multimedia in Java. JMF collects and plays multimedia data in Java applications or Java applets. JMF itself supports both RTP and IP Multicast Technique, so it is very convenient to transmit and play audio or video back with JMF.

4 Multimedia information flow

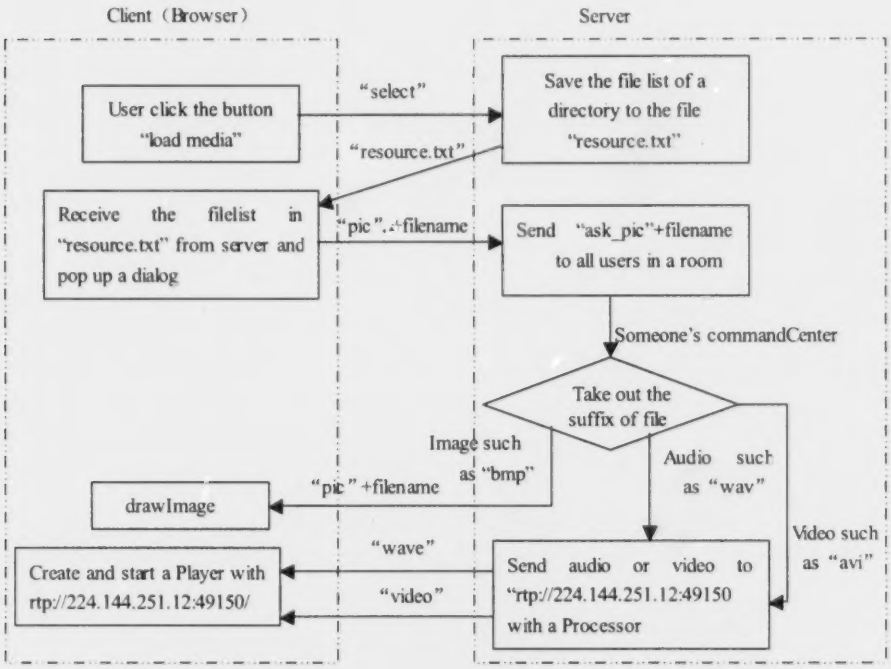


Fig.1 Multimedia information flow

Multimedia information flow is as shown in the figure 1. Taking the example of transmitting loaded multimedia information, the system flow is given out while users discuss using the whiteboard. When a user wants to load multimedia on the client, the client will send message ("C", "select", 0) to the server, which indicates the user wants to select loaded files. On receiving this message, the Sever sends a file list that is stored in a file named as "resource.txt" to the client. Then the client reads the file list out of that file and displays it in a new file-selecting dialog box. Hence the user can select the file that he wants to load and the message ("C", "pic", 1, filename) is sent to the server.

After the server receives this message, it sends the message ("pic"+ filename) to every user object that belongs to the server. Please note that this message is sent not to the client side but to the related user-information object in the server. According to the suffix of the file, the server knows it is an image, an audio or a video file that is needed by the client. If a picture is wanted, a message ("S", "pic", 1, filename) is sent to the client and the client calls drawImage () function to present the image by its filename. If the audio or video is wanted, the Server will create a D-class multicast address and send multimedia data to this address. Meanwhile the Server sends to each user in the room a message "audio"(in case of audio data) or a message "video" (in case of video data). Thus the clients are informed to join in the related multicast address so that the audio or video can be played back.

5 Conclusions

In order to test the performance of new system, we not only apply text, image, animation, and drawing graphic, but also apply most challenging time-based media – audio and video – to this system. The result is rather good (Testing condition is: rate of network is over 40 Mbps, one server and 5 concurrent users, on-line transferring and playing back audio and video).

Remote education is an application on networks that develops rapidly in recent years. With the never stopping development of network technique and multimedia technique, the users' demand on remote education will be higher and higher. We combine CSCW technique into remote education and make the system possess more and better mutual functions. Based on the past man-to-PC mutual mechanism, we add man-to-man mutual mechanism to the system. Now the educating process becomes more vivid, and better education effect is achieved.

The real-time communicating ability of most B/S model software in present cannot satisfy the users' demands. Taking this factor into consideration, we design and use CTP to transmit control message and non-time-based media information and combine RTP and IP Multicast Technique with CTP to fulfill the transfers and playback of multimedia information. Hence the real-time communication ability of the system is enhanced. Compared with the present whiteboard in B/S model, the system has stronger function in transmitting the multimedia. It can't only transmit the audio and video in files, but also can transmit the live audio and video to get better effects in education. The students can hear or see the teacher and communicate with him or her in real time.

Though most present software in B/S model are weaker than those in C/S model, the convenience that they possess provides a large latent market. Furthermore, with the development of the browser and other related techniques, the functions of software in B/S model will become more and stronger. In a word, the prospect of software in B/S model is promising.

References

[1] Liang ,Ting-Peng. When Client/Server Isn't Enough: Coordinating Multiple Distributed Tasks, Computer of IEEE, May 1994

[2] Mohammad Banikazemi. IP Multicast: Concepts, Algorithms, and Protocols http://src.doc.ic.ac.uk/computing/internet

[3] Nathaniel S. Borenstein, Computational Mail as Network Infrastructure for Computer-Supported Cooperative Work, Proceedings of CSCW 92, 1992, pp 67-74

[4] RTP: A Transport Protocol for Real-time Applications, RFC1889 http://src.doc.ic.ac.uk/computing/internet/rfc/rfc1889.txt

[5] Teege G. Object-Oriented Activity Support: A model for Integrated CSCW System. Computer Supported Cooperative Work. 1996, 5

Navigation Script for the World Wide Web

Sachio Hirokawa*, Kengo Nishino and Daisuke Nagano*****
** Computing and Communications Center, Kyushu University,*
**E-mail: hirokawa@cc.kyushu-u.ac.jp*
*** *** Graduate School of Information Science and Electrical Engineering, Kyushu University*
***E-mail: Kengo.Nishino@ma3.seikyou.ne.jp*
****E-mail: nagano@matu.cc.kyushu-u.ac.jp*

In the World Wide Web, there is rich material for education. We propose a language to navigate students through the educational material on WWW. Navigation script makers can describe a tour with sequential, parallel and selective controls. It supports multiple Threads where video and audio accompany a browsing window. The language is described with XML and implemented in Java. So, the system can be used as an applet and as an application.

Keywords: **Hypermedia navigation ; Web graph ; XML ; JAVA**

1 Introduction

In the World Wide Web, there is rich material for education. For example, many university teachers give the contents of their lectures as their homepages. This paper describes a system which utilizes internet resources as educational material and makes them into an organized tour. The tour is described in a script language and an interpreter program navigates students through the material on WWW. Students are navigated automatically and interactively while they browse html-files and listen to and watch continuous multimedia.

We need to collect necessary pages from web resources containing a lot of garbage in order to make lists of URLs for our educational purpose. It is important to have students understand the relation between the collected pages and grasp the whole view of the field. When they do not understand the relation, or when they forget how they arrived the page, they feel that they got ``lost in webspace". There is a proposal of using web graphs as imaginary map of WWW[3]. A web graph is a directed graph whose nodes are URLs and whose edges are links between URLs. The web graph is more intuitive than just a list of URLs. But a web graph is nothing but a static representation of WWW. There is no mechanism how to lead students with material on the graph. There is no dynamic process to navigate them. We propose a script language that describes the navigation of WWW.

Maps are useful for navigation of real world and for navigation of WWW. For example, the page of Mapion http://mapion.co.jp/ shows geographic maps of towns. Besides, ``car navigation systems" based on GPS are becoming popular. RWML[5] and NVML[6] are proposal to combine the geographic map and the information on WWW. NVML describes the driving course, distance, time and supplies messages and images for specified points. When the car passes the point, a message and a image will appear according to a signal from GPS. The main concern of these researches is in geographic maps and navigation in real world. The maps we consider are imaginary maps of internet resources. Our goal is to design a language to describe a tour of WWW and to implement an interpreter of the language.

Ariadne[4] is a system of WWW navigation. It has a browser window and a separate window of tour. A user views the map of the tour and can proceed forward, backward and can choose if there are branches on the tour. But user needs to control every step of navigation. Our system supports both interactive and automated navigation. Another feature of our system which lacks in Ariadne is the parallel navigation. In our system, while a user is watching a browser window, another navigation thread can play audio data.

WebOFDAV[1] is a visualization system of web graph. When a user is traversing a series of URLs, the system draws the local graph of visited pages. The graph changes dynamically following the user. WebOFDAV is useful to tell where we are on WWW and powerful to get rid of the problem of lost in webspace. But the graph is used only for an aid for browsing and no navigation route is provided.

The rest of paper is organized as follows. The section 2 analyses the basic feature of navigation of WWW. The section 3 describes the navigation script using XML and explains the visualization of the scripts. The section 4 introduces a virtual machine with two stacks, which enables forward and backward navigation. The section 5 summarizes the paper.

2 Navigation Script

The most important feature of the navigation system is to guide the user around web pages in specified order. Therefore, we adapt sequentiality into navigation language. And to make the contents of html-files easier to understand, we need to combine audio, video, and images together with the usual browsing window. We introduce parallelism. To increase the variation of the navigation depending on each visitor, we add selection mechanism in the language. We design the language as a structured programming language with sequential, parallel and selective controls. The basic navigation units are multimedia data specified as URLs.

We chose XML as the description language of the navigation for simplicity and extendability. As implementation language we chose Java. We use ``XML Parser for Java"[2] for XML parser,and ``JMF"[7] for multimedia data. We describe the language as the following DTD (Document Type Definition).

```
<!ELEMENT statement (simple|sequential|parallel|select)>
<!ELEMENT simple (message)>
<!ATTLIST simple kind CDATA #REQUIRED
   target_name CDATA #REQUIRED
   play_time CDATA #REQUIRED
   delay_time CDATA #REQUIRED>
<!ELEMENT message (#PCDATA)>
<!ELEMENT sequential (simple|sequential|parallel|select)*>
<!ELEMENT parallel (simple|sequential|parallel|select)*>
<!ELEMENT select (selector)+>
<!ELEMENT selector (simple|sequential|parallel|select)>
<!ATTLIST selector selectname CDATA #REQUIRED>
```

Each tag and parameters have the following meaning.

- <statement>: This tag represents the root of navigation tour. It may contain subtours as children. There are four kinds of tours,<simple>,<sequential>,<parallel> and <select>.
- <simple>: This is the basic unit of the navigation. It contains a few lines of messages to describe the contents of the web page. It has the attributes of kind, target name, play time and delay time. Target name specifies the URL of the data. The kind describes the kind of multimedia data. Play time is the duration time and delay time is the time to wait before play.
- <sequential>: It may contain subtours of the kind <simple>, <sequential >, <parallel> and <select>. Subtours are followed consecutively.
- <parallel>: It may contain subtours of the kind <simple>, <sequential>, <parallel> and <select>. Subtours are activated in parallel.
- <select>: This tag causes a pause of the system. User can choose the navigation selectively from the given subtours. Those subtours are provided as children with the tag <selector>.
- <selector>: It may contain a subtour of the kind <simple>, <sequential>, <parallel> and <select>. It has the selectname as an attribute, which is used in the select menu.

3 Navigation Window, Control Panel and Browsing Window

Fig 1 is a screenshot of the system, which has a browser window, a quicktime movie screen, the controller screen and the window of navigation script.

We chose the representation with nested boxes for the visualization of navigation script instead conventional DOM-tree of XML nodes for several reasons. The most important feature of the navigation is the flow of time. To visualize this, we draw the subtours of a sequential tour from left to right. In Fig 1, time goes horizontally from left to right. Parallel tours and visualization of selection are placed vertically. The difference is that each subtour of the selection has its name, specified with its selectname, and the order in the choice. For example, if a selection has three choices, the second subtour is displayed as ``2/3 selectname".

Visualization of navigation script is not only for static view. It has a control panel and user can go forward and backward along the navigation. When a node is displayed on the browser window, the node in the navigation window is highlighted. So, the user has always global view of the navigation.

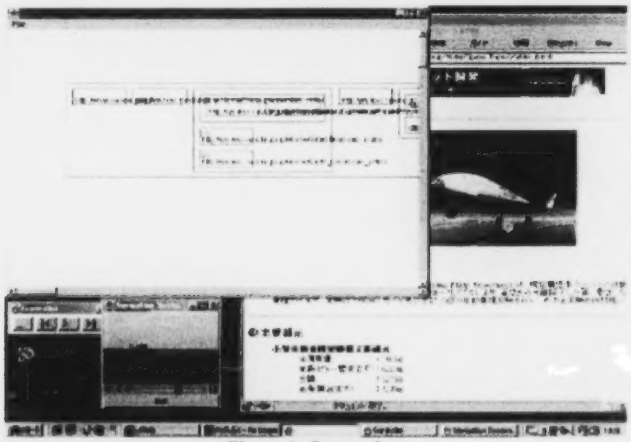


Figure 1: Screenshot

4 Interpreter of Navigation Script

Navigation is performed according to the kind of statement. Parallel statement opens a new browser window and a different thread performs the navigation in parallel.

The interpreter has two modes, the fully automatic mode and the interactive mode. Basically, the interpreter displays the specified html-files on the browser window. It displays the html-file on the screen for "play time" and changes to the next screen. When the user wants to see in detail, he can make a pause. He can go backward as well. The controller interacts with the user. The functions of the controller are "pause", "play", "forward", "backward", "rewind" and "stop". The "play" and "pause" toggles the mode. The "forward" and "backward" are for interactive mode. The browser screen moves one step in the sequential statement. This control is different to the controllers of multimedia players for the continuous media.

To realize forward/backward control in the navigation, we use two stacks of statements in the interpreter. The first stack "do"contains the list of statements to follow. The second stack "done" contains the list of statements already performed. The interpreter is realized by a transition of states depending on the top of the two stacks.

4.1 Forward Transition

Due to the limit of space, we only explain the forward transition concerning to parallel statement. If a parallel statement contains substatements, the interpreter creates n-1 threads which begin execution with ``done" stack empty and whose "do" stack contains the substatements. For example, a parallel statement "<parallel>a b c</parallel>" creates two new threads(Fig 2).

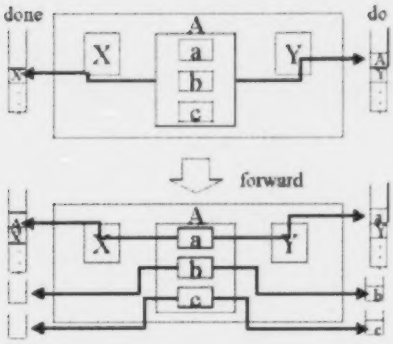


Figure 2: Forward Transition for Parallel Statement

4.2 Backward Transition

In the backward transition, the interpreter pops the statement at the top of ``done" stack and pushes it on "do" stack. If it is a sequential statement, then all the substatements are poped out of the "do" stack. A situation, where the "done" stack is empty, occurs only after a forward transition of a parallel statement. To go backward from such a situation, we need to delete such threads activated by the parallel statement.

5 Conclusions

We proposed a language for the navigation of WWW and described its implementation. The material of a navigation tour is web pages and multimedia data on WWW. The navigation script is defined as DTD of XML. Anyone can create a dynamic navigation from a static list of URLs. The language supports multimedia data and provides sequential, parallel and selective constructs of the tour.

References

[1] M. L. Huang, P. Eades, R. F. Cohen, ``WebOFDAV -navigating and visualizing the Web on-line with animated context swapping", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 638-642, (1998).

[2] IBM, ``XML Parser for Java", http://www.alphaWorks.ibm.com/tech/xml4j/(accessed on August 9,2000).

[3] D. Ikeda, T. Taguchi, S. Hirokawa, ``Developing a Knowledge Network of URLs", Proceedings of Discovery Science '99', Springer Lecture Notes in Artificial Intelligence Vol. 1721, 328-329, (1999).

[4] J. John, A.T. Jensen, K. Geronbak, ``Ariadne:a Java-based guided tour sys-tem for the World Wide Web", Proceedings of 7th international WWW conference, Computer Networks and ISDN Systems, Vol. 30, no. 1-7, 131-139, (1998).

[5] RWML Working Group, ``Road Web Markup Language (RWML) Draft Ver.0.71a (in Japanese)", http://www2.ceri.go.jp/its-win/RWML/RWML-071.html (accessed on August 9,2000), (1999).

[6] M. Sekiguchi, K. Takayama, H. Naito, Y. Maeda, H. Horai, M. Toriumi, "NaVigation Markup Language (NVML)", submission to the World WideWeb Consortium, http://www.w3.org/TR/NVML(accessed on August 9,2000), (1999).

[7] Sun Microsystems, ``Java Media Framework", http://java.sun.com/products/java-media/jmf/2.0/index.html (accessed on August 9,2000).

Networked Constructive CAI System Putting Emphasis on Communication and Discussion—An Example of Proportion-concept in Mathematics of Elementary School

Pou-Yah Wu*, Yi-Ling Lu, Ruey-Chuan Wu, Hsiao-Yun Wu and Shin-Pey Chen**
Department of Mathematics Education, National Tainan Teachers' College, Taiwan
E-mail: *pywu@ipx.ntntc.edu.tw **a8817209@wwes.tnc.edu.tw

New courses in mathematics of elementary school in Taiwan emphasize constructive pedagogy about solving problems, reflection, studying and learning, communication and discussion. The development of computer technology provides the environment of discussion, facilitating the convenience for communication. This study adapts itself to the change of teaching material for new courses, establishing connection by the operation of lineal graph. As far as the system is concerned, via elucidating the process of solving the problems, the system attain the effect of reflection; it establishes the virtual students and room for on-line discussion to achieve the aims of studying and learning, communication and discussion; letting the platform to the students to fulfill the concept of constructive pedagogy. After the future leased network become more popular and the computer interfaces become more humanized, we believe that the effects of communication and discussion will become better. Besides, the norms of discussing the order in this system will leave much to be desired.

Keywords: **CAI, mathematics of elementary school, proportion concept, Web-based learning.**

1 Introduction

New mathematics courses of elementary school in Taiwan adopting constructive pedagogy in 1993, thinking that the learning of mathematics knowledge is cultivated gradually in the processes of solving the problems, reflection, discussion and modification. Mathematics' meaning is formed individually, but the accumulated thoughts of the wholly social mass and cooperation can provide the best learning environment of mathematics. We hope that we can provide the learning environment of mathematics from the accumulated thoughts and cooperation by means of the networked constructive learning environment. The constructive pedagogy of new courses aims at the communication and discussion between the students[1]; however, communication and discussion waste much time. Thus, there is deficiency of time in teaching in the real pedagogy; nevertheless, the discussion of the virtual students and networked on-line learning can well make up the limitation of time and space, owing to the fact that the learning activities can be carried on at any moment and at any place through the network. The need of clarifying the concepts to communicate and discuss between emphasized by new courses can also come true. This study aims to associate the virtual students and networked learning, designing networked constructive learning environment, providing a environment for communication and discussion, helping students construct the concept of proportion, letting the communication can be undertaken immediately between the learners, between the learners and the virtual students, making up a wholly cooperative learning environment, thereby facilitating the students to clarify and to develop mathematics concepts.

2 Principles of System Construction

2.1 Basis of Learning Theory

Constructive pedagogy let the students establish his conceptual structure with new things; the teacher helps the students construct knowledge only. Thus, the teacher plays the role of posing the problems; the real solver of the problems is the student. Basically constructivism stresses the concept of learner-centeredness. With a view to fulfilling the educational ideal of child-centeredness, new courses emphasize the students' natural thought and the individual difference[1]. Why the students' natural thought be stressed? Because the learner has to construct knowledge positively, and he constructs the knowledge on his own natural thought. To adapt the various natural thoughts, in addition to "time difference" of the individual difference in the process of the students' learning, the so-called "route difference" is added [3]. Thus, the learner may adopt different ways of solving problems to form various records. New courses stress the activity of solving problems and reflection to accumulate related experiences of activities to serve as the foundation of upholding mathematics knowledge. Thus, the issued culture within the class in the lower grade courses, then, emphasizing discussed culture in classes of higher grades, partly discussing students via classes, and partly reflecting his own thoughts about solving questions[1].

2.2 Basis of Course Content

Old courses in 1975 emphasize the processes manifested; therefore, what the old courses lay stress on the proportion concepts is the exercise of the abstract meaning on ratio, thus looking upon the definition of "ratio" as the multiplicity relationship between comparative amount and that of standard, and using the viewpoint on "A• B=A ÷ B =A/B" to look at the questions of ratio; while what new courses emphasizes is the process that children construct mathematics concepts, therefore new courses think radio is two amounts A and B, causing the match relationship owing to some reason, calling these number A and B have equal relationship., and using "radio" is "A• B" to record the equal relationship between A and B, considering the question of ratio is based on equal relationship and transfer to another equal relationship of the same value, via the simultaneous repetition and the equal cut activity of the two amount of the equal relationship [2]. The previous activity of ratio problems in new courses in 1993 is that of exchange, and the solving tools of ratio problems are the graph of ratio line. Owing to the operation of lineal graph, we can grasp the relationship of radio to further the activity meaning of transference.

2.3 Basis of System Establishment

The system is a learning environment in the internet, adopting three-tier client/server system architecture, namely adding a layer of Service Server to the original structure of two -tier client/server system architecture. In the three -tier client/server system architecture, the management part of learning data is in the charge of Database Server, Web Server assumes the responsibility for teaching; whereas the client user is carried on by all kinds of learning activities through browser.

3 Simulation of Networked Constructive Pedagogy

In order to grasp the "route difference" of the students' mature concept, the system must recognize clearly how the students think about the problems and how they solve the problems so as to adjust the next activity according to the students' thought and to help children clarify the concepts by using the communication of solving the problems and mode of discussion, so the learner's mathematics knowledge can be upheld accordingly[4,6]. Thus, the system designs operation tool table (as in Figure 1), in which all sorts of tools represent various modes of thought. The students have to utilize these tools to solve the problems; owing to the different tools, the system can grasp the students' process of solving the problems and thought. The flowchart of teaching in this system (as in Figure 2) starts with posing the problems as far as the pedagogic process of any problem, then it is up to the children to decide if they need to be provided clues or graphic emblems to help comprehend the messages of the problems. If necessary, the system has to check out the problems of the same lineal graph as number of ratio problems from database of "ratio lineal graph" and the lineal emblem (as in Figure 3); if the students have comprehended the messages of the problems, enter the students' solving the problems. The students solve the problems with all sorts of tools in tool table; then the system judge the mode of solving by the difference of thought of tools• strategy 1, strategy 2,.•. •Different types of solving enter various tableau, and ask the students explicate the process of solving. The system designs some problems according to the types of solving, helping the students reflect. Through the issue and clarification, the spirit of "mode of communication in the process of solving" would come true. After reflecting the process of solving, the students can choose to study and learn the virtual students' other ways or discuss and communicate with others on the line (as in Figure 4). In case there are students, they can enter discussion room for discussion (as in Figure 5); if there is no student on the line or no one wants to study and learn from the perspectives of others, you can enter the virtual students' various ways and elucidation (as in Figure 6)[5].

4 Architecture and Implementation of System

4.1 Design Environment and Tools

This system uses Windows NT server as server as platform. The developing languages include HTML, JavaScript, Active X, ASP (Active Server Page) and so on. ASP is used as the chief way of control and ASP and ODBC (Open Database Connectivity) are also exercised to go with them. The management of teaching material and the users become simplified. As far as the editing course software, Authorware 5 is mainly utilized as the developing tool.

4.2 System flowchart

• (1) Pedagogic situation of networked construction

The flowchart of pedagogic system on the networked construction is manifested in the Figure 7 and the explanation is as follows. The system, through the previous analysis in advance of the class, judges the students' a priori knowledge, by which the system poses the problems, letting the learner solve the problems by themselves. While the students encounter the bottleneck of solving, he can choose the types of the basic lineal graphs or the lineal graphic emblems, and he may discuss and communicate with the students on the line or with virtual students; if the student solve the problem successfully, demand the process of solving and explain those of solving (reflection), then discuss and communicate with the students on the line or with the virtual students. Afterwards, ask the students to record again and explain the process of solving the problem, exploring if the student canuse and repeat the strategy of solving in an even simpler and more abstract method, meaning to judge whether the students can comprehend others' methods of solving to proceed the overall assessment finally. Before putting an end to the system, a test about ratio level of thought development as nonroute subject will be exercised on the students, thereby the director will reach a deeper realization of the students' development.

• (2) Database for "student model": Student model consists mainly of four databases, recording the students' basic data, analyzing their process of solving the problems, the routes of learning and the constructive concepts so as to comprehend their learning state for the reference of posing the problems, by which to understand the students' bottlenecks in learning in order to help them.

• (3) Database of "posing problems of constructive pedagogy": It saves the teaching content of constructive pedagogy, which contains various types of pedagogic processes, providing the system with sufficient competence to adjust pedagogy positively.

• (4) Database of "questions for tests": It stores the questions for pretest and posttest. The pretest is used to comprehend the students' acquired knowledge, whereas the backward test, according to the various aims, can be divided into two kinds--formed test and overall test, adopting the proper mode of test.

4.3 Functions of On-line Communication

• (1) Discussion group: This is an open, instead of being a synchronous, discussing place, letting the learner put up the problems on the cooperative notebook while encountering difficulty; other users can answer these problems.

• (2) Discussion room: It provides a synchronous and open discussing place, in which the learner can put forth the explanation, suggestion and exchanging viewpoints as to the difficulty aroused in learn ing or as to various strategies for solving the problems.

• (3) On-line call: It belongs to the way of one-to-one real-time communication, providing the user with a brief piece of information immediately, to other users on the line or even the teacher, asking them to undertake discussion in Discussion Room.

4.4 Operation flowchart

When the user enters the system by using browser for the first time, the user has to register in advance (as in Figure 8), by which the system acquires the user's related basic data, so as to proceed to analyze and check. Then take the pretest about background knowledge of learning point to understand if the software content meets the students' need. The system will set the problems according to all types in the problem database (in order to avoid repetition, each type of problems are given at random), and record the state of the learner's study, according to which, the system would produce routes of connection automatically; and it changes the original learning routes by means of the artificial intelligence. It undertakes the proper learning route according to the students' learning state. Later on, whenever the user enters by using browser for the first time, he has to key in the user name and password. The system can proceed to check, and after making sure, the system will continue the previous learning in accordance with the learning record left in advance. When the learner surveys each teaching activity, the system can record the learning process serving as the analysis of learning. The learner can utilize the function of check to understand hie own state of learning. After each learning is finished, the system will demand each learner record the process of solving and then pose the problems again to give the learner the test; according to the learner's answering state,

which pedagogic activity will be decided to be carried on actively accordingly.

5 Conclusions

Constructive learning theory will be developed far better if it is carried on network by constructive pedagogy, because networked learning can provide an excellent environment for discussion, upholding the convenience for communication; networked learning can attend to the individual difference, because each student is a leading role. The learner can control the progress of learning by himself, achieving the suitable learning. Networked learning the students' social circles of interaction become larger, not confined to the group of his own class. However, if the real situation by simulation can be added, it is believed that it will draw much attention from students' learning, promoting the learning effect.

References

[1] The seminar of Taiwan Elementary Teachers . 1996 . Teacher Handbook of Experimental Textbook in Mathematics of Elementary School, Volume 9.

[2] Chu-Tsun Chen. (1998). "The Equal Relationship and Lineal Graph", Collected Issue of Elementary Education. Taipei . The seminar of Taiwan Elementary Teachers .

[3] Ning, Tzyh-chiang,.(1993)."Spirit and Innovative Trend of New Course in Mathematics for Elementary Education —Seen from Perspective of Constructivism", Scholarly Magazine for Scientific Education, Vol. 1 No. 1, pp. 101-108.

[4] Dalgamo, B. 1997 . Constructivist Computer Assisted Learning Theory and Techniques. WWW. 21 Oct. 1997. Available http://services.canberra.edu.au/~barney/articles/ascilite96/paper.htm

[5] Hiltz, S. R.. "Teaching in a Virtual Classroom. 1995 International Conference on Computer Assisted Instruction ICCAI'95 Hsincku, Taiwan". http://it.njit.edu/njIT/Department/CCC/VC/Papers/Teaching.html (1995).

[6] Squires, D. "Can multimedia support constructivist learning? WWW, 21 Oct. 1997. Available" http://www.spirit.net.au/ACEC96/papers/squir.htm (1997).

Figure1. Operation tool table.

Figure2. The flowchart of teaching in the system.

Figure3. Lineal emblem.

Figure4. To discuss and communicate with the virtual students or on-line students.

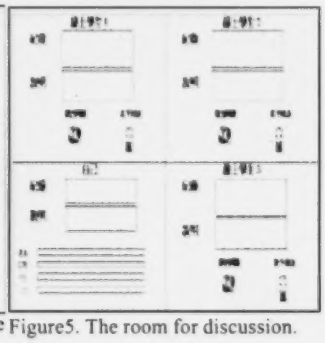


Figure5. The room for discussion.

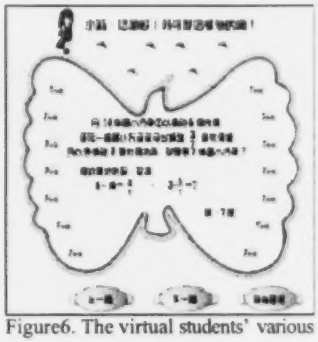


Figure6. The virtual students' various strategies.

BEST COPY AVAILABLE

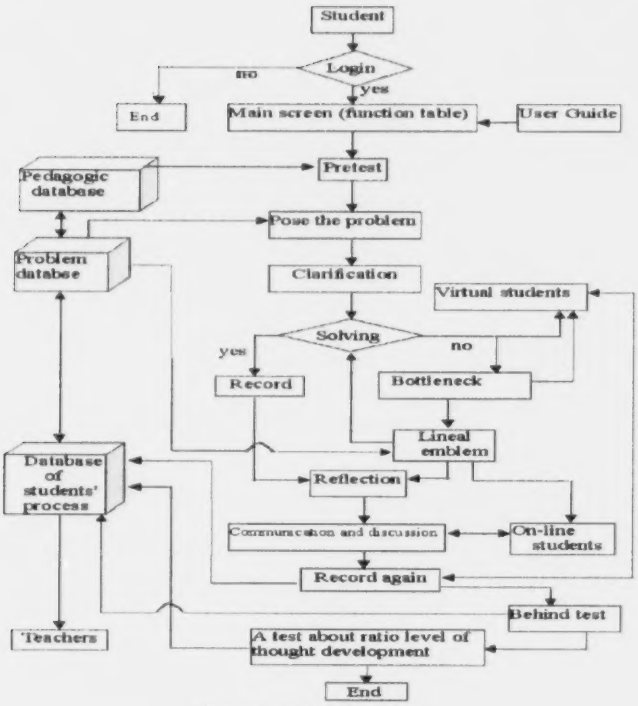


Figure 7. System flowchart.

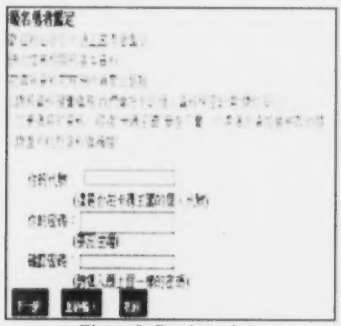


Figure8. Registration.

Online Education: A Learner-Centered Model with Constructivism

Kam Hou VAT
Faculty of Science & Technology
University of Macau, Macau
fstkhv@umac.mo

This paper describes the initiative to construct a WWW-enabled course and project support environment for undergraduate education, aimed to uphold the constructivist's ideas of active learning. The system is intended to create learning experiences that invite students to construct knowledge and to make meaning of their worlds of learning. In particular, we discuss the educational framework of our design through the Problem-Based Learning (PBL) approach, from the perspectives of the architect of the intellect. We also describe the incremental prototyping process of software development, through scenarios of participatory design of our students in Software Engineering at the author's affiliated faculty. The paper concludes by discussing the challenge of implementing the fully functioning constructivist WWW-based environment through blending the art and science of teaching into creative cognitive designs.

Keywords: **Constructivism, Problem-Based Learning (PBL), Learner-Centered Philosophy**

1 Introduction

With the advent of the World Wide Web (WWW or Web) towards the end of the 20th Century, the use of this Internet-based hypermedia technology in education has become the trend of today. The Web is aimed to facilitate learning in different disciplines, and is becoming the major driver to construct numerous experimental Web-based support environment in campuses around the globe. However, online education in the form of Web-based instructions (WBI) or Web-enabled learning environment, without an anchoring philosophy of education, could easily become a technology-rich educational wasteland. The theme of this paper is to investigate how the insights of our educational visionaries [5] could be designed into our Web-based support environment, to suit the unique schemata of individual learners. Actually, such designs require rigor in identifying certain essential elements of the constructivist architecture. And they represent challenges to the learning in our daily classrooms, which has typically involved having students repeat newly presented information on tests or in reports. Constructivist teaching practices help learners internalize, or transform new information, which in turn makes further understanding possible. Therefore, as instructional designers, the guiding question in tackling our Web-based design is this: How do we create a technology-enhanced learning environment that engages students in the types of activities that will take on their initiative and responsibility for their own learning?

2 Project Background

In the spring of 1999, a group of junior students in Software Engineering, initiated an informal study group (ISG) [15] with the author's facilitation. The ISG's mission is to help students develop their team-based technical interest in preparation for their graduation project. And we started exploring the ongoing development of Web-based distributed applications with online education as one of our first discussion topics. During the discussion, the author, as an instructor, expressed his difficulties in traditional classroom setting, to recognize students' intellectual and motivational problems, to explain to them a difficult part of the subject matter, to provide clear tasks, and to coach students in specific problem-solving activities. These issues indeed go far beyond the classroom walls. As students, they expressed their need for a learner-centered atmosphere whose focus is put on the needs, skills, and interests of the learners, and whose goal is

to encourage active exploration and construction in the course of learning activity. Likewise, we developed the initial idea of creating an environment where anyone is free to learn, to construct and refine new meaning in one's own learning, and to have enough channels to ask for help, when necessary, in the form of some extended service of a good teacher. We continue our expedition into Web-based technology to turn out the project ideas of creating a) a course support environment for active learning, and b) a project support environment for problem-based learning (PBL). The former has been given the project name **REAL** [13] to imply a Rich Environment for Active Learning, while the latter, **SUPER** [14] to denote SUitable and Practical Educational Resources for group-based project work. And in either project, we have not ruled out the familiar face-to-face classroom interactions between teacher and students, as one of the essential aspects of the learning process.

3 Pedagogical Intakes

In selecting the pedagogy of our Web-based environment, we have borrowed from the legacies of our educational visionaries in blending the art and science of constructivist teaching. John Dewey's designs embedded learning in experience [3]. He advocated field studies and immersion in experiences to stimulate learning. Jean Piaget's work influences constructivist educators through designs of discovery learning [9]. Students manipulate subject matter and objects representing the subject matter as they interpret their findings. He believed that learners' internalization leads to structural changes in how they think about something as they assimilate incoming data. Today, constructing meaning on the basis of one's interpretation of data is the heart of science inquiry, problem-based learning models, and case studies. Lev Vygotsky's theory [16] suggests that we learn first through person-to-person interactions and then individually through an internalization process that leads to deep understanding. This belief in the social process of idea making permeates today's interactive classroom led by skillful teacher questioning. Reuven Feuerstein's mediated learning theory [4] refutes the concept of an unchanging intelligent quotient (IQ) and leads to intense examination of how the classroom affects students' metacognition. He believes that the discovery process requires intervention from the teacher to guide learning. On examining the varied work of the master architects, and trying to crystallize the essential elements of the constructivist architecture, we see an array of tools emerging. They include a learner-centered curriculum; enriched environments; interactive settings; differentiated instruction; inquiry, experimentation, and investigation; mediation and facilitation; and metacognitive reflection.

4 Instructional Design

We expect the instructional design of our Web-based support should increase student participation and communication through re-designing the delivery of college lectures to incorporate more student online activities and instructor's feedback before, during and after the contact session. The environment is expected to develop students' abilities to generate problems, to engage in collaboration, to appreciate multiple perspectives, to evaluate and to actively use knowledge. From the designers' standpoint, we have included the following enabling ideas:

a) *Enable students to determine what they need to learn through questioning and goal setting.* It is believed that students should work to identify their knowledge and skill deficits, and to develop strategies in the form of personal learning goals for meeting those deficits. The emphasis is to foster a sense of students' ownership in the learning process. If teachers, through the Web-based support environment, can guide the students in identifying what they already know and what they need to learn, then knowledge gaps and mistakes can be viewed in a positive way such as another opportunity to learn. And students can assume more responsibility in addressing their own learning needs during any instructional unit.

b) *Enable students to manage their own learning activities.* It is believed that students should be enabled to develop their learning plans, which should describe priorities, instructional tactics, resources, deadlines, roles in collaborative learning situations, and proposed learning outcomes, including presentation and dissemination of new knowledge and skills, if applicable. Traditionally, these instructional events are arranged by teachers to be obeyed by students, in order to accomplish a specified set of pre-determined objectives. Yet, it is not advantageous for students to learn to be self-directed. To manage their own learning activities, students must be guided and supported by the teacher, through the Web-based environment, slowly taking on more and more responsibility of their own learning.

c) *Enable students to contribute to one another's learning through collaborative activities.* It is believed that

students should be encouraged and supported to discuss and share their personal findings. Particularly, we should enable students to become co-builders of the course/learning resources through evaluating and refining the entries their peers put into the Web-based depository. Collaborative group-based learning seems appealing to achieve the purpose. Students, nevertheless, must be educated to recognize what they are trying to learn in group-work, value it, and wish to share that value with others. Teachers can provide this sense of accountability and belonging by structuring students' work in the support environment with such concept as computer-supported cooperative work (CSCW).

It is convinced that the efficacy of the learning environment is a function of many complex factors, including curriculum, instructional methodology, student motivation, and students' developmental readiness. Trying to capture this complexity onto the design of our Web-based environment, is more an ongoing iterative process than a one-time activity. So we develop scenarios of situated learning support applicable to both individual course taking and group-based project work. These scenario-based supports are then incorporated into the environment incrementally, subject to our students' participatory testing.

5 Scenario-Based Support

Imagine attending a class where the instructor, after giving an introduction of what the course is entailed, invites you to visit his/her course support environment on the Web. On entering the Web-based environment, you are offered the privilege of creating your own personal space in the form of a customizable Web page guarded by your self-assigned identifier and password. Within your personal Web space, you are furnished with some tools to start your Web-life. These include a communications facility to keep one another in touch (email and newsgroup); a calendar planner to track your appointments or commitments (meetings or homework due dates, or project deadlines); and a frequently-asked-questions (FAQ) tool to send for instructor's help when encountering difficulty in housekeeping the personal space. Also, there are pathways to other service modules:

a) Course Information. This module provides such information as the course description, pre-requisite requirements, evaluation policy, references list, and other details such as time and location of the lectures. It also includes links to the instructor's contact details, his/her teaching/research profile, and the course schedule showing timetable for class with links to the study materials before, during and after contact sessions. Also included is the announcement service representing the most up-to-date information sent to the students from the instructor.

b) Course Resources. This module comprises the study materials prepared by the instructors, and the contributions representing students' submitted or reported work of interest to other students. Study materials can further be cataloged and managed as different resources: study notes, tutorial handouts, supplementary lecture details, or Web-links in the Internet. It could also include FAQs of the course: homework, quiz's, tests, examinations, and projects.

c) Course Assessment. This module keeps track of students' performance. The score each student obtained after completing a specific activity is recorded with enough details for evaluation at the end of the course. Students are encouraged to propose their own study plan to earn the accumulated score required, to complete the course. This service is designed into the Learning Contract [7] component to individualize the learning process for any individual learner. Typically, a student is required to write a formal agreement, which details what will be learned, how the learning will be accomplished, the period of time involved, and the specific evaluation criteria to be used in judging the completion of the learning.

d) Course Inquiry. This module fulfills several requirements of the teacher-student inquiry interaction. These include: a) a sense of dedicated space for an extended collaboration between teacher and student; b) an incremental delivery of inquiry results from teacher to student; and c) visibility of the inquiry interactions to avoid duplicating effort, and to encourage discovery of related interests. When an inquiry is initiated by a student, a request Web page is generated which is specific to that interaction and to which the teacher and student return frequently for their interaction. This request Web page (meeting space on the Web), contains the relevant material required for the specific inquiry interaction, say, contact details of the student and the teacher in the form of Web links or email addresses. Each request Web page supports several types of interaction: posting comments, recording actions, uploading/downloading files. These can be carried out at any time in any order. This feature is designed to support the often-time extended discussion and incremental result delivery of the teacher-student collaboration. Also, since the completed

request Web page could be visible to any registered student or teaching staff within the Faculty intranet, this increases the general awareness of the teacher's activities in consulting students, and avoids duplicating efforts of other staff in dealing with similar questions from students. More importantly, when users browse the inquiry activities over the Web, they are always exposed to information as to who was involved in what, and eventually they will learn about one another's specialties and interests. Hopefully, they will form communities centered about specific knowledge and interest; such are considered as important assets of any educational institute.

Now, on visiting the Web-based support environment and reading the latest announcement for the next lesson, you are aware that the next lesson is about group-based project work. According to the instructor's message, group project work is an essential component of any academic degree; many professional societies worldwide emphasize project and group work as preparation for professional practice. Also, you are to follow the problem-based learning (PBL) approach to work in teams. And you will be introduced to the teaming process and the PBL support of the Web-based environment.

6 Problem-Based Learning (PBL)

It is understood that project work is recognized as having many educational and social benefits, in particular providing students with opportunities for active learning. However, teaching, directing and managing group project work is not an easy process. This is because projects are often: *expensive* demanding considerable supervision and technical resources; and *complex* combining design, human communication, human-computer interaction, and technology to satisfy objectives ranging from consolidation of technical skills through provoking insight into organizational practice, teamwork and professional issues, to inculcating academic discipline and presentation skills. In preparing our students to get started with group-based project work, we have oriented towards the PBL learning model. According to the literature [1, 2], the modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management.

6.1 PBL Pedagogy

The PBL approach focuses education around a set of realistic, intrinsically motivating problems to fit the interests and needs of the learners. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how [10]. When applied to the course setting, PBL should encourage students' active participation, and develop in them self-directed learning and problem-solving skills while they interact, discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and final reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

6.2 PBL Activities

Students, on being presented with a problem or scenario, are made aware that initially they will not possess enough prior information to solve the problem at hand or to clarify the scenario immediately. These problems are often ill-structured, but devised according to concrete, open-ended situations. They are reminded that they must identify, locate, and use appropriate resources, and ask questions referred to as "learning issues" on the various aspects of the problem. These learning issues should help them realize what knowledge they require to construct a solution, and thus focus their learning efforts and establish a means for integrating the information they acquire. Often, they are encouraged to perceive themselves as managers of their own in terms of time, material resources, and the complexity of the problems that can be handled one at a time by the group. It is expected that the PBL students have to iterate through some relevant stages of activities: analysis, research, and reporting, with discussion and feedback from peers and the instructor at each stage.

• *Analysis.* Throughout this stage, students organize their ideas and prior knowledge related to the problem, and start defining its requirements. This helps them devise a specific statement of the problem. Meanwhile, they are encouraged to pose learning issues, defining what they know and what they do not know. This helps them assign responsibilities for research, eliciting and activating their existing knowledge as a crucial step in

learning new information.

• *Research.* Throughout this stage, students collect necessary information on specific learning issues raised by the group. They may conduct library searches, seek sources on the Internet, collect data, and interview knowledgeable authorities. More importantly, students teach themselves as they research their learning issues. It is intended that when they come to realize the complexity and texture of the problem, they may often see that information is a means to the ends of managing problems effectively.

• *Reporting.* At this stage, students report their findings to the group. Individual students become "experts" and teach one another. Subsequently, their discussion may generate a possible solution, or new learning issues for the group to explore further. Final solutions are constructed, and the facilitator's feedback should help students clarify basic information, focus their investigations, and refine their problem-solving strategies, besides addressing whether the original learning issues were resolved and whether the students' understanding of the basic principles, information, and relationships is sufficiently deep and accurate.

6.3 PBL Teamwork Experience

It is important that PBL students are taught how to work in teams and positively experience the team process because the team skills they acquire are applicable throughout their future careers. The PBL team process requires each team composed of 3-5 students, to be assigned a supervisor (instructor) and a client if applicable. The client's role is to clarify the project, and to resolve ambiguities as they arise, whereas the supervisor's is to guide, motivate and provide feedback to the team. Also, one of the team members is designated the team leader for the duration of the project, whose role is to coordinate the team activities, and to ensure effective team communications. The leader also has to interface with the supervisor, arrange meetings with clients when necessary, and facilitate meeting through setting agendas, taking minutes, and allocating tasks. Each team member has to help set the team goals, accomplish tasks assigned, meet deadlines, attend team meetings and take a turn editing a document to be submitted at the end of each major stage of project development.

Meanwhile, PBL students are made aware of the difficulties in teamwork throughout the project period. These include setting realistic project goals, carefully allocating tasks to team members, managing time, and communicating and managing shared group documents. Teams have regular meetings to which they invite their supervisor, and in which they organize themselves to manage the project. Students are often reminded of setting appropriate agendas before meeting, assigning enough time to the agenda items during meeting, restating the decisions made at the meeting, and converting decisions into action items after meeting. They are also advised on clearly separating the social and work aspects in meetings, and assessing each meeting for doing it better next time. Moreover, it is suggested that teams plan their project around major deadlines of individuals in the team thereby acknowledging the other commitments team members may involve.

Deadlines represent the milestones set down for the PBL students to submit project documents and to receive evaluation. Each team member is assessed by their supervisor and their team peers. The supervisor's evaluation is based on what each team member adds to the meetings and what the instructor perceives each member's contributions to the team to be. The peers' evaluation is based on a confidential rating sheet, to be completed by each team member at the end of each major phase of the project. This rating sheet should include each team member's contribution for that phase with explanatory comments. And the overall project assessment is made up of the group grade and the individual grade. The former is the same for each group member and is based on the quality of the documents produced and the product developed. The individual component is based on the quality of the student's contribution to the documents and the product, their participation in group-meetings, their commitment to the team process, and their professional attitude developed.

7 Scenario-Based PBL Support

Imagine you have just attended the second lesson on PBL and group project work. And you realize that the PBL support available in the Web comprises both the learning and performance aspects. These are actually a series of strategies and Web-based solutions that use instructional design principles to improve students' work-based performance according to the real-life PBL activities. And you are invited to visit the PBL-specific Web site to register as a PBL-user. The registration process invites you to fill in a Web form including a simple questionnaire for teaming purpose. You are now allowed to enter the PBL-support environment with your PBL identifier and personal password returned after the registration.

And for exploratory purpose, you have just navigated to the PBL Web page for the Software Engineering course *SFTW 300 Software Psychology* (Figure 1). Here you are presented with a number of projects to express your preferences to join through filling in another Web form activated by clicking the link "Join a Team" in the same page. You can then find out which team and project have actually been associated with you by clicking the link "Identify Your Team" also in the same page. On knowing which project to engage, you could click the suitable PBL Space link, i.e., "S300F99P3" in this case, to navigate to the suitable PBL Space (Figure 2). The PBL Space is assigned for each PBL group for project management on the Web. It contains links to the project itself, the PBL Group (including its members' links), the PBL Client, and the PBL Supervisor. Each of such links is associated with a set of related links for information and support of the project. Among the numerous support links in the PBL Group, you can find the *Work Space* link, which leads to the "Group Work Space" (Figure 3) Web page. This page contains links to individual group members and to specific PBL support, as well as to the project interim progress. Clicking on the individual member's link (PWS) leads to the "Personal Work Space" (Figure 4), where each group member's progress in terms of PBL activities (analysis, research, reporting, implementation) is tracked.

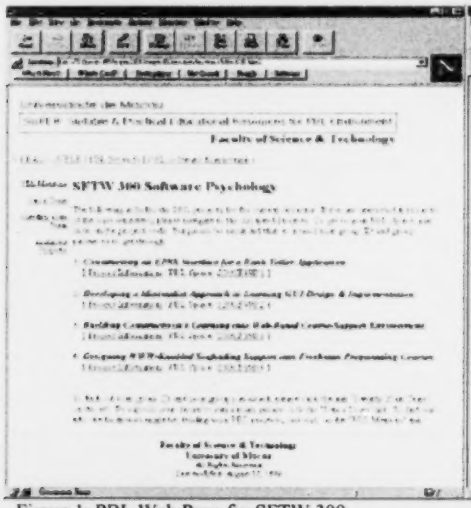


Figure 1: PBL Web Page for SFTW 300

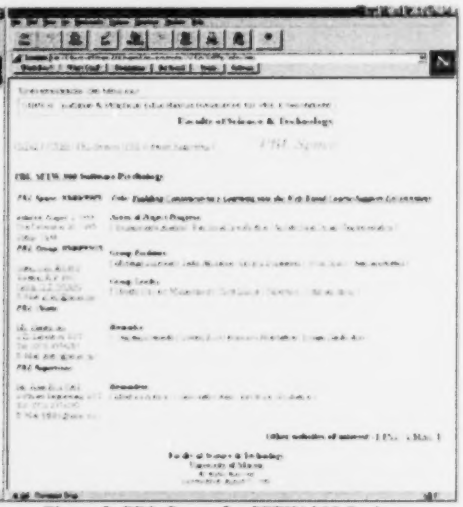


Figure 2: PBL Space for SFTW 300 Project

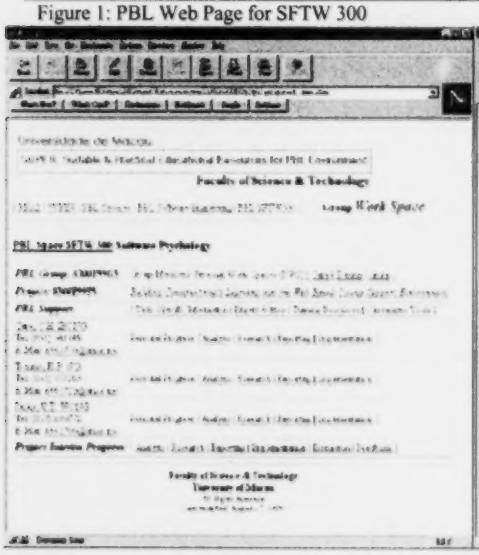


Figure 3: Group Work Space for a SFTW 300 Project

Figure 4: Personal Work Space for a SFTW 300 Project

BEST COPY AVAILABLE

8 Software Development

Our database-driven Web-based support environment has been developed as a series of distributed applications, by employing a mixture of object-orientation, client/server, and Internet (Web browsers, Web servers – HTML, HTTP, FTP) technologies, to deliver the desired support functionality. Such applications are largely event-driven because of the intensive graphical user interface (GUI) programming (e.g., handling the points and clicks) and/or because of the message exchanged between clients and servers over the Web. The specific types of individual Web applications constructed can be categorized into such classes as: a) static HTML-based, b) server-side (CGI-based) and c) client-side (Java-based or JavaScript-based). And the major steps followed to develop the distributed applications could be abstracted as follows:

a) Analysis. Establish users' requirements of what information are needed by whom and wher., in terms of functionality, performance, security, operability, and management of the distributed applications. And develop an object model that shows conceptually how the information will be organized, accessed, manipulated, and presented in terms of objects.

b) Architecture. Partition the architecture concerns into: *data architecture*, determining what data sources (HTML, files, databases) will be needed, where they will be located, and how they will be accessed; *software architecture*, determining what will be written as CGI/Java code, what will be constructed as modules called by CGI/Java, where will the various objects/modules reside, and how they will be invoked (CORBA, RPC); *infrastructure architecture*, determining the servers where the home pages and the objects/modules will reside, the type of gateways that will be employed, the type of middleware that will be needed to invoke remote services and objects (CORBA, ActiveX, RPC, SQL), and the type of computing platforms (PC Windows, UNIX, Linux, Windows NT) used.

c) Implementation and Deployment. Build the HTML pages (including the Java-powered pages) by coding HTML or using filters that generate HTML from other data sources (e.g. Word documents). Then develop and test the software modules and objects. If necessary, purchase the appropriate infrastructure components. Fourth, test, install and deploy the system, followed by maintenance and the iterative re-design process.

9 Prototyping Process

The Web-based support in our online environment is developed incrementally through a user-driven iterative prototyping process, which involves our instructional designers, teachers, and students in the participatory development. This involves creating a series of function prototypes used to clarify the objectives of the system in light of design exploration between the designer and the users (teachers and students), so that the users gradually understand what can be achieved with the technology. Our knowledge of requirements, design and implementation may be incomplete in any one cycle; however, there has been progressive build-up of a structure, which will lead to the desirable system. Specifically, we have referred to the Dynamic Systems Development Method (DSDM) [12] for project guidance, which walks us through four main phases of the DSDM life cycle.

The *feasibility study* phase is to define the high level functional requirements of the environment, which refer to the educational support issues. This phase should produce an outline prototyping plan and establish the main non-functional requirements, such as the hardware and software to develop and deliver the system. The *functional prototype iterations* phase is to clarify the detailed require ments for the system. Its output includes a series of prototypes that demonstrate the main system functionality. These early visual prototypes are mainly used to clarify the system objectives between the designers and users. The *design prototype iterations* phase is to refine the functional prototype into a robust product after a more situated evaluation of system requirements. It involves satisfying all the non-functional requirements; i.e., producing a system that will work effectively on the target hardware in the organizational setting. It is understood that all the possible components of the system do not have to be developed in unison. Some may move on to the design and build phase while others are still at the functional clarification stage. The *implementation* phase involves placing the system in the user environment, carrying out any required training, reviewing the system and assessing further developments. The output should include a delivered system, user manuals/training, and project review document.

10 Conclusion

It is experienced that the conventional approach to education remains the instructivist one, in which knowledge is perceived to flow from experts to novices. This transmissive view of learning is most evident in the emphasis on lectures, in the use of textbooks to prescribe reading, and in the nature of tutorials and assessment methods. It assumes that the process of good teaching is one of simplification of the truth in order to reduce student confusion. Yet, this simplification could deny students the opportunity to apply their learning to dynamic situations. We question the transferability of the instructivist learning and ask how much of that which is assigned to academic learning ever gets applied to actual scenarios, when there is such a rapid surge in knowledge commonly associated with the birth of the "Information Age." This is a transference problem. Actually, the content product of learning is assuming a less important role relative to the process of learning as the life of information content shortens and the need for continual learning increases. In designing the Web-based support of our learner-centered environment, we have tried to reoriented towards a meaningful direction by reducing the obsession with knowledge reproduction. And PBL represents one such relief from the constructivist pedagogy. Greening [6] describes it as a vehicle for encouraging student ownership of the learning environment. There is an emphasis on contextualization of the learning scenario, providing a basis for later transference, and learning is accompanied by reflection as an important meta-cognitive exercise. Also, the implementation of PBL is done via group-based work, reflecting the constructivist focus on the value of negotiated meaning. Besides, it is unconfined by discipline boundaries, encouraging an integrative approach to learning, which is based on requirements of the problem as perceived by the learners themselves.

Undeniably, constructivism is a philosophy of learning that is having a major effect on the way that education is conducted today. In this paper, we have tried to spell out the working characteristics of constructivism [11], which have actively shaped the design of our Web-based support. These include: 1) Meaning is not transmitted. Instead, learning occurs as a process of adjustment of existing concepts. 2) Understanding is based on interaction among a complex weave of factors, such as the learners' goals and existing concepts, the content of the learning experience, the context where the learning occurs. 3) Puzzlement motivates learning. This sense of dissatisfaction emerges from experiences that threaten existing conceptual structures. 4) Social negotiation and viability are the principle forces involved in the evolution of knowledge. They ensure that learning is anchored both by the learning community and by the need to test constructions against reality. The effects of such testing are the adjustments in the structure of concepts held by the learner. So, one thing is evident: constructivist learning experiences can exert high cognitive demands on learners [8], and not all learners could respond well to the challenge. We believe the constructivist ideas assembled here make up what we might call pragmatic constructivism. Namely, constructivism could be viewed as a toolbox for problems of learning. If a particular approach does not solve the problem, try another. In keeping with this flexibility, active, social and creative learning can play out in rather different ways, depending on the circumstances. Although the term constructivism suggests a single philosophy and a unique potent method, there is not such thing as a one-size-fit-all. Rather, our suggestion is to look at constructivism like a Swiss knife with various blades for various needs. That is also the learner-centered philosophy behind our Web-based support for online education.

References

[1] Albanese, M., and Mitchell, S., " Problem-Based Learning: A Review of Literature on Its Outcomes and Implementation Issues," Academic Medicine, Vol. 68, No. 1, 1993, pp. 52-81.

[2] Barrows, H., " How to Design a Problem-Based Curriculum for the Pre-Clinical Years," New York: Springer, 1985.

[3] Dewey, J., " Experience and Education," New York: Macmillan, 1938.

[4] Feuerstein, R., " Instrumental Enrichment: An Intervention Program for Cognitive Modifiability," Baltimore: University Park Press, 1980.

[5] Fogarty, R., " Architects of the Intellect," Educational Leadership, Vol. 57, No. 3, 1999, pp.76-78.

[6] Greening, T., " Scaffolding for Success in Problem-Based Learning," Medical Education Online, 3(4) 1998, pp.1-15. http://www.utmb.edu/meo/

[7] O' Donnell, J.M., and Caffarella, R.S., "Learning Contracts," In M.W. Galbraith (Ed.), Adult Learning Methods. Malabar, Florida: Krieger Publishing Company, 1990, pp. 133-160.

[8] Perkins, D.N., "What constructivism demands of the learners?" In T.M. Duffy & D.H. Jonassen (Eds.), Constructivism and the Technology of Instruction: A Conversation (pp. 161-165). Hillsdale, NJ:

Erlbaum 1992.
[9] Piaget, J., "Piaget's Theory," In P. Mussen (Ed.), Carmichael's Manual of Child Psychology. New York: Wiley, 1970.
[10] Ryan, G., "Student Perceptions about Self-directed Learning in a Professional Course Implementing Problem-Based Learning," Studies in Higher Education, Vol. 18, 1993, pp. 53-63.
[11] Savery, J.R., and Duffy, T.M., " Problem-Based Learning: An Instructional Model and its Constructivist Framework," Educational Technology, 35(5) 1995, pp. 31-38.
[12] Stapleton, J., "DSDM: Dynamic Systems Development Method – The Method in Practice.," Addison Wesley, 1997.
[13] Vat, K.H., "REAL: Towards a WWW-Enabled Course Support Environment for Active Learning," Faculty Technical Report, FST/SE-1999-01, University of Macau, Macau.
[14] Vat, K.H., "SUPER: Towards a WWW-Enabled PBL Support Environment for Software Engineering Education," Faculty Technical Report, FST/SE-1999-02, University of Macau, Macau.
[15] Vat, K.H., "Training E-Commerce Support Personnel for Enterprises through Action Learning," In Proceedings of the 2000 ACM SIGCPR Conference, Chicago, Illinois, USA, Apr. 6-8, 2000, pp.39-44.
[16] Vygotsky, L.S., "Mind in Society: The Development of Higher Psychological Processes," Cambridge, MA: Harvard University Press, 1978.

Schema Theory-based Instructional Design of Asynchronous Web-based Language Courses

C. Candace Chou
Interdisciplinary PhD Program in Communication and Information Sciences
University of Hawaii
Email: chou@hawaii.edu

Instructional design (ID) provides a framework to facilitate both teaching and learning activities. ID also prescribes desirable learning outcomes. This paper introduces the implementation of an ID template in web-based language courses. The ID template incorporates several cognitive strategies based on schema theory. A schema-theory-based model provides a useful framework for knowledge organization and information processing. In a course that emphasizes reading comprehension, schema theory accounts for how learners construct meaning from texts based on the information they encounter, the prior knowledge they already have, and the way they interact with the new information. The ID template consists of four instructional sequences. The cognitive strategies, ID examples, and purposes for each sequence are illustrated. The sequences include warm-up activities, preparatory activities, core activities, and post activities. Each sequence is interconnected with the others and looped back to the beginning in each lesson unit. The preliminary evaluation results indicate the degree of student satisfaction for the ID template for various external and internal factors.

Keywords: **instructional design, schema theory, cognitive strategies, web-based foreign language instruction**

1 Introduction

Instructional design (ID) plays a critical role in the success of distance education. ID is an interdisciplinary science that provides a theoretical background for the design and implementation of instructional units to achieve desirable learning outcomes. ID principles encompass theories in both learning and instruction. Although the instructional design for web-based instruction does share some common principles with instructional design for traditional classroom teaching, the modes of instruction and learning are quite different from each other. The roles of learners and instructors continue to go through fundamental changes as well. What kind of instructional theories can be best applied to web-based education? There is no one single universal theory for all instructional design as the objectives, learning contexts, subject matters, and expected learning outcomes vary from one field to another. The development of ID also depends on the pedagogical principles that the instructors or instructional designers adapt to. The views on instructional design can be approached from different perspectives such as behavioral (Gropper, 1983); systematic (Gagne, Briggs, & Wager, 1992); structural (Scandura, 1983); motivational (Keller, 1983), transactional (Merrill, 1997); and cognitive (Tennyson, 1990; West et al., 1991). Cognitive schema theory especially receives prominent attention in the field of instructional design and language education for its emphasis on the use of aid for perception, learning, comprehension, and recall (Anderson, 1984; West et al., 1991). This paper focuses on the application of schema theory to the instructional design of language courses delivered through the World Wide Web. The preliminary evaluation results are summarized at the end.

2 Theoretical Framework

Why is ID important in web-based distance education? Reigeluth (1983) argued that ID is a linking science between theory and practice. This linking science was further elaborated by Tennyson and Schott (1997): "As a field of study, it provides a theoretical foundation to principles of instructional design, a research base confirming the theoretical foundations, and a direct involvement in the application of those principles" (p. 1). ID theories prescribe the variables and conditions required for certain learning outcomes. Furthermore, the practice of ID utilizes various methods and technologies to develop learning environments based on these theories (Tennyson & Schott, 1997). Many ID models have been developed and the theoretical bases vary greatly. A typical model includes the following five steps: "(1) setting the *objectives;* (2) *preassessment*, that is, determining whether the target students have the prerequisites to benefit from the instruction; (3) *planning the instruction*; (4) *trial*, that is, presenting the instruction for developmental purposes; and (5) *testing* and *evaluation*" (West et al., 1991). Each step can be further divided into more detailed instructional sequences. The focus of this paper is on planning the instruction based on cognitive learning theories. Schema theory is an especially appropriate cognitive learning theory because of its emphasis on knowledge organization and representation.

There is no one single theory called schema theory. It has evolved and become the basic component of many cognitive learning theories. According to cognitive theorists, schemas or schemata are mental data structures that represent our knowledge about objects, situations, events, self, sequences of actions and natural categories (Anderson, 1985; Rumelhart, 1981). Schemata are also like scripts of plays (Schank & Abelson, 1977). In other words, schemata are chunks of knowledge stored in the human mind by patterns, structures, and scaffolds (West et al., 1991). Based on Rumelhart's definition (1981), schemata serve the function of "scaffolding." Knowledge is perceived, encoded, stored, and retrieved according to the chunk of information stored in the memory. Schemata facilitate information processing. Schema can be "instantiated" by specific examples of concepts or events. For example, one's schema for "teaching" can be instantiated by viewing a scenario on the interaction between a teacher and students. As soon as schemata are instantiated, one can associate or recall more similar scenarios (Bruning et al, 1995). Schema theory is appropriate for language instruction due to its powerful explanation of memory and recall. In the case of reading comprehension, schema theory accounts how learners construct meaning from texts based on the information they encounter, the prior knowledge they already hold, and the way they interact with the new information (Bruning et al, 1995, p. 275). As summarized by Andre (1987), schemata serve the following important function in reading comprehension:

1. Providing the knowledge base for assimilating new text information
2. Guiding the ways readers allocate their attention to different parts of reading passages
3. Allowing readers to make inferences about text materials
4. Facilitating organized searches of memory
5. Enhancing editing and summarizing content
6. Permitting the reconstruction of content (Bruning et al., 1995, p. 275).

Schemata provide the backgrounds for learners to comprehend a text by inference. Schemata also make it possible to summarize a passage by selecting the parts that are important to them. These processes cannot be completed without the knowledge structures that schemata provide. Since one of the elements of schema theory is making predictions based on what learners already know, making the link between the old information and the new information has generated a great deal of research interest. Two areas of research in this direction are advance organizer and schema activation.

Advance organizers employ the structure of some materials that the learners are already familiar with as the framework of the new materials. In other words, advance organizers are designed to offer "ideational scaffolding for the stable incorporation and retention of the more detailed and differentiated material that follows" (Ausubel, 1968, p. 148). Advance organizers are relevant introductory materials that are introduced in advance of the core texts. Recent studies have also shown that providing short and concrete examples for upcoming events are more useful to readers than abstract, general, and vague learner organizers (Corkill et al., 1988).

Schema activation refers to the design of activities for the purposes of activating learner's knowledge in

similar fields prior to learning new subject matters (Bruning et al., 1995). They are often in the forms of short questions. In a way, schema activation serves similar purposes of advanced organizers by linking new information with old information that the learners already know. However, schema activation relies more on the learners to generate information from their previous knowledge base. Schema activation works better if the schema activating activities are relevant to the to-be-learned information. A study on the reading comprehension of a group of fifth-graders showed that the group with relevant schema activation remembered the reading texts better than the groups with non-relevant schema activation (Peeck et al., 1982).

There are also many other cognitive strategies that help students with reading comprehension. These strategies are designed to help students in gaining control of their learning process for the purpose of comprehending reading texts. Bruning et al. (1995) summarized the following five strategies for reading comprehension:

1. *Determining importance:* Instructional activities can be designed to help learners locating the main ideas of the text. Without knowing the main ideas, readers would have a hard time understanding the text.
2. *Summarizing information:* Students should not only learn to summarize the main ideas in a passage but also generate a text that represents the original one. Students' reading skills improve when their summarization skills improve.
3. *Drawing inferences:* Studies have shown that the ability to make inferences is positively associate with reading skills (Dewitz et al., 1987; Raphael & McKinney, 1983). Good readers are usually good at guesswork.
4. *Generating questions:* Good readers ask questions frequently. Through self-questioning or peer-exchanged questions, learners will have a better understanding of texts.
5. *Monitoring comprehension:* Readers should have the ability of knowing when they understand the text and when they do not. A good reader also has the ability to detect errors and inconsistencies in the reading materials. When they become critical of the reading texts, they do a better job in detecting errors. Peer editing or peer-critiquing is a good way to monitor comprehension (Bruning et. al., 1995, p. 279-284).

The next section describes how some of the cognitive strategies can be employed in the instructional design of web-based language courses.

3 Instructional Design Template for Web-based Language Courses

The web course introduced in this paper is the first one in a series of Asian language courses using the same instructional design templates. There is a lack of higher-level language courses (3rd year and above) in Less Commonly Taught Languages (LCTLs) such as Asian languages and other non-Roman languages in American universities and colleges. Yet, the need for higher-level language courses does exist for students who would like to continue language studies. The objectives of the web courses are to provide opportunities for students whose institutes do not provide language courses in LCTLs and to disseminate information on the ID model of pedagogically sound language instruction. The first course that is currently offered through the University of Hawaii systems is a Chinese reading and writing course at the 3rd and 4th year level. A Chinese listening/reading/writing course and a Korean reading/writing course will be offered in fall 2000. More courses in Japanese and other LCTLs are in the planning stage at present. The instructional design template is summarized as follow:

Goal: To improve Chinese reading and writing skills.

Objectives:

1. Students will possess the skills to decipher reading materials through a series of cognitive strategies.
2. Students will improve writing skills through continuous revisions, peer-critique, and teacher feedback.
3. Students will have a good command of vocabulary in the subject matters covered in the course.
4. Students will co-construct knowledge together through collaborative tasks in building word bank, grammar clinic, and essay database.

Content: The content covers a wide variety of topics based on authentic teaching materials collected from China and Taiwan, including topics such as cuisine, travel, medicine, celebrities, university, and so on. These materials were developed into ten self-directed reading lessons on a CD-ROM. The web course uses the CD-ROM as the core reading materials. Each web lesson unit was designed to enhance the understanding of the equivalent core text in the CD-ROM.

Format of the Instruction: The World Wide Web and the CD-ROM were selected to deliver the instruction and course content. Asynchronous communication via email and web-forum are the means for student-student and student-teacher interactions.

Table 1 Instruction design template for web-based language courses

ID Sequence & Modules	Cognitive Strategies	ID Examples	Purposes
1. Warm-up activities	Schema activation	Word bank	Brainstorming on terminology Co-construction of knowledge base
2. Preparatory activities	Advance organizer	Picture matching	Preparation for forthcoming texts
3.1 Core activities	Determining importance Drawing inferences	Working on CD-ROM reading activities	Determining the importance of information
3.2 Core activities	Generating questions	Q&A	Self-questioning
3.3 Core activities	Scaffolding	Small Group Discussions	Debate/Discussion/Role Play Use input for other activities
3.4 Core activities	Monitoring comprehension	Grammar Clinic	Peer editing with teacher feedback
4.1 Post activities	Modeling	Sample essay	Teacher demonstration
4.2 Post activities	Recall	Language work	Monitoring comprehension
4.3 Post activities	Summarizing information	Composition & revision	Individual output with collective database on writing samples

Sequence of Instruction: The framework of the instruction sequence is adapted from Hiple and Fleming's (1996) work which is specifically designed for foreign language instruction. The ID examples are developed by the instructors Fleming & Lu (1999) for web-based language courses. There are eight units in each web course. Each unit employs the following four sequences of instruction.

1. *Warm-up activities:* These activities employ simple and short questions to activate learners' previous knowledge relevant to the subject matter. For example, on the unit for cuisine, students are asked to write down two or three things they know about Chinese cooking. Their responses are put into a database called the "word bank." By the end of each unit, students have accumulated an abundant collection of glossary under a specific language topic.
2. *Preparatory activities*: Students are asked to match some descriptions with pictures. These pictures provide a background information of the lesson and prepare the students for the forthcoming texts.
3. *Core Activities*: There are four components in Core Activities: working on the CD-ROM, Q & A forum, Small Group Discussions, and Grammar Clinic. Students first go through the reading activities in the CD-ROM. They then post questions about the content of the CD-ROM on the Q & A web forum. Following that, they are divided into three-member or two-member small groups to carry out a conversational task. Take the cuisine unit for example, they have to make up their minds on which restaurant to go to for dinner. One conversation example is provided so that students know in advance the scope and depth of the expected conversation. In Grammar Clinic, the instructors pick several erroneous sentences from the Small Group Discussions and post them

at the Grammar Clinic (a web forum) for peer editing and critiquing. All these sentences are posted anonymously.

4. *Post Activities*: In the final stage the learners model from teacher's examples and peers' writings before they work on their own essays independently. First, the teacher provides a sample essay and a language matching exercise to reinforce the key words in the essay. Gradually, teachers withdraw help and let the student compose their own essays. If they have a hard time starting, they can view other students' submissions of essays in the database to come up with more ideas.

Among the eight units, the last two units are designed for language exchange with native speakers from the country of the target language. For more details, please refer to the web site (http://www.lll.hawaii.edu/yuedu). The ID template can be modified for different language instruction. The Word Wide Web is an especially perfect media since all information is recorded and saved in the database. Students can always go back to review the collective database for their own review.

4 Evaluation of the web course

In the evaluation process, the instructional design team is interested in student feedback on the sequences of instruction. At the end of each unit, students are asked to fill out an anonymous feedback form that consists of 10 questions on a five-point Likert scale. Comment areas are provided for each question. Table 2 shows the preliminary partial results on the ID template evaluation.

Students had provided valuable feedback to the instructional design team. The team was able to use this feedback to adjust course content and activity design. Generally speaking, students agreed that most instructional design modules are useful for their learning. The degree of helpfulness varies from module to module. However, it seems that the students generally did not like the use of the CD-ROM. One reason is that the CD-ROM could only be used on a Macintosh while 95% of the students in the class used PC-compatible computers. PC users were restricted to use campus Macintosh computers to access the content in the CD-ROM. Furthermore, since the CD-ROM was developed for self-directed learning, there was also a lack of interaction between students and teachers. Finally, there were some bugs in the programming of the CD-ROM. Students were not enthusiastic about the programming bugs. The team is in the process of converting the CD-ROM into cross-platform media and fixing the bugs.

Table 2 Feedback on Instructional Design Lesson Template

1 = Strongly disagree; 2 = Disagree; 3 = Slightly Agree; 4 = Agree; and 5 = Strongly Agree		Unit 2 (mean)	Unit 4 (mean)	Unit5 (mean)	Unit7 (mean)
	Post Unit feedback questions	(n=11)	(n=9)	(n=11)	(n=9)
Q1	I have gained new knowledge from this unit.	4.09	3.78	3.73	3.56
Q2	When I ask for help, the instructors respond in a timely way.	4.45	4.33	4.09	3.33
Q3	When I ask questions, the instructors give me the answers I need.	4.36	4.33	4.09	3.67
Q4	The warm-up activities are useful. (i.e. contributing and sharing vocabulary)	3.73	3.78	3.73	3.44
Q5	The preparatory activities are useful. (i.e. matching pictures to text)	3.91	3.67	3.36	3.22
Q6	The content of the core lessons (CD-ROM) is well designed.	3.18	3.33	2.91	NA*
Q7	The forum discussions (i.e. Q&A, role-play, small group discussion) are useful.	4.09	3.78	3.73	3.33
Q8	The grammar clinic is helpful.	3.45	3.89	3.73	NA*
Q9	The language work is at the proper level of difficulty.	4	4.00	3.55	3.56
Q10	The essay writing is at the proper level of difficulty.	4.09	4.22	4.09	3.67
	Average	3.94	3.91	3.701	3.473

* Unit 7 is designed for language exchange. The questions on CD-ROM and Grammar Clinic are not applicable.

As for the web-based instructional modules, the warm-up activities were not deemed as useful as the instructional design team had expected them to be. When monitoring student online activities through the server-tracking program, it was found that most of them did not go back to use the database after submitting

the required entries. The instructor started requiring the students to incorporate the vocabulary into their essays towards the end of the semester. By then, it may have been too late to see how the change in instructional strategy would affect the way the students utilize the database. This is a good lesson for instructional designers. All instructional sequence should be interconnected and continuously looped back to the beginning. If the instructional modules are designed as stand-along units, students will not see the purpose of building on the knowledge based that they have co-constructed.

Finally, there seems to be a slight decline in the helpfulness of the ID modules when comparing the average in table 2. The perceived helpfulness declines especially in unit 7. The change in instructional format (i.e., language exchange) and the more specialized topic (i.e., movies) may have posed a greater challenge for less competent students. Interviews with the student may help to find out the real reasons. Nevertheless, the comments from students were overall positive. Here are a few comments from the students.

" The warm-up activities have been very helpful in preparing for the entire lesson."

"The preparatory activities makes one think harder about the subject material."

"Small group discussion wasn't as interesting as the previous units because there were a little interactions among students."

" I believe I would not have learned all of the new words from a textbook. Contributing and sharing vocabulary for this unit has really helped my ability to read the Chinese newspaper's entertainment section."

"The text for this section was presented in a way that forced me to focus and analyze more fully the meaning. A good challenge which I enjoyed."

" This unit helped me to learn unique vocabulary for discussions with almost any Chinese speaker. I am more confident that I can carry a conversation with a Chinese speaker about my favorite movie."

"While on occasion some vocabulary has been a little bit difficult, once I put the sentence or paragraph into context, the usage of the vocabulary became more clear."

5 Conclusions

ID sets up a framework for desirable learning outcomes. The incorporation of cognitive strategies helps students to efficiently achieve the learning objectives. It can be found from their comments that the students valued greatly the aspects of online interaction and co-construction of a knowledge database. It is through the collaborative tasks that they are able to interact for a purpose, i.e., for the completion of a task that has a real-world application. The overall ID objectives have been met through the instructional sequences. Nevertheless, there is not much evidence supporting the effectiveness of the ID modules other than students' own remarks. Further study on the comparison of the actual online activities (e.g. tracking the mouse clicks) with their perceptions on the usefulness of each ID module can provide more insight into the effectiveness of the instructional design. In addition, an objective panel of language experts to evaluate the performance of the students could also provide assessment to the final learning outcomes.

References

[1] Anderson, R. C. (1984). Role of reader's schema in comprehension, learning, and memory. In R. C.

[2] Anderson, J. Osborn, & R. J. Tierney (Eds.), *Learning to read in American schools: Basal readers and content texts*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[3] Anderson, R. C. (1985). *Cognitive psychology and its implications*. New York, NY: Freeman.

[4] Andre, T. (1987). Questions and learning from reading. *Questioning Exchange, 1*, 47-86.

[5] Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. New York, NY: Holt, Rinehart and Winston.

[6] Bourdeau, J., & Bates, A. (1997). Instructional design for distance learning. In S. Dijkstra, N. Seel, F. Schott, & R. Tennyson (Eds.), *Instructional design international perspective: Solving instructional design problems* (Vol. 2, pp. 369-397). Mahwah, NJ: Lawrence Erlbaum Associates.

[7] Bruning, R. H., Schraw, G. J., & Ronning, R. R. (1995). *Cognitive psychology and instruction*. (2nd ed.). Englewood Cliffs, NJ: Prentice Hall.

[8] Corkill, A. J., Bruning, R. H., & Glover, J. A. (1988). Advance organizers: Concrete vs. abstract. *Journal of Educational Research, 82*, 76-81.

[9] Dewitz, R., Carr, E. M., & Patberg, J. P. (1987). Effects of inference training on comprehension and comprehension monitoring. *Reading Research Quarterly, 22*, 99-119.

[10] Fleming, S., & Lu, J.-Y. (1999). *CHN399a: Chinese Reading and Writing Course*. Available: http://www.lll.hawaii.edu/yuedu.

[11] Gagne, R. M., Briggs, L. J., & Wager, W. W. (1992). *Principles of instructional design*. (4th ed.). Fort Worth: TX: Harcourt Brace.

[12] Gropper, G. L. (1983). A behavioral approach to instructional prescription. In C. M. Reigeluth (Ed.), *Instructional-design theories and models* (pp. 101-161). Hillsdale, NJ: Lawrence Erlbaum Associates.

[13] Hiple, D., & Fleming, S. (1996). *Stages of a receptive skill lesson development*. Available: http://www.lll.hawaii.edu/workshops/chinesenet/lessons/stages.html.

[14] Keller, J. (1983). Motivational design of instruction. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[15] Merrill, M. D. (1997). Instructional transaction theory: An instructional design model based on knowledge objects. In R. D. Tennyson, F. Schott, N. Seel, & S. Dijkstra (Eds.), *Instructional design international perspective: Theory, Research, and Models* (Vol. 1). Mahwah, NJ: Lawrence Erlbaum Associates.

[16] Peeck, J., Bosch, V. D., & Kruepeling, W. (1982). The effect of mobilizing prior knowledge on learning from text. *Journal of Educational Psychology, 74*, 771-777.

[17] Raphael, T. E., & McKinney, J. (1983). An examination of fifth- and eighth-grade children's question answering behavior: An instruction study in metacognition. *Journal of Reading Behavior, 15*, 67-86.

[18] Reigeluth, C. M. (1983). *Instructional-design theories and models: An overview of their current status*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[19] Rumelhart, D. E. (1981). Schemata: The building blocks of cognition. In J. T. Guthrie (Ed.), *Comprehension and teaching: Research reviews* (pp. 3-26). Newark, DE: International Reading Association.

[20] Scandura, J. M. (1983). Instructional strategies based on the structural learning theory. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: An overview of their current status* (pp. 383-437). Hillsdale, NJ: Lawrence Erlbaum Associates.

[21] Schank, R. C., & Abelson, R. (1977). *Scripts, plans, goals, and understanding*. Hillsdale, NJ: Lawrence Erlbaum Associates.

[22] Tennyson, R. D. (1990). Integrated instructional design theory: Advancements from cognitive science and instructional technology. *Educational Technology, 30*(8), 14-21.

[23] West, C., Farmer, j., & Wolff, P. (1991). *Instructional design: Implications from cognitive science*. Englewood Cliffs, NJ: Prentice Hall.

SimPCS: A Web-based PCS Learning Tool

Chyi-Ren Dow, Yu- Feng Hwang, and Jong-Shin Chen
Department of Information Engineering
Feng Chia University, Taichung, Taiwan 407
{crdow, baterma, and jschen}@pluto.iecs.fcu.edu.tw

With rapidly growing interest in the area of wireless communications in recent years, the wireless resource allocation problem has received tremendous attention. The demand has led to intensive research and studying efforts for personal communication systems (PCS). Many related courses have been offered and corresponding web-sites were developed. Unfortunately, most of the web-sites contained only static and pre-defined PCS information. The utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS by using only the conventional education materials. This work designs, develops, and implements a web-based PCS learning tool that meets the above criteria. The system provides the merits of personality, transparency, efficiency, scalability, portability, and flexibility. It offers simulation and data analysis so that the user can learn actively and understand easily the advanced issues of PCS.

Keywords: **Web-based learning, PCS, simulation, performance visualization**

1 Introduction

Computer-assisted instruction (CAI) programs based on Internet techniques, especially on the WWW, provide new opportunities in various applications. Due to the reason that the growing popularity of the World Wide Web, the characteristic of its portability, wide acceptance, and comprehensive availability can help us to solve many problems related to conventional CAI systems, which lack portability and local availability.

A PCS system is a wireless network that provides communication service with mobility to its subscribers. With rapidly growing interest in the area of wireless communications in recent years, many related courses (e.g., wireless communications, mobile computing, personal communication systems, etc.) have been offered and corresponding web-sites were developed. However, most of the web-sites contain only static and pre-defined information of PCS. Few web-based PCS learning tools have been developed to provide a highly interactive facility for users.

The wireless resource allocation problem has received tremendous attention in the last few years and the demand has led to intensive research and studying efforts for the related topics. Unfortunately, the utilization of wireless resources is determined by many complex factors such as geography, the distribution of mobile subscribers, and the communication congestion. It is difficult to understand the characteristics of PCS systems by using only the conventional education materials. Simulators can be used to identify various characteristics of PCS systems and to support decisions and understanding by giving the possibility of experimenting with different scenarios [24].

However, the simulation of a PCS scenario is time consuming for large-scale PCS systems. Therefore, scalability is an essential factor for the simulation of PCS systems. As well known, conventional sequential simulation techniques can not adequately fulfill such simulation requirements, necessitating the development of parallel simulation techniques capable of doing so. On the other hand, when very great amount of users use the simulation system at the same time, the load of the server will be quite heavy so that the performance decreases rapidly and the response time of a simulation experiment increases.

It is essential that a learning system should be capable of providing the flexibility of usage profiles and services for different users. Users can be classified according to the conditions of user's ability, frequency, and so on. It is expected that each user may have an adaptive interface and configuration to fit his/her requirement. Furthermore, in order to improve the performance of a simulation system, the technologies of parallel processing and caching should be applied. The user may reuse previous simulated results without doing a long-running simulation experiment again, thereby reducing the waste of computation resources of application servers. It not only reduces the waste of the computation resource but also provides real-time services for users.

In light of above discussions, we develop SimPCS, a web-based learning tool for PCS which integrates simulation and computing in a multimedia learner environment with various enhanced functionalities. The proposed system has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. The system can be used to help users to understand the concepts of PCS systems. By using the PCS simulation and data analysis, the users can understand the advanced issues of PCS environments (e.g. resource allocation, probability of blocking call, etc.).

The rest of this paper is organized as follows. Section 2 discusses the architecture of conventional CAI systems and related technologies applied to our system. Section 3 describes the proposed system architecture. The implementation of our system and a prototype are illustrated in Section 4. Section 5 discusses the usage profiles and case studies. Finally, conclusions are offered in Section 6.

2 Related Work

In recent years, training environments based on computational simulation are being used much more frequently and the importance of simulators is widely appreciated. They are used to support decisions and understanding by giving the possibility of experimenting with different scenarios. For a training environment, one thing that is commonly assumed is that the trainee has a reasonable amount of knowledge about the subjacent model and is capable of analyzing and learning from the simulation results [4]. Form a user's aspect, the tools must have characteristics of convenience, auto-analytic, assistant, resource sharing and so on [10,18,20]. The rationale behind the use of multimedia in education is that some media transmit certain kinds of information better than others. This makes it possible to give media an extremely important role in the context of education and learning [6]. The motivation for the use of simulation in an education is that it supports an active learning approach and maximizes the learner control [18]. The degree of available learner control defines the perceived level of interactivity of a course [19]. Learner control is seen as the control over learning strategy, manipulation of learning content and description of content [14]. The claims are that an active learning approach facilitates learning. Learners appear to be more engaged and have better motivations. Simulation enables learners to make their own errors, try to find these out, explore these and learn from these. Moreover, simulators are powerful in situations in which they otherwise would be difficult or impossible to give training or education. It is realized that simulation needs to be embedded in an instructional environment to fulfill an instructive role in a satisfactory manner [23].

In this way the content of a conventional CAI program, which is necessarily limited, can be strongly expanded. Web-based CAI programs differ from conventional CAI software [8,12-13,17,21] significantly and therefore require a specific consideration. It can be utilized on almost all of computer platforms. The materials of CAI systems can be shared since WWW is based on the network technologies. The learners can be free from restrictions of space or time. Conventional CAI programs can be stored on data media, installed, and used on stand-alone computers [1]. By contrast, WBT (web-based training) programs are based on Internet technology, in particular on WWW technologies. Generally, CAI programs can be subdivided into three layers: presentation, teaching, and domain data and knowledge. These combinations generate different types of architectures [6].

Many efforts have been made to improve the limitations of wireless communications [9,11]. In order to increase the system capacity, many advanced channel allocation schemes were proposed [13,21]. Another way to increase the system capacity is to split the cell into micro-cells. The micro-cell architecture is an efficient way to increase the total available channels but additional infrastructures are needed [21]. Many simulation languages and tools have been developed for the simulation of large-scale networks such as cellular mobile systems. Parsec, a parallel simulation language, can be used to develop simulations for complex systems and mobile wireless networks [16,22]. Other systems were developed that can simulate large-scale cellular mobile systems [2]. They used discrete event scheme to model cellular mobile systems

and proposed the synchronization schemes to avoid faults distributed computing environments. Lin [15] proposed a PCS handoff simulator that supports arbitrary PCS cell structure and can be used to evaluate the call blocking probability or forced termination probability.

3 System Architecture

In this section, we describe an overview of our system architecture and the functionality of each component. Figure 1 illustrates the system architecture layout from three different viewpoints, the interaction type, distributed teaching program, and system configuration. For the interaction type, the system provides methods of presentation, browsing, and simulation. The user can interact with the system through various interaction types. For the distributed teaching program, it describes the architecture of client-server and layers for distributed teaching. For the system configuration, it describes the detailed modules of the system.

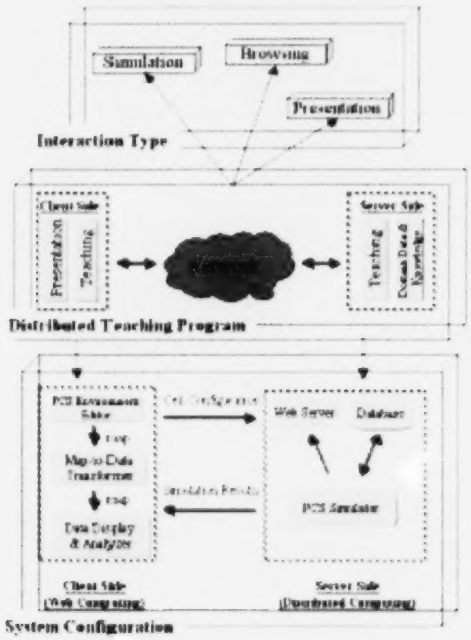


Fig. 1 System architecture

3.1 Interaction Type

SimPCS provides three interaction types including browsing, simulation, and presentation. The details of each interaction type are described as follows.

(1) Browsing:

Here, the user can determine the contents and the consequences of the presentation by accessing the contents through freely navigable hypertext. Internet users can browse the system through a Java-enabled GUI (graphical user interface). In order to reduce the response time of simulation, the caching mechanism is applied, which allows the user to quickly obtain the simulation results and without wasting the computational resources of the application server. Moreover, it provides basic functions to support analysis and display of performance information. The user can determine the contents and the consequences of the presentation by accessing the contents through borrowing.

(2) Simulation:

In the simulation system, the user can easily construct a PCS environment. Then, the user can assign the parameters related to the PCS environment. Next, the parameters are embedded to our parallelized simulation system. Finally, users can use visualization functions to analyze the characteristics and observe the performance variation of different factors. In addition, the system provides various virtual objects to let the user simulate a real environment. On the other hand, the techniques of parallel processing and caching are applied to the system to improve the efficiency of the system.

(3) Presentation:

In this case, the system presents the information in a linear manner just like slide show. The system provides static education materials such as slides, notes, simulation results, and other related information. The system can also be used to support distance learning of PCS environments.

3.2 Distributed Teaching Program

The distributed teaching architecture offers the best performance and the least network traffic of all web-based training architectures. The system we provide belongs to this architecture. On the client side, the presentation layer constitutes the interface between the user and the teaching layer. It is responsible for the presentation and management of usage profiles. It provides the flexibility of usage profiles and services for different level of users. The teaching layer handles user activities (mouse actions, inputs and so on), and then responses to the presentation layer. It is implemented in our system with JAVA programming language to process user activities. On the server side, the teaching layer is responsible for the simulation of PCS systems and processes queries. In order to improve the performance of simulation, the techniques of parallel processing and caching are applied. In the domain data and knowledge layer, the simulation data is saved in a database. It has considerable advantages: multi-stage queries to the data and knowledge layer can be completely created and executed on the server.

3.3 System Configuration

The system configuration consists of many modules. On the client side, the user can use any Java enabled browser. Internet users can communicate with the system through the GUI. The server side provides the ability of the simulation. The PCS environment construction system is used to minic a PCS environment. After constructing an environment, a map representing the environment is transferred to cell configurations. The cell configurations are sent to the PCS simulator and the map is sent to the performance data analyzer. The PCS simulator is used to simulate the behaviors of mobile hosts on the constructed PCS environment. After the simulation, the results are sent to the performance data analyzer/display. Then, the system analyzes the performance data and visually displays it on the map. The database server stores cell information and simulation results obtained from the application server.

The client side is java-based interface. It can enable the users access the system through a WWW browser. The client side consists of a PCS environment constructor and a performance data analyzer. The PCS environment constructor consists of a PCS environment editing module and a map-to-data transformer module. Their features are listed as follows:

(1) **PCS Environment Editor:** the PCS environment construction system is an iconic editor. It provides many iconic objects to represent different things such as a station, highway, or city. With these objects, the user can set up different parameters to change the cell configuration. For instance, the user can set up a station or a city in a cell and the system will automatically change the parameters of the cell such as the number of MHs and call arrival rate. This mechanism makes the simulator more practical.

(2) **Map-to-Data Transformer:** the transformer is used to transfer the map (constructed by PCS environment construction system) to readable parameters for the simulator.

On the server side, the simulation system consists of three components: a Web server, a database server and an application server. The Web server is in charge of communication with the client and manages the application server. The database server stores cell information and simulation results obtained from the application server. Because the database server provides a caching mechanism, the user may replay the

simulation results without wasting the execution resource of the application server. Therefore, simulation is more efficient. The application server is responsible for the execution of the PCS simulator. The application server can be a distributed computing environment (i.e. a network of workstations or a supercomputer). The PCS simulator on the application server can simulate large cellular mobile systems more efficiently with these powerful platforms.

The PCS simulator is used to simulate the behaviors of MHs on a specific PCS environment. The basic behavior of a base station (BS) is to provide channel allocation service and communication service for mobile hosts (MHs) within its service range (cell). The BS chooses a channel to serve when a MH needs a communication. If no channel is available, either a channel is borrowed from neighboring cells or call blocking occurs. For details, we refer readers to [5].

The client side and the server side can be used independently or together. This will facilitate other PCS simulators to embed to our system. Users can use the PCS environment constructor to construct a simulation environment. Then, they can use performance analysis/visualization tools to analyze results.

4 Implementation and Prototype

In this section, the classification of the system modules is discussed. SimPCS can be used to help instructors to create motivating lectures and allow the students to do experiments so they can understand relative wireless information in depth. Users may compose and simulate a PCS environment using various modules. Figure 2 illustrates the hierarchical relation of these modules.

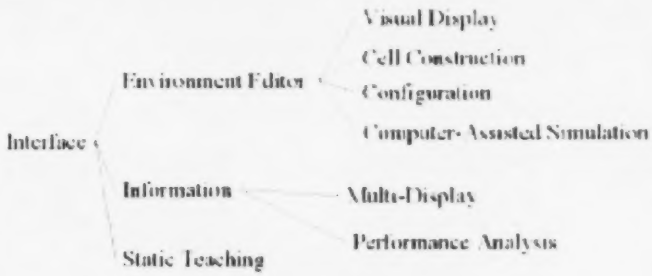


Fig. 2 The hierarchy of modules

(1) Interface module, is the front-end object for SimPCS. It offers the basic functionality required for an interactive program. Its main types of the widgets used to make a control are the pull-down menus and panels, which have the basic file operations and customization at this level. Figure 3 is a snapshot of our system. This layer is the root of all modules of our system. It consists of the environment editor, the information modules, and the static teaching module.

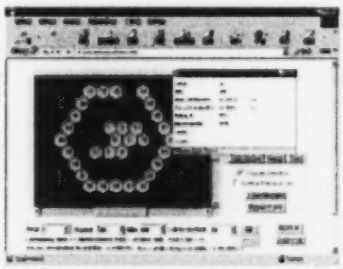


Fig. 3 A snapshot of the system

(2) **Environment editor module**: provides the establishment of a virtual environment. It enables the user to compose and establish complex conditions with virtual objects (e.g., house, river and road), to import and edit a map and save an established map.

(3) **Visual display module**: is an advanced feature of the system. It provides many iconic objects such as a station, highway, or city. With these objects, users can construct a mimic PCS environment. It enables users to simulate a PCS environment. Within the environment, the user can set up different parameters to change the cell configuration.

(4) **Cell construction module**: is responsible for establishing the cells in a selected area of the map. The user can directly select the cells on the map with the mouse. The module can create cells after constructing the environment. Figure 4 shows an example of cell distribution. The module also provides a mechanism of recombination. It uses the performance visualization grains to advance the visualization capability [4]. The technique facilitates to reorganize the performance visualization grains and support various presentations. The system can merge/split the performance visualization grains for specific geographical areas or cells.

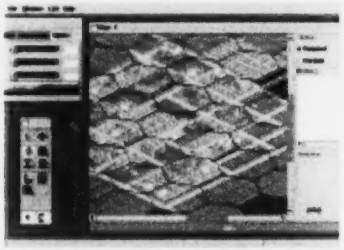


Fig. 4 Cell establishment

(5) **Configuration module**: offers the function of configuration of the objects. It allows users to set and configure the properties and limitations of the objects. The user can set call holding time and residence time of each mobile host. Figure 5 shows the dialog of configuration.

Fig. 5 Configuration

(6) **Computer-assisted simulation module**: as suggested by the name, provides the simulation of practiced conditions. It provides the user with methods to generate parameters of practiced conditions and transmit the queries and parameters form the user interface on front-end to the simulator which applies parallel/distributed computing techniques on the server. It also allows the user to choose several processors in order to run the programs simultaneously. The users can explore their behaviors after simulation.

(7) **Information module:** offers the information of simulation results, which consists of multi-display module and analysis module.

(8) **Multi-display module**: offers advanced presentation forms. It not only displays the static information (e.g. cells, channel, blocked call and so on) but also provides different presentation forms according to different configurations. Currently, two presentation modes are available to the users, color and numeric. In the color-oriented mode, the simulation results can be expressed by different colors. For instance, high blocking probability can be expressed by red color and low blocking probability can be expressed by green color. With this mode, the user can easily identify the area with high blocking probability. On the other hand, the numeric-oriented mode offers users the capability to see the details of each cell.

(9) **Performance analysis module**: provides the basic functions of performance analysis. SimPCS provides statistical analysis functions for the performance data. The main objective is to allow support the users in their efforts to understand the results and behaviors of simulation. The users can analyze the different results and behaviors of simulation according to different factors (e.g. new call blocking, forced termination). Figure 6 illustrates the different types of analysis of simulation results with histograms and pizza graphs.

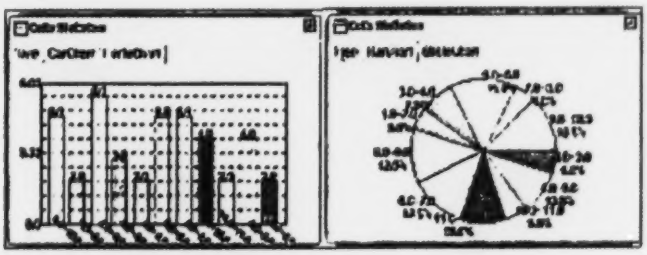


Fig. 6 Different types of analysis

(10) **Static teaching module**: is used to present static education materials. The information of PCS is presented in some manners just like slide show, notes, and simulation results.

After this brief description above, we can refer to the fact that actual prototype of SimPCS has been implemented with Java programming language in an object-oriented development environment.

5 Usage Profiles and Case Studies

This section gives different scenarios of using SimPCS for different users and discusses the services for them. Figure 3 depicts a snapshot of SimPCS for novice users. First, a novice user can select different parameter values such as number of rings(cells), number of channels in a BS, number of MHs in a cell, and the average call arrival rate of MHs. After the novice user selects the parameters, SimPCS accesses the pre-simulated (caching technique) data from the database system and presents the probabilities of new call blocking and forced termination, using the predefined PCS system model. The user can then use the visualization function to refine the presentation of the performance data. Figure 3 illustrates the snapshot of the system with statistical analysis.

The simulation system provides flexibility that means the simulator should provide different services for different users. The proposed performance visualization system classified target users into three groups: novice or first-time users, knowledgeable users, and expert frequent users. Each group will have a different usage jurisdiction. Figure 7 illustrates the relationship between users and operations.

(1) **Novice or First-Time Users** – True novice or first-time users know little of PCS systems nor do they want to understand the concept of PCS systems. These users will use a menu to select items to play with (i.e. ring of cells, number of channel, number of MHs in a cell, and call arrival rate). By choosing different the menu item and seeing the quick feedback on the screen, they will be exposed to an overview of PCS systems. The results have been stored in the caching mechanism on the database server, thereby, reducing system response time.

(2) **Knowledgeable Users** – Knowledgeable users understand concepts within PCS systems such as new call blocking, forced termination, call arrival rate, and so on. The proposed system allows knowledgeable users to execute the PCS simulation with their own parameters. These users tune the allocation of the resource by changing predefined parameters and observe the performance difference between their options.

(3) **Expert Frequent Users** – Expert "power" users are experts with the PCS systems and will develop and implement a PCS system to verify their research. The expert users will construct a PCS environment to mimic the real environment for evaluating performance. Since our prototype provide the capability to construct and mimic PCS environments, users can embed their simulation protocols into our system and use the analysis/ visualization tools to analyze the performance data.

BEST COPY AVAILABLE

Fig. 7 Available functions for users

6 Conclusions

This work designs, develops, and implements SimPCS, a web-based PCS training and learning tool, to provide users a more flexible learning environment and give users full user-control capabilities. SimPCS can be easily used through a web browser to achieve the goal of cooperative testing and learning. It can simulate large-scale PCS systems up to thousands of cells. SimPCS has the merits of personality, transparency, efficiency, scalability, portability, and flexibility. SimPCS provides many user-directed features. It not only simplifies the complexity of programs but also supplies convenience for the users. Furthermore, the system provides the user with several editing components of the visualization system and many iconic objects to design the simulated environment by clicking the mouse directly. Although related investigations extensively perform simulation studies, relatively few web-based,- large-scale PCS learning tools are developed as these models are rather time consuming. SimPCS uses the distributed teaching architecture, which offers the best performance and the least network traffic of all architectures. In addition, parallel processing and caching mechanisms are applied to improve simulation efficiency on server-side and offer a real or accelerated-time simulation.

Acknowledgment

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC 89-2213-E-035-010.

Reference

[1] A. Bittorf, J. Bauer, M. Simon, and T. L. Diepgen, "Web-based training modules in dermatology," MD Computing 14 (5), pp. 371– 376, (1997).

[2] C. D. Carothers, R. M. Fujimoto, and Y. B. Lin, "Simulating population dependent PCS network models using time warp," in Proceedings of the IEEE 45th Vehicular Technology Conference, July, (1995).

[3] M.A. de Juan, M.A. Leon, B. Martin-Calero, A. Mendoza, A. de los Ojos, J.R. Peran, and L.J. de Miguel, "Decision making based on a discrete event simulation tool," in Proceedings of 7th IEEE International Conference on Emerging Technologies and Factory Automation, pp. 335 –341, (1999).

[4] C. R. Dow, J. S. Chen, Y. F. Huang, "Visualization of performance data on PCS systems," International Symposium on Multimedia Information Processing, Taipei, Taiwan, December 14-16, pp. 28-33, (1999).

[5] C. R. Dow and S. H. Hung, "A web-based parallel simulator for cellular mobile systems," ISCA 12th International Conference on Parallel and Distributed Computing Systems Conference, Fort Landerdale, Florida, USA, August, pp. 18-20, (1999).

[6] P. M. Greenfield, Electronic technologies education, and cognitive development. In D.E. Berger, P. Pezdek and W.P. Banks(eds.), "Applications of cognitive psychology: problem solving, education, and

BEST COPY AVAILABLE

computing.," Lawrence Erlbaum, Hillsdate. NJ, (1987).
[7] M. Haag, L. Maylein., F.J. Leven, B. Tönshoff, and R. Haux, "Web-based training: a new paradigm in computer-assisted instruction in medicine," International journal of medical informatics, Volume: 53, Issue: 1, January, pp. 79 – 90, (1999).
[8] J. Hooper, J. O'Connor, R. Cheesmar, and C.P. Price, "Tutorial software for clinical chemistry incorporating interactive multimedia clinical cases," Clin. Chem. 41, pp. 1345–1348, (1995).
[9] S. Jordan, "Resource allocation in wireless networks," Journal of High Speed Networks, vol. 5, no. 1, (1996).
[10] A. Kaddouri, B. Khodabakhchian, L.-A Dessaint, R. Champagne,L. Snider, "A new generation of simulation tools for electric drives and power electronics," Proceedings of the IEEE International Conference on Power Electronics and Drive Systems, pp. 348 –354, (1999).
[11] I. Katzela and M. Naghshineh, "Channel assignment schemes for cellular mobile telecommunication systems," Personal Communications magazine, June, (1996).
[12] R. Klar and U. Bayer, "Computer-assisted teaching and learning in medicine," Int. J. Biomed. Comput. 26, pp. 7-27, (1990).
[13] C. Lalle, "A hypermedia system for parasite identification," Int. J. Biomed. Comput. 41, pp. 175–180, (1996).
[14] D.M. Laurillard, "Computers and the emancipation of student: giving control to the learner," Instructional Sci.,16, pp. 3-18, (1987).
[15] C. W. Lin and Y. B. Lin, "Development of a PCS handoff simulator," Master Thesis, Department of Computer Science, National Chiao-Tung University, June, (1997).
[16] W. Lin, C. C. Chiang, H. K. Wu, V. Jha, M. Gerla, and R. Bagrodia, "Parallel simulation on environment for mobile Wireless Networks," in Proceedings on Winter Simulation Conference, (1996).
[17] H. Pasterkamp, "Computer assisted learning of chest auscultation: the respiration acoustics laboratory environment," in: van Bemmel, Zvaronova (Eds.), Knowledge, Information and Medical Edu-cation, Elsevier, North Holland, pp. 244–251, (1991).
[18] M. Piccolotto and O. Rio, "A computer-based teaching tool for structural design," Materials Science and Engineering A196, pp. 109-120, (1995).
[19] L. Polwman, "An ethnographic approach to analyzing navigation and task structure in interactive multimedia: some design issues for group use.," In A. Monk, D. Diaper and M.D. Harrison (eds.), People and Computer VII. Cambridge University Press, Cambridge, UK, (1992).
[20] J.B. Pugliesi and S.O. Rezende, "Intelligent hybrid system for a training and teaching environment," ICCIMA '99. Proceedings. Third International Conference on Computational Intelligence and Multimedia Applications, pp. 148-152, (1999)
[21] F. Puppe and B. Reinhardt, "Generating case-oriented training from diagnostic expert systems," machine-mediated learning 5 (3,4), pp.199– 219, (1995).
[22] J. Short, R. Bagrodia, and L. Kleinrock, "Mobile wireless network system simulation," ACM Mobile Communication Networking Conference, November, (1995).
[23] K. Tait et al., "Sim/10 first intermediate report on authoring tools for simulation," DELTA project D1014 SAFE, (1989).
[24] P. van Rosmalen and J. Hensgens, " The use of computer simulations in training," Materials Science & Engineering - A - Structural Materials: Properties, Microstructure and Processing, Volume: 199, Issue: 1, August 1, pp. 109-120, (1995).

Simulating Engineering Professional Practice Using an Interactive Web-based Resource: A Virtual Engineering Consultancy Company (VECC)

Robert M. Corderoy[*] and Paul Cooper[**]
[*]*Centre for Educational Development and Interactive Resources*
E-mail: bob_corderoy@uow.edu.au
[**]*Department of Mechanical Engineering, Faculty of Engineering*
E-mail: paul_cooper@uow.edu.au
University of Wollongong. Australia

A well designed PBL environment can assist and support students in building heuristics that will enhance their ability to solve problems in the real world. Problem based learning is situated in the context of a meaningful 'real world' based environment which draws on 'real variables' without the 'risk factor' normally associated with everyday practice. It poses an ill-structured, 'real world' based problem which drives the learning. Posing the problem before learning takes place provides relevance, challenge and interest, and is a powerful motivational strategy. This paper reports on the development of an on-line, problem based learning (PBL) environment (the VECC) in which students develop and practice engineering consultancy skills. Evaluation of the pilot implementation with 3rd year Engineering students at the University of Wollongong is briefly outlined. The VECC models the skills and processes of an 'expert consultant' "a professional engineer" in the field of Heat Transfer within a supported learning environment so that 'novice' student's develop appropriate problem solving skills vital for their later engineering practice. The power of a web-based environment to provide platform which supports both synchronous and asynchronous computer mediated communication enables students to interact with a virtual client in an environment which is "safe" and highly flexible.

Key Words: **Problem based learning, virtual environments, problem solving, consultancy, virtual client.**

1 Introduction

Traditionally, students graduating from engineering courses have had limited if any exposure to the wide range of practical skills centred on 'real world' contextualized problem solving and client contact which engineers must have 'in the filed' to be successful. There are many reasons for this, often based in the pedagogical approach characteristic of the institution in which they are trained. Providing a 'risk free' and cost effective environment in which students may develop and practice such skills is perhaps the other major influencing factor. A possible solution to this impasse is to provide a means of developing and practicing these skills using simulated environments.

Universities and other tertiary institutions throughout the world are rushing to embrace alternative delivery methods, particularly those that utilise the versatility and power of the World Wide Web. This is in response to the globalisation of education, the recognition of the need to provide mechanisms which will maximise opportunities for and support life long learning and the need to expand the boundaries to encompass educational experiences which are set in 'real world' contexts. The scope and boundaries for what is possible in such environments is limited only by the imagination of developers and the limitations of the web in its

present form. The web is a dynamic medium whose boundaries are being extended almost daily.

Further, suggests Burnett (1997) [3], the use of the Web will continue to expand as it becomes more stable, easier to use and more accessible to everyone. What we are learning from using the Web today will provide the confidence and expertise to take advantage of the advances in its technology. Now is the time according to Alexander (1995) [1] to stop focussing on the technology itself and to start focussing on what students are to learn, and the best way for them to achieve these learning objectives. This indeed was one of the key issues of "Secrets of On-line Teaching".

In recent times many of these institutions have experimented with the use of on-line delivery with the purpose in mind of extending access to educational experiences to a wider audience on a any time, any place basis. In many cases, the results have been less than satisfactory and have fallen short of student expectations for a number of reasons. The problem is exacerbated by a number of factors. These include: time and funding restraints; the often unjustified self perception of expertise in the field and the mistaken belief by many that, putting a subject or teaching resource on-line involves little more than providing content as a web based document. Given that this situation will probably not change in the foreseeable future, how can we as teachers/designers/developers ensure that our web-based resources are effective, efficient and supportive life long learning?

"An understanding of the techniques and protocols of on-line teaching and learning and the processes of both the design of new and the conversion of pre-existing resources has become essential for academics, as universities throughout the world embrace alternative delivery methods in response to the globalisation of education." Corderoy & Lefoe (1997) [5]

2 Design Issues for On-line learning Environments

An integrated online environment such as the VEEC provides a set of tools, systems, procedures and documentation that facilitates the occurrence of any or all parts of the learning experience using some form of computer mediated communication. Moving to web based delivery of a subject or any aspect of that subject will carry with it the need for both the designers and the teachers to recognize and act on the many issues associated with such environments.

The logistics of setting up and running this type learning experience mirrors the issues that are addressed in setting up any on-line course. In general the issues can be identified as belonging to three basic categories identified in any on-line learning environment, namely technical support, pedagogical and equity issues.

Some of the more important issues include:

- Interface easy to use and navigate
- Bandwidth limitations
- Security and submission of work
- Equity of access to the technology
- Unfamiliar format for some - provide time to adjust
- Lecturer's participation - make regular contact - ensure all have accessed by a certain time
- Lecturer's willingness to moderate/facilitate collaboration
- Consider cultural differences
- Work load changes for lecturer
- Perceived inequality of experience

Of these, the authors single out technology problems including access, interaction and communication and workload as being crucial to successful learning outcomes for students working in on-line environments

2.1 Technology

The students need to be 'trained' in the basic use and operation of the technology before they start and this is often best achieved by 'face to face' instruction at the start of session. As a good rule of thumb, problems are minimised by designing to the 'lowest common denominator' in terms of available technology. Related to this aspect is the equity issue of student access.

2.2 Interaction/Student Participation and Enthusiasm

One of the most significant challenges for those using on-line teaching environments is the 'silent student'. Ensuring that the students engage in the learning is closely related to the degree of interactivity fostered between students and their peers as well as between the students and the instructor. Success in the latter is dependent upon an instructors commitment to providing 'rapid feedback' to submitted tasks and posed questions as well as regular personal 'checking in' on-line. Such commitment provides an incentive for all students to be active and enthusiastic.

2.3 Resources/Time and Workload

There is a need to consider carefully the design and structuring of on-line environments, particularly those which already exist in a traditional format. Content cannot be simply 'placed on the web'. Time and effort must be spent in considering the resources and structure needed to best present the materials in the 'new environment'. Developing materials for on-line delivery is not an easy or short process. Both the teacher and the students must be committed to accepting a greater workload as a trade-off for the value of working in an environments which mirrors 'real life' situations and skills application.

3 Developing the VECC

The VEEC has been developed on a sound pedagogical basis using a team approach, utilising the specific skills of each team member. The Faculty of Engineering and the design/development team at the Centre for Educational Development and Resources at the University of Wollongong, Australia, have been involved in the development of a prototype over the past 18 months. The VECC is a highly interactive and innovative web based simulated consulting environment, based in the 'real world' problems and processes usually associated with the task of a professional consulting engineer in the area of Heat Transfer. It provides an environment which models the 'experts' heuristic's for solving the problem, facilitating the development of an appreciation and understanding of the application of the skills and processes needed in a real world consultancy in the 'novice' student. The result will be a graduate engineer who is better prepared for the 'real world' engineering practice.

This flexible, web delivered, student-centred resource provides not only training in specific technical area, but also orientation and experience in professional practice. This type of advanced training has been demonstrated to have significant benefits to students entering the workforce. Ryan *et al.*, (1996) [8]

The framework of the VECC package is modelled on the resources that one finds in a real engineering consultancy office. The consultant in such an office will have developed an expertise in their chosen field - in this case Heat Transfer - and will also undertake continual professional development. This CAL learning environment will therefore foster a positive attitude in students towards lifelong learning. Candy *et al.*, (1994) [4]

The Industrial Problem Solving Assignments are the main educational vehicle for building students' confidence in tackling real world situations and complex tasks. This feature differentiates the VECC from other engineering CAL packages. To quote Laurillard (1993) [6], "we cannot separate knowledge to be learned from the situations in which it is used". In the VECC, students will immediately see the relevance of the engineering theory to be used, since they must actively search for the appropriate theoretical model. That search is the same process the student will eventually use as a practicing professional engineer.

When using this resource the student role-plays a consultant who carries out all the managerial and technical tasks required to expedite a number of high-level Industrial Problem Solving Assignments. This problem-based learning approach "confronts the students" Boud *et al.*, (1991) [2] with 'real world' based ill-structured problems and scenarios which provide a stimulus for learning and in so doing "encourages the students to take a deeper approach to learning". Ramsden (1992) [7]. The PBL approach enriches the learning outcomes by simultaneously developing higher order thinking skills and disciplinary specific knowledge bases and skills. It promotes the student to the active 'practitioners' role in the process.

The consultant's activities include:

- negotiating with the client on cost and timetabling of the consultant's services
- obtaining the client's technical brief and tendering for the project
- sourcing technical information such as plant dimensions
- making on-site measurements of temperatures or other parameters
- student-centred learning through the Computer Aided Learning (CAL) module integral to the Virtual Engineering Consultancy Company
- simulation of real-life problems using a toolbox of simulation resources.

4 Expected Outcomes

The most significant expected outcomes for students using this web-based package include:

- A PBL based CAL resource that provides Engineering students with training in professional practice as consultants in Heat Transfer Engineering through 'virtual access' to 'virtual clients'.
- The simulated 'real world' environment that the web provides will provide them with a better understanding not only of the processes involved in professional Engineering practice but also the relationship between the Engineers and client.
- Improved effectiveness of delivery to a diverse student population of full-time, part-time and off-campus students.
- Improved skills in collaborative working and negotiation.
- Improved attractiveness of University of Wollongong Engineering graduates to potential employers.
- Flexibility in terms of meeting the course requirements with regard to time and place and individual learning styles.
- Improved opportunity for students to be active members of the cohort in all facets of the course.

5 The Pilot Virtual Engineering Consultancy Company (VECC)

To date the fundamental structure of the VECC and a substantial number of software resources (including interactive Heat Transfer simulations) have been developed. The complete package will eventually contain in excess of 30 simulations which will support and develop the students understanding and proficiency in aspects of Heat Transfer including: furnace insulation; steel quenching; conduction and boiling heat transfer.

Extensive work has also been carried out on the structuring of the 'theory section' of the package. Consideration has been given the 'chunking' of this considerable resource so as to provide a meaningful resource for the students while at the same time being 'easily accessible' within a web based environment.

The centre of the VECC resource is the consultant's office (Fig 1) that models a typical engineering office in the real world and has facilities including:

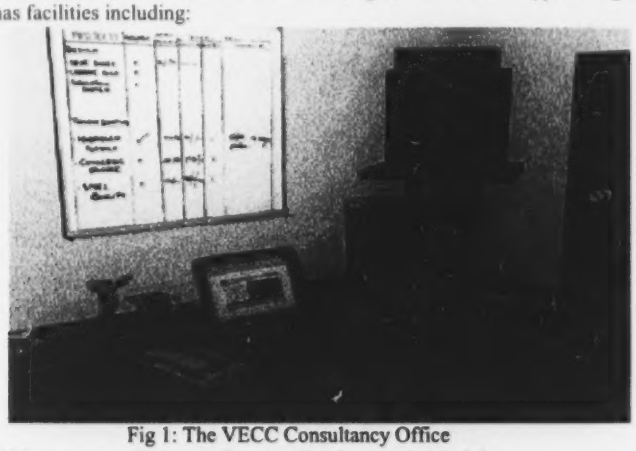


Fig 1: The VECC Consultancy Office

In summary, the VECC resource will eventually comprise three main Modules;

- **Training (CAL) Module** - the student uses resources such as simulations, text-based material, videos, animations, etc to learn the fundamentals of Heat Transfer theory.

- **Trouble-shooting Module** - here the student has to solve challenging real-life problems that are far more in-depth than conventional engineering assignments. In an example already developed, the student's client is a corporation that has just built and commissioned a large hydrogen production furnace. The furnace is overheating and the student must find out why, suggest remedial measures and act as an expert witness in a court case.

- **Design Module** - Students design a number of pieces of thermal equipment to satisfy a specification from their client. Examples will include a transistor heat sink and car radiator. The detailed design of thermal equipment is not a topic normally covered in an undergraduate course on Heat Transfer perhaps because it requires a problem-based learning approach and yet it can be one of the most rewarding aspects of an engineering student's study.

- A **project management whiteboard** that will be automatically updated as a student progresses through the study programme.

- A **laptop computer** which is the virtual gateway to the web and provides contact with the clients (the lecturer) for each project, resources external to the VECC and the brief containing full technical details. (Appendix 1)

- A **video monitor** for access to video clips of site visits, illustrative fluid visualisation experiments, lecture presentations, etc.

- A **desktop computer** which represents a powerful computing resource where the heat transfer simulations are located. These already include four unique simulations of important conduction heat transfer situations. Each simulation deals with a real world problem and will be used as part of the consultant's exploration of the case studies.

- A **telephone** for initial contact with the consultant's clients achieved using an audio track.Hello, Chris Garbutt here. I'm the Engineering Manager of Heat Treat TM. Our company deals with a large variety of construction projects involving thermal and chemical processing. We struck some heat transfer problems with one of our projects involving a furnace that is not operating as was planned and we're asking your consultancy firm, along with others, to tender for a trouble shooting role in fixing the problem.

  If you are interested in taking on this challenging consultancy, a brief containing full technical details of the project at our company's web site can be accessed through your laptop computer. I hope you can help us out. Please E-mail me if you have any queries. Bye for now.

- A **virtual library** of books which is the link into the CAL module where the student explores the topic of Heat Transfer through the problem-based learning approach of the VECC.

6 Pilot Evaluation

Students who took part in the pilot implementation had access to a limited prototype version of the 'complete' site. At this stage of its development, some of the segments of the VECC exist as discrete units that are independent of the overall structure. It was expected that this may cause some navigational/continuity problems for some students, however early anecdotal evidence collected from the students seems to suggest that this was not the case. Approximately 80 3rd year engineering students (20 groups comprising 3 or 4 students each) used the VECC to complete a major assignment during semester 1. Each group consulted in various degrees with the client using the E-mail link, used the various resources available within the consultancy office to support their investigations and develop their 'solutions' to the 'posed problem'.

Data collected during this pilot includes: student interviews and comments including a special forum where technical issues and the learning processes were discussed; lecturer's observations; archived E-mail communication between the lecturer and students and; individual marks awarded to students together with the lecturer's 'quality of answer' evaluation.

6.1 The Students' perceptions

Comments made by students to the lecturer include:

- convenient and easy to use;
- provides for flexibility in their study schedules;
- provides access to a greater richness of resources;
- helped them develop an understanding of the issues critical to client management;
- motivating;
- provides time to consider actions and issues
- allowed them to develop collaborative networks
- use of a real world problem put the theoretical concepts learned and the analytical skills developed into the context of their future activities as professional engineers and;
- comfortable working in this delivery mode.

6.2 The Lecturers' perceptions

Although at this early stage in development there is no longitudinal data for comparison, the lecturer is confident that data to be collected during the continued development and use of the VECC will support and re-enforce observations made so far including:

- overall performance of the majority of groups is better than past years, not just in terms of the overall mark but in the quality of the answers;
- role play appears to have contributed to a deeper understanding of the problem and possible solutions and enriched the learning experience;
- there has been no change in the completion rate, the number of students 'opting out' is about the same as usual;
- students who took full advantage of this support by contacting the 'client' (lecturer) performed better than those who did not;
- seems to be a time efficient way of presenting both the technical information and the processes involved in consultancy in a richer environment;
- flexibility for both students and lecturer is a 'real plus' and;
- the students seemed to be more motivated and this is reflected in their willingness to explore the resource base fully, developing better quality answers.

7 Future directions

There are several issues unique to technology based delivery which need to be investigated with respect to the VECC. The student groups had minimal exposure to the 'structure' and process of the VECC in lectures. Did this add to the cognitive load placed on them so that unnecessary effort was expended on learning about the system, rather than from it? Experience shows that with poor design, there can be an enormous increase in the cognitive load for students and the result is a poorer outcome than expected. To address this, it is envisaged that an extensive help system will be provided within the package. Specific lab sessions prior to using the system will also be run to allow students time to become familiar with the package. Such 'user support' mechanisms are an essential part of complex learning systems and it is essential that all students avail themselves of it. Ensuring that they do is one of the keys to facilitating useful student interaction with the learning environment. The issue of preferred learning styles and the 'students' fit' to the delivery mode needs to be explored.

8 Conclusion

Flexible modes of delivery such as Web based instruction can provide an effective means of addressing the problems of increasing student demands, decreasing funds, the need to establish a presence in the

international market place and rapid technological change. The rapid rise in the development of sophisticated and improved technologies has been the driving force behind the widespread embracing of the concept of flexible delivery and the application of the many and varied tools upon which it is based in the field of education and life long learning. The VECC is a web based flexible learning tool which provides students with 'real world' based experiences in professional practice. Early indications suggest that students are benefiting from this virtual consultancy learning environment which uses a problem based learning approach to develop the skills which are vital to engineering practice in the real world.

References

[1] Alexander, S. (1995) Teaching and learning on the World Wide Web. *Proceedings of AUSWEB95 The First Australian World Wide Web Conference*, Southern Cross University, Lismore. Australia.

[2] Boud, D. & Faletti, G. (1991) (eds) The Challenge of Problem-Based Learning. Kogan Page, London.

[3] Burnett, D. (1997) TiLT Seminar Series – Confessions of an Online Teacher. http://www.scu.edu.au/services/tilt/tsf/on/dale/bsemsummary.html

[4] Candy, P. Crebert, G. & O'Leary, J. (1994) Developing Lifelong Learners through Undergraduate Education. *NBEET Report No 28*, Canberra.

[5] Corderoy, R. M. & Lefoe, G. (1997) Tips and Secrets for Online Teaching and Learning: An inside View. *Proceedings of ASCILITE 97*. Perth.

[6] Laurillard. D (1993) Rethinking University Teaching: A framework for the effective use of educational technology. Routledge. New York

[7] Ramsden. P. (1992) Learning to Teach in Higher Education. Routledge, London.

[8] Ryan G, Toohey, S. & Hughes, C. (1996) The purpose, value and structure of the practicum in higher education: A literature review. *Higher Education 31*, 355-377.

Appendix 1

YOUR BRIEF

Heat Loss Calculations

If you choose to accept this assignment HeatTreat requires you to:

- to calculate the total heat loss from the furnace walls and roof (as a first approximation assume a outside surface heat transfer coefficient to be $20W/m^2$ including both convection and radiation heat transfer)
- to calculate the interface temperature between the Zirconia Blanket and the Mineral Wool to ensure that the latter does not overheat.

Surface Temperatures

The client has measured outside temperatures on the outside of the furnace to be in the range of 105 to 170°C. These are potentially very hazardous. You must perform the following tasks. A map of some of the surface temperature measurements is shown below.

Outside Wall Temperatures

Furnace level	1	2	3	4	5	Floor
Mean outside surface temp (°C)	75	64	68	70	68	52

a) Carry out a sensitivity analysis of one of the wall the surface temperatures to the outside heat transfer coefficient (calculate the expected radiation heat transfer coefficient assuming emissivity, $\varepsilon = 1$, and then vary the convection heat transfer coefficient in a range that would be expected under normal weather conditions ie between 5 and $20W/m^2K$, say).

b) Determine whether the firebrick insulation shown in the design drawings is likely to have been put in place correctly (if the insulation has not been properly installed legal action may be taken against the insulation installation sub-contractors). Assume the flue duct wall temperature is equal to the gas temperature of Section 6 of the furnace.

c) Recommend a solution to these high surface temperatures problems. Some possibilities include:
Add extra insulation to outside of furnace (you must calculate how much must be added and whether the resulting temperature of the structural steel is within acceptable limits).
Shut down furnace and replace internal insulation in problem areas (very much a last resort represents a very high cost option).?

Summarise your recommendations.

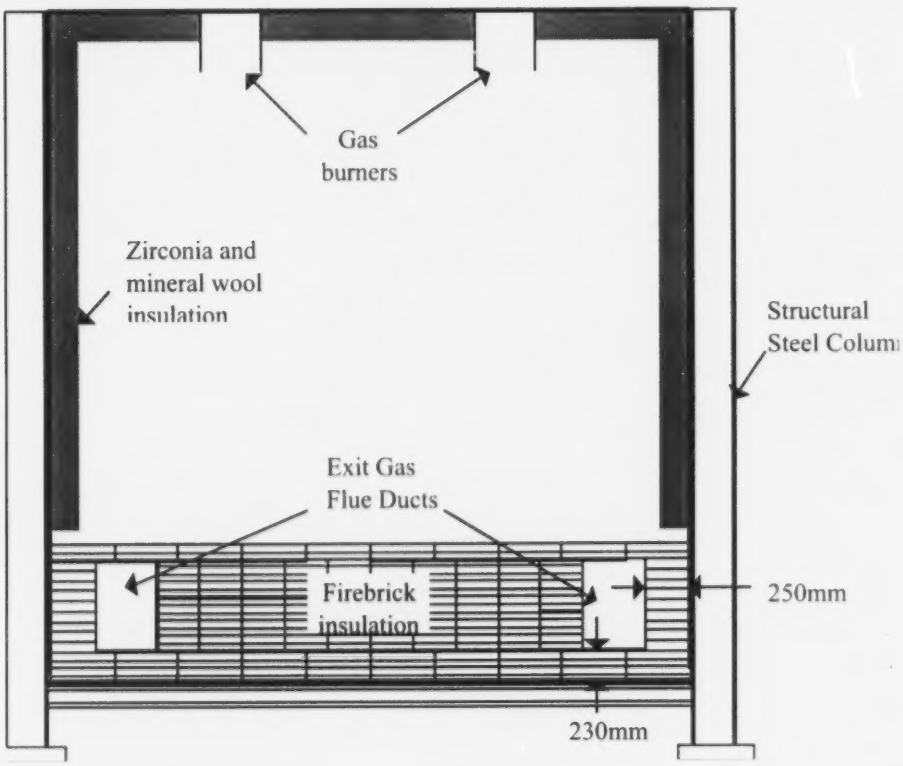
Further information

It is up to you to source any further information that is required. Local sources of information include:

- the training module "Conduction Heat Transfer" on your desk
- thermophysical data of various materials in the appendix of "Conduction Heat Transfer"
- simulations and video footage available on the desktop computer and video screen.

Remember that obtaining relevant information is often a critical task in high level engineering work and decision making.

If you require specific information on this Brief please contact your client at the following E-mail address. Paul_Cooper@uow.edu.au.



Layout of furnace insulation and structural steel.

Student Use of Learning Strategies in Web-Based Courses

Ching-Chun Shih* and Ann D. Thompson**
Iowa State University
**E016 Lagomarcino Hall, Ames, IA 50011, USA*
Tel: +1-515-294-1941
Fax: +1-515-294-9284
Email: ccshih@iastate.edu
***N131 Lagomarcino Hall, Ames, IA 50011, USA*
Tel: +1-515-294-5287
Fax: +1-515-294-6206
Email: eat@iastate.edu

The purpose of this paper is to present the preliminary analysis of student learning strategy use in Web-based courses provided by the Master of Science in Agronomy Distance Education Program at Iowa State University, U.S. This study involved 28 students taking 8 courses of this program in the fall of 1999 and spring of 2000. Each student was asked to report their learning strategy use for each lesson they took. The 9 learning strategy categories developed by Pintrich, Smith, Garcia, & McKeachie (1991) were used to classify students' use of learning strategies. It was found that students used most of the organization, rehearsal, and metacognitive self-regulation learning strategies and least of the critical thinking strategies. None of the peer learning and help seeking strategies was reported in the Reflective Learning Journals. The learning strategies students used to cover the learning materials, such as taking notes, viewing the lessons via the CD-ROM/WWW, and doing the reading before viewing the lessons, were the most frequently reported strategies in students' Reflective Learning Journals. Future research is needed to investigate and survey student use of learning strategies and to differentiate student use of learning strategies between high achieving and low achieving students.

Key words: **Web-based learning, learning strategies, reflection**

1 Introduction

The latest in the long line of learning technologies is the World Wide Web (WWW). As the WWW is becoming popular, its use as means of delivering instruction is also growing. The World Lecture Hall lists over 1000 courses that are delivered by higher educational institutions via the Web, and this list is growing daily (World Lecture Hall, 2000). However, Alexander (1998) argued that research questions about application of new technologies should not be in terms of media such as print, video, computer, or face-to-face instruction. The most important question should be: what is known about the ways students learn via the new technology.

Identifying students' learning strategies can help educators understand how students process learning materials in different ways. According to Cross and Steadman (1996), learning strategies are behavior skills which learners can use to improve their understanding, integration, and retention of new information. Learning strategies include a wide variety of cognitive processes and behavioral skills (Weinstein & Meyer, 1991). Pintrich and his colleagues developed a learning strategy instrument, Motivation Strategies for Learning Questionnaire (MSLQ) (Pintrich, Smith, Garcia & McKeachie, 1991). This instrument includes two main sections: one on motivation and one on learning strategies. The learning strategy section consists of nine learning strategy categories. They are: rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, and help seeking

(Pintrich, Smith, Garcia & McKeachie, 1991). The description of the 9 learning strategy categories are listed as follows:

(1) Rehearsal: Basic rehearsal strategies involve reciting or naming items from a list to be learned.
(2) Elaboration: Elaboration strategies help students store information into long-term memory by building internal connections between items to be learned.
(3) Organization: Organization strategies help the students select appropriate information and also construct connections among the information to be learned.
(4) Critical thinking: Critical thinking refers to the degree to which students report applying previous knowledge to new situations in order to solve problems, reach decisions, or make critical evaluations with respect to standards of excellence.
(5) Metacognitive self-regulation: There are three general processes that make up metacognitive self-regulatory activities: planning, monitoring, and regulating.
(6) Time and study environment: Time management involves scheduling, planning, and managing one's study time. Study environment management refers to the settings where the students do the class work.
(7) Effort regulation: Effort regulation is self-management, and reflects a commitment to completing ones' study goals, even when there are difficulties or distractions.
(8) Peer learning: Dialogue with peers can help a learner clarify course material and reach insights one may not have attained on one's own.
(9) Help seeking: Another aspect of the learning environment that students must learn to manage is the support of others. This includes both peers and instructors.

In the fall of 199, the Master of Science in Agronomy Distance Education Program at Iowa State University, U.S. started providing interactive multimedia courses in which most course materials and resources were accessed and delivered through the WWW and CD-ROM. One of the goals of this program was to provide a way for professionals working in industry and the government to gain an advanced degree in Agronomy without having to attend the campus in person. The curriculum consists of 12 courses, a 1-credit workshop, and a 3-credit creative component, which totals 30 semester credits (Iowa State University, 2000). The courseware integrates content material on CD-ROM/WWW with the interactive tools of WebCT (WebCT, 2000) on an ISU server. The WebCT tools allow students to interact electronically with their instructors and classmates by utilizing a course calendar, discussion board, chat room, student homepage, assignment, emails, and student records. The program began with an enrollment of fifteen students in a pilot program in 98/99 academic year. In the fall of 2000, Eighty-one students are enrolled in the program.

What do we know about the ways students learn via the new technology, the WWW? What are the learning strategies used by students in the Masters of Science in Agronomy Distance Education Program? To answer these questions, research on the learning strategies used by students in Web-based courses is needed. This type of research will assist educators in delivering quality Web-based instruction in a manner that will help students become better learners in distance education.

2 Purpose

The purpose of this study is to report the preliminary analysis of learning strategies used by students in Web-based courses provided by the Maters of Science in Agronomy Distance Education Program at Iowa State University in U.S.

3 Methods

The study involved 29 students taking 8 Agronomy courses provided by the Mater of Science in Agronomy Distance Education Program in the fall of 1999 and spring of 2000. Each student was asked to complete a Reflective Learning Journal for each lesson. Usually, each course consists of 15 lessons per semester. Four open-ended questions were included in the Journal. They were: (1) Summarize the major points of this lesson; (2) What is the most valuable concept you learned from the lesson; (3) What concepts in the lesson are still unclear to you; and (4) What learning strategies did you use in this lesson? Using student responses to the last question, this paper focuses on studying the student use of learning strategies. The 9 learning strategy categories in the MSLQ (Pintrich, Smith, Garcia, & McKeachie, 1991) were used to classify students' use of learning strategies.

4 Results

Regarding the use of learning strategies, most of the students reported that they finished the assigned readings before the lesson; took notes while viewing the lessons; viewed the lessons on CD/WWW at a fixed schedule; printed off the lesson content on CD/WWW including text, diagrams, pictures, graphs, and study questions for future review; read the textbook and viewed the lessons more than one time; used notes to review the lessons; and kept up with weekly readings or assignments. In addition, many students did a quick read-through before they viewed the lessons; restudied the parts of the lessons that were not clear during the first time; related the concepts they had learned from the previous lessons; and made progress on a daily bases. Most interestingly, one student even copied illustrations from the lessons every week and saved them to his computer desktop as wallpaper for quick reference. He said, "[the wallpaper] sometimes helps my memory and understanding." Another student reported that he needed to find quiet time to study and avoid distraction of the family members. In his journal, he wrote that, "quiet time when our new baby is not crying enhances learning! I have to admit that mom is doing a great job in that department for me!"

Learning strategies reported in students' Reflective Learning Journals were analyzed and classified according to the 9 learning strategy categories developed by Pintrich et al. (1991) (See Table 1). Students used most of the organization, rehearsal, and metacognitive self-regulation learning strategies and least of the critical thinking strategies. None of the peer learning and help seeking strategies was reported in students' Reflective Learning Journals. However, 10 learning strategies did not fit into Pintrich's categories. They were the strategies that students used to "take" the lessons either through CD-ROM or WWW, and try to cover and understand the learning and reading materials. These were the most frequently reported learning strategies in the Reflective Learning Journals.

Table 1. List of learning strategies used by students

Learning strategy Category[1]	Learning strategies used by students
1. Rehearsal	1. Highlight the key topics of the lesson to refresh my memory
	2. Read the textbook more than one time
	3. View the lessons more than one time
	4. Review information posted on the discussion board
	5. Review my notes and information posted to the discussion board
	6. Copy all the questions to my Word file before working through the lesson to help me memorize the key concepts
2. Elaboration	1. Correct/annotate my notes later after I take them
	2. Write out a narrative summary of the lesson
	3. Use other sources of information, e.g., personal reference texts, Internet, to improve understanding of the lesson material
	4. Do cross-referencing between lessons and put things together
	5. Analyze my answers to the assignments/study questions
3. Organization	1. Make simple charts to organize my material
	2. View the chapter headings to obtain the purpose of the lessons
	3. Use my notes to review the lessons and as a study guide
	4. Relate the concepts I have learned from the course
	5. Use lesson objectives to determine the important factors in the lesson
	6. Re-organize my notes for future review
	7. Do discussion topics to tie things together
	8. Ask myself how the current topic relates to all the topics I have learned in the previous lessons
4. Critical thinking	1. Question the answers that were given by the classmates/instructor
	2. Use note cards for glossary of terms to quiz myself
5. Metacognitive self-regulation	1. Quiz myself on what the key focus of the lesson
	2. Review some of the last lesson to allow better understanding of overall plan
	3. Use quiet time and avoid distraction of the family members

	4. Use the Reflective Learning Journal as a study guide and review outline of the lesson 5. Go back to textbook and lessons to clarify my questions 6. Restudy the parts of the lesson that were not clear on the first time
6. Time and study environment	1. Spend certain amount of time reviewing material every day 2. Complete all the assignments before the due dates 3. Study the lesson in a regular basis each week 4. Study the lesson at a fixed schedule
7. Effort regulation	1. Try to focus on some of the more difficult principles and work through them several time 2. Decide those least understood concepts and spend extra time on them 3. Print off my computer notes and add my own pen-written notes on them 4. Print off the lessons' pages, important illustrations and study questions for later study
8. Peer learning	None
9. Help seeking	None
10. Other[2]	1. Take notes as I read the book/CD lesson 2. Study all the questions ahead of time before studying the lessons 3. Develop a vocabulary list of terms I don't know 4. Do a quick read through before view the lesson 5. Finish readings before viewing the lessons via CD-ROM/WWW 6. Visualize the processes of the concepts in the lessons 7. Copy illustrations from the CD/WWW lessons and save them as wallpaper on my computer 8. Read the lessons very slowly and carefully to make sure I understand the material clearly 9. Spend a portion of my time reviewing all pictures, charts, graphics to make sure I really understand what they are presenting 10. View the discussion as posted by the classmates

[1] Learning categories that are based on Pintrich, Smith, Garcia, and McKeachie (1991)
[2] Learning strategies that did not fit Pintrich's et al. categories

5 Conclusions

In conclusion, a variety of learning strategies were found in the Reflective Learning Journals. In this distance education program, students tended to use more of the organization, rehearsal, and metacognitive self-regulation learning strategies and least of critical thinking strategies. However, none of the peer learning and help seeking strategies was reported. The learning strategies students used to cover the learning materials, such as taking notes, viewing the lessons, and doing the reading before viewing the lessons via the CD-ROM/WWW, were the most frequently reported individual strategies in students' Reflective Learning Journals.

This study provided a good basis for the instructors of this distance education program to understand how individual students learned via CD-ROM/WWW. However, in order to ensure student success in Web-based instruction, future research is needed to survey student use of learning strategies and correlate student use of learning strategies with their achievement. Additionally, it is necessary to differentiate student use of learning strategies between high achieving and low achieving students. To date, the researchers are developing a learning strategy instrument based on the results of this study. The results of the survey study will be posted in the program website to inform the learning strategy use by the high and low achievers in the program. This will help students learn how to learn and become better learners in the Web-based learning environment.

References

[1] Alexander, S., "Teaching and learning on the World Wide Web", http://www.scu.edu.au/ausweb95/papers/education2/alexander/ (accessed on August, 1998).

[2] Cross, R. C., & Steadman, M. H., "Classroom research: Implementing the scholarship of teaching," San Francisco: Jossey-Bass Publishers, (1996).

[3] Iowa State University, "Master of Science in Agronomy Distance Education Program," http://masters.agron.iastate.edu, (accessed May, 2000).

[4] Pintrich, R., Smith, D. A. F., Garcia, T., & McKeachie, W. J., "Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ)," Educational and Psychological Measurement, Vol 53, pp. 801-813, (1991).

[5] WebCT, http://webct.cc.iastate.edu:8900/ (accessed May, 2000).

[6] Weinstein, C. E. & Meyer, D. K., "Cognitive learning strategies and college teaching," College teaching: from theory to practice, New directions for teaching and learning, No 45, pp.15-26, (1991).

[7] World Lecture Hall, http://www.utexas.edu/world/lecture/ (accessed May, 2000).

Students' Attitude toward WPSS in Supporting Classroom Learning

Hsiu-Ping Yueh
Department of Agricultural Extension, National Taiwan University,
#1, Sec. 4, Roosevelt Rd, Taipei 106, Taiwan
Tel: 886-2-23630231-2750
FAX: 886-2-23647221
Email: yueh@ccms.ntu.edu.tw

While the web-based learning environment has become more flexible and has more functions than traditional instructional media as well as many computer-assisted instruction, the EPSS has also become an expanding area within the field of education. This paper first describes the features of and rationale behind electronic performance support system as well as web-based performance support system; demonstrates the implementation of the web-based performance support system in assisting students' learning in a real-time multicast distance classroom; discusses the research methodology; explores the effectiveness of the use of the web-based performance support system in supporting students' learning; and provides conclusions and implications for the filed of education.

Key Words: **Distance Education, Electronic Performance Support System (EPSS), Web-based Performance Support System (WPSS)**

1 Introduction

Electronic Performance Support System (EPSS) was originally defined as a system that provides just-in-time information, advice, learning experiences, and tools in the form of electronic to help people perform a task with the minimum support from other people [3]. Based on the early definition, EPSS was perceived by many people as an interactive computer-based environment which attempts to facilitate or improve human performance such as problem solving abilities within some target application domain. To help organizations design and develop EPSS with a broader systems thinking approach, Raybould (1995) proposes that an EPSS is "the electronic infrastructure that captures, stores and distributes individual and corporate knowledge assets throughout an organization, to enable an individual to achieve a required level of performance in the fastest possible time and with the minimum of support from other people"(p.66)[6].

A number of existing technologies have been selected and integrated into design and development of an EPSS, such as artificial intelligence (AI), hypermedia, computer-based training (CBT), intelligent tutors and microworlds [5]. With the impact of the growth and development of network technology, internet or intranet has become one of the most important delivery vehicle for the EPSS. A Web-based Performance Support System (WPSS) is an innovative approach by utilizing the technologies of the world-wide-web (WWW). For a WPSS, the web is not only a delivery medium, it also provides contents and serves as subject matter experts (SMEs) as well. The DISTED (Distributed Information System & Training for Educators at a Distance Education) as an example of a WPSS has successfully functioned as a system which helps educators design, delivery and evaluate teaching in the interactive distance education [7]. The WPSS has been proved to be a better design than the traditional EPSS in terms of it's features such as cost-effectiveness, open architecture, universal acceptance and pervasive delivery [2].

Many training experts contended that Electronic Performance Support Systems are the learning tools of the 21st century [4]. While most of the major developments and applications of EPSS were designed for industrial and

commercial settings, more and more educators in many academic organizations have begun to adopt the concept and implement EPSSs in their classes. As the educational environment becomes more dynamic, the possibility of adequately imparting necessary knowledge to learners within a limited instructional schedule is increasingly challenging. Considering that our knowledge base is expanding rapidly and information is being updated at the speed of telecommunications, some educators therefore started to employ an integrated use of EPSS to facilitate learners' information retrieval. For example, Schwen, Goodrum, & Dorsey (1993) used the EPSS to create an enriched learning and information environment [8]; Law (1994) employed the metaphor of "cognitive training wheels" to describe EPSS as it facilitates learners' acquisition of skilled performance.

According to the early definition of EPSS, there are usually four major components embedded in a performance support system which includes information, training, advice and tools. To improve the functions and the design and development of a better performance support system, many researchers proposed different models of putting together an EPSS with necessary components. Gery (1991) listed three levels of functionality with four components at each level, they are user interface, help, coach/advisor, and tutor [3]. McGraw (1995) suggested that the components of an EPSS should include the human-computer interface, the help system, the coaching/advisor system, and the tutor component [5]. Baker and Banerji (1995) proposed an approach to design and implement of EPSS facilities based upon the use of a multi-layered model containing four basic levels including human-computer interface, generic tools, application specific support tools, and application domain [1]. In general, an EPSS should have four typical components including tools, information base, advisor, and learning experiences [9] to be able to support performance.

While we are moving into the resource-based learning environment in the field of education, the way of teaching and instruction has been changed accordingly. Teachers are no longer experts but facilitators or guilders; textbooks is also instead by a variety of learning resources and media. Internet is a very good tool in terms of providing the resource-based learning environment. The world-wide web with hypertext markup language (HTML) provides an easier way to present large volumes of text electronically, using efficient client/server architecture to transfer different kinds of data, such as texts with fancy fonts, colorful graphics, even sound and video clips in packets across the internet. As an integrated tool, WWW allows users to share and transfer data files easily, as well as communicate and interact more effectively. Also as a self-directed learning tool, a WPSS provides a rich environment with up-to-date information, real-world learning experiences, as well as worldwide learning resources, with which students can self-pace, monitor, and evaluate their learning.

2 Method

The purpose of this study were to investigate the effectiveness of the WPSS in supporting students' learning as well as to understand students' attitude toward this system. The target population for this study is a class of students (82 students totally) registering in the distance education course titled "Web-based Instruction and Training" in Spring 1999. A WIT Web Site was designed and developed as a web-based performance support system to assist students' learning of this course. At the end of the semester, a copy of questionnaire was also designed and distributed to students to collect their perception toward this Web Site. Moreover, students' answers to a posttest essay of the final exam were reviewed for the purpose of evaluation. The data collected were analyzed by means of Descriptive Statistics, correlation, and regression study.

3 Results

For the attitude survey, most students showed positive attitude toward content information (usefulness, richness, helpfulness), format design (screen design, visual images design, layout consistency, links arrangement), and composition (organization, presentation, delivery, references) of this WIT Web Site. Besides, students' comments also showed that most students thought this Web Site is a useful tool in general especially it meets different learning needs of students. Furthermore, the results showed that there is a moderate correlation between students' attitude with their final exam scores. And findings suggest that most students are willing to use this kind of supporting system in their learning if other courses could provide in the future.

4 Conclusions

1. Evidence from students' attitude survey and feedback comments shows that the web based performance support system is a powerful tool in terms of assisting learning especially in the distance education learning environment. It serves as a self-directed learning tool with which students can self-pace, monitor, and evaluate their learning, which may in turn facilitate students in developing life-long learning skills.

2. Results of this study also shows that the WIT Web Site provides a powerful communication channel between instructor and students, as well as students at different learning sites in the distance education course. More specifically, the web-based discussion boards were claimed by students to be a very useful tool to expand the interaction and communication outside classroom.

3. Most Electronic Performance support Systems were used in the industrial settings in the past, however, results of this study has approved that a WPSS can also be an excellent tool for providing just-in-time assistance in the learning environment of formal education. Students perceived it as a good learning tool in many aspects including the application to future study in other contexts or subject areas. This experience of facilitating students learning on the internet can be applied in other curriculum at different levels of schools.

Reference

[1] Baker, P., & Banerji, A., "Designing electronic performance support systems, Innovations in Education and Training International, 32(1), 4-12. (1995)

[2] Chang, C. C. (1999). Designing, developing and evaluating an electronic performance support system for performing and learning instructional designing tasks. In G. Cumming et al. (Eds.), Advanced Research in Computers and Communications in Education (Vol. 2, pp. 423-426). Ohmsha: IOS Press.

[3] Gery, G., "Electronic performance support systems: How and why to remake the workplace through the strategic application of technology". Tolland, Mass: Gery Performance Press. (1991).

[4] Hoyt, B.R., Stockman, M., & Thalmann, J., "Design and implement custom electronic performance support systems (EPSS) for training in project based classes. ASCUE Proceedings, 100-107. (ED document 410925) (1997)

[5] McGraw, K.L., "Selecting appropriate functionality and technologies for EPSS, Innovations in Education and Training International, 32(1), 13-22. (1995).

[6] Raybould, B., "Making a case for EPSS, Innovations in Education and Training International, 32(1), 65-69. (1995)

[7] Remmers, E. (1998). Guidelines for WWW-based support environments for education professionals . URL: http://mw75.student.utwente.nl/~elka/litstudy/

[8] Schwen, T. M., Goodrum, D.A., & Dorsey, L. T., "On the design of an enriched learning and information environment (ELIE). Educational Technology, 33(11), 5-9. (1993)

[9] Yueh, H., Liu, F., & Wang, P., "Assessing the effectiveness of a web-based EPSS. Paper presentated at the Annual Conference of the Association for Educational Eommunication and Technology, St. Louis, MO. (February, 1998).

The analysis of social discourse in a network-based learning community --The GeoSchool Experience

Fe-ching Chen *and Huo-Ming Jiang**
**Center for Teacher Education National Central University*
Chung-Li, Taiwan 320
E-mail: fcc@cc.ncu.edu.tw
***Institute of Atmospheric Science National Central University*
Chung-Li, Taiwan 320
E-mail: Jiang@front.atm.ncu.edu.tw

This paper is the first of a series of papers introducing the GeoSchool Project, a complex study to construct a network-based Earth Science learning environment for high school students. The set of papers will cover the following topics: (1) the theoretical foundations and research methodology; (2) data collecting and investigation software tools for visualization and quantitative analysis; (3) the project-based learning model; (4) issues raised by network-based learning experiences versus traditional classroom experiences; (5) the learning portfolio and social discourse; (6) the results and their implications. While in this paper we are focused on the analysis of social discourse and its implications in the GeoSchool experiences. 2685 articles were analyzed to discover the characteristics of the social discourse in the learning activity on the web. These articles were posted by 15 high school students and 10 mentors during a 15-day study on atmospheric science on the web. This is a study of the learners' authentic interactive process. The examination of the actual initiation and diminishing of threads in the social discourse reveals not only the characteristics of a network-based learning community mainly consisted of high schools, but also important scaffolding issues in the inquiry process. The paper looks into the following issues: What were the major categories of the 2685 posted articles? What kind of questions the learners asked? What kind of questions brought in replies and what didn't? What were the major categories of the mentors' articles? How could the mentor's scaffolding be helpful? What were the characteristics of the longer discussion threads? How could the learners scaffold each other? ... etc. After answering these questions we could then look into the broader aspects of a network-based learning community, namely, what influences did the network based learning environment have on the inquiry-based learning process of the high schools, what could we learn from the mentor-learner interactions, when did meaningful learning actually take place.

Keywords: **learning community, scaffold, mentor, Geoschool, social discourse posted articles**

1 Introduction

The thought that network-based learning environment facilitates learners to construct their own knowledge, to be reflective, and to be socially interactive has been fruitfully applied to science learning. The implication of inquiry learning in network-based learning environment also presents a number of significant challenges (Edelson, Gordin, & Pea, 1999). However, research on this field seldom showed a picture in detail of learners' interactions in such a technology-supported environment. Our goal has been to explore realistically what is the shared learning experience high school students might have and how do they articulate their own understanding, comment on each other's thoughts, and bear distributed expertise.

In this paper, we will describe and classify the articles posted on the network by both the learners and the mentors into categories in order to reveal the underlying learning styles, obstacles and scaffolding strategies. We discovered a number of characteristics of the learners' learning style and the social discourse in the network-based learning community.

2 THE PROJECT-BASED LEARNING MODEL

Over the past 3 years, the authors have been engaged in the development of cooperative project-based learning (PBL) environment of GeoSchool (http://geoschool.ncu.edu.tw). According to the definition of Krajcik (Krajcik, et al, 1998), the features of PBL learning include (a) a driving question; (b) investigations and artifact creation; (c) collaboration; (d) use of technological tools. The PBL in our GeoSchool is designed to facilitate five stages of inquiry and three steps of Co-op Jigsaw II (Kagan, 1992) teamwork. The five stages of inquiry are: problem definition, deciding variables to use and the procedures to take, data collection, data analysis and interpretation, drawing conclusions and presenting the findings. The three steps of teamwork are to form teams, to form expert groups to develop individual expertise, and then to go back to the team to share expertise. Figure 1 depicts this PBL learning model.

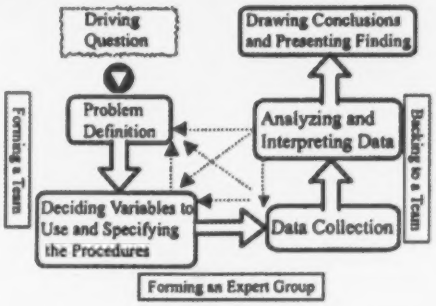


Figure 1. Cooperative PBL model

3 ROLE OF DISCOURSE IN SCIENCE LEARNING

The two major contemporary thoughts on science education are constructivism and the reflective practice. The constructivist approach involves heavy social discourse and interactions in its problematic, action taking, and reflective stages. Although reflection can be an individual activity, it can also be a social activity to be influenced by a community. Therefore the role of social discourse in science learning is gaining more importance than before. The social discourse can be helpful throughout the inquiry based learning process. For example, the learners could be inspired in the social discourse to revise and refine their original low-level factual problem definitions for higher-level abstraction; social discourse could also lead the learners to become aware of the inconsistency between their problem definitions and the conclusions they are trying to draw.

4 METHOD

4.1 Participants and Design

Participants were 15 high school students (10 girls and 5 boys), aged 16 to 17 years old, enrolled in 9 different senior high schools located in north, middle, and south part of Taiwan separately. In addition to the students, 10 university graduates and professors majored in atmospheric science also joined and served as mentors in the inquire process. Every three students formed a team by selecting one of the several driving questions they were interested in. No more than one member can come from schools in the same area so that they would be forced to communicate through the network-based learning environment. The assignment to the teams is to investigate and answer the assigned problem with justification. At the second step, each

member of a team was assigned to one of the three different expert groups. A member should go on-line to his respective expert group to inquire knowledge and to bring back to his team to finish the assignment collectively as the third step. The students were given a database of primary knowledge source on CD containing background theories and factual data but not the plain answers to the assigned problems. They were also allowed to acquire knowledge outside of either resource.

The five assigned investigative problems were (1) while a cold front is passing through Taiwan, would it be colder in the north than in the south, (2) would a stationary front lingering on the east coast cause heavy rain falls, (3) what the influences of a storm cold front passing through Taiwan on the amount of rain falls in the north and in the south respectively, (4) would the amount of rain falls brought in by 'Spring-rain stationary front' be more than that brought in by 'Mei-yu stationary front', (5) after a cold front passed through, would the temperature in high mountains be lower than that on the level ground. While the three expert groups were scaffolding knowledge on (1) climatic factors, (2) weather map, (3) high altitude atmospheric exploration, respectively.

4.2 Procedure

The complete network-based learning program ran through a 2-week period. The learners in the study were instructed to follow the curriculum set for each team and the instructions were supplemented with on-line 'tour-guide'. Before the learning program took place, the students were gathered on one-day workshop on operational knowledge. They were tutored on concept map, PBL model, the usage of database of primary sources, the know how about getting on-line and to participate in the GeoSchool network-based learning environment. Returning home from the first day gathering, the learners did not meet face-to-face in the following 14 days except on the web in their respective team area in GeoSchool. The mentors worked with the learners every day on the web. After the conclusion of their problem assignment, all the participants did meet at the last day of the program to reflect and share their experiences through this network-based learning program.

4.3 Data collection and analysis

We used a portfolio of artifacts including assignments, concept maps, reports, and posted articles to create the study on how the learners engaged in the social discourse during the network-based learning period. Each learner's posted articles were recorded by the web-BBS/DNEWS system in the GeoSchool environment for analysis.

Data were analyzed in several phases. First, DNEWS record file was transformed into Excel format and the posted articles were displayed in table format. Then, the nature and contents of each article was analyzed and the columns of qualitative descriptors in the table were checked as the classification of this article. In addition to the categorization of the articles according to their nature and contents, the insight of the social discourse were also looked into in order to discover the characteristics of (1) the interaction between mentors and learners, as well as among learners, (2) the initiation and diminishing of the threads in the social discourse, particularly threads with questions included that sustained more than 5 thematic discussions (re-posts), and (3) the correlation between style and responses.

4.4 RESULTS

The results are presented here in five parts. They are the statistics of the classification of the articles posted by the learners and the mentors, the content properties of the social discourse and the questions raised in the posting, and the effectiveness of the scaffolding strategies applied by the mentors.

4.4.1 The Classification of the Articles Posted by the Learners and the Mentors

Table 1. Classification of Articles Posted by Learners

No.	Category	Frequency	Percentage
3	Social interaction	906	38.5
6	Content knowledge	628	26.7
7	Group progress & self-regulation	499	21.1
1	Network	123	5.2
4	Database of primary sources	103	4.4

2	PBL model	66	2.8
5	Methodology in science	31	1.3
Total		2356	100.0

Table 2. Classification of Articles posted by Mentors

No.	Category	Frequency	Percentage
6	Content knowledge	136	32.9
2	PBL model	64	15.5
3	Social interaction	55	13.3
1	Network	53	12.8
5	Methodology in science	48	11.6
7	Reinforcement	39	9.4
4	Database of primary sources	18	4.4
Total		413	100.0

The statistics of the attributes of the articles posted by the learners and the mentors are shown in table 1 and 2. The categories 1 to 6 in the classification are the same in both groups, while the 7th category is 《Group progress & self-regulation》 for the learners and 《Reinforcement》 for the mentors. Apparently, social interaction is the most important discourse for high school students on the web. Articles on 《Content knowledge》 and 《Group progress & self-regulation》 ranked the second and the third, which implies that the learners are diligent and motivated and the problem assignments were challenging to domain knowledge. The low ranking of mentors' effort on 《Reinforcement》 also verifies this derivation because it did not seem necessary. The mentors were by no means parsimonious in offering encouragements.

In contrast, mentors spent more time in prompting on the 《PBL model》 in addition to content knowledge, whereas the learners didn't care too much about it. The issues on 《methodology in science》 were the least brought up actually revealed its unfamiliarity to the high school students. They were generally insensitive to the methodology issues. However, the low frequencies on 《Network》 and 《Database of primary sources》 seemed to reflect the learners' proficiency in accessing network and the CD database of the primary content knowledge sources. The GeoSchool user interface was friendly and the one-day workshop on the operational skills at the beginning was effective.

4.4.2 The Threads

Table 3. The Distribution of Elicited Discourse Threads

No.	Category	# of Threads	Percentage of Threads	Total posted articles
3	Social interaction	60	37.3	494
6	Content knowledge	59	36.6	573
7	Group progress & self-regulation	26	16.1	172
1	Network	9	5.6	52
2	PBL model	4	2.5	36
4	Database of primary sources	2	1.2	13
5	Methodology in science	1	0.6	6
Total		161	100.0	1346

In order to explore what kind of interactions the learners were interested in, we traced the part of discourse that are sustained more than 5 round of responses. The ranking of the categories of threads is almost the same as the classification of the learners' articles as shown in Table 1. These threads covered 1346 articles, which is 50.1 % of the total. An average of 8.3 posted articles per thread were categorized across the seven categories as shown in Table 3.

4.4.3 The Questions Raised

Table 4. The Distribution of the Questions Raised

No.	Category	Frequency	Percentage
6	Content knowledge	196	37.4
7	Group progress & self-regulation	141	26.9
3	Social interaction	114	21.8
1	Network	28	5.3
4	Database of primary sources	17	3.2
2	PBL model	15	2.9
5	Methodology in science	13	2.5
Total		524	100.0

The biggest category of the questions raised is 《content knowledge》. It appears that the learners were involved in the justification of their own responses or in the evaluation of other's responses while operate in a self-prompting dialogic mode. The second biggest category of the questions raised, 《Group progress & self-regulation》, is referred to plan, monitor, and evaluate progress, divide responsibilities, manage procedures and affect as well as task completion. It seems that the network-based environment provide a convenient channel for coordination. The third biggest category 《Social interaction》 reveals needs of interaction and entertainment on learning which were not allowed and encouraged in traditional classroom environment.

4.4.4 Strategies Mentors Applied with Effect

Table 5. The Strategies Applied by Mentors in Scaffolding 《Content Knowledge》

Item	Strategy	Frequency	Percentage
H	Answer directly	43	37.4
A	Ask back	25	21.7
E	Suggestions & hints	16	13.9
C	Remind their prior experience	10	8.7
G	Pretend to be a peer learner	6	5.2
D	Give examples & draw an analogy	6	5.2
B	Ask question back to create a conflicting situation	5	4.3
F	Illustrate terminology	4	3.5
Total		115	100.0

Among 342 articles posted by the mentors, 223 (65.2%) were justified to be helpful. Table 5 shows the strategies with effect applied by mentors in scaffolding discourse of category 《Content Knowledge》. Not surprisingly, the guided prompts that with significant effects were《Answer directly》, while《Give examples & Draw an analogy》 and 《Ask question back to create a conflicting situation》 were less worked.

5 DISCUSSION

Although there have been some insightful studies examining collaborative learning in science (Coleman, 1998; Edelson, Gordin, & Pea, 1999; Krajcik, et.al.,1998; Lin, et.al., 1999), few have attempted to investigate whether the formation of network-based learning community will promote learners' reflective practice or ability of inquiry. This study sought to document a rich description of the social discourse under the Geoschool environment in order to understand the impact of a network-based environment on social discourse in science learning. Following issues deserve further discussions on the interpretation of out results.

5.1 The interpretation of the percentage of the categories.

One of the purposes we classify learners' posted articles into categories is to discover the characteristics of the learner's interactive process and the behavior pattern of the inquiry based learning of high school students.

At the beginning of the study, we thought the percentage of each category represented the importance of it. We found that the three largest categories collectively accounted for almost 86% of all posted articles categorized. The rests were on 《Network》, the 《Database of primary sources》, the 《PBL model》, and the 《Methodology in science》. They were fairly evenly distributed over the remaining smaller categories.

However, cross-referenced by other artifacts, we realized that inquiry did pose many challenges for learners. Among the challenges, the use of the database of primary sources and the familiarity of inquiry skills are the most difficult ones. In short, being small does not mean that the smallest categories can be ignored. On the other hand, the smallest percentages should be interpreted as the reflection of learners' limited experience and inability to elicit discussions.

5.2 The effects of discourse with mentors

The effects of mentor's role in the social discourse of learning can be further elaborated in the following ways:

First, the existence of mentors has impacts on learners' motivation. One learner wrote: "We've got to think of some insightful questions to ask the mentor, otherwise our group would be looked down upon by her (group E #120)." Reflecting on and articulating explanations on the web, from one perspective, is much the same as that in front of others. That places the inquiry on the table and leaves it open to evaluation and criticism. This is a characteristic of the discourse in the network-based community.

Second, the mentors in the social discourse present a sense of certainty and authority for the learners. One learner wrote: "I just transformed data into a figure. I would like to share the finding with you. I'm afraid that you would think that I'm an idiot because my score on Earth Science is B at school. The finding might be just wrong. I'm looking forward to your comments (group E #551)."

Third, reinforcement is another effect the mentors can have on the learners. Different from the scaffolding provided by technology, mentors are sensitive to the quality of inquiry and can be more encouraging to the learners.

5.3 The unhelpful scaffolding Styles

Sustained inquiry should be a key element in science learning. There are several styles of scaffolds that proved to be ineffective.

First of all, the responses with scandal connotation would be of absolutely no help. One mentor wrote: "hello, hello, I don't think you are the kind of people who accepts others' opinion without reasons. ... Pick your brain, otherwise it will gather spider web.

Besides, some mentors are very enthusiastic in helping learners whenever they got stuck. One mentor wrote: "I am so impressed by you guys' sustained discussion. I can't help but prompting something. ... Try to think about ... Then how about ...Why not..." The pattern described above is to raise several questions continually. The effect of this kind of scaffold is usually followed up by no further response. The reason for such a failure can be seen from at least two aspects. On one hand, the learners usually doesn't like to answer so many questions at once; on the other hand, the mentor provides the prompt at a time when learners are not in need. Therefore no further discussion would emerge. Many threads were ended up with mentor's big talk, which didn't facilitate the inquiry process but in effect killed it.

Interestingly, in the category of 《Reinforcement》, we can also find some unhelpful scaffolds. For some aggressive mentors, affirmative comments quite often followed by mentor's expectation of higher-order inquiry skills on learners. For example, the learner might be asked to provide further justification or reconcile what they know and do not know. This kind of reinforcing style also threatens the learners.

5.4 When does the meaningful learning occur?

It is difficult for the mentors to realize when was it appropriate to offer a prompt. The answer can be found by examining what these learners were actually doing during their natural unguided discussions. We found that later intervention is better than earlier intervention. However, with no intervention at all, the peer

learners might encounter difficulties accepting one another's point of view and might not be able to overcome conflicts before giving up. The excerpts below are two learners' discourse in such a case (group D#342-347).

Learner A: Let's propose hypothesis#3 as "Both 'Spring-rain stationary front' and 'Mei-yu stationary front' cause weak upward convective motion.".

Learner B: I think this hypothesis should be modified as "'Spring-rain stationary front' causes strong upward convection; while 'Mei-yu stationary front' causes weak convection." What do you think?

Learner A: Why?

Learner B: It makes more sense from what I know.

Learner A: We can still stick to the original one and continue with the derivation. If the final result turns out to be wrong, we could just overthrow the hypothesis later on.

Learner B: No comments ... Shouldn't we make assumptions with as much sense as possible instead of groundless wild guesses?

6 CONCLUSIONS

As a tailpiece, it is worth commenting on the analysis of posted articles on the web. To explore the authentic interactive process of learners, we classified 2865 posted articles. It was a time-consuming task. However, it was this process of classification that uncovered the underlying interactive dynamics among the members of the network-based learning community.

Apparently, the influences of social discourse on science learning were multi-faceted. In the social discourse, the learners' were motivated, timely encouragements were provided; scaffolding was also facilitated for their understanding of content knowledge. However, inappropriate scaffolding styles could turn into just the opposite.

The percentages of the social discourse in the categories reflect the learners' initiation on aspects of learning activity, however, they do not imply the importance of the categories in the learning process. Low percentage of a category could be caused by the difficulties of inquiry skills and reflective practice encountered by the learners in the discourse. Therefore, a comparison of different group dynamics warrants further study.

ACKNOWLEDGEMENTS

This work has been supported by the National Science Counsel under the Grant NSC 88-2511-S-008-002 and NSC 88-2511-S-008-006. We owe our sincere acknowledgement to all the researchers, participating teachers, and research assistants in the GeoSchool Project for their crucial contributions. Finally, we owe a special thanks to Professor Tse-Liang Yeh, who continually and willingly gave his time to view the manuscript and provided us with his expertise, advice, questions, and support.

References

[1]Coleman, E.B. (1998).Using explanatory knowledge during collaborative problem solving in science. *Journal of the Learning Science*, 7(3&4), 387-427.

[2]Edelson, D.C., Gordin, D.N. & Pea, R.D. (1999). Addressing the challenges of inquiry-based learning through technology and curriculum design. *Journal of the Learning Sciences*, 8(3&4), 391-450

[3]Kagan, S. (1994). *Cooperative Learning*. CA: Resources for Teachers, Inc.

[4]Krajcik, J.,Blumenfeld, P.C., Marx, R.W., Bass, K.M., Fredricks, J, & Soloway, E. (1998). Inquiry in project-based Science classrooms: initial attempts by middle school students. *Journal of the Learning Sciences*, 7(3&4), 313-350.

[5]Lin, X., Hmelo, C., Kinzer, C.K., & Secules, T.J. (1999). Designing technology to support reflection. *Educational Technology Research & Development*, 47(3), 1042-1629.

The Application of Scaffolding Theory on the Elemental School Acid –Basic Chemistry Web

***Zangyuan Own, Kai-Pein Wong**
Department of Applied Chemistry, Providence University
#200, Chun-Chi Road, Shalu, Taichung, Taiwan 433
Tel: +886-4-6329216
Fax: +886-4-6327554
E-mail:zyown@pu.edu.tw

The knowledge of chemistry is base on the realization of fact and experiments, students must try to infer, experiment and realize deeply to achieve the goal of highly efficient learning. Base on the scaffolding theory, we have designed a three- tier client-server web title which is a distributional database formats about the chemistry subject-"Acid and Base chemistry" for elemental school students. We use a lot of multimedia animation and Internet techniques to create a scaffolding environment make students learn it instantly and mutually. It turn out that all the students have excellent improvement learning outcomes. All the experts, the interaction designing experts, the network experts, software designers and primary school teachers gave a positive affirmation about the web title; the teaching content and the interaction design are all get the very positive confirmation. The result of learning effect is very convention; the statistical analysis shows that all learners who entered this web site made a great progress in their knowledge test. Besides, ANOVA statistical analysis shows that this scaffolding chemistry web site made a great help for L type learners. Learners' previous science knowledge has nothing to do with the study effect.

Keywords: **Scaffolding Theory• •Acid-Base Chemistry• •Web Title and Learning Effect**

1 Introduction

Because of the shortage of real experience and the misconception of teaching content, traditional teaching cannot inform the students about the concepts which teachers want to deliver. With the development of the Internet, the form of education is shifted from teacher center to the learner center. The future of science teaching is base on the new nine-year consistent project, it is important to integrate the Internet as a major tool to enforce this project. All of these will help improve the quality in elemental chemistry education for our children.

2 Motive and purpose

In these coming years, internet was the major domain of research academics and government officials. In the 1990s Internet software took giant leaps forward in usability. The biggest change came with the development of the World Wide Web (WWW), a vast tract of the Internet accessible to just about anyone who could point to buttons on a computer screen. It led the Internet's transformation from a text -only environment into a multimedia landscape incorporating pictures, animation, sounds, and even video.

The teaching by the Internet exceeds the traditional passive one-way learning, but stresses on interaction. Taking the advantage of instant pass by the Internet, you can browse through all kinds of fascinating information sources and discover worlds of knowledge. We create a web page about the chemical

experiments- the acid and base in nature environment. By the global of networks, we can easily transform the information by character, animation and video. The different learning effect which associated with different learning style students, different ages, different sex and different previous knowledge of science may cause the different learning out come.

3 Theory background

The scaffolding theory brought up by a Russian psychologist (L. S. Vygotsky). He sustains students with the scaffolding techniques through out his teaching process. In the beginning of the scaffolding, it would be a process from other-regulation develops to social negotiation. In teaching, the teacher will design a temporary supporting constructions thought out the whole lecture, which help the learner to develop his learning ability. It is called scaffolding. There are two important subjects within the scaffolding theory. There are communication and cognition, the function of social cognition is to make the learners improve his abilities in solution and self-examination, and students certainly be promoted by the active learning styles.

Scaffolding instruction means that the teacher can help the learner make the most of their potential. Under scaffolding instruction, student will join the learning activity positively instead of remaining passive. Thus, an individual would have his own cognition framework.

There would be six important principles about the instruction.

1.In the real teaching activity, the teacher is the scaffolding maker for the learner.
2.The supporting degree is dependent on the standard of the learners; there would be a modification.
3.The more the ability of the learner increases, the less the support decreases.
4.The support is in proportion to the standard of the activity.
5.The suppor will be modified gradually and at any time. Then it would keep on.
6.Make the learner independent.

In the learning effect, many scholars announce their research results. They would analyzed what kind of the learner is and then decide to create the appropriate on-line instruction web page. Different learning-styled students in CAI(Computer-assisted instruction) would have different learning effects in various feedback.

The feedback is composed of the following four parts:
No feedback. (2) Knowledge of results feedback. (3) Informative feedback. (4) Informative feedback in personal language.

According to the research results by the scholars Dori and Yohim(1990), students in proper sequence may have highly-efficient learning effects. On the contrary, learning by leaping ways was low efficient learning effect. The former is called L type, and the latter is called W type. It means that different learning style may cause various learning effects to students.

The learning ways of students are classified into Super-L, L, W and Super-W type. There are large parts of high school students with L type in particular. The second position is W type. The L type (straight-line) means students follow the learning materials and never change the route. The W type means students don't follow the learning materials and change the route all the time. The Super-W type means that students may play out the entire learning process. It has a strong relation between the learning style and the logical thinking talent.

4 The Research Method

System Installation

The research is base on a web title course, it is a Three-Tier Client-Server sets. Most browsers accepted this kind of device. Server can share responsibility for the management to the request of client. It can transform the information from the database by the request of the client, then the client will process the information it got from the server.

To achieve harmony with education, the government has computerized all elemental schools, but the

schools have not been equipped with highly-performance computer. Microsoft bring up an idea of thin client. A computer with modem and browser can use this system. To have a better web title designed, we got the type called 3-Tier (Figure 1). It bases on the platform of Windows NT 4.0 Server SP6. We created the Web Server with Microsoft Internet Information Server 4.0. As a result of dealing with the users' get-in information, we use the MS-SQL 7.0 Server system as a platform for database.

In the process of making the web site, we use a computer with Pentium III 450 processor, which is associated with Front page 2000 to design all the required homepages. And we use the common draft tools (Adobe Photoshop and Macromedia Flash) to deal with pictures and make them more interactive. Finally, we use the SPSS statistics system to analyze the results of learning effect.

The part of system interface, we use ASP(Active Sever Page) to design the interface, and take the advantage of Visual C^{++} to create a stable and efficient web page in the core part .

5 The Research Object

Our research is aimed at the students in Grade Six of elemental school. The design for course content

We take a lot of real household materials, which is concern about acid and base as teaching examples. Such as the lemon• Clorox and vinegar. The nature of soap water is slippery. If you wet your clothes carelessly with sulfuric acid• hydrochloric acid or sodium hydroxide, the clothes would be damaged. And they will scorch the skin. There would be the calculation of the PH. The definition of acid and base is on the produced amount of H^+ and OH^-.

The vinegar is composed of five percent of acetic acid. The molecular formula of acetic acid is written as CH_3COOH. The one hundred percent of acetic acid is called icy acetic acid. The reason why a lemon has acidity is that it is composed of lemon acid.

In the laboratory, the ammonia NH_3 is a base. It is because it produces a lot of OH^- in water. The ammonium ion is acid. It is composed of H^+. At the normal temperature, the HCl is gaseous state. It is a acid. The carbonic acid H_2CO_3, Sulfuric acid H_2SO_4, boric acid is all acids. There are common base such as sodium hydroxide NaOH and calcium hydroxide $Ca(OH)_2$. Sodium bicarbonate $NaHCO_3$ is a base; it has a common name called baking soda. People with much hydrochloric acid in gastric juice may take some medicine composed of magnesium hydroxide to neutralize.

The experts and scholars suggest that we should create a interactive web page of scaffolding theory should base on the acid-base knowledge map which is created at beginning of the course. The another major frame is an on-line discussion section. Initially we would have some general questions about acid & base, which the students have to find out their own solutions. If their answer is correct, then they can enter another subject, otherwise they have to keep on finding the answers. In the process of learning, students may have an efficient learning freedom by the active video program we provide with in the web page.

The content of the web
1.Question-learning function induce students to learn.2.Question of situation in our daily life.3.A simple operation interface.4.To stress on vision and hearing.5.Guided learning then learning control.

There are twelve units in the teaching material, which is a scaffolding design.
1.Litmus paper. 2.The nature of liquid.3.The definition of alkaline-liquid operation.4.The definition of acidic-liquid operation.5.The definition of neutral-liquid operation.6.The reaction between alkaline and acidic liquid.7.The neutralization of acid and alkali.8.The application of neutralization of acid and alkali.9.The nature of acid and alkali.10.The nature of sodium hydroxide.11.The advanced concept of acid.12.The advanced concept of alkali.

Most of elemental school students cannot understand the nature of acid and base. So we classify the course into two parts, which may happen in real life and in the textbook. We ask the students to register as they entering the studying web page. And let them brow though the entire house, which have five areas (kitchen, bathroom, living room, backyard and bedroom), all fill of the brand name items. The computer will record the pass way of learner, which then will be analysis to learning style (W-type or L-type). If the learner follow every step of the computer, they will have 10 points, which is classify as L-type, if the learner did not

follow the step which computer direct, they will deduct 2 point for each time, the points lower than 3, it is classify as W-type. The acid-base lecture is designed base on scaffolding theory. The system would determine when to removes the scaffolding setup or not by the amount of the correct analysis of computer generated data and suggestion by the experts and the scholars. After a serious study, this system is set up to remove the scaffolding structure when students scored seventy percent of designed questions. Before the system removes the scaffolding structure, the on-line instructor is standing by the side to help them solve some difficult problems. It's so-called on line ICQ.

For example, if students ask what the hydrochloric acid is by the on line ICQ. The instructor will pub out and tell the student that it's a kind of corrosive solution, which is used to clean your bathroom

The hydrochloric acid also exists in our stomach; it helps us in the digest. You can clean the lavatories in the schools or in our home with it, too. And all of these questions and answers will be put into Acess database as a Q&A databank for future use.

If the scaffolding has been removed, a discussion section will appear on the screen. Students can ask any question or play the teacher part to answer questions. We can save lots of the teaching resource in the way.

All the pretest and posttest questions are substrate from ACS (American Chemical Society) test bank, which is careful designed and tested for, determine chemistry knowledge of students.

6 Result and Discussion.

From January 10 to March 10 we have selected 221 students to analyze. And the result of analysis is as follow (table 1):

Table 1. The analytic table about the learning style

Category	Amount	Average	Standard varies
Boy	118	5.65	1.13
Girl	103	5.81	2.08
Whole	221	5.72	1.57

Research Sample

There are 221 students enter our web site for learning acid and base concepts, base on their data collected, we picked up forty learners (twenty are L-type, twenty are W-type) as our study samples. L-type (Boys >7.78, Girls>7.89) and W-type (Boys < 3.52, Girls<2.73)

Evaluate the Web Site

We invited five elemental school science teachers, five teaching scholars, five software designers, and ten elemental school students to evaluate the web site. The average results are in table 2.

Table 2. Statistic of evaluation result

Item	Software designers	Teaching scholars	Elemental teachers	Elemental students
Homepage design	4.50(90%)	4.50(90%)	3.75(75%)	4.50(90%)
Teaching material	3.75(75%)	4.25(85%)	4.75(90%)	4.10(83%)
Interface	4.30(86%)	3.90(78%)	3.60(85%)	4.70(94%)
Whole style	4.25(85%)	4.25(85%)	4.50(90%)	4.50(95%)

In the aspect of homepage design, elemental schoolteachers gave us lower points (3.75). They thought that instructional contents should be more intensive, and the relation knowledge should increase to enrich our web site. The software designers thought that the homepage should be more vivid than previous to stress the topics.

In the aspect of teaching material, some students complain that contents are not obvious, and we should introduce topics clearly.

In the aspect of interface, the teaching scholars and software designers thought that the operation should be familiar with users. In the meanwhile, they generally praised us in animation, and encouraged us used more.

At whole aspect, they all thought that web base learning indeed archiving the instruction targets.

Learning Effect

After tested, all eighty students had been improved in their acid & base knowledge. The overall improved score average is 18.15. L-type learners average improved 23.35, and W-type learners average improved 12.95 (table 3). It is obvious that our web site have much help in learning acid-base chemistry.

Table 3. The statistics of achievement test

L-type	Pretest	Posttest	Improved	W-type	Pretest	Posttest	Improved
Average	55.80	79.15	23.35	Average	51.75	64.70	12.95

We used the SPSS statistics software running data to analysis the deviation. The P value of learning style relation to score of pretest is 0.063, which is greater than 0.05, indicated that the learning style has no relationship to the pretest score. (table 4)

Table 4. Deviation analysis of different learning style relate to pretest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	529.256	3.499	0.063
Inaccuracy	158	151.258		
Total	159			

The P value of learning style relation to the score of posttest was 0.015, which was smaller than 0.05. It indicate that posttest score was relation to learning style, which means that L-type learning style improved remarkable. (table 5)

Table 5. Deviation analysis of different learning style relate to posttest score

Deviation source	Degree of free	Average square root	F	P
Learning style	1	1829.256	5.993	0.015
Inaccuracy	158	305.240		
Total	159			

7 Conclusion

Instruction by Internet is the better way in teaching chemistry at present day. According to our research, we have three conclusions:

1. After using the web site, the learners all had improved their test score remarkably. It shows that it is a better learning process for students to study acid-base chemistry in the elemental school.
2. The P value of learning style relation to posttest score was 0.015, which was smaller than 0.05. It shows that L-type learner had positive progressed in using scaffolding web site.
3. After the experts evaluated the web title, this acid-base chemistry web indeed bringing on-line instruction into full play. This web site's design style could be a very good example for the future science web sites.

Reference

[1] Daonian Liu, L.J.W, David W;"*Delivering a Chemistry Course over the Internet*", Journal of Chemical Education ;Vol.75 No.1 January 1998.

[2] Chris M, Mohammed J N, Penny J G; "*Web-based technology in a constructivist community of learners*", British Journal of Educational Technology, Vol 30 No 1 1999 pp.65-68.

[3] K. A Burke, Thomas J. G, Mark A. W; "*Developing and Using Conceptual Computer Animations for Chemistry Instruction*" ,Journal of Chemical Education., Vol. 75 No. 12 December 1998.

[4] Ned H. M; "*Integration of Computational Chemistry into the Chemistry Curriculum*",*Journal of Chemical Education*", Vol. 75 No.2 February 1998.

[5] Richard D. M; "*Chemistry on the Web*", Journal of Chemical Education; Vol 73 No.1 January 1996.

[6] Willian J. T, Jr; "*The Multimedia Chemistry Laboratory: Perception and Performance*", Journal of Chemical Education; Vol 73 No.9 September 1996.

The Design and Implementation of Automatic Exercise Generator with Tagged Documents based on the Intelligence of Students:AEGIS

Tsunenori Mine Akira Suganuma Takayoshi Shoudai
Graduate School of Information Science and Electrical Engineering, Kyushu University
6-1 Kasuga-kouen, Kasuga, 816-8580 JAPAN
E-mail:{ mine@is, suga@is, shoudai@i }.kyushu-u.ac.jp

Abstract

Many Internet technologies enable us to hold lectures with Web contents and even develop new lecture methods using the technologies. This paper proposes AEGIS (Automatic Exercise Generator based on the Intelligence of Students) that generates exercises of various levels according to each student's achievement level, marks his/her answers and returns them to him/her. In order to realize this feedback mechanism, we currently restrict the question-types which are generated to the following three types: multiple-choice question, fill-the-gap question, and error-correcting question. All question-types can be generated from the same tagged document. The aim of this system is to help the students understand the lecture with exploiting preexisting electronic documents.

Keywords: Artificial Intelligence in Education, Web-Based Learning, Exercise Generator

1 Introduction

As the Internet has come into wide use, WWW environments provide lots of opportunities to various fields. In the educational domain, Web data are being exploited as useful materials. We have been developing Web-based self-teaching systems and building the tools for helping students understand their subjects[1, 2, 3, 4].

We are currently focusing on the automatic student's achievement level evaluator that generates an exercise from tagged documents, presents it to students and marks their answer automatically. We call the system AEGIS (Automatic Exercise Generator based on the Intelligence of Students)[6, 7].

Creating exercises which are suitable for students is not easy. When we try to make some exercises for them in classes, we have to take at least their achievement level into considerations. The well-considered exercises are useful not only to measure the achievement level of students but also to improve their performance. It is not easy task for any teacher to make exercises of various difficulties according to their achievement level. Besides, it is very important to mark the students' answers and return the marked results to them for keeping their learning enthusiasms. This task becomes harder in proportion to the number of the students in a class[5].

This paper discusses AEGIS, which generates the three question-types from the same tagged data. Guessing the achievement level of each student from his/her trial history, AEGIS selects the most suitable question-type and exercise for him/her according to not only his/her achievement level but also the difficulty of the tagged data. After marking his/her answer, AEGIS returns it to him/her with its explanation.

The aim of this system is to exploit pre-existing electronic documents, in particular, our on-line documents shown at our Web site (http://cl.is.kyushu-u.ac.jp/Literacy) and to help students understand their lecture whose materials are set up as Web data so that they even at home can try exercises using AEGIS through the Internet.

The rest of this paper is constructed as follows: Section 2 shows related works to discuss the difference from AEGIS. Section 3 describes question-types that AEGIS deals with, considering both view points of students(answerers) and teachers(questioners) and Section 4 describes the exercise generating process by AEGIS. Section 5 shows the overview of AEGIS.

2 Related Works

A lot of automatic quiz generators have been proposed so far. Browning et. al. proposed Tutorial Mark-up Language(TML in short) to generate questions automatically[8, 9]. TML has a couple of tags to specify a question, a multiple-choice and a message. It requires a correct answer in a multiple-choice tag to mark a student's answer to the question. Carbone et. al. proposed CADAL Quiz[10], which generates a multiple-choice quiz from a question database. After marking a student's answer, CADAL Quiz returns the result to him/her and tutors. Both of them restrict the question type only to a multiple-choice quiz. On the other hand, ClassBuilder[11] generates many kinds of quizzes and grades a student's answer. However, all of them do not mention any effect of making the difficulty level of question-type change according to the students' achievement level. In order to improve their performance and keep their enthusiasm to challenge the quiz for a long time, it is indispensable to consider their performance level for generating their exercise. This point is the difference from other systems. AEGIS makes use of pre-existing electronic documents so as to embed tags into them, generates exercises automatically with tagged documents according to students' achievment levels, and reestimates both their levels and the difficulty level of the generated question through marking their answers.

3 Question-Types

There can be several types of a question in every subject. Since our aim is to get a computer generate an exercise and mark student's answer to it, we thus restrict to the following three question-types: multiple-choice question, fill-the-gap question, and error-correcting question.

Multiple-choice question. Students choose the correct answer from a given candidate list.

Example. Complete the sentence. Choose your answer from the following list.

Data structures need to be studied _____ order to understand the algorithms.

(1) an (2) in (3) on (4) at (5) by

Fill-the-Gap question. Students try to fill in the blank of a given sentence with the correct answer without any help.

Example. Fill in the blank with the right word.

Data structures need to be studied _____ order to understand the algorithms.

Error-correcting question. Students have to find the wrong expression in a given sentence and correct it.

Example. Right or wrong? Correct the sentence if it is wrong.

Data structures need to be studied an order to understand the algorithms.

All of these question-types can be constructed from a sentence by replacing one or more consecutive words with a blank or a wrong expression. We call the region replaced *hidden region*. We note that these three question-types have different difficulties even if they are constructed from the same *hidden region*. Figure 1 shows the tagged data to be used for generating the above three types of questions.

```
⟨QUESTION SUBJECT="idioms"⟩
Data structures need to be studied ⟨DEL CAND="an,on,at,by"⟩ in ⟨/DEL⟩ order to understand the algorithms.
⟨/QUESTION⟩
```

Figure 1: The tagged data to generate three question-types shown in Section 3

Students' View Point

Every multiple-choice question has surely the correct answer in its candidate list and contains the information that leads students to the correct answer. They can therefore make their choice with confidence from the list. In the case of a fill-the-gap question, they have to fill in the blank by themselves with their convinced answer without any information about the answer. Comparing both question-types, we can say

that a fill-the-gap question is more difficult than a multiple-choice one. In the case of an error-correcting question, it forces them to determine whether or not there is an error in the question sentences and to correct it if it is found. An error-correcting question gives no information leading them to its correct answer, and the wrong expression in the sentences is not clear for students. We can therefore say that an error-correcting question is the most difficult one for students among those question-types.

Teachers' View Point

Once teachers set a *hidden region*, the efforts that are required to make with the three question-types are similar. The process for making exercises is as follows: in the case of a fill-the-gap question, the teachers have nothing to do. There is no information that they have to add to the exercise paper. We can say that a fill-the-gap question is the easiest one which is made among these three question-types. In the case of an error-correcting question, teachers have to think of at least one wrong expression which can be replaced with the *hidden region*. In the case of a multiple-choice question, they have to prepare several distractors to construct a candidate list. We can say that a multiple-choice question requires more information than an error-correcting one. From their points of view, a fill-the-gap question is consequently the easiest one which is made, and an error-correcting question is easier than a multiple-choice one.

4 Automatic Exercise Generating

4.1 Exercise Generating Process

The exercise generating process from teaching documents is summarized as follows:

1. Setting a *hidden region*: teachers make clear their intention why they want to ask the question to their students, that is, they consider which of the *hidden regions* is the most suitable for their intention.

2. Selecting a paragraph or sentence(s) from teaching documents: the sentences before and after *hidden regions* are often of importance to ask their students the unique answer of the question. We call the paragraph or sentence(s) a *question region*. A *question region* may have more than one *hidden region*.

3. Constructing a candidate list: a multiple-choice question requires a couple of distractors to set up a list of answer candidates. Any distractor should be natural so as to be added to the list. This list depends on the teacher's intention.

These three steps are deeply related to the teachers' intentions. It is not easy to extract such intentions automatically from the teaching documents. AEGIS system thus deals with tagged documents that already have the information such as *hidden regions* and candidate lists.

4.2 Necessary Information for Generating Exercises

In order to embed the above three kinds of information into the teaching documents, we define the following three tags: QUESTION, DEL, and LABEL.

QUESTION surrounds a *question region*, that is, the statements between ⟨QUESTION⟩ and ⟨/QUESTION⟩ are a *question region*. In the region, there can possibly be some expressions that are related to a *hidden region*. They can be good hints to lead students to the correct answer.

SUBJECT is the unique attribute of QUESTION. Its value stands for the subject or topic of *question region*.

DEL indicates a *hidden region*, which is the word(s) or sentence(s) between ⟨DEL⟩ and ⟨/DEL⟩.

A fill-the-gap question can be generated only by replacing the *hidden region* with a blank.

CAND is one of DEL's attributes. It is used to specify a candidate list.

LABEL has an attribute NAME that specifies a dependency relation with a *hidden region*. The sentence/s surrounded by LABEL tags is/are presented as a reference for the answer of a question, which will be generated with the DEL tag whose REF's value is the same as that of the NAME of the LABEL.

⟨QUESTION SUBJECT="W_S"⟩ *question region* ⟨/QUESTION⟩		
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
⟨DEL CAND="CANDIDATE" LEVEL="PAIR" GROUP="ID" REF="ID"⟩ *hidden region* ⟨/DEL⟩		
CANDIDATE	::=	W_S | W_S,CANDIDATE
W_S	::=	word or symbol, where a backslash (\) must be added just before the symbol if it is a comma (,), double quotes ("), or a backslash (\).
PAIR	::=	LOW,HIGH
LOW	::=	an integer between 1 and 10
HIGH	::=	an integer between 1 and 10
ID	::=	keyword
⟨LABEL NAME="ID"⟩ sentences ⟨/LABEL⟩		
ID	::=	keyword

Figure 2: Tags for exercise generations

4.3 Necessary Information for Adjusting Difficulty Level of Question

The additional three attributes of DEL, which contain the information on the difficulty of solving the exercise, are LEVEL, GROUP, and REF. They specify the difficulty of each *hidden region*, and the connections to other *hidden region*.

LEVEL specifies the difficulty of the exercise to be generated from a *hidden region* itself. The value of this attribute is a pair of integers between 1 and 10. These integers specify the lowest and highest achievement level of the students who can try the exercise. AEGIS system determines whether or not the *hidden region* is worth being transformed into the exercise by comparing the student's achievement level from the both values of LEVEL.

GROUP specifies the dependency relation between *hidden regions* and holds the uniqueness of the correct answer. This GROUP is used to adjust the exercise level. If we want to generate more difficult exercises, all the *hidden regions* that have the same values in GROUP are replaced with blanks or wrong expressions at the same time. On the other hand, for generating easier ones, some of the *hidden regions* in the group are not transformed because those regions help students answer the question as hints.

REF specifies the dependency relation between a *hidden region* and other expressions than the *hidden region*. Both the region and expressions are specified with LABEL. If a *hidden region* is connected to an expression, the value of REF in the *hidden region* is the same as that of NAME in the expression with LABEL.

5 AEGIS system

5.1 Overview of AEGIS

The AEGIS system consists of three databases: *Exercise DB* (**EDB** in short), *User Profile DB* (**UPDB** in short) and *Level Management DB* (**LMDB** in short), and three main database managers: *Exercise Generator* (**EG** in short), *Answer Evaluator* (**AE** in short) and *Level Manager* (**LM** in short). The overview of AEGIS is shown in Fig. 3.

Teaching documents with the tags are compiled into the **EDB** and **LMDB**. All of the *question regions* are indexed sequentially and each *hidden region* is labeled with its own subindex of the index of each *question region*. The level of a *hidden region*, which is deeply related to the level of the question to be generated from the *hidden region*, is stored in the **LMDB** together with the index of the *hidden region*. The level of each *hidden region* in **LMDB** is reexamined regularly. **UPDB** keeps students' trial histories with their current achievement level.

EG and **AE** make communications with the users (students) through Web browsers after being invoked through CGI (Common Gateway Interface).

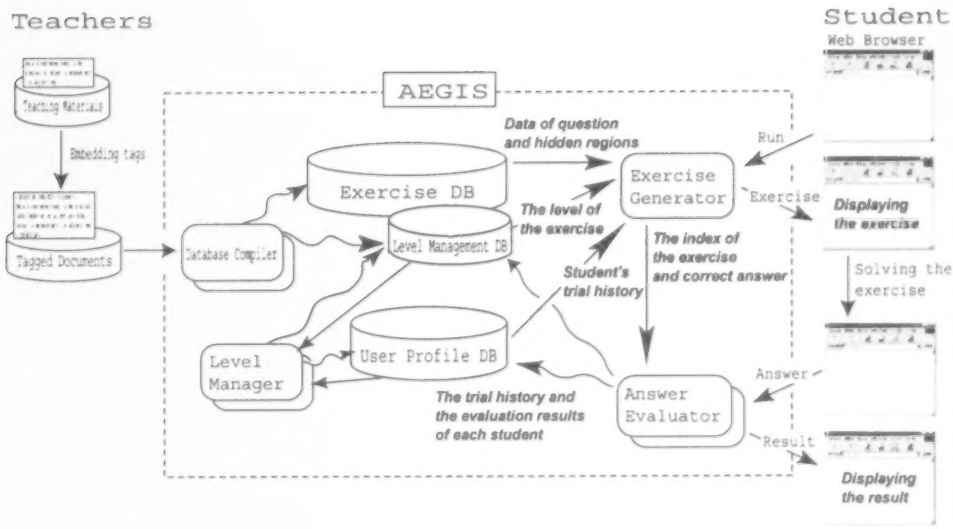


Figure 3: Overview of AEGIS

5.2 Exercise Generator(EG)

The exercise request from a student invokes **EG**. The **EG** searches the most suitable *hidden region* in **EDB** with looking over both the student's profile stored in **UPDB** and the level of the *hidden region* stored in **LMDB**, and determines the question-type of the *hidden region*. As mentioned in section 3, every question level has a relation to the question-type. **EG**'s decision process of the question-type thus employs the following strategy: If the student's achievement level is closer to the lowest number in LEVEL of the *hidden region*, **EG** selects a multiple-choice question as the question-type with high probability. On the other hand, if it is closer to the highest number in the LEVEL attribute, **EG** selects an error-correcting one.

Once **EG** determines the question-type of the *hidden region*, it is not difficult to generate the question. This is because the *hidden region* represents the correct answer of the question which is generated and teachers have already given the list of distracts explicitly with CAND attribute. Now, let's see how **EG** works when it generates the three kinds of questions:

- *Multiple-choice question*: **EG** randomly constructs one possible list for the multiple choice with both the correct answer and some distracts and outputs a question, which is generated by replacing the *hidden region* with a blank, with the list.
- *Fill-the-Gap question*: **EG** outputs a question which is generated only by replacing the *hidden region* with a blank.
- *Error-correcting question*: **EG** outputs a question which is generated by replacing the *hidden region* with one of the wrong answers specified in the CAND attribute.

Figure 4 shows an example of teaching documents with the tags. It is a piece of the teaching documents in the elementary course of Computer Literacy at our university. This course is taken by all first and second year students, about 2,300 students[5]. The teacher's intention in the example document is to teach how to use multiply and divide operations. Figure 5 shows the three question-types which are generated from the document.

5.3 Answer Evaluator(AE)

After outputting a question to the student, **EG** sends the following three kinds of information to ask **AE** to mark his/her answer: the index of a *hidden region*, the question-type, and the correct answer. After

In the previous section, we learned a program for adding two integers and showing the answer on the display. In the similar way, for all basic arithmetic operations including addition, subtraction, multiplication, and division, we can make a Pascal program in the following way.
⟨QUESTION SUBJECT="arithmetic operations"⟩
This program computes the multiplication and division for two input integers and shows the answer.

```
program enzan;
var x,y:integer;
   seki,shou:integer;
begin
   write('Input two integers : ');
   readln(x,y);
   seki:=⟨DEL CAND="x,xy,x×y,x mul ,-" LEVEL="1,5"⟩x*y⟨/DEL⟩;
   shou:=⟨DEL CAND="x/y,x÷y,xdivy,x mod y" LEVEL="1,5"⟩x div y⟨/DEL⟩;
   writeln('Seki:',seki);
   writeln('Shou:',shou)
end.
```

⟨/QUESTION⟩
The 7th statement multiplies x by y, and the 8th statement divides x by y. We note that the answer of "div" is an integer.

Figure 4: Example of teaching documents with the tags

(a) Multiple-Choice (b) Fill-the-Gap (c) Error-Correcting

Figure 5: Three questions generated from the document in Figure 4

marking his/her answer by matching with the correct answer, **AE** shows him/her the marked result and stores it with the index of the *hidden region* and the question-type into the **UPDB**.

5.4 Level Manager(LM)

Although the initial value of the level of each *hidden region* is specified by teachers, it continues to move up and down according to the students' achievement levels, which will change as time goes by. The supplement manager **LM** processes their achievement levels statistically, computes the revised level of each *hidden region*, and stores it into the **LMDB**. **LM** increases the difficulty level of a question if a student whose level is greater than the level of question answers it wrongly, and decreases if a student whose level is less than the level of question answers it correctly. The new difficulty level of a question is consequently determined as shown in Fig.6.

After updating **LMDB**, **LM** updates the student's achievement level according to the difficulty levels of all questions he/she correctly answered.

Now, we show the formal definition of calculating both the achievement level of a student and the difficulty level of a question. Let $s_{i,t}$ and $q_{j,t}$ be the achievement level of student S_i and the difficulty level of question Q_j at time t respectively, where $1 \leq s_{i,t} \leq 10$,$1 \leq q_{j,t} \leq 10$. $s_{i,t}$ is recursively calculated with $q_{j,t}$ at stated periods and vice versa. They are defined as follows:

BEST COPY AVAILABLE

$$s_{i,t} = \begin{cases} 1 & \text{if } m_{s_i,t} = 0 \\ \frac{1}{m_{s_i,t}} \sum_{j=1}^{m_{s_i,t}} q_{j,t} \cdot \delta_{i,j} & \text{otherwise} \end{cases} \qquad \delta_{i,j} = \begin{cases} 1 & \text{if } S_i \text{ answered } Q_j \text{ correctly} \\ 0 & \text{otherwise} \end{cases}$$

$$q_{j,t} = \begin{cases} q_{j,t-1} + \frac{\sum_{i=1}^{m_{q_j,T}} |s_{i,\tau_i(\tau)} - q_{j,t-1}| \cdot \xi_{i,j}}{\sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}|} & \text{if } \sum_{i=1}^{m_{q_j,T}} |\xi_{i,j}| \neq 0 \\ q_{j,t-1} & \text{otherwise} \end{cases}$$

$$\xi_{i,j} = \begin{cases} -1 & s_{i,\tau} \text{ is less than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ correctly} \\ 1 & s_{i,\tau} \text{ is greater than } q_{j,t-1} \text{ and } S_i \text{ answered } Q_j \text{ wrongly} \\ 0 & \text{Otherwise} \end{cases}$$

Where $m_{s_i,t}$ stands for the number of questions that S_i tried by t and τ is the latest time such that S_i tried to answer Q_j and $t-1 < \tau \leq t$. T is the set of τ. $m_{q_j,T}$ stands for the total number of students who tried Q_j in T. $q_{j,0}$, which is the initial difficulty level of the question Q_j, is given with the attribute $LEVEL$ of DEL tag by teachers.

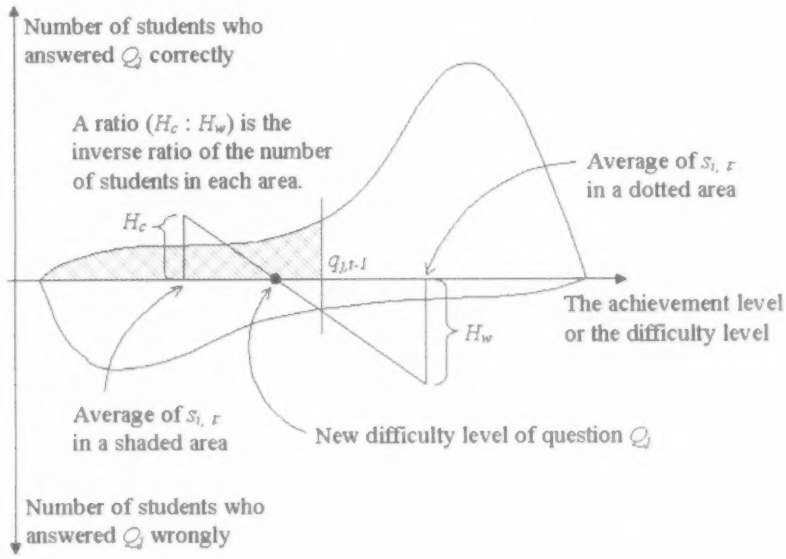


Figure 6: Renewing Difficulty level of Question based on Student's Achievement Level

6 Conclusions

We discussed our new Web-aided system AEGIS. The system is currently implemented in Perl scripts and CGI. We have a plan to evaluate this system by applying it to the real courses of Computer Literacy, which are taken by more than 2300 students at our university. We hope it will work fine as an educational tool for every student and help him/her to understand his/her subjects if teachers can make tags in their teaching documents. Also, we plan to implement a tagging tool and an algorithm to generate another kind of exercise that allows more than one correct answers.

Acknowledgments

We thank Dr. Teruko Mitamura at Carnegie Mellon University for her helpful comments to improve this paper.

This research was partly supported by the Grant for Special Academic Research P&P from Kyushu University and the Ministry of Education, Science, Sports and Culture, Grant-in-Aid for Encouragement of Young Scientists(A), No. 11780281, 2000.

References

[1] H. Sato, T. Mine, T. Shoudai, H. Arimura, S. Hirokawa: On web visualizing how programs run for teaching 2300 students. In *Proc. Int. Conf. on Computers in Education, ICCE'97*, pages 952–954, 1997.

[2] T. Mine, D. Nagano, K. Baba, T. Shoudai, S. Hirokawa: On-web visualizing a mechanism of a single chip computer for computer literacy courses. In *Proc. Int. Conf. on Computers in Education, ICCE'98*, volume 2, pages 496–499, 1998.

[3] R. Fujimoto, A. Suganuma, T. Mine: Development of a classroom management system on the web. In *Proc. Int. Conf. on Computers in Education, ICCE'99*, volume 2, pages 756–759, 1999.

[4] R. Fujimoto, Y. Tsutsumi, A. Suganuma: Cacce: Computer aided cooperative classroom environment. In *World Conference on Educational Multimedia, Hypermedia & Telecommunications*, page 1686, 1999.

[5] S. Hirokawa, T. Miyahara, T. Mine, T. Shoudai, M. Mori: Teaching 2300 students with www – practice and experience at kyushu university. In *Proc. ERI'96*, pages 59–63, 1996.

[6] T. Shoudai, A. Suganuma, T. Mine: AEGIS: Automatic Exercise Generator with Tagged Documents based on the Intelligence of the Students, Joint Conference on Knowledge-Based Software Engineering, to appear. JCKBSE2000, Brno, Czech Republic, 2000

[7] T. Mine, T. Shoudai, A. Suganuma: Automatic Exercise Generator with Tagged Documents

Considering Learner's Performance Proceedings of WebNet2000, San Antonio, Texas, to appear as a short paper, 2000

[8] P. Browning, J. Williams, D. Brickley, H. Missou: Question Delivery over the Web using TML http://www.ilrt.bris.ac.uk/netquest/liveserver/qbanks/demos/paul/lboro/ohp1.html, CAA, 1997

[9] P. Browning: TUTORIAL MARKUP LANGUAGE - A CBA SYSTEM http://www.soton.ac.uk/~ukgec/workshop/5-cba/minutes.htm#TUTORIAL, 1998.

[10] A. Carbone, P. Schendzielorz: A Web-Based Quiz Generator for Use in Tutorials and Assessment Global J. of Engng. Educ., Vol.I, No.3, 1997 http://www.eng.monash.edu.au/usicee/gjee/vol1no3/paper20.htm.

[11] ClassBuilder GradeBook And Exam Creation Software: http://www.classbuilder.com/

The Design of CAI with Thinking Activity to Progress Constructive Teaching
- An Example of Division-concept in Mathematics of Elementary School

Pou-Yah Wu*, Mei-chueh Shao, Kai-Ren Chen, Ying-Xin Zhong, Ting-Wei Lin and Cheng-Wei pan.
Department of Mathematics Education, National Tainan Teachers' College, Taiwan
**Pou-Yah Wu's e-mail:pywu@ipx.ntntc.edu.tw*

This study aims at establishing a computer assisted learning system of division-concept of networked elementary school mathematics course based on constructivism and stress on students' thinking activities. It explores how students' thinking manifest on network, how the thoughts of the learner and those of the students on-line transfer, and how the thinking of the virtual students' solving problems reflect, so as to develop a set of CAI system about constructive pedagogy. In the system, we provide the learners with diverse tools for thinking activity, letting him/her choose what he/she needs to solve problems. We use network technology to simulate the real learning situation and to make the learner and the user on the line and the virtual students to communicate and discuss immediately. By setting up the CAI system that is compatible with the mathematics education of the elementary school in Taiwan now, we expect the learner to establish the right concepts positively so as to attain constructive pedagogic concept.

Keywords: **Constructive pedagogy; Division of Mathematics; Elementary School; Networked CAI; Thinking Activity.**

1 Introduction

The course design of pedagogy in Taiwan before 1993 is based on objective theory of knowledge. However, the pedagogic design ignores the complex and interactive phenomenon practically. Therefore, mathematics of elementary school in Taiwan in 1993 adopts pedagogic theory of constructivism [6]. Constructive pedagogy improve the shortcomings of the traditional pedagogy; but it also cause the deficiency of pedagogic duration owing to the orders of discussion and reflection in case it is put into practice in the real pedagogic environment. With the popularity of network, provided constructive concepts are applied to the learning environment of network, CAI effect would be promoted further. This study aims to design networked pedagogic environment matching "basic division-concept in mathematics of elementary school" by the learner's thought, using network technology, letting the learner have an environment to learn at home. The traditional CAI system neglects the positive learning and the interaction between the learners. So, we take into how to facilitate the interactive relationship between the system and the learner. Through the transmission of the networked thought, the learners can real-time communicate, making up a whole constructive learning environment, hoping to attain the constructive pedagogic concept.

2 Principles of system establishment

2.1 Basis of learning theory

The pedagogy of constructivism lies in stressing "knowledge is constructed positively by the learner", so that pedagogic design should arrange activities of learning-orientation. In the process of learning, the teacher serves as "problem poser" whereas the students acts as "problem solver"; the teacher plays the role of assistance, and the learner should construct knowledge positively through the interactive discussion between the learners [2]. Each learner utilizes his previous concepts to expound the phenomena around, and then comes up with adjustment or assimilation toward his acquired cognitive structure to establish new concepts. Besides, the learning situation is also an important part of the content, functioning to help the learner to comprehend the differences between the perspective on conceptual traits. Thus, the learning activities ought to provide learners with quasi-actual experimental situation to manipulate, explore. By means of the cognitive conflict brought about by the students in the process of the activity, challenging his original concepts, he/she constructs the right concepts via the discussion and coordination with one another.

2.2 Basis of course content-concept of division

Division is the anti-calculation of multiplication. Both multiplication and division are thought of as the transformation of unity quantity. The so-called "transformation of unity quantity" refers to that using unity quantity as that described by calculating unit, transforming to another description by calculating unit using another unity quantity [1,3]. The situational mode of division question is categorized into two basic principles of including division and even division. Seen from the viewpoints of "transformation of unity quantity" to look at the questions of multiplication- division, the questions of multiplication is to reduce the quantity suggested in the units of higher layers (units accumulated by several units of lower layers) to the activity of transformation from the quantity suggested by units of lower layers; whereas the questions of division "including division" is on the contrary, that is, the quantity suggested by the units of lower layers changed into the transformation activity by the quantity suggested by the units of higher layers. As to even division, it is an activity of new unity quantity of high layers and unknown unity quantity.

2.3 Foundation of system establishment

This system is a learning environment constructed on the network, adopting three-tier client/server system architecture, and meaning adding a layer of service server on the original client-server two-tier client/server system architecture. In the structure of three-tier client/server master-slaver, the part of management of learning data is in the charge of database server, web server takes charge of teaching jobs, while the users of client proceed all kinds of learning activities via browser.

3 Pedagogic design of networked construction

3.1 Pedagogic design of constructive division of new course

The two questions types of division (including division and even division) should be reckoned as different ones, then helping students combine these two types of questions gradually. And by the activity of consecutive subtractions solving questions to communicate with the relationship, then introducing the format of division calculation. Thus, in the design of pedagogy, place the two combined types of characters, letting children solve problems by tangible objects or emblems and try to record the activity of solving questions. After solving the questions including division and even division successfully, try further to grasp the times of distribution including viewpoints of division when confronted with them again [4,5]. The number of unity quantity can be decided by the times of distribution to help students realize and construct the relationship containing two types of questions as to including division and even division. Finally they can introduce the processes of solving questions concerning the methods of many-steps subtraction recording including division and even division and discuss and form the formulas using " ÷ "taking notes of the common sense about the activity of solving questions including division and even division, letting children construct the whole meaningful concept of division.

3.2 CAI pedagogic design of constructive pedagogy by thinking activity

This system emphasizes the spirit of construction to help students establish the concept of division, thereby, expecting the system to become more congenial to the real pedagogic environment. We let the computer become a virtual teacher, besides posing problems, he/she can judge the students' types of solving problems and mode of operation, and providing the dialectics and clarification and discussion undertaken between the users or between the user and the virtual students. Thus, the design of the problems by this system is introduced by the ordinary ones of daily situation to make sure if students have grasped the messages of the problems and communicate and clarify the messages with each other through asking (As in Figure 1). After posing the problems and clarifying the messages, let the students solve the problems. In order to make the system grasp the process of solving problems and thinking, we design "tool table of operation of thinking activity", which contain tangible objects, representation, digits and the symbol of calculations and so on. For example, as shown in Figure 2, if learner choose "to bakery", then the tangible objects can be used to solve the problems. If the learner choose "drawing circles", then representation can be used as the tools of solving the problems (As in Figure 3); if the learner choose "to digital factory", then digits can be used as the tool of operation (As in Figure 4). By the tool of operation chosen by the user, the computer can grasp what he thinks. If the user fails to solve the problems by themselves, they can discuss with others on the line, or discuss by the activity of solving the problems of the virtual students (As in Figure 6and 7) to attain the cooperation and learning. At last, after the user solve the problems successfully, the computer will play the role of the virtual teacher, raising questions to let the user to fortify the concepts, avoiding no continual between the user's order of thought and the concept (As in Figure 5). Then posing problems again to judge the students' learning state in order to proceed another activity dynamically. In doing so gradually, the system expects the learner construct an overall meaningful concept of division.

4 Architecture and implementation of system

4.1 Design environment and tools

This system uses Windows NT server as server platform. The developing languages include HTML, JavaScript, ActiveX, ASP (Active Server page) and so on. Using ASP as the main way of control, and exercising ASP and ODBC (Open Database Connectivity) to go with it, making the user's management of teaching material simplified. In the aspect of editing course software, Authorware5 is a chief developing tool.

4.2 System flowchart

The system flowchart we designs just as Figure 8 shows, the general elucidation is as follows:

1. Pedagogic situation of networked construction: In the beginning, the system would ask the user to register data to set up the database of students' basic data. At the outset of the course, the system will judge the user's competence by the pretest; then according to the basis, the system can pose the problems. After clarifying the messages of the problems, the system lets the user proceed to solve the problems. After solving the problems successfully, it lets the user carry on a series of on-line discussion and communication with the students or virtual students. Based on the acquired knowledge, the students construct the concepts, and fortify or revise the concepts through the experience of reflection. Again, the system poses the problems to judge the students' learning situation, then it proceeds the next teaching activity.

2. Database of "student model": It consists mainly of three databases:

(1) Database of students' basic data: It is used to record the students' basic data such as name, age, the experience of using the computer and so on.

(2) Database of learning: It is used to record the course units the students have learned, the learning state and duration of each unit, and the students' learning results and so forth.

(3) Database of learning achievement: It records the students' assessment about answering and the mode of students' operation.

3. Database of "posing problems of constructive pedagogy": It stores the material content of division pedagogy. The content contains two types of division problems (including division and even division) and various types of processes pedagogic activities.

4. Database of problems: It stores the problems for pretests and posttests.

4.3 Function of on-line communication

Because the system aims at establishing a more compatible with the learning environment of real pedagogy, so that this system design a series of communicative mechanism on the line to help students proceed the learning activities to produce the learning effect. The details will be narrated as follows:

1. Group of discussion: It is an open but not synchronized function on the line. Once the user encounters the learning difficulty, he/she can put the problems on the discussion place, and when other users see them, they can put forth the ways of solving these problems.

2. Room for discussion: It is an open and synchronization for communication. This on-line unction can improve the fact that the single CAI system fails to undertake the defects of communication and discussion immediately. Take Figure9 for example, the user in the room for discussion can carry on the mutual discussion, communication to solve the problems with other users on the line for their learning difficulty.

3. On-Line call: This is a one-to-one synchronous communication way, enabling the learners to proceed one-to-one discussion and forward the brief introduction to other users on the line.

4.4 Operation flowchart for User

When the user enter the system by using browser for the first time, the system would demand the user to register, thereby getting the user's data to set up student model basic data for database, and letting the user accept the pretest to judge the user's level of operation, and recording the user's answering situation. Utilizing the user's answer for reference, modifying the connection dynamically, letting the user connect the courses properly. Afterwards, whenever the user enters the system, he has to register user name and password as the recognition. The system then will proceed next activity according to the user's previous record. When the user undertakes the learning activity, the system will take down the learning state each time, so as to analyze if the user's learning state will attain the expected aim and will be used as learning analysis.

5 Conclusions

With the approach of eased network age, the network will definitely become the trend. Thus, establishing CAI system on the network cannot be delayed. In the light of these, we hope the constructive pedagogy combine with network to make up for the deficiency of pedagogy, letting the learners have more learning space, so as to acquire the real mathematics concepts. This study proceeds to test by the pedagogic content of "division-concept" of elementary school, presently testing all the functions provided by the system, hoping to reassess pedagogic content and system in many months, looking forward to reaching the learners' interaction, fulfilling the pedagogic concept indeed, letting children construct whole mathematics concept.

References

[1] 甯自強, "單位量的變換(一):正整數乘除法運思的啓蒙", 教師之友, Vol. 34, No 1, pp. 27-34, (1993).

[2] 甯自強, "國小數學科新課程的精神及改革動向—由建構主義的觀點來看—", 科學教育學刊, Vol. 1, No 1, pp. 101-108. (1993).

[3] 甯自強, "單位量的變換(二)", 教師之友, Vol. 36, No. 5, pp. 35-44, (1995).

[4] 楊瑞智, "國民小學數學新課程中年級除法教材的設計"八十二學年度數學教育研討會,嘉義,台灣,pp.119-136(1993).

[5] 楊瑞智, "國民小學實驗課程整數乘除算則的教材處理",八十六學年度數學教育研討會,嘉義,台灣 pp.98-113(1997).

[6] 蘇育任, "建構主義式教育的迷思與省思", 國民教育集刊, No. 5, pp. 121-139, (1997).

[7] 吳博雅, 王偉仲, 謝堅, 曾彥鈞, 陳詩茹, 牛晉媛, "網路建構式電腦輔助教學系統之研究—以國小數學科面積基本概念爲例", 1999 中華民國 CAI 研討會論文發表, pp. 159-165, (1999).

[7] Dalgarno, B. Constructivist Computer Assisted Learning: Theory and Techniques. WWW. 21Oct. 1997. Available: http://services.canberra.edu.au/~barney/articles/ascilite96/paper.htm (1997)

[8] Hiltz, S. R. Teaching in a Virtual Classroom. 1995 *International Conference on Computer Assisted Instruction ICCAI'95* Hsincku, Taiwan http://it.njit.edu/njIT/Department/CCC/VC/Papers/Teaching.htm

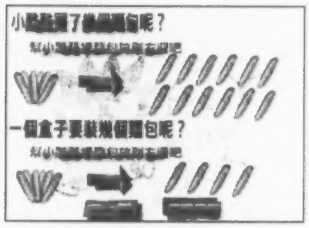


Figure 1:The Clarification of the problem

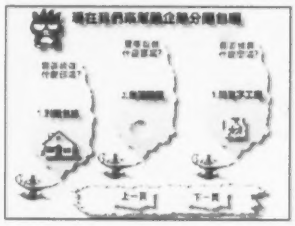


Figure 2:The choice of operation tool of problem solving

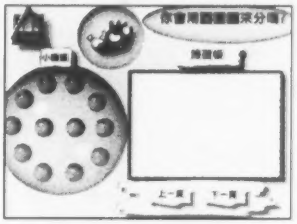


Figure 3:The presentation of thinking activity - representation

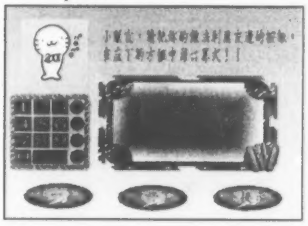


Figure 4:The presentation of thinking activity - digital and operator symbol

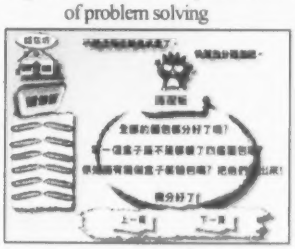


Figure 5:Reflection and discussion

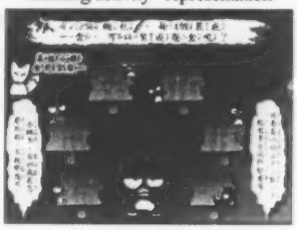


Figure 6:The strategies of virtual students

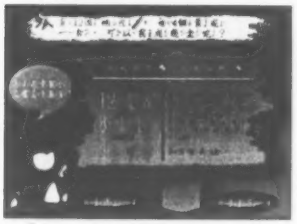


Figure 7: The communication of solving methods of virtual students

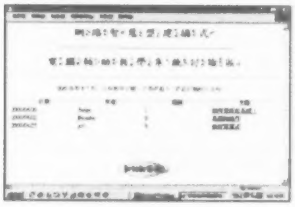
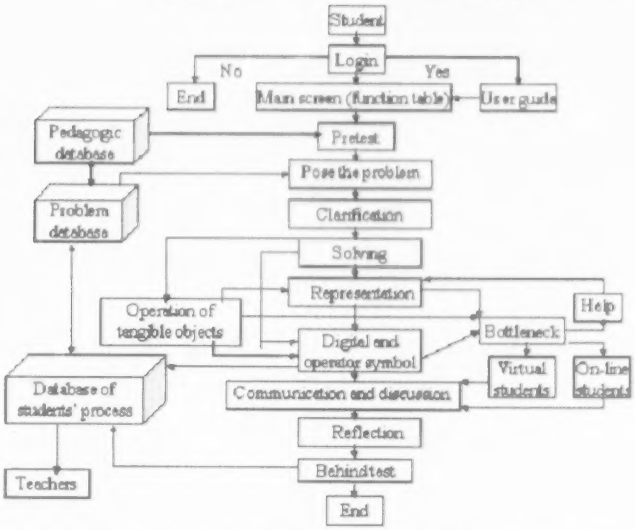


Figure 9: Group of discussion



Figurre8: The design of networked constructive pedagogy with thinking activity

BEST COPY AVAILABLE

The Development and Evaluation of a Learning Support System for Converting Web Pages

KOYAMA Yasuhiro*, YOKOYAMA Setsuo, AKAHORI Kanji***
**Graduate School of Decision Sciences and Technology, Dept. of Human System Science, Tokyo Institute of Technology, 2-12-1 O-okayama, Meguro-ku, Tokyo, TEL: 03-5734-3233*
yasu@ak.cradle.titech.ac.jp akahori@ak.cradle.titech.ac.jp
***Information Processing Center, Tokyo Gakugei University*
yokoyama@cs.u-gakugei.ac.jp

In recent years, the use of the Internet for school projects has become popular, even in the primary level. One of the difficulties in the use of the Internet is the arrangement and integration of Web materials to meet the learner's goals. This paper presents a tool that will help meet this challenge. It will also describe how the tool was developed and what are the results of its evaluation. The features of this tool are the following: 1) learner can easily gather Web pages as thumbnail of a screen image; 2) learner can make a list of thumbnails; 3) thumbnails can be sorted, with comments added; 4) arranged thumbnails can be displayed by HTML. Further, the learner can make a presentation using thumbnails. The authors later conducted an experiment to verify the effectiveness of this tool in arranging Web pages. The developed thumbnail tool and the browser's bookmark tool were compared. The results showed that our developed tool was more effective than the bookmark tool, especially in following areas: (1) more recognizable contents of Web pages (2) easier operation, and (3) more user-friendly for students.

Keyword: **WWW, Exploring Projects, Screen Image, Thumbnail, Bookmark**

1 Introduction

In recent years, the use of the Internet for school projects has become popular, even in the primary level. In Japan, Ministry of Education will implement the integration of technology in K-12 starting 2002. Thus, students will need to have the skills needed when using the Internet for various school subjects. For project-based learning using the Internet, the popular tool for surfing and gathering online data will be the search engine. It enables the easy gathering of various online data. But not all online data is reliable and accurate. Also, if not updated, the data or information in web pages can become obsolete. So learners need a tool that will help collect, select, organize and integrate the web pages that meet their learning needs.

Currently, the tool that is available to learners is the bookmark tool. It enables users to save Web pages with its title. It also makes it easy to access the web site's URL. But the bookmark tool leaves much to be desired in terms of the organization and integration of online data. Because data gathering using search engines is a vast task, there is an immediate need for easy browsing. The bookmark tool is a tree-structured file system, which is not quite adequate for quick and easy browsing. Moreover, it is hard for learners to appreciate the significance of Web pages when they appear only as text names when bookmarked.

In addition to doing research projects, learners also engage in making presentations of their projects using the Internet. To help learners in this activity, the authors proposed a tool that will provide students an easy way of making a file for their presentation. So, the authors developed and evaluated a learning support system which will enable learners to arrange and integrate Web more effectively.

2 Conceptual Framework for Tool Development

To reduce the load on making our choice information , the following 2-part approach was taken:

(1) The centralized of system approach. In advance searches, the tool will automatically narrow down the search to the closest level possible (filtering approach). This means the goal is an intelligent tool that can select information and improve the precision of narrowing down the search.

(2) The centralized of human approach. By adding available information as hint, in order to reduce extraneous information. This a support to the select available information.

The overall goal of this 2-part approach is to enable an easy narrowing down of a search.

When gathering web pages for a school project using the Internet, the tool that was developed by the authors enables the capturing of web pages and viewing them as thumbnail images. The authors believe that thumbnail images are more effective in providing visual cues of the content of Web pages. And, by displaying thumbnails, learners can arrange Web pages holistically, that is, they can visualize the whole composition. The authors made the hypothesis that more visual information as that provided by thumbnail images will be more effective when arranging Web pages for a project or presentation.

For presentations, the popular tool is Microsoft PowerPoint. Compared to OHP presentations, the use of motion pictures and animation makes a presentation more dynamic. But for children who are beginning computer users, the use of such tools may not be easy or may require more technology resources than what is available. But, by converting web pages directly to a HTML coding for presentation, the learning curve will be lower. So the authors proposed to add the function of being able to integrate selected web pages into a HTML coding for presentation in the development of their new tool.

3 The development of the new tool

3.1 Overview of the new tool

The developed new tool enables users to arrange Web pages using thumbnail images (**Figure1**). The functions of the developed tool are: listing thumbnails, sorting, and scrolling. The added function of a memo or comment line is to enable the users to add new information or data. The developed tool will then automatically generate the HTML coding for presentations. Through the use of HTML, learner can easily make a presentation (**Figure4**). **Figure2** shows the system configuration. The procedure for the use of the developed tool is as follows:

1) Learner displays Web pages or self-produced HTML pages using Web browser.
2) Screen image of Web pages and page title are saved to a database.
3) Lists of thumbnail from the database are displayed. Learner arranges web pages on the display, and add own comments to thumbnail.
4) Finally, using the arranged materials, learner makes a simple presentation

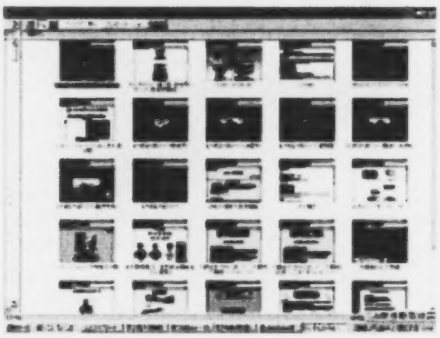


Figure1: A page showing the list of thumbnail images 1

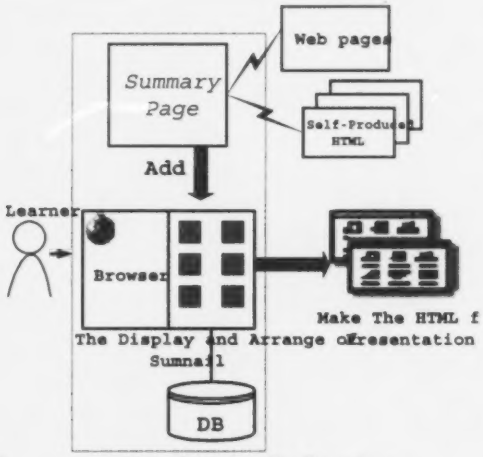


Figure2: System Configuration

3.2 The type of display Web page

In displaying the collected Web pages, the following 3 modes were used.
[1] Converting to thumbnail screen images
[2] Manipulating the original Web pages
[3] Making a presentation
The following sections explain further these 3 types.

3.2.1 Converting to thumbnail screen images

When selecting Web pages to put together, the user clicks a button to add a Web page. The web page is then converted to a thumbnail screen image (**Figure3**). Thumbnail screen images are Bitmap file made of large volume of data, so this Bitmap file is converted to a JPEG file. After that, the thumbnail is saved to the database.

3.2.2 Manipulating the original Web pages

By double clicking the thumbnail screen image, the learner can access the original Web page. It is just conceivable that learner will want to arrange the thumbnail web pages, and at the same time, have access to the original web pages. **Figure3** shows how the original web page and the lists of thumbnails are displayed at once. To change the display size, the learners can move from side to side, the display size control button located at the center of the display.

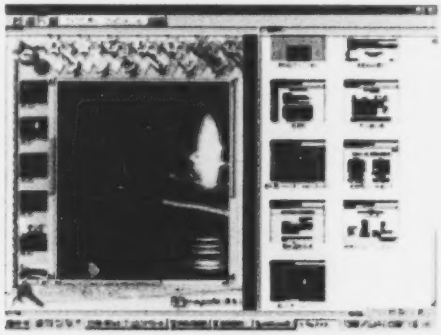


Figure3: A page showing the list of thumbnail 2

3.2.3 Making a presentation

Figure4 is the display of HTML for presentation. Arranged thumbnails are displayed in a sorted order. Learners can make a presentation using the display. Each Web page is composed of a link to the thumbnail, a link to the URL, and an area for comments or memo. The purpose here is to provide a function that will enable the easy arranging and integrating of Web pages for a presentation.

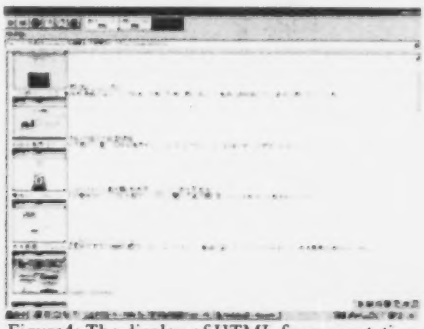


Figure4: The display of HTML for presentation

4 Evaluation of the tool

4.1 Purpose

The object of this evaluation is to verify the usability of the tool developed by the authors. Particularly, it will study the thumbnail screen images' usability for arranging Web pages. The subjects are the tool group using the developed tool and the bookmark group using only the regular bookmark tool. The groups were given the task to arrange Web pages about a specific theme. To collect data, the following were done:

(1) conduct a questionnaire survey. Subjects evaluated the operationality of the tool and were asked to give written comments of their experience of using the tool.

(2) In terms of arranging web pages, users compared the tool with the bookmark tool, and the analyses of the following data items were done.

1. work time
2. total number of times a URL is accessed
3. number of times a URL is re-accessed (the same Web page is accessed more than 2 times)
4. number of times thumbnails are sorted
5. number of times thumbnails are deleted

4.2 Method

The subjects arranged Web pages based on a theme using the developed tool and the bookmark tool. Thirty (30) Web pages were prepared in advance by the experimenter. To get a history of how they operated the tools (history of operation), a video record of how the subjects used the tool was made from a TV converter to a VHS video tape. After the experiment, the subjects answered the questionnaire. The experiment had the following stages

1. The use of the developed tool and the bookmark tool was explained to the subjects;.
2. The content of the task (theme of project) was explained to the subjects
   Theme A: the sights of Tokyo that you want to introduce to friends
   Theme B: the sights of Osaka that you want to introduce to friends
3. To eliminate order of effect, the subjects were divided into 4 groups (Table 1).

	Former	Latter
1Group	Theme A Using the tool	Theme B Using bookmark
2Group	Theme B Using the tool	Theme A Using bookmark
3Group	Theme A Using bookmark	Theme B Using the tool
4Group	Theme B Using bookmark	Theme A Using the tool

Table1: Subject groupings in the experiment

4.3 Results

To compared the developed tool and bookmark tool, questionnaire data was analyzed for significance using the t-test The results are given in **Table2**.

	Average	Result
Thumbnail screen image is more recognizable	**4.17**	**
The lists of thumbnail are more recognizable '	**4.17**	**
Useful for arranging web pages	**3.83**	*
Recognizes the contents of a web page	**4.33**	**
Useful for school projects that use the Internet	**4.67**	**
Useful for making a presentation	**4.42**	**

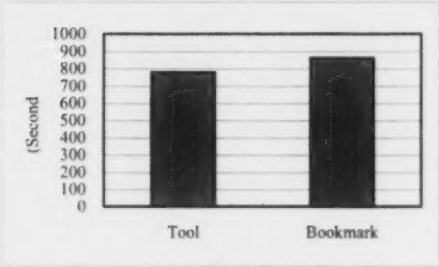
*p<.05,**p<.01 t-test (two-tail test) the average(max5)

Table2: The results of the questionnaire

T-test results show that web page titles with thumbnails are more recognizable than text-only web page title. And as to browsability, the lists of thumbnail are more recognizable than the tree structure of the bookmark tool. Inquiry as to "useful for arrangement" was significant at the 0.05 level. But as to the ability of operation in the questionnaire, couldn't get level of significance. Because the interface of sorting the thumbnails will not be enough to good for learner.

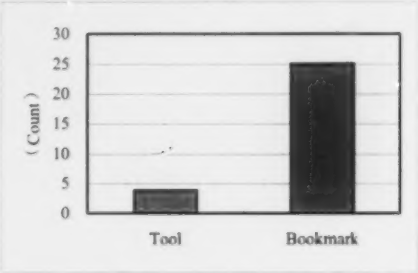
In the analyses of the history of operation (reference 4.4 (2)), the record shows that the thumbnail screen image is useful to learner when arranging web pages. The results are indicated in **Figure6-10**. From the results, the following items were verified:

* For shorter work time, the developed tool is comparatively more efficient than the bookmark tool (Figure6).
* By using the thumbnail screen image, the learner is able to better recognize the contents of the web page (Figure7,8).
* Lerner is comparatively able to estimate whether to use web pages or not (Figure10).



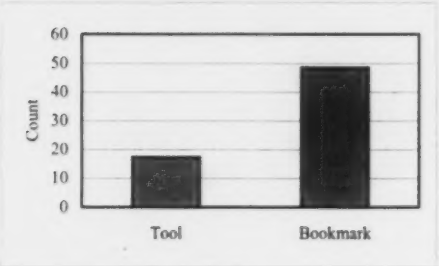
+p<.1

Figure6: Comparing the average of work time



**p<.01

Figure8: Comparing the average number of times of re-accessing URL



**p<.01

Figure7: Comparing the average of the total number of times of accessing URL

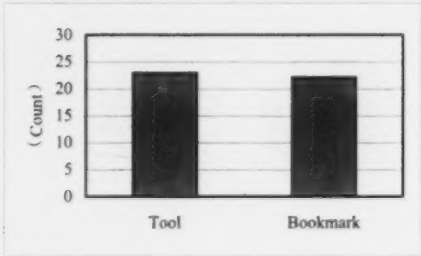
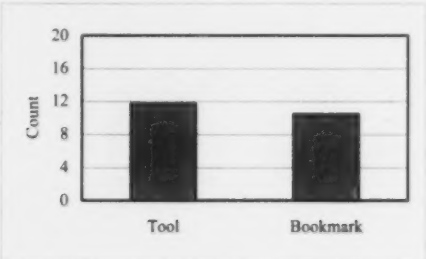


Figure9: Comparing the average number of times of sorting thumbnails



+p<.1

Figure10: Comparing the average number of times of deleting thumbnails

4.4 Analysis

The results of the evaluation procedures show that

1) based on the questionnaire, there were good results as to the functionality of the thumbnail screen images. And from the subjects' comments, "the lists of thumbnail is useful", "helps better recognize contents of the web page", and "the arrangement of web pages using the tool is convenient and useful".
2) based on the results of history of operation, work time, in terms of the number of times of accessing and re-accessing the URL and the number of times of deleting thumbnails, got good results in the given level of significance.

In terms of browsability, providing the user with a list of thumbnail is more useful than the bookmark tool. Accordingly, for arranging web pages, the list of thumbnail was better for integrating the collected data and for reviewing them. For arranging web pages, the results of the history of operation show that the developed tool is more useful than the bookmark tool.

5 Conclusions

In this research, a tool for learning to support the arrangement and integration of web pages was developed and evaluated. The results of the study can be summarized as follows:

1. Development of the learning supporting tool
   This research addressed the problem of selecting information for research projects using the Internet [1.Introduction], and examined how to resolve the problem by developing a tool that is both effective and user-friendly. The research also considered the interface of the tool and provided a conceptual framework [2.Conceptual Framework for Tool Development] in its development.
2. The evaluation of subjects about ease of operation and usefulness of the tool
   In the experiment phase of the paper [4.The evaluation of tool], a questionnaire was used to measure the as to ease of operation and usefulness of the tool., and got good results.
3. Verifying the efficiency of the tool for manipulating web pages
   When it comes to accessing and re-accessing URLs, the tool was more useful than the bookmark tool. For arranging web pages, the availability of a list of thumbnail images made it easier to integrate the selected web pages and to review them.

5.1 Future Studies

For future studies, the following are recommended:

1) Modification of the tool and adding more functions
2) A detailed analysis of the operation history

Acknowledgement

The authors would like to thank Dr. R. Santiago for her great assistance.

References

[1] Akai, K. and Koike, H., "Experimental Studies on Visual Search of Image Files" (in Japanese), The Special Interest Group Notes,: Information Processing Society of Japan(IPSJ), Vol.98, No.35, 98-H1-78, pp.27-32(1998)

[2] Ueda, M., "Development of a system of learning support using the Internet" (in Japanese),: Japan Society for Educational Technology(JET), 99-4, pp.9-16(1999)

[3] Mizobuchi, S. and Furuyama, T., "An analysis on the effect of indexes on WWW information selection process" (in Japanese), The Special Interest Group Notes of IPSJ,: Information Processing Society of Japan(IPSJ), Vol.98, No.116, 98-H1-81, pp.31-36(1998)

The Impact of Web-Based Interactive Multimedia on Conceptual Development

Ying-Shao Hsu
Department of Earth Sciences
National Taiwan Normal University, Taipei, Taiwan
yshsu@cc.ntnu.edu.tw

The purpose of this study was to examine students' conceptual development through their use of a web-based interactive multimedia under different instructional strategies. A web-based interactive multimedia was developed to facilitate students' conceptual development in condensation in this study. We selected first-grade students in Luodong Senior High School as the sample. In view of the results, there was no sufficient evidence that showed significant difference of students' learning between traditional instruction and a web-only or teacher-web instruction. One of reasons was that some students in the groups of web-only instruction and teacher-web instruction cannot complete their learning activities in 70 minutes. Further work on promotion of students' computing skills and science process skills should be warranted before examining the effects of web-based lessons on students' conceptual development.

1 Background and Rationale for Study

Recent developments in computer technology are providing new support to the learning environment. These developments make complex human-machine interaction and multimedia products possible and powerful and make accessing structured information sources much easier. The forms and functional elements of the multimedia consist of text, graphic images, audio, video, and animation . The merging of various types of media allows learners select their own mode/representation during learning and make associations or links between the different representations (McCarthy, 1989). Ambron (1986) sees computer-based multimedia learning stations allowing users to "browse, annotate, link, and elaborate on information in a rich, nonlinear, multimedia data base, explore and integrate vast libraries of text, audio, and video information" (p. 7). Schroeder (1991) pointed out that interactive multimedia systems should include the following components: 1) the information or data system; 2) the software for accessing the information; 3) the hardware or technology; and 4) the communications system needed to connect all these parts. The digitization of media and the rapid growth of networks make storage and retrieval of digital material, local or remote, possible under users' choices. Choices made by the user determine how the system responds to and what information is going to present next. Such learning materials that includes many types of media incorporating with dynamic linking are called interactive multimedia.

A computer simulation named mtnSim, which is an interactive multimedia, was designed with authentic situations, multiple representations, and the capability of reviewing previous actions supporting science learning. Interacting with an instructional simulation can enable learners to gain a better understanding of a real system, process or phenomenon through exploring, testing hypotheses, and discovering explanations for the mechanisms and processes (Burton et al., 1984; Goldenberg, 1982; Lunetta & Hofstein, 1991; Mellar & Bliss, 1993; Raghavan & Glaser, 1995). In order to engage learners in higher-order thinking, such as hypothesis testing and speculating, simulations need to be designed as easy-to-manipulate environments that enable learners to experiment with ideas. Thomas and Hooper (1992) stated: "A computer based instructional simulation is a computer program containing a manipulatable model of a real or theoretical system." (p. 498). Simulation differs from a flexible tutorial environment in that instructional simulation does not provide explicit feedback, but alters the state of the model in response to students' actions in accordance with rules governing the simulated system. The researcher thinks the definition of instructional simulation by Thomas and Hooper seems to support learner-centered learning. Therefore it is adopted in this research.

Well-designed simulations should promote realism, encourage exploration, permit multiple representations

and enable recording. Thus, the simulation design should be the integration of these features and learning theories. Moreover, these structured simulation environments are often safer, much less expensive and easier to access than the real-world counterparts (Recker, Govindaraj, & Vasandani, 1998). The computer simulation used in this research, called MtnSim (see Fig 1), was designed with the structured simulation environments as guidelines. The purpose of this study was to examine students' conceptual development after they used a web-based interactive multimedia under different instructional strategies.

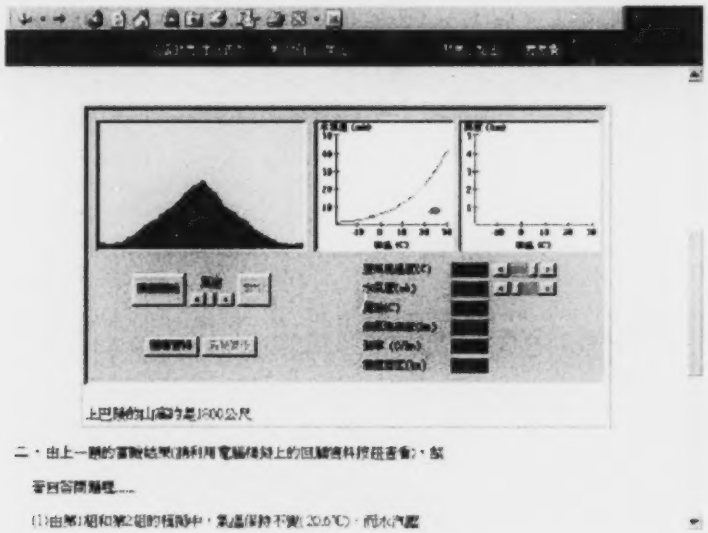


Fig 1: The appearance of mtnSim

2 Methodology

In this study, the author used experimental research for collecting data. The data collection consisted of the integration of three instruments: web-based interactive multimedia, paper-and-pencil tests, and questionnaire of attitude to computers, and computer protocols. Students participating this study took the pretest a week before the treatments (three types of instructions each lasted 70 minutes). All students' actions were recorded through the network to a central database. The posttest was administrated one week after the treatments.

Sample

First-grade students in Luodong Senior High School were selected as the sample in this study. There were 39 students in the group of traditional instruction, 21 in the group of web-only instruction and 22 in the group of teacher-web instruction.

Instruments

1. Web-Based Interactive Multimedia (Air Over Mountains)

A lesson, "Air Over Mountains", in form of web-based interactive multimedia was designed and deployed onto the site called "The Depot of Instructional Resources in Earth Sciences"(URL= http://earth.geos.ntnu.edu.tw/depot/index.asp). The lesson consists of three parts: (a) daily-life examples: In order to connect students' daily -life experiences, students can see pictures which show drops of water on the wall inside a half-full bottle for a period of time, some drops of water outside a can of icy drink, and mist on the glasses when some one eats hot food (see Fig 2-4). Those are good examples for condensation in daily life and they can help students to retrieve knowledge for further learning. (b) clouds around one side of the mountain: Weather data (see Fig 5-7) show it is different between the windward side and the leeward side of the mountain. Why are there more rainfalls on the windward side during winter in Taiwan? Students can use MtnSim (a web-based simulation, see Fig 1) to test out their ideas about this question. The main concepts in the MtnSim simulation are condensation aloft and adiabatic temperature changes. Condensation occurs either when water vapor is added to the air or when the air is cooled to its dew point (Lutgens & Tarbuck, 1992). The

BEST COPY AVAILABLE

adiabatic process causes temperature change; either it cools down when air is allowed to expand or it warms up when air is compressed. The mountain forces air to move upward to higher altitudes and the air expands as it passes through regions of successively lower pressure. This process is called adiabatic cooling which makes cloud formation possible. In contrast, as air descends the leeward side of the mountain it becomes warmer and drier due to compression. With the realistic image of a mountain and the actual sounds of wind and thunder, MtnSim can evoke the learners' stimuli of perception. This design that tries to embed students in authentic situations may motivate learners to engage in extended exploration of this simulation. (c) foehn: The definition and weather data of foehn are provided. Students can find out the characteristics of foehn by watching weather data. Then, they can learn more about what causes foehn by testing ideas in MtnSim as well.

Fig 2: half-full of bottle

Fig 3: A can of icy drink

Fig4: mist glasses

Fig 5: A map of Taiwan

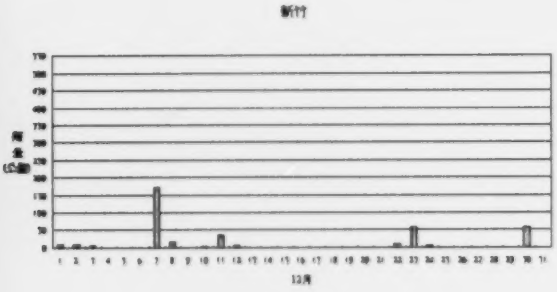


Fig 6: Weather data at Hsin-Chu weather station

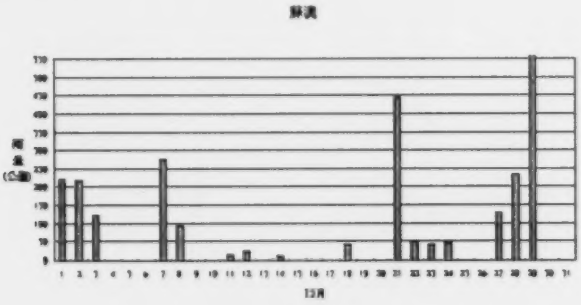


Fig 7: Weather data at Su-Ao weather station

2. Pretest and posttest: In order to investigate students' conceptual development, a test on concepts related to saturation and condensation (20 items) was used for both pretest and posttest.
3. Survey of attitude to computers: The questionnaire was designed to investigate students' attitude to computers including 24 items.

Data Analysis

The treatment was the independent variable of this study. Comparisons among three groups, traditional instruction, web-only instruction, and teacher-web instruction were investigated. For traditional instruction, the teacher printed out the pictures used in the web-based lesson and made them as transparences in order to make the same concepts taught in classroom as in the web-based lesson. For web-only instruction, students worked with "Air Over Mountains" lesson alone in a computer room. For teacher-web instruction, the teacher provided instructional directions when students interacted with "Air Over Mountains" lesson in a computer room.

Two dependent variables were measured, conceptual understanding (pretest and posttest) and attitude to computers. After the collection of data, analysis of variance (ANOVA) was used to analyze the data. The significant level of 0.05 was used for all statistical tests in this study.

Results

The results of the research are represented with a list of research questions and their answers derived from the data analysis.

Question #1: Is there difference on students' concepts between before and after interacting with web-based interactive multimedia?

To examine whether there were significant differences in students' conceptual development between before and after using "Air over mountains" lesson or before and after classroom teaching, repeated t tests were calculated (see table 1). The data analysis indicated that there was no significant difference in students' conceptual development between before and after using "Air over mountains" lesson either in web-only instruction group or teacher-web instruction group. However, there was a significant difference before and after classroom teaching. The teacher printed out the pictures and graphs from "Air over mountains" lesson as transparencies. With the same materials, the teacher interacting with students in classroom made students' understanding better. The possible reason was that the pictures and graphs were well-illustrated by the experienced teacher who had taught Earth Science in Senior High School for about 10 years. The factor of teacher characteristics played an important role in this case.

Table 1: Repeated t tests for pretest and posttest of concepts

	Mean (SD)		Repeated t values
	pretest	posttest	
Traditional instruction	11.5 (2.25)	13.1 (2.44)	4.81 ($p<0.00^{**}$)
Web-only instruction	11.5 (2.54)	11.6 (1.86)	0.24 ($p<0.81$)
Teacher-web instruction	10.8 (2.34)	11.2 (3.27)	0.64 ($p<0.53$)

Question #2: Is there difference on students' concepts between three instructional groups?

To investigate whether a significant difference in students' conceptual development between three instructional groups, a repeated one-way analysis of variance was calculated. The independent variable was the type of instructional activity and the dependent variable was the score of test on concepts related to saturation, condensation, and foehn. The data analysis showed there was a significant difference in students' conceptual development between three instructional groups (see Table 2). From Post-Hoc analysis, students' conceptual development in the group of traditional instruction was significantly higher than the groups of web-only instruction and teacher-web instruction. One of reasons was because students in the groups of web-only instruction and teacher-web instruction cannot complete their learning activities in 70 minutes. Students need to be well-trained in computing skills before they used web-based lessons so that they can save time on typing.

Table 2: Repeated one-way ANOVA for students' conceptual development for three groups

	Mean (SD)		Repeated one-way ANOVA
	pretest	posttest	
Traditional instruction (N=39)	11.5 (2.25)	13.1 (2.44)	F=4.12(P<0.02**)
Web-only instruction (N=21)	11.5 (2.54)	11.6 (1.86)	
Teacher-web instruction (N=22)	10.9 (2.34)	11.2 (3.27)	

Question #3: Is there difference of students' attitude to computers between three groups?

To test if there was a significant difference in students' attitude to computers between three types of instructional groups, a repeated one-way analysis of variance was calculated (see table 3). The independent variable was the type of instructional activity and the dependent variable was the score of questionnaire on attitude to computers. The data analysis showed there was not a significant difference in attitude to computer between three types of instructional groups.

Table 3: Repeated one-way ANOVA for students' attitude to computers

Scores on Attitude	Mean (after recoding negative items)		Repeated one-way ANOVA
	pretest	posttest	
Triditional instruction (N=39)	89.3	86.6	F=1.10 (P<0.34)
Web-only instruction (N=21)	88.5	87.4	
Teacher-web instruction (N=22)	95.5	95.4	

3 Conclusions

The purpose of this study was to examine students' conceptual development after they used a web-based interactive multimedia under different instructional strategies. Unfortunately, there was no satisfactory evidence that showed students learned better in a web-only or teacher-web instruction. The possible reason was that students did not possess enough computing skills such as typing and browsing web page, and science process skills such as understanding the meaning of weather data, exploring the simulation controlling variables, and making sense of relationships between variables. It is suggested to accommodate students more trainings on computing skills and science process skills before examining the effects of web-based lessons on students' conceptual development.

References

1. Ambron, S. (1986). New visions of reality: Multimedia and education. LEARNING TOMORROW: JOURNAL OF THE APPLE EDUCATION ADVISORY COUNCIL, 3, 5-13. ERIC number ED 302

180.

2. Burton, R. R., Brown, J. S., and Fiscker, G., (1984). Skiing as a model of instruction. In B. Rogoff and J .Lave, Everyday cognition: Its development in social context. Cambridge, MA: Harvard University Press.
3. Goldenberg, E. P., (1982). Logo: A cultural glossary. Byte, 2, 210-299.
4. Kafai, Y. B., (1995). Mind in play: Computer game design as a context for children' s learning. Hillsdale, NJ: Lawrence Erlbaum Associates, Publishers.
5. Lunetta, V. and Hofstein, A., (1991). Simulation and laboratory practical activity. In B. Woodnough, Practical science. Miltonkeynes, PA: Open University Press, (pp. 125-150).
6. Lutgens, F. K. and Tarbuck, E. J., (1992). The atmosphere: An introduction to meteorology. Englewood Cliffs, NJ: A Simon & Schuster Company.
7. McCarthy, R. (1989, June). Multimedia: What the excitement's all about. ELECTRONIC LEARNING, 8(3), 26-31. ERIC number EJ 395 537.
8. Mellar, H. G. and Bliss, J., (1993). Expression the student's concepts versus exploring the teacher's: Issues in the design of mociroworlds for teaching. Journal of Educational Computing Research, 9(1), 89-112.
9. Raghavan, K. and Glaser, R., 1995, Model-Based analysis and reasoning in science: The MARS curriculum, Science Education, 79(1), 37-61.
10. Recker, M. M., Govindaraj, T. & Vasandani, V. (1998). Student diagnostic strategies in a dynamic simulation environment. Journal of Interactive Learning Research m 9(2), 131-154.
11. Schroeder, E. E., (1991). Interactive Multimedia Computer Systems. ERIC Digest. ERIC Document Reproduction Service No. ED340 388.
12. Thomas, R. A. and Hooper, E., (1992). Simulations: An opportunity we are missing. Journal of Research on Computing in Education, 23(4), 497-513.

The Internet-based Educational Resources of the U.S. Federal Government

Andy Wang* and Krishelle Leong-Grotz**
**University of California at Berkeley,*
2325 Blake Street, #201, Berkeley, CA 94704,
andy@café.berkeley,edy
***Case Western Reserve University*
School of Medicine, Class of 2003,
ktl3@po.cwru.edu

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right information on a particular topic for their students takes time. Current initiatives, such as FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning resources. This paper aims to introduce some of the United States' successful programs.

1 Introduction

One of the main priorities of the Clinton administration is to make sure that all Americans have the best education in the world. One of the goals of this "Call to Action for American Education" is to bring the power of the Information Age into all schools in the United States. This initiative requires connecting every classroom and library to the Internet, making sure that every child has access to multimedia computers, giving teachers the training they need to be as comfortable with the computer as they are with the chalkboard, and increasing the availability of high-quality educational content. When America meets the challenge of making every child technologically literate, children in rural towns, suburbs, and inner city schools will have equal access to the same knowledge base.

United States Federal agencies have made significant contributions to expanding this knowledge base. For example, "White House for Kids," is a home page with information on the history of the White House. NASA has a K-12 initiative, allowing students to interact with astronauts and to share in the excitement of scientific pursuits such as the exploration of Mars and Jupiter, and the experiments conducted on the Space Shuttle. Students participating in the GLOBE project (Global Learning and Observation for a Better Environment) collect actual atmospheric, aquatic, and biological data and use the Internet to share, analyze, and discuss the data with scientists and students all over the world. With support from the National Science Foundation, the Department of Energy, and the Department of Defense's CAETI program (Computer-Aided Education and Training Initiative), the Lawrence Berkeley Laboratory has developed a program that allows high school students to request and down-load their own observations of the universe from professional telescopes.

Of these government programs, four of these are as follows:

2 FREE (Federal Resources for Educational Excellence)

On April 18, 1997, President Clinton asked Federal agencies to determine what "resources you can make available that would enrich the Internet as a tool for teaching and learning." In response, more than 40

Federal agencies formed a working group to make hundreds of federally supported education resources available on the FREE website.

Some of the subjects of the FREE include arts, educational technology, foreign languages, health and safety, and mathematics. Agencies involved include Centers for Disease Control and Prevention, National Gallery of Art, National Science Foundation, Peace Corps, Consumer Product Safety Commission, and the Smithsonian Institution.

3 GEM (Gateway to Educational Materials)

GEM began in 1996 after the National Library of Education (NLE) Advisory Task Force sought to find ways to apply library and information science skills to help educators find lesson plans and teacher guides on the Internet. GEM provides links to free Internet materials, partially free materials, and to resources that require a fee or registration to be used. There are two ways to access the education resources on GEM —Browsing and Searching. Browsing GEM is sampling from lists of predetermined categories (e.g. mathematics, language, education by grade level). Searching GEM is looking for any information containing the keywords of the query (e.g. algebra lesson plan). This website provides access to educational materials found on various federal, state, university, non-profit, and commercial Internet sites.

4 ERIC (Educational Resources Information Center)

The Ask ERIC service (Education Resources Information Center), supported by the Department of Education, has a virtual library of more than 900 lesson plans for K-12 teachers, and provides answers to questions from educators within 48 hours -- using a nationwide network of experts and databases of the latest research. Abstracts of some 1,300 (Educational Research Information Center) ERIC Digests are available online and text-searchable. A menu of services offered on the Internet not only introduces the user to ERIC documents, but also leads to other databases in education. It began in 1992 as a project of the ERIC Clearinghouse on Information and Technology and is now, with the ERIC Clearinghouse, a component of the Information Institute of Syracuse at Syracuse University. Today, Ask ERIC encompasses the resources of the entire ERIC system and beyond. Got an education question? Ask ERIC! The main components of Ask ERIC are:

1. Ask ERIC Question & Answer (Q&A) Service
   Need to know the latest information on special education, curriculum development or other education topics? Just Ask ERIC! When you submit your education question to Ask ERIC Q&A, you' ll receive a personal e-mail response from one of our network information specialists within two business days! We will send you a list of ERIC database citations that deal with your topic and will also refer you to other Internet resources for additional information. It' s that easy!

2. Ask ERIC Virtual Library
   The Ask ERIC Virtual Library contains selected educational resources, including 1000+ Ask ERIC Lesson Plans, 250+ Ask ERIC Info Guides, searchable archives of education-related listservs, links to Television Series Companion Guides, and much more!

3. Search the ERIC Database
   The ERIC database, the world' s largest source of education information, contains more than one million abstracts of documents and journal articles on education research and practice. By searching Ask ERIC' s web-based version of the ERIC Database, you can access the ERIC abstracts, which are also found in the printed medium, Resources in Education and Current Index to Journals in Education. The database is updated monthly, ensuring that the information you receive is timely and accurate.

5 Parents Guide to the Internet (16 page informational booklet)

This new, 16-page booklet, produced by the U.S. Department of Education, gives parents an introduction to the Internet and is "intended to help parents --regardless of their level of technological know-how--make use of the on-line world as an important educational tool. The guide cuts through the overwhelming amount of

consumer information to give parents an introduction to the Internet and how to navigate it. Most importantly the guide suggests how parents can allow their children to tap into the wonders of the Internet while safeguarding them from its potential hazards.

This guide was produced with the sort of collaborative effort that American schools need in order to succeed. U.S. Department of Education staff worked with leaders from parent and education organizations, the private sector, nonprofit groups and others in order to give parents a clear and comprehensive overview of the Internet and its vast educational potential. In the same way, schools need support from every corner of the community in order to provide students with a high-quality education.

6 Conclusion

More than ever before, a high-quality education offers Americans the best path to a rewarding career and a fulfilling quality of life. As citizens of the Information Age, Americans must include access to technology among the elements of an education that is based on high standards of achievement and discipline. But incorporating technology into the Nation's schools is too big a job for the schools to tackle on their own. Teachers need support and involvement from parents, grandparents, businesses, cultural institutions and others in order to make effective in-class use of the wonders of technology.

The Internet is an international computer network composed of thousands of smaller networks. Recently, through United States federal, state, and regional education networks and commercial providers, the vast resources of the Internet are increasingly available to administrators, school library media specialists, and classroom teachers. The web puts learning within the reach of anyone with Internet access. One of the most popular uses of this new medium, among teachers, is searching for ways to help students learn. But finding the right resource on a particular topic for their students takes time. And time is in short supply for our teachers. Current initiatives, such as those outlined, FREE, GEM, ERIC, and Parents Guide to the Internet, meet this goal of improving online learning.

References

1. Becker, Henry J. Information Technology in Teacher Education: Survey of Current Status. Washington, D.C.: National Technical Information Service, U.S. Department of Commerce, March 1994.
2. Bernie Poole's EdIndex, Web Resources for Teachers and Students, http://www.pitt.edu/~poole/edmenum.html
3. Consortium for Policy Research in Education. CPRE Policy Briefs, June 16, 1995.
4. Cotton, E. G. (1998). "The Online classroom: Teaching with the Internet, third edition." Bloomington, IN: EDINFO Press. (ISBN-1-883790-29-8). (ED 413 606)
5. Educational Resources Information Center (ERIC) web site, http://www.askeric.org/
6. Federal Resources for Educational Excellence (FREE) web site, http://www.ed.gov/free/.
7. Gateway to Educational Materials (GEM) web site, http://www.thegateway.org
8. Junion-Metz, G. (1996). "K-12 resources on the Internet: An instructional guide." Internet workshop series, number 5. San Carlos, CA: Library Solutions Press. (ISBN-1-882208-14-5). (ED 389 316)
9. K-12 computer networking. (1995). "The ERIC Review," 4(1). (ED 392 413)
10. Lankes, R. D. (1996). "Bread and butter of the Internet." ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 402 925)
11. Maeroff, Gene I. Changing Teaching: The Next Frontier. The National Foundation for the Improvement of Education, 1994.
12. McKinnon, P. Alistair, and Clesson S. Bush. "Technology for Education: What is the Federal Role?" Educational Technology 4 (1993): 37-41. Michalski, Jerry. Release 1.0: Esther Dyson's Monthly Report. New York: EDVenture Holdings, Inc., May 1995.
13. Milken Family Foundation. Expanding Classroom, Shrinking World: Resource Guide. Los Angeles, May 4, 1995.
14. National Center for Education Statistics, U.S. Department of Education. Advanced Telecommunications in U.S. Public Schools, K-12. Washington, D.C.: U.S. Government Printing Office, 1995.
15. National Center for Education Statistics, U.S. Department of Education. Annual Revenues and Expenditures: Public K-12 Schools. Washington, D.C.: U.S. Government Printing Office, 1991 and 1994.

16. Parents Guide to the Internet web site, http://www.ed.gov/pubs/parents/internet/
17. Serim, F. & Koch, M. (1996). "NetLearning: Why teachers use the Internet." Sebastopol, CA: Songline Studios, Inc. and O'Reilly & Associates, Inc. (ED 396 700)
18. Tennant, R. (1996). Internet basics: Update 1996. ERIC Digest. Syracuse, NY: ERIC Clearinghouse on Information & Technology. (ED 392 466)
19. U.S. Congress, Office of Technology Assessment. Teachers and Technology: Making the Connection. Washington, D.C.: U.S. Government Printing Office, April 1995.
20. U.S. General Accounting Office. School Facilities: America's Schools Not Designed or Equipped for 21st Century. Washington, D.C.: U.S. Government Printing Office, 1995.

The network learning supported by constructivism

Song-Min Ku
E-mail:sppman@icemail.nknu.edu.tw

1 Introduce

Network learning gives a chance to educators to rethink and investigate the learning modules and styles. Therefore the educators can rearrange learning strategies and develop new learning environment to validate the learning strategies and ideas. Although network learning cannot affect the learning completely and fully, at least network learning offer the environment to fulfill the ideas of constructivism.

2 Setting up the network learning environment

2.1.To provide multiple and abundant materials:

The network learning resources provide the objective and existed knowledge, the multi-angle and multi-level experiences to give learners various stimulations. In other words give the learners a chance to create multiple constructions, the same learner create different level construction at distinct time.

2.2.Give learners the authentic problems:

The important mission when teachers proceed with the instruction of constructivism is to arrange and provide the abundant and fitted learning environment, to offer and assist learners to construct knowledge actively and successfully.

2.3.Encourage learners raise various solving methods for the problems:

Promote learners to think of the problems by multi-angle ways. In order to encourage learners to discuss, think, argue and learn cooperatly, thus the learning have to be proceeded with dialog and communication.

2.4.Clear learning goals and concepts:

In internet world no place is too far away to be reached. If let learners grope or learn alone, it's usually happen that learners disorientate in the internet world. Thus if there is no clear goal, learning activity will be one pattern of browse and the emphasis will be neglect. Let learning activities concentrate at the learning goals or concepts, learners will get more complete knowledge, understand the key points, thus increase learning effects.

2.5.Learners can present viewpoints fully:

The internet world is a multi-person and pluralistic environment . In addition to self-learning, learners can see the learning portfolios of others. The learners review the cognition of others by self-viewpoint, furthermore to imitate and learn the others, and self-viewpoint can also be referred by others. Learners develop one kind of self-thinking in the environment of arguing with others again and again. Thus learners are no more silencers, but the learners are encouraged to present their viewpoints or opinions.

2.6.Adaptive courses:

There are individual differences between learners, learning processes or learning strategies of learners are different from others. Thus the design of courses should be considered about the individual

difference,adapted to learning situation of learners. Arrange different course to match the learning situation and abilities of learners, thus learners got the individual learning.

3 Conclusion

It's convenient to search information and data in World Wide Web. The convenience is important factor to encourage learners to construct the self-knowledge. In the process of learners participating and learning actively, learners will feel that they have got self-learning goal.

In constructivism it's important factor that learners participate actively in learning process. Thus learners must participate self-learning activity positively. Learners should search and find knowledge what they want actively.In network learning environment the learning activities are emphasized the" internal control" directed by learners, and requesting learners to learn by their strategies in the process of learning activities.

4 References

[1] Chih-Yu Chan(1996),"Cognition and Knowledge: Constructivism VS. Acceptance", Journal of Education Research, 49,25-38.

[2] Chi-Hsien Lin(1999),"The design and application of network leaning environment", Journal of Information and Education,67,34-48.

[3] Kuei-Fa Chiu,(1996). "Situation learning concept and computer aided learning: The study of learning community " Taipei: Shih Ta Press.

[4] Kuei-Fa Chiu,(1996). "The study of network learning: The another space of education research", The 12th Science Education Seminar, Roc. December.

[5] Kuei-Fa Chiu,(1997), " The development of network learning environment supported by education", Environment education and information network seminar, May.

[6] Shih-Ju Chang(1997),"The meaning of internet hypertext and hypermedia applied in instruction with constructivism", Journal of Information and Education, 58 ,39-48.

The Production of Web-based Interactive Video From Structured Script

Cheng-Huang Yen
Dept. of Management & Information, National Open Univ.
172 Chung-Cheng Road, Lu Chow, Taipei County, Taiwan 24702
Tel: +886-2-22894846
Fax: +886-2-28484944
E-mail:yench@mail.nou.edu.tw

The use of AV (audiovisual) media has had great impact on instruction in distance education. However, lack of a systematic methodology, existing instructional video programs cannot be used as effectively on Web as in the case of TV broadcast. Simply by digitizing video programs to AV streams will not gain much from learners' view. In our research, we propose the notion of structured script writing. The design and production of Web-based interactive video from structured script enhances reusability of content modules and reduces demand on network bandwidth. Most importantly, learners are able to conduct a hyperlink-style learning process which turns out to be much more effective than viewing video programs sequentially. Learning activities are also easily integrated with digitized media.

Keywords: **Web-based learning, Distance education, Audiovisual media production**

1 Introduction

TV production has been an effective, though expensive way to create AV media for instructional purposes. Every finished video includes an amalgamation of elements recorded in a script. A script simplifies production by specifying what and how settings, action, and actors become part of the video so the director can plan ahead. Although TV production runs routinely, the quality and effectiveness of every instructional video differs significantly. It has been evidenced that the script stage is critical for successful TV production. In our research, we take script writing to another level; i.e., structured script. The major goals are as follows:

1. *Enhance reusability of content module:* The video programs can be partitioned into reusable modules such that instructional elements may be reused or shared among different programs. Structured scripts lead to a natural partition of video programs.
2. *Facilitate the design of Web-based learning material:* The notion of hyperlinks has been used in the production of Web-based learning and training material. Embedded standard and extended tags appeared in structured scripts can map video content to HTML-like format. The mapping can be automated by software.
3. *Reduce the demand on network bandwidth:* Without partition, video programs are streaming down to users' computers which are normally hooked up to the Internet by low bandwidth access lines. A proper partition by topic will eliminate the need to transfer the whole program and thus save 30% to 70% of bandwidth usage.
4. *Automate the production of Web-based interactive video:* A typical distance education institution produces an average of 40 video programs per semester. The length of a video program ranges from 30 minutes to 20 hours. This amounts to a mass production of instructional video programs within a very short timeframe. It is both a need and a demand to automate the transformation of traditional video program to Web-based interactive video. The channels of distribution can also be diversified.
5. *Enable flexible learning sequences:* Traditional TV broadcast forces learners' to follow a non-stop sequential format which is inconvenient and against the nature of individualized open learning. Web-based open learning provides a variety of learning sequences and formats.

2 Related Research

In our research, video-based instructional media refer to traditional studio production or live instructional activities recorded on tape for later broadcast or distribution [8]. From learners' point of view, simply by watching the instructional video offers no experience of interaction. However, the visual content along with good design at the script stage could provide great assistance to learners, especially in the area of distance education. The use of interactive video in instruction and learning has been practiced extensively in both academic and corporate environments [3,5]. Improvised video programs can hardly provide effective assistance in a formal learning situation which requires precision and in-depth coverage.

Including the script stage in the video production process is a legitimate choice in most successful cases [4,8]. However, the sequential and flat nature of traditional script does not leave much room for integration with other media and for adding interaction. Structured scripts, like HTML in WWW, open a new way for producing effective Web-based interactive video. Recent advances in virtual university and network-based education suggest widespread use of computer-based media [1,2]. AV media can become part of the computer-based media [7]. However, traditional institutions need to pay for extra investment on video production and distance education institutions need to find a way to transform their video assets to digital merchandise. Structured scripts will help solve the dilemma.

3 A Definition of Structured Script

A typical script includes a video and an audio part presented along a sequential timeline. Various techniques can be used to enhance the presentation of instructional content in a video program. The elements of a script may appear in any format listed in Table 1. The adoption of these formats depends on the nature of the program, the design by content and media expert, etc. A script may contain a combination of several different formats of presentation.

Table 1. Popular presentation styles

1	*Commentary*
2	*Single performer*
3	*Interviews*
4	*Talk shows*
5	*Illustrated talk*
6	*Demonstrations (music/dance/computer)*
7	*Drama*
8	*Electronic insertion*

Most script writers are aware of different formats of presentation. However, few of them notice the formats' implications on how the video programs can be partitioned. Table 2 lists a typical script that follows traditional style. Based on the script, the director knows when, what and how to record on the tape. The actor is also aware of what should be performed by viewing the script. By the time the video program is finished, we need to scan through the tape to find a way to divide the program into video content modules. Just by looking at the script will not give us much clue about how the partition should be made.

Table 2. Non-structured scipt

Video	Audio
TC Java Basics 1. basic concepts 2. resources 3. related topics SP	Java is an object-oriented programming language. JDK (Java Developer's Kit) provides Java compiler and other tools for developing Java applications. ..... Java is noted for its support for cross-platform software development. Many Internet applications are written in Java.

Without making too much change, we re-write the same script as shown in Table 3, the so-called structured script. In our definition, a traditional script is composed of a video and an audio part synchronized along the timeline. A structured script is, on the other hand, distinguished by the following features:

1. *The margin of divisible units should be clear.* Suppose the video program will be partitioned by topics, the start and end of a topic should be signaled by some sort of tags. For example, the STC tag in Table 3 denotes the start of the topic, Java.
2. *There exists a hierarchy that organizes and inter-relates all units.* For example, the script in Table 3 reveals a hierarchy shown in Figure 1. The elements in the video part must be organized by certain content-specific criteria.

Table 3. Structured script

Video	Audio
STC Java TC Java basics 1. basic concepts 2. resources 3. related topics SP cross-platform software development Demonstration My first Java program	(music) Java is an object-oriented programming language. JDK (Java Developer's Kit) provides Java compiler and other tools for developing Java applications. .... (Java is noted for its support for cross-platform software development. Many Internet applications are written in Java.) ..... Step1. Enter MS-DOS mode, Step2. Type in a Java program, Step3. Compile and test the program.

Table 1 suggests a taxonomy of video contents by the formats of presentation. There are other ways to classify the same information in a script; e.g., the table of contents of a course or a lesson. No matter which classification scheme is chosen, the content of a script will be structured according to some sort of criteria. The resulting structure leads to reusable content mo dules. In the design of Web-based content, these modules can easily be organized in hyperlink-style Web pages. In our research, structured script writing follows well-defined style guide which can be specified by the tags' syntax and semantics. In a practical situation, a structured script editor can be used to help follow the rules.

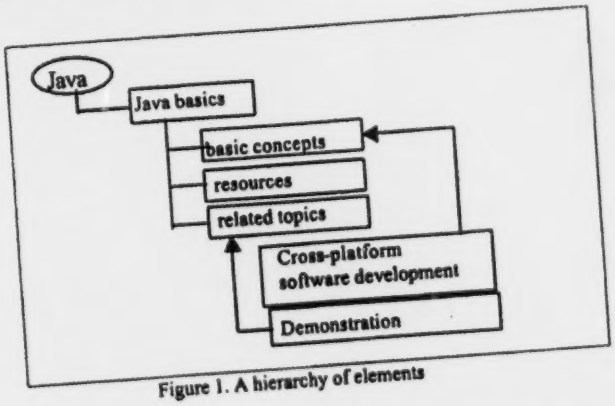


Figure 1. A hierarchy of elements

4 The Process and Methodology

Although TV broadcast still plays a major role in reaching most audience, network-based media have been growing in a pace much faster than traditional media. Since all kinds of media can be digitized and integrated into computer files, there is possibility that video-based instructional media can also be distributed in the form of network-based media. However, the design and production of traditional video-based instructional media has not been guided along this direction. Most existing instructional tapes are not able to function at least as well on the network, not to mention adding learning activities or interaction to these video programs.

Our research is focused on establishing a methodology and a mechanism for producing instructional video that works for broadcast and is able to help learners on the network. We are not aimed to investigate technical details on post-production of digital media. Instead, we are trying to look for answers on the following question, ''what kind of content in what format should be included in instructional videos and how?'' Figure 2 shows an overview of the production process. TV broadcast is more expensive and less flexible than distribution through Web hosts. However, Web access consumes a significant amount of network bandwidth for AV streams. On the other hand, studio production of videos is expensive. In the same professional area, many topics are likely to overlap in different programs. To reduce cost and enhance effectiveness, we can take advantage of studio production of video programs by changing the process of the script stage in a way that finished videos can easily be transformed to Web-ready media. The script stage is critical since later production steps are all based on the finished script.

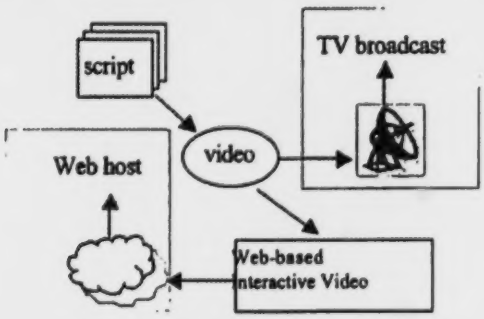


Figure 2. An overview of the production process

In order to achieve optimality among cost and effectiveness factors, there is a need to divide video programs to well-defined units. By well-defined we mean the unit should be complete and self-explanatory. Once the video program is divided into units, Web-based media will be feasible since viewers will not need to download the entire video program. The problem of reproducing the same content can also be avoided since the video unit is reusable. Obviously, the script stage is the most critical step toward a favorable solution. We re-shape the script writing process in the following ways:

1. *Component-based script creation*: Script writers or designers must be able to identify the components appeared in the script. Instead of dividing a script into components, we suggest a practice of component-based design at the beginning. Every component is identified by certain criteria; e.g., topic, presentation format, etc.
2. *Hierarchical planning*: The content of a script comes from a course or a lesson. The structure of the course or lesson is embedded in the script. At the script stage, how the content is divided or inter-related should be planned ahead. Later production of Web-based material will benefit from the pre-built hierarchy. Since the hierarchy is strongly content-specific, content expert should play the key role in this process.
3. *Extended tag set:* Existing notations used in script writing do not provide enough modeling capability for automated partition of structured scripts. We use an extended tag set. Part of the set is listed in Table 4. With this addition, it becomes feasible to develop a software editor for the creation and processing of structured script. The syntax and semantics of these tags are part of the style guide for structured script writing.

Table 4. Extended tag set for script writing

Tag	Usage
STC	The starting point of a topic
TC	Tele-card
SP	Superscription
VC	Video clip
CV	Computer video
CM	Commentary

Once the script is created structurally, studio production can proceed as usual. The next step is to import digital Beta-cam video source onto a post-production workstation. The video source becomes computer files. Since the original structured script contains meaningful tags, we can divide the video file into content modules based on the semantics of these tags. Figure 3 shows that the content modules can then be incorporated in the design of Web pages. These pages may be used and reused in various lessons, courses, and curriculum. There exists a transition between toc (table-of-contents) style and hyperlink style domain-specific contents.

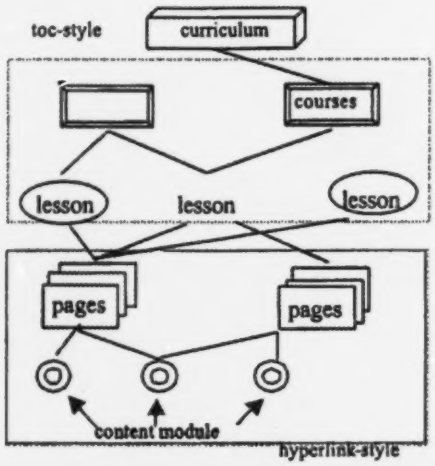


Figure 3. From toc-style to hyperlink style content presentation

The video content modules have no interaction at all. To add interaction to Web-based material, a variety of learning activities can be designed and integrated with various instructional media [6]. Figure 4 depicts the flow of learning activities. Learners start to work on the assignment through the interface of the Web browser. The assignment has been designed to help learners follow a sequence of steps to get result for discussion. The learning process can be evaluated and repeated. After finishing the assignment, learners may perform a test to see their own progress and head to the next assignment. In Figure 4, we can see that the video components produced from structured scripts are used for creating Web-based learning material. With the addition of the interactive design, the original video components are transformed to interactive video.

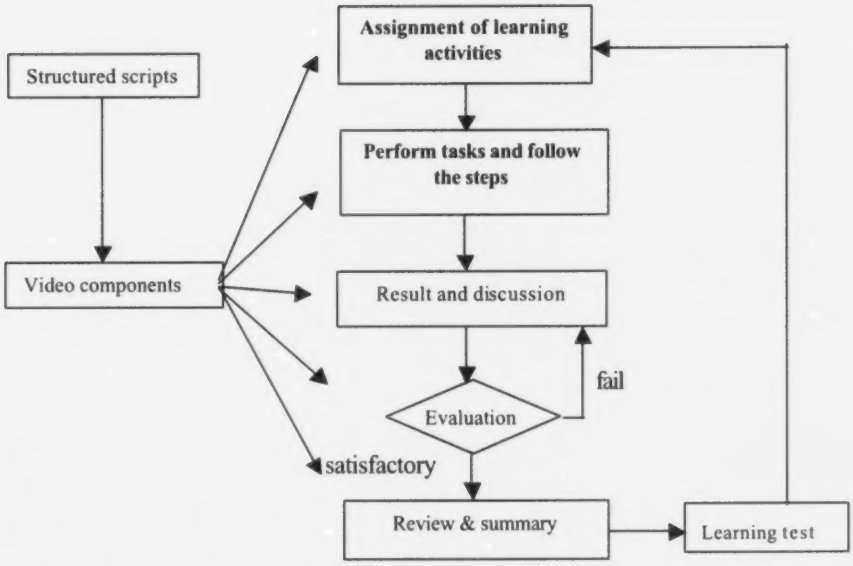


Figure 4. Interactive learning component

5 Experience Report

We choose a computing course, Data Structures, to exemplify the reference model resulted from the research. The reference model describes a formal process for producing instructional video suitable for integration with other digitized instructional media. Feedback and analysis collected from activities and experience of teaching the course is used to explain the strength and weakness of our approach.

1. Learning with interaction provides essential experience for successful learning.
2. Video programs alone are not able to provide required interaction.
3. Structured scripts are helpful for designers of Web-based instructional material.
4. The extended tag set for structured scripts should be clear and easy to use.
5. The reference model needs more instances to exemplify the use of tags, style guide, partition criteria, etc.

6 Conclusions

The learning experience by viewing a video program is different from browsing through a CBT (Computer-Based Training) lesson. However, the video part of both; i.e., traditional video programs and CBTs, may come from the same studio production process. Structured scripts have the potential of making video programs suitable for both TV broadcast and Web hosting. Content experts will take more responsibility on improving the quality and effectiveness of instructional videos. Media experts should carry on to provide assistance on the integration of learning activities with video content modules. Technical staff will then have enough information to build Web-based interactive video and other related learning and instructional material.

References

- Burgess, W. E. *The ORYX Guide to Distance Learning*. 2nd Ed. ORYX PRESS, 1997.
- Chellappa, R., Barua, A., and Whinston A. B. "An Electronic Infrastructure for a Virtual University". *Communications of the ACM*, pp. 56-58, 1997.

••••Collis, Betty. *Tele-learning in a Digital World : The Future of Distance Learning*. Thomson Computer Press, 1996.
••••Eustace, G. *Writing for Corporate Video*. Focal Press, 1990.
••••Hall, Brandon. *Web-Based Training Cookbook*. John Wiley & Sons, 1997
••••Horton, W. *Designing Web-Based Training*. John Wiley & Sons, 2000.
••••McCormack, C., et al. *Building a Web-Based Education System*. Wiley Computer Publishing, 1997.
••••Millerson, G. *Effective TV Production*. Focal Press, 1983.
••••Swain, D. V. *Scripting for Video and Audiovisual Media*. Focal Press. 1981.

The Rhetoric of the web—A semiotic approach to the design and analysis of web-documents

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper seeks to discuss possible approaches through which semiotics and rhetoric can be applied to the World Wide Web seen as a multimedia; or, in other words, possible approaches through which Web-sites and Web-pages can be studied and designed from a semiotic point of view-The aim of the paper is thus to outline a coherent theoretical, methodological and analytical framework for the study and design of Web-documents based on semiotics and rhetoric. This paper has analytical, theoretical, methodological, as well as practical implications. It is of interest in relation to the analytical and theoretical understanding of the new and rapidly growing web medium, and in relation to methods of examining this phenomenon. The study shows the concepts and categories from the field of semiotics and rhetoric are highly relevant to the area of the web and it indicates that the concepts presented here can form the building blocks for a more general 'Semiotics of Cyberspace'. The observations from this study may also have an effect on conventional theory formation and understanding within semiotics, rhetoric, and communication research and media studies. However, it also has implications for the construction and design aspects since the design of Web-documents and Web-sites must be based on actual knowledge of the conditions and possibilities for communication and the construction of signs, codes and meaning in the new medium.

*The paper was not available by the date of printing.

The Status of Cyber University in Korea and its Future Direction

Wang, Sukhee *, Kim, Youngsil**
Bisan Dong, Dongan-gu, Anyang-Si, Kyungki, Korea
Daelim College of Technolog, Computer Science Dept.
*Tel.: * 82-31- 467- 4882, ** 82-31-467-4884, Fax . : * 82-31-467- 4888*
** e-mail: shwang@daelim.ac.kr, ** e-mail: YSKIM@daelim.ac.kr*

Cyber universities create innovative and more effective approaches to teaching and learning. In Korea, cyber universities are running in many different ways: universities established as an example case designated by Education Ministry, universities opened for life-long education, and cyber graduate school for educating professionals in many fields. Also, cyber campus for college level has started in many technical colleges. In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

Key Words: **cyber school, cyber university, Interactive learning, Web-based learning**

1 Introduction

Cyber student population is dramatically increasing since the development of information communication technology. Evolution of information technology allows us to learn anywhere, anytime. Since 1988, five universities including Seoul National University have been selected as model case cyber universities, and ten universities including Sogang University as experimental case. According to this policy, Seoul National Cyber University opened four courses in March, 1998. In the first semester of 2000 school year, total of 24 courses were opened.

Some of the model case cyber universities are Bool Cyber University, Open Cyber University, and Seoul Cyber Design University. Also, experimental case universities are Korea Cyber University (KCU) and Information Technology Cyber University, a consortium of 14 universities including Kangwon, Kyunghee, Korea National Open University sponsored by Education Ministry.

Cyber universities for life-long education are Unitel Cyber Campus and Campus 21. Campus 21 was established by Netist, Internet Contents Development Company, in 1998. Now courses in Information Technology field, Foreign Language field, and Programming field are available. [1,3,8]

So far, these cyber universities were not allowed to confer degrees on students. However, since March 2000, cyber universities, permitted from Education Ministry, confer degrees on students by Life-Long Education Law. Education Ministry received application for establishment of cyber university until June 2000. Sixteen cyber universities and one In-company cyber university are now registered.

In this paper, we study the present status of cyber universities, its critical issues, and direction of its development in Korea. We focus on necessity of cyber universities consortium, allowing students enrolled in traditional universities to take certain amount of credits from cyber classes, and basic requirements for high-quality cyber lectures.

2 Present Status

Cyber universities program delivers unparalleled convenience and flexibility in the pursuit of their bachelor's, master's and professional bachelor's degree. They also offer customized training programs and reeducation programs for employees to many of the corporations. In Korea, the cyber universities and the courses they offer are increasing, and many of the students are willing to attend cyber universities due to their cost and time reduction, higher retention rates and self-paced training and performance support. Now, we would like to introduce some desirable cases.

2.1 KCU (Korea Cyber University)

KCU is the first cyber university consortium of 37 universities including Hanyang, and Younsei University, sponsored by Chosun Daily News, and Digital Chosun. In the first semester of 1999 school year, there were 507 classes, 25,389 students enrolled in, in the following semester, 706 classes, and 41,293 students. Korea Cyber Universities are planning to open classes to the public so that the students can pursue their degrees online. [3]

2.2 OCU (Open Cyber University)

OCU, selected as the designated institution from the Education Ministry in February 1998, is composed of 14 participated universities five cooperating universities, and 3 organizations. The 444 courses have been offered until first semester 2000. In fall semester 2000, 244 courses will be opened. [10]

2.3 Information Technology Cyber University

Consortium of 15 universities is take part in IT Cyber University. Total 26 multimedia lecture contents are completed including 12 internet technology courses, 2 IT general courses, 6 web based multimedia courses, and 4 IT venture classes. [4]

2.4 Namhae College

Inside NAMHAE Cyber Academy, there are cyber lecture room, broadcasting room, discussion room, chatting room, on-line evaluation room. And also, graphic file and audio lecture files are available. 345 classes have been offered so far, 1st semester in 2000, 84 courses were opened. [5]

2.5 Present Status

The Education Ministry has received 16 applications to launch degree-offering cyber universities, which are set to open March 2001, for the first time in Korea. By the June, 2000 deadline, four consortia of universities, eight individual universities and four private groups submitted applications to operate institutions offering courses on the Internet. Thirteen of them applied to provide bachelor's degrees, while the remaining three wanted to open courses for junior college diplomas. According to their submitted plans, the 16 applicants would recruit a combined total of 15,800 students in 81 departments. Samsung Electronics applied to set up an in-house college program for its employees. Samsung's plan envisages establishing a "Samsung Semiconductor Institute of Technology" that would offer a four-year bachelor's degree program and a two-year diploma course on digital and display engineering. It would be the nation's first accredited institution of higher learning set up exclusively for employees of a specific company. Education Ministry is planning to finish screening the applications by November, 2000.

3 Critical Issues

Cyber university hold great promise for enriching educational opportunity, especially for the homebound, or geographically isolated students. However, these advantages are overshadowed by many concerns.

3.1 General Aspects

* For cyber universities are at the point of beginning, law, technology, management system and marketing strategies are not yet fully established. Therefore, students don't have confidence in getting degrees.
* In cyber universities, there is lack of opportunities meeting professors face-to-face.
* Many of the students who have low-speed modem, spend lots of time to downloading lecture materials. When the lecture is transferring, time delaying is the most critical problem for real-time question and answer.
* For the cyber students don't have opportunities to meet other classmates or professors, the students don't have a chance to have social relationships, and get personality and ethics education.
* Due to the expanding of cyber universities, the traditional education system, which have played a great role in our history, is threatened. So, it is important to maintain balance of both education system.
* Lack of fund for developing high-quality multimedia contents and running cost is the biggest problem. In 1999, for example, the Information Technology Cyber university spent $2million for developing 26 multimedia lecture contents (about $50,000 per course).

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught. [6,7]

3.2 Faculty and Student Aspects

* For faculty in Korea, developing courseware and teaching takes too much time. So, they feel over-burdened on developing courseware and preparing lectures. In Korea, professors are obliged to teach for at least nine hours a week. However, in the case of Information Technology Graduate Cyber School, the professors are obliged to teach for three hours(one course) a week.
* It is hard for faculties to teach due to the diversity of student level. Also, it takes too much time to grade student's reports and quizzes. So, many teaching assistants should be available.
* Students have difficulties in course registration, dropping, adding and changing. [12,13]. In addition, it is hard for students to adapt due to the differences of platforms.
* Lack of interactiveness for intellectual motivation, and debating opportunities might result in passive participation for students. Moreover, flexibility of lecture schedules for employed students are not usually available.

4 Future Direction

Cyber campus must create an academic milieu that empowers the professional growth of faculty. The Cyber school must also create innovative and more effective approaches to teaching and learning. To implement the above objectives, the Cyber school will accomplish the followings.

* Testing: Exams should be available for each course.
* Feedback: immediate feedback provides each student with the topics they need.
* Security: Cyber university delivers all this safely and securely.
* Academic faculty must maintain control of shaping, approving and evaluating distance- education courses.
* Faculty should be compensated and given time, training and technical support to develop and conduct classes, and they should retain intellectual property rights over online materials.
* Students must be given advance information about course requirements, equipment needs, technical training and support throughout the course.
* Students should have opportunities to meet professors face-to-face whenever feasible.
* Full undergraduate degree programs should include classroom-based coursework.
* Quality of graphic resolution for multimedia files.
* Chattingroom in which professors and students are involved should be offered.
* Proper feedback for reports and projects should be offered.

* Online evaluation room and discussion room should be made.
* Shortening the time used for downloading the lectures should be considered.
* In classes offered by consortium, it should include high quality of contents, and the video will at least include 30% of the lecture. Also, in-class teaching (face to face) should be required at least twice a semester.
* Especially for college level, there are two ways of getting involved in cyber campus. First, students can take 80% of their credit at school and other 20% at any other cyber college. Second is allowing the students to take certain amount of cyber classes. This is for the students who have jobs during the day, for there are many difficulties attending the classes for them. Eventually, it will not only benefit in time reduction but also in higher retention rates.
* For developments of these high-quality cyber class contents and efficient operation, supporting of funds, technologies, software, and hardware is urgently needed.
* Cost and time reduction to develop multimedia lecture contents. New courses should be added regularly to give users access to the most current application and topics.
* Higher retention rates: Cyber university offers content in the form of interactive multimedia, users learn faster and retain more information.

Cyber school will develop innovative and more effective approaches to teaching and learning. It will meet these objectives by creating a collaborative group of faculty who, with technical support, will work together to discover what online technologies are available, to determine how they can be used to transform the educational experience, and to assess their teaching effectiveness.

This ongoing collaborative effort will result in continuing faculty professional development and a transformation in how students are taught.

5 Conclusion

The possibilities of cyber universities are endless as educators and students alike enthusiastically tout the convenience and advantages. But many professors worry about the accelerated pace and are trying to place some brakes on the race.

One-million member American Federation of Teachers, which includes about 110,000 college and university professors, approved at its Philadelphia convention a resolution calling for a set of quality standards for college-based distance-education programs. [2] Of course, it is critical that we hold this kind of programs to a high standard of academic rigor. However, We need to keep basic requirements to maintain high quality cyber lectures and student level. And also, government funding, technical equipment's, hardware/software supporting from the company, and tele communication infrastructure should be maintained.

References

Most of the internet site accessed on at the end of June to the beginning of July, 2000).

[1] Radford University http://www.runet.edu/~cyberu/intro.html

[2] Applied Technology Partners http://www.atpcorp.com/exam/university.html

[3] Korea Cyber University http://www.chosun.com/class/koreauni1.html

[4] Information & Communication University http://cyber.icu.ac.kr

[5] Namhae College http://www.namhae.ac.kr/infomanager1/main2.htm

[6] Kwak, Dukhoon (2000), "Management of Cyber university -Case Study: Information Technology Cyber University", Schoolnet 2000, Proceedings, PP.276-284

[7] Lee, Dongman, "Information and Communications University: Cyber Lecture", Schoolnet 2000, PP.400-408

[8] Campus 21 http://www.campus21.co.kr/home/default.asp

[9] Internet Library http://www.peacenet.net/english/internet/trend/1.htm

[10] Open Cyber University http://www.ocu.ac.kr/open_menu/introduction/default.htm

[11] Dongui Cyber University http://www.dit.ac.kr:82/menu6.htm

[12]"Integrated Information Services for 21st Century Education", June, 2000, Choongchung College

[13]"The Direction of Development for Integrated University Information System", Invited Seminar Proceedings, June 2000, Korea Info-Tech Co.

Tracking and Guiding Tools for Learning Groups in a Web Collaborative Learning System

Kuo-Liang Ou, Chen-Chung Liu, Jiun-Ren Huang, and Gwo-Dong Chen
Department of Computer Science and Information Engineering
National Central University
Chung-Li TAIWAN 32054
Tel.: +(886)3-4227151ext 4504 Fax.: +(886)3-422-2681
Email: klou@db.csie.ncu.edu.tw

Owing to prevent a learning group from failing, teachers need to observe the group learning situation, and discover its causal dependence in a web collaborative learning system. Therefore, teachers need to record the web logs and try to analyze these row data. However, the web logs amounts are often exceeding the teachers' readability and becomes to be meaningless. This work presents some assisting tools of Bayesian belief network supported another window to observe the leaning situation objectively, and predicts the probability of the learning situation before the end of semester. This work was experimented on managing a web collaborative learning with 706 students online. The results represents these tools relieved the teacher of tedious data collection and analysis, analyzed the causal dependence of each learning features, discovered the hidden learning features related with the social interdependence, and prevent the students learning from failed.

Keywords: **Bayesian Belief Network, Collaborative Learning, Learning Features, WWW**

1 Introduction

In existing web learning systems, students may feel lonely without learning companions. Many researches have indicatethat students will learn better when they learn in a group [1] [2] [3]. Thus, the group learning mechanism can be adopted into web learning to overcome the lonely study issue. A web collaborative learning system requires the teacher to put lots of efforts in tracking and guiding these groups on the web. It is difficult for teachers to capture the group learning status from the huge amount of unorganized web logs. The situation is even worse when hundreds of students are involved in collaborative learning, and it is difficult to get information from them [16]. Therefore, many assisting tools for analyzing the web logs were developed. [4]

However, most of these tools focused on providing summary of how the website is being accessed, for example, the statistics of access time, access frequencies, and the access location of web page. In fact, these numeral results and statistics are not enough for a teacher to obtain the status of learning groups in a collaborative learning system. Teachers ask for information to help them promote the collaborative learning performance. Example information includes whether a group leader success in fulfilling her/his role; whether there is distrust existing among group members, and low perceptions of help and assistance [5].

Moreover, a teacher needs information to track the social interdependence of a learning group. Johnson [1] identified that *social interdependence* is a key factor that affects the success of learning groups. The *social interdependence* includes the goal, reward, resource, role and task interdependence. The problem is these impact factors cannot be captured directly by analyzing access logs. Furthermore, the inter-group communication context is not apparent. Therefore, it is a challenge for a teacher to obtain the status of these impact factors immediately when tracking and guiding a web collaborative learning system.

Once the impact factors of a web collaborative learning is detected, the graphical model for representing the causal relationships is required for teachers to make a decision to teach strategies and intervene groups' learning online. In order to preventing a group from failing in the early semester, an appropriate invention is needed. After constructing such causal map for several times, teacher will accumulate some experiences of how to prevent groups from failing in time. However, this kind of individual experience is not reusable for other teachers or teaching assistants.

There we summarized two issues mentioned above when teachers try to manage the web collaborative learning.

- Discover the impact factors of learning situation:
  Since the social interdependence affects the collaborative learning deeply, teacher need some assisting tools to find out the impact factors hidden in web logs and group portfolios.
- Prevent groups to be failed by experience analysis:
  At the end of semester of a collaborative learning, the experience and logs could be an important reference for the next semester. If teacher could find out the impact reason of specific states, her/he could prompt the group to learn or prevent the group from failing.

To resolve the issues listed above, our research tried to employ some data mining techniques and supported some useful information for teachers to manage the web collaborative learning.

The participators in this research included 7 teachers, 5 teaching assistants and 706 students. All of these participators teaching and learning via video compacted disc (VCD), and collaborated the group works and discussed to members on web. Students were divided into 2 classes: Class-A and Class-B. Both classes were used the same teaching strategies and curriculums. In this research, the learning logs of Class-A were used for constructing the relational map between each learning feature. It was the simulated past-experience for predicting the learning states of Class-B. The result shows that with the assistance of these useful tools, teacher could track and guide the web collaborative learning with meaningful learning states, discover the impact factors associated with the social interdependence, and predict the learning state and make a teaching decision online.

2 The Bayesian Believe Network

This work employed the Bayesian belief network (BBN) [6] to model the learning situations and represented the causal relationship between these situations in a graphical map. The BBN is a directive map composed by some nodes and arcs, these nodes and arcs represent the joint probability distribution for a set of variables. In this research, the nodes represent the group's *Feature Space (FS)* [7], and the arcs represent the relationship and the joint probability of two FS. It is named as "FS-based Bayesian belief network (FSBBN)". In Figure 1, it is an example for illustrating the FSBBN of a web-based collaborative learning: the "Learning Failed" node represented the group grade less than 60 at the final of semester. The "Homework Late Submitting" node represented the group homework were submitted after the deadline. The "Less Discussing" node represented the discussion amount in discussion place were less than 3 post each day. The "Less Login" node represented the average login times of a group less than 1. The "Leader Failed" node represented the group leader were failed in his jobs. The arcs in BBN represented the causal relationships between each node, and were constructed by the Bayesian Classifier. The Bayesian Classifier figured out the probability of each node that was affected by the previous nodes.

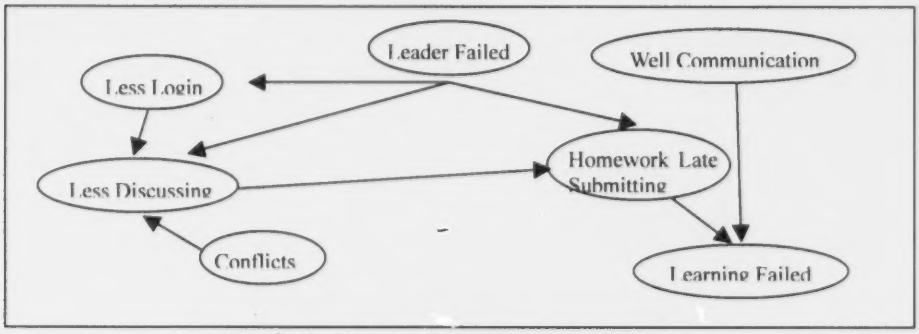


Figure 1: The example of Bayesian belief Network

Some probability tables deducted the directive arcs in FSBBN. Table 1 presents the probability of "Learning Failed" of a group, where "Learning Failed" is abbreviated to F, "Homework Late Submitting" is abbreviated to H, and "Well Communication" is abbreviated to W. The direct effects of "Learning Failed"included the probability of "Well Communication" and "Homework Late Submitting" both. Moreover, the direct effects of "Homework Late Submitting" included the probability of "Leader Failed" and "Less Discussion". In this way, the effects of "Learning Failed" included the probability of "Well Communication", "Homework Late Submitting", "Less Discussion", "Less Login", "Conflicts and Leader Failed".

	H,W	H,¬W	¬H,W	¬H, ¬W
F	0.35	0.93	0.02	0.54
¬F	0.65	0.07	0.98	0.56

Learning Failed

Table 1: The probability of Learning Failed

The FSBBN makes assistance for teachers finding out the relationships between each learning FS. It also supported the need for teaching decision in a web-based collaborative learning system, and will be illustrate in the following chapters.

3 Applying the Data Mining Tools in Learning Tracking and Teaching Guidance

To track students' learning status, teacher must to obtain the relationships between each impact factors of collaborative learning. In this chapter, several BBN tools support a directive map that illustrate these FS and help teachers to discover the objective causal relationships between these FS. These causal relationships support teachers to make a decision and promote the group to learn, prevent the group to be failed at the end of semester. This chapter will introduce some of free-wares and show how to apply these public tools in constructing a FSBBN and managing a web-based collaborative learning.

3.1 Observing the collaborative learning states and find out the impact factors

Bayesian Knowledge Discoverer (BKD) is noncommercial classification software for research, released by Knowledge Media Institute of Open University of UK. [8]. The aim of BKD is to provide a Knowledge Discovery tool able to extract reusable knowledge from databases, without expecting any particular methodological background from the user. To this aim, BKD uses BBN as a graphical representation of the dependent model in the database. Once the BBN generated from data, the network can be used as a self-contained reasoning system, able to provide observation, predictions and support decision making for a teacher.

The BKD needs a text file exported from database for constructing the BBN. The input data could be numeric or discrete data. To generated the complete causal network of a web collaborative learning, the input data of BKD should include the learning FS, personal profiles, online access statistics collaborative portfolios, and discussion situation. In Table 2, it illustrated that the teachers' interesting items about the learning situations. There are two groups of items: (1) learning FS (2) online statistic. All the values in this group were discrete Yes/NO or a label of level. The other items in second group were the online statistic from database, including the students' profiles, web accessing and discussion.
In Table 2, the "Conflict" means if the members have ever conflicted on the project goal with members, it represented the goal independence of a group. The "Lack Leadership" means the group leader failed in her/his role, it represented the leaders' role independence. The "Poor Comm" means the members made the communications with others rarely on the issues of project. The "Distrust" mean students have low trust with members about the discussion content and sharing resource, both of above FS represented the resource interdependence of a group. The "Poor Help" means if members did not like to help others in collaborative

project, it represented the reward independence of a group. The "Query Work" means the number that member query the current result of group project. It represents task interdependence of a group. Finally, the "Lower Grade" means the group failed in learning and got lower grades.

Group id	Conflict	Lack Leadership	Poor Comm	Distrust	Poor Help	Query Work	Disc Online	Email	Disc Lonely	Lower Grades	...
1	N	N	Y	N	N	64	6	6	48	Y	
2	Y	N	Y	N	N	165	4	21	14	N	
3	Y	Y	N	N	Y	0	0	13	19	Y	
4	N	N	N	N	N	44	3	19	13	N	
5	Y	N	Y	N	N	196	4	26	25	N	
6	Y	N	N	N	N	198	57	6	170	N	
7	Y	N	Y	Y	N	91	4	27	33	N	
8	Y	N	Y	N	N	175	3	6	41	N	
9	Y	Y	Y	N	N	68	1	8	16	N	
10	N	N	Y	N	N	70	7	13	23	Y	
...											
35	Y	N	Y	N	Y	12	2	3	15	Y	

Table 2: The input file for BKD (Class A)

After the input file import into the BKD, the system will construct a FSBBN for teachers to observe the relationships and the probability model for decision-making, like the example in Figure 1.

3.2 Experience reuse to prevent groups to be failed

To prevent groups to be failed early, the teacher would like to predict the group's learning state at the end of semester by the current states and her/his past teaching experience. The ideal to predict the learning states is to classify the new FS into the classes divided by the past FSBBN. In traditional classification tools, it contains two steps for prediction: first the system is trained by teacher's experience on a set of past data. The second, system will classify the cases by the trained set. The Robust Classifier (Roc) [8] is also noncommercial classification software for research, released by the Knowledge Media Institute of Open University of UK. It supports an efficient tool for teachers to classify the past FS into several classes, and predict the new FS into these classes.

There are four steps of Roc to predict a set of real-time FS illustrated as follows:

1. Define the Bayesian classifier from a database:
2. Class selection and discretization:
3. Learning the past learning FS:
4. Predictions the real-time FS:

There is an example how a teacher using the four steps to prevent the group learning failed:

Step1. Collecting the learning FS and online access data as the input file. Table 2 illustrated the teacher collected the input data of Class A for constructing the classifier. The input file has the same file format as the input file for BKD system.

Step2. Select one of the FS of input data as the class. For example, the teachers are interesting to obtain which group with the real-time FS will get lower grade at the end of semester.

Step3.After the Roc learning procedure proceed in this step, it generated the probability of each FS to the selected classes (Lower_Grades). In Table 3, two of FS: "Conflict" and "Leader_Failed" was listed and illustrate the probability of the group to be failed and get lower grades (Lower_Grades)

Step4. Predict the probability of learning failed via the online data of Class-B. Although Class-A and Class B were hold at the same semester, for prove the ability of prediction in this paper, the online FS of Class B were used as the test data. In case of the prediction were hold before the end of semester, some data were absent until the end of semester when predicting. In this research, several FS of Class-B were marked as '?' for simulating this situation.

Class Lower_Grade						
N Y	Attribute Conflict			Attribute Leader_Failed		
(0.690) (0.310)		Y	N		Y	N
	N	(0.621)	(0.379)	N	(0.172)	(0.828)
	Y	(0.385)	(0.615)	Y	(0.231)	(0.769)

Table 3: The results of Roc learning procedure

In Table 4, the coverage shows all the cases of Class B are predictable in RoC. The column "Lower Grades" is the original FS of Class B. It must be noted that in a real life case, this value of "Lower Grades" of Class B will not be known until the end of semester. The column "Predicted Result" is predicted by RoC with the input data in and the learning data. It is clearly that the system predicted group 1 would not get a Lower Grades at the end of semester. And the fact matched this prediction. However, the prediction of group 2 mismatched the fact. The column "Probability" represents the probability of such predictions of each group. In this experiment, the predicted result showed that the accuracy is 77.77% (28 correct, 8 incorrect). This credible result of RoC provides teachers not only predict the probability of each group to be Lower Grades, but also all other FS groups of social independence and will be discussed in next chapter.

Group id	Predicted Result	Lower Grades	Probability
1	N	N	0.561
2	N	Y	0.977
...	...	...	...
36	Y	Y	0.897
Correct:	28		
Incorrect:	8		
Accuracy:	77.77 %		
Coverage	100.0 %		

Table 4: The output file of predicted result (Class B)

4 Experience and Result

In this chapter, teachers exhibit a web-based collaborative learning on the "Introduction of Computer Network and Applications" course. The data mining tools such as BKD and Roc were employed and help teachers to observe the learning states, intervene the learning to promote collaborating and illustrated the ability to prevent the group to be fail before the end of semester.

4.1 The participants and the grouping on web

The participators included 7 teachers, 5 teaching assistants and 706 students in Taiwan. The 63% of students are teachers in high school, and all graduated form colleges or above. The 706 students were divided randomly into tow class named Class-A and Class-B. After the first month for students to be used to the environment, functions and operations, students were grouped into several heterogeneous groups by the grouping tools [9]. The grouping criterion included the personal profile and thinking style [10]. There were 35 groups in Class-A and 36 groups in Class-B, average 9.9 students in a group. The 63.5% of students are also the teachers in high school and all graduated from college or above. It represents most of the students did not have the difficult to get on-line. The students read the curriculums from video compacted disc (VCD). After the reading work, students must register in the NCUVC [11][12][15] collaborative learning system. The NCUVC support a web discussing space, collaborative project space and sharing resource in space, etc. The first group task is to elect the cadres, included the leader, co-leader and the clerk, and check-in the group private working space. The group private working space supported the online and offline discussion room, a resource sharing space, a portfolio space, a project scheduler, and a window for querying the member working states.

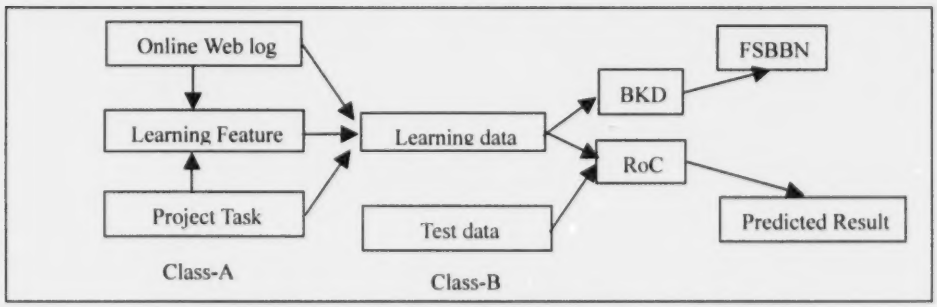


Figure 2: The process for observing and predicting the learning situation

Figure 2 illustrates the process for teachers to observe the learning FSBBN and predict the learning situation. For observing the learning states, teachers collected all the online/offline data to be the learning data and the input data for BKD system. The output of BKD is the form of graphical FSBBN. For predicting the learning situation of Class-B, teacher employed the training data to be the first input data of RoC system. The online data of Class-B is the test data and second input data of RoC. The result classified the cases of Class-B into the classes of Class-A, and support probability of each class for teachers.

4.2 Observe the learning states

After all the groups were ready to work together, teachers assigned the first project to each group. It is a collaborative project for constructing the web site for teaching the techniques of web programming. In the progress of project, teacher would like to observe the learning and working states of each group. There two type of observing method supported NCUVC. First, the subjective FS: teachers could construct the FS subjectively and focus on the specific group learning/working states, which are interesting for individual teacher. Because different teachers will define different FS for each group, it is the subjective observing tool dependent on teachers. Second, the objective FSBBN: it is a causal map based on the FS and all the accessing logs on web, the BKD system will construct the FSBBN for each group. Therefore, teachers could track the learning states and the causal relationships between each FS and access log. Because the causal map was constructed by the Bayesian method, it support the objective observing tool. The following figure is an example for observing the learning Class-A.

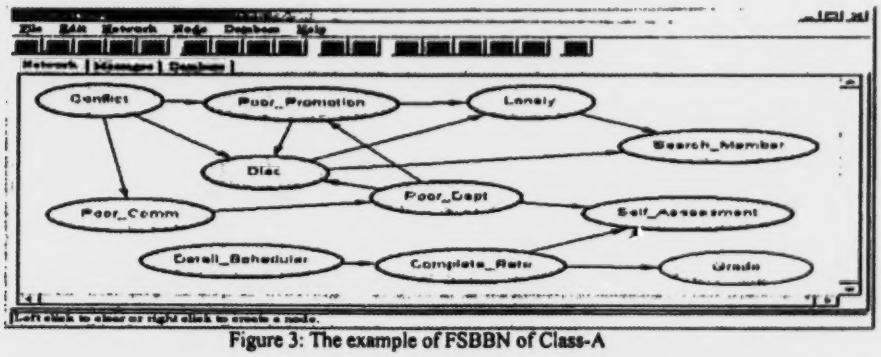


Figure 3: The example of FSBBN of Class-A

In Figure 3, teachers were interesting the causal relationships of homework grades (Hw_Grade) of each group. This FSBBN illustrated that the homework grades were influenced by the complete rate of homework (Complete_Rate). The BKD also figured out the probability of each level of Complete_Rate (high,mid,low) and the level of Hw_Grade(good,general,poor). It was illustrated in the following table.

Complete_Rate \ Grade	Good	General	Poor
High	0.956	0.022	0.022
Mid	0.006	0.990	0.004
Low	0.028	0.042	0.930

Table 5: The probability of Complete_Rate and Hw_Grade

It is clearly that the group with higher complete rate, it has higher probability (0.956) to get good grade at the end of semester. In contract, the lower complete rate has higher probability (0.930) to get poor grade. Thus, teachers could observe the causal relationships of each learning features with the help of FSBBN.

4.3 Discover the causal relationships between FS and social interdependence

The social interdependence exists when the outcomes of individual are affected by each other's action [1] [13]. It plays an important role for the success of a collaborative learning. However, teachers have difficult for observing the social interdependence without face-to-face interaction on web. In this chapter, all the social interdependence was transformed into the form of FS and the FSBBN, these representation could be a

window for observing and predicting the level of social interdependence. With the categories made by Johnson's *Interdependence Typology* [1] the five type of *positive interdependence* must be discussed first. The next table illustrated the web collaborative learning FS related to John's positive interdependence. Johnson's positive interdependence was not evident These FS were classify by teachers' subjectivity

Positive Interdependence	Feature Space
Goal interdependence	Goal_discuss, Query_group_portfolio, Query_members_work, ...
Reward interdependence	Grades, Help_members ,Answer_discussion,...
Resource interdependence	Discussing, Upload_resource, Query_resource, ...
Role interdependence	Allot_task, Leader_failed, Individual_responsibility, ...
Task interdependence	Portfolio, Query_scheduler, ...

Table 6: The associated feature space for observing the positive interdependence

However, some FS associated with these positive interdependence was hidden and not listed in the teachers' subjective FS. The Bayesian method could discover these *missing data* [14] and the causal relationships. In this experiment, teachers tried to collect all the web logs and the result of questionnaires, transformed these data into 70 FS as the input file of BKD. The BKD could discover the missing related FS associated with this social interdependence. First, teachers classified the groups into two classes: goal interdependence and poor goal interdependence. The new class was added into the system as the new FS and named as "Goal_Interdependence". Teachers could selected all the FS or a set of FS including the new FS as the input data of BKD. After the analysis of BKD, the new related FS associated with "Goal_Interdependence" could be discovered in the FSBBN.

4.4 Prevent the group to be failed

In chapter 4, the Roc system supported the credible prediction for the FS of Class B with the experience of Class A. In this experiment, the correct rate is 77.77% is good enough for a teacher to prevent the group to be failed. In fact, some irrelative learning data will reduced the correct rate. For saving time and increase the correct rate of prediction, teachers would like to migrate the redundant FS and remain the necessary FS. The issue is which FS should be migrated and which FS should be remained? The positive interdependence supported a good idea about this issue. In Table 7, teachers tried to predict the probability of learning failed (Low_Grades) with different FS associated with the positive interdependence.

Learning data	Correct Rate of Prediction
Goal interdependence FS	100%
Reward interdependence FS	88.89%
Resource interdependence FS	88.89%
Role interdependence FS	66.66%
Task interdependence FS	86.11%
All the FS	77.77%

Table 7: The correct rate of prediction with different type of FS learning data

The result illustrated that teachers selected different part of FS related with the social interdependence and improve the correctness of prediction. It is interesting that in this experiment, the FS related with goal interdependence has the most dependent relationship with the group grades. The FS related with role interdependence has the least dependent relationship with the group grades. Therefore, teachers could observe the goal interdependence FS at next semester to prevent the group from being failed. Teachers could not only predict the fail probability of a group, but also predict any FS with the subset of all the FS in this system.

5 Conclusion

To assist a teacher in tracking and guiding a web collaborative learning this work has presented the assisting tools for observing the group states, discovering the impact factors of learning situation, and reuse the experience to predict the learning state. The Bayesian method supports an efficient way to achieve these purposes. Without the proposed mechanisms, a teacher must spend considerable time in trying to analyze situation from huge amount of unorganized web logs. The causal relationships of learning situations were hard to track. To predict the learning situation depended on teacher's individual experience that is imprecise

and could not be reused for other teachers. This work (1) transformed the huge amount of meaningless web log into the form of readable and meaningful feature space, (2) supported the graphical FSBBN for observing the learning states and discovering the hidden impact factors of web collaborative learning, (3) predicted the learning situation successfully before the end of semester with the online learning situation and experience of past semester.

Observation and tracking the group's learning situation help teachers determine instructional strategies and group's learning performance. With the advantage of feature space and FSBBN, teachers can observe learning performance and analyze the influence of learning situations. The learning space is constructed as a hierarchical graph and teachers can define features for themselves via the instructional domain knowledge, doing to easily and meaningfully. The FSBBN illustrated the causal map of learning situations. With the past experience of tracking and guiding, teachers could predict the learning situation before the end of semester. Therefore, teachers could intervene the group learning to prevent the group from being failed.

Finally, the experiment result demonstrates that teachers' tracking and guiding a web collaborative learning with 706 students were successful and efficient.

Acknowledgement

The authors would like to thank the National Science Council of the Republic of China for financially supporting this research under Contract No. NSC88-2520-S-008-002.

Reference

[1] Johnson, D.W., and Johnson, R.T. "Learning together and alone" (33rd ed.). Egnlewood Cliffs, NJ: Prentice Hall

[2] Collis, B., Andernach, T., & Van Diepen, N. "Web Environments for Group-Based Project Work in Higher Education". International Journal of Educational Telecommunications. No.3 Vol.2 pp.109-130.

[3] Shotsberger, P.G., Smith, K.B., & Spell,C.G. "Collaborative Distance Education on the World Wide Web: What Would That Look Like?", Proceeding of CSCL, 1995. pp.312-316

[4] Zaïane O., Xin M., and Han J. "Discovering Web Access Patterns and Trends by Applying OLAP and Data Mining Technology on Web Logs". ADL 1998: 19-29

[5] Adams, D.M. and Hamm, M.E. "Cooperative Learning, Critical Thinking and Collaboration Across the Curriculum". Charles C Thomas Publisher, 1990

[6] Gertner, A.S., Conati, C., VanLehn. K. (1998). Procedural Help in Andes: Generating, Hints Using a Bayesian Network Student Model. AAAI/IAAI 1998: 106-111

[7] Ou, K.L. Chen, G.D., Liu, C.C., and Liu, B.J "Instructional Instruments for Web Group Learning Systems : The Grouping, Intervention, and Strategy" Proc. The 5th Annual Conference on Innovation and Technology in Computer Science Education, 2000

[8] Ramoni, M. and Sebastiani, P. "An introduction to the Robust Bayesian Classifier". KMI Technical Report Kmi-TR-79, Knowledge Mddia Institute, The Open University, Milton Keynes, 1999

[9] Chen, G.W., Ou, K.L., and Liu, C.C. "Instructional Instruments for Grouping, Intervention, and Strategy Analysis on Web Group Learning Systems". Proc. International Conference on Compters in Education 99, Chi-ba, Japan. (October, 1999)

[10] Sternberg, R. "Thinking Styles" ,Cambridge University Press.

Gertner, A.S., Conati, C., VanLehn. K. (1998). Procedural Help in Andes: Generating, Hints Using a Bayesian Network Student Model. AAAI/IAAI 1998: 106-111

[11] Ou, K.L., Chen G.W., and Liu,B.J. "A Group Learning Environment in a Virtual Classroom Built on WWW". Proc. 6th International Conference on Computer Assisted Instrution, 1997

[12] Liu, C.C., Chen, G.W., Ou, K.L., Liu, B.J., and Horng, J.T. "Managing Activity Dynamics of Web Based Collaborative Applications". International Journal of Artificial Intelligence Tools, Vol. 8, No. 2

[13] Webb, N.M. "Peer interaction and learning in small groups". International Journal of Educational Research, 13(1), pp. 21-29.

[14] Little, R.J.A. and Rubin, D.B. "Statistical Analysis with Missing Data". Wiley, New York.

[15]Ou, K.L., Chang, C.K., & Chen, G.D."Web-based Asynchronous Discussion System". Internatinoal Conference on Computers in Education 1998.

[16] Chang, C.K., Chen, G.D., Ou, K.L., & Liu, B.J. "Student Portfolio Analysis for Decision Support of Web-Based Classroom Teacher by Data Cube Technology". ED-MEDIA/ED-TELECOM 98

TWO TYPES OF VIRTUAL SCHOOL IN INET SUPPORTED BY TEACHER'S GROUP—COLLABORATION TYPE AND LOOSELY CONNECTED TYPE

Shoichi Kinosita* and Nobuyuki Arakawa**
*SEITOKU University, *550, Iwase, Matsudo, Chiba, Japan 271-8555,*
E-mail: kino@po.jah.ne.jp
**Kamishinmei Elementary School, *Futaba-4, Shinagawa-ku, Tokyo, Japan*
Email: arakawa.nobuyuki@nifty.ne.jp

1 Introduction

We construct a virtual school in INET since December 1997 about elementary and secondary education. This virtual school is collaboration type. About 10 teachers are the managers who control the open and close to the courses. This members also join to "Project Group for Learning Process" founded at 1984 in Matsushita Audio-Visual Research Foundation. The courses are consists of Japanese Language, Mathematics, Social Science, Natural Science, Arts, etc. The writer of each course is voluntary and often invited by the manager. The system of this school is controlled by CGI program that counts and classify the visitors.

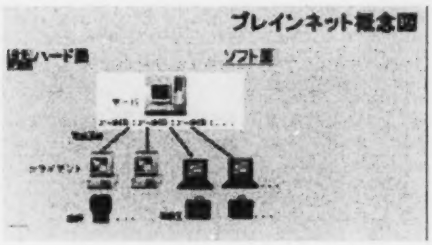


fig. 1 Structure of Type [A]

The other type -Loosely connected- virtual school will be appeared in several months. This type is the mirror image of writer's daily lesson. The writer is also the teacher at a classroom and the course is the same contents as the lesson at the class. The first purpose of this type is the help for absent student at lesson with inevitable reason.

The second purpose is the teacher's skill up the teaching methods and fill up his contents. Each course is gazed by the other writer and visitor by critical viewpoints and comments may send to him by E-mail or another way. These comments will effective for the writers. The writers are loosely connected by browsing and criticize for each other.

2 Comparison of Two Types of Virtual School

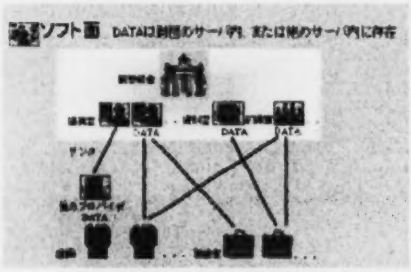


fig. 2 Software Structure of Type [A]

Let's call collaboration one is the type [A] and a loosely connected one is the type [B]. Type [A] may have fine course by fine teacher by the reason of solid watch and control and severe criticism. But the number of writers may be limited because of difficulties to make fine or excellent course. In fact, the number of writers of our school is about 20 teachers today. The increase of number of writers is very slow.

Type [B] may readily have many teachers because the reporting of own daily lesson wants little efforts except for some reviews and writing time.
On the other hand, the quality of course may not be

expected, and the learners to be supposed are very restricted.

Results

The two types [A] & [B] will be exist parallel to each other and exchange the writer, or perhaps invite the writer for type [B] at first and next to type [A] if the course will fine and universal.

The Language of both types is Japanese and every learner or visitor needs to read Japanese Language. This is an issue that is easily overcome by some Japanese to English interpretation software. Our two schools slightly gather the writers who want to spread their unique lesson and the effect appeared in the mutual discussion about order in lesson, resources, tools, and illustrations in both type.

fig. 3 Front Page of Type [B]

There are many virtual schools in Japan and all over the world. These are almost supported by ministry of education, nation, or company who have many staffs working with development and editing. Our tiny two virtual schools will combine the teacher's skill and fine lessons from voluntary teachers in Japan or other country and serve the chances to learn for many learners who can't go to the school with willingness to learn.

References

[1] Our type [A] Home Page, http://www.mef.or.jp/bnm/(accessed on July 20,2000)
[2] Our type [B] Home Page, http://www.kinosita.itabashi.tokyo.jp/(accessed on July 20,2000)

Virtual Inhabited 3D worlds and Internet Based Learning Environments

Jens F. Jensen
InterMedia Aalborg, Aalborg University
Niels Jernersvej, NOVI4-215, DK-9220 Aalborg East, DENMARK
Phone: +45 98 15 62 79 Fax: +45 98 14 24 44
E-mail: jensf@hum.auc.dk

This paper addresses some of the central questions currently related to 3-dimensional Inhabited Virtual worlds (3D-IVWs) and their virtual interactions and communication in Internet Based Learning Environments. First, 3D-IVWs-seen as a new and unique form of multimedia-are introduced and the social construction of the 3D-IVW technology is briefly discussed. Second, a selection of the basic concepts and identifiable entities in 3D-IVW s is denned and commented upon. Third, modes of interactivity and (virtual) interactions between users, avatar, bots, etc. in the new Virtual Worlds are briefly presented and typologized. Finally, two Internet based virtual inhabited 3D learning environments -one US-based and one based in Denmark- will be described and analysed.

*The paper was not available by the date of printing.

WALTZ: A Web-based Adaptive/Interactive Learning and Teaching Zone

Long-Chyr Chang, Heien-Kun Chiang, and Pi-Shin Wey
Da-Yeh University
112, Shan-Jiau Rd., Da-Tsuen, Changhua 51505
Tel: +886-4-8528469~3138
E-mail: long@aries.dyu.edu.tw

Web-based 3D life-like learning environment is becoming a major research topic. WALTZ supports dynamic, collaborative, and synchronous/asynchronous learning activity in 2D/3D virtual environments. In this paper, an overview of WALTZ's architecture and design philosophy is presented. Then, a WALTZ-style Pythagorean theorem learning space is shown to illustrate the powerfulness of the WALTZ environment. The ultimate goal of WALTZ is to provide an active and pleasant social learning environment for learners to study collaboratively and waltz happily in shared virtual, dynamic and yet exciting learning spaces.

Keywords: **Web learning, Virtual Reality, Collaborative Learning, CAI**

1 Introduction

The World Wide Web (WWW) opens a new learning space that learners can communicate and share their idea in this wonderful virtual world. The new learning space provides versatile ways of communication and interaction that would make learning more fun and entertaining than ever before. It has captured great attentions from CAI (Computer Assisted Instruction) researchers since its debut as it has great potential to surmount the difficulties and weakness of traditional CAI systems [5,7,8]. Up to date, most web-based CAI systems only support asynchronous learning and still use 2D hypermedia style to showcase their learning materials and instructions [13]. Some systems [3] might support collaborative learning additionally, however, they are still far away from success as the new way of learning also brings new problems that are even more challenging for educators. There is no simple way of knowing what the best web-based learning environment would be and how to utilize this environment effectively for teaching as well as learning. It is a research area that needs to be seriously explored through the cooperation of experts from different disciplines such as subject content experts, instruction developers, CAI researchers, and web engineers etc. Despite such problems, most educators would agree that discovering leaning, collaborative learning, learning by doing, and learning with fun are among those of effective learning methods according to Constructivism [2,9,12]. Fortunately, recent rapid progress of web technologies such as JAVA, VRML, and network technologies bring a new opportunity for implementing the learning methods described above. Before VRML was created in 1994, web spaces are flat. Most web systems are hypermedia style, which do not have enough expressive power of modeling real world entities. The living world specification [11,14] in 1997 illustrates emerging needs of dynamic and interactive 3D shared virtual worlds. Today there are many popular 3D avatar (virtual human) based virtual society (mainly for social meeting and chatting) websites [1]. The trend of web windowing systems is moving from 2D multimedia representation to 3D shared virtual space. WALTZ foresees the integration of the two media will become a popular form of presenting learning materials as well as a virtual fun place to play, learn and exchange idea. Many studies have also indicated that a successful web-based learning system not only has to be content-rich but also highly interactive as well as highly adaptive to meet the needs of learners [5,8]. Transforming 2D virtual classrooms into life-like 3D learning space is certainly one of the research directions that deserve special attention.

WALTZ, a research project under active development, is a web-based adaptive/interactive learning and teaching zone, which supports dynamic, collaborative, and synchronous/asynchronous learning in 2D/3D

virtual environment. WALTZ envisions that the CIA (Content, Interaction and Adaptivity) learning model will be an essential ingredient of future successful web-based CAI (Computer-Aided Instruction) systems. The CIA learning model is developed based on the Interaction Model of Gilbert [5] and Instruction Design Model of Moallem [15]. The CIA learning model has three corner stones: Content, Interaction and Adaptivity. The overlay areas of each neighboring corner stones are versatile representation, adaptive instruction and adaptive interaction. Figure 1 illustrates the CIA model in detail.

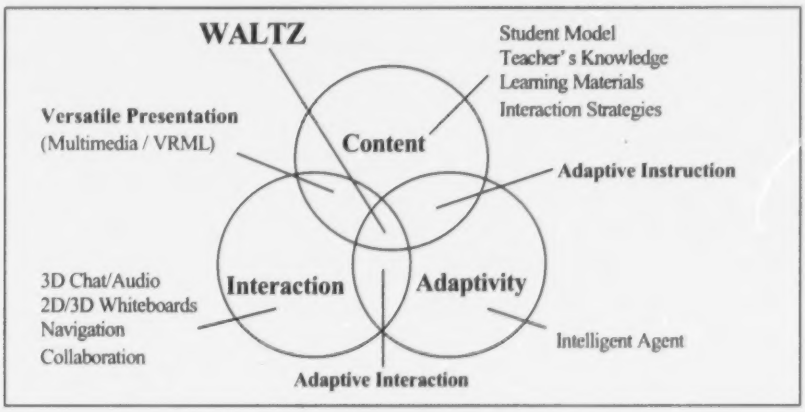


Figure 1. WALTZ's CIA Learning Model

2 An Overview of WALTZ

The main goal of WALTZ is to develop a web-based interactive and adaptive environment based on the CIA learning model so that it can be easily adapted to any instructional and learning subjects according to the theory of constructivism. WALTZ is capable of supporting discovering learning, project-based learning and collaborative learning in 2D/3D shared virtual learning space. WALTZ supports the following features:

(1) Dynamic interaction and flexible communication

WALTZ supports two types of interaction: Human-Computer Interaction and Social Interaction. The former supports instructional interaction and emphasizes individual and adaptive learning. Learners can browse information, navigate virtual worlds, and respond to problems that are dynamically generated from the WALTZ's system according to student's learning status. The latter supports collaborative mechanism and emphasizes collaborative learning among students, student and teacher, groups of students, and the whole class. In addition to support asynchronous communication in traditional 2D virtual classroom setting, WALTZ also supports synchronous communication in both 2D shared and 3D shared learning space as well.

(2) Versatile presentation of multimedia and virtual reality

Both multimedia and virtual reality have their advantages and disadvantages. Multimedia learning has great success in instruction and learning in recent years. Virtual reality is the best technology to provide 3D life environment. Web-based multi-user environment are even envisioned as one of the popular user interface in the future [9]. However, it is still hard to construct a high quality VR system in terms of cost and technology. Furthermore, virtual reality might not be suitable for all types of instruction. Thus, the use of both multimedia and virtual reality technologies in alearning system will be able to support a rich and effective learning environment that attracts students.

(3) Agent-based learning environment

Based on Constructivism, an ideal learning system should provide adaptive learning scenarios, where teaching materials and learning activity would be individualized according to students' mental model and learning needs. WALTZ supports helper-agents, which would interact with learners in several ways. For

example, an instruction agent would present an easier course material to a learner if it found the current content is too difficult for him/her. An interaction agent would suggest a group of learners to use a 3D whiteboard instead of a 2D whiteboard if they were trying to understand the three dimensional structure of molecules. WALTZ's virtual classroom could be populated with shared objects and active agents, such as user agents (represented by virtual human) and helper-agents so that users can enjoy and learn effectively in the social learning environment.

(4) Collaborative mechanism for activity management

Recently, group learning has been found to have a positive effect during learners' learning process [6,17]. In order to effectively support WALTZ's virtual, shared, and interactive social world, a set of collaborative mechanisms has been developed to manage interactions among students, teachers, and instructional content. These mechanisms [4] include object association, automatic object notification and change management, object delegation, object negotiation, object constraint, and object history tracking. Built on top of these collaborative mechanisms; WALTZ constructs an agent-based group activity model, where each participant is modeled as a user agent to manages the dynamic behaviors of all participants in an activity.

(5) Standard VRML authoring language for shared multimedia contents

Content development plays an important role of a successful web-based learning system. WALTZ supports authoring tools for shard virtual worlds based on multi-user VRML living world specification. This feature will make developments of shared 3D contents almost as easy as non-shared static 3D contents. Message passing between shared objects on different computers will be through new prototyped VRML nodes and WALTZ communication subsystem will update the states of each shared object once they are changed.

(6) Open architecture and platform independent web-based learning environment

The enchantment of web-based learning environment in WALTZ is due to its global network connectivity, simplicity and yet friendly user interface, and extensible architecture. The implementation of WALTZ is based on JAVA , VRML and standard network technologies so that it can be easily applied to other systems or platforms. A client can use current popular web browsers, such as Microsoft Internet Explorer or Netscape Navigator (with VRML plug-ins, such as Cosmo player or Cortna player) to browse information, navigate, and communicate with other clients in the WALTZ.

WALTZ is expected to be able to

- represent different media information effectively,
- construct various learning scenarios by integrating the technologies of virtual reality, multimedia, and World Wide Web, and
- to provide activity management facilities and collaborative mechanisms to enable highly interactive collaboration among all students, teachers, and instructional material in collaborative learning activity.

3 The Architecture of WALTZ

WALTZ is basically a client/server distributed virtual reality system. The client side provides human-machine interface that uses the technologies of audio, image, HTML, VRML, and the Java Internet capabilities to provide a web-based multimedia/virtual classroom according to the theory of Constructivism. Its environment contains JAVA control applet, multimedia, virtual world interface and collaborative tools such as text chat tool and shared whiteboard. Figure 2 illustrates the architecture in detail. Each client (user) can join one to multiple sessions to collaborate with other participants in 2D/3D shared virtual classrooms (or learning spaces). The server side is composed of five main components: (1) collaborative mechanisms subsystem, (2) VRML world server, (3) intelligent agent-based server, (4) Web server, and (5) communication subsystem for supporting real-time synchronous or asynchronous message interchange. The collaborative mechanisms subsystem ensures that the inter-dependency/intra-dependency of all activities/participants will be maintained and validated during their interaction. In addition, notification, delegation or negotiation protocols will be executed once some events of interest are triggered. The VRML world server will handle all VRML events coming from the event manager and updates the states of each shared VRML objects. The agent-based helpers communicate with the activity manager in inferencing and discovering potentially new learning patterns of students based on the diagnosis and feedback of students'

learning history. A communication subsystem supporting TCP/UDP/RTP protocols is used by all components of WALTZ to facilitate the real-time synchronous or asynchronous communication of interacting objects (or entities). The web server is responsible for downloading multimedia and VRML representation of instructional materials or virtual learning space.

4 Pythagorean Theorem Learning Space

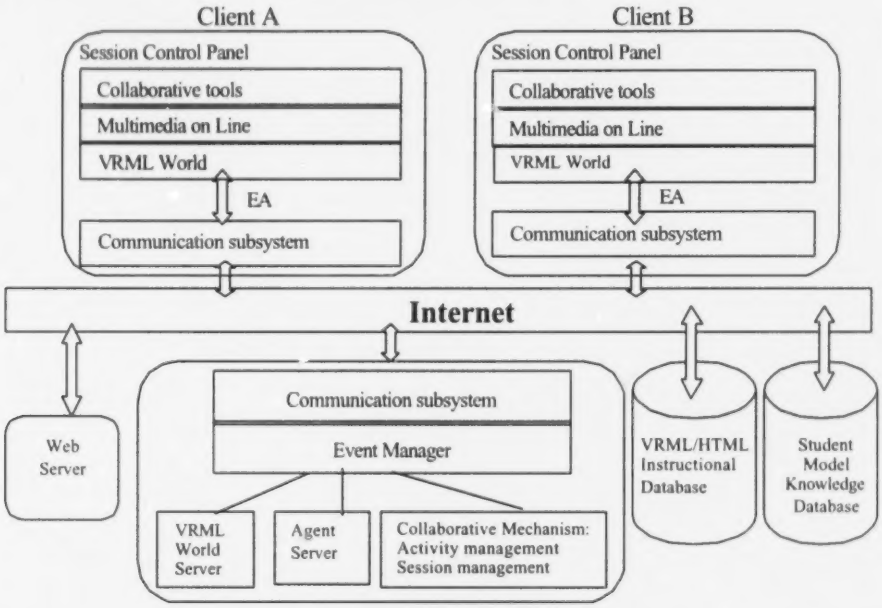


Figure 2. The Architecture of WALTZ

Pythagorean theorem is an interesting mathematical subject of the eighth grade students in Taiwan. It has rich heritage in mathematical history. Based on our survey, most current web-based systems teaching Pythagorean theorem only focus on the 2D interactive theorem proving process. WALTZ, in contrast, not only offers 2D interactive theorem proving process but also provides several key learning components to help students better understand the fundamentals of Pythagorean theorem. Figure 3 is an entry to the Pythagorean theorem learning space, where users can meet and navigate the virtual world dynamically or enter into any one of the learning components described below. The user interface contains two parts: VRML virtual world and JAVA applet control panel. The VRML virtual world is the learning space, provided by the WALTZ web server, where learners can navigate the virtual world, enter into a learning session, and meet other learners in the same session. The control applet provides chat tools so that a learner can talk to other learners for collaborative work.

The design of WALTZ-style Pythagorean Theorem learning space intends to support the features that are listed in Section 2. Current implementation of the WALTZ-style Pythagorean Theorem learning space consists of the following five learning components:

(1) Multimedia instructions

In WALTZ, instructional design of Pythagorean theorem covered three on-line learning sections: history of Pythagorean theorem, prerequisite knowledge and skills of Pythagorean theorem, and all the concepts about Pythagorean theorem. Since Pythagorean theorem is related to the mathematical concepts in both algebra and geometry and each concept need different multimedia features for presentation. Thus, different multimedia components such as text, graphic, animation, sound etc. were carefully designed and arranged in the interface to present the subject domain.

(2) Collaborative and interactive Pythagorean theorem proof/verification

One of the major features of WALTZ is the collaborative learning environment for Pythagorean theorem proof/verification. The activity manager in WALTZ provides facilities for instructors/learners to create/modify/delete/join an activity/session, to assign permission, to set constraints, to record the history of learners' Pythagorean practices, and to support group awareness during their collaborative learning. Figure 4 is an interactive program that allows users to learn Pythagorean theorem by experimental method. Students can drag each vertex of the triangle. If it is a right triangle then one can visually verify if it satisfies the Pythagorean equation: a^2+b^2=c^2. If it is an acute (or obtuse) triangle then the Pythagorean equation is not valid and a^2+b^2 >(<) c^2. Figure 5(a) shows a collaborative Pythagorean theorem proving program in action which not only support collaboration but also group awareness (i.e. can visually see who is making the move). All participants in a collaborative application is managed under the control of activity (or session) manager, as shown in figure 5(b).

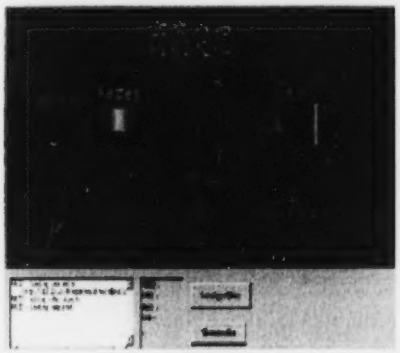


Figure 3. Pythagorean theory learning space

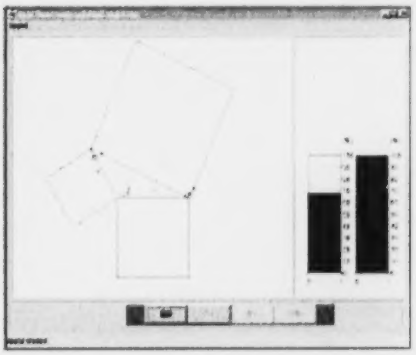


Figure 4. An obtuse triangle: a^2+b^2< c^2

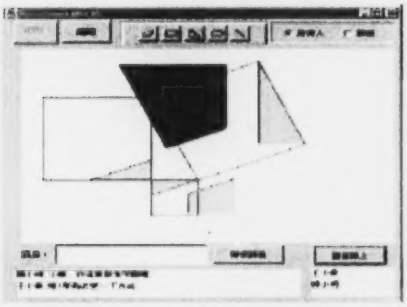


Figure 5(a). Collaborative Pythagorean application

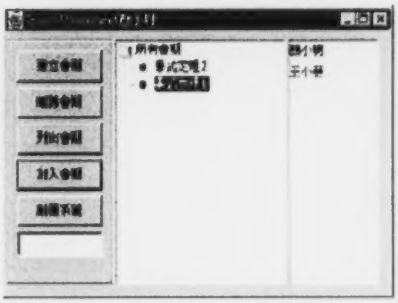


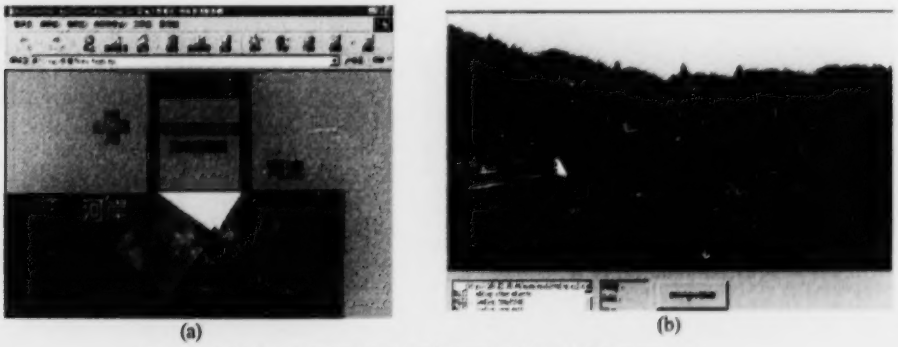
Figure 5(b). Session management

(3) Adaptive multimedia on-line testing

Traditional drill and practice CAI was criticized too boring to be used for young students. A web-based on line test without multimedia will have the same problem. A precompiled multimedia CAI program using Shockwave or Flash authoring technologies provides a better solution, however, it is not easy to change or add new contents adaptively into the program without recompiling the whole program. WALTZ is a dynamic virtual environment which can add/delete objects during users' learning journey. WALTZ intends to support an adaptive multimedia testing mechanism. Students will be given multimedia style test questions based on their current learning status. The multimedia test problems are generated on the fly by converting text -based questions stored in the database into multimedia representation. WALTZ will classify questions and suggest appropriate multimedia templates to make the conversion almost as easy as a PowerPoint presentation.

(4) Multi-user Project-based Pythagorean theorem virtual environment

To support project-based collaborative learning, a virtual environment is constructed. Team members can join the same session to solve the mathematical puzzles generated from the WALTZ system by interactively moving pieces of puzzle into the right place according to Pythagorean theory. Since WALTZ is a shared virtual environment that supports collaborative learning, each member of the team can see actions from other team members and they can communicate with each other to discuss how to solve the puzzle before they can go on to their next journey. Figure 6(a) & (b) illustrates a situation that a team must solve the puzzle of bridge using Pythagorean theorem before they can pass through the river and enter into the forest to continue their next journey.



(a) (b)

Figure 6 (a) & (b). Project-based multi-user collaborative learning space

(5) Pythagorean resource

Besides the aforementioned components, WATLZ also provide useful utility tools, such as online notepad and calculator that users can use conveniently. In addition, many different web sites relate to Pythagorean theorem were linked in WALTZ for learners to acquire various information easily.

5 Conclusion and Future Research

Due to progressively advanced development of 3D graphics and open network technologies, a web-based learning system that provides asynchronous and hyperlink-style environment might not attract young students in the feature. In addition, such systems will have great difficulty in constructing a situated, dynamic, and collaborative learning environment according to Constructivism. Therefore, This research proposed a CAI learning model from which a new architect of a web-based 3D life-like learning space, WALTZ, is created. By using Pythagorean theory as a case study, the study has demonstrated that WALTZ has a great potential to provide an improved learning environment over traditional virtual classroom setting.

Though WALTZ is still far from perfect, this research indicates that it deserves special attention among CAI research community. Next generation of WALTZ will focus on dynamic behaviors of agents via current state of the art MPEG-4 technology.

Acknowledgement

This research is founded by National Science Council (grant#: NSC 88-2520-S-212-004) in Taiwan.

References

[1] Blaxxun Interactive, http://www.blaxxun.com/ (accessed on June 2, 1998).

[2] Brooks, M. & Brooks, J., "In Search of Understanding: The Case for Constructivist Classrooms", Alexandra, VA:ASCD, (1995).

[3] Carlson, S. & Hawkins, R., "Linking Students Around the World: The World Bank's New Educational

Technology Program", Educational Technology (September-October), pp. 57-60, (1998).
[4] Chiang, H. K. & Lin, C. H., "A Study of Collaborative Mechanisms for Web Teaching and Learning", Journal of Da-Yeh University, Vol 8, No 2, pp. 63-79, (1999).
[5] Gilbert, L. & Moore, D. R., "Building Interactivity into Web Courses: Tools for Social and Instructional Interaction", Educational Technology (May-June), pp. 29-35, (1998).
[6] Harasim, L., "A Framework for Online Learning: The Virtual-U", Computer, pp. 44-49, (1999).
[7] Henin, I. & Droctor, L., "Incorporating the Web as Teaching Tool: Introduction", http://web.uvic.ca/~esg9/emo/emomain.html/ (accessed on May 1, 1999).
[8] Hughes, C. & Hewson, L., "Online Interactions: Developing a Neglected Aspect of the Virtual Classroom", Educational Technology (July-August), pp.14-55, (1998).
[9] Jung, B. & Milde, J., "An Open Virtual Environment for Autonomous Agents using VRML and Java", VRML 99 Proceeding, (1999).
[10] Kearsley, G. & Shneiderman, B. "Engagement Theory: A Framework for Technology -Based Teaching and Learning", Educational Technology (September-October), pp. 20-23, (1998).
[11] LW, "Living Worlds Specification, Draft 2", http://www.livingworlds.com/draft_2/index.htm (accessed on April 12, 1998).
[12] Merrill, M. D., "Constructivism and Instructional Design", Educational Technology, Vol 31, No 5, pp. 45-33, (1991).
[13] Merrill, P. F., Hammons, etc., "Computers in Education", NY: Simon & Schuster Company, (1996).
[14] Mitra, K., "Living Worlds", http://www.livingworlds.com/draft_1/lw_ideas.html (accessed on November 21, 1997).
[15] Moallem, M., "Instructional Design Model and Teacher Thinking: Toward a New Conceptual Model for Research and Development", Educational Technology (March-April), pp. 5-18, (1998).
[16] Pesce, M., "VRML: Browsing and Building Cyberspace", New Riders, (1995).
[17] Sherry, L. & Myers, K. M., "The Dynamics of Collaborative Design", IEEE Transactions on Professional Communication, Vol 41, No 2, pp. 123-139, (1998).

Web Based Real plus Virtual Observatory Project

Masato SOGA, Takuma OKUNO, Hideaki KAWANISHI
Faculty of Systems Engineering, Wakayama University
930, Sakaedani, Wakayama, 640-8510, Japan
Tel: +81-73-457-8457
Fax: +81-73-457-8112
E-mail: soga@sys.wakayama-u.ac.jp

We have been developing remote telescope system, which can be used by remote site via Internet with web user interface. Student in remote site can control the telescope easily and can see live picture of celestial bodies. If there is time difference between student's site and telescope's site, the student can see live picture of celestial bodies in daytime in classroom. It will be strong tool to learn astronomy. Moreover we are also developing virtual observatory which shows the status of the real telescope in a virtual space. The virtual observatory supports virtual planetarium, so that student in remote site can know what can be seen in the sky of telescope's site. Moreover a learning environment to learn the structure, behavior and function of telescopes were developed in virtual world. The remote telescope system is easy to use, so that it neglects chance to learn how to use the telescope. In science education, it is also important to teach how to use equipments. The learning system compensate for it.

Keywords: **Remote Telescope, Virtual Observatory, Astronomical Educaion**

1 Introduction

We have developed a remote telescope system in a public observatory in Japan [1]. This first version has a web based user interface, and remote student can use the system from remote site via Internet. If the client site has certain time difference between Japan, the student can see live picture of the celestial bodies in daytime. Moreover the student can operate the telescope as he/she wishes by using slight motion buttons on the web based user interface. This first version was the world first interactive remote telescope which offers live picture on a web user interface in 1997, though a remote telescope offering still image was made before[2].

Although the first version of the remote telescope system were quite successful, it has some problems. The system does not have the function for exclusive control. The exclusive control is necessary in the multi-user environment, because more than two clients cannot use the system simultaneously. On the first version, the student must promise the date and time of the usage in advance.

Another problem of the first version is that the telescope is too huge (105cm reflector) to use as a remote telescope. Besides the dome of the observatory is not controlled from remote site. Therefore the staff of the observatory must always help the usage.

We are now developing second version of remote telescope system to solve the problems of the first version. The second version uses small telescope (Meade LX200 20cm reflector), so that it is easier to use as a remote telescope.

The second version has a scheduling system, which can work as the exclusive control. Clients can reserve the date and time of usage of the remote telescope on a web page for scheduling. The system has 3D planetarium as well as web user interface. The planetarium shows what can be seen in the real sky where the telescope is located. Moreover the second version supports vertual environment to learn structure, behavior and function of various types of telescope. These virtual planetarium and virtual environment for

learning are regarded as virtual observatory. Although today some other remote telescopes has been developed in the world [3-6], our remote telescope is unique which supports virtual observatory.

2 Scheduling system

The scheduling system was developed for multi-user usage (Fig.1). It has two important function. They are exclusive control system and reservation system. Exclusive control system enables to permit usage by only one client at every time. If a student tried accesses to the system during the usage by another student, the exclusive control system reject it, and make him/her wait until the superior student terminates the usage. Reservation system enables to reserve date and time of usage in advance. The reserved usage is superior to non reserved usage, so that non reserved usage is terminated by force when it is the time of reserved usage.

The scheduling system is made by using CGI(Common Gateway Interface), and the CGI program works by a scheduling web page on a public directory. Clients' information such as account information and reservation information, is preserved in a file in the scheduling system. Since the file includes very important contents, it must be protected from illegal access. The file is not on the public directory, but on a private directory to which cannot be had access. The security is kept by this method.

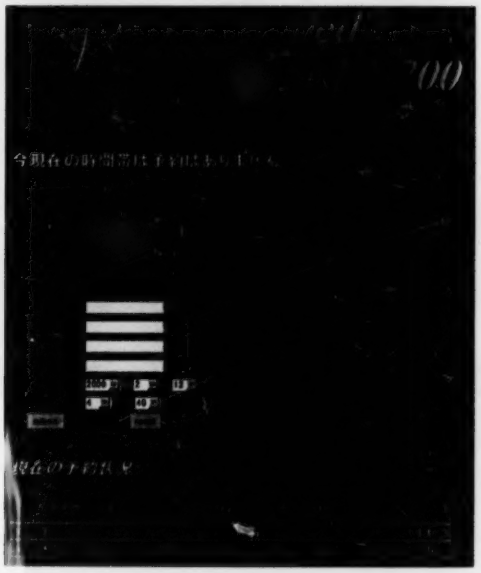


Fig.1 Scheduling system

3 Live picture

The live picture of celestial bodies enhances students' learning of astronomy (Fig.2). There are two methods to send live picture. One is by stream, the other is by still image series. We are currently using the latter way. SGI O2 Unix workstation is used as a camera server. O2 has a program which takes still image with CCD camera. Our system utilize the program, and automatically save JPEG picture in every three second into a same file in the camera server. We also developed Java applet which has access to the file, and read it, then display the still images continuously. Remote clients can see live picture as if it is animation.

4 Remote control of the telescope

A student can control the telescope from remote site. In the first version of the remote telescope system, we

BEST COPY AVAILABLE

used CGI to control the telescope. In the second version, we considered that we would use CGI on a HTTP server, however CGI has the following problems.

(1) When a client terminate usage of the telescope, it is impossible for the server to refuse connection.

(2) More than two clients can have access to the remote telescope system simultaneously at anytime. Therefore it is impossible to realize exclusive control.

Fig.2 Live picture (Example: Moon)

(3) In a collaborating learning, more than two clients have access to the system simultaneously. In this case, the same number of CGI process as the clients' number run in the server, so that the load of the server become heavy.

We used Java applet in order to solve the problems. The merit of communication by Java applet is as follows.

(1)When a client terminates usage of the telescope, it is possible for the server to disconnect the connection.

(2) It is possible to realize the exclusive control.

(3) It is possible for the server to send various information to Java applet at client machine.

By these reason, we developed a telescope control program by Java applet. The procedure of usage is as follows.

(1) A client set a target celestial body, and push the submit button. Then the command to control the telescope is sent to the server program.

(2) The server program receives the command and send it to serial port. Then the telescope receive the command, and it moves to get the target.

(3) The telescope send status to the server, after it finish moving.

(4) The server program send the status to applet at the client machine.

Figure 3 shows the procedure.

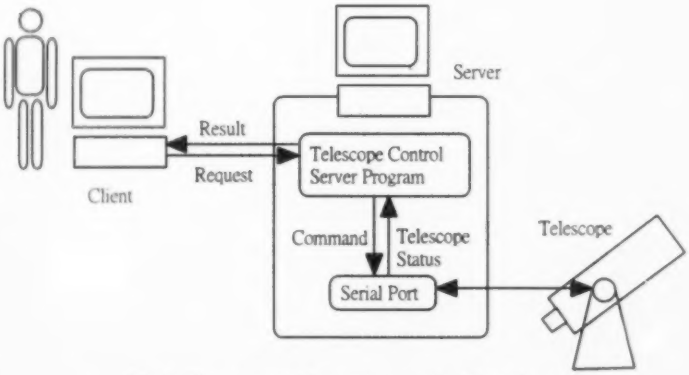


Fig.3 The process of remote control of the telescope

5 Graphical user interface

The GUI of remote telescope system is made by applet. The GUI by applet in second version has the following functions (Fig.4).
(1) To move telescope by setting target's coordinates
(2) To move telescope by selecting a target in a menu
(3) To move telescope by slight movement buttons
(4) To show local time where the telescope is located
(5) To show universal time
(6) To show the rest of the reserved time
(7) To show some information about the target

In the above, functions (1)-(3) are the same as the first version. A student can control the telescope easily by the GUI. The slight movement buttons enable the student to move the telescope slightly, so that the student can scan the celestial body. This function is especially useful when the student observes apparently large target such as the moon. The student can feel as if he/she is traveling over the moon by space ship.

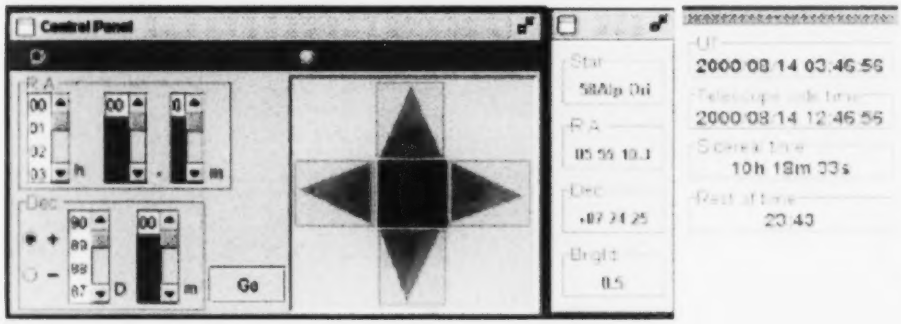


Fig.4 Graphical User Interface

6 Virtual Planetarium

The planetarium is made by Java3D (Fig.5). The planetarium reflects the real sky where the telescope is located by calculating sidereal time. Remote clients in all over the world can know what can be seen in the sky at that time at telescope site, such as stars, planets, nebulas, and galaxies. The planetarium also has a telescope model in the center of the planetarium. It is a kind of virtual telescope. The virtual telescope reflects the real telescope. The direction of the virtual telescope indicates that of real telescope. By this function, clients can know easily in which direction the telescope is. Since a beam line from virtual telescope to celestial sphere is shown in the planetarium, the user can easily recognize which star the telescope catches currently. Besides when the user click one of stars on the virtual planetarium, both virtual and real telescopes start to move, and catche the target star.

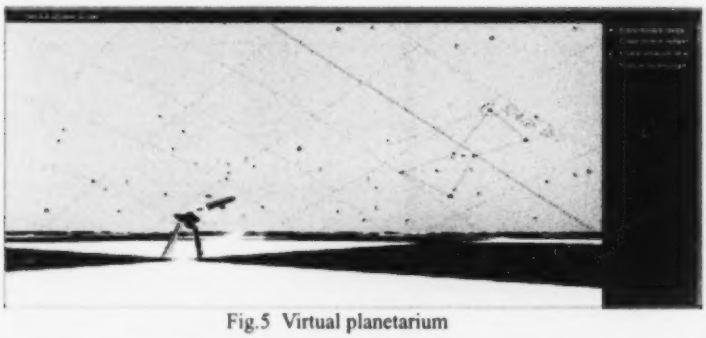


Fig.5 Virtual planetarium

BEST COPY AVAILABLE

7 Learning environment for learning telescopes in virtual world

In science education, it is important for students to observe target in real world as well as to learn how to use the equipments for the observation. The remote telescope system enables to observe real celestial bodies in the classroom. Nevertheless it neglects to learn how to use telescope. Because students can easily operate the remote telescope system without knowing the structure of the telescope and every function of each part.

We have been developing a system in virtual world, by which students can learn kinds of telescopes, every structure, every characteristics, and every function. The system is made by VRML, and the telescopes in the virtual world can be moved around two axes. The astronomical telescopes are classified optical structure and by mounting structure independently. Therefore the system has a table which shows the combination of optical structure and mounting structure (Fig.6). Some combinations exist and other combinations do not exist. If a combination exists, a circle is filled in the table. If it does not exist, a cross is filled. Triangle means seldom existence, dot means rare existence. This table guides students to every combination. If a student click a symbol (circle, triangle, dot), then the telescope is shown with the combination of optical and mounting structure.

Since the virtual telescopes can be rotated around two axes by mouse dragging, students can learn how to operate telescopes. Besides students can learn the function of every axis by rotating it. For instance, one axis of equatorial mounting is set in the direction to polar star (Fig.7). The telescope can track a celestial target by rotating around the axis, because the celestial target moves in the sky in accordance with earth's self rotation.

Moreover the virtual telescopes show optical structure of them, and show ray trace. When the a student rotates a virtual telescope, he/she can know how the focus point of the telescope moves. Students can learn the focus points do not move in some types of telescope. They can know such type of telescope is useful for attaching heavy equipment on the focus point.

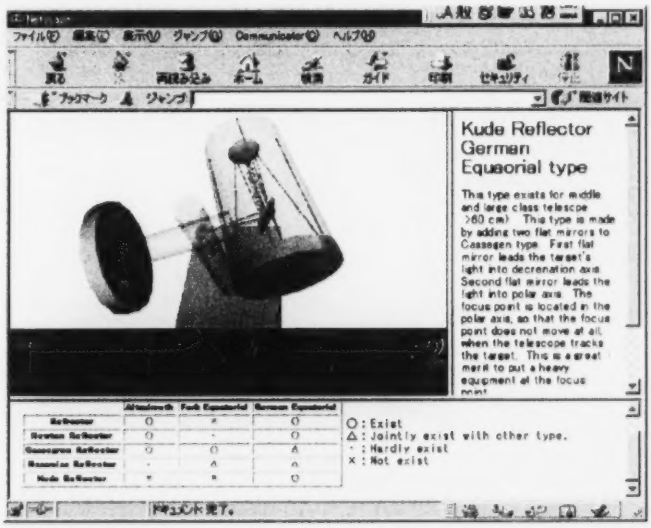


Fig.6 Virtual environment for learning structure and behaviour of various type of telescope

8 Conclusions

In this paper, we described the second version of remote telescope system. We explained scheduling system, telescope control, GUI, live picture, virtual planetarium and learning system. This total system can be regarded as synthesis of real observatory and virtual observatory. The real observatory offers live picture of celestial bodies. The virtual observatory offers planetarium and learning system. In the remote telescope

BEST COPY AVAILABLE

system, students can operate the telescope easily, so that it neglects the chance of learning how to use the telescope. In science education, it is also important to learn how to use the observation equipment. The virtual observatory compensates for it.

The student can observe real celestial objects by real observatory from remote site. If there is time difference between the client site and observatory site, the student can observe real celestial objects in daytime in classroom. It will be a strong tool to learn astronomy. This system brings experimental environment into classroom in astronomical domain.

Our future work is to make dome or sliding roof and to install the telescope in it.

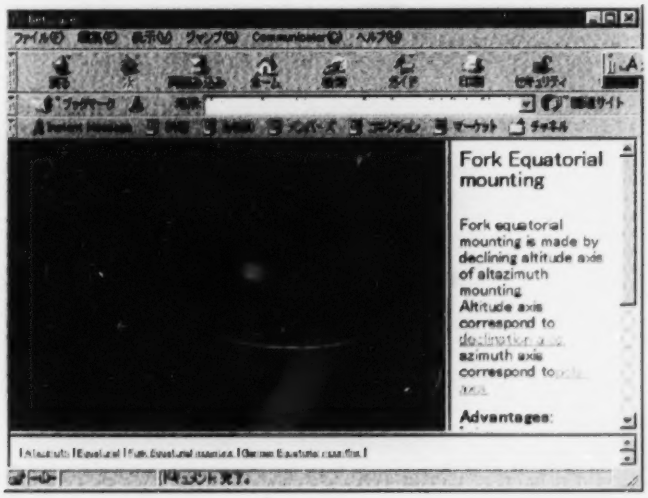


Fig.7 Virtual environment for learning function of parts of a telescope

References

[1]M.Soga, K.Watanabe, T.Tanaka, M.Sakamoto, H.Tanaka, S.Toyomasu, M.Okyudo, J.Arimoto, "A Remote Control System of a Telescope by WWW and Real Time Communication for Astronomical Education", Proc. of World Conference on Educational Multimedia/Hypermedia / World Conference on Educational Telecommunications (ED-MEDIA / ED-TELECOM'98), pp.1305-1310

[2] Mark J.Cox, John E.F.Baruch (1994). Robotic Telescopes: An Interactive Exhibit on the World-Wide Web. 2nd International Conference of the World-Wide Web, 1994

[3] Hands-On Universe, http://hou.lbl.gov/

[4] The CWRU Warner and Swasey Observatory Nassau Station, http://astrwww.cwru.edu/nassau/nassau.html

[5] Remote Access Astronomy Project Remotely Operated Telescope, http://www.deepspace.ucsb.edu/rot.htm

[6] Telescope In Education, http://www.mtwilson.edu/Science/TIE/

BEST COPY AVAILABLE

Web Speaking: A Language Learning System in the Web

David Lo, Wen-Tsai Liao and Ming-Syan Chen
Department of Electrical Engineering and Computer & Network Center
National Taiwan University
Tapei,Taiwan, ROC

Due to recent technology advances, an increasing number of applications are being ported to the Web at rapid pace. Such applications include Web Phone, Web Fax, Web BBCall, to name a few. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time. In this paper, we develop an interactive language learning system in the Web, called Web Speaking. By using Web Speaking, students are able to learn languages anywhere at any time as long as a Web interface is provided. Web Speaking is in essence a two-tier client-server architecture, and is divided into two components, namely (1) the language learning player at the client-side and (2) the course content provider at the server side. In this system, we put not only the course content but also the corresponding audio files in the server side in order to support a multimedia-teaching environment. The language-learning player runs at the client side and provides a user interface to access the course materials in the server. In addition, Web Speaking is able to improve the language speaking ability of the students with the display of the speech waveform which is generated by using the algorithms isolating the utterances of the speech. Students can capture the difference between the waveforms of their own speaking and the standard one provided by the instructor, and improve their speaking accordingly. By this language learning package, we can automate the procedures of preparing audio course materials, greatly facilitate the language learning by the students, and conduct data mining on student behavior. The teaching quality of language learning can thus be improved.

Keywords: **Distance learning, speech analysis, two-tier client-server architecture, World Wide Web**

1 Introduction

Recently, an increasing number of applications are being ported to the Web at rapid pace, including Web Phone, Web Fax, Web BBCall, and so forth. Among others, network education has emerged as an important Internet application since it not only avoids the limitation of physical learning locations but also keeps the flexibility of teaching time [1,2,3,5,6,7,8]. Traditionally, the students have to be present in the language-learning classrooms and use specific language learning mechanisms to improve their speaking ability. However, the major disadvantage of the traditional language learning is the limitation of time and space. For example, the students may have an English class in the Monday morning at the language-studio classroom and that class could be their sole opportunity to practice their language speaking, since the instructor is only present at that moment. Consequently, the effectiveness of the traditional language-learning systems is limited.

In this paper, we develop an interactive language learning system in the Web, called *Web Speaking*. The Web Speaking system we developed in the Computer and Network Center at National Taiwan University is in essence a two-tier client-server architecture. Through a Web interface, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space. In addition, using Web Speaking, students can communicate with the instructors interactively via the mechanism provided, and the teachers can timely edit the course materials

by writing the content of text and recording the audio files in response to the students' requests very easily. These are the very advantages of Web Speaking over some stand-alone commercial language-learning applications which are usually lack of interactive features.

In addition, the other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students to help the students to learn language speaking better. In Web Speaking, we implement the algorithms isolating the utterances of the speech [9,10] to improving the students' speaking ability. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. It is worth mentioning that Web Speaking system is meant to help the teachers to improve their teaching quality, and should be viewed as an auxiliary tool for teaching. By no means do we assert that Web Speaking is able to completely replace the role of an instructor or in any way to lessen the need for a teacher to personally interact with students. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

The paper is organized as follows. Section 2 depicts the whole system architecture. Section 3 presents the implementation and functionality of the Web Speaking. Section 4 concludes this paper.

2 The System Architecture of the Web Speaking

We use a two-tier client-server architecture for the Web Speaking system. The reason of using the two-tier client-server architecture is that it can provide our two key components, i.e., the language-learning interfaces at the client side and the course content provider at the server-side. This architecture can be easily extended to a three-tier one if an additional gateway is required in this application.

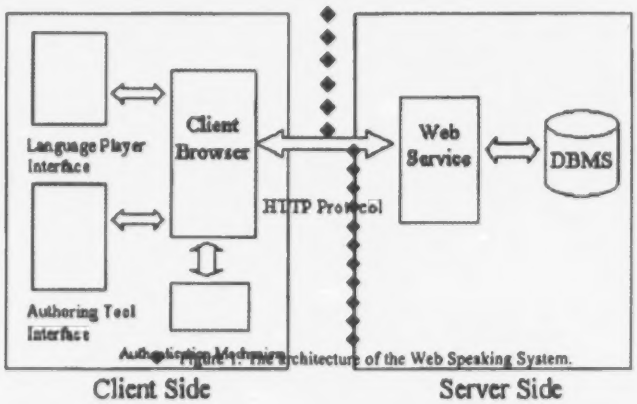


Figure 1. The architecture of the Web Speaking System.

Based on the two-tier client-server architecture, the Web Speaking System is designed as the Figure 1. At the client side, both the language player interface and the authoring tool interface use the DBMS (Database Manager System) to access the course materials in the server via the HTTP protocol in the Internet/Intranet. The program at the serve side then accepts the requests from the clients and returns the results of the requests to the clients. The DBMS at the server side saves not only the course materials but also the information of the users, including the students and the teachers. Using an authentication mechanism, the player is able to verify the user identification via the Web and to provide different user interfaces for students and teachers, as one form of personalized service. For instance, the students are only allowed to use the language player interface whereas the teachers can use both the language player interface and the authoring tool interface. The following subsections will introduce the operations of the Web Speaking System briefly.

2.1 The language learning player at the client side

To assist the students in language leaning on listening and speaking, the user interface (UI) of Web Speaking provides the functions of playing the audio files and those of recording the user's voice. Furthermore, the UI displays the wave shapes of the audio files and the user's voice for users to capture the differences and to improve their speaking. For example, once the user selects one topic of the course in upper-left area of the Figure 2, i.e., "There are always two sides to everything." In Figure 2, not only will the content be shown in the upper-right area but also the shape of this audio appears in the middle area. When the users are playing back the audio in the middle area, an indicator will run along the shape of the audio to indicate the exact timing of audio playing.

In addition to listening the audio and watching the shape of it, the users are also able to record their voice into the system, play it out, and compare its shape with the standard one in the course material. In order to prepare the course materials easily and automatically, Web Speaking provides an interface to authorize the use of course materials and to upload and download materials automatically from the course content provider. This is a very convenient feature for the teachers who are not familiar with the operations of the transmitting files in the Web. Furthermore, the teachers could edit the content of the course material and record the audio easily via this interface, such as adding a new topic of the course material or creating a new course in the upper-right area in the Figure 3. They can also playback and record the audio file of the course materials in the bottom area. As such, the language-learning player, including the language learning interface and the course material authoring tools interface, runs at the client side and provides a user interface to access the course materials in the server. In addition, we use the algorithms isolating the utterances of the speech to display the speech waveform in order to facilitate the language learning of students.

Note that the user needs to use the local resources, such as the I/O of the audio interfaces and the I/O of the storage interfaces at the client side. However, this I/O access is not allowable for the browsers, such as the Internet Explorer and the Netscape Navigator. Therefore, we implement a stand-alone language-learning program at the client side by using the Microsoft Visual Basic 6.0 programming tools.

2.2 The course content provider at the server- side

The major tasks of the server are to save and update the teaching materials and to query the databases when so necessary. These tasks are implemented by using the PHP script language and MySQL database at the server side. Since the PHP script language has been integrated with MySQL database, we use it to query the databases (MySQL). The client can then use the HTTP protocol to communicate with the server.

The course content provider is mainly a server combining the Web service and the database manager. It employs the PHP script language to access the MySQL database and to response the client's requests. As mentioned earlier, the server side of Web Speaking saves not only the contents of the courses but also the corresponding audio files in order to support a multimedia-teaching environment. Once the server gets a request, the content provider fetches the requested materials by the user from the database, and then, if the corresponding authentication succeeds, returns the result to the client.

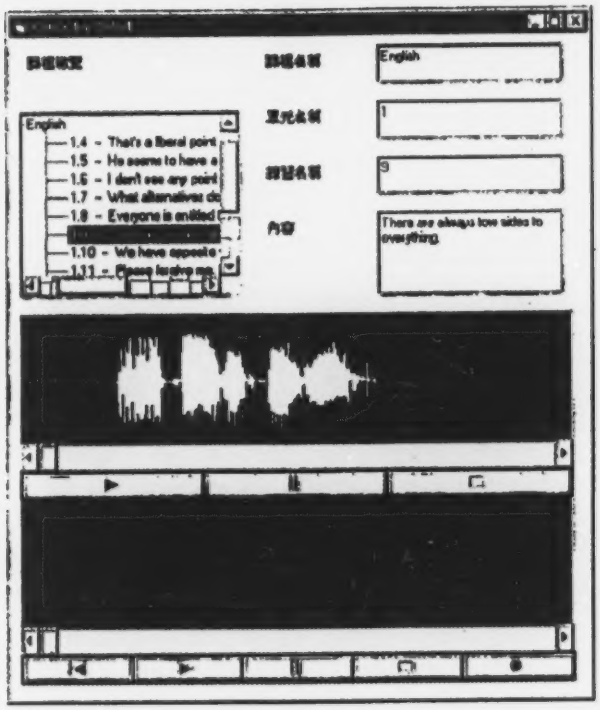


Figure 2: The language-learning player for the students

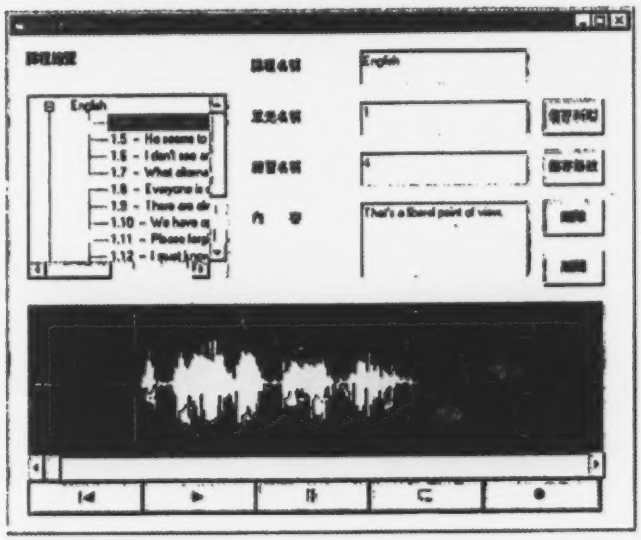


Figure 3: the authoring tools for the teachers

BEST COPY AVAILABLE

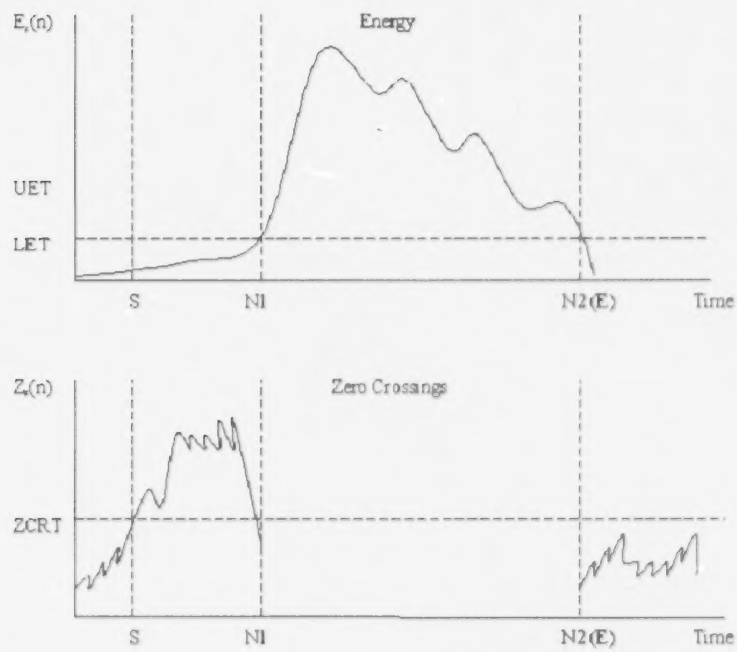
3 End Point Detection for Speech in Web Speaking

We introduce in this section the algorithm used to detect the endpoints of isolated utterances. To help the user learning the language speaking, we display both the waveforms of the speech produced by the user and the standard one prepared by the teacher. In addition, we isolate the utterances of the speech to help the user to understand how the speech looks like. This endpoint detection method [10] uses two parameters, i.e., the short-term energy ($E_s(m)$) and zero crossing rate ($Z_s(m)$), to detect the endpoints of an utterance. These two parameters are calculated as follows, where s(n) means the speech signal, w(n) means the window function, and N means the length of the window.

$$E_s(m) = \sum_{n=m-N+1}^{m} s^2(n)$$

$$Z_s(m) = \frac{1}{N} \sum_{n=m-N+1}^{m} \frac{\left|\operatorname{sgn}\{s(n)\} - \operatorname{sgn}\{s(n-1)\}\right|}{2} w(m-n)$$

$$where \quad \operatorname{sgn}\{s(n)\} = \begin{cases} +1, & s(n) \geq 0 \\ -1 & s(n) < 0 \end{cases}$$



◆ Figure 4: Illustration of the endpoint detection algorithm.

The endpoint detection algorithm is depicted in Figure 4 and described below.

Step 1. Assume that the window function *w(n)* is a rectangular function with the window size *N* being 10 ms, and the first 100 ms of the speech signal is background noise. Then, use this signal segment to calculate the mean and variance of $E_s(m)$ and $Z_s(m)$.

Step 2. Using the statistics derived from Step 1, determine three thresholds, i.e., the upper energy threshold (UET), the lower energy threshold (LET), and the zero crossing rate threshold (ZCRT).

Step 3. Search from the beginning until the energy $E_s(m)$ exceeds the threshold UET. Then, run backward until the energy $E_s(m)$ falls below the threshold LET. We call this point the tentative beginning point N1. The tentative ending point N2 is calculated in a similar way.

Step 4. From the tentative beginning point N1, we examine the zero crossing rate for the previous 250 ms

signal segment. If there are more than three occurrences of counts above the threshold ZCRT, we select the first point backward from N1 whose zero crossing rate is higher than ZCRT as the beginning point (S) of the word. If there are no more than three occurrences of counts above the thres hold ZCRT, the tentative beginning point N1 is directly selected as the beginning point of the word. The ending point (E) is decided in a similar way with exception that the forward searching direction replaces the backward one.

By using the above algorithm we can partition the waveforms of the speech. Furthermore, the language-learning player displays the shapes in the screen and also indicates the timing when the waveform of the speech plays. Thus, this functionality of the language-learning player offers not only the playout of the audio but also the display of the waveform shapes at the same time. This is a very helpful feature for students to learn language speaking.

Note that we can collect students' practicing records in the Web Speaking system. Through some data mining techniques, we can find useful information about the student behaviors, e.g., the common mistakes made by the students. Clearly, using such information discovered, the instructor is able to improve their language teaching by reminding the students of how to speak better when the students encounter common problems.

4 Conclusions

In this paper, we developed a Web Speaking system to improve the language learning and teaching for the students and the teachers. By using Web Speaking, the students are able to not only learn the lessons anywhere at any time but also practice their speaking at leisure pace, thus overcoming the limitation imposed by time and space in traditional teaching environments. The advantage of Web Speaking over some stand-alone commercial language-learning applications lies in the full interactivity Web Speaking provides. The other major contribution is to provide the displays of the speech waveforms produced by the teachers and the students in order to help the students to learn language speaking better. Through the display of the speech waveforms, students can perceive the difference of the speech waveforms between their own speaking and the one prepared by the teacher, and improve their speaking accordingly by themselves.

Web Speaking has been distributed to some language learning groups in our campus for experimental use and been well received thus far. We believe that by exploiting the availability of Internet, Web Speaking is very instrumental to the traditional in-class teaching and will improve the quality of teaching results significantly from both the perspectives of students and instructors.

Acknowledgement

The authors are supported in part by the Ministry of Education Project No. 89-E-FA06-2-4-7 and the National Science Council, Project No. NSC 89-2219-E-002-007 and NSC 89-2213-E-002-032, Taiwan, Republic of China.

References

[1] E. Bilotta, M Fiorito, D. Iovane and P Pantano, "An Educational Environment Using WWW", Computer Networks and ISDN Systems, 27, pp. 905-909, 1995.

[2] "CEIBA," High Performance Computing Lab of Department of Electrical Engineering of National Taiwan University, ftp://www.cc.ntu.edu.tw/pub/Webcourse/.

[3] J. Chang, M. S. Chen and I. P. Lin, "Design and Implementation of a Software Package for Network Education", Proc. of the 2000 International Conference on Engineering Education, August 14-16, 2000.

[4] M. S. Chen, J. Han and P. S. Yu, "Data Mining: An Overview from Database Perspective", IEEE Trans. on Knowledge and Data Engineering, Vol. 8, No. 6, pp. 866-883, December 1996.

[5] "Distance Learning in National Taiwan University", National Taiwan University, http://www.cc.ntu.edu.tw/~ccdl.

[6] D. Dwyer, K. Barbieri and H. M. Doerr, "Creating a Virtual Classroom for Interactive Educations on the Web", Computer Networks and ISDN Systems, 27, pp. 897-904, 1995.

[7] B. Ibrahim and S. D. Franklin, "Advanced educational uses on the World Wide Web", Computer

Networks and ISDN Systems, Vol. 27, No.6, Apr. 1995.
[8] J. C. Jehng, Y.F. Shih, S. Liang and T. W. Chan, "TurtleGraph: a computer supported cooperative learning environment", The Proceedings of the World Conference on Educational Multimedia and Hypermedia, Vancouver, Canada, AACE, pp.293-298, 1994.
[9] M. C. Lai, B. H. Chen and S. M. Yuan, "Toward a new educational environment", World Wide Web Journal, Issue One: Conference Proceedings, Fourth International World Wide Web Conference, O' Reilly & Associates, Inc., pp. 221-230, Nov. 1995.
[10] L.R. Rabiner and M.R. Sambur, "An Algorithm for Determining the Endpoints of Isolated Utterances", The Bell System Technical Journal, Vol. 54, No. 2, February 1975, pp. 297-315.

Web-Based Learning Portfolio (WBLP): An Electronic Authentic Assessment Tool on Web

Chi-Cheng Chang
Graduate Institute of Technological and Vocational Education
National Taipei University of Technology
No 1, Sec. 3, Chung-Hsiao E. Rd., Taipei, Taiwan 106
Fax: +886-2-27812897
E-mail: samchang@mail.tku.edu.tw

A web-based learning portfolio (WBLP) for authentic assessment has been constructed, in the hope to help record, display, search and analyze student learning process data. The WBLP system has been officially implemented in a course at the university for a semester. The results of the system evaluation and effects show that most students consider that the system is helpful to improve the learning process and accomplishing quality, to understand the authentic learning process and outcome, to provide chances for displaying and improving works.

Keywords: **Portfolio, Portfolio Assessment, Web-Based Portfolio, Electronic Portfolio**

1 Research Background

The negative impacts of the traditional paper-and-pencil assessment method are commonly found in researches by scholars in Taiwan and abroad. These contain examination-oriented instruction and the inability to assess high-order cognitive abilities and affective attributes in common (Herman, 1992; Glaser & Silver, 1994). However, the defects that do not comply with contemporary learning theories are not only criticized by many scholars but also provide a theoretical foundation for the improvement of traditional assessment and creation of new assessment methods. From the viewpoint of recently developed constructivist learning theory, knowledge should not be accepted passively, it should be actively constructed by cognition. Therefore, instead of using simple knowledge instruction, an instructor should be a facilitator and adviser of instruction to help learners create a knowledge construction environment. The instructor should give guidance and support, in order to help learners become actively involved in the learning process and construct their own knowledge. Furthermore, situational cognition claims that learning should be applied to real life situations and emphasize on student involvement and understanding in the learning process.

Traditional assessments, which are made according to the student's memory of the message given by the instructors, are unable to effectively measure the results of these two learning theories. The changes in the student's cognition and learning process, involvement and interaction have become the new foundation for learning effect assessment. Traditional assessment does not effectively measure students' ability to organize relevant information or present a coherent argument, and lack sensitivity to the individual growth that teachers desire in students (Cole & Ryan, 1995). Therefore, when traditional assessment is unable to effectively reflect a student's learning process, there is a need for new types of assessment. In response to the needs of the new learning theories such as constructivist learning, and to improve upon the insufficiency and limitations of traditional assessments, new assessments come out one after another in various forms and names.

Based on the aforesaid beliefs and importance concerning learning portfolios, this research designed, constructed and evaluated a learning portfolio on the World Wide Web architecture according to the portfolio assessment concept by combining the characteristics and functions of computer and network

technology. Furthermore, this portfolio was conducted on a subject at the university to evaluate its functions and effects. The objectives of the research are:

1. To design and construct a web-based learning portfolio that satisfies the needs of university students in Taiwan.
2. To assess the functions and effects of a web-based learning portfolio and its impact on learning of students.

2 Functions of WBLP

The WBLP system is built upon an Intel Pentium-II CPU system and MS Windows NT Server 4.0 Operation System. The Web server uses the MS Internet Information Server (IIS) 4.0, and the database uses the MS Access 97. In addition, MS FrontPage 98 was used to create basic page layout and hyperlink architecture for web pages and MS Visual InterDev 6.0 was used as an assistant tool for system function development and ASP (Active Server Page) programming. System development and construction were conducted right after the determination of tools. The functional architecture of the WBLP system is shown in Figure 1.

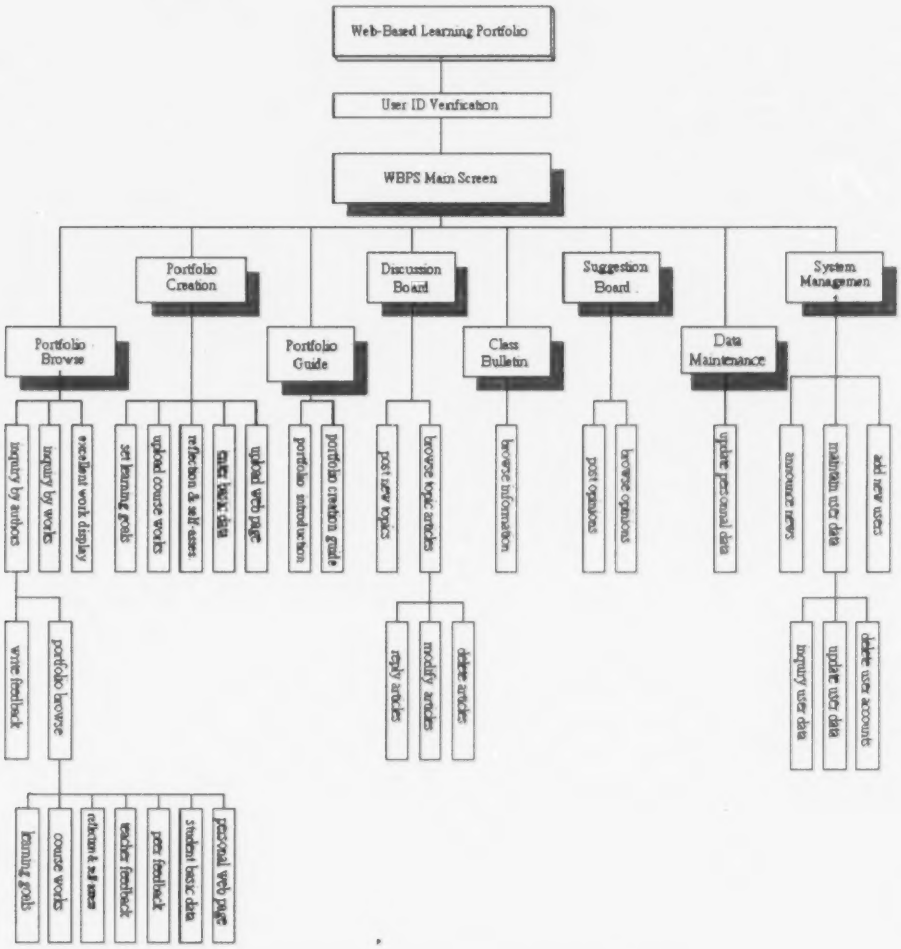


Figure 1 Functional architecture of the web-based learning portfolio

2.1 User ID Verification

BEST COPY AVAILABLE

The target users of this study were students and teachers in a Computer and Instruction course for the Teacher Preparation Program at one university. A user ID verification was established to identify the users. A guest account was also assigned to allow interested visitors to browse students' learning portfolio.

2.2 Portfolio Creation

The WBLP system aims at enabling students to produce their personal learning portfolios fast and easily through the interface provided by the system. Students create the portfolios with the purpose of proving their learning, and concretely demonstrating their efforts and outcomes. Students can use the WBLP system to complete learning goal setting, course work upload, reflection and self-assessment record writing, data basic setting and modification, and personal web page upload by filling out the forms (see Figure 2).

Allowing students to upload their ongoing or completed works in the WBLP system aims at concretely representing their efforts and accomplishments as well as examining and analyzing their works. According to the rationales of portfolios, they must contain students' in-progress and completed works as well as their self-reflections and self-assessments on both their learning and the selected works. Unfinished work might be placed in the portfolio to identify a problem area, and to prompt the student to reflect why it is a problem and what might be down about it. For today's students to be self-determining, they must self-set learning goal, self-monitor, self-reflect and self-evaluate. Allowing students to write their self-reflection and self-assessment statements in the WBLP system aims at providing them with the opportunity to profoundly reflect on their learning process and outcomes. According to Cole, Ryan, & Kick (1995), allowing students to have decision-making power about the selected artifacts may make the students feel ownership of the portfolio.

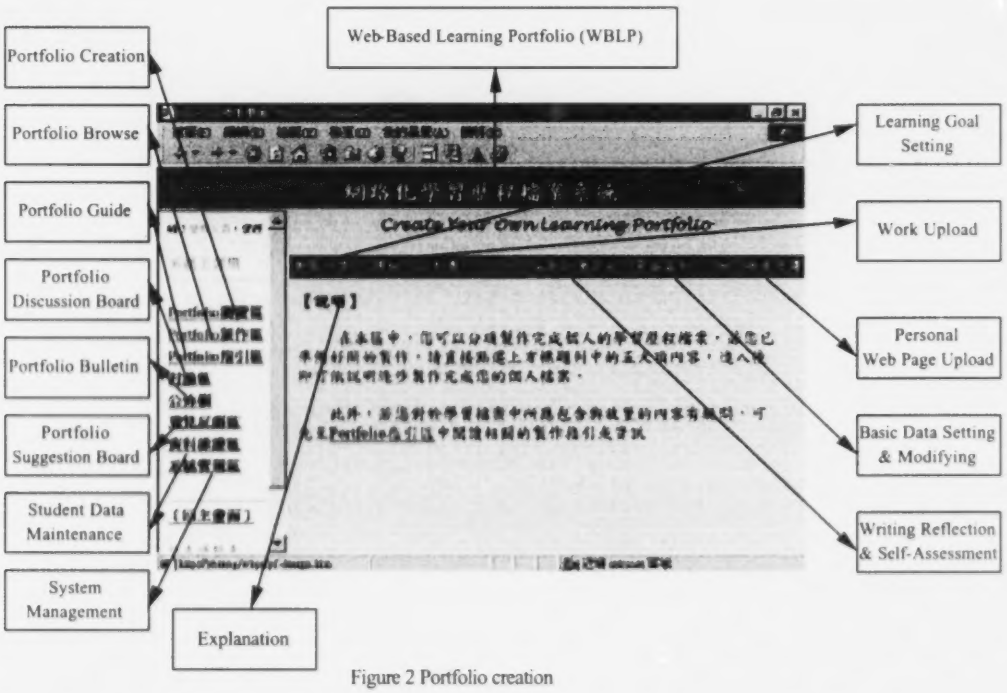


Figure 2 Portfolio creation

2.3 Portfolio Browse

A user may inquire or browse any portfolio by student name. Both students and teachers can browse the contents of individual student portfolios. Browsing areas include learning goals, course work, reflection and self-assessment records, teacher feedback, peer feedback, basic data, and personal web page. A user may

also inquire/browse any portfolio by works. Both students and teachers can directly browse the contents of the work. Moreover, both teachers and students may add their feedback and grades while browsing the portfolio. Teachers can use the portfolio-browse mechanisms in the WBLP system to collect interim evidence to identify the students' stumbling blocks and to document the movement toward mastery. In additions, teachers can identify areas of strengths and weaknesses by viewing the whole working processes of the students. For students, they might gain a clear view of their peers' learning processes for reference and thus benefit on their learning.

2.4 Portfolio Guide

The guide provides informa.ion concerning the creation of a learning portfolio, including (1) content selection: contents of portfolio according to teacher requirements or group discussion; (2) assessment criteria: criteria of assessment done by teachers ant students together; (3) portfolio creation guide: brief description of rules to be followed for portfolio creation. The contents of this function are subject to adjustment nonetheless they aim at helping students to create their own portfolio. Teachers and peers might provide students with guidance about selecting content of a portfolio, decide assessment criteria, and creating portfolios as well as clarifying why they have identified them as such.

2.5 Portfolio Discussion Board

Provides an asynchronous discussion channel for students to discuss things related to the course and the creation of a learning portfolio. The main issues can be: (1) portfolio content selection criteria; (2) portfolio assessment criteria; (2) portfolio creation manner; and (4) course contents: issues relate to the course. The portfolio becomes a focal point for student-teacher and student-student discussions about issues that have been raised in the learning process. The discussion regularly enables the teacher to talk with students about their growth and reflections. This kind of sharing between teacher and student may be ongoing on the World Wide Web. Farr & Tone (1994) claim that student-teacher discussion is key to the success of portfolio assessment and a vital part of the portfolio methodology. In this kind of exchange and sharing, portfolio assessment likely becomes a key and effective instructional activity. Some teachers have argued that scheduling conferences is quite needed, but conducting them is one of many difficulties in the implementation of successful portfolio assessment (Farr & Tone, 1994). The conferences that the teacher schedules with each student in a traditional way are sometimes expensive to be conducted due to the factors of time and place. In indeed the student-teacher interaction does not need to regularly happen only at scheduled time periods, it can occur informally and frequently, even daily via the WBLP on World Wide Web.

2.6 Portfolio Bulletin

To provide the latest information and news, including system notice, portfolio activities, course information and news. Portfolio activities might include setting learning goal, uploading works, writing reflection and self-assessments, displaying excellent artifacts, writing peer-assessment statements, viewing peers' portfolios and works, and so forth. In order to motivate students, teachers might announce a variety of assessment procedures as scoring students' portfolios, or a regular time period for examining portfolios and rating the content within.

2.7 Portfolio Suggestion Board

This is a communication channel between students and teachers as well as between students and a system manager to enable students to receive feedback on their problems, opinions and suggestions about the WBLP system and portfolio creation. It is also a place for students to share their feelings and experiences about portfolio creation and usage. Students can also use the suggestion board to present options about instruction.

2.8 Student Data Maintenance

To enable students to browse, update and modify their personal data. These data include name, major, telephone number, e-mail address, post address, personal interests, and personal specialties.

2.9 System Management

Exclusive for teachers or the system manager to add new user accounts and to manage student data, including inquiry, browse, modification, add, and delete student data. In addition, teachers or system manager can directly announce news by filling out the form.

3 Database of WBLP

The design of the database is crucial to the smooth operation of the entire system. Three databases were designed to store and manage students' learning portfolios

3.1 Portfolio Database

The portfolio database is the core section of the WBLP system and the place for storage and management of student learning portfolios. Different application goals (such as supporting multiple courses, more classes but one course) of a web-based portfolio lead to various complexity in the considerations of database design. Due to the limits on time and labor, the system presently can simply handle the course load for one class. The student ID number was used as primary index for the portfolio database. The database contains three data tables, which are associated with the student ID.

1. Student data table: stores student basic data, e.g., name, ID number, major, interests, and specialty.
2. Portfolio data table: stores the contents of student learning portfolio, including learning goal, course work, reflection and self-assessment record, teacher feedback record, peer feedback record, and personal web page; where only the learning goal is stored in memo form, the course work column gives the total number works, while only respective filenames are stored in the rest of the columns.
3. Course work data table: in consideration of the differences of works within the student learning portfolio, the record of the table will be updated dynamically when students upload a new work. Data include work-file path, work outline, date of update, status of completion, and grade of works.

3.2 Discussion Database

It is an independent database specially designated for the portfolio discussion board, including two main data tables:

1. topic data table: store information and contents related to the topic of discussion.
2. article data table: store information and contents of articles of discussion, associated by the column of Title ID with the topic data table.

3.3 Bulletin Database

It is designated for the portfolio bulletin board containing only one news data table to store system notices, course information and news as a dynamic message announcement and presentation for teachers and system manager.

4 Implementation and Evaluation of WBLP

4.1 Implementation

The WBLP system was implemented during the middle of second term of the 1998 school year (late April to middle June). The revised and updated prototype system is open to 35 undergraduate students taking the Computer and Instruction course of Teacher Preparation Program until the summative evaluation of system for a period of one and a half month. The implementation and operation are generally good. As the learning portfolio is a new assessment, and through the use and creation of personal learning portfolio, a student can personally experience the assessment and process to understand the nature and contents of the method, which is helpful to the future instruction work of pre-service teachers. Moreover, most assignments and works of the course are presented in electronic data/file, they are very suitable for the creation, management and presentation of web-based learning portfolio. Therefore, the course has been selected as a subject of the system.

As portfolio assessment is new, most students do not have the idea or experience of the assessment. Before the implementation, the students were given a brief introduction to the assessment, so that they could have a better understanding of the portfolio assessment. In addition, an online help/guide is provided in the WBLP system to help users understand the functions, contents and creation of a learning portfolio. After the system implementation, teachers required and encouraged students to use the system according to the course schedule, and subsequently to complete the creation of personal learning portfolio. Moreover, each student is required to write a reflection and self-assessment for each course work, though feedback and assessment on peers' work is not compulsory. At the same time, online assistant has helped teachers to view and numerate the creation of portfolio, learning goal, reflection and self-assessment record, peer feedback and assessment, and student works.

4.2 Evaluation of Functions and Effects

The system summative evaluation includes user-based and expert-based evaluations in terms of system functions, overall design and interface operation, implementation and uses, and impacts on learning.

4.2.1 User-based Evaluation

A survey using a 5-point rating scale questionnaire was given to the 35 undergraduate students in the subject course. Then a random sampling was used to select 5 students for further interviews to have an in-depth understanding of the system function design and learning portfolio creation.

In system function design, besides a lower agreement to the personal web page upload (average 3.75), all other items have an average over 4, which shows that there is still room for improvement in the system upload process. The majority of students agreed and very much agreed, which means that the system functions can satisfy the needs of users. The reasons for the lower agreement of web page upload may include the inability to support upload by directory of data file, a user may need to upload web pages file by file, which makes things very inconvenient; moreover, most students are inexperienced to web page creation and fail to following the instructions of producing web pages, as a result, access paths of web page files are incorrect, and web pages are unable to normally display.

In overall system design and interface operation, user agreement is over 4.0, and there is no disagreement, which suggests that the performance in system architecture, screen and window design, color or background layout and ease to operation is quite good.

In system implementation and application, most students would browse the course works and personal web pages of peers (average over 3.5), so students should be encouraged to browse other contents of the portfolio. Possible reasons are the limited implementation period of the WBLP system. It is difficult for a student to create his own portfolio and browse that of all other students. Browsing other students' course works and web pages may help in the creation and improvement of one's own work. Moreover, most students have browsed their own feedbacks from teachers and peers (average over 4). In personal portfolio creation, most students would browse related information provided in the portfolio guide/help (average 4.27). In practice, most student reflected that the creation of personal learning portfolio is time-consuming (44% agreed, average 3.37); however, there is only a slight difference between agreed and disagreed in the writing of learning goal, reflection and self-assessment record, and peer feedback. From the viewpoint of an average under 3, there is little problem.

In impacts to learning, the Table 1 reveals that the following six items have an average over 4.5, which means that the majority agreed. The results show that most users have a positive attitude toward the system's assistance in personal learning process and outcome, i.e., the system can help students in learning the course.

Table 1 Percentages and averages of student agreement in WBLP impacts on learning (n=35)

Evaluation Items	Percentages of student agreement (%)					
	5	4	3	2	1	Average
1.The system enables students understand the achievements of other students	67	33	0	0	0	4.67
2.The system is helpful for learning the course	70	27	3	0	0	4.67
3.The system enables students learn the feedback and suggestions from other students	60	37	3	0	0	4.57
4.Browsing peers' work will be helpful to improve the quality of one' s own	63	30	4	3	0	4.53
5.The system enables students learn the feedback from teachers	63	27	10	0	0	4.53
6.Expectation for the WBLP system in other courses	60	33	7	0	0	4.53

Note. 1.Evaluation items with an average below 4.5 are not included in the table.
2.The numbers of 5, 4, 3, 2, 1 denote a 5-point rating scale with 5 being strongly agree and 1 being strongly disagree.

4.2.2 Expert-based Evaluation

Three experts (including the instructor of the course, portfolio expert and assessment expert) were invited to use the system, and an interview was made after a week.

In the pertinence of portfolio contents, experts expressed that the WBLP system contents has satisfied the basic needs of a learning portfolio, however, more information concerning the things that happened in class or interesting events, literature or presentation data will enrich the system. In addition, the system is designed for the Computer and Instruction course, teacher application is less self-controlled and spontaneous; the content is more ' teacher-guided' , and student involvement is not concerned.

In system functions (e.g., portfolio creation, browse, guide, discussion, bulletin, suggestion and data maintenance), the WBLP system has displayed the characteristics and functions of learning portfolios in general, they are appropriate and support basic learning portfolio creation/browse. However, for the system management function, the teacher' s grading mechanism on student works, automatic recording function, and score statistic functions can be added to facilitate instruction and assessment. A portfolio assessment scoring function can be added to provide student self-assessment, peer-assessment and teacher-assessment mechanisms, e.g., online creation of assessment table, self-assessment table, peer-assessment table, score automatic recording and statistic functions.

In overall interface design and operation, the system is quite easy-to-use, however, some descriptions of how to create portfolio can be clearer, and the display speed of course work is a bit slow and affect the smooth browse of works.

In assistance to student learning and teacher instruction, the WBLP system can provide an effective and appropriate creation and browse environment of learning portfolio, and can help teachers and students to understand the authentic learning process and accomplishment of students. Moreover, it may provide a chance for students to improve their own works and view that of the others, which are very helpful to learning process. However, students present only the completed work in the portfolio, and the process is harder to display. Therefore, if the collection and display of the in-process works of students are enabled, the system can effectively reflect the process of student learning.

5 Conclusions and Future Works

Tradition portfolio assessment still relies on man-made data collection and a writing-centered learning process. The difficulties in data storage, search and management after long-term implementation have become a problem in the development and implementation of portfolio assessment (Mullin, 1998; Smith &

Tillema, 1998; Niguidula, 1993). Fortunately, the impact of computer technology has facilitated the production of electronic or computer-based portfolios, which not only solves the problem of huge amounts of data storage, but also enables students to combine text, pictures, images and sounds to present richer and more diversified file content through multimedia. In addition, computer technology is a great aid to data collection, update and management of electronic portfolio (Lankes, 1995). The creation of an electronic portfolio however requires peripheral devices (such as a scanner to change a picture into digital format), hard disk, diskette, or CD-ROMs, for storage, printers, etc.. In this respect the World Wide Web will become a common solution for recording a learning portfolio. The availability of the World Wide Web will not only facilitate the recording, editing, searching and analysis of learning portfolio data, learners and teachers can also share data with other users through Internet browsing functions.

Making use of the portfolio assessment concept, this study integrated the characteristics and functions of computer and network technology to design and construct a web-based learning portfolio, in the hope to help record, display, search and analyze student learning process data. Besides being an electronic assessment too for supporting teacher instruction, the WBLP system provides functions for students and teachers to browse and understand the authentic learning status of the others to improve the interaction between students and to let students understand the learning performance and progress of their peers. The functions of the WBLP system include portfolio creation, portfolio browse, portfolio guide, portfolio discussion board, portfolio class bulletin, suggestion board, student data maintenance, and system management. Databases used in the WBLP include student portfolio database (including student basic data table, portfolio data table, course work data table), discussion database (including topic data table, article data table), bulletin database (including news data table).

The WBLP system has been officially implemented in a course at the university setting for approximately a semester, both the implementation and operation are quite good. The results of system evaluation and effects show that most students consider that the system to be helpful in improving the learning process and accomplishing quality, understanding the authentic learning process and outcome, providing chances for displaying and improving works. Besides the time-consuming portfolio creation, students hold a positive attitude to the overall operation and instructional application of the system. Next step we will continue qualitative and quantitative experimental studies to further understand more about the true impact of web-based portfolio learning on students' learning process and outcomes.

Acknowledgement

This research was conducted under the support of National Science Council of Taiwan, ROC, project no: NSC 89-2511-S-032-001.

References

[1] Cole, D., Ryan, C., & Kick, F., "Portfolios across the curriculum and beyond", CA, Thousand Oaks: Corwin Press, (1995).

[2] Farr, R. & tone, B., "Portfolio and performance assessment: Helping students evaluate their progress as readers and writers", Fort Worth, TX: Harcourt Brace College Publishers, (1994).

[3] Glaser, R. & Silver, E., "Assessment, testing, and instruction: Retrospect and prospect", Review of Research in Education, No.20, pp.393-419, (1994).

[4] Herman, J. L., "What research tells us about good assessment", Educational Leadership, No.49, pp.74-78, (1992).

[5] Lankes, A. M. D., "Electronic portfolios: A new idea in assessment", (ERIC Digest EDO-IR-95-9) [Online] Available: http://ericir.syr.edu/ithome/digests/portfolios.html, (1995)..

[6] Mullin J. A., "Portfolio: Purposeful collections of student work", New Directions for Teaching and Learning, No.74, pp.79-87, (1998).

[7] Niguidula, D., "The digital portfolio: A richer picture of student performance", (ERIC Document Reproduction Service NO. ED 400 261), (1993).

[8] Smith, K. & Tillema, H., "Evaluating portfolio use as a learning tool for professionals", Scandinavian Journal of Educational Research, Vol.42, No.2, pp.193-205, (1998).

Web-Based Subject-Oriented Learning Program on Geophysics For Senior High School

Rong-Kuan Yang* Yi-Ben Tsai and Shi-Jen Lin*****
** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
e-mail: rk@eqm.gep.ncu.edu.tw
*** Department of Earth Sciences, National Central University, Chung-li, Taiwan,*
E-mail: ybtsai@eqm.gep.ncu.edu.tw
**** Department of Management Information System, National Central University, Taiwan*
E-mail: sjlin@mgt.ncu.edu.tw

Homepages of contents on the topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been composed for the subject-oriented learning program for senior high school students. Learning test activities were performed to testify the teaching and learning effect via Internet. The homepage contents bear the characteristics of (1) scientific theory-based descriptions, (2) more local examples, (3) highly relating to common life, (4) more dynamic illustrations, and (5) providing interesting practicing works. The results of subject- oriented learning test activities in this study show that the learning style, learning procedures and the homepage contents are all highly accepted by the participants from senior high school. And the learning effect is obvious as judged by comparing the pre-learning and the after-learning concept diagrams drawn by each individual participant.

Keywords: **subject-oriented learning program, learning test activities, concept diagrams**

1 Introduction

Internet system supplies plenty of knowledge conveniently and quickly, the explorer can achieve the purpose of self-learning by collecting, reading, analyzing and combining different kinds of data via Internet. For the purposes of improving the learning environment, enhancing the teaching quality, and raising the learning effect on Earth Sciences education for senior high school, web-based course contents on topics of Earthquake, Plate Tectonics Theory and Chi-Chi Earthquake in the field of Geophysics have been set up based on the idea of subject-oriented learning program [2]. Senior high school students can not only do the self-learning but also exchange their learning ideas with others through Internet learning system under different conditions of time periods and places. By joining the study results from fields of education, computer technology, geophysics and geology, subject-oriented learning test activities for each specific subject were performed respectively with the participation of volunteered teachers and students from different senior high schools so as to evaluate the learning effect of Internet learning system.

2 Objectives

By especially considering the educational idea of subject-oriented joint learning mode[1], homepage contents were set up. Internet learning test activities were performed by using joint learning software and concept diagram drawing software developed by the computer technologist' s [3]. The major objectives of the study are as follows:

1) Setting up basic web-based contents on Earth Sciences so as to enhance the teaching and learning interests for high school education, the contents may also serve to a better understanding of the earth environment for social people.

2) Setting up the effective searching catalog so as to assist in surveying and collecting related data.
3) Assisting in solving educational problems and improving learning effect through Internet communication system.

3 Subject-Oriented Joint Learning Test Activity

Subject-oriented learning strategy was the major concern in the study. Participants were advised to carry out the learning program by reviewing and collecting related contents through Internet. All the communications were put through BBS posts or e-mails, there were volunteer helpers, college students, to respond all proposed questions from time to time. Team works were important besides individual learning as well, each would share personal learning results with others and came out a group report, individual learning effect was evaluated by comparing the pre-learning and after-learning concept diagrams.

After entering the web site "gepedu.gep.ncu.edu.tw" (Fig. 1), participants would click the right icon to choose the specified subject for the activity. Each one should draw a pre-learning concept diagram by connecting the provided concept terms with proper words after watching the "Miss story" (a short documentary film) prepared for the subject. And then, the major stages for the learning test activity were:

1) Participants were separated into groups of different topics on the specified subject based on his own study interest.
2) Every group set up its study assumptions and strategy; certain assignments were distributed to each individual member of the group.
3) Group members started to survey and collect related data for the topic, and all the working records were kept by using joint learning software.
4) Participants bearing the original role of topic group were re-divided into different groups of experts to cover more study fields. Members discussed and shared personal study ideas and results with others.
5) Each participant returned to his original group of topic and made after-learning concept diagram a group report for the study was also made with the efforts of all the group members.

4 Results and Discussions

Three learning test activities were finished in the study [2]; detailed descriptions of the activities are in Tables 1 to 3. When first learning test activity on Earthquake was being held; related software was not well developed. Internet function was limited to content reviewing. By the time of second learning test activity on Plate Tectonics Theory software was more fully developed, all works were done under Internet environment; more working records were preserved in personal joint learning files for the second and the third activities. All discussions and questions among the students were put through BBS posts and e-mails; volunteer helpers joined the discussions and also answered the questions in time. There are 119 posts from the second activity and 552 posts from the third activity, most of the posts are highly related to the learning program. Each participant finished drawing two concept diagrams in pre-learning and after-learning stages respectively, there are 24 diagrams from the second activity and 46 diagrams from the second activity. And each group had also submitted the group report as required in the learning activity in time, there are 2 and 3 reports for the first and the second activities respectively. Plenty of discussions and notes have also been recorded in the joint learning software in Internet. However, the insufficiency of the Internet system and the learning pressure under traditional education system may interrupt the continuous progressing of the learning program, occasional oral communications seem to be necessary. Though the ability in data analyzing, reducing and deducing may not be well satisfied, students show obvious improvement in the knowledge of the subject as judged by comparing and analyzing the individual pre-learning and after-learning concept diagrams and from group reports.

5 Conclusion

Homepage contents for all the three subjects are highly acceptable to high school students and teachers, most of them confirm with the learning effect of the subject-oriented joint learning program. If the traditional learning pressure would be suitably released, students will be more willing and free to perform self-learning program through Internet learning system even though they are not very well familiar with the operation of the used software.

References

[1] Chen, F. C., "The study of a cooperative project-based learning design in network-based environment", NSC Study Report, NSC-88-2511-S-008-002, pp. 1-8(1999)

[2] Chin B. H., Yang, R. K. and Wang, C. Y., "Development of a learning environment for solid earth (geophysics) through Internet", NSC Study Report, NSC-88-2511-S-008-005, pp. 1-5(1999)

[3] Lin, S. J., Chou, S. C., Chen, Y. M., Chan, T. W., "A study of Internet-based collaborative project learning environment", NSC Study Report, NSC-88-2511-S-008-003, pp. 1-8(1999)

Table 1 Learning Test Activity on Earthquake

Time	1998.5.3, 1 day
Location	computer room in Wuling Senior High School
Participants	12 high school students, 3 high school teachers, 17 volunteer helpers(students and teachers from Department of Earth Sciences, National Central University)
Subject	Earthquake
Group of Topic	Occurrence and Distribution, Intensity and Magnitude
Working Pattern	content reading via internet, one to one oral communication, working processes recorded by volunteer helpers
Evaluation Materials	concept diagram, questionnaires, working records

Table 2 Learning Test Activity on Plate Tectonics Theory

Time	1999.2.27~1999.3.6, 8 days
Location	computer rooms in Wuling Senior High School, ChenSheng High School and National Central University, personal working environments
Participants	6 students and 1 teacher from ChenSheng High School, 6 students and 1 teacher from Wuing Senior High School, 7 volunteer helpers from National Central University
Subject	Plate Tectonics Theory
Group of Topic	Continental Drift, Sea Floor Spreading
Group of Expert	Dynamics, Mechanism, Effect
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software, three assignments

Table 3 Learning Test Activity on Chi-Chi Earthquake

Time	2000.2.2~2000.2.26, 25days
Location	computer room in National Central University, personal working environments
Participants	4 students and 1 teacher from ChenSheng High School, 2 students and 1 teacher from TaoYuan High School, 2 students and 1 teacher from Wuling Senior High School, 3 students and 1 teacher from HsinChu Experimental High School, 2 students from ChungLi High School, 5 students from HsinChu High School, 2 students from HsinChu Girls' High School, 2 students from ChenDer High School, 1 students from ChuTung High School, 7 volunteer helpers from National Central University
Subject	Chi-Chi Earthquake
Group of Topic	Mechanism, Analysis, Effect
Group of Expert	Focus, Magnitude, Focal Mechanism, Hazard
Working Pattern	Besides software learning on the first day and evaluation meeting on the last day, all the other works were all carried out via Internet.
Evaluation Materials	pre-learning and after-learning concept diagrams, questionnaires, BBS posts, working records in joint learning software

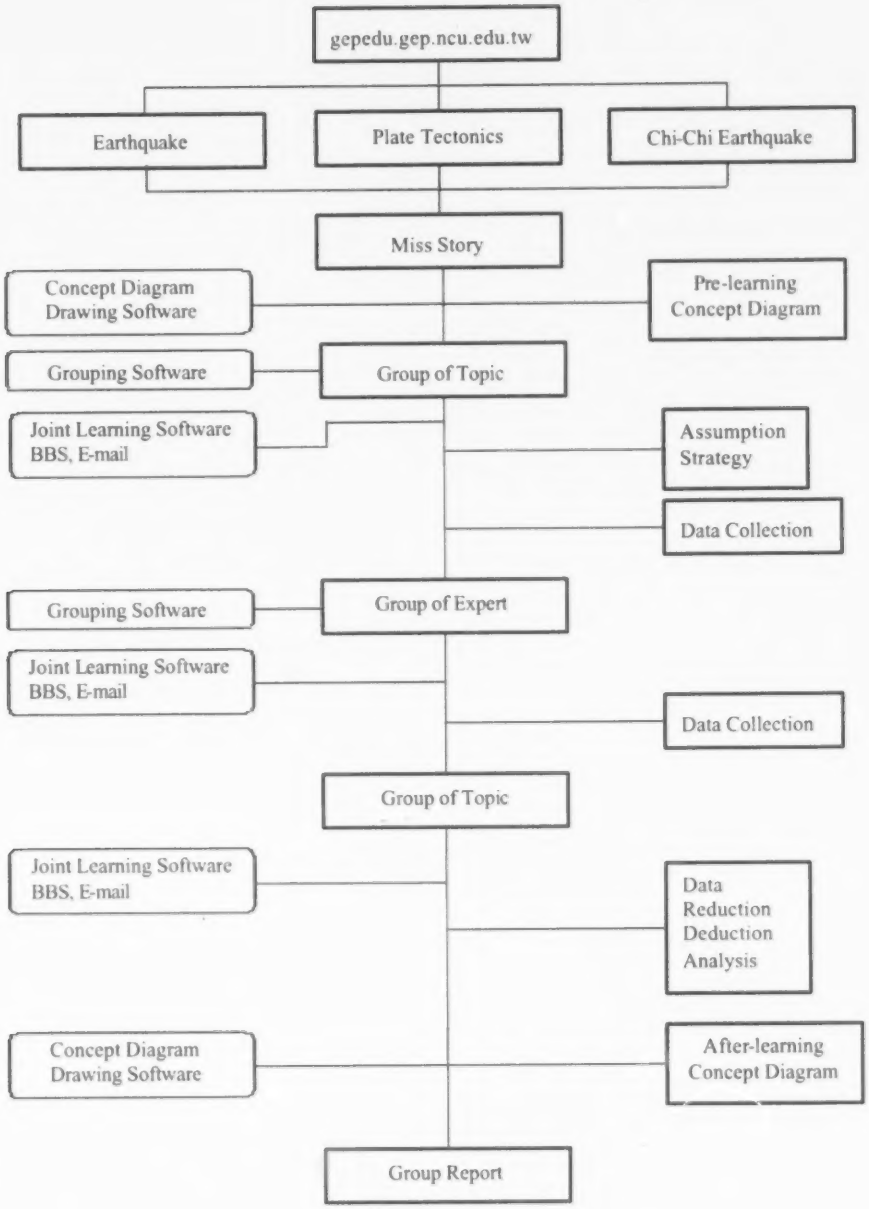


Figure 1 Flowchart for subject-based joint learning test activity

WWW-Supported Environments for Learning and Teaching Statistics

Katsuyuki Suenaga*, Hiroshi Yadohisa, Naoko Sakurai***, Kazunori Yamaguchi****, Michiko Watanabe*****and Chooichiro Asano********

** Graduate School of Science and Engineering, Kagoshima University, Kagoshima 890-0065, JAPAN; sue@sci.kagoshima-u.ac.jp*

*** Department of Mathematics and Computer Science, Kagoshima University, Kagoshima 890-0065, JAPAN; yado@sci.kagoshima-u.ac.jp*

**** Institute of Asia-Pacific Studies, Waseda University, Tokyo 169-0051, JAPAN; sakurai@wiaps.waseda.ac.jp*

***** College of Social Relations, Rikkyo University, Tokyo 171-8501, JAPAN; kyamagu@rikkyo.ac.jp*

****** Department of Economics, Toyo University, Tokyo 112-0001, JAPAN; michiko@hakusrv.toyo.ac.jp*

****** Department of Information Science, Soka University, Tokyo 192-8577, JAPAN; QYG04340@nifty.co.jp*

In this paper, we introduce an integrated environment for education of Statistics on WWW. The environment is composed of three Web sites; ITLS (Interactive Text for Learning Statistics on WWW), EBSA (Electronic Book for Statistical Analysis on WWW), and DLLSA (Dynamic Link Library for Statistical Analysis). ITLS is an electronic text of Statistics with graphics, sounds, and interactive software which made by JAVA. EBSA is an electronic library of statistical books which made of the PDF format files. These books are scanned and trans-formed from real books which copyright is expired. DLLSA is a statistical software library of DLL files.

Keywords: **Interactive learning environments, Multimedia and hypermedia in education, Self-driven experiments**

1 Background

Recent rapid coverage of computer networking over wide area of Japan has brought the big change of education environment at universities. In these 1 or 2 years there can be seen lots of universities, especially in non scientific division, have set up the computer networking education system over their several lectures where both teachers and students can access to internet Web sites during the lecture time. It also can be seen at overseas education institutes that there have been increasing of statistical education sites [11][12][13][14] or related reports [1][3][4][6][10].

On the other hand, the society needs the persons with the ability of economical data analysis or econometrical analysis among the general sections especially in finance division. It means graduates from social sciences department with an ability of data analysis will be much more needed who had not so many times got the lecture related to statistical data analysis during university days. Statistics is good discipline for computer networking education because it is important for students to learn not only the theory but also the moving of practical data with changing parameters which will lead them to another side of understanding of real world. It can be expected that interactive education with internet Web will bring the multi-dimensional effects to education world. Those are why we have started jointly developing new styled education system for statistics on Web site. It also could be seen that the government recommend to make more use of networking at education scene in line with the change of world education environment.

2 Purposes and Functions

The purposes of our statistical education system on Web are as follows. i) Joint development of education Web sites with which practical statistics education can be realized, ii) Non scientific students' master of data analysis for actual practice, iii) Teachers can keep their material for education jointly, aiming contents' standardization, iv) Students can learn everywhere they are. We are aiming students can participate to our Web sites and get effective learning chances of statistics and econometrics with interactive ways. It can be expected students would keep highly motivation of learning through active operation of some parameters or data on Web site by themselves. It is clear that this is quite different from traditional education way at the point of students are active in learning without their realizing.

Let me show the concrete functions. i) Retrieval by keyword and its supplementary explanation, ii) Download of lecture slides and practical data, iii) Linkage to reference sites, iv) Offering of database for practice, v) Setting of question and answer section, vi) Online questionnaires system. In addition, Web texts contain some easy comments, colored contents, hyper linked material, images and dynamic graphs to help students who are far from printing types can understand statistical concepts.

Figure 1: Top page of ITLS (http://www.sci.kagoshima-u.ac.jp/~itls/)

3 Contents and Characteristics

We have named our online education system as "ITLS (Interactive Text for Learning Statistics)" which is the abbreviation of interactive text for learning statistics (URL: http://www.sci.kagoshima-u.ac.jp/~itls/). Although students can learn statistics and econometrics along this system's chapter contents, chapters are independent each other, so it doesn't matter going to their objects directly. By trying to interactive learning with this system, students can get statistical, econometrical and other economical index or knowledge depending on their own ability. An interactive and visual learning will much make possible the diversified understanding comparative with the usual learning way only by paper texts.

BEST COPY AVAILABLE

Figure 2: Descriptive statistics

Figure 3: Regression analysis

Figure 4: Dynamic graph of scattergram

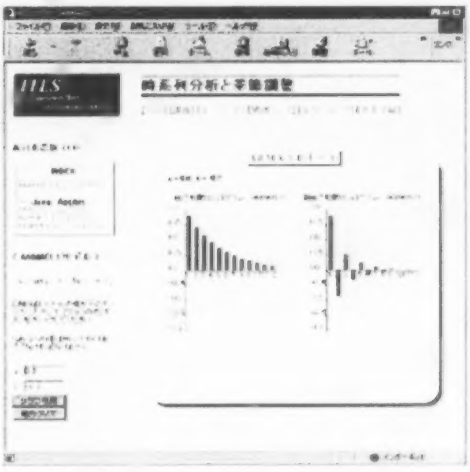


Figure 5: Dynamic graph of correlogram

Figure 2 shows multi-modal distribution in the chapter of descriptive statistics. In this chapter students can get the objective visual panel of contents by retrieving left side keywords list. There are any other explanatory panels of descriptive and inference statistics in this Web system. It is greatly more important for students to see the distribution form visually than to understand statistical concepts only without visualization. Figure 3 shows the regression analysis by familiar tool, for example, Microsoft excel. Each chapter has used the excel or other statistical analysis software as its practical tool, at the same time in the early chapter it has been showed how to use excel as statistical analysis tool mainly. At the demonstrative step of statistics learning, it will be indispensable for students to make use of at least one statistical and analytical software tool which is not common to install in each personal computer at universities except excel.

Figure 4 and 5 show interactive statistical graph. It is not so easy for students who are majo ring not scientific division to understand the relationship between graph and its fixing parameters. These styled system of viewing the dynamic change of various kinds of statistical graph have brought them both visual and intuitive understanding without mathematical formula. This interactive graph making system has been built by JAVA applet or other software tools. There are another contents such as download of lecture slides, making practices into database, setting question and answer section and online questionnaire survey of user along

whose analytical results we will update our Web contents better in the future. The bulletin of question and answer is very important for all users because it is the best database of several kinds of question and its response from anyone on all sorts of questionnaire of statistical stages. Developing resources and tools also are considered very important module with which the system will be organized better hyper-linked cooperative developing environment.

Figure 6: Top page of EBSA (http://www.sci.kagoshima-u.ac.jp/~ebsa/)

Figure 6 shows our new Web site of "EBSA (Electronic Book for Statistical Analysis)" with which everybody access to this site can do of online reading over old or new valuable books on Web. Now we have provided several important books on this site. These books open to the public under permission of the copyright holder and the publisher. Since these electronic books are scanned and transformed from real books into the PDF format files, we can download and print out all and/or selected contents of the books. Figure 7 shows one of the top page of an electronic book. Each top page contains four parts; the first and the second parts are the links to the contents and the index pages, respectively. The third part is used for keywords search. The fourth part is the print image of the real book. We rewrite these index and contents as text from the image so as to be used by keywords search.

BEST COPY AVAILABLE

Figure 7: Top page of an electronic book

Figure 8: Contents of an electronic book

Figure 9: Index table of an electronic book

Figure 10: Result of a keywords search

Figure 8 and Figure 9 show the contents and the index table of one of the electronic books, respectively. On the contents page as Figure 8, we can read the regarding part of the book by clicking the name of the section or the subsection. On the index page as Figure 9, we can see the target page directly by clicking the index word. Figure 10 represents the result of the search by "• • •(factor)". This search system can and/or search by multi keywords. The regular expression can also be used in this system and the search can be applied to a selected book or all books in our system.

4 Effects

On students side, they can learn statistics wherever they are, at the lecture room, PC practicing room, home or any other place with Internet environment. Teachers also have the great merits. First, they can have common texts if they are under such circumstances of connecting to internet world. This site can be utilized by every faculties who are not majoring statistics. Texts will be set in the newly one whenever someone will notice another precise contents, in addition this means it would be realized the standardization of education will be led to. The best quality of texts and education will always be hoped.

BEST COPY AVAILABLE

5 Integration

When we use the statistical analysis software, knowledge of statistics is indispensable for us. It can be seen several reports about the effectiveness of the standing statistical analysis software with statistics education [5][7][8][9]. Working statistics with analytical software will much be an expected style of learning over interactive Web system. Under such background, our project team has already prepared a new library of Dynamic Link Library (DLL) for statistical analysis, which is available as a statistical engine or which can be called from existing general statistical software, for examples SAS, SPSS, S and so on.

The DLLs could be considered as a library for applications on the Windows system as well as that for programming. The DLL contains one or more functions that are compiled, linked and stored separately from the applications using them. One of the advantages of DLLs is that multiple applications can access the same DLL. The DLLs in our library can be accessed from any statistical software or spreadsheet-type software if such software has a facility to call functions or subroutines in DLLs. Source codes for DLLs can be written in several programming languages, for examples, C++, FORTRAN, BASIC, PASCAL and so on.

The contents of multivariate analysis section, for example, are as follows. i) Principal Component Analysis, ii) Metric Multidimensional Scaling, iii) Latent Class Analysis, iv) Hierarchical Cluster Analysis, v) Corresponding Analysis, vi) Discriminate Analysis. All contents of our library can be downloaded and used freely. Details for the library and published DLLs can be obtained from our web site (URL: http://www.sci.kagoshima-u.ac.jp/~dllsa/).

The necessary factors of integrated statistical education system of interactive way on Internet are now on ready among our project team members. To be concrete, it is important and urgent to merge statistical analysis software routines above with online learning system on Web as mentioned before, adding to attach the enrichment of interfaces.

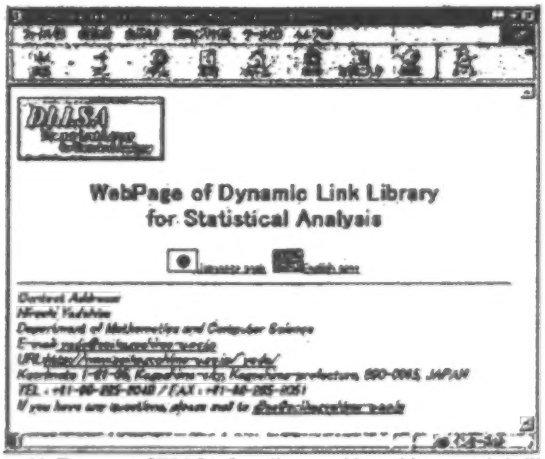


Figure 11: Top page of DLLSA (http://www.sci.kagoshima-u.ac.jp/~dllsa/)

6 Future

Though there are not so many reports about this kind of educational system whole over the world, we can meet some excellent reports about interactive education system on Web [11][12][13][14]. One of our mission is the enrichment of the contents. The join forces of lots of facultics belonging to statistics section will demonstrate the strong power for cooperative Web texts production system. Our next target is achievement of "international cooperative project". We have the plan of translating the part of contents to international version. Now we appreciate the joint research with German colleague who had already established interactive Web site [3][14].

BEST COPY AVAILABLE

Finally, we would like to introduce the integrated site of our projects. All contents discussed in this paper can be obtained from this site (URL: http://www.sci.kagoshima-u.ac.jp/~stat/).

Figure 12: Integrated site of our projects (http://www.sci.kagoshima-u.ac.jp/~stat/)

References

[1] de Leeuw, J., "The UCLA Statistics Textbook and Module", Bulletin of the International Statistical Institute, 51st Session Proceedings, Vol. 2, Istanbul, Turkey, pp. 55-58, (1997).

[2] Liu, L.-M., Chan, K-K., Montgomery, A. L. & Muller, M. E., "A system-independent graphical user interface for statistical software", Computational Statistics and Data Analysis, Vol. 19, pp. 23-44, (1995).

[3] Mittag, H. J., "Emphasizing Visualization and Activities in Teaching Introductory Statistics by Interactive Multimedia", Bulletin of the International Statistical Institute, 52nd Session Proceedings, Vol. 2, Helsinki, Finland, pp. 275-278, (1999).

[4] Müler, M., "Computer-assisted statistics teaching in network environments", In: Payne, R. and Green, P. (Eds.), Proceedings in Computational Statistics 98, Physica-Verlag, Heidelberg, pp. 77-88, (1998).

[5] Nakano, J., "Graphical user interface for statistical software using internet", In: Payne, R. and Green, P. (Eds.), Proceedings in Computational Statistics 98, Physica-Verlag, Heidelberg, pp. 407-412, (1998).

[6] Sakurai, N., Watanabe, M., Hashimoto, H., Yamaguchi, K. & Inoue, T., "Developing a Textbook for Learning Statistics on the Internet", Bulletin of the International Statistical Institute, 52nd Session Contributed Papers, Vol. 3, Helsinki, Finland, pp. 481-482, (1999).

[7] Sato, S., "Introduction to "Web Decomp"-Seasonal Adjustment System on WWW-", Proceedings of the Institute of Statistical Mathematics, Vol. 45, pp. 233-243 (in Japanese), (1997).

[8] Thioulouse, J. & Chevent, F., "NetMul, a world-wide web user interface for multivariate analysis software", Computational Statistics and Data Analysis, Vol. 21, pp. 369-372, (1996).

[9] West, R.W., "Statistical Applications for the World Wide Web", Bulletin of the International Statistical Institute, 51st Session Proceedings, Vol. 2, Istanbul, Turkey, pp. 7-10, (1997).

[10] Yamaguchi, K., Inoue, T., Yadohisa, H. & Watanabe, M., "Educational statistical software on the world wide web", Proceedings in Computational Statistics 98: Short Communications, Bristol, Great Britain, pp. 127-128, (1998).

BEST COPY AVAILABLE

[11] Aoki, S., http://aoki2.si.gunma-u.ac.jp/lecture/index.html (accessed on July 31, 2000)
[12] Abe, K., http://www1.tcue.ac.jp/home1/abek/htdocs/stat/ (accessed on July 31, 2000)
[13] Ohnishi, H., http://econom01.cc.sophia.ac.jp/ (accessed on July 31, 2000)
[14] Mittag, H. J., http://www.fernuni-agen.de/STATISTIK/ (accessed on July 31, 2000)